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# African Eggplant

## Description

African eggplant, *Solanum aethiopicum*, is a deciduous shrub in the family Solanaceae which is grown for its edible fruits which are cooked and eaten as a vegetable. African eggplant is a highly branching plant which can grow up to 2 m (6.6 ft) in height. The leaves of the plant are arranged alternately on the stems and have smooth or lobed margins. Leaf blades may reach up to 30 cm (11.8 in) in length and 21 cm (8.3 in) in width. The leaf petioles are oval or elliptical in shape, reaching up to 11 cm (4.3 in) in length. Plants produce clusters of up to 12 white flowers which develop into egg or spindle-shaped berries which are red to orange in color with a smooth or grooved surface depending on variety. African eggplant may also be referred to as scarlet eggplant, bitter tomato, mock tomato, garden egg or Ethiopian nightshade and is native to Africa, likely resulting from the domestication of a related species, *S. anguivi*.

## Crop Details

Scientific Name: *Solanum aethiopicum*

Common Name: african scarlet eggplant,bitter tomato (En); aubergine amare, aubergine africaine, aubergine ã©carlate, tomate amare, djakattou (Fr); ézæ¢...èŒ, (Cn); nakati etope, berenjena escarlata (Sp).

*African eggplant fruit*

*African eggplant*

*African eggplant flowering*

## Uses & Benefits

African eggplant is grown primarily for its bitter orange-red fruit, which may be eaten boiled, steamed, pickled or in stews with meat and other vegetables. Young leaves are also often used in soups.

African eggplants are a source of fiber, potassium, and offer traces of beta-carotene, ascorbic acid, iron, and calcium.

## Varieties of African Eggplant

African eggplants, scientifically known as *Solanum aethiopicum*, vary in color and shape based on the cultivar. The species is divided into four main groups: Gilo, Shum, Kumba, and Aculeatum. Each group has unique characteristics:

**Gilo** : Edible fruits that vary from spherical to oval shapes.

**Kumba** : Has a primary stem with edible leaves and fruits, which can be green or red.

**Shum** : A short plant with small, smooth leaves. Its shoots are edible, but its small fruits are bitter and less preferred.

**Aculeatum** : Recognized for its flat fruits, often grown for ornamental use.

## Propagation

### Basic Requirements

Growth requirements for African eggplant vary with variety. All types grow best in full sun and well-draining, deep soils with a pH between 5.5 and 6.8. Gilo types grow best at daytime temperatures between 25 and 35°C (77 and 95°F). Kumba types can grow in hotter temperatures of up to 45°C in low humidity, whereas Shum types require warm and humid conditions in order to thrive. No varieties of African eggplant tolerate very cold or water-logged conditions.

### Growing from Seed

African eggplant seeds can be collected from fully ripe fruits. Once the seeds have been extracted, they should be laid out on a piece of paper to dry in a place where they are not exposed to direct sunlight. Once dry, seeds can be stored for many years and still remain viable. Seeds should be planted in a prepared nursery bed and should be sown 15 cm (6 in) apart with a further 20 cm (8 in) between rows. Seedlings are ready for transplanting when they reach 15 to 20 cm (6–8 in) in height and have 5–7 leaves. Plants should be hardened prior to transplanting by gradually reducing the amount of water they receive. Plants should be spaced 50 cm (20 in) apart allowing 75 cm (30 in) between rows.

### General Care and Maintenance

African eggplants will benefit from frequent irrigation during the dry season, particularly when fruiting, to ensure high yields. The crop should be weeded as required to prevent competition. Addition of fertilizer in the form of cattle or chicken or cattle manure or compost will improve yields.

### Harvesting

African eggplant is typically ready for harvest 100 to 120 days after planting. The fruit should be harvested before the skin changes color from white to pale yellow when the skin becomes tough. Fruits should be harvested regularly to

encourage maximum fruit production. Young leaves may be harvested from 45-60 days of growth.

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# Alfalfa

## Description

Alfalfa, *Medicago sativa*, is an herbaceous perennial in the plant family Fabaceae (peas and beans) which is primarily grown as a forage crop which can be grazed by animals or harvested as hay to be used as an animal feed. Alfalfa has a deeply penetrating taproot and the stems of the plant branch from a woody base, growing upright and erect or along the ground. The leaves of the plant are made up of three individual leaflets (trifoliate) which are narrow and oval or oblong in shape with a smooth upper surface and slightly hairy lower surface. Alfalfa plants produce flowers on racemes (flower stalks) and each raceme possesses 10–35 densely packed purple flowers. Alfalfa produces spirally coiled seed pods each containing 2–6 seeds. Pods may have a smooth or hairy outer surface. Alfalfa plants can reach a height of 120 cm (47 in) and live for between 3 and 8 years. Alfalfa is also commonly referred to as lucerne and is believed to have originated in Caucasus area, north-western Iran and north-eastern Turkey.

### Crop Details

Scientific Name: *Medicago sativa*

Common Name: lucerne, purple medic (En); alfalfa, mielga (Sp); luzerne (Fr); luzerna (Pt); à¤...à¤²à¥à¤«à¤³/à¤²à¥à¤«à¤³/ (Hi).

*Alfalfa seed pods*

*Alfalfa beds in field*

*Alfalfa plants in bloom*

*Alfalfa flowers*

*Close-up image showing trifoliate alfalfa leaf*

*Healthy alfalfa foliage*

*Alfalfa ready for cutting*

## Uses & Benefits

Alfalfa leaves are edible and can be eaten as a leafy vegetable. Alfalfa is used primarily as forage for animals and is cut and stored as hay or silage. As a legume, the plant fixes nitrogen so can be used to increase nitrogen in the soil and is a commonly used cover crop. Alfalfa is a good source of vitamins, calcium, iron, phosphorus and potassium.

Besides its use as feed, alfalfa has been traditionally used as a medicinal herb for humans. Its seeds and dried leaves can be consumed as supplements, or sprouted as edible alfalfa sprouts.

## Varieties of Alfalfa

Farmers growing alfalfa should consider the following factors when selecting varieties to plant:

**Purpose :** Decide why you're growing alfalfa. If it's for making hay, focus on varieties that can withstand time and yield a lot. If it's for grazing, pick types that can grow back quickly after grazing.

**Dormancy & Winterhardiness :** Check the dormancy rating of the variety you want to plant. Ratings range from 1 (very dormant) to 10 (not dormant). In places with warm winters and little frost, go for varieties with ratings of 9 or 10.

**Disease and Pest Resistance :** Choose varieties that can at least moderately resist common diseases like bacterial wilt, fusarium wilt, phytophthora root rot, verticillium wilt, and anthracnose.

**Forage Yield :** It's a good idea to see if a variety has performed well in your specific region before deciding to plant it. This helps ensure a good yield.

## Propagation

### Basic Requirements

Alfalfa is adapted to grow in a wide variety of environments but it requires careful management. Alfalfa grows best in deep, fertile, well-draining soils with a pH between 6.0 and 7.0. Alfalfa has a deep and vigorous root system and quickly depletes nutrients from the soil. If grown in a soil that is poor in nutrients, the crop may require the addition of copious amounts of fertilizer. The vigorous root system means that alfalfa can tolerate dry periods and still give a good yield.

### Seeding

Soil should be well prepared prior to planting alfalfa seeds. A firm seedbed is recommended to improve the stand by improving seed contact with the soil. This helps seeds to retain moisture and prevents new roots from drying out. The soil can be firmed prior to planting by using a roller. The seedbed should also be free of weeds and kept moist. Alfalfa fields should be sown 5 cm (2 in) deep in rows spaced 45 to 60 cm (18 to 24 in) apart. Seeds should be watered

immediately and the bed kept moist while the seedlings emerge.

## General Care and Maintenance

The alfalfa stand should be kept free from weeds. The easiest way to achieve this when the crop is being grown on a commercial scale is with the use of a pre-plant herbicide. There are several of these products available for use on alfalfa. Fertilizer should be applied in accordance with soil test results. Lime, phosphorus and potash are the most important nutrients for a healthy alfalfa stand.

## Harvest

Alfalfa is harvested at different times depending on its intended use. Alfalfa which is cut between the late bud and early bloom stage generally gives acceptable yields of high quality feed without reducing the quality of the stand. In contrast, repeated harvest of alfalfa which is still in the vegetative stage of growth leads to a reduced stand. In the first year, alfalfa can generally be harvested twice without any detrimental effect on winter survival; once in summer prior to the flowers emerging, and once later in the year with the date depending on location. Alfalfa is usually harvested by combine and baled as hay or cut for direct feeding to animals.

Alfalfa bales

Harvested alfalfa field

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## Common Pests and Diseases

### Diseases

#### Category : Viral

**Alfalfa mosaic** Alfalfa mosaic virus (AMV)

*Alfalfa mosaic symptoms on alfalfa*

### **Symptoms**

Yellow streaks parallel to leaf veins; yellow-green mottling of leaves; distorted leaves; stunted plant growth.

### **Cause**

Virus

### **Comments**

Transmitted by aphids; also spread via infected seed and pollen.

### **Management**

Plant resistant cultivars; control aphid populations on plants; use virus free seed.

## **Category : Fungal**

### **Anthracnose *Colletotrichum trifolii***

*Anthracnose lesions on alfalfa stems*

### **Symptoms**

Large diamond shaped lesions with white centers on lower portion of stems; young dead shoots take on a characteristic "shepherds crook" appearance.

### **Cause**

Fungus

### **Comments**

More common in warm weather and periods of high moisture.

### **Management**

Cannot be managed in established alfalfa stands; cut crop before major losses occur.

### **Common leaf spot *Pseudopeziza medicaginis***

*Symptoms of Common leaf spot on alfalfa foliage*

*Symptoms of Common leaf spot on alfalfa foliage*

*Symptoms of Common leaf spot on alfalfa foliage*

### **Symptoms**

Small circular brown-black spots with uneven margins on leaves; leaves turning yellow and dropping from plant; raised brown fungal fruiting bodies may be visible in cool wet weather

### **Cause**

Fungus

### **Comments**

More common during periods of high rainfall

### **Management**

Harvest infected alfalfa early to avoid severe infections which reduce hay quality; rotating crops may reduce incidence of disease

### **Downy mildew *Peronospora trifoliorum***

*Symptoms of downy mildew on alfalfa*

*Downy mildew symptoms on lower leaf surface of alfalfa*

*Downy mildew symptoms on upper leaf surface of alfalfa*

### **Symptoms**

Young leaflets may be dwarfed, twisted and cupped downward; light green or yellow blotches on leaves; a gray downy growth may be visible on infected leaves during cool, wet weather or during periods of high humidity.

### **Cause**

Fungus

### **Comments**

Pathogen spread by wind or by splashing water.

### **Management**

Grow resistant cultivars; cut alfalfa crop while still in prebloom stage; sow crop in Spring to reduce chance of seedlings becoming infected.

## **Fusarium wilt *Fusarium oxysporum f. sp. medicaginis***

### **Symptoms**

Wilting shoots followed by bleaching of leaves and stem; rapid wilting of stems on only one side of plant; may be a reddish tinge to leaves; red streaks in root stele.

### **Cause**

Fungus

### **Comments**

Disease emergence favored by high soil temperatures.

### **Management**

No satisfactory method of management; plant resistant alfalfa varieties.

## **Lepto leaf spot *Leptosphaerulina trifolii***

*Close up of Lepto leaf spot lesion*

*Lepto leaf spot symptoms on alfalfa*

*Lepto leaf spot symptoms on alfalfa*

### **Symptoms**

Small red-brown flecks on leaves and petioles which develop into lesions with tan center and irregular brown margins; leaves become necrotic but remain attached to the plant.

### **Cause**

Fungus

### **Comments**

Occurs wherever alfalfa is grown.

### **Management**

Disease incidence and severity can be reduced by planting cultivars reported to have some resistance, using certified seed and rotating crop with a resistant plant such as soybean for at least 2 years.

## **Category : Oomycete**

## **Aphanomyces root rot *Aphanomyces euteiches***

### **Symptoms**

Infected seedlings have yellow cotyledons (seed leaves) with other leaflets beginning to turn yellow; seedlings dying back, seedlings with stunted growth; decaying roots in established plants leading to symptoms resembling nitrogen

deficiency.

#### Cause

Oomycete

#### Comments

Disease is more easily spread in moist soils and over a wide range of temperatures.

#### Management

Grow varieties that have some resistance to the disease; only plant alfalfa in well draining soil.

### **Phytophthora root and stem rot** *Phytophthora megasperma*

*Phytophthora root and stem rot symptoms on alfalfa*

#### Symptoms

Chlorotic or reddish leaves which drop from plant; rotted roots which are yellow-brown in color; roots eventually turn black.

#### Cause

Fungus

#### Comments

Disease more prevalent in water saturated soil.

#### Management

Grow resistant cultivars; try to improve drainage if soil has tendency to be waterlogged.

### **Category : Bacterial**

### **Bacterial wilt** *Clavibacter michiganense subsp insidiosus*

*Cross sections of a healthy root (right) and diseased roots (centre and left) of lucerne infected by Clavibacter michiganensis subsp. insidiosus.*

*Discoloratioion of alfalfa stele caused by infection with bacterial wilt*

*Alfalfa plant suffering from bacterial wilt (left) compared with healthy plant (right)*

#### Symptoms

Dead plants scattered around field; stunted plants with small leaves and stems; bunchy appearance of plants; leaves curling upwards; plants wilting during day and recover at night; chlorotic leaflets; death of plants.

#### Cause

Bacterium

#### Comments

Occurs wherever alfalfa is grown, important disease in the US.

#### Management

Plant resistant cultivars.

### **Category : Fungal, Oomycete**

### **Damping off** *Pythium ultimum*

*Pythium irregularare*

*Pythium violae*

*Rhizoctonia solani*

*Phytophthora megasperma*

### Symptoms

Failure of seedling to emerge; light brown, seedlings with light brown water-soaked roots and stems; collapse of plants; plant dry up and die.

### Cause

Oomycete Fungi

### Comments

Occurs more often in cold temperatures when growth of seedlings is slow and in moist soil.

### Management

Treat seeds with fungicide prior to planting.

## Pests

### Category : Insects

#### Alfalfa caterpillar *Colias eurytheme*

Adult male butterfly

Alfalfa caterpillar (*Colias eurytheme*)

Adult female butterfly

### Symptoms

Defoliation of plants; entire leaf consumed, including midrib; adult insects are yellow-orange to white butterflies; larvae are bright green, velvety caterpillars which can reach 3.8 cm (1.5 in) in length; larvae have a white strip running down the side of their body.

### Cause

Insect

### Comments

Damage is most severe when eggs are laid in recently cut fields.

### Management

Avoid unnecessary applications of insecticides to promote populations of natural enemies; organically grown alfalfa can be treated with *Bacillus thuringiensis*, harvest crop early to avoid serious damage.

#### Alfalfa weevil *Hypera postica*

Damage to alfalfa plants caused by alfalfa weevil

Alfalfa weevil larvae and feeding damage to plant

Alfalfa weevil larva

Adult alfalfa weevil

### Symptoms

Leaves skeletonized and appear bronzed; plants may be completely defoliated; adult insect is a dark gray beetle 0.5 cm (0.2 in) in length; larvae are pale green grubs with a thin white line down the center of their back and a brown head; larvae spin a cocoon and pupate on leaves or in soil.

### Cause

Insect

### Comments

Weevils overwinter in crop debris and emerges in Spring; both adult insects and larvae damage plants.

### Management

Treatment of alfalfa weevils should be focused on the period before the first cutting; cutting the crop before budding is organically acceptable and can prevent serious damage and kill off most weevils; other control methods include the application of appropriate insecticide.

## Aphids (Cowpea aphid, Blue alfalfa aphid, Pea aphid, etc) *Aphis craccivora*

*Acyrthosiphon kondoi*

*Acyrthosiphon pisum*

*Cowpea aphid colony on alfalfa*

*Pea aphids on alfalfa leaf*

### Symptoms

Small soft bodied insects on underside of leaves and/or stems; aphids are generally green in color but cowpea aphid is black and colonizes stems; aphids inject a powerful toxin into alfalfa which stunts plant growth and may kill the plant; aphids also secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants.

### Cause

Insect

### Comments

Blue alfalfa aphid and pea aphids prefer cooler temperatures and are most abundant in Spring and Fall; cowpea aphids are generally a sporadic pest but are most common in Spring.

### Management

Insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use.

## Beet armyworm *Spodoptera exigua*

*Young larvae*

*Beet armyworm eggs covered in white hairs*

*Beet armyworm larva*

### Symptoms

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside.

### Cause

Insect

### Comments

Insect can go through 3–5 generations a year.

### Management

Organic methods of controlling the beet armyworm include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae.

## **Threecornered alfalfa hopper** *Spissistilus festinus*

*Adult threecornered alfalfa hopper*

*Threecornered alfalfa hopper*

### **Symptoms**

Stems girdled causing part of plant to above to break and turn red, purple or yellow; adult insect is green and wedge-shaped, tapering towards rear end; insect has a triangular area on back visible from above and piercing-sucking mouthparts; nymphs are soft bodied and gray-white in color.

### **Cause**

Insect

### **Comments**

Insect also a pest of other plants including soybean; may be 3-4 generations of insect per year.

### **Management**

Applications of appropriate insecticide if insect becomes problematic.

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# Almond

## Description

The almond tree, *Prunus dulcis*, is a deciduous tree in the family Rosaceae which is grown for its edible seeds (nuts). The tree has brown or gray bark and either an erect or weeping growth habit depending on the variety. The trunk can reach 30 cm (12 in) in diameter. Almond leaves are 7.5–13 cm (3–5 in) long with a serrated edge and grow alternately on the branches. The tree produces white to pale pink flowers and hairy green fruits which are oblong in shape. The fruit is a drupe, containing a single seed. The seed is protected by a hard brown shell. At maturity, the flesh of the fruit becomes leathery and splits to reveal the nut inside. Nuts generally measure 3.5 to 6 cm (1.4–2.4 in) in length. Almond trees can reach heights between 4 and 10 m (13–33 ft) and have a commercial lifespan of between 30 and 40 years. Almond may be referred to by variety and this includes bitter almond almond nuts are generally about long and may also be referred to as sweet or bitter almond depending on variety and originates from wild species found in Central and Southwest Asia.

*Almonds in tree*

*Almonds and blossoms*

*Almonds*

*Flower close-up*

*Almonds in Spring*

*Almond trees in blossom*

## Uses

The almond nut is eaten raw or processed into butter, flour, extract, oil, paste, syrup, and milk. Almond oil is used as a flavoring agent in baked goods, perfumery and medicines. Sweet almond oil is used for cosmetic creams and lotions.

## Propagation

**Basic requirements** Almond grows best in Mediterranean climates with warm, dry summers and mild, wet winters. The optimal temperature for their growth is between 15 and 30°C (60–85°F) and the tree buds have a chilling requirement of between 300 and 600 hours below 7.2°C (45°F) to break dormancy. Almond trees will grow best when planted in deep, well-draining loam although they can withstand drought and grow in poor soils. The trees benefit from being planted in areas sheltered from frost and wind as trees bloom early and can therefore be susceptible to damage from late frosts. Trees will generally bear nuts after 3 to 4 years with the nut crop developing after blossom, in the fall.

**Propagation** Almond trees are most commonly propagated by budding. Dormant wood is collected in winter when the trees are dormant and stored until Spring. T-budding is usually carried out in Spring and involves joining a bud from one variety to the rootstock of another. The bud is taken from a parent with desirable characteristics and grows to produce a new tree. Trees may also be propagated by grafting. Cuttings are taken from trees during dormancy and grafted to a suitable rootstock in the Spring. **Planting** Once trees have been acquired from a nursery, it is important to plant as soon as possible and keep the roots moist in the meantime. Almond trees should be planted by digging a hole just deep enough to accommodate the root ball. The tree should be planted by carefully backfilling the soil into the hole around the tree after it has been properly positioned. Planting depth should not exceed the height of the graft union. The soil around the newly planted tree should then be tamped and watered deeply but not excessively. If planting multiple trees then they should be spaced in rows 6–7 m (20–23 ft) apart with 5–6 m (16–23 ft) between each tree. **Pruning** Almond trees should be pruned in the first year and every subsequent year to help thin the canopy and prevent disease. The first pruning is critical in establishing the canopy shape. Three limbs should be selected to form the basis of the trees canopy and all others removed, including any growth below the lowest limb. In the second year, two scaffolds (lateral branches which grow to form a Y with the primary limbs) should be selected and the rest removed. Aim for the remaining scaffolds to be evenly spaced around the canopy. **General care and maintenance** Almond trees will benefit from a layer of mulch around the base to prevent the growth of weeds and conserve soil moisture. Mulch should be spread around the tree in a 1 m (3 ft) radius. Leave a gap between the mulch and the trunk to prevent rotting the trunk. In addition, an application of fertilizer should be made once in Spring before any new growth and again in the Fall.

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Last updated July 14th 2023 by Eluby Kawelama based on knowledge from CGIAR, CABI and FAO. Discussion with Jan Kreuze of CIP

## Common Pests and Diseases

### Diseases

#### Category : Other

##### **Almond brownline and decline** *Peach yellow leafroll mycoplasma*

###### **Symptoms**

Stunted tree growth; drooping/wilting of leaves; brown necrotic areas under bark

###### **Cause**

Phytoplasma

###### **Comments**

Most common on young trees; grow trees from pathogen free stock

###### **Management**

Stunted trees should be removed and replaced; plant only certified pathogen free trees

##### **Almond kernel shrivel** *Peach yellow leafroll phytoplasma*

###### **Symptoms**

Late blooming; new growth stunted; paler, smaller leaves; kernels of nuts shriveled at harvest

###### **Cause**

Phytoplasma

###### **Comments**

Most common where peach rootstock has been used for grafting; remove infected trees

###### **Management**

Remove diseased trees; plant only certified trees

#### Category : Bacterial

##### **Almond leaf scorch; golden death** *Xylella fastidiosa*

###### **Symptoms**

Chlorotic leaf margins; necrosis of leaf margins beginning toward tip of leaf and spreading to base; patches of necrotic tissue with chlorotic margin

###### **Cause**

Bacterium

###### **Comments**

More of tree will be affected each year; bacterium can infect rye, blackberry and nettle and if these plants are nearby they may act as reservoir; transmitted by leafhoppers and spittle bugs

###### **Management**

If discovered early (while disease affects only one branch) disease can be removed by pruning primary scaffold 5 to 10 ft

below symptoms; older infections may require the tree to be removed and replaced

## **Crown gall** *Agrobacterium tumefaciens*

### **Symptoms**

Galls of various sizes on roots and root crown below the soil line; galls may occasionally grow on the trunk; galls are initially light colored bulges which grow larger and darken; galls may be soft and spongy or hard; if galling is severe and girdles the trunk then young trees are weakened due to constricted vascular tissue; trees may be stunted and rarely die

### **Cause**

Bacterium

### **Comments**

The bacterium enters host plants through wounds and causes plant cells to proliferate and cells to be undifferentiated, leading to the formation of a gall

### **Management**

Only plant disease-free nursery stock; plant trees in well-draining soils; avoid wounding the plants as much as possible; fresh wounds can be treated with a biocontrol agent (*Agrobacterium tumefaciens* K84), if available, to prevent the bacterium colonizing

## **Category : Fungal**

### **Alternaria leaf spot** *Alternaria alternata*

#### **Symptoms**

Light brown lesions on leaves which expand to form circular lesions on leaf blade or semi-circular lesions on margin; leaves may develop light yellow necrosis which dries and turns tan in center of leaves; infected leaves dropping from tree; fruit does not drop from tree

#### **Cause**

Fungus

#### **Comments**

Disease emergence favors warm weather

#### **Management**

Late spring treatment with appropriate fungicide if Alternaria symptoms are present

### **Anthracnose** *Colletotrichum acutatum*

#### **Symptoms**

Blighting of blossom; dieback of limbs; death of foliage with leaves remaining attached; nuts with orange lesions

#### **Cause**

Fungus

#### **Comments**

All cultivars susceptible; occurs more often in warm, wet conditions

#### **Management**

Fungicide treatment and cultural practices required to control disease. Orchards with a history of anthracnose infections should be sprayed at 5-10% bloom and applications should be repeated every 10 to 14 days; dead infected branches should be pruned; low angle nozzles should be used in orchards with spray irrigation to prevent wetting of leaves

### **Brown Rot Blossom Blight** *Monolinia laxa*

#### **Symptoms**

Blighted blossoms; stigma and anther of flowers turning brown and necrotic; blossom collapsing and turning brown; light brown powdery fungal masses may be visible on infected flowers; gummy exudate at base of flowers; cankers forming on twigs associated with blossoms

**Cause**

Fungus

**Comments**

Disease emergence favors frequent rainfall during bloom

**Management**

Fungicide application at 5-10% bloom and full bloom to protect flowers; one application at full bloom usually sufficient if there is no rainfall; two or three applications should be made if bloom is accompanied by rainfall

**Hull rot** *Rhizopus stolonifer*

*Monolinia* spp

*Monilia* on a tender fruit Almond

*Monilia* on a tender fruit Almond

**Symptoms**

Tan lesions on hulls which enlarge and cause fruit to shrivel; dark gray spore masses visible between hull and shell; leaves in proximity to infected fruit may wither and curl; leaf death occurs on side of shoot closest to infected fruit

**Cause**

Fungus

**Comments**

Hulls of fruit are susceptible to hull rot until they are dry

**Management**

Management of irrigation should be practiced. Reduce irrigation at hull split; demethylation inhibitor and quinone outside inhibitor fungicide may be applied in combination with irrigation management

**Shot hole** *Wilsonomyces carpophilus***Symptoms**

Circular purplish spots on foliage which enlarge and turn chlorotic then tan; drying of lesions causes missle of lesion to drop out of leaf causing small holes to develop

**Cause**

Fungus

**Comments**

Spores transmitted in water; disease more common in wet conditions

**Management**

If fungal fruiting structures are present in Fall (visible under a hand lens as small black spots in the center of lesions) then a fall treatment with fungicide is required; fungicide should be applied before wet periods to protect tree

**Verticillium wilt (Blackheart)** *Verticillium dahliae***Symptoms**

Leaves on one side of tree turning yellow; wilting early in season

**Cause**

Fungus

**Comments**

Fungus overwinters on soil, recurring each year; problematic if orchard is interplanted with other susceptible plants e.g. cotton, tomato, melon

**Management**

Orchards should not be intercropped with susceptible plants e.g. cotton, tomatoes or melons; solarization or fumigation of soil prior to planting may be used to kill fungi in soil

# Pests

## Category : Insects

### **Pavement ant (Southern fire ant)** *Tetramorium caespitum*

*Solenopsis xyloni, S. molesta*

*Southern fire ant*

*Pavement ant*

#### **Symptoms**

Hollowed out nuts on ground

#### **Cause**

Insects

#### **Comments**

Prevalent in orchards using drip or spray irrigation

#### **Management**

Monitor orchard for ants in April and May; apply ant baits before harvest to manage high ant populations; remove nuts from orchard floor as soon as possible

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# Aloe Vera

## Description

Aloe vera is an herbaceous perennial in the family Liliaceae grown for its succulent leaves which have a variety of culinary and medicinal uses. The plant grows best in full sunshine and requires little water for its establishment, growth and reproduction. It prefers areas with mean annual temperatures within the range 19-27°C, but can tolerate temperatures ranging from 10°C to 35°C.

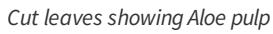
The Aloe vera plant has a short, stout stem and a rosette of fleshy, lanceolate leaves which have a serrated margin of small white teeth. The leaves may be flecked with white and are pale green or grey-green in colour. Aloe vera plants produce a conspicuous inflorescence composed of densely packed pendulous yellow flowers on a spike which can be up to 90 cm (35 in) in height. The plant itself can grow to be 1 m (3 ft) in height, it takes 4-5 years to mature and can live for up to 100 years if well cared for.

Aloe vera is indigenous to Eastern and Southern Africa. It belongs to a large class of plants known as "xeroids" characterised for its ability to close its stomata completely to avoid loss of water. This adaptation allows plants to survive long and extreme drought periods.

## Crop Details

Scientific Name: *Aloe vera* (L.) Burm.f.

Common Name: true aloe (En); aloë's officinal, aloë's vrai, aloë's vulgaire (Fr); lu hui (Cn); sabila, sājvila (Sp).

Aloe plants producing suckersCut leaves showing Aloe pulpAloe flowersAloe vera flower spikeAloe plant from aboveAloe vera plant

## Uses & Benefits

Aloe vera plants are grown for medicinal value including improving digestion and boosting the immune system. They are also grown for extraction of the gel inside the leaves. The gel is used in desserts, yoghurts and beverages. The gel is also commonly used as a home remedy for treatment of burns and to prevent constipation. It is also used as a skin and hair nourisher.

The plant contains vitamins A (beta-carotene), C and E, which are antioxidants. It also contains vitamin B12 and folic acid.

## Varieties of Aloe Vera

The Aloe genus includes over 500 plant species. Aloe plants are divided into three rough groups: tree aloes, shrub aloes and stem-less aloes. The groups can be differentiated through leaf colour, toothing, shape, as well as plant height and flowering style.

Some species are grown as ornamentals for their attractive architectural leaves and colourful flowers. Zebra aloe (*Aloe saponaria*) variety is characterized by its distinctive white stripes or spots on the leaves. Arabian aloe (*A. rubroviolacea*) has long blue-green leaves with red teeth and is planted outdoors in warm climates; the leaves turn red if exposed to full sun. *Aloe barbadensis miller* is known for its thick and fleshy leaves that contain a high concentration of gel and is valued for its medicinal properties.

## Propagation

### Basic Requirements

Aloe vera grows best in full sunshine and requires little water for its establishment, growth and reproduction. It prefers areas with mean annual temperatures within the range 19-27°C, but can tolerate temperatures ranging from 10°C to 35°C. It is adapted to areas with mean annual rainfall in the range 700 mm to 3000 mm. During the winter months in the subtropics, the plant becomes dormant and utilizes very little moisture. The pH of the soil should range from 6 to 7.5, and it should be fertile and well-drained.

### Growing from Seed

Aloe Vera can be grown from seeds, but is most easily propagated from suckers which are readily produced by the mother plant. The suckers are commonly referred to as ‘pups’. The pups should be cut from the main root by gently uprooting the mother plant and finding the point of attachment. The young plant should be cut from the parent using a sharp knife. Pups can be safely removed when they have several sets of leaves. The young plants should be planted in their own pot and watered deeply. Refrain from overwatering to force the growth of new roots. If multiple plants are

being planted, provide them with individual pots or plant at least 60 cm (24 in) apart outdoors.

When planting using seeds, aim at a spacing of 3ft by 3ft. Spacing is extremely important for high quality harvest. A typical Aloe Vera plant has 25 leaves which extend up to full length of between one foot and 2 feet. This is why experts recommend a minimum spacing of 3 feet all round.Â Planting the seeds in organic matter-rich, well-drained soil is recommended.

### **General Care and Maintenance**

Aloe plants are generally very easy to care for but care should be taken to avoid overwatering. The plants should be watered deeply but allowed to dry out before the next watering. Check the soil prior to watering. Allow the soil to dry down to a depth of 7.5 to 10 cm (3-4 in) for older, well-established plants or 3.5-5 cm (1-2 in) for younger plants. In addition, although Aloe plants require lots of light, sitting them in full sun can be harmful and it is best to position potted Aloes in a bright window. If the plant is receiving too much sun, the leaves will begin to turn brown.Â Â Aloe vera can tolerate moderate wind conditions, but excessive wind can damage the leaves and lead to dehydration.Â Â Balanced organic or slow-release fertilizers rich in nitrogen, phosphorus, and potassium can be applied during the growing stageÂ to support healthy growth.

### **Harvesting**

Aloe plants are usually harvested 4 times per year. The crop takes some 18 to 24 months to mature. Ideally, you should take around three leaves per plant. That comes to a total of 12 leaves per plant every year (keep in mind that only older outer leaves are harvested). You can expect an annual harvest of 60,000 kilograms of Aloe Vera per acre per year.

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## **Common Pests and Diseases**

### **Diseases**

## **Category : Fungal**

### **Aloe rust *Phakopsora pachyrhizi***

#### **Symptoms**

Small, pale yellow spots on leaves which expand and turn brown; orange spore masses may be present on underside of leaf; leaves may drop from plant.

#### **Cause**

Fungus

#### **Comments**

Disease emergence favors cool temperatures and high humidity.

#### **Management**

Disease is self limiting and requires no treatment.

### **Anthracnose disease *Colletotrichum gloeosporioides***

#### **Symptoms**

The initial appearance of small round to oval, dark green water-soaked which later become circular spots with tan to light brown center. As the spots mature the center of the lesion become reddish brown to brown color. With progress in disease the lesions join together to form big necrotic area.

#### **Cause**

Fungus

#### **Comments**

Disease is favored by warm, wet weather; spread easily during wet weather by water splash.

#### **Management**

Application of suitable fungicides.

### **Basal stem rot *Fusarium* spp.**

#### **Symptoms**

Base of plant turning reddish brown to black and rotting.

#### **Cause**

Fungi

#### **Comments**

Fatal disease of aloes; disease emergence favors cold, damp conditions.

#### **Management**

Pieces of plant may be saved by taking cuttings above rotted portion.

## **Category : Bacterial**

### **Bacterial soft rot *Pectobacterium chrysanthemi***

#### **Symptoms**

Watery, rotting leaves which are darker in color; young leaves wilting and collapsing; leaves bulging due to gas formation inside.

#### **Cause**

Bacterium

#### **Comments**

Bacteria survive in plant debris in the field; disease emergence favored by hot, wet weather.

#### **Management**

Fatal disease; avoid over-watering plants.

# Pests

## Category : Insects

### Aloe vera aphid *Aloephagus myersi*

*Aloe vera aphid infestation*

*Damaged plant*

*Aloe vera aphid damage*

*Aloe vera aphid (Aloephagus myersi)  
adult*

*Aloe vera aphid (Aloephagus myersi)*

#### Symptoms

Both adults and nymphs feed at the bases of the leaves or in rolled ends of damaged leaves. They also secrete honeydew which is resulting in sooty mold development. Severe infestation leads to slow growth and stunting.

#### Cause

Insect

#### Comments

One of important quarantine pest.

#### Management

Organically acceptable methods of control include the application of insecticidal soap and preservation of natural enemies.

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# Amaranth

## Description

Amaranth is the name given to a group of approximately 70 species of annual or short-lived perennial plants in the genus Amaranthus including several species of aggressive edible weeds native to the US such as Amaranthus retroflexus (redroot pigweed). Amaranths are branching broad-leaved plants with egg-shaped or rhombic leaves which may be smooth or covered in tiny hairs. The leaves have prominent veins, can be green or red in color and have long petioles. The plants produce single flowers on terminal spikes which are typically red to purple in color. Amaranths can reach up to 2.5 m (6.6 ft) in height and are usually grown as annuals, harvested after one growing season. Amaranth may also be referred to as Chinese spinach and their origin is unclear due to their worldwide distribution.

### Crop Details

Scientific Name: *Amaranthus* spp. (*A. cruentus*, *A. dubius*, *A. spinosus*, *A. tricolor*, *A. caudatus*)

Common Name: pig weed, african spinach (En); pinard piquant, amarante, pinard malabar (Fr); amarantos, moco de pavo, (Sp); èžšèœ (Cn)

Mexican Amaranth - *Amaranthus cruentus*

*Amaranthus*

Red amaranth (*Amaranthus cruentus*)

*Amaranthus caudatus*

*Green Amaranth*

*Amaranthus seed head and seeds*

*Amaranthus hybridus var.  
paniculatus (L.) Thell.  
(AMARANTHACEAE)*

*Amaranthus flowering*

*Amaranthus tricolor*

## Uses & Benefits

Amaranth leaves and stems are commonly eaten after cooking in a manner similar to spinach. There are four main species which are cultivated as vegetables; *A. cruentus*, *A. blitum*, *A. dubius*, and *A. tricolor*. Several species, such as *A. caudatus*, *A. cruentus* and *A. hypochondriacus* are grown as a grain crop in places such as Mexico, Nepal and India and are used to produce cereals and snacks. The leaves are cooked alone or combined with other vegetables. The seeds are ground into flour or cooked into porridge.

The leaves are rich in manganese, calcium, iron, vitamins A, B and C while the seeds are rich in beta-sitosterol and other phytosterols.

## Varieties of Amaranth

Of all the indigenous tropical leafy vegetables, amaranth has the largest number of species and varieties. The choice of variety varies widely among regions and is dictated largely by the species available. Regardless of species, the choice of variety is influenced by individual preference for leaf color and taste. To identify which varieties are best adapted to your location, compare during different growing seasons the yield potential of currently grown varieties with that of other available varieties.

**A. tricolor** : *Amaranthus tricolor* is a first growing herbaceous plant of 30–125 cm height. This variety comes in various leaf colors such as dark green, red, scarlet, maroon, purple, yellow, and cream.

**A. blitum** : It grows between 10 and 80 cm tall, sometimes reaching 90 cm. The leaves are green or more or less purple in color and matures 4 weeks after sowing.

**A. dubius** : It grows up to 150 cm in height. This variety can be green or tinged purple. The flower clusters are in spikes on side branches and these can be branched. Harvesting may be done 3-4 weeks after sowing.

**A. hybridus** : The stems are thick and often ribbed or tinged with red. The leaf and stem surfaces have small fine hairs.

## Propagation

### Basic Requirements

Amaranth grows from sea level to 2400 m altitude. The different species may suit different altitudes. Normally the hotter it is the better it grows and it generally thrives within a temperature range of 22-30°C. A minimum temperature of 15-17°C is needed for seed germination. Amaranth is grown during both wet and dry seasons, though irrigation is normally required for dry season crops since the rate of transpiration by the leaves is fairly high. Frequent application of water is required, related to the stage of growth of the crop and the moisture-retaining capacity of the soil. It can however

tolerate periods of drought after the plant has become established. It is adapted to low to medium humidity.

Amaranth grows best in loam or silty-loam soils with good water-holding capacity, but it can grow on a wide range of soil types and soil moisture levels. Amaranth can tolerate a soil pH from 4.5 to 8.

### **Growing from Seed**

Amaranths are propagated from seed and can be planted either by transplanting or direct seeding. Certified seeds with special attributes, such as tolerance/resistance to pest and diseases and high yielding should be used. Indirect seeding, seeds are either broadcasted or sown in rows at 0.5 to 1.0 g per m<sup>2</sup> of bed. Since Amaranth seeds are very small, seeds are mixed with sand at a ratio of 1g seed to 100g sand for easy sowing and uniform stand. Farmers can instead choose to mix 1 part of amaranth seeds to 4 parts of chicken manure or ash.

Seeds should be sown to a depth of 2 cm (0.4–0.8 in) in rows spaced 50 cm (20 in) apart and covered with a very light layer of soil. When the seeds germinate allow them to grow for one week, before thinning the plants to keep 20 cm (8 in) spacing from each other.

### **General Care and Maintenance**

Amaranth is easy to care for and requires little maintenance. While the seedlings are young, it is important to remove any weeds from around the plants to prevent competition. Applying a layer of mulch will help to prevent weeds and conserve soil moisture. The plants will benefit from supplemental irrigation during dry periods and the addition of fertilizer once or twice throughout the growing season. 160 kg/acre of NPK 10-10-20 is recommended. The crop should be top dressed to promote better re-growth with CAN at monthly intervals. 15 days after transplanting, apply N at 20kg/acre as top-dressing.

### **Harvesting**

Amaranth leaves are harvested by thinning and clipping. During thinning, the whole plant is uprooted. Thinning starts 2-3 weeks after germination or when the plant has 6-8 fully grown leaves. Leaves can also be clipped at regular intervals. Clipping may start 3-4 weeks after germination. The tender leaves are clipped once a week until the onset of flowering. Frequent harvest prolongs the harvest period and delays onset of flowering.

Grain amaranth varieties are usually ready to harvest after about three months. The flowers can simply be cut from the plant using a pair of scissors and set in a warm, dry place to finish drying out. When the flowers are dry, seeds can be removed by brushing or by beating the flowers in a bag. Passing the beaten flowers through a fine screen mesh can help to remove the seeds from the chaff.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Anthracnose** *Colletotrichum gloeosporioides*

###### **Symptoms**

Necrotic lesions on leaves; dieback of leaves and branches

###### **Cause**

Fungus

###### **Comments**

###### **Management**

Avoid damaging plants and creating wounds for pathogen to enter; plant resistant varieties

##### **Damping-off** *Rhizoctonia* spp.

*Pythium* spp.

###### **Symptoms**

Poor germination; seedling collapse; brown-black lesions girdling stem close to soil line; seedling fail to emerge from soil

###### **Cause**

Fungus

###### **Comments**

Disease emergence favors wet soils

###### **Management**

Avoid planting seeds too deeply; do not plant seeds too thickly to promote air circulation around seedlings; do not over-water plants

##### **Wet rot (Choanephora rot)** *Choanephora cucurbitarum*

###### **Symptoms**

Water-soaked lesions on stems; lesions have hairy appearance due to presence of fungal spores; may cause loss of leaves

###### **Cause**

Fungus

###### **Comments**

Fungus mainly attacks plants that have been damaged by insects or by mechanical means; spread by air currents and via infected seed; disease emergence favors warm, moist conditions

###### **Management**

Plant varieties resistant to disease; only use certified seed; do not plant crop densely; treat disease with copper fungicides if it emerges

### Pests

#### Category : Insects

## Damping-off diseases Pythium spp. Rhizoctonia solani

*Amaranth plants with 'damping-off disease' symptoms of the fungus Phytophthora spp.*

### Symptoms

Seeds may rot in the soil before emergence (pre-emergence damping-off) or seedlings may exhibit stem canker above the soil line and/or root necrosis. Affected seedlings eventually wilt (post-emergence damping-off). The disease is favoured by high soil water content and low soil temperatures. Also, dense planting without sufficient aeration enhances disease development.

### Cause

The disease is caused by *Pythium aphanidermatum*, *Rhizoctonia solani* and *Aphanomyces* sp.

### Comments

The disease is favoured by high soil water content and low soil temperatures. Also, dense planting without sufficient aeration enhances disease development.

### Management

Use disease-free seeds.

Avoid over watering.

Avoid dense planting.

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# Anise

## Description

Anise is an annual herbaceous plant in the *Umbelliferae* family that is primarily grown for its fruits, which are used as a spice.

The plant has alternately arranged leaves and a grooved stalk. The petioles on the lower leaves can range in length from 4 to 10 cm (1.6 to 3.9 in), and they are rounded with a serrated edge. As the plant grows taller, the upper leaves get increasingly shorter and feathery.

The aniseed plant produces umbels of white flowers as well as an oval, hairy fruit with one seed that is flattened and hairy. An annual plant, anise has a height range of 45 to 60 cm (17.7 to 23.6 in) and only has one growing season. Anise may also be referred to as aniseed and originates from the Mediterranean

## Crop Details

Scientific name: *Pimpinella anisum*

*Anise flowers*

*Anise*

*Anise plant*

## Uses & Benefits

Aniseed is widely used to flavor pastries; it is the characteristic ingredient of a German bread called anisbrod. Aniseed is also widely used in meat and vegetables throughout the Mediterranean and Asia. It is widely used as an herbal tea and has been used medicinally since ancient times. Absinthe, anisette, and Pernod liqueurs are flavored with the essential oil.

The leaves are used as an alcohol flavour in drinks like raki. Salads can also contain leaves

## Preserving and Storing Anise

Drying: Dry anise seeds on trays of paper for several warm days outdoors. After drying, pasteurize the seeds in the oven at 100°F for 15 minutes.

Storing: Store leaves and seeds in an airtight container.

## Propagation

Basic prerequisites Temperatures between 6 and 24°C (42.8-75.2°F) and 12 to 18°C (53.6-64.4°F) are ideal for anise growth in temperate and subtropical climates. Frost won't be tolerated by the plants.

Anise can be grown successfully in a range of soil types, although it thrives best in soils with a pH of

5.0 to 8.0. The plants grow poorly in sandy or heavy clay-based soils and thrive best in well-draining loam.

Since they are sensitive to transplanting, seedlings grow best when planted directly outside. The seeds benefit from being soaked overnight before planting to speed up germination, and they should only be sown after all threat of frost has passed. Before planting the seeds, the planting area should be ready by tilling the soil to a fine tilth.

If multiple plants are being grown, allow 2.5-15 cm (1.0-6.0 in) between individuals within the row and a further 15-90 cm (6.0-35.4 in) between rows. The seeds should be sown between 1 and 3 cm (0.4-1.2 in) deep. Keep the seedbed moist as the seeds germinate by not letting the soil entirely dry out.

## Where to Plant Anise

Anise seeds should be planted in a sunny, wind-free location in the garden. Due to its thin stems, this herb may require staking if the wind picks up. Finding the ideal location in your garden for anise may need some trial and error because it is usually very sensitive to the hot sun and chilly northern winds.

For a sweet licorice aroma just feet from the kitchen, you may also grow anise in pots right outside your back door. Try planting anise alongside coriander in a colorful collection of pots with other herbs that have similar growing requirements.

## How and When to Plant Anise

The anise plant is sensitive to cold weather. Plant anise outdoors in warm climates with a long growing season after the final spring frost and after the soil has warmed up.

Anise seeds should be sown indoors in biodegradable pots eight weeks prior to transferring the seedlings outside once all threat of frost has gone in colder locations with a shorter growing season.

Anise seeds take a while to sprout. In actuality, it could take up to four weeks until the first seedlings poke their heads from the soil.

Anise seeds should be sown at a depth of 1/4 inch; germination takes 20 days or so.

Plant spacing should be between 6 and 18 inches. Plants should be spaced at least 18 inches apart once they are 6 weeks old.

Grow six anise plants for fresh leaves and cooking, and twelve for seeds and preservation.

*Planting a companion anise*

Companion planting: Anise is said to promote the growth of cilantro. Aphids and fleas are believed to be repelled by the strong scent of anise. Never grow anise near carrots or radishes. Grow creeping thyme beneath the foot of anise.

*Light.*

Full sun is ideal for anise growth. Aim to place your anise plants where they will receive at least 6 hours of daily direct sunlight.

*Water and Soil.*

Plant anise in loamy, well-drained soil. Add several inches of compost to very heavy soil to give plants the light-textured soil they prefer. When the ground starts drying up, water anise, but do not overwater it.

*Fertilizing.*

Around your anise plants, spread a layer of compost to help with fertilizer supply during the growing season. Around midsummer, you can also give your plants a dose of all-purpose fertilizer.

#### *Harvesting of the seeds.*

Cut the flower stalks and seed heads, then hang the stalks upside down in a warm, dry, shaded area. Wrap the seed heads in a paper bag so that the seeds will fall into the bag. Thresh the seeds after drying, or pasteurize them for 15 minutes in a 100°F oven. Before the first fall frost, finish the harvest.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Alternaria blights** *Alternaria* spp.

##### **Symptoms**

Small round yellow, brown or black spots on leaves; concentric ringed pattern; holes in leaves where lesion has dropped out

##### **Cause**

Fungi

##### **Comments**

Spread by seed; poor air circulation favors spread

##### **Management**

Treat seeds with hot water prior to planting; prevent disease by keeping plants well watered; if disease emerges remove and destroy plant; remove all plant debris from soil as fungi can survive on pieces of plant

#### **Downy mildew** *Peronospora umbellifarum*

*Plasmopara nivea*

##### **Symptoms**

Yellow spots on upper surface of leaves; white fluffy growth on underside of leaves; lesions become darker as they mature.

##### **Cause**

Fungus

##### **Comments**

Disease affects young, tender leaves; disease emergence and spread is favored by prolonged leaf wetness.

##### **Management**

Plant pathogen-free seed; do not overcrowd plants; rotate crops with non-umbelliferous varieties.

#### **Powdery mildew** *Erysiphe heraclei*

##### **Symptoms**

Powdery growth on leaves, petioles, flowers, stalks and bracts; leaves becoming chlorotic; severe infections can cause flowers to become distorted.

##### **Cause**

Fungus

##### **Comments**

Fungus can spread long distances in air; disease emergence is favored by high humidity and moderate temperatures; infection is most severe in shaded areas.

##### **Management**

Plant tolerant varieties; avoid excess fertilization; protective fungicide applications provide adequate protection; sulfur application can be used if infection occurs early in season.

#### **Rust** *Puccinia* spp.

*Uromyces* spp.

*Nyssopsora* spp.

##### **Symptoms**

Light green discolored lesions on leaves which become chlorotic; yellow-orange pustules on underside of leaves; stems

bend and become swollen or distorted; plants may be stunted.

#### Cause

Fungi

#### Comments

Some species infect only parsley while others have alternative hosts which may provide a reservoir for the disease; disease emergence is favored by high humidity.

#### Management

Plant in well-draining soils to reduce humidity around plants; apply appropriate systemic fungicide.

## Pests

### Category : Insects

#### Aphids (Willow-carrot aphid) *Cavariella aegopodii*

Carrot-willow aphid colony on stem

Carrot-willow aphid colony

Carrot-willow aphid

#### Symptoms

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants.

#### Cause

Insect

#### Comments

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed; willow-carrot aphid will also attack parsnip, carrot and celery.

#### Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use.

#### Armyworm *Pseudaletia unipuncta*

Armyworm adult

armyworm (*Pseudaletia unipuncta*)  
larvae

Armyworm

#### Symptoms

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside.

## Cause

Insect

## Comments

The armyworm, *Pseudaletia unipuncta*, is sometimes called "true armyworm" to distinguish it from other species that include "armyworm" in the common name. In Florida, Fall armyworm, *Spodoptera frugiperda* is often called armyworm, and occurs frequently; in contrast, *Pseudaletia unipuncta* is not found frequently in Florida.

This insect can go through 3–5 generations a year.

## Management

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae.

## Cutworms *Agrotis* spp.

*Peridroma saucia*

*Nephelodes minians*

and others

Greasy cutworm (*Agrotis ipsilon* aneituma) adult

Colorful larva of the variegated cutworm (*Peridroma saucia*).

Cutworm severing plant stem

## Symptoms

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5–5.0 cm (1–2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed.

## Cause

Insects

## Comments

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato.

## Management

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically.

## Category : Nematodes

### Root knot nematode *Meloidogyne* spp.

Galls or nodules associated with the root system caused by root-knot nematodes.

## Symptoms

Galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; reduction in plant vigor; yellowing plants which wilt in hot weather.

**Cause**

Nematode

**Comments**

Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or garden with this type of soil is most likely.

**Management**

Plant resistant varieties if nematodes are known to be present in the soil ;check roots of plants mid-season or sooner if symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens.

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# Apple

## Description

The following are the crop details for the apple:

Scientific name: *Malus domestica*

Local names: Tufaha (Swahili)

Order: Rosales

Family: Rosaceae

Genus: *Malus*

*Ripe apples on tree*

*Young fruits beginning to develop*

*Apple tree*

*Apple blossoms*

*Apple fruits ripening on the tree*

## General Information

An apple is a deciduous tree grown for its fruits, known as apples. Apple fruits are one of the most widely cultivated fruits in the world. They are round (pome) in shape and range in color from green to red. Apples may also be referred to as "mela" or "appel." The domestic apple tree is believed to have originated from Western Asia and the Mediterranean, having several wild ancestors. China is the largest producer of apples worldwide.

## Apple Varieties in Kenya

In Kenya, the average production quantity from an apple orchard is 6 to 10 tons of apples per acre. Apple farming is confined to the highland regions of Kiambu, Kitale, and Nandi. The commonly grown apple varieties in Kenya include Winter Banana, Anna, Top Red, Braeburn, Fiji, Golden Dorset, and Cripps Lady.

**Winter Banana:** A delicious apple variety, medium to large in size, with a yellow-green base color and a light to cloudy orange color on top.

**Anna:** A medium-sized apple with a red color or pink blush over a light green to yellow skin. The flesh is creamy white, very sweet, and juicy when fully ripe.

**Top Red:** The fruit is large and recognizable by its cone shape and intense red color. These apples are sweet and very aromatic, with crunchy and juicy flesh.

**Braeburn:** The fruit is not quite round and appears to be half green and half reddish in color.

**Fuji:** A bi-colored apple, typically striped with yellow and pinkish-red. It is known more for its flavor and firm texture than its slightly lopsided appearance.

**Golden Dorset:** A medium-sized, firm, and sweet fruit with a golden to soft yellow color.

**Cripps Lady:** Also known as Pink Lady Apples, they are named for their reddish-pink blush color. They are very firm and have a tart flavor and effervescent finish.

## Climate Conditions, Soil, and Water Management

Apple trees grow best in the tropics and at higher latitudes. They require a mild growing season and a cold winter to break their dormancy. In these latitudes, the tree will flower in spring and the fruit will ripen in the fall. In the tropics, the leaves will remain on the tree longer, making it essentially evergreen, and flowering and fruiting will happen sporadically throughout the year unless the tree manages to enforce a uniform cycle across the entire tree by bending shoots to create a wide tree.

In Kenya, apples grow at altitudes of 1800m-2800ml, with rainfall requirements of 1000mm-1800mm per year. Apple trees require fertile, well-drained, and well-aerated loamy-sandy soil, with a slightly acidic to alkaline pH of 5.5-6.5. Apples require a lot of moisture during the flowering and fruiting stage. Therefore, if you are growing apples in hotter regions, you will need to irrigate your trees. However, keep in mind that excess water around the root zone will encourage disease outbreaks and result in low crop yield. The best method of irrigating apples is through drip irrigation.

## Uses

Apples are most commonly eaten fresh but can also be used for baking and cooking. They can be processed into applesauce, cider, vinegar, juice, or butter. Slices can be dried for later consumption. Apples can also be used for the extraction of useful compounds such as fructose and pectin. Apples are rich in fiber, Vitamin C, minerals, and antioxidants. They provide the following nutrients:

Calories: 95

Fiber: 4 grams

Carbohydrates: 25 grams

Protein: 0.3 grams

Sugar: 10.4 grams

Fat: 0.2 grams

Vitamin C: 14 percent of the Reference Daily Intake (RDI)

Vitamin K: 5 percent of the RDI

Potassium: 6 percent of the RDI

Water: 86 percent

## Planting Procedure

When planted from a seed, an apple tree can take six to ten years to mature and produce fruit of its own. Apple trees are small to medium-sized, reaching heights of 5–10 m (16.4–32.8 ft), with a central trunk that divides into several branches. The leaves of the tree are oval in shape and can reach up to 13 cm (5.1 in) in length and 7 cm (2.8 in) in width.

The standard method of propagating apple trees is by budding. When planting an apple nursery or orchard, it is highly advisable to plant seedlings budded from rootstock to prevent an increase in bud dormancy. Budded trees should be pruned in the first year to encourage new shoot growth.

In the tropics, apple trees require careful management to make heavy crop loads sustainable. This includes bending shoots, pruning the tips, and defoliating the trees. Flowers are also removed to promote growth until the first fruit production, generally after 2 years.

Apple trees can also be propagated by grafting and mound layering. Grafting involves joining the lower part of one plant (rootstock) with the upper part (scion) of another. Grafting is usually done during the dormant season and must be performed on dormant scion and stock wood.

Mound layering is used to propagate apple clonal rootstocks. Soil is mounded around shoots that have been cut back, thereby stimulating roots to grow at the base of the shoots. A year before propagation begins, 8–10 mm (0.3–0.4 in) diameter stock plants are planted in rows and then cut back to 45–60 cm (17.7–23.6 in). They are then grown for one year.

In the spring, the plants are again cut back, this time to 2.5 cm (1 in) above the ground. New shoots gradually form, and more soil and bark are added in mounds around the plants. This cycle can continue throughout the growing season. Then the shoots are harvested by cutting close to the bases. The mother stool beds are then left exposed until further growth of the new shoots has occurred, and another cycle of hilling begins.

Apple seedlings are planted with a depth of 10-12 inches and spaced 8-10 feet apart in rows.

## **Harvesting**

An apple is ready for picking when its background skin color turns from green to yellow. The fruit comes off easily when harvested. Harvesting apples at the right time is key, not only to obtain the highest quality fruit but also to maximize the storage life.

Maturation time is dependent on weather conditions during the growing season. Early maturing apples are harvested in August-September.

There are several reasons why proper picking technique is important. First, simply pulling apples from the tree with force is likely to bruise the fruit and remove the stems. Apples without stems do not store as well as apples with stems.

Second, it is easy to identify apples that have been picked incorrectly. They will have noticeable fingerprint bruises. Make sure to palm instead of grab when picking. Yanking tends to remove spurs from the tree. These fruit spurs represent next year's crop, so by pulling them off, there will be fewer apples to harvest next year. In addition to not pulling the apples from the tree, there are some other actions that are important to avoid.

Apples that have touched the ground are a potential source of contamination. Never mix apples from the ground with picked apples. Apples that are decaying or rotten should be dropped on the ground and never placed in your bin. Do not throw or drop apples into your bucket, as this will certainly cause bruising. And always avoid squeezing the fruit when picking.

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## **Common Pests and Diseases**

### **Diseases**

## Category : Fungal

### Apple scab *Venturia inaequalis*

Symptoms on leaves Apple Scab	Infected fruits scab on apple	Infected fruit Scab symptoms
Scab symptoms	Scab symptoms on apple foliage	Scab symptoms
Scab symptoms on fruit	Scab symptoms on fruit	Scab symptoms on apple foliage

#### Symptoms

Yellow or chlorotic spots on leaves; dark olive green spots on leaves and fruit; may be a velvety growth on spots on undersides of leaves; twisting of leaves; distorted leaves; severely infected leaves turn yellow and drop from tree.

#### Cause

Fungus

#### Comments

Fungus overwinters on dead foliage on ground; spores dispersed by wind; high moisture encourages fungal growth.

#### Management

Remove all leaves dropped from tree in the fall and compost to prevent any diseases surviving in debris; application of zinc and fertilizer grade urea in the Fall may be necessary to speed leaf drop, lime should then be added to fallen leaves; fungicide application may be necessary in areas where leaves remain wet for periods in excess of 9 hours; fungicides such as copper soaps and Bordeaux mixture should be applied if there is a chance of wet period as soon as leaf tips emerge.

### Black rot *Botryosphaeria obtusa*

Mummified fruit due to black rot and frog eye symptoms on leaf	Irregular brown spots/blotches with lighter centers and darker borders on leaves due to black rot disease	Frog eye symptoms on leaf
Symptoms on fruit	Infected fruits	Infected fruit Black rot on apple
black rot on apple; late season infection	black rot on marginal fining apple leaves	Symptoms of black rot on apple fruit
Symptoms of black rot on apple fruit	Symptoms of black rot on apple fruit	

#### Symptoms

Purple flecks or circular lesions which are brown in the centre and purple at margin; red flecks, purple lesions and/or brown black rings on fruit.

#### Cause

Fungus

#### Comments

Spores can overwinter in twigs or fruit remaining on the tree and spread during rainfall.

### Management

Remove dead wood, mummified fruit and cankers from trees to reduce spread of disease; burn any prunings that have been made from the tree; disease can be controlled by applying fungicides from silver tip to harvest.

## Cedar apple rust *Gymnosporangium juniperi-virginianae*

Infected leaves

Cedar apple rust disease

Cedar apple rust on apple

Aecia on the lower surface of apple leaf covered in spores

Symptoms of cedar apple rust on apple foliage

Aecia on the lower surface of apple leaf

Lesions on apple foliage

Lesions on apple foliage

Symptoms of cedar apple rust on apple foliage

### Symptoms

Bright orange or yellow patches on top side of leaves surrounded by a red band and small black spots in the center; by mid-summer, cup-like structures called aecia form on the leaf undersides; these become covered in tubular structures from which spores are released.

### Cause

Fungus

### Comments

Fungus requires two hosts to complete lifecycle; forms galls on Eastern red cedar and spores are carried by wind to apple; use caution when planting apple close to red cedar.

### Management

Plant resistant varieties where possible; remove nearby red cedar; if growing susceptible varieties in proximity to red cedar follow a fungicide program.

## Flyspeck *Zygomphiala jamaicensis*

Flyspeck

flyspeck (*Schizothyrium pomi*)

Flyspeck and sooty blotch on apple fruit

### Symptoms

Shiny black fungal fruiting bodies appear as dots arranged in irregular to circular pattern on fruit surface.

### Cause

Fungus

### Comments

Outbreaks usually follow above average summer temperatures and frequent rainfall.

### Management

Prune trees to open canopy and promote drying of fruit surface; fungicides may be applied as a preventative measure.

## Powdery mildew *Podosphaera leucotricha*

*Powdery mildew symptoms on apple fruit*

*Powdery mildew symptoms on apple fruit*

*Powdery mildew symptoms on apple foliage*

*Powdery mildew on apple leaves*

### Symptoms

White velvety patches on underside of leaves; chlorotic spots on top side of the leaves

### Cause

Fungus

### Comments

Fungal spores overwinter in buds; spread by wind

### Management

Prune out infected shoots while dormant in early spring; apply sprays at pink bud stage to reduce build up; organic treatments include application of lime and sulfur

**Sooty blotch and flyspeck** Caused by a complex of *Leptodontium elatius*, *Peltaster fructicola* and *Gastrumia polystigmatus*

*Sooty blotch and flyspeck on apple fruit*

### Symptoms

Sooty blotches with an indefinite margin on surface of fruit; blotches may coalesce to cover entire fruit; shiny black fungal fruiting bodies appear as dots arranged in irregular to circular pattern on fruit surface

### Cause

Fungi

### Comments

Infections occur mainly during periods of high rainfall and high humidity

### Management

Plant trees in area with good sunlight and air circulation; prune trees to an open center; blemishes superficial and can be washed off

## Category : Bacterial

**Fire blight** *Erwinia amylovora*

<i>Fire blight on apple</i>	<i>Widespread fire blight dieback symptoms throughout an apple orchard</i>	<i>Infected shoot and fruits</i>
<i>Fire blight symptoms on apple foliage</i>	<i>Fire blight symptoms on apple foliage</i>	<i>Fire blight symptoms on apple foliage</i>
<i>Fire blight symptoms on apple foliage</i>	<i>Fire blight symptoms on apple foliage</i>	<i>Fire blight symptoms on apple foliage</i>
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<i>Fire blight symptoms on apple foliage</i>	<i>Fire blight symptoms on apple foliage</i>	<i>Fire blight symptoms on apple foliage</i>

## Symptoms

Plant appears as if it has been scorched by fire; watery exudate may be present on infected areas.

## Cause

Bacterium

## Comments

Bacterium overwinters in bark or cankers; spread by pollinating insects and by rain splash.

## Management

Cut out diseased wood; treat with Bordeaux mixture or approved fixed copper materials for organic production; streptomycin or copper application to blossoms may be necessary to prevent spread.

## Category : Oomycete

## Phytophthora crown and root rot *Phytophthora* spp.

<i>Damaged fruit</i>	<i>Phytophthora collar rot (<i>Phytophthora</i> sp.) on a young apple tree.</i>	<i>Phytophthora root and crown rot symptoms on apple tree</i>
<i>Phytophthora root and crown rot symptoms on apple trunk</i>		

## Symptoms

Leaves wilting but remain attached to the tree; reduced growth; early senescence; cankers at soil level, dark discoloration of bark which is slimy when wet.

## Cause

Fungus

## Comments

Infection encouraged by poorly draining soil.

## Management

Practice good water management to prevent emergence of disease; do not over-water trees or allow water to accumulate in soil; there is no treatment for Phytophthora infection once present; no apple varieties are resistant to all strains of the pathogen.

## Pests

## Category : Insects

## Aphids (Green apple aphid, Woolly apple aphid) *Aphis pomi*

*Eriosoma lanigerum*

apple aphid (*Aphis pomi*)  
overwintering eggs

apple aphid (*Aphis pomi*) infestation

Woolly aphid damage

Woolly apple aphid damage

Woolly apple aphid colony

Woolly aphid infestation

Infestation of apple tree with woolly  
apple aphid (*Eriosoma lanigerum*)

Cankerous tumours on apple shoot  
caused by colonies of *Eriosoma  
lanigerum*.

Perennial canker on an apple tree,  
caused by woolly aphids (*Eriosoma  
lanigerum*).

Woolly apple aphid colony

Green apple aphid colony on crab  
apple

Woolly apple aphid infestation on  
crab apple

### Symptoms

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, woolly apple aphids are covered in masses of white, wool-like material; green apple aphids are dark green when they first hatch and change to yellow-green with darker green spots as they mature; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants.

### Cause

Insects

### Comments

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed.

### Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use.

## Apple maggot *Rhagoletis pomonella*

<i>External symptoms of injury on apple.</i>	<i>Female adult insect</i>	<i>Adults captured on Pherocon AM trap</i>
<i>apple cut open to show damage by the apple maggot (<i>Rhagoletis pomonella</i>).</i>	<i>External appearance of apples damaged by the apple maggot (<i>Rhagoletis pomonella</i>).</i>	<i>Apple tree with a yellow sticky trap for apple maggots (<i>Rhagoletis pomonella</i>).</i>
<i>Apple maggot (<i>Rhagoletis pomonella</i>) damage to apple</i>	<i>Paradise apple injured by apple maggot (<i>Rhagoletis pomonella</i>).</i>	<i>Symptoms of apple maggot on fruits</i>
<i>Apple maggot damage</i>	<i>Adult insect</i>	

## Symptoms

Misshapen, pitted and sunken areas on fruit surface; browning and rotting of apple flesh.

## Cause

Insect

## Comments

Surface damage caused to fruit by female laying her eggs; larvae damage flesh by burrowing and feeding.

## Management

Use red spherical sticky traps to trap adults, place one trap for every 100 apple fruits; bag apples by tying or stapling polythene bags around fruit to prevent adults laying eggs - cut corners from bags to ensure air supply to fruit; spray fruit with insecticide prior to eggs being laid.

## Codling moth *Cydia pomonella*

<i>Tunneling made by exiting codling moth larva</i>	<i>Codling Moth Larva in Apple</i>	<i>Infected fruits</i>
<i>Damage caused to an apple fruit by the codling moth <i>Cydia pomonella</i> in the field.</i>	<i>Damage to apple fruit by moth larvae</i>	<i>Codling moth larva in apple fruit</i>
<i>Moth pupa in apple fruit</i>		

## Symptoms

Holes and burrows in fruit; holes may be blocked with crumbly brown frass (insect excrement); wounds may be shallow or may be deep burrows extending to the fruit's core; adult insect is a dark brown moth; larvae are pink with a brown head and may be up to 1.3 cm (0.5 in) long.

## Cause

Insect

## Comments

Insect usually undergoes 2-4 generations per year.

## Management

Proper pruning methods help to open out tree canopy to ensure treatments penetrate interior of the tree and reach

larvae; removal of any wild hosts or trees in abandoned orchards helps remove reservoirs of insect; organically acceptable control methods include application of Entrust and kaolin clay; small scale growers and home gardeners can remove infested fruit by hand before larvae leaves fruit to reduce insect population; successful reduction of insect population in large scale orchards is usually achieved by mating disruption by releasing pheromones over successive years.

### **Leafhoppers (White apple leafhopper, Rose leafhopper)** *Typhlocyba pomaria* *Edwardsiana rosae*

*White apple leafhopper adult*

*white apple leafhopper Nymphal skin*

*Characteristic white stippling on crab apple leaf caused by leafhoppers*

*White apple leafhopper nymph on underside of leaf*

#### **Symptoms**

White stippling on foliage; may be a reduction in fruit size; black specks of frass on fruit; sticky exudate on fruit and leaves caused by excretion of honeydew by insect.

#### **Cause**

Insect

#### **Comments**

Damage resembles that of spider mites but is much more noticeable; insect usually reaches highest number close-to or after harvest.

#### **Management**

Control of leafhoppers is becoming problematic as they are developing resistance to organophosphate insecticides; sprays of appropriate insecticides are most effective at controlling the insect before the adults emerge; monitor trees for appearance of nymphs.

### **Leafrollers (Omnivorous leafroller, Redbanded leafroller, etc)** *Platynota stultana* *Argyrotaenia velutinana*

*omnivorous leafroller (*Platynota stultana*) larva*

*Redbanded leafroller on apple leaf*

#### **Symptoms**

Leaves of plant rolled and tied together with silk webbing; feeding damage to rolled leaves; defoliation of plant; silk webbing may also be present on fruits and fruits may have substantial scarring from feeding damage; larvae wriggle vigorously when disturbed and may drop from plant on a silken thread.

#### **Cause**

Insect

#### **Comments**

Adult insect is a moth which can fly over several miles to find suitable hosts.

#### **Management**

Monitor plants regularly for signs of infestation; remove weeds from plant bases as they can act as hosts for leafrollers; *Bacillus thuringiensis* or Entrust SC may be applied to control insects on organically grown plants; apply sprays carefully to ensure that treatment reaches inside rolled leaves.

### **Roundheaded apple tree borer** *Saperda candida*

*Damaged tree*

*Adult insect*

*Larvae*

*Roundheaded apple tree borer  
(*Saperda candida*) adult*

*Borer holes at base of tree*

### **Symptoms**

The presence of bore holes at the base of tree which are covered by pigtail-shaped frass and/or darkened areas in the bark due to sap flow are the proof of insect infestation. The young may kill by one or two larvae infestation. The older trees show drying and break off near the base.

### **Cause**

Insect

### **Comments**

The insect is quite common in US and Canada. The host range of this insect is apple, pear, quince, mountain-ash, hawthorn and serviceberry.

### **Management**

Use of trunk wraps to avoid insect attack. Removing and killing of larvae from the tunnel if possible. Application of suitable insecticide.

## **Stinkbugs (Various)**

*Adult red shouldered stink bug*

### **Symptoms**

Dark colored pinpricks on fruit; depressed dimples on fruit surface with white, pithy area underneath; stink bugs often carry pathogens in their mouthparts which can cause secondary infections and decay of fruit; adult insect is shield-shaped and brown or green in color; may have pink, red or yellow markings; eggs are drum shaped and laid in clusters on the leaves; larvae resemble the adults but are smaller; insect frass may be visible on the fruit is small, brown teardropped shaped deposits

### **Cause**

Insect

### **Comments**

Adult insects overwinter under leaves, on legumes, blackberries or on certain weeds such as mustard or Russian thistle

### **Management**

Remove weeds around crop which may act as overwintering sites for stink bugs and practice good weed management throughout the year; organically accepted control methods include the use of insecticidal soaps, kaolin clay and preservation of natural enemies

## **Category : Mites**

### **Spider mites**

*Tetranychus urticae*

*Characteristic stippled leaf caused  
by spider mites*

### **Symptoms**

Leaves stippled with yellow; leaves may appear bronzed; webbing covering leaves; mites may be visible as tiny moving dots on the webs or underside of leaves, best viewed using a hand lens; usually not spotted until there are visible symptoms on the plant; leaves turn yellow and may drop from plant

#### **Cause**

Arachnid

#### **Comments**

Spider mites thrive in dusty conditions; water-stressed plants are more susceptible to attack

#### **Management**

In the home garden, spraying plants with a strong jet of water can help reduce buildup of spider mite populations; if mites become problematic apply insecticidal soap to plants; certain chemical insecticides may actually increase mite populations by killing off natural enemies and promoting mite reproduction

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# Apricot

## Description

Apricot, *Prunus armeniaca* is a deciduous tree in the family Rosaceae grown for its edible fruit. The apricot tree has an erect growth habit and a spreading canopy. The leaves of the tree are ovate with a rounded base, pointed tip and serrated margin. The tree produces white to pink flowers, singly or in pairs, and a fleshy yellow to orange fruit. The apricot fruit is a drupe with skin that can be smooth or covered in tiny hairs depending on the variety and a single seed enclosed within a protective outer shell (stone). Apricot trees can reach 8–12 m (26–39 ft) and can live anywhere between 20 and 40 years depending on variety and growth conditions. Apricots may have as many as three centers of origin in China, Central Asia and the Near East.

*Apricot blossoms*

*Ripening fruits*

*Green fruit on tree*

*Apricot fruit on tree*

## Uses

Apricots can be consumed fresh or dried. They may also be processed into jams and jellies, syrup or juice.

## Propagation

**Basic requirements** Apricots have a high genetic variability and as a result, they also have a wide range of growing conditions. The trees tend to bloom early compared with other stone fruits and are therefore susceptible to damage from late frosts. Apricots will grow best in deep, well-draining soils and will not tolerate water saturating. Apricots have a chilling requirement (period of cold required to break dormancy) of between 250 and 1200 hours below 7°C (45°F) depending on the variety. In addition, most apricot trees do not require a second variety for cross-pollination.

**Propagation** Apricot trees are usually propagated vegetatively to maintain the desirable genetic characteristic of the parent. Trees can be propagated from cuttings or by budding and grafting. Cuttings are lengths of stem usually taken from the previous years growth of an established tree. Cuttings are taken in late winter or early spring and rooted so that they produce a whole new tree. Budding and grafting involves joining two genetically distinct plants one is used for the lower part called the rootstock and another is used for the upper part, known as the scion. The scion is attached by inserting a bud from the desired variety under the bark of the rootstock so that it produces a new tree. **Planting** Apricot trees should be planted in full sun. In colder regions it is beneficial to plant them close to a north facing wall which helps reduce the speed with which the trees warm in the spring, delaying bloom. Plant bare root trees in a pre-dug hole which is slightly wider than the root ball. Backfill the hole so that the tree is planted to its original planting depth. It is usually possible to identify this from changes in the color of the bark. If planting multiple trees, space them at least 7.6 m (25 ft) apart. **General care and maintenance** Apricots should be pruned annually and are generally trained to an open center. Annual pruning encourages new fruit spurs. When the tree is bearing fruit, it is important to thin the fruits to leave 3 or 4 per cluster. This allows fruits to become larger and prevents the tree from reducing production the following year. Trees should be watered regularly during the growing season to aid with fruit development. During dry periods, water trees every 10 to 14 days. Apply water deeply and widely, to at least the width of the canopy. Trees will also benefit from the application of a nitrogen fertilizer in Spring.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Armillaria root rot** *Armillaria mellea*

*Armillaria fruiting Bodies*

*Armillaria mycelial mat*

*Mushroom and mycelial fan  
characteristic of armillaria root rot  
(*Armillaria sp.*)*

### Symptoms

If tree is infected after it has reached 5 years of age then typical symptoms include poor terminal growth and small leaves; around midsummer the whole tree suddenly collapses; in orchards trees usually die in a circular pattern; infected trees often have a fan-shaped white fungal mat growing between the bark and wood of the crown.

### Cause

Fungus

### Comments

Fungus survives in dead roots; symptoms similar to Phytophthora root rot.

### Management

Once a tree is infected there is no treatment and it should be removed, fumigants do not control fungi in soil adequately; do not plant apricot in newly cleared forest or on the site of old orchards with a history of Armillaria.

## Brown rot blossom *Monolinia* spp.

*Lesions on apricot fruit due to  
Monilinia fructicola, M. laxa & M.  
fructigena. Top left-control; top  
centre-M. laxa; top right-M.  
fructigena; bottom left-M. fructigena;  
bottom centre-M. fructicola; bottom  
right-M.laxa.*

### Symptoms

Death of young blossoms and associated twigs and leaves; small tan cankers with dark margins on twigs; gummy exudate at base of flowers; brown spore masses on flowers in humid conditions.

### Cause

Fungi

### Comments

Fungi survive in mummified fruit and dead twigs.

### Management

2-3 fungicide applications are required during bloom to control disease; application very important at red bud stage; applications should be made every 14 days or less if there is continued heavy rainfall.

## Eutypa dieback *Eutypa lata*

### Symptoms

Cankers on branches, usually associated with a pruning wound which is several years old; discolored sapwood may extend above and below canker; leaves on branches around canker may suddenly wilt as branch dies; leaves remain attached to branches; discoloured bark and inner wood; gummy amber exudate may be present.

### Cause

Fungus

### Comments

Fungus enters fresh pruning wounds with rainfall 2-6 weeks after pruning; emergence of disease most common in Fall or Winter.

### Management

Infected limbs should be removed 1 ft below any internal symptoms before harvest; if pruning is conducted outwith this time a fungicide should be applied to the pruning wounds.

**Jacket rot** *Botrytis cinerea*

*Sclerotinia sclerotiorum*

*Monilinia laxa*

*Monilinia fructicola*

**Symptoms**

Brown discoloration of fruit under jacket occurring while flower parts still attached to fruit

**Cause**

Fungi

**Comments**

Disease emergence favored by wet conditions during bloom and jacket stage

**Management**

Fungicide treatment applied at full bloom

**Powdery midew** *Sphaerotheca pannosa*

*Podosphaera tridactyla*

*Powdery mildew symptoms on apricot fruit*

**Symptoms**

Round powdery white patches of fungal growth on fruits and leaves; rusty patches on fruits which turn brown and leathery and may crack

**Cause**

Fungi

**Comments**

*S. pannosa* infects plant in Spring. *P. tridactyla* infects plant in Summer and Fall

**Management**

Apply fungicide during bloom and fruit development

**Ripe fruit rot** *Monilinia fructicola*

*Monilinia laxa*

*Symptoms of ripe fruit rot on apricot fruits*

**Symptoms**

Dark brown circular spots on fruit; tan spore masses may be visible in center of spots; diseased fruit may not drop from tree

**Cause**

Fungi

**Comments**

Fruit rot symptoms will appear within 48 hours of rain

**Management**

A protective fungicide treatment may be necessary if heavy rains are forecast 2-3 weeks prior to harvest

## Rust *Tranzschelia discolor*

Rust symptoms

### Symptoms

Pale yellow-green spots on both upper and lower leaf surfaces which are angular in shape and turn bright yellow in color; spots on lower leaf surface develop orange-red spores.

### Cause

Fungus

### Comments

Fungus overwinters in twigs or in leaves which remain attached to the tree.

### Management

Rust can be prevented by spraying trees with protective fungicides; application is usually carried out one, two and three months before harvest in areas prone to early season outbreaks of the disease and after harvest in areas where disease is less problematic or emerges later in the season.

## Shot hole disease *Wilsonomyces carpophilus*

*Shot hole disease symptoms on a peach fruit caused by Wilsonomyces carpophilus. This disease on peach is distinguished by profuse gumming.*

*Peach fruit displaying symptoms of infection with Shot Hole Disease (Coryneum blight - Wilsonomyces carpophilus).*

### Symptoms

Brown lesions with purple edge on fruit, twigs and buds; holes in leaves due to lesions which have dried and dropped out; brown lumps developing in the center of lesion (visible with hand lens); buds turning brown or black and exuding sap; tan lesions with brown margins which exude sap on twigs.

### Cause

Fungus

### Comments

Fungus survives in buds and twigs; spores spread by water splash.

### Management

Application of Bordeaux mixture before rains in Fall are sufficient to protect dormant buds and twigs over winter.

## Verticillium wilt *Verticillium dahliae*

### Symptoms

Withering of leaves on one or more spurs on 1 year old wood; leaves are dull and stunted; fruit small; older cherry trees do not recover from disease

### Cause

Fungus

### Comments

Fungus survives in soil or in debris from other susceptible plants

### Management

Plant apricot in soil with no history of disease; keep trees adequately fertilized and watered

## Category : Bacterial

## Bacterial canker *Pseudomonas syringae*

### Symptoms

Cankers on twigs at bases of flower and leaf buds, in pruning wounds or at the base of spurs which exude amber colored gum; cankers spread upwards and form sunken areas in winter; if pathogen enters dormant buds they may be killed or open normally in Spring before collapsing in early Summer; infected buds may be symptomless.

### Cause

Bacterium

### Comments

Disease emergence favors high moisture and low temperatures in the spring; young trees particularly susceptible; trees grown in sandy soils that drain poorly are also susceptible.

### Management

Ensure that a suitable apricot variety and rootstock is chosen based on geographic location and environmental conditions to prevent stress to tree which predisposes tree to canker disease; apply protective copper spray to trees before flowering; prune trees in early summer to decrease likelihood of infection.

## Crown gall *Agrobacterium* spp

*Crown gall*

*Gall symptom*

### Symptoms

Galls on root and/or crown of tree which can range in size from so small they are not visible to the naked eye up to 10 cm (4 in) in diameter; galls first become visible as white, fleshy swellings that grow rapidly and become tan to brown in color; galls typically develop at the site of a wound and new galls form adjacent to old ones the next year.

### Cause

Bacterium

### Comments

Infection with crown gall begins at the site of plant wounds; disease emergence is favored by poorly-drained, alkaline soils and previous feeding damage by nematodes.

### Management

Chemical control of the disease is generally ineffective; an effective bacterial biological control is available for commercial production; cultural control methods include: planting only certified, disease-free material, planting apricot in well-draining soil, rotating infected fields with a non-host before apricot is planted and also using good sanitation practices.

## Category : Oomycete

## Phytophthora root and crown rot *Phytophthora* spp.

*A tree with a Phytophthora crown rot infection caused by Phytophthora spp. in the field.*

### Symptoms

Poor new growth; leaves chlorotic, small in size and sparse; fruit may be small, brightly colored and susceptible to sunburn; shoots may suffer from dieback and tree will often die within weeks or months of first signs of infection or decline gradually over several seasons; root crown may show signs of decay which develops into a canker; bark of infected crown tissue turns dark brown; cankers may occur on aerial parts of plant.

### Cause

Oomycete

## **Comments**

Severity of disease is linked to soil moisture content; water-saturated soils promote development of fungus.

## **Management**

Plant trees on a small mound to promote drainage; avoid over-watering trees in spring; treat soil around newly planted trees with fungicide; minimize the frequency and duration of water saturated soil; trees should be propagated from resistant rootstock and application of appropriate systemic fungicides may provide some protection from the disease.

## **Category : Viral**

### **Plum pox virus** *Plum pox virus (PPV)*

*Symptoms of plum pox virus on apricot fruit and leaves.*

*Leaf symptoms of plum pox potyvirus infection on apricot.*

*Symptoms of plum pox on fruits and seed on apricot, showing brownish depressions and grooves on the surface.*

*Fruit symptoms of plum pox potyvirus infection on apricot.*

*Infected fruit*

*Symptoms of plum pox virus on apricot fruits*

## **Symptoms**

Pale green chlorotic spots, rings and lines on leaves which appear in early summer; pale rings, lines and spots on fruit; fruit flesh dry and flavorless; fruit may be markedly deformed.

## **Cause**

Virus

## **Comments**

Virus is transmitted by aphids but most common method of spread is diseased plant material.

## **Management**

Plant certified healthy material; remove infected trees from orchard; chemical sprays to control aphids may prolong spread of virus.

## **Pests**

## **Category : Insects**

### **European earwig** *Forficula auricularia*

*European earwig adult*

*Adult male and female European earwigs (*Forficula auricularia*) on a flower.*

*Aggregation of earwigs at tip of plant*

*European earwig*

## **Symptoms**

Mature trees generally tolerate damage well; if damage is caused to shoot tips of young trees then growth may be stunted; shallow, irregularly shaped areas may be present on fruit surface where insect has fed; insects are brown and shiny with a pincer-like structure at the end of the abdomen; can reach 1.3 cm (0.5 in) in length.

## **Cause**

Insect

## Comments

Earwigs are nocturnal and generally undergo two generation per year.

## Management

Remove all weeds from around tree bases; remove all pruning debris and loose bark around trees; wrapping trunks tightly with plastic wrap before nymphs emerge can stop them climbing up the tree; if using insecticide, apply early in Spring when earwigs begin to be active.

## Fruittree leafroller *Archips argyrospila*

*Adult fruittree leafroller (*Archips argyrospila*)*

*Adult insect*

*Fruittree leafroller larva*

## Symptoms

Leaves of plant rolled and tied together with silk webbing; feeding damage to rolled leaves; defoliation of plant; silk webbing may also be present on fruits and fruits may have substantial scarring from feeding damage; larvae wriggle vigorously when disturbed and may drop from plant on a silken thread.

## Cause

Insect

## Comments

Only one generation of insect per year.

## Management

Monitor plants regularly for signs of infestation; remove weeds from plant bases as they can act as hosts for leafrollers; avoid planting pepper in areas where sugarbeet or alfalfa are grown nearby; *Bacillus thuringiensis* or Entrust SC may be applied to control insects on organically grown plants; apply sprays carefully to ensure that treatment reaches inside rolled leaves.

## Green fruitworm Various

*speckled green fruitworm (*Orthosia hibisci*) ate instar larva*

*Green fruitworm*

## Symptoms

Large holes chewed in leaves and fruit; pale green caterpillars with white stripe down middle of back present on leaves and fruit.

## Cause

Insect

## Comments

Insect usually overwinters as adult moth and undergoes only one generation per year.

## Management

If larva become damaging to trees then sprays of *Bacillus thuringiensis* will control young larvae effectively and can be applied during bloom; other organically acceptable control methods include application of Entrust; appropriate insecticides can be used as spot treatments if infestation is localized or applied shortly before, or during, petal fall.

## Mealy plum aphid *Hyalopterus pruni*

*Multiple Life Stages*

*mealy plum aphid massed on leaf*

*Mealy plum aphid colony*

## **Symptoms**

High levels of infestation may cause stunted vegetative growth; black soot mold developing on leaves and branches; insect is small and soft-bodied, green in color and covered in white, mealy wax.

## **Cause**

Insect

## **Comments**

Infestations usually appear in small pockets in orchards; insect eggs overwinter and hatch in Spring.

## **Management**

Organically grown trees can be sprayed with neem oil to control aphid populations; chemical control of the aphid is rarely necessary.

## **Peach twig borer *Anarsia lineatella***

*Peach twig borer (Anarsia lineatella) adult*

*Peach twig borer larvae*

## **Symptoms**

Death of shoot tips; feeding damage to fruit, usually at stem end; larvae are dark brown and white with a black head; adult insect is a gray-brown moth.

## **Cause**

Insect

## **Comments**

Peach twig borers overwinter as larvae in a specialized cell known as a hibernaculum; overwintering sites are located in rough areas of bark on 1 to 4 year old wood in crotch of limbs.

## **Management**

Most effective method of treatment is well-timed applications of insecticide around time of bloom; organically acceptable insecticides include *Bacillus thuringiensis* or Entrust; infestations can also be treated with appropriate organophosphate or pyrethroid insecticides.

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# Artichoke

## Description

The following are the crop details for Artichoke:

Scientific Name: *Cynara scolymus*

Order: Asterales

Family: Asteraceae

Genus: *Cynara*

*Harvest*

*Globe artichoke leaves*

*Bee visiting globe artichoke flower*

*Globe artichoke flowers*

*Globe artichoke flowering*

*Flower close-up*

*Globe artichoke foliage*

*Developing flower buds*

*Globe artichoke*

## General Information

Artichoke, scientifically known as *Cynara scolymus*, is a herbaceous perennial thistle cultivated for its edible fleshy flower head, commonly referred to as the "heart," which is considered a delicacy. The plant has arched, irregularly lobed leaves that are silvery green, reaching a length of 50–82 cm (19.7–32.3 in) and bearing a few spines. The buds grow up to 3-4 inches in diameter, have a rounded base, and taper to a tip or block shape. These buds are harvested at an immature stage before they open and reveal the flower.

The flower head itself measures 4–8 cm (1.6–3.1 in) in diameter and consists of numerous triangular scales and purple-colored individual florets. Artichokes take about 150 to 180 days to mature after sowing and can reach heights of 1.4–2 m (4.6–6.6 ft). Originating from Southern Europe and the Mediterranean, the globe artichoke is known by various names, including leaf artichoke, artichoke, artisjok, artichaut, carciofo, alcachofra, alacachofra, or kharsuf.

Italy stands as the largest global producer of artichokes.

## Artichoke Varieties

**Green Globe Artichoke:** The most common type with wide, deep green buds and a light purple tinge. Excellent for use in salads.

**Imperial Star Artichoke:** Produces 4-5 inches wide buds with a similar flavor to the green globe variety, albeit slightly sweeter.

**Violetta Artichoke:** Known for its thick purple leaves, this variety offers 5 inches long and 3 inches wide artichokes. It has a nutty, buttery flavor and is commonly used in salads.

**Big Heart Artichoke:** This variety features a large, fleshy base weighing around a pound, and it grows without thorns. The buds are dense and measure 3-5 and a 1/2 inches wide.

**Baby Anzio Artichoke:** The smallest variety, measuring just 2 inches in diameter. It is harvested early, resulting in a tasty bud with a sweet and nutty, caramel-like flavor.

## Climate Conditions, Soil, and Water Management

Artichokes are cool-season crops and thrive in deep, fertile, and well-drained loam or loamy clay soils with a pH between 6.0 and 8.0. They require high environmental humidity levels and ample sunlight.

It is essential to avoid planting artichokes in extreme heavy clay or light sandy soils. In cases where drainage is an issue, raised bed culture is recommended, as it leads to warmer soil temperatures in spring and faster establishment.

The optimal daytime temperature for artichokes is 20–22°C (68–71.6°F), with an ideal nighttime temperature of 12–14°C (53.6–57.2°F). While these plants can tolerate both cold and high temperatures, extreme conditions can reduce the tenderness of the flower heads. Frost, in particular, can cause blistering in the flower heads and may even kill the buds.

Artichokes can grow on slightly sloped fields, but such areas require frequent irrigation to ensure the development of high-quality flower heads. However, waterlogged soil should be avoided, as artichokes cannot tolerate excessive moisture.

Throughout the growing season, artichoke plants require frequent watering, which can be done either 1-3 times per week or once every 2-3 weeks. Adequate water supply during the flowering and bud formation stage is crucial for the formation of a satisfactory number of flower buds, resulting in higher yields.

## Uses

Artichokes are primarily cultivated for consumption and can be enjoyed either raw in salads or cooked. They offer nutritional value, providing a significant source of folic acid, magnesium, iron, and potassium. Additionally, each artichoke contains less than 40 calories, about two grams of protein, and nine grams of carbohydrates.

Apart from consumption, artichokes can be canned, pickled, or processed to produce tea, liqueur, or extract secondary metabolites such as cynarin and chlorogenic acid for use in alcoholic beverage preparation. Due to their high antioxidant content, artichokes are considered a health food and have potential benefits in lowering cholesterol and regulating blood sugar levels.

## Planting Procedure

Artichokes are usually propagated vegetatively from underground shoots known as "ovoli" or from the suckers, stumps, or dried shoots from the previous growing season. Alternatively, they can be grown as annual plants from seeds. For vegetative propagation, existing globe artichoke plants should be divided in Fall or Winter when the plant is dormant. Shoots should be selected from plants that produce well and should be removed when they reach a height of about 20 cm (8 in).

To remove the shoots, they should be cut from the mother plant at the root using a sharp knife and gently loosened from the soil and existing root ball. These separated shoots should then be planted in a freshly prepared bed. The roots should be set to a depth of 15 to 20 cm (6-8 in) and spaced 1.2 to 1.8 m (4-6 ft) apart. Closer spacing may lead to fewer secondary buds. During the first year, flower heads should not be harvested to allow the new plants to establish.

For seed propagation, artichoke seeds should be started indoors about two months before the last frost date in the respective area. The seeds should be sown 2.5 cm (1 in) deep in a seed-starting mix within small 4-inch pots. Generous sowing is recommended, as germination success is around 70%, and not all emerging seedlings will produce high-quality plants. Once the seedlings have been hardened and all danger of frost has passed, they can be transplanted outdoors. Plants should be spaced 0.9 m (3 ft) apart in rows that are also spaced 0.9 m (3 ft). After the first year, any plants not producing well should be removed to achieve a final spacing of 1.2 to 1.8 m (4-6 ft) between plants.

## Nutrient Management

During the growing season, globe artichokes benefit from the application of a balanced fertilizer once every month. It is crucial to keep the plants from drying out, so the soil should be kept consistently moist. Insufficient soil moisture and plant stress during bud formation can result in poorly formed, tough buds of lower quality that do not size well. On the other hand, over-irrigation and long-term soil saturation should be avoided, particularly for heavier soils.

To conserve soil moisture, applying a thick mulch is recommended. However, the mulch should be removed when the plants begin to bud, and a generous layer of compost should be used instead. After harvest, the plant stems should be

cut back to ground level or slightly below the soil line. For winter protection, the plants' roots should be mulched with plenty of organic mulch, such as about 20cm/8 in of straw and/or leaves. Additionally, covering the plants with a cardboard or styrofoam box filled with straw and leaves can further protect them during winter.

## Harvesting

Globe artichoke flower buds should be harvested before they start to open. Smaller, immature heads are more tender than older buds that are closer to opening. The buds color and appearance subtly change as they reach the harvest stage.

Using a sharp knife, the buds should be cut from the plant, leaving a 2.5 to 7.5 cm (1-3 in) section of stem with each bud. After harvesting all the buds from a plant, the plant should be cut down to the ground. Harvested buds should be inspected for insects, disease, and cosmetic damage.

Under proper cold storage conditions, artichokes can store well for three to four weeks. The ideal storage temperature ranges from 32° to 34°F, with humidity levels between 90 percent and 95 percent.

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## Common Pests and Diseases

### Diseases

#### Category : Viral

##### **Artichoke curly dwarf virus** Artichoke curly dwarf virus (ACDV)

###### **Symptoms**

Plant growth reduced; plant lacking vigor; leaves may be distorted with dark necrotic spots and/or patches; deformed buds

###### **Cause**

Virus

###### **Comments**

Currently not known how virus is spread; use disease free crowns to propagate or certified seed

###### **Management**

Use only certified planting material; remove and destroy infected plants to limit spread

## Category : Bacterial

### Bacterial crown rot *Erwinia chrysanthemi*

#### Symptoms

Stunted plant growth; wilted leaves in high temperatures; plant collapse; new leaves do not expand and turn brown and dry; crown tissue becomes soft and rots; black discoloration when cross-section of stem taken.

#### Cause

Bacterium

#### Comments

May be spread by cutting tools; digging and splitting crowns may cause new plantings to become infected.

#### Management

Do not use infected crowns as planting material; start plants from seed or disease free transplants.

## Category : Fungal

### Botrytis rot or gray mold *Botrytis cinerea*

*Close up of diseased bracts showing symptom  
sporulation of the pathogen*

*Gray mold on closely related  
Cardoon*

#### Symptoms

Crown of plant slimy and foul smelling; fuzzy white to gray mold present.

#### Cause

Fungus

#### Comments

More prevalent when rainfall is high.

#### Management

Plant in light, well-draining, fertile soils; avoid overcrowding plants and planting seeds too deeply; do not wet foliage when watering, water plants at base; remove crop debris from soil after harvest.

## Category :

### Fusarium Wilt *Fusarium oxysporum* f. sp. *cynarae*

#### Symptoms

Wilting, yellowing, and stunted growth.

#### Cause

Fungus

#### Comments

#### Management

Practise crop rotation, planting disease-resistant varieties, and ensuring proper soil drainage.

## Pests

## Category : Insects

## **Armyworms (Beet armyworm, Yellow striped armyworm) *Spodoptera exigua***

*Spodoptera ornithogalli*

*Yellowstriped armyworm  
(*Spodoptera ornithogalli*) larvae*

*Yellowstriped armyworm  
(*Spodoptera ornithogalli*) adult*

*Beet armyworm (*Spodoptera exigua*) adult*

*Beet armyworm (*Spodoptera exigua*) egg mass*

*Beet armyworm (*Spodoptera exigua*) early stage larvae*

*Beet armyworm larva*

### **Symptoms**

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside.

### **Cause**

Insect

### **Comments**

Insect can go through 3–5 generations a year.

### **Management**

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae.

## **Artichoke aphid *Capitophorus elaeagni***

*Lady bug and aphids and ants on artichoke*

*Artichoke aphid colony*

### **Symptoms**

Leaves curling and turning yellow; reduced plant growth; small, deformed buds; stalks cannot support weight of buds and droop; sooty mold growing on plants due to honeydew deposits secreted by insect; insect is small, soft-bodied and pale green to yellowish green in color.

### **Cause**

Insect

### **Comments**

Symptoms occur when aphid numbers are large; insects should be visible on underside of leaves; become more problematic in high temperatures and humidity.

### **Management**

Destroy plant immediately after harvest to prevent population spread; wash aphids from plants with a strong stream of water; insecticidal soaps or oils such as neem or canola oil are effective organically acceptable methods of control.

## **Artichoke plume moth *Platyptilia carduidactyla***

*Platyptilia carduidactylus – Artichoke Plume Moth*

*Artichoke plume moth*

## Symptoms

Holes in leaves and stems which are discolored black and filled with frass (insect excrement).

## Cause

Insect

## Comments

More of a problem when growing artichoke as a perennial.

## Management

Pick all infested buds at harvest and destroy; cut plant stems above ground, shred plants and incorporate into soil; apply *Bacillus thuringiensis* or insecticide.

## Flea beetle (Palestriped flea beetle) *Systema blanda*

*palestriped flea beetle (Systema blanda)* adults feeding injury

*Palestriped flea beetle*

## Symptoms

Small holes or pits in leaves that give the foliage a characteristic “shot hole” appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5–3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance.

## Cause

Insects

## Comments

Younger plants are more susceptible to flea beetle damage than older ones; older plants can tolerate infestation; flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year.

## Management

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application of diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied.

## Loopers (Cabbage looper, Alfalfa looper) *Trichoplusia ni*

*Autographa californica*

*Cabbage looper (Trichoplusia ni)*  
adult

*Alfalfa looper (Autographa californica)* larva

*alfalfa looper (Autographa californica)* adult

*Cabbage looper*

## Symptoms

Large or small holes in leaves; damage often extensive; caterpillars are pale green with a white lines running down either side of their body; caterpillars are easily distinguished by the way they arch their body when moving; eggs are laid singly, usually on the lower leaf surface close to the leaf margin, and are white or pale green in color.

## Cause

Insect

## Comments

Insects overwinter as pupae in crop debris in soil; adult insect is a dark colored moth; caterpillars have a wide host range.

## Management

Looper populations are usually held in check by natural enemies; if they do become problematic larvae can be hand-picked from the plants; an organically acceptable control method is the application of *Bacillus thuringiensis* which effectively kills younger larvae; chemical sprays may damage populations of natural enemies and should be selected carefully.

## Category : Mites

### Spider mites (Two-spotted spider mite) *Tetranychus urticae*

*Close-up view of two-spotted spider mites (*Tetranychus urticae*)*

*Two spotted spider mite (*Tetranychus urticae*)*

*two-spotted spider mite adult*

## Symptoms

Leaves stippled with yellow; leaves may appear bronzed; webbing covering leaves; mites may be visible as tiny moving dots on the webs or underside of leaves, best viewed using a hand lens; usually not spotted until there are visible symptoms on the plant; leaves turn yellow and may drop from plant.

## Cause

Arachnid

## Comments

Spider mites thrive in dusty conditions; water-stressed plants are more susceptible to attack.

## Management

In the home garden, spraying plants with a strong jet of water can help reduce buildup of spider mite populations; if mites become problematic apply insecticidal soap to plants; certain chemical insecticides may actually increase mite populations by killing off natural enemies and promoting mite reproduction.

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# Arugula

## Description

Arugula, *Eruca sativa*, is a leafy annual vegetable in the family Brassicaceae which is grown as a salad green. The arugula plant possesses a rosette of basal leaves which grow low to the ground. The leaves of the plant are deeply lobed and dull green in color. The plant produces clusters of white or light yellow flowers which will develop into a seeded fruit. Arugula will reach maturity after 45–60 days and can reach a height of 20–100 cm (7.9–39.4 in). Arugula may also be referred to as rocket, roquette, rucola, or rugula and originates from the Mediterranean regions of Morocco and Portugal.

*Arugula foliage*

*Arugula seedlings*

*Arugula flowers*

## Uses

Arugula leaves are sharp tasting and can be used in salads or as a seasoning. They can also be cooked prior to consumption.

## Propagation

**Basic requirements** Arugula is best grown in the cooler temperatures of Spring and Fall as summer temperatures trigger flowering and the leaves become excessively bitter. Arugula grows best in full sun in a rich, well-draining soil with a pH between 6.0 and 8.0. The plants can tolerate some light shade, particularly in hotter temperatures. **Planting** Arugula is commonly direct seeded and can be planted 1 to 2 weeks before the last frost date. Seeds can also be started indoors 4-6 weeks prior to the last frost to get a head start on the growing season. Arugula grows best in cool temperatures but can be damaged by frosts so it is best to provide it with cover if a late frost is forecast. Plant seeds by sprinkling on the ground and lightly covering with soil. Keep the soil moist. The seeds should germinate in 3 to 10 days. **Harvesting** Arugula is ready to harvest in about 40 days. Harvest leaves from the outside of the plant by pinching them off with your fingers or snipping them with a pair of scissors. The center of the plant should be left undisturbed to promote new growth.

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## Common Pests and Diseases

### Diseases

#### Category : Bacterial

##### **Bacterial leaf spot (Bacterial blight)** *Pseudomonas syringae*

*Xanthomonas axonopodis*

##### **Symptoms**

Small water soaked or brown spots on leaves; yellowing leaves.

##### **Cause**

Bacteria

##### **Comments**

More common in cold temperatures; spread by seed or water splash.

##### **Management**

Treat seeds with hot water prior to planting; remove infected plants immediately to prevent spread; do not wet foliage when watering; rotate crops regularly.

#### Category : Fungal

##### **Downy mildew** *Peronospora parasitica*

##### **Symptoms**

Irregular brown flecks or spots on tops and bottoms of leaves; downy mold on underside.

##### **Cause**

Fungus

##### **Comments**

Spores can travel long distances by wind; poor air circulation and moisture can encourage fungal growth.

## **Management**

Do not wet foliage, water plants from base; avoid overcrowding plants; remove infected plants and any debris from soil.

## **White rust** *Albugo candida*

*White rust pustules on the leaf underside.*

*White rust pustules on lower leaf surface*

### **Symptoms**

White blisters or pustules on underside of leaf; upper leaf turning yellow; leaves necrotic.

### **Cause**

Fungus

### **Comments**

High moisture and cool temperatures encourage growth and spread of white rust.

### **Management**

Rotate crops with non-cruciferous varieties to prevent disease build up; plough plants into soil; apply fungicide to foliage and soil.

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# Asparagus

## Description

Asparagus, *Asparagus officinalis*, is an herbaceous perennial plant in the family Asparagaceae which is grown for its young shoots, or spears, which are eaten as a vegetable. The asparagus plant is tall with scale like leaves emerging from the underground stem (rhizome) and has stout stems and feathery foliage. The flowers are bell shaped and occur alone or in pairs. They are green-white to yellow in color. After flowering, a round red berry is formed with 1 to 6 black seeds. Asparagus can live for 20 or more years and can attain a height between 100–150 cm (39.4–59.1 in). Asparagus originates from Europe, northern Africa, and western Asia.

*Asparagus harvest*

*Asparagus fruits*

*Emerging asparagus shoots*

*Field grown asparagus*

*Asparagus foliage*

*Asparagus*

## Uses

Asparagus spears can be eaten raw or cooked. They are low in calories and very low in sodium. Asparagus is a particularly good source of vitamin B6, calcium, magnesium, zinc, vitamin A, vitamin C, vitamin E, vitamin K, thiamin, riboflavin, rutin, niacin, folic acid, iron, phosphorus, potassium, copper, manganese, selenium, chromium, dietary fiber,

and protein.

## Propagation

**Basic requirements** Asparagus grows best in regions with hot days and cool nights and requires 90–150 days of cold temperature to break dormancy. It will grow in most soils as long as they are well-draining and will grow optimally at a pH between 6.5 and 7.0. Asparagus should be planted in a sunny location in the home garden and it is best to avoid low lying areas as a late frost will cause damage to newly emerged spears. **Growing from seed** Growing asparagus from seed is more time consuming and labor intensive than growing from divided crowns. If growing from seed, be aware that you will be unable to harvest the spears for longer than if grown from crowns (spears can generally be harvested in the third year after planting). Asparagus seeds should be sown indoors 12 to 14 weeks before planting outside. This should be timed so that the outdoor planting date is after all danger of frost for your area. Seeds should be sown in mix, planting 0.6 cm (0.25 in) deep. The seeds should be kept moist, but not wet and will germinate in approximately 3 weeks. Seedlings should be fully hardened off prior to planting outdoors, using a cold frame where possible. **Transplanting** The asparagus nursery bed should be prepared in advance by digging deeply to break up the soil and incorporating plenty of organic matter such as well-rotted manure and by blending a complete fertilizer into the soil just prior to transplanting. Plant the seedlings 25 to 38 cm (10-25 in) apart in a trench approximately 10 cm (4 in) deep. The trench should be gradually filled in as the seedlings grow. Keep the soil moist by providing about 2.5 cm (1 in) of water weekly. Once the plants are established, irrigation is generally only required in very dry areas due to the deep root system that the plant produces. It is important to control weeds as not only will it prevent any competition with the asparagus plant but it will also ensure that the young spears can be seen and harvested at the correct time. The asparagus plants should be transplanted to their final planting site in the second year following the directions for planting crowns (below). **Planting crowns** When purchasing asparagus crowns, choose disease-free, 1 year old crowns from a reputable grower. All-male hybrids tend to produce more spears than females and are a good choice for growing at home. Crowns should be planted once the soil has warmed to 10°C (50°F). Dig a trench 12 to 15 cm (5-6 in) deep and add super phosphate fertilizer to provide the crowns with nutrients immediately after planting. Position the crowns in the trench 30 to 45 cm (12-17 in) apart. It does not matter how the crown are oriented in the trench as they will grow regardless. Backfill the trench to the original level. If planting more than one row, allow at least 1.5 m (5 ft) between rows. New spears should begin to emerge from the soil within a week of planting. Avoid harvesting the spears until the following year. Allowing the ferns to develop and provide energy for the crown to produce spears the following year. **Harvesting spears** Allow asparagus ferns to remain until the Spring before cutting or mowing them back to the ground to allow new spears to grow. The new spears are ready to harvest when they reach 17 to 22 cm (7-9 in) in length. The spears can simply be snapped by hand close to the ground. The spears can be harvested every 2 to 4 days for a period of 4 to 6 weeks in the second year (third year if grown from seed). Avoid over-harvesting as this will decrease the yield the following year. The harvest can be extended in the third year (fourth for seed grown plants) to 6-8 weeks.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Asparagus rust** *Puccinia asparagi*

Rust (*Puccinia asparagi*) symptoms

#### Symptoms

Orange pustules on spears and ferns; yellowing ferns and dieback.

#### Cause

Fungus

#### Comments

Prevalent in areas of high humidity; refrain from over and under watering.

#### Management

Manage irrigation and ensure plants are not under or over-watered; cut and destroy diseased ferns; dust plants in sulphur.

##### **Cercospora Blight of Asparagus** *Cercospora asparagi*

*Cercospora leaf spot (Cercospora asparagi) symptom*      *Cercospora leaf spot (Cercospora asparagi) symptom*

#### Symptoms

The appearance of small, oval spots with gray or tan color with reddish brown borders on the needles and small branches. The symptom progress from lower part of fern to upper part.

#### Cause

Fungal

#### Comments

The pathogen is favored by high humidity. The spores from the lesions are spread by rain and wind.

#### Management

Remove and burn the infected plant material and crop residue. Avoid over head application of water. If the disease is severe spray suitable fungicide.

##### **Fusarium wilt** *Fusarium oxysporum*

#### Symptoms

Weak, spindly spears; red/brown discoloration

#### Cause

Fungus

#### Comments

Very little can be done to prevent spread once fungus is introduced; plant resistant varieties and use clean seed

## **Management**

Plant only disease free seed; minimize stress to plants by following good fertilization and watering practices; plant tolerant varieties; stop harvest when productivity falls below 70%

## **Category : Oomycete**

### **Phytophthora crown and spear rot *Phytophthora* spp.**

#### **Symptoms**

Soft, watery lesions on stem near soil; brown lesions

#### **Cause**

Oomycete

#### **Comments**

Wet growing season promotes Phytophthora infection; plant in well-draining soil

#### **Management**

Plant disease free transplants in Phytophthora free soil; avoid over-watering plants; may be necessary to treat soil with fungicide

## **Pests**

### **Category : Insects**

#### **Asparagus beetle (spotted asparagus beetle) *Crioceris asparagi***

*Crioceris duodecimpunctata*

Larva(e) asparagus beetle (*Crioceris asparagi*)

Adult spotted asparagus beetle (*Crioceris duodecimpunctata*)

asparagus beetle (*Crioceris asparagi*) larvae

Spotted asparagus beetle (*Crioceris duodecimpunctata*) adult

Adult of asparagus beetle

asparagus beetle (*Crioceris asparagi*) adult

Asparagus beetle on asparagus spear

Asparagus Beetle eggs on asparagus spears

Asparagus beetle

#### **Symptoms**

Chewed spear tips; brown stains; bleached ferns.

#### **Cause**

Insect

#### **Comments**

Adult beetles attack spears in Spring; larvae attack ferns.

#### **Management**

Hand pick beetles from plants; remove and destroy any asparagus berries; apply insecticide if feeding damage is extensive; remove mulch from base of plants in fall to remove overwintering larvae.

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# Avocado

## AVOCADO

The following are the crop details for avocado fruit

Scientific name: *Persea americana*

Local Names: Parachichi (Swahili)

Order: Laurales

Family : Laurel

Genus :Persea

### Description

Avocado, *Persea americana*, is an evergreen tree in the family Lauraceae which grown for its nutritious fruit, the avocado. The avocado tree is large and dome shaped with oval or elliptical leaves arranged in a spiral on the tips of branches. The leaves have a red pigmentation when they first emerge and turn green as they mature. Avocado trees produce clusters of small, green-yellow flowers at the end of twigs and a large, fleshy, pear-shaped fruit with a single large seed. The fruits can be purple to green in color with smooth or warty skin depending on variety. The flesh of the fruit is yellow-green in color and has the consistency of butter. Each fruit contains one large seed. Avocado trees grown from seed can take 4–6 years to produce fruit whereas grafted plants may produce fruit within 1–2 years. The tree can reach a height of 20 m (65.6 ft) and originated in the rainforests of Central America.



## Uses

The avocado is usually consumed fresh as a fruit or as an ingredient in salads or savory dishes. It has a markedly higher fat content than other fruits and is a staple in diets that have limited access to foods with high contents of monounsaturated fats. It is the main ingredient in guacamole, a popular Mexican dip. In Asia, avocados are used in desserts and dessert drinks.

## Avocado nutrition

Avocados have a lot of calories. The recommended serving size is smaller than you'd expect: 1/3 of a medium avocado (50 grams or 1.7 ounces). One ounce has 50 calories.

Avocados are high in fat. But it's monounsaturated fat, which is a "good" fat that helps lower bad cholesterol, as long as you eat them in moderation.

Avocados offer nearly 20 vitamins and minerals. So in a 100-gram serving, you get:

485 milligrams of potassium

81 micrograms of folate

0.257 milligrams of vitamin B6

10 milligrams of vitamin C

2.07 milligrams of vitamin E

## Avocado growing in Kenya

The main varieties of avocado grown in Kenya include; Hass, Fuerte and Puebla avocados. Fuerte is grown largely for local/ domestic consumption while Hass avocado is mainly grown for export and takes about 5 years to bear fruits.

Avocado season in Kenya is between March and September, depending on the varieties grown.

The main areas where avocados are grown in Kenya are the central highlands of Kenya mainly Thika, Muranga, Nyeri, Embu and Meru areas. However, there are other avocado growing zones outside Central Kenya. These include Eldoret, Kisii, Subukia, Nakuru and Naivasha.

## Avocado growing in Tanzania

The popular avocado varieties produced in Tanzania are Hass, Fuerte, Pinkerton, and, to some extent, Puebla.

Tanzania's prominent avocado-producing areas are in the regions of Mbeya, Njombe, Songwe, and Iringa in the southwest, as well as in Kilimanjaro, Arusha, and Tanga in the northeast of the country, where coffee and tea are

traditionally grown.

## Avocado in Uganda

Uganda is a tropical country located in East Africa. They have perfect conditions for avocados and have well-established varieties growing in the country since the 1550s. Uganda has high-quality soil, a warm climate, and ideal rainfall patterns for growing avocados. In fact, Uganda has the most consistent rainfall pattern in the world.Â Hass Avocado are a bit controversial in the Ugandan agricultural sector.

Avocado is mainly grown in the western region of Uganda which is known for its fertile soil and favorable climate, which are ideal for avocado cultivation. The districts of Mbarara, Isingiro, and Bushenyi are among the main avocado-producing areas in the region.

## Avocado variety

The main varieties include:

### Fuerte

The main variety grown in Kenya Hybrid of Guatemalan and Mexican races with thin skinned green-pebbled fruit of very good flavour. This variety has many lines with different shapes; the pear shaped fruit is preferred in the export market. Matures 6-8 months after flowering.

### Haas

Vigorous grower and bears medium-sized, rounded, rough-skinned, black fruits. Propagates well. Matures 8-9 months after flowering.

### Nabal

Bears fruit in alternate years. Its green fruits have a good flavour. Matures 8-9 months after flowering.

### Puebla

Spreading, dark green tree bearing deep purple to maroon round fruit. This variety is normally used as a rootstock. Matures 5-7 months after blossoming.

Others include 'Reed', 'Simmonds', 'Booth 7&8', 'Pinkerton', 'Bacon', 'Lula' and 'Taylor'

## References

[Avocados | Infonet Biovision Home. \(infonet-biovision.org\)](#)

[How to Plant, Grow, and Harvest Avocados - Harvest to Table](#)

[Avocado | Climate needed to grow Avocado tree \(psu.edu\)](#)

[Hog plum | Description & Fruit | Britannica](#)

### Avocado Farming Guide - Cropnutes

<https://pangonionlinemarketing.com/hass-avocado-farming-in-uganda-the-good-bad-and-ugly/#:~:text=Eastern%20region%3A%20The%20eastern%20region%20of%20Uganda%20is,well-draining%20soil%2C%20which%20are%20conducive%20to%20avocado%20production> .

[Tanzania Avocado Production and Exports - TanzanialInvest](#)

# **Propagation**

## **Basic requirements**

Avocados thrive in subtropical or tropical climates but can also be grown successfully in cooler areas of the world. The optimum temperature for growing avocado is between 25 and 33°C (77–91.4°F) with moderate humidity levels. Once established, trees can tolerate temperatures down to around -2°C (28°F) with minimal damage but young trees will not tolerate freezing temperatures. Avocado requires a well draining, aerated soil and they produce a shallow root system which require a warm soil for efficient water and nutrient uptake. Although trees will tolerate low rainfall, irrigation, particularly during flowering and fruit set, will ensure high fruit yields.

## **Propagation**

Avocados are commonly propagated from seeds but the seeds will not breed true to type and this should be taken into consideration before planting. Clonal plants are obtained from budding and grafting from a parent tree to ensure the offspring are of the same high quality of the parent. In plantations, seeds can be sown directly in the soil. 2 to 3 seeds are usually sown and thinned later to leave the strongest seedling for grafting. Seeds may also be sown in containers and grown for 2 to 3 months before planting at the final site.

## **Planting**

Avocado seedling should ideally be planted in the Spring when the soil has warmed through. Choose a location that receives full sun and has protection from the wind. The trees should be planted by digging a hole a little wider than the root ball and gently easing the tree into the hole. Slow release fertilizer can be added to the hole at planting but is not necessary. Care should be taken not to disturb the roots as much as possible and the hole should be carefully backfilled and the soil tamped to prevent dislodging. Trees should be planted 4.5 to 6 m (15–20 ft) apart in rows spaced 6 m (20 ft) apart.

## **General care and maintenance**

Newly planted young trees should be mulched after planting with several inches of straw or woodchips. Young trees will also benefit from staking which will help to prevent wind damage. Wood stakes should be driven into the ground outside the root ball allowing 2 stakes per tree. The tree should then be tied loosely to the stakes to provide support while it establishes. Young trees should be irrigated and the root ball should not be allowed to dry out. Trees should be watered every few days. Water trees at and around the base to ensure the root ball is wetted. Trees are usually fertilized at around 4 weeks after planting. Add half a cup of urea every 4 to 6 weeks during the growing season.

## **Manuring**

One avocado tree can yield 250-300 kg of fruit per harvest season. This causes a high demand on soil nutrients. To determine the right amount of manure to apply the soil should be tested annually.

## **Pruning**

Initial pruning may be done to give the tree a good shape. Otherwise pruning is limited to the removal of dead wood and parasitic plants.

Remove all sucker and dead branches from main trunk branches.

Prune canopy to keep the tree to a height of 5-8 m and for ease of picking. The tree is very susceptible to sunburn, therefore pruning should be minimised.

Prune the larger tree roots by cultivating to a depth of 50 cm around the edge of the tree canopy. The area around the tree should be kept clean by weeding and removal of all fallen fruits.

## **Harvesting**

Harvesting starts at 3-4 years from planting but a good yield is obtained from the 6th year onwards. It is not easy to tell when the fruits are ready for harvesting unless they are of the varieties that change colour at maturity. Harvest a sample and keep at room temperature. If they soften within 7-10 days without shrivelling then the fruit of that age are ready for harvesting.

## Common Pests and Diseases

### Diseases

#### Category : Viral

##### **Algal leaf spot** *Cephaleuros virescens*

*Algal leaf spot symptoms*

*Algal leaf spot symptoms*

*Close up of algal leaf spot lesion*

*Algal leaf spot symptoms*

*Algal leaf spot symptoms*

*Algal leaf spot symptoms*

#### Symptoms

Raised, orange-red spots on both upper and lower surfaces of leaves; spots may coalesce to form irregularly shaped patches; spots may also be present on twigs and branches; when the surface of the spot is scraped away, a gray to dark necrotic crust is visible

#### Cause

Alga

#### Comments

Disease affects many fruit trees in the tropics; infection is unsightly but often harmless

#### Management

Ensure that trees are properly pruned and fertilized to promote vigor; remove all weeds from around tree bases; employ a wider tree spacing to increase air circulation around the trees; badly infested trees can be treated with copper containing fungicides

##### **Sunblotch** Avocado sunblotch viroid (ASBVd)

#### Symptoms

Red, yellow, pink or white streaks running the length of young stems; white, yellow or red blotches on fruit

#### Cause

Viroid

#### Comments

Can be transmitted by grafting

#### Management

Frequently sanitize all pruning equipment with disinfectant; plant only certified nursery stock

#### Category : Fungal

##### **Anthracnose** *Glomerella cingulata*

*Anthracnose symptoms*

### **Symptoms**

Chlorotic and necrotic spots; dead leaf tip; defoliation; brown or purple lesions on new shoots

### **Cause**

Fungus

### **Comments**

Spores spread by rain splash; high moisture and warm temperatures encourage spread

### **Management**

Prune dead twigs and branches from tree before fungi produce spores; knock dead leaves out of canopy; keep harvested fruit dry and cool

## **Black streak** Avocado black streak

### **Symptoms**

Elongated black streaks on bark; cankers parallel to growth of limbs; black blotches with distinct margins on green wood; cankers on bark cause cracks which ooze sap; removal of bark over cankers reveals dark discoloration underneath

### **Cause**

Unknown

### **Comments**

Disease emergence favors adverse growing conditions for avocado; more common in Guatemalan cultivars

### **Management**

Avoid stressing trees by following good fertilization and irrigation practices

## **Scab** *Sphaceloma perseae*

*Avocado scab symptoms*

*Scab symptoms*

*Avocado scab*

### **Symptoms**

Oval or irregular brown or purple spots on fruit with rough texture.

### **Cause**

Fungus

### **Comments**

High humidity encourages scab growth and spread.

### **Management**

Plant tolerant varieties; spray with copper containing fungicides.

## **Stem-end rot** Many different fungal species. Depends on growing region. Mainly *Botryosphaeria dothidea* in the US.

### **Symptoms**

Shrivelled tissue at stem end; dark brown or black lesions at stem end and eventually over entire fruit; fruit covered in

mycelium

#### Cause

Fungi

#### Comments

Environmental conditions may determine which fungal species is most common; spores can spread by wind or rain.

#### Management

Prune dead limbs and twigs; prune and harvest in dry conditions; provide trees with sufficient irrigation; apply a thick layer of mulch

### Category : Bacterial

#### Bacterial soft rot *Erwinia herbicola*

*Erwinia carotovora*

#### Symptoms

Gray to black, mushy, foul smelling rot on fruit; fruit has darkened metallic sheen

#### Cause

Bacteria

#### Comments

Bacteria may be present on leaves but do not cause damage unless plant is stressed or bacteria enter the plant through a wound

#### Management

No treatment for disease; use certified seed; disinfected tools and cuttings; employ crop rotation; remove plant debris from soil

### Category : Oomycete

#### Phytophthora root rot *Phytophthora cinnamomi*

#### Symptoms

Black lesions on roots; black, brittle roots; small, yellow leaves; premature leaf drop; decline in fruit yield

#### Cause

Oomycete

#### Comments

Wet soils encourage Phytophthora infection; plant in a well draining soil.

#### Management

Minimize water splash between trees by not working in a wet orchard; prune out dead limbs and twigs; remove fruit from the ground; dispose of dead wood and fruit away from trees

## Pests

### Category : Insects

#### Avocado thrips *Scirtothrips perseae*

Avocado thrips

Scarred avocado fruits

#### Symptoms

Obvious feeding scars on fruit; scars begin as scabs or leathery patches and spread across fruit; adult insect is orange-yellow in color with distinct brown bands and reaches 0.7 mm (0.03 in) in length

#### Cause

Insect

#### Comments

Insect thrives in cooler temperatures; insect may undergo 6 or more generations per year

#### Management

Addition of coarse organic mulch about 6 inches thick below trees may help to reduce survival of thrips pupating in soil; if insecticides are to be applied, a selective insecticide should be selected to reduce damage to populations of natural enemies; Sprays of Entrust are organically acceptable

### Western avocado leafroller (*Amorbia*) *Amorbia cuneana*

*western avocado leafroller (*Amorbia cuneana*) larvae*      *Adult western avocado leafroller (*Amorbia cuneana*)*

#### Symptoms

Upper surface of leaves consumed, leaving thin brown membrane or leaves skeletonized; defoliation of tree; terminal leaves joined together by silk webbing; scarred fruit; young larvae are yellow-green and mature to dark green and a short, dark horizontal line on the side of their thorax; adult is a orange or tan moth with dark markings and bell-shaped wings.

#### Cause

Insect

#### Comments

Females can lay 150-200 eggs during her lifetime; insect generally undergoes 3 generations per year.

#### Management

Healthy avocado trees can tolerate feeding damage well but insect may become problematic if defoliation causes sunburn on fruit; applications of selective insecticides such as *Bacillus thurengiensis* help to conserve populations of natural enemies; pruning trees so that terminal foliage does not touch helps to prevent leafroller movement between trees.

### Category : Mites

### Persea mites *Oligonychus perseae*

*Persea mites (*Oligonychus perseae*) damage to avocado leaf*      *Mite damage*      *Persea mite damage*

*Damage to avocado leaf due to mite*      *Persea mite (*Oligonychus perseae*) injury*      *Persea mites (*Oligonychus perseae*) damage to avocado (*Persea americana*) leaves*

*Mite damage on leaf underside*      *Mite damage on avocado fruit*      *Symptoms of mite feeding on avocado leaf*

#### Symptoms

Tree dropping leaves and becoming defoliated causing sunburn damage to exposed bark and fruit; mites cause the development of circular chlorotic to brown spots on the undersides of the leaves and fruit surface; dense colonies of

mites produce silk webbing which may appear as a silvery spot; large mite populations can cause the entire tree canopy to appear lighter in color.

### **Cause**

Arachnid

### **Comments**

Persea mites are most damaging on Hass and Gwen varieties.

### **Management**

Ensure the tree is adequately fertilized, pruned properly and irrigated to avoid unnecessary stress to the tree which can make them more susceptible to mite attack; persistent infestations may require treatment with an appropriate chemical; organic controls include several types of horticultural oil.

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# Azolla

## Description

The following are the crop details for Azolla

Scientific name: *Azolla pinnata*

Family: *Salviniaceae*

Clade: *Tracheophytes*

Division: *Polypodiophyta*

Kingdom: *Plantae*

Order: *Salviniales*

Scientific Name *Azolla pinnata* R. Br.

Common Name mosquito fern

*Azolla pinnata*

*Feathered mosquito-fern (Azolla pinnata)*

*Azolla filiculoides*

*Azolla (macro)*

*Azolla fronds*

*Azolla*

## Description

*Azolla* is a genus of seven species of aquatic ferns in the family Salviniaceae.

They resemble duckweed or other mosses more than other conventional ferns because of how reduced and specialized they are. Only two fern species have published reference genomes, and *Azolla filiculoides* is one of them.

*Azolla pinnata*, an aquatic fern from the Azollaceae plant family, is largely used as cattle fodder. With a main stem and pinnate side branches, azolla is a tiny branching plant.

The side branches are longer at the base of the stem than at the top giving the fronds a roughly triangular shape. Each frond is composed of many overlapping rounded leaves which are covered in tiny hairs on their upper surface.

Fronds are bright green in color, but they can take on a reddish tint when they are exposed to direct sunshine. On the water's surface, floated fronds resemble red velvet. Individual fronds can grow to a length of 1.5 to 2.5 cm (0.6-1.0 in).

*Azolla* is a plant whose native habitat stretches from Africa through India, Southeast Asia, and Australia. Other names for azolla include red azolla, feathery mosquito fern, water velvet, and African azolla.

## Uses

The *Azolla* plant is commonly grown as a fodder plant for animals and as a companion plant for rice since it fixes nitrogen and suppresses weeds.

## Propagation

Basic prerequisites *Azolla* must be grown in freshwater or moist mud in order to flourish since if allowed to dry out, the plants will die within a few hours.

*Azolla* plants spread quickly and can be grown in ponds or specially constructed pits. Strong water currents could damage the plant's fronds if it is cultivated in water, hence there should be little to no current.

The ideal conditions for azolla growth are in standing water that is 4 to 7 pH and between 5 and 12 cm (2.0â€“4.7 in) depth. The soil at the bottom of the pond or pool shouldn't be accessible to the plant's roots because this can result in nutrient deficits.

Plants will grow optimally at temperatures between 20 and 28°C (68-82.4°F) in partial shade or full sunlight. Heavily shaded areas should be avoided.

Propagation Azolla is first cultivated by seeding a prepared pit or pond. The azolla will rapidly colonize the water and start reproducing on its own. To enable the plant to recolonize, some of the harvest ought to be set aside.

To keep the pond from being too congested, plant materials should be collected on a daily basis.

*Growing azolla*

## Habitat

*A. pinnata* is a floating aquatic fern that can be found at low to moderate altitudes on the surface of tiny, quiet ponds or backwaters without waves.

It can entirely cover the water surface in ponds in cattle paddocks and other bodies of water with high nutrient levels, where it becomes exceptionally profuse. It can survive on damp soil near rivers, ditches, and ponds, which can help the plant withstand dry conditions and low water levels.

Lowland populations in New Guinea are found between 3 and 60 meters above sea level and highland inhabitants are found between 1000 and 3000 meters above sea level.

Plants from the highlands and those from the lowlands, however, are not readily distinguishable from one another.

## Biology and Ecology

The genetically known number of chromosomes in the genus *Azolla* is n=22, with various variants. This most likely means that the original count, which came from n=11, was a tetraploid n=22. There have been reports of n=22 in tropical Africa, n=33 in Asia, and n=44 in Australia for *A. pinnata*.

Tropical and subtropical regions experience year-round physiology and phenology growth.

Although there isn't a clear connection between sporulation and color change, crowding frequently causes spore reproduction as well as a change to red hue. Fronds can double in size every three days when they divide vegetatively, which causes them to expand incredibly quickly and colonize new lakes and ponds.

phosphorous shortage aids in the development of *A. pinnata*'s red coloring. The upper leaf surfaces are completely water-repellent, and if the plant is completely buried, it swiftly floats back up on its right side. Deoxyanthocyanins are found in *A. pinnata* and prevent molluscs from eating on it. Biology of Reproduction by fragmenting the fronds, vegetative reproduction is accomplished.

Spores are produced during sexual reproduction and dispersed into the water. The heterosporous nature of azolla is an obvious adaption to an aquatic environment. Typically paired micro- and megasporocarps are borne in the axils of submerged lobes, basally on the branches, and are completely surrounded by a thin indusium. Sporangia are produced in sporocarps. A few of to many globose microsporangia, each bearing 32–64 microspores, are present in the big, globose microsporocarp.

A single megasporangium with a single megaspore is present in the smaller megasporocarp. Spores might be smooth, trilobate, globose, pitted, or sculptured. In the microsporangium, microspores are embedded in the outer border of a number of mucilaginous masses (massulae), each of which has several to numerous hooked (glochidiate) or unhooked, septate or non-

septate processes on some or all of its sides.

Megasporangia apical massulae, on occasion known as "floats," can be three or nine. Criteria for the environment Although Azolla grows more quickly under eutrophic environments, nitrogen levels are not particularly significant for their development. It is particularly prevalent in (wet) rice fields in the nations of Southeast Asia.

Utilizing the symbiotic blue-green algae's capacity for nitrogen fixation, it serves as a natural fertilizer. The cyanobacterium *Anabaena azollae* has a symbiotic relationship with other members of the genus. Algae inhabits the intercellular spaces of Azolla's basal leaves as an endophyte.

Heterocysts in the algal cell fix atmospheric nitrogen, which is then transported as ammonia to Azolla.

## Control and Prevention

The national list of registered pesticides or the appropriate authority should be consulted to ascertain whether products are legally permissible for use in your country when contemplating chemical control due to the varying laws surrounding (de)registration of pesticides. Use of pesticides must always be legal and in accordance with the directions on the label.

### Chemical Control

Applications of terbutryn, glyphosate, and diquat can kill *A. pinnata*. Kerosene and a wetting agent mixed together can be used for controlling *A. pinnata*.

Thick mats on reservoirs and slow-moving waterbodies have an adverse economic impact on water users. Agriculture, recreation, and municipal usage of water are some of those that are most severely impacted.

## Impact to the Environment.

*A. filiculoides* grows rapidly in eutrophic water systems, easily outcompeting native plants. An anaerobic environment is produced below an *A. filiculoides* mat by decaying root and leaf debris and the absence of light.

In addition to very little have the ability to survive in such conditions, poor odors, color, and turbidity lower the quality of drinking water. Cases of livestock and game producers losing animals as a consequence of them refusing to drink from contaminated waterbodies or drowning as a result of mistaking the mat for solid ground have been reported.

According to reports, the weed also encourages the growth of diseases that are waterborne, water-based, and water-related, as well as increases water loss through evapotranspiration.

## Impact on Biodiversity

Waterbodies up to 10 hectares in size may develop dense mats (5–20 cm thick) due to *A. filiculoides* infestations. It has been established that these infestations have a profound negative influence on the biodiversity of aquatic ecosystems and have significant ramifications for all facets of water use.

The eastern Cape rocky in South Africa, one of the last surviving habitats for the threatened fish species, had become so overrun

with the weed that *S. bainsii* faced extinction if the biological control program had not been so successful.

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## Pests

### Category : Insects

#### Azolla weevil (Water Fern Weevil) *Stenopelmus rufinasus*

*Stenopelmus rufinasus* adult insect

*Azolla* weevil

Adult weevil

##### Symptoms

Weevil feeds on Azolla and result in complete eradication of fern. So generally it is used as biocontrol agents to control Azolla in ponds and lakes.

##### Cause

Insect

##### Comments

The insect is very small measure 2.1 mm (1.8-2.3 mm) which originated in North America.

##### Management

No known control measures available.

#### Golden apple snail *Pomacea canaliculata*

Eggs of apple snails (*Pomacea* sp.)

apple snail (*Pomacea canaliculata*) shell

apple snails (*Pomacea* sp.) eggs

*Island applesnail* (*Pomacea maculata*) adults

apple snails (*Pomacea* sp.) shell

Adult *Island applesnail* (*Pomacea maculata*)

##### Symptoms

The snails feed during the night and at dawn on young succulent plants such as newly transplanted rice crops, weeds

and Azolla.

#### **Cause**

Mollusc

#### **Comments**

The golden apple snails are fast growing and females can lay egg masses of up to 500 eggs per week.

#### **Management**

Deep ploughing and harrowing during off-season kills all the snails in the soil. One must make sure that Azolla is free from apple snails and their egg when transferring from one location to another. Cayuga black ducks can use as a biocontrol agent to control snails.

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# Banana

## Description

### Crop details

Scientific name: *Musa paradisiaca*

Order: Zingiberales

Family: Musaceae

Genus: Musa

Local names: Ndizi (Swahili), Matoke (Luganda)

Other names:

English: Banana

Spanish: Banana

German: Banane

French: Banane

Italian: Banana

Russian: Банан

Chinese: 香蕉 (xiāngjīāo)

Japanese: バナナ (banana)

Arabic: الموز (mawz)

Hindi: केला (kelā)

Korean: ᄊ”Ѐ, ~Ѐ, ~ (banana)

Swedish: Banan

Dutch: Banaan

Portuguese: Banana

## General Information

Bananas are a type of fruit that grows on a large herbaceous plant that is native to Southeast Asia. They are one of the world's most popular and widely grown fruits, with many varieties being cultivated for both commercial and home use. Bananas are long, curved fruits with smooth, yellow, and sometimes slightly green skin. The average length of a banana is about 7 to 9 inches, and it is about 2 to 3 inches in diameter. The skin of the banana is usually yellow when it is ripe, but it can also be green, red, or purple depending on the variety.

The inside of a banana is composed of several fleshy, cream-colored segments, which are surrounded by thin, white membranes. The segments are held together by a central core, and they contain small, black seeds that are not usually eaten. The flesh of the banana is soft, slightly sweet, and has a slightly sticky texture.

Bananas are typically planted in the rainy or monsoon season when the soil is moist and can provide enough water to the young plants. In tropical and subtropical climates, where bananas are widely grown, the planting season typically occurs between April and June. In regions with a dry season, the planting may occur in September or October, after the rainy season. It is important to note that the specific planting time may vary depending on the local climate and growing conditions. Additionally, some commercial banana farms may plant bananas year-round in controlled greenhouse or field environments.

The crop is propagated through vegetative reproduction, meaning new plants are produced from existing plant material rather than from seeds. The most common method of propagation is through the use of "suckers" or "pups," which are shoots that grow from the base of the mother plant. The suckers are carefully removed from the mother plant and planted in a new location, where they will develop into a separate plant. In commercial banana farming, the suckers are often treated with rooting hormones to encourage faster and more vigorous growth.

Another method of propagation is through the use of "rhizome" or "corm" cuttings, which are pieces of the underground stem of the banana plant that can be used to start a new plant. This method is less common but may be used in some cases, particularly for rare or specialty varieties of bananas.

Bananas are one of the most popular and widely grown fruits in the world, with their largest production occurring in countries near the equator. They thrive in tropical and subtropical climates and are commonly grown in India, China, the Philippines, Ecuador, Brazil, Uganda, Colombia, Indonesia, Cameroon, and Honduras. However, this is not an exhaustive list, as bananas are also grown in other tropical and subtropical regions, including parts of Africa, South America, and Southeast Asia. The specific areas where bananas are grown can vary based on local growing conditions, including temperature, rainfall, soil type, and market demand.

Banana plantation, Hawaii

Developing bunch of bananas

Banana plants

Close-up of banana bunch

Banana flower

Ripe harvested bananas

Bunch of bananas growing on tree

Close-up of banana leaf

Banana plants

## Banana Varieties

There are many different varieties of bananas, ranging in size, color, flavor, and texture. Some of the most common and widely grown varieties include:

**Cavendish** : This is the most common variety of banana found in grocery stores and is known for its sweet flavor and yellow skin.

**Plantain** : Plantains are a type of banana that is larger and less sweet than Cavendish bananas. They are typically used for cooking and are a staple food in many countries in Africa, South America, and Southeast Asia.

**Red Banana** : This variety of banana is smaller and sweeter than the Cavendish and has a red or pink skin when ripe.

**Lady Finger Banana** : This variety of banana is smaller and sweeter than the Cavendish and is a popular snack in many countries.

**Blue Java Banana** : This variety of banana is also known as the "Ice Cream Banana" due to its creamy texture and sweet flavor. It has a blue-green skin when ripe.

**Musa Basjoo** : This is a hardy banana variety that is native to Southeast Asia and can grow in cold climates. It has a green skin and a sweet, slightly tart flavor.

Uganda is one of the largest producers of bananas in the world and grows a variety of different types. Some of the most common banana varieties grown in Uganda include:

**East African Highland Banana (EABH)** : This is the most widely grown cooking variety in Uganda and is a staple food in many households. It has a dense and starchy flesh. Examples include "NAROBAN5", "Kyibuzi" and "Mbwazilume".

**Ngeyi** : This variety of banana is smaller and sweeter than the East African Highland Banana and is commonly eaten when ripe. Examples include "Sukali Ndizi" and "Bogoya".

**Cavendish** : This variety of banana is similar to the one found in grocery stores and is also grown in Uganda. It is best eaten when roasted on fire. An example is "Gonja".

**Plantain** : Plantains are a type of banana that are larger and less sweet than the Cavendish and are used for cooking. It is a brewery variety that is mainly planted to extract juice and fermented to make beer. It grows under vast environmental conditions. Examples include "Kayinja", "Kisubi", "Mbiide" and "Musa".

**Brewery variety** : This is mainly planted to extract juice, which is then fermented to make beer. They grow under vast environmental conditions. Examples include "Kayinja", "Kisubi", "Mbiide" and "Musa."

**Other local varieties** : In addition to these more widely grown varieties, there are many other local varieties of bananas grown in Uganda, each with its own unique flavor and texture.

## Uses

Bananas are a good source of vitamins and minerals, including vitamin C, vitamin B6, and potassium, and are often used as a healthy snack or ingredient in smoothies and other foods. The fruit is the most widely used part of the plant and can be eaten fresh or cooked or processed into starch, chips, puree, beer, vinegar or dehydrated to produce dried fruit. The fruit may also be processed into flour which is used in baking, soups or beverages. The flowers of the plant may be used as a vegetable. Fresh leaves have a high protein content and can be fed to cattle. Other uses for leaves include polishing floors, lining pots or wrapping food.

## Climatic conditions, soils and water

Bananas are a tropical crop that grows best in warm, humid conditions with high rainfall. Here are the key climatic conditions, soils, and water management considerations for growing the crop.

### Climatic conditions

Bananas are a tropical crop that grow best in warm, humid conditions with abundant rainfall. The ideal temperature range for growing bananas is between 20°C and 30°C, with a preferred temperature range of 25°C to 28°C. High humidity levels are also important for supporting healthy growth and fruit production. Bananas require a minimum of 1000mm of rainfall or irrigation per year to support growth and fruit production. However, it is important to note that the specific climatic requirements may vary depending on the variety of banana being grown and local growing conditions. It is essential to work with local agriculture experts to ensure that the right climatic conditions are in place for successful banana cultivation.

### Soils

Bananas grow best in well-drained, fertile soils with a high organic matter content. They require good aeration and a pH of 5.5 to 7.0. They are also sensitive to soil-borne diseases and to combat this problem, old suckers can also be replaced by young ones.

### Water

Bananas require regular watering, especially during the dry season, to support growth and fruit production. Over-watering or waterlogging can lead to root rot, so it is important to ensure good drainage and to avoid standing water around the plants. Drip irrigation systems are commonly used for banana cultivation to conserve water and reduce the risk of disease.

*Pruning a banana plant*

*Pruning a banana plant*

## Planting Procedure

Planting bananas may vary depending on the variety being grown and local growing conditions. It is important to work with local agriculture experts or PlantVillage Dream Team officers to ensure the best planting and growing practices for your specific situation. Here is the common procedure:

**Preparation:** Start by selecting a suitable site for growing bananas, taking into consideration factors such as soil type, drainage, and climatic conditions. Test the soil pH and fertility and amend as necessary.

**Propagation:** Bananas are usually propagated by planting shoots or suckers that have sprouted from the parent plant. Cut a sucker from the parent plant and remove all but the top 2-3 leaves.

**Planting:** Dig a hole in the soil 45x45x45 cm in size and 3m x 3m apart [promise O2] that is large enough to accommodate the roots of the sucker. When digging, place the top black soil on the upper side of the hole and brown or subsoil on the lower side. Place the sucker in the hole, making sure the top of the roots is level with the soil surface, leaving a dome-shaped valley on the surface. [promise O3] Backfill the soil around the roots and water thoroughly.

**Mulching:** Apply a layer of organic mulch around the plant to conserve moisture and suppress weeds.

**Irrigation:** Bananas require regular watering, especially during dry periods. Make sure the soil is consistently moist, but not waterlogged.

**Fertilization:** Bananas need regular fertilization to support healthy growth and fruit production. Apply a balanced fertilizer, such as 10-10-10, at the recommended rate, according to soil test results.

**Pruning:** Prune off the older, lower leaves of the plant as they yellow to keep the plant healthy and improve air circulation.

## **Harvesting**

Banana harvesting is the process of collecting ripe or near-ripe bananas from the plant. The timing of the harvest is crucial, as it will determine the quality of the fruit and its intended use. To harvest bananas, one must first identify when the fruit is mature, which can be determined by observing signs such as yellowing of the fruit and leaves. Once the bananas are ready to be harvested, a sharp, clean knife should be used to cut the stem of the banana bunch from the plant. It's important to handle the bananas carefully to avoid bruising, and to gently place them in a container or on a flat surface for transport. If the bananas are harvested when they are still green, they will need to be ripened before eating by placing them in a warm, well-ventilated area until they are yellow and soft to the touch. Ripe bananas can be stored at room temperature for a few days or in the refrigerator to slow down the ripening process. The exact procedures for harvesting bananas may vary depending on the variety of banana being grown and local growing conditions. It's recommended to work with local agriculture experts, such as those from the PlantVillage Dream Team, to ensure the best harvesting and handling practices for your specific situation.

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## **Common Pests and Diseases**

### **Diseases**

#### **Category : Fungal**

##### **Anthracnose *Colletotrichum musae***

*Colletotrichum* symptom and sporulation

*Anthracnose of banana*

*Anthracnose symptom*

*Anthracnose symptoms*

*Anthracnose on banana*

*Anthracnose on banana fruits*

## Symptoms

Brown spots on fruit peel; large brown to black areas; black lesions on green fruit.

## Cause

Fungus

## Comments

Wet conditions promote growth and spread of disease; spread by rainfall through plant or banana bunch.

## Management

Commercially produced fruit should be washed and dipped in fungicide prior to shipping; protect fruit from injury; remove flower parts which can harbour fungus.

## **Banana speckle** *Mycosphaerella musae*

### Symptoms

#### Cause

#### Comments

## **Black sigatoka (Black leaf streak)** *Mycosphaerella fijiensis*

*Black sigatoka infected plant*

*Black sigatoka symptoms*

*Infected leaf*

severe leaf damage due to black sigatoka disease

*Symptoms*

*Lesions caused by black Sigatoka disease.*

*Symptoms of black sigatoka on banana foliage*

## Symptoms

Red/brown flecks or spots on underside or topside of leaves; spots with dark or yellow border and grey centre; death of leaf surface; bunch not developing

## Cause

Fungus

## Comments

Currently the most important disease of banana; promoted by high moisture and spores spread by wind

## Management

Export plantations may require regular fungicide applications; increase plant spacing to improve air circulation and reduce humidity; remove leaves with mature spots

## **Cigar end rot** *Verticillium fructigena*

## ***Trachysphaera theobromae***

*Banana infected with cigar end rot*

*Cigar end rot initial symptoms*

*Cigar end rot symptoms (initial infection)*

*Banana fingers infected with cigar end rot disease*

*Cigar end rot*

*Finger with symptoms of cigar end rot*

### **Symptoms**

Tips of fingers initially begin to darken and wrinkle; tips of fingers develop a dark rot; if *Verticillium* fungi are present then the rot is typically dry and the tips become mummified, if *Trachysphaera* is present, the rotted are become covered with white spores which gives the fingers the ashen appearance characteristic of cigar end rot.

### **Cause**

Fungus

### **Comments**

Disease is of economic importance in Central and West Africa; it also occurs in India, Iran, South Africa, South America, the Canaries and the West Indies.

### **Management**

Infected flowers should be removed from the plant; bunches should be bagged using perforated polyethylene; chemical control may be necessary in the case of severe infestations.

## ***Cordana leaf spot* *Cordana musae***

*Infected leaf*

*Symptoms due to cordana leaf spot*

*Cordana leaf spot on banana leaf*

*Symptoms of cordana leaf spot*

*Cordana leaf spot*

*Cordana leaf spot of banana,  
caused by Cordana musae.*

*Cordana leaf spot damage*

*Cordana leaf spot symptoms*

### **Symptoms**

Initially the lower leaves shows oval shaped yellow or pale brown spots near the leaf margins. As the disease progress, the central dead brown area of spots is covered by concentric zonation which is surrounded by a yellow halo. The individual spots may join together to form large necrotic area.

### **Cause**

Fungus

### **Comments**

The disease is favored by hot and humid condition. The pathogen mainly spreads by water splash and wind.

### **Management**

Remove all the infected leaves and burn them. If the disease is severe spray copper based fungicides.

## ***Panama disease (Fusarium wilt)* *Fusarium oxysporum f. sp. cubense***

<i>Chlorosis of leaves from Fusarium wilt</i>	<i>Splitting of rhizome due to Fusarium wilt</i>	<i>Internal necrosis within the pseudostem</i>
<i>Fusarium wilt discoloured banana vascular bundle</i>	<i>Splitting of pseudostem due to fusarium infection</i>	<i>Yellowing of leaves due to fusarium</i>
<i>Symptoms of Panama disease on banana</i>	<i>Wilting caused by Panama disease</i>	<i>Symptoms of Panama disease on banana</i>

### **Symptoms**

The fungus infect roots and grow inside xylem vessels which in turn blocks flow of nutrients and water to plant. We can see reddish brown discoloration of vascular tissue by cut opening rhizomes and pseudostem. The above ground symptoms are yellowing of older leaves; splitting of leaf sheaths; leaves wilting and buckling; death of entire canopy.

### **Cause**

Fungus

### **Comments**

It is very lethal disease which mainly spreads through soil, running water and infected rhizome. It is one of the first disease of bananas to have spread globally.

### **Management**

Use disease free planting materials; currently no effective treatment once plants are infected.

### **Rhizome rot *Erwinia carotovora***

*Erwinia chrysanthemi*

*Symptoms of rhizome rot in banana      Symptoms of rhizome rot in banana      Symptoms of rhizome rot in banana*

*Symptoms of rhizome rot in banana*

### **Symptoms**

Pseudostem breaks from rhizome; rhizome will not germinate; internal tissue yellow/brown and watery

### **Cause**

Bacteria

### **Comments**

Bacteria live in soil and enter plant through wounds; disease encouraged by wet, humid conditions

### **Management**

Select only high quality, disease-free rhizomes fro propagation; disinfect all tools used for propagation regularly; allow seed pieces to dry before planting

### **Yellow sigatoka *Mycosphaerella musae***

### **Symptoms**

Pale green flecks on leaves which enlarge to chlorotic streaks; streaks enlarge and turn brown with chlorotic halo; mature lesions are gray with a dark brown border; lesions coalesce and kill large areas of leaves

### **Cause**

Fungus

### **Comments**

Spores spread by wind, rain and irrigation water;

### **Management**

Export plantations may require regular fungicide applications; increase plant spacing to improve air circulation and reduce humidity; remove leaves with mature spots

### **Category : Bacterial**

#### **Banana bacterial wilt (BBW) / Banana xanthomonas wilt (BXW)** *Xanthomonas campestris* pv. *musacearum* (*Xcm*)

*Bacteria infected fruits*

*Xanthomonas infected plant*

*Banana infected with Banana Xanthomonas Wilt (BXW)*

*Banana Xanthomonas Wilt- infected banana plants*

*Banana suckers infected with Xanthomonas*

*Banana fruits infected with Banana Xanthomonas*

### **Symptoms**

The infected plant shows yellow leaves which later turn brown and die. If infection occurs at later stage of crop, male buds exhibit dry rot and blackening . Premature uneven ripening of fruits in the bunch. The infected fruit show rusty brown discolouration in pulp. Infected parts ooze yellow bacteria after cut.

### **Cause**

Bacteria

### **Comments**

In Uganda locally it is called as 'kiwotoka'. The disease is mainly transmitted by insects, farm equipments, animals and infected rhizomes. BBW was first recorded in Ethiopia (1968) mainly on banana and enset. Later the disease spread to Uganda (2001) and eventually to other eastern African countries.

### **Management**

Use disease free planting material. Roughing of infected plant and destroy them. Removing of excess male buds prevent disease spread. Disinfect the farm equipments.

### **Moko disease** *Ralstonia solanacearum*

#### **Symptoms**

Older leaves chlorotic, wilted and collapsing; spreads to entire canopy; collapse of pseudostem

### **Cause**

Bacterium

### **Comments**

Can be spread root to root or by insects or human activities such as machete pruning.

### **Management**

Banana plantations should be regularly monitored for presence of disease; if Moko is present, male buds should be removed and all tools thoroughly disinfected; infected plants may need to be destroyed along with any neighbouring plants

### **Category :**

#### **Banana BBTV Leaf**

#### **Symptoms**

#### **Cause**

Comments

## **banana\_blackSigatoka\_leaf**

Symptoms

Cause

Comments

## **Banana Black Sigatoka Leaf**

Symptoms

Cause

Comments

## **banana\_BXW\_bunch**

Symptoms

Cause

Comments

## **Banana BXW Fruit Cut**

Symptoms

Cause

Comments

## **banana\_BXW\_fruitCutCrosswise**

Symptoms

Cause

Comments

## **banana\_BXW\_fruitUncut**

Symptoms

Cause

Comments

## **Banana BXW Leaf**

Symptoms

Cause

Comments

## **banana\_BXW\_stemCutCrosswise**

Symptoms

Cause

Comments

## **Banana Fruit Cut BXW**

Symptoms

Cause

Comments

## **Banana Leaf Black Sigatoka**

Symptoms

Cause

Comments

## **Banana Leaf BXW**

**Symptoms**

**Cause**

**Comments**

## **banana\_yellowSigatoka\_leaf**

**Symptoms**

**Cause**

**Comments**

## **Banana Yellow Sigatoka Leaf**

**Symptoms**

**Cause**

**Comments**

## **Category : Viral**

### **Banana mosaic** Cucumber mosaic virus (CMV)

*Banana mosaic symptoms*

*Banana mosaic symptoms on  
banana foliage*

*Banana mosaic symptoms on  
banana foliage*

*Banana mosaic symptoms on  
banana foliage*

### **Symptoms**

Chlorotic mottling or stripes on foliage; distorted fruit which may have chlorotic streaks or mottling; distorted leaves; leaf necrosis

### **Cause**

Virus

### **Comments**

Transmitted by aphids; may be transmitted through infected seed

### **Management**

Remove susceptible host plants from around plantation; plant virus-free material

## **Bunchy top** Banana bunchy top virus (BBTV)

<i>BBTV symptoms on banana leaf</i>	<i>BBTV symptoms on banana leaf sheath</i>	<i>BBTV symptoms on banana leaf sheath</i>
<i>BBTV symptoms on banana petiole</i>	<i>BBTV symptoms on banana flower</i>	<i>Banana bunch top symptoms</i>
<i>Banana bunch top symptoms</i>	<i>Banana bunch top symptoms</i>	<i>Banana bunch top symptoms</i>
<i>Banana bunch top symptoms</i>	<i>Banana plants showing typical bunchy top symptoms</i>	<i>Banana bunch top symptoms</i>
<i>Banana bunch top symptoms</i>	<i>Banana bunch top symptoms</i>	<i>Symptoms of Bunchy top of Cavendish banana</i>
<i>Banana bunch top symptoms</i>		<i>Banana bunch top symptoms</i>

### **Symptoms**

Dark green streaks in leaves; chlorotic and upturned leaf margins; leaves brittle and erect; plant has a ~bunchy top; no bunches produced

### **Cause**

Virus

### **Comments**

Aphid transmitted; when infected symptoms appear after two more leaves are produced

### **Management**

Plant less susceptible varieties; destroy infected plants to prevent spread of disease

## **Pests**

### **Category : Insects**

#### **Banana aphid *Pentalonia nigronervosa***

<i>Banana aphids on pseudostem</i>	<i>Colony of banana aphids (<i>Pentalonia nigronervosa</i>)</i>	<i>Banana aphids (<i>Pentalonia nigronervosa</i>) Vector of Banana bunchy top virus (BBTV)</i>
<i>Banana aphids in the whorls of the pseudostem</i>	<i>Ants and banana aphids (<i>Pentalonia nigronervosa</i>) on foliage of Chinese banana.</i>	<i>Banana aphids (<i>Pentalonia nigronervosa</i>), cast skins, and ants.</i>
<i>Close-up of wingless banana aphid</i>		<i>Banana aphid colony</i>

### **Symptoms**

Deformed plants with curled, shriveled leaves; if infestation is severe, galls may form on leaves; colonies of aphids usually

present in crown of plant at base of pseudostem or between the outer leaf sheaths; aphid is soft-bodied and red-brown to almost black in color.

### Cause

Insect

### Comments

Colonies are often tended by ants; populations can build rapidly during warm weather.

### Management

Chemical control does not provide protection against transmission of Banana bunchy top and direct feeding damage is not usually severe enough to warrant spraying; insecticidal soaps can help control aphid populations; plants infected with bunch top should be removed and destroyed to prevent spread.

## Banana skipper *Erionota thrax*

The caterpillar feeds and molts within the rolled leaf.

Banana skipper pupa

banana skipper just emerged from pupae

Banana skipper damage

Adult banana skippers

Banana skipper adult

Larvae of Banana skipper

Leaf rolling of banana caused by larvae of the banana skipper, *Erionota thrax*.

Banana skipper larvae

Incising and rolling up of banana leaf by banana skipper

Damage to banana leaf

Rolling of leaf due to banana skipper

### Symptoms

Usually larvae feed on leaves. Typically the feeding involves incising and rolling up of leaves.

### Cause

Insect

### Comments

The insect also attacks coconut and other palm species. The pest is common in Southeast Asia and Pacific islands.

### Management

Encourage and release natural enemies to check the population of skippers. Hand pick the larvae and kill them.

## Banana weevil *Cosmopolites sordidus*

Weevil damage to banana

Weevil damage to banana

Banana weevil

Weevil damage to banana

Weevil damage to banana

Weevil damage on pieces of banana corm

Banana weevil damage

Banana corm damaged by weevils

Banana weevil larva

Adult banana weevils

### Symptoms

Reduced plant growth; reduced fruit production; tunnels may be visible in corm as rounded holes up to 8 mm in diameter; plants wilting and toppling over; destruction of root system; plant death; adult insect is a hard-shelled beetle which is almost black in color; adult is commonly found between leaf sheaths; larvae are creamy-white, legless grubs with a red-brown head

#### Cause

Insect

#### Comments

Insects are nocturnal, feeding and mating only at night

#### Management

Plant only healthy plant material, do not plant if any tunnels are visible; hot water treatment of clean trimmed suckers can be used to kill off many eggs and grubs; applications of neem powder can reduce weevil numbers; appropriate insecticides applied at time of planting can help control weevil numbers

### **Coconut scale** *Aspidiotus destructor*

*Coconut scale infestation*

*Coconut scale*

*Banana infected with coconut scale*

*Coconut scale insects infesting a banana fruit*

*Coconut scale on banana*

*Close up view of colony of coconut scale on banana leaf*

#### Symptoms

Small, flat, whitish scales, usually on undersides of leaves but may also attach to petioles, peduncles and fruit; plant tissue discolored and yellowing.

#### Cause

Insect

#### Comments

Coconut scale attacks a large number of hosts including coconut and other palm species, avocado, cassava, papaya, guava and sugar cane; most common in tropical regions.

#### Management

Biological control is the best way to manage scale, with lady beetles providing the most effective protection.

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# Barley

## Crop details

The following are the crop details for barley:

Kingdom: Plantae

Phylum: Angiosperms

Class: Monocots

Order: Poales

Family: Poaceae (Grass family)

Genus: Hordeum

Species: Hordeum vulgare

*Harvested barley grains*

*Barley beginning to ripen*

*Barley ready for harvest*

*Barley ready for harvest*

*Stubble in harvested field*

*Green barley field*

*Green barley*

*Barley spikes*

*Barley*

## Crop description

Barley is classified under the genus "Hordeum" and the species "vulgare." It's an important cereal crop that belongs to the Poaceae family and is widely cultivated for its various uses in human consumption and industry.

Barley, *Hordeum vulgare*, is an edible annual grass in the family Poaceae grown as a cereal grain crop. It is a tall grass with a hairy stem that stands erect and produces spikelets at the head.

The nodes and internodes make up the stem. The internodes are hollow, as opposed to the solid internodes. The inflorescence, or spike, where the grain is generated, is supported by the stalk.

The heads of the barley seeds are triangular spikes made up of rachis and three spikelets apiece. 20–60 grains are produced by each spike. Barley plants freely tiller and usually have one to six stems. Seed heads are not produced by the tillers. An annual crop, barley may grow to a height of 80 to 100 cm (31.5–39.4 in) and is harvested every year. Barley was initially domesticated in the Fertile Crescent of the Middle East and is sometimes referred to as spring barley or winter barley.

## Varieties

There are several varieties of barley, each with its own characteristics and uses. Some common barley varieties include:

~ Two-row barley (*Hordeum vulgare* var. *distichum*)

~ Six-row barley (*Hordeum vulgare* var. *hexastichum*)

~ Hulless barley (*Hordeum vulgare* var. *nudum*)

~ Malting barley (varieties selected for beer production)

~ Feed barley (used for animal feed)

These varieties differ in terms of grain size, shape, color, and suitability for different purposes.

Barley is mostly farmed in Kenya's upland portions of the Rift Valley, especially in locations with milder climates and conducive soils. Kenyan farmers frequently cultivate the following types of barley:

**Barley Varieties:** Varieties like "Baraka" and "Tudor" are commonly grown for malting and brewing purposes. These varieties have been developed to meet the requirements of the local climate and brewing industry.

**Growing Regions:** Barley is often cultivated in regions such as Nakuru, Uasin Gishu, Nandi, and parts of the Aberdare Range due to their favorable climate and altitude.

It's important to note that agricultural practices and crop choices may vary over time, and it's always a good idea to consult with local agricultural authorities or experts for the most up-to-date information on barley cultivation in specific regions of Kenya.

## Uses

Barley is cultivated as a food cereal in the tropics and subtropics in India, Nepal, Tibet, Afghanistan, Russia, Ethiopia, North Africa, and the Andean region of South America. The straw produced is used as animal feed, bedding, and to cover the roofs of houses.

In temperate regions, barley is used in malt production to brew beer and make other distilled alcoholic beverages, particularly whisky.

## Climatic conditions, soils, and water management

### ***Climatic Conditions***

Barley is a cool-season crop and thrives in temperate climates. It prefers moderate temperatures during its growth stages. During its growth phases, it prefers warmer temperatures. During the growth season, the ideal temperature ranges for barley cultivation are between 15 and 20 °C (59 and 68 °F). Frost may be tolerated by barley to some extent, but excessive cold or heat could damage the plant's development.

### ***Soils***

Barley can be grown in a range of soil types, but it prefers well-drained soils with good water-holding capacity. Loamy soils with good organic matter content are generally ideal for barley cultivation. Heavy clay soils can hinder root growth and drainage, while sandy soils may require more frequent irrigation.

### ***Water Management***

Proper water management is crucial for barley farming:

### ***Irrigation***

Barley requires adequate moisture, especially during its early growth stages. Proper irrigation is important to ensure uniform germination and establishment. However, overwatering should be avoided to prevent waterlogging, which can lead to root diseases.

Rainfed vs. Irrigated: Depending on the local climate and rainfall patterns, barley can be grown as rainfed or irrigated crop. In areas with reliable rainfall, rainfed barley can be successful. In drier regions, irrigation is necessary to supplement water needs.

### ***Timing***

Water stress during critical growth stages, such as flowering and grain filling, can significantly reduce yield. Proper irrigation timing is essential to support these stages.

### ***Mulching***

Mulching can help conserve soil moisture, reduce evaporation, and suppress weed growth. This can be

particularly beneficial in areas with limited water availability.

## ***Water Quality***

The quality of irrigation water is important. Salinity and alkalinity can negatively impact barley growth. Proper water testing and management can help mitigate these issues.

# **Propagation**

Planting procedure of barley

Here's a general planting procedure for barley:

### ***Site Selection***

Choose a well-drained field with good sunlight exposure. Barley prefers cooler temperatures, so select a location that provides moderate to cool climatic conditions.

### ***Soil Preparation***

Prepare the soil by plowing or tilling to a depth of 6-8 inches. Remove weeds, rocks, and debris from the field. Incorporate organic matter or compost to improve soil structure and fertility.

### ***Seed Selection***

Choose high-quality barley seeds from reputable sources. Select a suitable barley variety based on your region's climate and intended use (e.g., malting, feed, or forage).

### ***Seedbed Preparation***

Create a smooth and level seedbed to ensure uniform germination and emergence. You can use harrows or other suitable equipment to achieve this.

### ***Sowing***

Barley can be sown either by broadcasting or drilling. Drilling is preferred for precise seed placement and even spacing. The recommended seeding rate varies depending on the variety, but a typical range is around 90â€“120 kg/ha (80â€“110 lbs/acre).

### ***Depth and Spacing***

Plant barley seeds at a depth of about 1-2 inches (2.5â€“5 cm). Row spacing can vary, but a common recommendation is around 6â€“8 inches (15â€“20 cm) between rows.

### ***Fertilization***

Apply balanced fertilizers based on soil test results and local recommendations. Barley has specific nutrient requirements, especially for nitrogen, phosphorus, and potassium.

### ***Irrigation***

Provide sufficient moisture for germination and establishment. Depending on local conditions, you may need to irrigate after sowing. Avoid waterlogging.

### ***Weed Control***

Monitor the field for weeds and control them using appropriate methods. Early weed management is crucial to prevent competition with young barley plants.

### **Disease and Pest Management**

Implement integrated pest management practices to control pests and diseases. Common barley pests include aphids, cutworms, and rust diseases.

### **Growth and Development**

As the barley plants grow, monitor their health and growth. Adequate water and nutrient management are important during the vegetative and reproductive stages.

### **Harvesting**

Barley is ready to harvest when the stalks and heads have turned from green to yellow and the seed heads are drooping towards the ground. Check the seeds for ripeness before harvest. They should be firm and crunchy and not doughy in texture. Commercially produced wheat is usually harvested using a combine. Smaller plots can be harvested by hand using a scythe or sickle. Small plots can be harvested by snipping off the heads with a pair of scissors.

Please note that specific procedures may vary based on your location, local conditions, and the type of barley you're planting. It's always a good idea to consult with local agricultural experts or extension services for guidance tailored to your region.

*Barley being harvested by combine*

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## **Common Pests and Diseases**

### **Diseases**

#### **Category : Bacterial**

**Bacterial blight (Bacterial leaf blight, Black chaff)** *Xanthomonas translucens* also known as *Xanthomonas campestris*

*Bacterial blight on wheat glumes*

*Leaf lesions generally appear as short necrotic streaks unless they coalesce into larger necrotic areas*

*Bacterial blight symptom*

*Symptoms in barley field*

*Bacterial blight symptoms in chaff row of barley*

### **Symptoms**

Water soaked spots on foliage; shriveling dead leaves; glossy yellow or brown streaks; plant appears stunted, slow plant growth.

### **Cause**

Bacteria

### **Comments**

Occurs wherever barley is grown.

### **Management**

Use only certified, disease-free seed; treat seeds with a fungicide prior to planting to prevent diseases which allow bacteria to enter easily; practice crop rotation to reduce disease build-up in soil.

## **Basal glume rot *Pseudomonas syringae***

*Wheat spike showing symptoms of basal glume rot (*Pseudomonas syringae* pv. *atrofaciens*)*

### **Symptoms**

Brown discoloration at base of the glume (bract covering the kernel); dark line where glume attaches to spike; water soaked spots on leaves; yellow and necrotic spots on leaves.

### **Cause**

Bacterium

### **Comments**

Occurs wherever barley is grown; spread by seed.

### **Management**

Treat seeds with a fungicide prior to planting to prevent diseases which allow bacteria to enter easily; practice crop rotation to reduce disease build-up in soil; plow crop residue into soil.

## **Category : Viral**

## **Barley stripe *Pyrenophora graminea***

*Barley stripe symptoms on barley leaves*

### **Symptoms**

Small yellow spots on seedling leaves; yellow to tan stripes along leaf blade before heading; red margins on stripes; death of diseased tissue; heads not emerging; plants stunted.

### **Cause**

Fungus

### Comments

Occurs wherever winter barley is grown.

### Management

Use only certified seed.

## Barley yellow dwarf Barley yellow dwarf virus (BYDV)

Symptoms of Barley Yellow Dwarf Virus.

Wheat showing an upright posture with thickened, stiff leaves, caused by barley yellow dwarf virus (BYDV). The virus also causes yellowing of the leaves and stunting.

The bright yellow of wheat leaves infected with barley yellow dwarf virus contrasts sharply with the deep green of normal, healthy wheat.

Yellowing of leaves of wheat caused by barley yellow dwarf virus (BYDV).

Barley yellow dwarf virus (BYDV) symptom

### Symptoms

Stunted growth of plants; yellow green blotches at leaf tip, leaf margin or leaf blade; leaves turning bright yellow, red or purple.

### Cause

Virus

### Comments

Transmitted by aphids; symptoms more apparent in colder temperatures.

### Management

Grow resistant or tolerant varieties; avoid planting crop very early or very late when aphid populations are high.

## Category : Fungal

### Common root rot *Bipolaris sorokiniana*

*Cochliobolus sativus*

*Fusarium culmorum*

*Fusarium graminearum*

Common root rot symptom

### Symptoms

Brown lesions on leaves nearest soil extending to stem; resembles drought; death of lower leaves; rotting roots.

### Cause

Fungi

### Comments

Generally occurs wherever barley is grown but is more common in water stressed plants.

### Management

No chemical treatments for this disease; plant crop in late fall to avoid warm soils which favor emergence of disease; do not fertilize crop excessively; use irrigation to reduce water stress.

## Covered smut *Ustilago hordei*

Covered smut symptoms on barley

### Symptoms

Stunted growth; late emergence of heads; kernels replaced with grey fungal masses.

### Cause

Fungus

### Comments

Smut masses burst during harvest and further transmit disease; crushed spore masses have an odor similar to rotting fish.

### Management

Use only certified smut-free seed; treat seeds with hot water prior to planting to kill fungi; treat seeds with contact fungicide; grow resistant varieties.

## Downy mildew *Sclerophthora rayssiae*

*Wheat downy mildew symptom-distorted head*

*Distorted wheat heads with crazy top symptoms.*

*Distortion of wheat heads caused by downy mildew (*Sclerophthora macrospora*)*

*Distortion of wheat heads due downy mildew disease*

### Symptoms

Dwarfed and/or deformed plants; flag leaves yellow; leathery leaves; heads distorted; seed not formed.

### Cause

Fungus

### Comments

Occurs wherever winter barley is grown, usually after excessive rainfall.

### Management

Plant crop in well-draining soils; control weeds in field which can act as reservoirs for the disease; sow seed only from disease free plants.

## Ergot *Claviceps purpurea*

*Symptoms*

*Sclerotia bodies*

*Sclerotia obvious in infected heads*

*Ergot (*Claviceps purpurea*) symptoms*

### Symptoms

Only head affected; flowers oozing sticky substance (honeydew); head appears dirty due to dust sticking to honeydew; diseased kernels turn to black mass of fungal mycelia.

### Cause

Fungus

### Comments

Not usually severe.

### Management

Till crop residue deep into soil to prevent spores being released into the air; control weeds, especially grasses, in field which act as a secondary host for disease.

## Eyespot (foot rot) *Pseudocercospora herpotrichoides*

Sample wheat plants showing symptoms of foot rot (*Pseudocercospora herpotrichoides*).

### Symptoms

Eye shaped lesions on basal leaf sheaths and stem; stems shriveled and/or collapsing; plants chlorotic; heads white and undersized.

### Cause

Fungus

### Comments

Widespread wherever barley is grown.

### Management

Rotate barley with leguminous plants; sow spring barley which is more tolerant of spring frosts.

## Fusarium head blight (FHB or scab) *Fusarium graminearum*

Fusarium head blight on barley caused by inoculation

Barley showing symptoms of Fusarium head blight (FHB), with sections of necrosis on the head. Barley normally has more points of initial infection than wheat, i.e., infection starts in multiple places on the head.

Barley spike showing symptoms of Fusarium head blight (FHB): chlorosis, necrosis, and the appearance of black perithecia, fruiting bodies containing spore sacs.

Kernel infected with head blight

Necrosis caused by Fusarium head blight (FHB) on six-row barley.

Scab or head blight infected spike

### Symptoms

Initial symptoms show bleaching of some of the florets in the spike. Under favorable conditions, premature blight or bleaching of whole spike may occur. As the disease progress head turns tan to brown discoloration. Also, we can see pink or orange color mold appears at the base of the florets. The kernels become shriveled, white, and chalky.

### Cause

Fungus

### Comments

Since the pathogen infects kernel, the disease causes high yield loss, low test weights and low seed germination. Another major problem is pathogen produces mycotoxin, deoxynivalenol (DON) which is an vomitoxin.

### Management

Grow available resistant varieties. If the disease is severe, spray suitable fungicide.

## Loose smut *Ustilago nuda*

*Ustilago tritici*

*Loose smut infected spikes*

*Loose smut symptoms*

*Difference between healthy and loose smut infected barley spike*

*Loose smut infected barley spikes*

*Loose smut (*Ustilago avenae*) symptoms*

*Loose smut symptoms on barley*

*Loose smut symptoms on barley (right) and wheat (left)*

### **Symptoms**

Early emergence of heads; dark green or black masses in place of kernels.

### **Cause**

Fungus

### **Comments**

Spores rupture out from protective membrane on heads; fungus can survive in infected seed.

### **Management**

Use only certified smut-free seed; treat seeds with hot water prior to planting to kill fungi; treat seeds with systemic fungicide (fungi inside seed) fungicide; grow resistant varieties.

## **Net blotch** *Pyrenophora teres*

*Close up of a Barley leaf up with Net Blotch.*      *Net blotch on barley*

### **Symptoms**

Dark green water soaked spots; narrow brown blotches with netted appearance, surrounding tissue yellow; stripes running the length of leaf.

### **Cause**

Fungus

### **Comments**

High humidity promotes spread of the disease.

### **Management**

Rotate barley with resistant crops; grow resistant varieties; remove and crop residue from soil surface; destroy volunteer barley plants.

## **Powder mildew** *Blumeria graminis*

<i>Close up of Barley leaf with Powdery mildew.</i>	<i>White cottony patches</i>	<i>Cottony mycelia on leaf.</i>
<i>Powdery mildew on leaf with cleistothecia present.</i>	<i>Cleistothecia, of various maturities, developing in dense mycelial mat</i>	<i>White cottony patches become dull gray- brown color due to development of fruiting bodies (cleistothecia)</i>
<i>Symptoms on lower leaf surface</i>	<i>Powdery mildew symptoms on lower and upper surface of barley leaves</i>	<i>Patches of white cottony growth on lower leaf surface.</i>

## Symptoms

Initially the lower leaf surface shows white, cottony patches of fungal growth. The upper surface of these patches exhibit chlorotic spots. As the disease progress, this white cottony patches become dull gray- brown color due to development of fruiting bodies (cleistothecia). The infected plants show slow growth.

## Cause

Fungus

## Comments

The pathogen is common in fields with high plant density, application of high nitrogen fertilizers, high relative humidity, and cool weather.

## Management

Grow available resistant varieties. Follow crop rotation. Keep the field free from weeds and other unwanted plants.

Remove and destroy the infected crop residue.

## Pests

### Category : Insects

#### Aphids (Bird cherry-oat aphid, Russian wheat aphid, Corn leaf aphid, etc.)

*Rhopalosiphum padi*

*Diuraphis noxia*

*Sitobion avenae*

<i>Symptoms of Russian wheat aphid</i>	<i>Russian wheat aphid (Diuraphis noxia) damage</i>	<i>Russian wheat aphid (Diuraphis noxia) infestation</i>
<i>bird cherry-oat aphid (Rhopalosiphum padi) adults</i>	<i>Barley spike infested with aphids</i>	<i>Russian wheat aphid (Diuraphis noxia) adult feeding on leaf</i>
<i>Bird cherry-oat aphid colony</i>	<i>More severe damage on a susceptible barley variety</i>	<i>Resistant barley plants showing slight damage from Russian wheat aphids</i>

## Symptoms

Yellow or white streaked leaves; flag leaves may be curled up; plants may be stunted and tillers may lie parallel to the ground; plants may turn a purple color in cold weather; insects are small and soft-bodied and may be yellow, green,

black or pink in color depending on species; insects secrete a sugary substance called "honeydew" which promotes the growth of sooty mold on the plants.

### Cause

Insect

### Comments

Fields should be checked for aphid populations periodically after emergence.

### Management

Sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use; in commercial plantations aphid numbers are usually kept in check by predators and natural enemies; beneficial insect populations should be assessed before chemical control is considered; if no beneficial insect populations are present and aphids are damaging then apply appropriate insecticides.

## Armyworms (Armyworm, Western striped armyworm) *Mythimna unipunctata*

*Spodoptera praefica*

Adult armyworm (*Mythimna unipunctata*)

Armyworm (*Mythimna unipunctata*) larvae

Armyworm (*Mythimna unipunctata*) adult

Larva of the true armyworm,  
*Mythimna (Pseudaletia) unipuncta*.

Armyworm

### Symptoms

Entire leaves consumed; notches eaten in leaves; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside.

### Cause

Insect

### Comments

Insect can go through 3–5 generations a year.

### Management

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae.

## Barley mealybug (Haanchen mealybug) *Trionymus haancheni*

Infested field Mealybug infestation

Adult mealybug sucking sap from leaves

Adult mealybug Adult female

Mealybugs at the base of the plant

Eggs in leaf sheath

Damage due to mealybug

## Symptoms

Both nymphs and adults suck the sap from leaves and stem resulting in yellowing and browning. Heavy infestation leads to a reduction in growth. Mealybug secretes honey dew which results in sooty mold development.

## Cause

Insect

## Comments

Appearance of white cottony mass near the base barley stem indicates mealybug infestation.

## Management

Encourage natural enemies. If infestation is severe spray suitable insecticide.

## Stinkbugs *Euschistus* spp.

*Stink bug (Euschistus quadrator)*  
eggs

*4th instar stink bug*

*5th instar stink bug (Euschistus quadrator)*

*Stink bug (Euschistus quadrator)*  
first instar nymphs

*stink bug (Euschistus quadrator)*  
adult on leaf

*Brown stink bug*

## Symptoms

Damage to head during milk or soft dough stage; stink bugs often carry pathogens in their mouthparts which can cause secondary infections; adult insect is shield-shaped and brown or green in color; may have pink, red or yellow markings; eggs are drum shaped and laid in clusters on the leaves; larvae resemble the adults but are smaller.

## Cause

Insect

## Comments

Adult insects overwinter under leaves, on legumes, blackberries or on certain weeds such as mustard or Russian thistle.

## Management

Remove weeds around crop which may act as overwintering sites for stink bugs and practice good weed management throughout the year; organically accepted control methods include the use of insecticidal soaps, kaolin clay and preservation of natural enemies.

## Wireworms *Aeolus* spp.

*Anchastus* spp.

*Melanotus* spp.

*Limonius* spp

*Wireworm larvae feeding on roots of corn*

*Wireworms feed on the kernels when the corn is planted and on the roots when the seed germinates and starts to grow.*

*Different stage of wireworm larvae*

*Wireworm larvae*

## Symptoms

Death of seedlings; reduced stand; girdled stems and white heads; wireworm larvae can be found in soil when dug round the stem; larvae are yellow-brown, thin worms with shiny skin.

## Cause

Insect

## Comments

Larval stage can last between 1 and 5 years depending on species.

## Management

Chemical control impossible in a standing crop, must be applied at preplanting or as a seed treatment; if wireworms are known to be present in soil fallow field during summer and till frequently to reduce numbers; rotate to non-host crop where possible; avoid planting susceptible crops after a wireworm infestation on cereals without either fallowing or applying appropriate pesticide.

## Category : Others

### Leaf Scald *Rhynchosporium secalis*

Infected leaves

Close-up of barley leaf scald

Barley leaf scald

Symptoms of leaf scald Leaf scald

Barley leaves infected with leaf scald

Barley plants infected with leaf scald

Scald symptoms

Symptoms of scald on barley

## Comments

Appearance of dark, pale or bluish gray lesions on leaves. As the disease progress, these spots enlarge into oval lesions with bluish gray centers and dark brown margins. The spots may join together and appear like rapid scalding.

## Cause

Fungus

## Comments

Disease is transmitted by water splash and infected seeds.

## Management

Use disease free seeds. Grow available resistant varieties. Follow crop rotation. Remove and destroy the infected crop residue. Keep field free from weeds and other crop plants.

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# Basil

## Description

Basil, *Ocimum basilicum*, is a short lived annual or perennial plant in the family Lamiaceae grown for its leaves which are used as a herb. The basil plant grows from a thick taproot and has silvery green opposite (paired) oval leaves which grow to be 3–11 cm (1.2–4.3 in) long and 1–6 cm (0.4–2.4 in), branching out from the central stem. The plant produces small white flowers which are clustered on a single spike at the top of the plant. Basil plants are often grown as annuals but may survive for several seasons with some care and can reach heights between 30 and 130 cm (11.8 and 51.2 in) depending on the variety. Basil may also be referred to as sweet basil, St. Joseph's wort, thai basil, lemon basil or holy basil depending on the variety and is native to India and other tropical regions of Asia.

*Basil plant flowering*

*Close-up of basil flowers*

*Different basil varieties*

*Basil leaves*

*Basil*

## Uses

Basil is commonly used as a fresh or dried herb in cooking and is popularly used in beverages in Southeast Asia.

Essential oil can be extracted from the leaves and used in cosmetics, dental products and perfume.

## Propagation

### Basic requirements

Basil is a warm season crop which will grow optimally in areas where daytime temperatures are consistently above 21°C (70°F) and nighttime temperatures stay above 10°C (50°F). Basil is very sensitive to frost and will need protected if a late cold snap is forecast. The plant will grow best in a fertile, moist soil with a pH between 6 and 7. Basil requires around 6–8 hours of sun every day and benefits from some shade in the afternoon.

### Sowing seeds

Basil seeds should be sown indoors 6–8 weeks before planting outside. Sow seeds in a sterile seed starting mix in seed trays or pots 0.2–1.0 cm (0.08–0.4 in) deep and water gently. Ensure the temperature remains between 15.5 and 27°C (60–80°F). Seeds should germinate in about 5 days at 21°C (70°F).

### Transplanting

Basil seedlings can be transplanted to the garden when they are between 6 and 8 weeks old, about 2 weeks after the last frost date. Plants should be spaced approximately 30 cm (12 in) apart, allowing 45 cm (18 in) between rows. Pinching back the growing tip of the plants after transplanting will encourage the growth of new shoots.

### Harvesting

Basil leaves can begin to be harvested any time after the plants have reached a height of 15–20 cm (6–8 in). Harvest leaves by pinching the leaves from the tips of the stems to encourage the more branching. Leaves should be pinched regularly to keep the plants productive and prevent them from going to seed.

Young basil plants

Basil seedlings

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## Common Pests and Diseases

### Diseases

## Category : Fungal

### Cercospora leaf spot *Cercospora ocimicola*

*Cercospora leaf spot symptoms on basil*

#### Symptoms

Circular to irregular dark spots on leaves with light centers

#### Cause

Fungus

#### Comments

#### Management

Avoid overhead irrigation and splashing plants with water, instead water plants from the base and apply a layer of mulch around the plants to reduce water splash; remove and destroy any symptomatic leaves; minor infections can be controlled by spraying weekly with a fungicide containing potassium bicarbonate

### Downy mildew *Peronospora belbahrii*

*Masses of purplish sporangia on the undersurface of a leaf.*

*Heavy spore production on the undersurface of the leaf may look like dust or dirt on the tissue.*

*Fruiting Bodies (sporangia) on lower surface of leaf*

*Chlorotic (yellow) patches (symptoms) on the upper surface of a basil leaf with downy mildew*

*Dark-colored fungal growth (sign) on the bottom surface of a basil leaf opposite the chlorotic (yellow) patches (symptoms) on the upper surface of a leaf with downy mildew*

*Downy mildew symptoms on basil foliage*

*Downy mildew symptoms on basil*

*Downy mildew symptoms on basil foliage*

#### Symptoms

Yellowing leaves; discoloration often begins around middle vein and spreads outwards; gray fuzzy or downy growth on lower surface of the leaves; brown to black angular necrotic patches on the plant.

#### Cause

Fungus

#### Comments

Yellowing leaves may be mistaken for nutrient deficiency; can be spread by contaminated seed.

#### Management

Grow tolerant varieties; apply protective fungicide; ensure good air circulation around greenhouse grown plants; use drip irrigation to avoid wetting foliage.

## Fusarium wilt *Fusarium oxysporum*

### Symptoms

Yellow, wilting leaves; brown streaks on lower surface of leaves; stunted growth; death of plant.

### Cause

Fungus

### Comments

Disease favors warm, wet conditions.

### Management

Use only disease free seed; treat seeds with hot water to kill fungi prior to planting; if present in field, rotate crop every 2-3 years with crop other than basil or mint.

## Gray mold *Botrytis cinerea*

Conidiophores with whitish conidial heads

Conidiophores with conidia

Wilting foliage on cankered stem at left due to grey mold infection

Gray mold infected basil stem

Conidiophores with conidia arising from infected tissue

### Symptoms

Dense, brown to gray fuzzy growth on stems and leaves and fallen plant debris; leaves dying and dropping from plant; severe lesions on stem may cause plant death.

### Cause

Fungus

### Comments

Promoted by high humidity and poor air circulation.

### Management

No chemical treatment available; avoid working in field in rainy conditions; remove infested leaves and/or plants; avoid overhead irrigation.

## Leaf spot *Pseudomonas cichorii*

*Colletotrichum* spp.

Infected stem

Symptoms on leaf

Infected plant Symptoms on stem

bacterial leaf spot infected leaves

bacterial leaf spot (*Pseudomonas cichorii*) symptom

Symptoms of bacterial leaf spot on basil foliage

Symptoms of bacterial leaf spot (*Pseudomonas cichorii*) on basil leaves

Symptoms on leaves and stem

### Symptoms

Angular or irregular brown or black water-soaked spots on leaves; streaks on stems.

### Cause

## Bacteria

### Comments

High humidity and overhead watering promotes spread of disease.

### Management

No treatment when present; use disease free seed and/or transplants; use wide field spacing to promote air circulation around plants; remove diseased leaves from plant and soil surface immediately.

### Root rot *Rhizoctonia solani*

*Pythium* spp.

### Symptoms

Failure of seeds to germinate; germinated seedlings collapsing; brown, shriveled area at base of stem; roots brown and water-soaked.

### Cause

Fungus

### Comments

Promoted by high humidity and poor air circulation.

### Management

Plant seeds in sterile soil; plant basil in well-draining soils.

## Category : Other

### Slugs & snails (Gray garden slug, Spotted garden slug, Brown garden snail, European garden snail , etc.) *Decoratus reticulatum*

*Limax maximus*

*Helix aspersa*

*Cornu aspersum*

dusky slug (*Arion subfuscus*)

amber snails adult

Banded wood snail Gray garden slug

Cartusian snail (*Monacha cartusiana*) feeding on leaves

European brown snail

### Symptoms

Irregularly shaped holes in leaves and stems; flowers and fruit may also be damaged if present; if infestation is severe, leaves may be shredded; slime trails present on rocks, walkways, soil and plant foliage; several slug and snail species are common garden pests; slugs are dark gray to black in color and can range in size from 2.5 to 10 cm (1-4 in); garden snails are generally smaller and possess a rounded or spiral shell.

### Cause

Mollusc

### Comments

Slugs and snails prefer moist, shaded habitats and will shelter in weeds or organic trash; adults may deposit eggs in the soil throughout the season; damage to plants can be extensive.

### Management

Practice good garden sanitation by removing garden trash, weeds and plant debris to promote good air circulation and reduce moist habitat for slugs and snails; handpick slugs at night to decrease population; spread wood ashes or eggshells around plants; attract molluscs by leaving out organic matter such as lettuce or grapefruit skins, destroy any found feeding on lure; sink shallow dishes filled with beer into the soil to attract and drown the molluscs; chemical controls include ferrous phosphate for organic gardens and metaldehyde (e.g. Buggeta) and carbaryl (e.g Sevin bait) for

non-organic growers.

## Pests

### Category : Insects

#### Aphids (Various spp.) Various

*Aphid on basil*

*Winged adult aphid*

*Aphid*

*Praying Mantis feeding on basil aphid*

*Aphid feeding on basil aphid*

#### Symptoms

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants.

#### Cause

Insect

#### Comments

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed.

#### Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use.

#### Cutworms, loopers, owlet moths, and underwings *Spodoptera exigua*

*Trichoplusia ni*

and others

*Larave on basil leaf Loopers*

*Cutworm damage Larva*

*Larvae feeding on basil leaf Larave*

#### Symptoms

The early stage larvae feeds on terminal clusters. Later stage larvae skeletonize the leaves. Also, they will cut the seedling stem near the base resulting in heavy loss.

#### Cause

Insect

#### Comments

The insect has a wide host range.

#### Management

Hand pick the larvae and kill them. Remove and destroy weeds and crop residue. Spray biocontrol agent (bacteria/virus)

to kill insects. If infestation is severe, spray suitable insecticide.

## Flea beetle *Phylotreta* spp.

*Flea beetle on basil*

*Adult flea beetle on a leaf.*

*Flea beetle damage to leaves*

*Flea beetle and damage on basil leaf*

### Symptoms

Small holes or pits in leaves that give the foliage a characteristic “hole” appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5–3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance.

### Cause

Insects

### Comments

Younger plants are more susceptible to flea beetle damage than older ones; older plants can tolerate infestation; flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year.

### Management

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application of diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied.

## Grasshoppers Various sp.

*Grasshopper feeding on basil leaf*

*Grasshopper on basil*

*Initial stage grasshopper nymphs damage*

*Grasshopper feeding on soybean leaves*

### Symptoms

Both adult and nymphs feed on foliage, buds, and tender stems. The first stage nymphs feed on leaves by forming circular holes. As the insect develops it feeds on entire foliage. Grasshoppers are very eager feeders.

### Cause

Insect

### Comments

It feeds on several crops including weeds.

### Management

Encourage birds in the field. If population is severe, spray suitable insecticide.

## Japanese beetle *Popillia japonica*

*Japanese beetle adult*

*Japanese beetle (*Popillia japonica*) larvae*

*Adult Japanese beetle on basil leaf*

*Adult Japanese beetle*

### Symptoms

Leaves skeletonized (only veins remaining); flowers and buds damaged; plant damage may be extensive; adult insect is a metallic green-bronze beetle with tufts of white hair protruding from under wing covers on each side of the body; adult beetles are approximately 13 mm in length; larvae are cream-white grubs which develop in the soil.

### Cause

Insect

### Comments

One beetle generation every 1-2 years; pheromone traps may actually attract more beetles to home gardens and should generally be avoided; beetle overwinters as larvae in soil; beetle has an extensive range of over 300 host plants.

### Management

If beetles were a problem in the previous year, use floating row covers to protect plants or spray kaolin clay; adult beetles can be hand picked from plants and destroyed by placing in soapy water; parasitic nematodes can be applied to soil to reduce the number of overwintering grubs; insecticidal soaps or neem oil can help reduce beetle populations.

## Leafminers *Liriomyza* spp.

*Leafminer larvae*

*Leafminer fly Leafminer damage*

*Leafminer pupae*

*Larvae still with in leaf mine*

### Symptoms

Thin, white, winding trails on leaves; heavy mining can result in white blotches on leaves and leaves dropping from the plant prematurely; early infestation can cause fruit yield to be reduced; adult leafminer is a small black and yellow fly which lays its eggs in the leaf; larvae hatch and feed on leaf interior.

### Cause

Insects

### Comments

Mature larvae drop from leaves into soil to pupate; entire lifecycle can take as little as 2 weeks in warm weather; insect may go through 7 to 10 generations per year.

### Management

Check transplants for signs of leafminer damage prior to planting; remove plants from soil immediately after harvest; only use insecticides when leafminer damage has been identified as unnecessary spraying will also reduce populations of their natural enemies.

## Category : Nematodes

## Root knot nematode *Meloidogyne* spp.

*Galls or nodules associated with the root system caused by root-knot nematodes. May be small or large.*

*Galls on a bean root infested with the root knot nematode Meloidogyne spp. in the field.*

### Symptoms

Galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; reduction in plant vigor; yellowing plants which wilt in hot weather.

### Cause

Nematode

### Comments

Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or garden with this type of soil is most likely.

### Management

Plant resistant varieties if nematodes are known to be present in the soil ;check roots of plants mid-season or sooner if symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens.

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# Bean

## Crop details

Scientific Name *Phaseolus vulgaris* L.

Order / Family Fabales: Fabaceae

Local Names Maharagwe (Swahili)

### Common Names

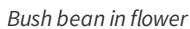
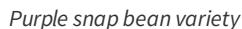
Bush beans, common beans, dry beans, dwarf beans, field beans, French beans (also known as green beans or snap beans), garden beans, haricot beans, kidney beans, pole beans or string beans

### General information

Many names are used for *Phaseolus vulgaris*. These include bush beans, common beans, dry beans, dwarf beans, field beans, French beans, garden beans, green beans, haricot beans, kidney beans, pole beans, snap beans or string beans.

However, presently, two distinct bean types are recognised in the region: **French beans** (green beans) and **common beans** (dry beans). French beans are the immature green pods of *P. vulgaris* and are primarily grown for export market to European Union and elite local urban markets. Common beans are the second most important staple food to maize for the local people.

Beans were introduced to Africa from Latin America several centuries ago. To date beans are a vital staple in Africa, providing the main source of protein. Common beans are mainly grown by women for subsistence and for the local market. French beans (green/snap beans) are grown as a cash crop by large scale and smallholder farmers. They are a major export vegetable commodity in Eastern Africa.

A small, light green bush bean plant with several flowers at the top of its stems.A purple snap bean pod, showing its characteristic curved shape and vibrant color.A cluster of small, delicate white flowers from a runner bean plant.A pole bean plant with several long, thin green bean pods hanging down from its branches.A green bean plant showing both its flowers (tiny white spikes) and young green bean pods.A close-up view of several bright green, smooth-textured green beans.

# Bean Varieties

## 1. Black Beans

Black beans are a staple in many Mexican and Brazilian dishes. They have a velvety-smooth texture and mild flavor. They also have a lower glycemic index than many other high-carb foods, helping to reduce the spike in blood sugar that occurs after eating a meal.

## 2. Black-Eyed Peas

This Southern staple has a beige hue with an eye-catching black spot, hence the name "black-eyed peas." They have an earthy flavor that complements salty foods like ham and bacon .

## 3. Cannellini Beans

Also known as white Italian kidney beans, these cream-colored beans are one of the most common types of beans. They are a popular addition to soups, salads, and many Italian dishes.

## 4. Chickpeas (Garbanzo Beans )

They have a round shape and a firm texture, making them a great salad topping.

## 5. Great Northern Beans

This is another type of white bean that is often mistaken for cannellini or navy beans

## 6. Kidney Beans

These beans are known for their vibrant red skin and white interior. They have a mild flavor, and make the perfect addition to any chili recipe.

## 7. Lima Beans

These beans get a bad rap, but there's actually so much to love when it comes to lima beans. They can be white, creamy, or green in color.

## 8. Pinto Beans

Pinto beans have an orange-pink color with rust-colored specks

## 9. Fava Beans

Fava beans, or broad beans, can be difficult to work with. They require that you remove them from their pods and then blanch them in order to get the skins off.

## 10. Navy Beans

This bean goes by many names: haricot, pearl haricot beans, white pea bean, and Boston bean. They have a mild flavor and creamy texture, and similar to Great Northern Beans, they do a great job of absorbing the flavors around them.

## 11 Adzuki Beans

These small, round red beans , Like other legumes, they're protein-packed and high in fiber.

## **12. Edamame**

Edamame are young soybeans which are usually eaten while still inside the pod.

## **13 . Cranberry Beans**

Rounding out the list are these striking cream-colored beans with red speckles. Also known as borlotti beans, cranberry beans have a creamy texture and a nutty flavor.

## **14. Soybeans**

Soybeans are dried and beige in color.

## **15 . Mung Beans**

These beans are one of the most consumed types in the world. They are small, round, and green with a white stripe going through them. They have a mild flavor and a starchy texture

# **climatic conditions and soil type**

Common beans grow within a range of temperatures of 17.5-27°C. Above 30°C flower buds are likely to fall and seeds are rarely formed at temperatures over 35°C. They are sensitive to night frost. Common beans are usually grown at altitudes between 600 - 1950 m in many tropical areas. A moderate well-distributed rainfall is required (300-400 mm per crop cycle) but dry weather during harvest is essential. Drought or waterlogging are harmful. Climbing cultivars will give economic yields in areas of high rainfall but the dwarf types appear to be more sensitive to high soil moisture levels.

Suitable soil types range from light to moderately heavy and to peaty soils with near-neutral pH and good drainage.

Common bean is susceptible to salinity.

The optimum temperature range for growing French beans is 20-25°C, but can be grown in temperatures ranging between 14 and 32°C. Extreme temperatures result in poor flower development and poor pod set. However, French beans mature faster in warmer areas. French beans can be grown between 1000 and 2100 metres above sea level. Rainfed cultivation is possible in areas with well distributed, medium to high annual rainfall (900-1200 mm) but to maintain a continuous production especially during the dry season, irrigation is essential. During the dry season up to 50 mm of water per week is required. This could be applied through furrow or overhead irrigation. French beans grow best on well drained, silty loams to heavy clay soils high in organic matter with pH 5.5-6.5.

# **Uses**

The common bean is used as a pulse and green vegetable eaten fresh or cooked. The beans can be dried, cooked in sauce and canned . The common bean is used as a pulse and green vegetable eaten fresh or cooked. The beans can be dried, cooked in sauce and canned .

# **Nutrition Value**

Beans are among some of the oldest cultivated vegetables. There are various types of beans that differ with shapes,

sizes, taste and nutritional facts. Kidney beans, pinto beans, broad beans, fava beans, lima beans, etc. are some of the different types of beans. Each of them is loaded with dietary fibers, proteins and major vitamins and minerals like vitamin A, vitamin C, potassium, calcium and magnesium. The amount of the above given nutrients varies from one type of bean to other. Beans are very low in fat and cholesterol and they also help to lower the bad cholesterol in the body. Since they are high in proteins, they make an excellent meat substitute for vegetarians. They are extremely low in calories and hence are a favorite food among the calorie conscious people. Before knowing more about beans nutritional value, let us take a look at some figures related to nutrition in beans.

### **Countries where beans is grown**

The main producing countries in the region are **Kenya, Tanzania, Uganda**, and more recently **Rwanda**. In Kenya, most of the crop is grown by smallholders and virtually all is exported to Europe. Estimates indicate that up to 50,000 smallholder families are involved in French bean production in Kenya.

The growth habit of common beans varies from determinate dwarf or bush types to indeterminate climbing or poleÂ cultivars. Bush beans are the most predominant types grown in Africa. However, improved climbing beans introduced to Rwanda in the 80's have since spread to other countries in the region. They are particularly grown in areas with limited land and high human population.

## **Propagation**

### **Basic requirements**

Common beans are warm-season crops and should be planted after all danger of frost has passed and the soil has warmed. Beans will grow best at soil temperatures between 15.5 and 29Â°C (60â€“85Â°F) and are sensitive to cold temperatures and frosts. Beans will grow best in a fertile, well-draining soil with a pH between 6.0 and 6.75. Beans will perform best in full sunlight.

### **Sowing seeds**

Beans should be direct seeded in the garden in when the soil has reached a temperature of at least 15.5Â°C (60Â°F), with the optimum temperature for germination being between 15.5 and 29Â°C (60â€“85Â°F). Planting at cooler temperatures leads to slow germination and promotes seed rotting. Seeds should be planted 2.5â€“3.5 cm (1â€“1.5 in) deep. Bush beans should be planted 5â€“10 cm (2â€“4 in) apart allowing 0.6â€“0.9 m (2â€“3 ft) between rows. Pole beans can be planted in both row and hills. In rows, seeds should be spaced 15â€“25 cm (6â€“10 in) apart allowing 0.9â€“1.2 m (3â€“4 ft) between rows. For a continuous harvest of beans over the summer months, make new plantings every 2â€“3 weeks.

### **Poles and trellises**

Pole beans should be provided with a pole or trellis to climb on to support the weight of the pods and allow light to penetrate to all parts of the plant, helping to prevent disease. Bean poles should have a rough surface to help the plant to grip and should be 1.8â€“2.1 m (6â€“7 ft) long. Three or four poles can be used to form a tripod onto which the plants can be trained. Bean trellises can be constructed easily using posts (or a tripod arrangement of poles), wire and twine. Position a post at either end of the area in which you wish to plant a row of beans and connect with two lengths of wire. The first wire should be approximately 13 cm (5 in) from the ground, and the second 1.5â€“1.8 m (5â€“6 ft) from the ground. Finally, use the twine to create a V-shaped trellis by tying the twine to the bottom wire, bringing it up to the top wire and looping it back down around the bottom wire. Continue to zigzag the string all the way along the wires to the second support before tying the twine off. A rough textured twine is best as it will encourage the plant to climb and twine around it. Pinch back the growing tips of the plants once they reach the top support to encourage the plant to branch.

### **Mulching**

Mulching with straw and cut grasses helps conserve moisture, promote adventitious root development and enhances

tolerance to bean fly maggot damage.

## Intercropping

Beans are excellent for intercropping with other food crops, such as maize, potatoes, celery, cucumber and can help supply the other crops with nitrogen to a limited degree. Longer season varieties of beans can fix higher amounts of nitrogen than short season varieties. Intercropping with chives or garlic helps repel aphids (KIOF - personal communication).

## Water management

A regular water supply is essential for French beans as moisture affects yields, uniformity and quality. Water stress during flowering reduces yields, as does waterlogging. Irrigation in dry spells is recommended as 35 mm per week at planting and 10 days post emergence, followed by 50 mm per week thereafter till end of production.

## Harvesting

Beans are generally ready for harvest approximately two weeks after bloom. The beans should be harvested just before the seeds are mature and before they form bumps on the pod. The pods should be firm and snap when they are bent. Pick beans every 2–3 days to ensure the plants remain productive. Pinch beans rather than pulling to avoid damaging the plant. Cut pole beans from the plant using scissors.

Pole beans planted beneath a trellis      Bean tripod and trellis

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## Common Pests and Diseases

# Diseases

## Category : Fungal

### Alternaria leaf spot *Alternaria alternata*

Symptoms of Alternaria leaf spot on bean leaves and pods

#### Symptoms

Small irregular brown lesions on leaves which expand and turn gray-brown or dark brown with concentric zones; older areas of lesions may dry out and drop from leaves causing shot hole; lesions coalesce to form large necrotic patches

#### Cause

Fungus

#### Comments

Disease emergence favored by high humidity and warm temperatures; plants grown in nitrogen and potassium deficient soils are more susceptible

#### Management

Plant beans in fertile soil; foliar fungicide application may be required

### Anthracnose *Colletotrichum lindemuthianum* (*Glomerella lindemuthiana*)

Infected leaf

Infected plant

leaf showing symptoms of beans anthracnose

Bean plants showing canopy symptoms

Close-up view of a bean pod, displaying symptoms of bean anthracnose

Close-up view of a bean leaf petiole, displaying symptoms of bean anthracnose

Anthracnose symptoms on beans and pods

Close-up of anthracnose lesion on bean pod

Symptoms of bean anthracnose

Anthracnose symptoms on bean pods

Anthracnose symptoms on bean pod

Anthracnose symptoms on bean pods

#### Symptoms

Small, dark brown to black lesions on cotyledons; oval or eye-shaped lesions on stems which turn sunken and brown with purple to red margins; stems may break if cankers weaken stem; pods drying and shrinking above areas of visible symptoms; reddish brown spots on pods which become circular and sunken with rust colored margin.

#### Cause

Fungus

#### Comments

Disease transmitted through infected seed; fungus can survive in crop debris in soil and reinfect crop the following season.

#### Management

Plant resistant varieties; use certified disease free seed; avoid sprinkler irrigation, water plants at base; plow bean crop debris into soil.

## **Bean rust** *Uromyces appendiculatus*

Symptoms	<i>Close-up view of the pycnium of bean rust</i>	<i>Aecia of bean rust (<i>Uromyces appendiculatus</i>) on the stem</i>
Rust pustules on bean leaf	<i>Symptoms on beans stem</i>	<i>Teliospores formed on infected leaves</i>
Telia of bean rust	<i>Initial symptoms of rust disease</i>	<i>Rust symptoms on bean pod</i>
small yellow or white spots due to rust disease	<i>Rust disease infected plants</i>	<i>Defoliation of bean leaves due to rust disease</i>
Bean leaves showing "green island effect" due bean rust disease	<i>Field of dry beans displaying prominent symptoms of bean rust</i>	<i>Telia of bean rust (<i>Uromyces appendiculatus</i>) on a bean leaf.</i>

### **Symptoms**

Initially the symptoms appear as small yellow/white spots on leaves. Later the spots become enlarged and shows raised brick red rust pustules (uredinia). Normally this pustules are surrounded by a yellow halo. Premature leaf drop may occur if the disease is severe.

### **Cause**

Fungus

### **Comments**

Spores (urediniospores) spread from one field to another by air. The black teliospores formed at the end of the crop season overwinter in the field and act as inoculum for next season crops.

### **Management**

Grow available resistant varieties. Remove and destroy the infected crop debris. Follow crop rotation. Keep the field free from weeds. If the disease is severe, spray suitable fungicide.

## **Black root rot** *Thielaviopsis basicola*

<i>Symptoms of black root rot (<i>Thielaviopsis basicola</i>)</i>	<i>Elongated red-purple lesions due black root rot on melon seedling</i>	<i>black root rot (<i>Thielaviopsis basicola</i>) symptom</i>
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### **Symptoms**

Elongated red-purple lesions on root tissue which turns dark gray to black; lesions coalesce to form large dark areas on roots and stems; deep lesions can cause stunted growth, wilting leaves, defoliation and plant death.

### **Cause**

Fungus

### **Comments**

Fungus survive in plant debris in soil.

### **Management**

Rotate crops with non-susceptible grasses; avoid excess irrigation or drought stress.

## **Fusarium root rot** *Fusarium solani*

*Roots of drybeans showing advanced symptoms of Fusarium root rot caused by Fusarium oxysporum f.sp. phaseoli.*

*Bean plant showing symptoms of fusarium wilt*

### Symptoms

Young plants stunted with chlorotic leaves; older plants with chlorotic leaves and some leaf drop; severely decayed roots which are hollow and dry.

### Cause

Fungus

### Comments

Fungus can survive in soil for several years.

### Management

Practice long term crop rotation; avoid over or under watering plants; some bean varieties exhibit some tolerance.

## White mold (*Sclerotinia timber rot*) *Sclerotinia sclerotiorum*

*Wilting of a dry bean plant in the field, an initial symptom of infection with white mold*

*Wilting and death of the bean canopy, an advanced symptom of infection with white mold*

*Advanced symptoms of white mold*

*White mold symptoms on bean plants caused by *Sclerotinia sclerotiorum**

*Fallen blossoms of dry bean that have been colonized by white mold*

*Mycelium and sclerotia of white mold*

*Advanced symptoms of white mold (*Sclerotinia sclerotiorum*) on the branches and pods of a bean plant.*

*White mold on bean stem and branches*

*Field infested with white mold*

*Symptoms in advance stage*

*Apothecia of white mold (*Sclerotinia sclerotiorum*) and fallen leaves of dry bean that have been colonized by white mold.*

*Bean pod and flower colonized by white mold*

### Symptoms

Flowers covered in white, cottony fungal growth; small, circular, dark green, water-soaked lesions on pods leaves and branches which enlarge and become slimy; cottony white growth may be visible on lesions during periods of high humidity; death of branches and/or entire plant.

### Cause

Fungus

### Comments

Fungus can survive in soil for in excess of 5 years; disease can be spread by wind, contaminated irrigation water and by infected seeds.

### Management

There is no true immunity to white mold in any bean varieties; rotate crops with non-hosts like cereals and corn; plant rows parallel to direction of prevailing winds to prevent spread of disease from secondary hosts nearby; avoid excessive nitrogen fertilizer; use a wide row spacing.

## Category : Bacterial

## **Bacterial blight** *Xanthomonas campestris* syn. *Xanthomonas axonopodis*

Symptoms on lower surface of leaf	Symptoms of common bacterial blight	common bacterial blight water soaking on dry bean leaf
Symptoms on both upper and lower surface of leaves	Common bacterial blight water soaking on dry bean leaf, canopy symptoms	Common bacterial blight water soaking lesions on dry bean pods, disease
Bacterial blight of beans	Lesions of common bacterial blight	Leaf lesions caused by bean bacterial blight
Symptoms of bacterial blight on bean foliage	Symptoms on bacterial blight on pods	Symptoms of bacterial blight on bean leaves

### **Symptoms**

Water-soaked spots on leaves which enlarge and become necrotic; spots may be surrounded by a zone of yellow discoloration; lesions coalesce and give plant a burned appearance; leaves that die remain attached to plant; circular, sunken, red-brown lesion may be present on pods; pod lesions may ooze during humid conditions.

### **Cause**

Bacterium

### **Comments**

Disease can be introduced by contaminated seed; bacteria overwinters in crop debris; disease emergence favored by warm temperatures; spread is greatest during humid, wet weather conditions.

### **Management**

Plant only certified seed; plant resistant varieties; treat seeds with an appropriate antibiotic prior to planting to kill off bacteria; spray plants with an appropriate protective copper based fungicide before appearance of symptoms.

## **Bacterial brown spot** *Pseudomonas syringae*

Bacterial brown spot on dry bean-branch lesions.  symptoms	bacterial brown spot on dry bean, canopy shot - hole damage, early necrosis, disease, <i>Pseudomonas syringae</i> pv. <i>syringae</i>	Infected bean pods  Cupping of young leaflets of dry beans, a symptom of bacterial brown spot disease
Lesions of bacterial brown spot on a bean pod.	Early shot-hole lesions on leaves of dry beans due to bacterial brown spot	Symptoms of bacterial brown spot
Bacterial brown spot disease symptoms	Infected leaf  "Water soaking" and necrosis on bean leaves, due to infection with bacterial brown spot disease	Symptoms of bacterial brown spot ( <i>Pseudomonas syringae</i> pv. <i>syringae</i> ) on foliage of dry beans.

## Symptoms

Small, dark brown necrotic spots on leaves which may be surrounded by a zone of yellow tissue; water soaked spots on pods which turn brown and necrotic; pods may twist and distort in area of infection.

## Cause

Bacterium

## Comments

Bacterium overwinters in crop residue; disease more severe when foliage is wet for extended periods.

## Management

Plant only certified seed; rotate crops regularly; remove crop debris from field after harvest.

## Halo blight *Pseudomonas savastanoi* pv. *phaseolicola*

*Halo blight "water soaking" on a mature pod of red kidney beans*

*Chlorosis*

*Infected plants Halo blight symptom*

*Halo blight "water soaking" on a young bean pod*

*halo blight symptoms on upper surface of common bean leaflet, note circular yellow spots*

*Halo blight "water soaking" on a mature bean pod*

*halo blight symptoms on lower surface of common bean leaflet, note small water-soaked spots*

*Chlorosis and isolated lesions of halo blight on dry beans.*

*Symptoms of halo blight on bean pods*

*Halo blight chlorosis*

*Halo blight chlorosis on bean leaves*

## Symptoms

Small water-soaked spots on underside of leaves which turn necrotic and become visible on upper surface; lesions may develop an area of chlorotic tissue around the spots; lesions on expanding leaves may cause distorted leaves; red-brown lesions may be visible on pods; pod lesions may ooze or may turn tan in color.

## Cause

Bacterium

## Comments

Bacterium survives in seeds and crop debris and enters plants through natural openings such as stomata and is spread by splashing water and soil movement.

## Management

Plant disease free seed or treat seed with an antibiotic to reduce levels of bacterium; rotate crops to non-hosts every 2 years; plow bean debris deeply in soil after harvest.

## Category : Fungal, Oomycete

## Damping-off *Rhizoctonia solani*

*Pythium* sp.

<i>Drybean seedlings showing symptoms of Pythium damping off caused by Pythium spp.</i>	<i>Drybean plants showing symptoms of Rhizoctonia and Pythium root rots caused by Rhizoctonia solani and Pythium spp. respectively in the field.</i>	<i>Fusarium damping-off (Fusarium solani) symptoms</i>
<i>Roots of drybean seedlings showing early symptoms of Rhizoctonia root rot caused by Rhizoctonia solani.</i>	<i>Roots of drybeans showing advanced symptoms of Rhizoctonia root rot caused by Rhizoctonia solani.</i>	<i>Damping Off on Snap Bean (Pythium and Rhizoctonia) Collapse of the lower stem area.</i>
<i>elongated sunken reddish-brown lesions on roots and stems at or below the soil line</i>	<i>Infected seedling</i>	<i>Rhizoctonia damping-off, blight and rot (Rhizoctonia solani) symptoms</i>
<i>Death of seedling due to damping off</i>		

## Symptoms

The pathogens attack any stage of crop beginning from seed rot; damping off of seedlings; or stunting, yellowing and death of older plants. Visible symptoms are the appearance of elongated sunken reddish-brown lesions on roots and stems at or below the soil line. Further the lesions girdle the stem, causing the death of the plant. Older plants may show little indication of the disease, although yields may be reduced. The pith may turn brick- red if invaded by the fungus.

## Cause

Fungus

## Comments

The pathogens are transmitted by irrigation water, soil and equipments.

## Management

Follow crop rotation with non host crops. Sow the seeds in warm soil with well prepared seed bed and proper depth. Treat seeds with a suitable fungicide.

## Category : Viral

**Mosaic** Bean common mosaic virus (BCMV)  
Bean common mosaic necrosis virus (BCMNV)

<i>Drybean leaflets showing symptoms</i>	<i>Infected leaves</i>	<i>Dry bean plants showing symptoms of Bean Common Mosaic Virus.</i>
<i>Leaves of a common bean plant showing symptoms of primary leaf necrosis caused by the Bean Common Mosaic Virus (BCMV).</i>	<i>Pods of common beans showing symptoms of black root necrosis caused by the Bean Common Mosaic Virus (BCMV).</i>	<i>A common bean plant showing symptoms of black root necrosis caused by the Bean Common Mosaic Virus (BCMV).</i>
<i>A common bean plant showing symptoms of black root wilting caused by the Bean Common Mosaic Virus (BCMV).</i>	<i>A common bean plant showing symptoms of stunting caused by the Bean Common Mosaic Virus (BCMV)</i>	<i>A common bean leaf of an infected plant showing leaf cupping and mosaic</i>
<i>Infected plant</i>	<i>Bean yellow mosaic on a bean leaflet showing the mosaic pattern</i>	<i>Bean yellow mosaic virus on a bean leaflet showing the mosaic pattern as caused by the Bean Common Mosaic Virus (BCMV).</i>
<i>Bean common mosaic virus symptoms on bean foliage</i>		

## Symptoms

Mottled dark and light green patterns on leaves; leaves may be distorted; yellow dots may be present on leaves; growth of plant may be reduced.

## Cause

Viruses

## Comments

BCMV can be transmitted by seed and has a worldwide distribution; BCMNV also transmitted through infected seed but geographic range more restricted.

## Management

Plant only virus-free seed; plant resistant varieties.

## Pests

### Category : Insects

#### **Aphids (Cowpea aphid, Pea aphid, etc.)** *Aphis craccivora* *Acyrrhosiphon pisum*

<i>Black Bean Aphid Aphis fabae</i>	<i>Close-up of Black Bean Aphids (Aphis fabae) colony</i>	<i>Cowpea aphid (Aphis craccivora) infestation</i>
<i>The aphids are tended by ants</i>	<i>Aphids on lower surface of leaves</i>	<i>Ladybird beetle feeding on bean black aphids</i>
<i>Winged aphids, the vectors of Bean Common Mosaic Virus (BCMV), on a bean leaflet.</i>	<i>Aphid infestation on bean plant</i>	<i>Pea aphid</i>

## Symptoms

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants.

## Cause

Insect

## Comments

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed.

## Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use.

## Armyworms (Beet armyworm, Western striped armyworm) *Spodoptera exigua*

*Spodoptera praefica*

Adult of beet armyworm

Beet armyworm (*Spodoptera exigua*) egg mass covered with hairs.

Larvae of beet armyworm

Beet armyworm egg mass hatching

Beet armyworm adult

Beet army worm late instar larvae

Damage due to early stage beet army worm larvae

Beet armyworm eggs

Beet armyworm (*Spodoptera exigua*) on leaf

## Symptoms

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside.

## Cause

Insect

## Comments

Insect can go through 3–5 generations a year.

## Management

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae.

## Corn earworm *Helicoverpa zea*

Larvae feeding on leaf Damages leaf      Larvae

Adult and larvae

Corn earworm (*Helicoverpa zea*)  
adults

Corn earworm on bean

## Symptoms

Larvae damage leaves, buds, flowers, pods and beans; young caterpillars are cream-white in color with a black head and black hairs; older larvae may be yellow-green to almost black in color with fine white lines along their body and black spots at the base of hairs; eggs are laid singly on both upper and lower leaf surfaces and are initially creamy white but develop a brown-red ring after 24 hours and darken prior to hatching.

## Cause

Insect

## Comments

Adult insect is a pale green to tan, medium sized moth; insect is also very damaging pests of corn; insect overwinters as pupae in the soil.

## Management

Monitor plants for eggs and young larvae and also natural enemies that could be damaged by chemicals; *Bacillus thuringiensis* or Entrust SC may be applied to control insects on organically grown plants; appropriate chemical treatment may be required for control in commercial plantations.

## Cutworms *Agrotis* spp.

*Peridroma saucia*

*Nephelodes minians*

and others

Bean leaf skeletonizer (*Autoplusia egena*) larva

French beans attacked by  
*Helicoverpa armigera*. Note the  
larvae within the bean.

Eggs of western bean cutworm  
(*Striacosta albicosta*)

Cutworm damage to bean seedling

Cutworm feeding on plant stem

Cutworms will curl up into a  
characteristic C shape when  
disturbed

Cutworm larva severing plant stem

## Symptoms

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5â€“5.0 cm (1â€“2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed.

## Cause

Insects

## Comments

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato.

## Management

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around

plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically.

## Leafminers *Liriomyza* spp

*Leafminer damage on bean plant leaf*

*Leafminer damage*

*Leafminer larvae*

*Larvae of leafminer*

*Tunnels caused by leafminer*

*vegetable leafminer (*Liriomyza sativae*) adult*

*An infested common bean leaf showing tracts of the leaf miner *Liriomyza* sp.*

*vegetable leafminer (*Liriomyza sativae*) on bean leaves*

*leafminer fly (*Liriomyza* sp.) adult*

*leafminer fly (*Liriomyza* sp.) pupa*

### Symptoms

Thin, white, winding trails on leaves; heavy mining can result in white blotches on leaves and leaves dropping from the plant prematurely; early infestation can cause fruit yield to be reduced; adult leafminer is a small black and yellow fly which lays its eggs in the leaf; larvae hatch and feed on leaf interior.

### Cause

Insects

### Comments

Mature larvae drop from leaves into soil to pupate; entire lifecycle can take as little as 2 weeks in warm weather; insect may go through 7 to 10 generations per year.

### Management

Check transplants for signs of leafminer damage prior to planting; remove plants from soil immediately after harvest; only use insecticides when leafminer damage has been identified as unnecessary spraying will also reduce populations of their natural enemies.

## Loopers (Cabbage looper, Alfalfa looper) *Trichoplusia ni*

*Autographa californica*

*soybean looper (*Thysanoplusia orichalcea*) on dry beans*

*Looper on bean leaf*

*Cabbage looper*

### Symptoms

Large or small holes in leaves; damage often extensive; caterpillars are pale green with a white lines running down either side of their body; caterpillars are easily distinguished by the way they arch their body when moving; eggs are laid singly, usually on the lower leaf surface close to the leaf margin, and are white or pale green in color.

### Cause

Insect

### Comments

Insects overwinter as pupae in crop debris in soil; adult insect is a dark colored moth; caterpillars have a wide host range.

## **Management**

Looper populations are usually held in check by natural enemies; if they do become problematic larvae can be hand-picked from the plants; an organically acceptable control method is the application of *Bacillus thuringiensis* which effectively kills younger larvae; chemical sprays may damage populations of natural enemies and should be selected carefully.

## **Mexican bean beetle *Epilachna varivestis***

Adult Mexican bean beetle

Adult beetle and damage to bean foliage

Mexican bean beetle larva

Mexican bean beetle damage to bean foliage

Eggs laid on underside of bean leaf

Bean plant infested with Mexican bean beetle larvae

### **Symptoms**

Irregular patches of feeding damage on underside of leaves which causes the top surface of the leaf to dry out, giving the leaves a lacy appearance; insect will also damage flowers and small pods; pods may be damaged so badly that they drop from the plant; adult insect is an orange-brown beetle with black spots; larvae are fat-bodied grubs which taper at the end and are in rows of conspicuous spines

### **Cause**

Insect

### **Comments**

Beetles can decimate bean crops; beetles overwinter as adults and undergo 2-3 generations per year

### **Management**

Some bean varieties may be less attractive hosts for the beetle, e.g. snapbeans are preferred hosts over lima beans; early varieties may escape damage form beetles beetle populations can be reduced by remove overwintering sites such as brush and leaves on the ground; handpick larvae and adults; brush eggs from leaves and destroy; apply insecticidal soap to leaf undersides if infestation is heavy

## **Stinkbugs (Conperse stinkbug, etc.) *Euschistus conspersus***

Florida Preatory Stink Bug,  
*Euthyrhynchus floridanus* (beneficial  
insect)

Stinkbug feeding on bean pod

brown stink bug (*Euschistus servus*)  
eggs

Globular stinkbug on leaf

Southern stinkbug feeding on bean  
leaf

Stinkbugs infestation on bean  
leaves

Predaceous anchor stink bug  
(*Stiretrus anchorago*) attacking  
green stinkbug nymph.

Conperse stinkbug

### **Symptoms**

Dark colored pinpricks on fruit surrounded by a lighter area that turns yellow or remains light green; stink bugs often carry pathogens in their mouthparts which can cause secondary infections and decay of fruit; adult insect is shield-shaped and brown or green in color; may have pink, red or yellow markings; eggs are drum shaped and laid in clusters on the leaves; larvae resemble the adults but are smaller.

### **Cause**

Insect

## Comments

Adult insects overwinter under leaves, on legumes, blackberries or on certain weeds such as mustard or Russian thistle.

## Management

Remove weeds around crop which may act as overwintering sites for stink bugs and practice good weed management throughout the year; organically accepted control methods include the use of insecticidal soaps, kaolin clay and preservation of natural enemies; chemical treatments are not recommended for tomatoes that are to be processed for paste or canning unless secondary infections with other pathogens are a concern.

## Category : Mites

### Spider mites (Two-spotted spider mite) *Tetranychus urticae*

*Spider mite symptoms on upper surface of leaves*

*Stippling injuries to leaves due to spider mites*

*Damaged leaf*

*Tropical spider mites necrosis to bean leaves on the field.*

*Underside of a bean leaf showing spider mites.*

*Spider mite infestation on lower surface of leaf*

*Spider mite infestation on bean foliage*

## Symptoms

Leaves stippled with yellow; leaves may appear bronzed; webbing covering leaves; mites may be visible as tiny moving dots on the webs or underside of leaves, best viewed using a hand lens; usually not spotted until there are visible symptoms on the plant; leaves turn yellow and may drop from plant.

## Cause

Arachnid

## Comments

Spider mites thrive in dusty conditions; water-stressed plants are more susceptible to attack.

## Management

In the home garden, spraying plants with a strong jet of water can help reduce buildup of spider mite populations; if mites become problematic apply insecticidal soap to plants; certain chemical insecticides may actually increase mite populations by killing off natural enemies and promoting mite reproduction.

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# Beet

## Description

The following are the crop details for Beet:

Scientific name: *Beta vulgaris*

Common name: Beetroot

Beet seedlings

Beet roots

Harvested beets

Beet greens

Beet foliage

Beet plants

## General Information

Beets are herbaceous biennial root vegetables in the family Chenopodiaceae grown for their edible root and young leaves. The plant is usually erect with a long main root and a rosette of leaves growing on stems.

The leaves are oval in shape, arranged alternately on the stem and grow 20â€“40 cm (7.9â€“15.7 in) in length. The roots

are usually red in color.

It produces sessile green flowers that are surrounded by leaf-like bracts and grow on a 4ft tall spike-like structure.

The plant produces sessile green flowers and can reach 1–2 m (3.3–6.6 ft) in height. Beets are usually grown as annual plants, harvested after one growing season.

Beets originated from the Mediterranean with Russia being the largest producer of sugar beets. They may also be referred to as beetroot, garden beet or spinach beet.

## Climate conditions, soil and water management

Beets are cool season vegetables with a long growing season. They grow best in cool climates but can tolerate some heat as well as some freezing.

### Temperature

The optimum temperature for their growth is between 15.5 and 18.3°C (60–65°F).

### Soil

Beets grow best in a loose, well drained soil with a pH between 6.2 and 6.8 and should be planted in full sun for optimum development.

They have a long taproot, therefore they like well drained loam soil that contain an abundant amount of organic matter.

### Watering

Even watering will promote the development of good quality roots and prevent the formation of rings in the root.

Keep the soil consistently moist but not waterlogged. Beets prefer even moisture to prevent cracking and toughening of the roots.

Water deeply and regularly, especially during dry spells. Aim for at least 1 inch of water per week, either from rainfall or irrigation.

## Beet Varieties

**Red Beet:** This is the most common and widely recognized beet variety. It has a deep red-purple flesh and skin. It contains an earthy and sweet flavor. Red beets are typically used in salads, pickling, and roasting.

**Golden Beet:** They have a vibrant yellow or golden flesh and a milder, sweeter flavor compared to red beets. They can be used in the same ways as red beets and are often preferred for their more delicate flavor.

**Chioggia Beet:** Also known as candy cane or candy stripe beets have pink and white rings on the inside creating a striking appearance. They have a mild, sweet flavor and are often used in salads to add a pop of color.

**Cylindra Beet:** Cylindra beets are elongated and cylindrical in shape, making them easy to slice and use in dishes like beet chips or for pickling. Contains a sweet and tender flavor.

**Detroit Dark Red Beet:** This heirloom variety is known for its deep, dark red color and sweet flavor. It's excellent for both fresh eating and canning.

**Bull's Blood Beet:** Bull's Blood beets have dark maroon leaves and deep red roots. They are often grown for their edible

greens and are used in salads or as a colorful garnish. They have an earthy and slightly sweet taste.

**White Beet:** White beets have white flesh and a mild, slightly sweet flavor. They are less common than red or golden beets but can be used in various recipes.

**Baby Beets:** These are simply young beets harvested at an early stage when they are small and tender. They can be red, golden, or any other variety, and are often used in salads or as a side dish.

**Forono Beet:** These beets are short and cylindrical, making them easy to slice into uniform rounds for cooking or pickling. Contains a sweet and tender taste.

## Uses

The roots are consumed after boiling and may be pickled in vinegar. The leaves of the spinach beet plant are consumed as a herb in Indonesia and Japan. Chemicals in the roots can be extracted and used as food coloring.

Beets contain a significant amount of vitamins A and C, calcium, iron, phosphorus, potassium, protein and carbohydrates. Beets are also high in folate, dietary fiber and antioxidants. They are high in betaine which is prescribed to lower toxic levels of homocysteine (Hcy) (which contributes to the development of heart disease, stroke and peripheral vascular disease). The highest levels of vitamins and other nutrients are available when the vegetables are eaten raw. The beet greens are high in vitamin A.

## Propagation

### Basic requirements

Beets are cool season vegetables with a long growing season. They grow best in cool climates but can tolerate some heat as well as some freezing. The optimum temperature for their growth is between 15.5 and 18.3°C (60°F–65°F). Beets grow best in a loose, well draining soil with a pH between 6.2 and 6.8 and should be planted in full sun for optimum development.

### Sowing

Beets are directly seeded and can be planted as soon as the soil is workable in Spring. The soil should be prepared for planting by ensuring land is well prepared with good drainage and enough organic matter.

The seeds are multi-germ clusters with two to five seeds. They are slow to germinate, so pre-soaking the seeds for 12 hours will encourage rapid and more even germination.

Plant one seed every 2.5 cm (1 in) at a depth of 13 mm (0.5 in) in rows spaced 30–40 cm (12–16 in) apart. Keep the seedbed well watered. Seedlings should emerge in 5 to 17 days at temperatures between 10 and 24°C (50°F–75°F).

When seedlings have reached between 7 and 10 cm (3–4 in) in height, thin to a final spacing of 7–10 cm (3–4 in) between plants. For a continuous harvest, plant seeds every 2–3 weeks as long as the daytime temperature stays below 26.6°C (80°F). Most beet varieties mature in 55 to 70 days.

Beetroot takes about two months to grow from sowing to maturity, mature height of the plant is about 9 cm.

### General care and maintenance

### Weeding

Keep the area around your beet plants free of weeds, as they can compete for nutrients and water. Remove any weeds

around plants by cultivating shallowly to avoid damaging the developing roots.

Use mulch (such as straw or wood chips) to help suppress weeds and retain soil moisture.

## **Thinning**

Thin beet seedlings when they are about 2-3 inches tall to provide adequate spacing between plants. This prevents overcrowding, allowing roots to develop properly.

Leave the healthiest-looking seedlings, spacing them 3-4 inches apart in rows.

## **Fertilizing**

Test your soil to determine its nutrient content, and fertilize accordingly. Beets generally benefit from well-balanced, fertile soil. Beets also require an adequate supply of nutrients, particularly phosphorus.

Apply a balanced, slow-release fertilizer or organic compost before planting.

Avoid excessive nitrogen, as it can lead to excessive leaf growth at the expense of root development.

## **Crop Rotation**

Practice crop rotation to prevent soil depletion and reduce the risk of disease. Avoid planting beets in the same spot in consecutive growing seasons.

## **Protection from Extreme Weather**

Beets prefer cool to moderate temperatures. If you're growing them in hot weather, consider providing some shade during the hottest parts of the day.

## **Pest and Disease Management**

Keep an eye out for common beet pests such as aphids, leafhoppers, and leaf miners. Remove affected leaves or use organic pest control methods as needed.

Practice crop rotation to reduce the risk of soil-borne diseases.

Beets are generally less susceptible to pests and diseases compared to some other crops, but it's still essential to monitor them regularly.

In case of frost, cover young beet plants with row covers or cloths to protect them.

## **Monitoring and Maintenance**

Regularly inspect your beet plants for signs of stress, disease, or pests. Early detection can help you address issues before they become severe.

Remove any dead or diseased leaves to promote air circulation and overall plant health.

*Harvest beet greens before they reach 6 inches in length*

*Beets are most tender when they are 1â€“2 inches in diameter*

# **Harvesting**

Young beet greens can be harvested for salads when they are 2.5â€“5.0 cm (1â€“2 in) high and older greens before they reach 15 cm (6 in) in length. Roots are also ready for harvest when the foliage starts to go limp.

The roots are ready for harvest when they have reached 2.5 cm (1 in) in diameter and are most tender before they exceed

7.5â€“10 cm (3â€“4 in).

Watering the soil the day before harvest or the day after rainfall makes pulling the beets easier. Pull beets out of the soil by firmly grasping the top and pulling the root out of the soil vertically. Alternatively, use a garden fork to dig the beets out of the soil. Cut the tops of the beets to 1.25â€“2.5 cm (0.5â€“1.0 in) above the root before storing the root. This helps keep the beets fresh.

Beets can be stored for long periods of time if they are very cool and very damp.

Once the top of the beets has been removed, roots are washed and stored in polythene bags to lengthen the shelf-life by reducing water loss during storage and transit.

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## Common Pests and Diseases

### Diseases

#### Category : Bacterial

##### **Bacterial blight** *Pseudomonas syringae* pv. *aptata*

*Symptoms on lower surface*

*Lower surface of infected leaf*

*Infected beet leaf*

*Bacterial blight symptoms*

*Signs of bacterial leaf spot  
(*Pseudomonas syringae* pv. *aptata*)  
on a beet leaf.*

## Symptoms

The infected leaves show irregular to circular shaped spots with tan to dark brown centers and dark black borders. In some instance symptoms also appear on the edges of the leaves which initially may appear water-soaked and later turn yellow and then necrotic. These spots may join together between the veins and the dried area falls off, which gives a ragged appearance.

## Cause

Bacterium

## Comments

The bacteria spreads mainly by splashing rainfall, mechanical and insect injuries. The pathogen also infects other crops like bean, eggplant, lettuce, and pepper.

## Management

Use healthy and disease free seeds.

## Scab *Streptomyces scabies*

### Symptoms

Small round spots on roots that enlarge, turn brown and rupture the epidermis; raised corky spots on root surface that are gray, white or tan in color.

## Cause

Bacterium

## Comments

Bacteria survive in soil; disease emergence favors dry conditions.

## Management

Do not plant in soil known to be infected; avoid crop rotation with potato.

## Category : Viral

### Beet curly top disease *Beet curly top virus (BCTV)*

*Beet severe curly top virus (BSCTV)*

*Beet mild curly top virus (BMCTV)*

*The beet leafhopper, vector of beet curly top geminivirus.*

*Beet leafhopper adult*

*Foliar chlorosis caused by the infection with Beet curly top virus*

*Sugar beet varieties show different degree of susceptibility to Beet curly top disease.*

*Beet curly top virus infected plant*

*Beet curly top virus infected plant showing characteristic inrolling of the leaf margins.*

*Left plant tolerant, right plant highly susceptible to Beet curly top virus*

*Plant infected with Beet curly top virus showing foliar chlorosis and curling of leaves*

*left two rows: variety tolerant to Beet curly top virus, right two rows: variety highly susceptible to Beet curly top virus*

*left: healthy beet leave, right: beet leave showing symptoms of curly top*

## Symptoms

The infected leaves become dwarfed, crinkle and rolled upward and inward. The veins become irregularly swollen on the lower surface. The diseased beet shows discoloration of the vascular tissue. The young roots become dwarfed and rootlets are twisted and distorted. The death of rootlets leads to growth of new rootlets which gives the hairy root appearance.

## Cause

Virus

## Comments

The beet curly top virus is transmitted by beet leafhopper, *Circulifer tenellus*. The virus infect many weed plants and act as a source of inoculum for the next cropping season.

## Management

Grow available resistant varieties. Keep the field free from overwintered weeds. Spray suitable insecticide to control leafhoppers.

## Beet western yellows virus *Beet Western Yellows Virus (BWWV)*

Infected field

Field of sugar beets showing typical foliar symptoms (chlorosis) caused by BWWV

Close-up of infected field

Close-up of sugar beet leaf showing typical symptoms

Close-up of sugar beet leaf showing typical symptoms of BWWV.

Sugar beet leaf showing typical symptoms of BWWV.

## Symptoms

The symptoms first start on older leaves as yellowing between the veins with possible small reddish brown spots which gives a distinct bronze cast on infected leaves. Later the leaves become thick, leathery, and brittle.

## Cause

Virus

## Comments

The virus is transmitted by aphids (green peach aphids and black bean aphids). It has an extensive host range.

## Management

Grow available resistant varieties. Keep the fields free from the previous season crop in the off season. Control aphids.

## Category : Fungal

### Cercospora leaf spot *Cercospora beticola*

Drying of leaves due to cercospora leaf spot disease

Damaged plant Infected leaves

Cercospora leaf spot infection

Severely infected plant

Cercospora leaf spot symptoms

Infected leaf

Cercospora leaf spot symptoms

Cercospora leaf spot symptoms

Cercospora leaf spot symptoms

Cercospora leaf spot symptoms

Cercospora leaf spot symptoms on sugar beet

## Symptoms

Brown to gray flecks or spots surrounded by red-purple halos on leaves; yellow or brown necrotic leaves.

## Cause

Fungus

## Comments

Fungal spores spread by wind and rain; high temperatures and humidity promote infection; fungus overwinters on crop residue or in seed.

## Management

Rotate crops every 2-3 years; apply a fungicide at first sign of disease; plow crop debris into soil immediately after harvest.

## Damping off *Rhizoctonia solani*

*Phoma betae*

*Pythium ultimum*

*Aphanomyces cochlioides*

*Infected sugar beet seedlings*

*Sugar beet seedling infected with damping off disease*

*Infected seedling*

*Damaged seedling*

*Aphanomyces seedlings damping-off*

*Damping off symptoms*

*Symptoms of damping-off on young beet plant*

*Constriction of stem near soil line due damping off disease*

*Beet seedling showing damping off symptom*

## Symptoms

Seedlings collapsing; blackened roots; constriction of plant crown.

## Cause

Fungi

## Comments

Warm, wet weather favors disease emergence; beet very susceptible.

## Management

Treat seeds with fungicide prior to planting; plant in well draining soil; do not plant until soil is sufficiently warm.

## Downy mildew *Peronospora farinosa*

*Spinach leaf showing angular chlorotic lesions caused by the pathogen Peronospora farinosa.*

*Underside of spinach leaf showing sporulation of the pathogen (Peronospora farinosa)*

*Dense mat of sporangiophores*

*Sporulation on lower surface of leaf*

## Symptoms

Plant leaves appear lighter green; small, puckered, thickened leaves; fuzzy gray growth on both leaf surfaces.

## Cause

Fungus

## Comments

Fungus survives in crop residues over winter to infect new crop.

## Management

Grow available resistant varieties. Remove and destroy the infected crop debris.

## Fusarium yellows and root rot *Fusarium oxysporum f. sp. spinaciae*

## *Fusarium oxysporum f. sp. betae*

Sugar beet field showing symptoms of infection with Fusarium wilt (*Fusarium oxysporum f.sp. betae*).

Symptoms of Fusarium wilt caused by *Fusarium oxysporum f.sp. betae*

Typically only one side of the leaves is affected and appear scorched.

Leaves become dry, brittle and remain clustered around the crown

Wilting of plant

Sugar beet (common beet) plants showing symptoms of Fusarium wilt caused by *Fusarium oxysporum f.sp. betae*

### Symptoms

The infected leaves exhibit yellowing between the larger veins. Later entire leaves become dry, brittle and remain clustered around the crown. Typically only one side of the leaves is affected and appear scorched. The vascular tissues of infected plants become discolored. Plant appear wilted during day time and recover at night. The tip of taproot becomes black due to rotting.

### Cause

Fungus

### Comments

The pathogen survive on weeds like pigweed, Kochia, and lambs quarters during off season.

### Management

Plant resistant varieties. Crop rotation with non host crop. Keep field free from weeds.

## **Powdery mildew** *Erysiphe betae*

Upper surface covered with white mycelial mat due to powdery mildew disease

Stems are also affected by powdery mildew

Powdery mildew symptoms on upper surface of leaf

Close-up of cleistothecia of powdery mildew

Varietal differences in powdery mildew tolerance on sugarbeet

Heavy infection with powdery mildew

Cleistothecia of powdery mildew

Small, scattered, circular, white mycelium mats on lower surface of leaf

Sugar beet leaf showing powdery mildew symptom. Note the chlorosis associated with the disease.

Sugar beet infected with powdery mildew under greenhouse conditions

Underside of leaf showing powdery mildew of sugar beet

close-up of mycelium patch of powdery mildew

### Symptoms

Initially the symptom appears on older leaves as small, scattered, circular, white mycelium mats on lower surface. Later all the leaves of the plant infected and appear dusty white on both surfaces. If the disease is severe the leaves become yellow and then turn purplish-brown.

### Cause

Fungus

### Comments

The spores are transmitted by air. If the weather conditions are good, one can see, particularly on the upper surface of the older leaves dark brown to black, globular, sexual reproductive structures (chasmothecia = cleistothecia).

### Management

Grow available resistant varieties. If the disease is severe, spray suitable fungicide.

## Pests

### Category : Nematodes

#### Beet cyst nematode *Heterodera schachtii*

Beet cyst (white dot in center of frame) on small roots of sugar beet plant

Beet roots showing cyst due to beet cyst nematode infestation.

Sugarbeet field showing damage caused by the beet cyst nematode

Root of sugarbeet infected with beet cyst nematode

Beet plants infested with beet cyst nematode

Healthy (left) and cyst nematode (*Heterodera schachtii*) infected roots (right) of sugar beet

Formation of cyst on beet roots

#### Symptoms

The symptoms may vary depend on the stage of the crop infected by the nematode. The infected seedling exhibit stunting and reduced leaf growth. Also the older leaves of seedlings will become yellow and wilted during the hot period of the day. Below ground, the roots appear stunted with lots of secondary roots. Also the infected roots show yellow-brown cysts. If the nematodes infect the older plants the symptoms are not much noticeable.

#### Cause

Nematode

#### Comments

Nematodes are mainly transmitted by irrigation water, equipment, weed plants etc.

#### Management

Keep the field free from weeds. Follow crop rotation. Deep summer plowing helps in exposing cyst in the soil to sunlight. Grow available resistant varieties.

#### Root knot nematode *Meloidogyne* spp.

Galled roots of beet

Galled roots of beet caused by root knot nematode

Root knot nematode symptoms

#### Symptoms

Galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; reduction in plant vigor; yellowing plants which wilt in hot weather.

#### Cause

Nematode

#### Comments

Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or garden with this type of soil is most likely.

#### Management

Plant resistant varieties if nematodes are known to be present in the soil; check roots of plants mid-season or sooner if

symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens.

## Category : Insects

### Darkling beetle (Rove beetle) *Blapstinus* spp.

*Staphylinid* spp

*Darkling beetle adult*

*Darkling beetle*

*Darkling beetle (Blapstinus interruptus) adult*

#### Symptoms

Feeding damage on stems; death of seedlings; seeds dug up; insect is a dull blue-black or brown beetle about 0.6 cm (0.52 in) long; tips of antennae are often enlarged, resembling a club.

#### Cause

Insect

#### Comments

Beetles are generally active at night; during the day beetles hide in organic debris.

#### Management

Ditches filled with water can prevent spread of beetle to/from adjacent fields; remove all weeds from garden borders; if beetle is problematic then appropriate insecticides can provide control; insecticides are usually in the form of baits.

### Leafminers *Lyriomyza* spp.

*Damage due to leafminer*

*Leafminer adult*

*Leafminer damage*

*Leafminer damage on Beets.*

#### Symptoms

Thin, white, winding trails on leaves; heavy mining can result in white blotches on leaves and leaves dropping from the plant prematurely; early infestation can cause fruit yield to be reduced; adult leafminer is a small black and yellow fly which lays its eggs in the leaf; larvae hatch and feed on leaf interior.

#### Cause

Insect

#### Comments

Mature larvae drop from leaves into soil to pupate; entire lifecycle can take as little as 2 weeks in warm weather; insect may go through 7 to 10 generations per year.

#### Management

Check transplants for signs of leafminer damage prior to planting; remove plants from soil immediately after harvest; only use insecticides when leafminer damage has been identified as unnecessary spraying will also reduce populations of their natural enemies.

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# Bergamot

## Description

Bergamot, *Citrus bergamia*, is an evergreen tree grown for its fruit, flowers and leaves, which are used primarily for the extraction of its lemon scented oil. Bergamot is an erect, branching tree with oval leaves that are alternately arranged. The tree produces clusters of white flowers and a fruit that resembles a pear-shaped orange. The fruit is green and turns yellow when ripe. Bergamot trees can reach up to 4 m (13.1 ft) in height and will remain productive for up to 60 years if managed well. Bergamot may also be referred to as bergamot orange or sour orange, and its origin is unknown, although it is almost exclusively grown in the coastal plains of southern Italy.

### Crop Details

Scientific Name: *Citrus bergamia*

Other Common Names: Bergamotto (Italian), bergamote (French), bergamotte (German), bergamot (Turkish), Бергамот (Russian)

*Bergamot orange tree*

## Uses & Benefits

Bergamot's essential oil is known for its ability to effectively combat stress, anxiety, depression, improve digestion, relieve pain and heal wounds.

On the skincare front, the oil's antibacterial and anti-inflammatory attributes make it a valuable asset against conditions like acne, eczema, and psoriasis.

Bergamot's distinctive citrus flavor is a staple in Earl Grey tea and culinary applications.

The oil produced by the flowers, leaves and rind of the fruit is used in eau de toilette, cologne and soap. The bitter fruit is used to make marmalade and to flavor liqueurs.

## Varities of Bergamot

Bergamot, when referred to in the context of plants, often relates to two main types: *Monarda didyma* (Bee Balm) and *Citrus bergamia* (Bergamot Orange). Here are common varieties of both:

### ***Monarda didyma* (Bee Balm)**

Jacob Cline: This variety features bright red, tubular flowers and stands out for its excellent mildew resistance. It's a favorite among gardeners and attracts pollinators like bees and hummingbirds.

Prairie Night: Known for its deep purple or nearly black flowers, Prairie Night is a striking addition to any garden. It also has a strong, pleasant aroma.

Raspberry Wine: With its vibrant, raspberry-colored blooms, this cultivar adds a burst of color to gardens. Its scent is reminiscent of raspberries, and it attracts pollinators.

Balmy Series: This series includes various colors like pink, purple, and lavender. The compact size of these plants makes them ideal for small gardens or containers.

### ***Citrus bergamia* (Bergamot Orange)**

Castagnaro: A popular Italian variety, 'Castagnaro' is known for its high-quality fruit and aromatic peel. It's primarily used in the production of Bergamot essential oil.

Calabrese: Grown in the Calabria region of Italy, this variety is highly prized for its fragrant and flavorful fruit, making it a key ingredient in Earl Grey tea.

Meyer Lemon Bergamot: This hybrid variety combines the traits of the Meyer lemon and bergamot. It offers sweeter and less acidic fruit with the signature bergamot aroma.

Djerba Bergamot: Grown on the Tunisian island of Djerba, this bergamot variety is known for its sweet and aromatic peel, which is used in perfumery and culinary applications.

## Propagation

### **Basic requirements**

Bergamot oranges grow best in regions with a pronounced change in season. They will grow best at temperatures between 12.8 and 37.8°C (55–100°F) during the growing season and 1.7 to 10°C (35–50°F) during dormancy. Mature trees can survive short periods of freezing, whereas young trees will be killed. Trees should be protected from frosts and freezing conditions to prevent damage.

The trees will also tolerate drought conditions but perform poorly in water-logged soil. Trees will grow best when planted in a well-draining sandy loam with a pH between 6.0 and 7.5. The soil must be deep enough to permit adequate root development. Trees require full sun and should be protected from wind, which can cause damage to the trees.

## **Propagation**

Bergamot seedlings are usually produced by grafting or budding to an appropriate rootstock, as seeds will not produce fruit true to type. Grafting is the process by which a scion from one plant is joined to the rootstock of another to produce a new tree. Budding is a special type of grafting where the scion that is joined to the rootstock consists of a single bud. Budding is commonly used in citrus propagation as it is the easier of the two processes and works very well.

## **Budding**

Budding should be carried out when seedling stems have reached roughly the diameter of a pencil (6–9 mm/0.25–0.36 in) and at a time when the bark of the rootstock tree is slipping (this is the term used to describe a period of active growth when the bark can be easily peeled from the plant).

Twigs (budwood) should be collected from the previous growth flush or the current flush so long as the twig has begun to harden. The twigs should have well developed buds and should be as close as possible to the diameter of the rootstock onto which they will be joined. It is extremely important to only collect budwood from disease-free trees. The use of diseased budwood can cause the spread of many serious citrus diseases, which can kill trees.

The budwood to be used for propagation should be trimmed to create budsticks that are 20–25 cm (8–10 in) by removing any unwanted wood and leaves. These budsticks can be stored for 2–3 months under the correct conditions but it is best to use them as soon as possible after cutting. The simplest way to join the budwood to the rootstock is by T-budding. The area to be joined should be pruned to remove any thorns or twigs and the cut should be approximately 15 cm (6 in) from the ground. Using a sharp knife, a 2.5–3.8 cm (1–1.5 in) vertical cut should be made in the stem of the rootstock, through the bark.

A horizontal cut should be made at either the top or the bottom of the vertical cut to produce a 'T-shape'. The horizontal cut should be made at a slightly upward-pointing angle and should reach through the bark. Remove a bud from a budstick by slicing a thin, shield-shaped piece of bark and wood from the stem, beginning about 1.25 cm (0.5 in) above the bud. This piece should measure 1.9–2.5 cm (0.75–1.0 in) in length. Immediately insert the piece of bud into the cut on the rootstock by sliding it under the opened bark so that the cut surface lies flat against the wood of the rootstock plant. Finish the join by wrapping the bud with budding tape. When the union is made and the tape is removed, the bud is forced to grow by cutting the rootstock stem above the join, about 2/3 of the way through the stem. This cut should be made 2.5–3.9 cm (1.0–1.5 in) on the same side as the join. The top of the seedling should then be pushed over towards the ground. This process, known as "lopping", allows all of the nutrients to be diverted to the bud. Once the bud begins to grow and reaches several inches in length, the lop can be removed completely from the seedling.

## **Planting seedlings**

Bergamot trees can be purchased as seedlings that have already been grafted and only require planting in the garden or orchard. The best time to plant citrus trees is in the spring, after all the danger of frost has passed in your area. Standard sized trees should be spaced 3.7–7.6 m (12–25 ft) apart in an area that receives full sunlight but is protected from strong winds, which can damage the trees. Planting against a south facing wall will help protect the tree in cooler climates.

## **General care and maintenance**

Newly planted trees require proper irrigation to ensure they become established. During the first year, water should be applied at the base of the trunk so that the root ball is kept moist to allow the roots to establish themselves in the soil. Newly planted trees should be provided with water every 3–7 days. The soil should be moist, but not wet. Trees planted in sandy soils will require water more frequently. Young trees will also require a light application of fertilizer every month in the first year.

## **Harvesting**

Harvesting bergamot, whether it's *Monarda didyma* (Bee Balm) or *Citrus bergamia* (Bergamot Orange), involves careful

timing and consideration of the specific plant type. For *Monarda didyma*, which is often grown for its striking flowers and aromatic leaves, the best time to harvest is when the blooms are in full glory. To maintain the plant's health and encourage continuous flowering, it's advisable to trim the flowering stems, cutting them just above a pair of leaves while ensuring not to remove more than one-third of the plant's height at a time. On the other hand, *Citrus bergamia*, primarily cultivated for its fragrant peel, is harvested during the winter months when the fruit is ripe. The fruit should be gently hand-picked to avoid damage to the tree and then carefully peel the bergamot, capturing the valuable essential oils. Proper harvesting methods are essential to maintaining the quality and utility of the harvested material.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Alternaria brown spot** *Alternaria* spp.

###### **Symptoms**

Infected fruit change color prematurely; brown or black lesions on young twigs, leaves and fruit; diseased fruit may fall from tree.

###### **Cause**

Fungi

###### **Comments**

Avoid overhead irrigation and excessive application of nitrogen.

###### **Management**

Plants that are stressed are more susceptible to the disease, ensure plants are provided with water and fertilizer; delaying harvest until diseased fruit has dropped from tree can reduce the number of fruit lost to the disease post harvest; preharvest treatment with fungicide is often ineffective.

##### **Black spot** *Guignardia citricarpa*

*citrus black spot (Guignardia citricarpa)*

*Black spot symptoms on lemon*

*Black spot on orange*

*Close up of black spot*

*Citrus black spot symptoms*

*Hard sunken spots with brown to black margins and gray necrotic tissuee in the center. Pycnidia could be present in the spots.*

*Black spot on fruits of Valencia orange caused by Guignardia citricarpa.*

### Symptoms

Small brown or black spot and speckles on rinds of fruit; premature fruit drop; reduced fruit yield; symptoms are often more apparent on the side of trees which receive most sunlight; infected leaves generally show no symptoms.

### Cause

Fungus

### Comments

Widespread in areas of the Southern hemisphere with summer rainfall; fungus survives in decomposing leaves on/in soil around infected trees; spores can be spread by wind and water splash.

### Management

Remove leaf litter from around trees to reduce inoculum; keep trees well irrigated during dry periods to reduce leaf fall; apply copper containing fungicides where appropriate.

## Powdery mildew *Oidium tingitaninum*

*Oidium citri*

### Symptoms

White powdery patches on upper surface of young leaves and possibly stems and young fruit; newly emerging leaves and shoots may be discolored; severe infestation can cause leaves to drop from plant, twigs to die back and premature dropping of fruit.

### Cause

Fungus

### Comments

Emergence of disease is favored by cool, damp weather conditions; very common in Asian countries.

### Management

Disease can be controlled by timely applications of fungicide to protect new growth flushes; systemic fungicides give longer periods of protection.

## Pseudocercospora leaf and fruit spot *Pseudocercospora angolensis*

### Symptoms

Lesions with gray centers and chlorotic halos on leaves; holes in leaves where lesions have dropped out; lesions may coalesce to produce chlorotic patches on leaves; raised tumor-like growths on young fruit; circular or irregularly shaped flat lesions on mature fruit.

### Cause

Fungus

### Comments

Can be devastating to citrus trees.

### Management

## Management

Control relies on the use of copper fungicides.

## Category : Bacterial, Fungal

### Canker *Xanthomonas axonopodis*

*Xanthomonas axonopodis* symptoms      Infected plant

*Xanthomonas axonopodis* symptoms  
on citrus leaves

Symptoms of canker on citrus

*Citrus* infected with *Xanthomonas axonopodis*

Symptoms of citrus canker caused  
by the plant-pathogenic bacterium,  
*Xanthomonas axonopodis*, on leaves  
and fruits of citrus plants

Citrus canker (*Xanthomonas axonopodis*) infected plant

bacterial leaf spot (*Xanthomonas axonopodis*) on orange

#### Symptoms

Slightly raised blisters on leaves with surrounding tissue turning yellow; lesion turn tan brown in color and develop a water soaked margin with white halo; centers of lesions become raised and develop a corky texture; lesions on stems and twigs are raised, corky and dark brown to black in color with an oily or water soaked margin; raised blister-like lesions develop on fruit; fruit lesions turn dark brown or black and are sunken; fruit drops from tree prematurely.

#### Cause

Bacterium

#### Comments

Serious disease in humid tropical and subtropical areas; disease spreads rapidly over short distances.

#### Management

Control of the disease is reliant on timely sprays of copper containing fungicides and the provision of windbreaks to reduce spread of inoculum from infected trees.

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# Black pepper

## Description

Black pepper, scientifically known as *Piper Nigrum*, is a climbing perennial plant in the family Piperaceae.

It is mainly grown for its fruit, which is processed to create black, white, and green peppercorns, commonly used as a spice in cooking.

The plants of black pepper may have either vining or bushy, woody stems.

The plant features simple, alternating leaves with an oval shape and produces clusters, or spikes, of 50 to 150 flowers. These flowers give rise to small, spherical green fruits that ripen to red.

Each stem has the potential to produce 20-30 of these spikes. While black pepper can grow to a height of 10 meters (33 feet) in the wild, under cultivation, it is usually maintained at a more manageable 3-4 meters (10-13 feet). Black pepper is a perennial plant with a lifespan of over 30 years, and it typically has a commercial lifespan of 12–20 years. This versatile spice is native to south and southeast Asia.

*White, green and black peppercorns*

*Black pepper fruits and foliage*

*Black pepper spikes*

## Varieties

Among the numerous pepper varieties, only a select few are important as spices. These include:

Black pepper hails from India, Malaysia, and Indonesia.

Bengal pepper originates in the mountainous regions of the lower Himalayas.

Java pepper is native to Malaysia and Indonesia.

Ashanti pepper is indigenous to tropical Africa.

Kubeben pepper is found in Indonesia and Malaysia.

## Uses

Black pepper plants are cultivated to produce black, white, and green pepper. The processing methods vary for each type:-

*Black pepper* is the result of drying the fruit to produce the familiar black peppercorns.

*White pepper* is produced by soaking the fruits in water for about a week to recover the seed from the decomposed fruit.

*Green pepper* is produced by drying unripe fruit in a way that retains its green color. Green peppercorns are often preserved by pickling.

Pepper is one of the oldest classic spices and is used as an ingredient in many spice mixtures, such as curry. Black pepper, white pepper, and green pepper all derive from the *piper nigrum* plant. The distinct types of pepper are obtained by harvesting at different stages of ripeness and applying different processing techniques.

Pepper seeds contain various components, including essential oil, piperine, chavicine, piperidine, fatty oils, resin, starch, and water. The alkaloid piperine is primarily responsible for the sharp taste associated with pepper.

## Propagation

Black pepper can be propagated using three main methods: dry seeds, cuttings, or stolons.

Cuttings are the most common method for commercial production. They are typically taken from the secondary runners of the plant and should have one or two leaves. These cuttings are rooted in a seedbed and then transplanted when the plant has 4-7 new leaves.

In cultivation, a trellis is used to support the plant, and the trellis should be at least 4 meters (13 feet) high.

When planting, black pepper should be spaced at 8 Å— 8 meters (26 Å— 26 feet), meaning 8 meters between individual plants and 8 meters between rows.

## Methods of propagation

### i). Seed Propagation

While propagation using seeds is possible, it's less common on conventional plantations due to the lengthy germination process.

Germination from seeds can lead to genetic diversity, including male and female plants.

Seeds are typically obtained by soaking fully ripened berries in water for 2-3 days, then removing the meat and drying them in the shade.

They are then planted in moist, shaded beds and will germinate after about 30 days. Transplanting to their final sites occurs after they have produced four leaves.

### ii). Cuttings Propagation:

The most widely used method of propagation is through cuttings taken from the terminal area of a healthy parent plant.

These cuttings are selected after removing the vegetation apex, leaves, and lateral shoots from the 3rd to the 7th knots.

Cuttings are planted in a seedling bed at an angle of 45° with 3-4 knots, leaving the uppermost leaves.

The seedbed must be kept moist and shaded. The cuttings usually take root after about 2 months, with a success rate of approximately 30%.

They can then be transplanted to their final sites.

### iii). Rooted Pepper Cuttings propagation:

Another method involves using rooted cuttings, where the shoots are directly attached to the plant itself.

The process is similar to standard cuttings, but a layer of moist moss or humus is bound around the 7th knot and secured with plastic foil.

After approximately 2 months, the shoot is cut away and acclimatized in a polyethylene bag in the planting bed before being transplanted to its final site.

This method yields a higher success rate for shoot rooting but involves more work.

## Climatic condition for black pepper cultivation

Black pepper (*Piper nigrum*) thrives in specific climatic conditions, which are crucial for its successful cultivation. These conditions encompass various factors, including soil, water temperature, spacing, and sunlight. Here's an overview of each aspect:

*a). Soil:*

Black pepper grows best in well-draining soils rich in organic matter.

The ideal soil pH for black pepper is around 5.5 to 6.5.

It requires good soil aeration and texture for healthy root development.

*b). Water Temperature:*

Black pepper is a tropical crop and prefers warm temperatures.

The crop tolerates temperatures between 10°C and 40°C.

The ideal temperature range for black pepper is 23°C to 32°C, with an average of 28°C.

Optimum soil temperature for root growth is around 26°C.

*c). Spacing:*

Adequate spacing is crucial for black pepper vines to grow well.

Typically, black pepper vines need about 3-4 meters of spacing between them, as they are climbers and require room to spread and climb.

*d). Sunlight:*

Black pepper plants require partial to full sunlight for healthy growth.

They need at least 4-5 hours of direct sunlight daily.

In regions with intense heat, providing some shade during the hottest part of the day can be beneficial.

Understanding and optimizing these climatic conditions is essential for the successful cultivation of black pepper. These factors contribute to the quality and yield of this popular spice.

## Care and Maintenance of Black Pepper Plants

Black pepper (*Piper nigrum*) is a popular spice known for its pungent flavor. Growing and maintaining black pepper plants can be a rewarding endeavor, but it requires proper care and attention to detail. Here's a guide on how to care for and maintain black pepper plants:

*1. Planting:*

Choose a suitable location with well-draining soil and partial sunlight.

Plant black pepper vines in rows or on trellises, allowing them to climb.

*2. Watering:*

Maintain consistent moisture, as pepper plants prefer slightly damp soil.

Avoid waterlogging, which can harm the roots.

*3. Pests and Diseases:*

Pests like aphids and scale insects are rampant; keep an eye on them.

You can remove dead or diseased branches to avoid diseases.

You will have to treat diseases like root rot promptly.

#### *4. Fertilization:*

Apply a balanced fertilizer with micronutrients regularly.

Use organic matter to enrich the soil.

#### *5. Pruning:*

Trim and prune the vines to encourage bushier growth.

## **Harvesting Black Pepper**

Black pepper harvesting is a crucial step in the spice production process. Here's how to harvest black pepper:

#### *1. Timing:*

Harvest black pepper when the berries turn from green to red or yellow, depending on the variety.

Avoid picking unripe or overripe berries.

#### *2. Methods:*

Handpick the berries or use tools like shears for larger harvests.

Be gentle to prevent damaging the vines.

#### *3. Post-Harvest Processing:*

Thresh the berries to separate them from the stems.

Blanch, dry, clean, grade, and package the peppercorns for market distribution.

## ***Prevention and Regulation of Pests and Diseases in Organic Pepper Cultivation:***

### **Choice of Site:**

Select a site that is well-drained and avoids waterlogging.

Ensure the presence of ample organic material in the soil.

### **Establishment of a Diversified Mixed Cultivation System:**

Implement a mixed cultivation system that includes a variety of crops.

This diversity can help reduce the risk of pests and diseases by disrupting their host plants.

### ***Removal of Diseased Plant Material:***

Regularly remove any diseased or infected plant material to prevent the spread of pests and diseases.

### **Light/Shade Management and Organic Material Enrichment:**

Manage the balance of light and shade in the cultivation area.

Enrich the organic material with tree pruning to improve soil health.

#### *Constant Renewal of the Site:*

Consider ongoing site renewal to maintain soil fertility and reduce the risk of disease buildup over time.

#### Lignin-Rich Mulch Material:

Use lignin-rich mulch material to stimulate the growth of actinomycetes in the soil.

Actinomycetes are natural antagonists to pathogens like Fusarium.

These measures are crucial for maintaining a healthy, disease-resistant organic pepper cultivation system. They focus on proactive steps to prevent and manage pests and diseases while promoting soil health and biodiversity.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Anthracnose** *Colletotrichum gloeosporioides*

###### **Symptoms**

Small brown specks with yellow halos on leaves, spikes and berries; defoliation and spike shedding; cracks on berries

###### **Cause**

Fungus

###### **Comments**

Cracking on berries encourages secondary infections with other fungal pathogens

###### **Management**

As anthracnose is primarily a disease that occurs during the rainy season, systemic fungicides are required to prevent chemicals leaching from the plant; 1% Bordeaux mixture can be applied during monsoon season; metalaxyl and fosetyl are also effective

##### **Charcoal rot** *Macrophomina phaseolina*

###### **Symptoms**

Discoloration of vine at soil line; cankers on stem may spread upwards; leaves may wilt and drop from plant; numerous small black sclerotia (fungal fruiting bodies) develop in affected tissues and can be used to diagnose the disease

#### Cause

Fungus

#### Comments

Fungus had a wide host range and affects beans, tobacco, soybean, pigeon pea and many other crops; disease is primarily spread via microsclerotia in the soil

#### Management

Organic soil amendments such as the addition of manure or neemcake can be used to reduce levels of inoculum in the soil

### **Root rot (Foot rot) *Phytophthora capsici***

#### Symptoms

Black water soaked lesions on leaves and/or stems during wet weather; symptoms usually develop on lower leaves which have been splashed by water; leaves wilt rapidly and drop from plant; entire vine is killed within a period of days to weeks

#### Cause

Oomycete

#### Comments

Can be transmitted to a field through infected runners or roots and adhering soil; foot rot is a destructive disease in Malaysia and Indonesia; emergence of the disease is favored by wet, poorly draining soil

#### Management

Avoid unnecessary tilling of soil which can be conducive to spreading the pathogen; a cover crop of grass can help prevent water splash on the plants and thus the spread of the fungi; amending the soil with neem cake suppresses the Phytophthora and provides nutrients to the vines; systemic fungicides such as metalaxyl and fosetyl can give some measure of control; efforts are being made to establish resistant varieties

## Pests

### Category : Insects

### **Pepper lace bug *Diconocoris hewitti***

Pepper lace bug nymph

Adult pepper lace bug

#### Symptoms

Brown or lack discoloration on inflorescences inflorescence and young berries wilting and turning gray; high infestations can cause inflorescence to collapse; lace bugs are sucking insects, the adult is gray-black in color and has distinctive horn-like protrusions on its shoulders; nymphs are light brown in color with a row of dark bristles on each side

#### Cause

Insect

#### Comments

Insect is a damaging pest of black pepper in Malaysia and Indonesia

#### Management

Small populations of the insect can be hand picked from plants and destroyed; insecticide application may be required to control high populations

## Striped mealybug *Ferrisia virgata*

*Striped mealybug infestation*

*Close-up of striped mealybug*

*striped mealybug (*Ferrisia virgata*)*

*Development of sooty mold on black pepper leaf*

*Ants tending mealybugs*

*Fruit spike damaged by mealybugs*

*Mealybugs*

### Symptoms

Poorly developed, stunted new growth; damaged fruits; yellowing leaves; insect excretes a sticky substance called honeydew which promotes secondary growth of gray molds; insects are soft bodied and relatively immobile; females are covered in waxy white threads; often tended by ants.

### Cause

Insect

### Comments

Mealy bugs are most abundant during periods of drought (post-monsoon), particularly when pepper plants are producing new growth and developing new fruit spikes.

### Management

Insects may be dislodged by spraying a strong jet of water on the plants; several applications of appropriate insecticides may be required to control heavy infestations.

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# Blackberry

## Description

Black pepper, scientifically known as *Piper Nigrum*, is a climbing perennial plant in the family Piperaceae.

It is mainly grown for its fruit, which is processed to create black, white, and green peppercorns, commonly used as a spice in cooking.

The plants of black pepper may have either vining or bushy, woody stems.

The plant features simple, alternating leaves with an oval shape and produces clusters, or spikes, of 50 to 150 flowers. These flowers give rise to small, spherical green fruits that ripen to red.

Each stem has the potential to produce 20-30 of these spikes. While black pepper can grow to a height of 10 meters (33 feet) in the wild, under cultivation, it is usually maintained at a more manageable 3-4 meters (10-13 feet). Black pepper is a perennial plant with a lifespan of over 30 years, and it typically has a commercial lifespan of 12–20 years. This versatile spice is native to south and southeast Asia.

*Blackberry bush*

*Fruit close-up*

*Thorns on blackberry stem*

*Fall foliage*

*Foliage and blossoms*

*Plants laden with fruit*

*Blackberry blossoms*

*Ripening fruits*

*Ripening blackberry fruit*

## Uses

Black pepper plants are cultivated to produce black, white, and green pepper. The processing methods vary for each type:-

*Black pepper* is the result of drying the fruit to produce the familiar black peppercorns.

*White pepper* is produced by soaking the fruits in water for about a week to recover the seed from the decomposed fruit.

*Green pepper* is produced by drying unripe fruit in a way that retains its green color. Green peppercorns are often preserved by pickling.

Pepper is one of the oldest classic spices and is used as an ingredient in many spice mixtures, such as curry. Black pepper, white pepper, and green pepper all derive from the *piper nigrum* plant. The distinct types of pepper are obtained by harvesting at different stages of ripeness and applying different processing techniques.

Pepper seeds contain various components, including essential oil, piperine, chavicine, piperidine, fatty oils, resin, starch, and water. The alkaloid piperine is primarily responsible for the sharp taste associated with pepper.

## Varieties

Among the numerous pepper varieties, only a select few are important as spices. These include:

Black pepper hails from India, Malaysia, and Indonesia.

Bengal pepper originates in the mountainous regions of the lower Himalayas.

Java pepper is native to Malaysia and Indonesia.

Ashanti pepper is indigenous to tropical Africa.

Kubeben pepper is found in Indonesia and Malaysia.

## Propagation

Black pepper can be propagated using three main methods: dry seeds, cuttings, or stolons.

Cuttings are the most common method for commercial production. They are typically taken from the secondary

runners of the plant and should have one or two leaves. These cuttings are rooted in a seedbed and then transplanted when the plant has 4-7 new leaves.

In cultivation, a trellis is used to support the plant, and the trellis should be at least 4 meters (13 feet) high.

When planting, black pepper should be spaced at 8 Å— 8 meters (26 Å— 26 feet), meaning 8 meters between individual plants and 8 meters between rows.

### **Methods of propagation:**

#### *i). Seed Propagation*

While propagation using seeds is possible, it's less common on conventional plantations due to the lengthy germination process.

Germination from seeds can lead to genetic diversity, including male and female plants.

Seeds are typically obtained by soaking fully ripened berries in water for 2-3 days, then removing the meat and drying them in the shade.

They are then planted in moist, shaded beds and will germinate after about 30 days. Transplanting to their final sites occurs after they have produced four leaves.

#### *ii). Cuttings Propagation:*

The most widely used method of propagation is through cuttings taken from the terminal area of a healthy parent plant.

These cuttings are selected after removing the vegetation apex, leaves, and lateral shoots from the 3rd to the 7th knots.

Cuttings are planted in a seedling bed at an angle of 45° with 3-4 knots, leaving the uppermost leaves.

The seedbed must be kept moist and shaded. The cuttings usually take root after about 2 months, with a success rate of approximately 30%.

They can then be transplanted to their final sites.

#### *iii). Rooted Pepper Cuttings propagation:*

Another method involves using rooted cuttings, where the shoots are directly attached to the plant itself.

The process is similar to standard cuttings, but a layer of moist moss or humus is bound around the 7th knot and secured with plastic foil.

After approximately 2 months, the shoot is cut away and acclimatized in a polyethylene bag in the planting bed before being transplanted to its final site.

This method yields a higher success rate for shoot rooting but involves more work.

## **Climatic Conditions for Black Pepper Cultivation**

Black pepper (*Piper nigrum*) thrives in specific climatic conditions, which are crucial for its successful cultivation. These conditions encompass various factors, including soil, water temperature, spacing, and sunlight. Here's an overview of each aspect:

*a). Soil:*

Black pepper grows best in well-draining soils rich in organic matter.

The ideal soil pH for black pepper is around 5.5 to 6.5.

It requires good soil aeration and texture for healthy root development.

*b). Water Temperature:*

Black pepper is a tropical crop and prefers warm temperatures.

The crop tolerates temperatures between 10°C and 40°C.

The ideal temperature range for black pepper is 23°C to 32°C, with an average of 28°C.

Optimum soil temperature for root growth is around 26°C.

*c). Spacing:*

Adequate spacing is crucial for black pepper vines to grow well.

Typically, black pepper vines need about 3-4 meters of spacing between them, as they are climbers and require room to spread and climb.

*d). Sunlight:*

Black pepper plants require partial to full sunlight for healthy growth.

They need at least 4-5 hours of direct sunlight daily.

In regions with intense heat, providing some shade during the hottest part of the day can be beneficial.

Understanding and optimizing these climatic conditions is essential for the successful cultivation of black pepper. These factors contribute to the quality and yield of this popular spice.

## Care and Maintenance of Black Pepper Plants

Black pepper (*Piper nigrum*) is a popular spice known for its pungent flavor. Growing and maintaining black pepper plants can be a rewarding endeavor, but it requires proper care and attention to detail. Here's a guide on how to care for and maintain black pepper plants:

*1. Planting:*

Choose a suitable location with well-draining soil and partial sunlight.

Plant black pepper vines in rows or on trellises, allowing them to climb.

*2. Watering:*

Maintain consistent moisture, as pepper plants prefer slightly damp soil.

Avoid waterlogging, which can harm the roots.

*3. Pests and Diseases:*

Pests like aphids and scale insects are rampant; keep an eye on them.

You can remove dead or diseased branches to avoid diseases.

You will have to treat diseases like root rot promptly.

#### *4. Fertilization:*

Apply a balanced fertilizer with micronutrients regularly.

Use organic matter to enrich the soil.

#### *5. Pruning:*

Trim and prune the vines to encourage bushier growth.

## **Harvesting Black Pepper**

Black pepper harvesting is a crucial step in the spice production process. Here's how to harvest black pepper:

#### *1. Timing:*

Harvest black pepper when the berries turn from green to red or yellow, depending on the variety.

Avoid picking unripe or overripe berries.

#### *2. Methods:*

Handpick the berries or use tools like shears for larger harvests.

Be gentle to prevent damaging the vines.

#### *3. Post-Harvest Processing:*

Thresh the berries to separate them from the stems.

Blanch, dry, clean, grade, and package the peppercorns for market distribution.

## ***Prevention and Regulation of Pests and Diseases in Organic Pepper Cultivation:***

### **Choice of Site:**

Select a site that is well-drained and avoids waterlogging.

Ensure the presence of ample organic material in the soil.

### **Establishment of a Diversified Mixed Cultivation System:**

Implement a mixed cultivation system that includes a variety of crops.

This diversity can help reduce the risk of pests and diseases by disrupting their host plants.

### ***Removal of Diseased Plant Material:***

Regularly remove any diseased or infected plant material to prevent the spread of pests and diseases.

### **Light/Shade Management and Organic Material Enrichment:**

Manage the balance of light and shade in the cultivation area.

Enrich the organic material with tree pruning to improve soil health.

#### *Constant Renewal of the Site:*

Consider ongoing site renewal to maintain soil fertility and reduce the risk of disease buildup over time.

#### Lignin-Rich Mulch Material:

Use lignin-rich mulch material to stimulate the growth of actinomycetes in the soil.

Actinomycetes are natural antagonists to pathogens like Fusarium.

These measures are crucial for maintaining a healthy, disease-resistant organic pepper cultivation system. They focus on proactive steps to prevent and manage pests and diseases while promoting soil health and biodiversity.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Anthracnose** *Elsinoe veneta*

*Close-up of Anthracnose lesions on Bristol black raspberry.*

*Anthracnose on Bristol black raspberry.*

*Anthracnose lesions on cane*

*Anthracnose lesions on cane*

#### Symptoms

Small purple or red circular lesions on canes which enlarge and develop a sunken gray, cracked center; margin of lesions become raised and purple; lesions coalesce to form large discolored areas; canes may eventually be girdled and die back.

#### Cause

Fungus

#### Comments

Fungus overwinters in diseased canes; emergence of disease is favored by prolonged periods of wet weather and excessive overhead irrigation.

#### Management

Cultural practices for controlling the spread of disease in the home garden include: avoiding excessive applications of nitrogen fertilizers, keeping areas surrounding plants free from weeds, avoiding overhead irrigation and watering only during the day, ensuring the plants have adequate time to dry out in the afternoon; commercial growers may require the use of fungicides for large plantations.

### **Blackberry rosette (Double blossom) *Cercospora rubi***

Disease symptoms	Proliferation of small, leafy shoots instead of normal shoot growth	<i>Cercospora</i> ; Witches broom on Blackberry
Blackberry rosette symptom	Abnormal proliferations of blackberry shoot	

#### **Symptoms**

Flowers with distorted petals and enlarged sepals which gives the appearance of a double flower; unopened flowers are enlarged and redder than normal; shoots may have abnormal proliferations; no fruit is produced on infected branches.

#### **Cause**

Fungus

#### **Comments**

Wild blackberries can act as a reservoir for the disease; flowers of uninfected canes can become infected from those on infected canes and will show symptoms the following year.

#### **Management**

The most effective method of controlling the disease is the use of resistant blackberry varieties; if plants are already infected but disease is not yet severe then remove and destroy any abnormal blossom clusters; old canes should be removed and destroyed immediately following harvest; fungicide application may limit damage; disease can also be controlled by only harvesting berries in alternating years, completely destroying the above ground part of the plants in the years in between; the planting may be split in two so that there is a harvest of fruit each year while the other half is cut back.

### **Botrytis fruit rot *Botrytis cinerea***

gray mold ( <i>Botrytis cinerea</i> ) mycelium with conidia	Rotting fruit covered with fungal growth of <i>Botrytis cinerea</i> (right) and <i>Rhizopus</i> sp. (left)	<i>Botrytis</i> mycelium on blackberry fruit
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#### **Symptoms**

Canes are bleached in appearance and develop flattened masses of black fungal fruiting bodies where grey mycelium and spores develop; flowers may become infected and become blighted by the fungus; infected drupelets on the fruit may develop a watery rot which is replaced by grayish brown fungal structures; if berries are left on the vines they become mummified.

#### **Cause**

Fungi

#### **Comments**

Emergence of Botrytis fruit rot is favored by cool and wet conditions; physical damage to fruit increases likelihood of infection.

#### **Management**

Promote air circulation around vines by using trellises or training the vines; avoid over fertilizing plants; protective fungicides can be used to control the disease and should be applied at intervals of 7-14 days from early bloom right

through to harvest.

## Cane and Leaf Rust *Kuehneola uredinis*

*Kuehneola uredinis* rust on the stem

Rust symptoms on stem

cane and leaf rust (*Kuehneola uredinis*) spore mass on cane

### Symptoms

The infected plant cane and leaves exhibit the small, lemon-yellow pustules. As the disease progress infected cane will show cracking and drying, whereas the leaves become spotted and dries off.

### Cause

Fungus

### Comments

It is a non systemic disease.

### Management

Prune out and burn infected cane and leaves.

## Orange rust *Gymnoconia peckiana*

Orange aecia bordered by white ruptured peridium.

Numerous bright orange pustules developing on the undersides of leaves.

Infected foliage covered with aecial pustules

Orange rust fruiting bodies (Aecia) on lower side of leaf

Blackberry orange rust

Orange rust infected leaves

Orange rust infected blackberry leaves

Healthy blackberry (left) compared with blackberry infected with orange rust (right)

Orange rust pustules

### Symptoms

New growth is weak and spindly and lacks spines; leaves are stunted and distorted and are pale in color; waxy pustules develop on leaf undersides and turn orange and powdery; infected leaves eventually drop from the plant.

### Cause

Fungus

### Comments

Wild brambles and dewberries may act as a reservoir for the disease; fungus overwinters in the host plant.

### Management

Infected plants should be removed in entirety; prune and burn fruiting canes after harvest; improve air circulation around foliage by pruning and trellising vines; spread of rust can be minimized by applying foliar fungicides wen the orange spores are being produced; if well managed, the disease is not usually serious.

## Powdery mildew *Podosphaera macularis*

### Symptoms

Light green chlorotic patches on foliage which later develops into powdery gray patches; leaves may be twisted or distorted; if infection is severe then shoots may become spindly with small leaves which cup upwards.

### Cause

Fungus

## Comments

Fungus overwinters in buds or on surface of canes; emergence of the disease is favored by warm, dry weather conditions.

## Management

If powdery mildew is known to be a problem in a particular area then avoid planting susceptible varieties; varieties bred in the US state of Arkansas, such as Navaho, Apache, and Arapaho, are known to be quite resistant to powdery mildew.

## Category : Bacterial

### Crown gall *Agrobacterium tumefaciens*

*Crown gall on cane*

*Stand dieback due to crown gall*

*Stand dieback from crown gall*

*Crown gall infesting cane*

*Crown gall on Munger black raspberry.*

*Gall on blackberry root system*

## Symptoms

Galls on canes and branches above ground or on root system; galls have a rough surface and a spongy texture; galls may darken and develop cracks as they mature; galls may have little or no effect on growth but can cause a reduction in vigor and death of plants.

## Cause

Bacterium

## Comments

Bacteria most commonly enter the plant through wounds created by pruning or from wind damage; the bacterium causes a proliferation of undifferentiated plant cells which form a gall.

## Management

Avoid planting in areas known to have been affected by crown gall for a period of at least three years; if an infected plant is found, destroy it immediately; a biological control agent called Galltron is available for use in blackberries which contains a nonpathogenic strain of *Agrobacterium* which is antagonistic to the bacterium which causes crown gall; roots of new plantings are dipped in the substance prior to planting to protect them.

## Pests

### Category : Insects

### Japanese beetle *Popillia japonica*

*Beetle feeding on foliage*

*Adult beetles feeding on foliage*

*Japanese beetles mating and feeding on raspberry leaves and fruit*

*Japanese beetles and damage*

*Japanese beetle*

## Symptoms

Leaves skeletonized (only veins remaining); flowers and buds damaged; plant damage may be extensive; adult insect is a metallic green-bronze beetle with tufts of white hair protruding from under wing covers on each side of the body; adult beetles are approximately 13 mm in length; larvae are cream-white grubs which develop in the soil.

## Cause

Insect

### Comments

One beetle generation every 1-2 years; pheromone traps may actually attract more beetles to home gardens and should generally be avoided; beetle overwinters as larvae in soil; beetle has an extensive range of over 300 host plants.

### Management

If beetles were a problem in the previous year, use floating row covers to protect plants or spray kaolin clay; adult beetles can be hand picked from plants and destroyed by placing in soapy water; parasitic nematodes can be applied to soil to reduce the number of overwintering grubs; insecticidal soaps or neem oil can help reduce beetle populations.

## Leafrollers (e.g. Omnivorous leafroller) *Platynota stultana*

Leafroller larvae

Adult insect

Omnivorous leafroller (*Platynota stultana*)

### Symptoms

Leaves of plant rolled and tied together with silk webbing; feeding damage to rolled leaves; defoliation of plant; silk webbing may also be present on fruits and fruits may have substantial scarring from feeding damage; larvae wriggle vigorously when disturbed and may drop from plant on a silken thread.

### Cause

Insect

### Comments

Adult insect is a moth which can fly over several miles to find suitable hosts; alfalfa and sugar beet are good hosts.

### Management

Monitor plants regularly for signs of infestation; remove weeds from plant bases as they can act as hosts for leafrollers; avoid planting pepper in areas where sugarbeet or alfalfa are grown nearby; *Bacillus thuringiensis* or Entrust SC may be applied to control insects on organically grown plants; apply sprays carefully to ensure that treatment reaches inside rolled leaves.

## Rednecked cane borer *Agrilus ruficollis*

Rednecked cane borer (*Agrilus ruficollis*) adult

Rednecked cane borers feeding inside Blackberry cane

Rednecked cane borer adult

Galls on canes

Tunnel in cane made by rednecked cane borer

Redneck cane borer mating

### Symptoms

Galls on canes which are usually 2.5-7.6 cm (1-3 in) in length; canes may die over winter above the galls; bud break may be delayed the following spring; canes with galls often do not produce fruit; adult insect is a slender, metallic black beetle; larvae are white, flat-headed grubs.

### Cause

Insect

### Comments

Female beetles deposit eggs on bark of canes and larvae burrow into primocanes.

### Management

Canes with galls should be pruned out and burned or buried to destroy overwintering larvae; remove any wild brambles nearby which may act as a reservoir for cane borer populations; if chemical treatment is required (generally if more than

5% of canes are affected) then it should be applied after bloom to limit damage to bees.

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# Blueberry

## Description

Blueberry is a crown forming, woody, perennial shrub in the family Ericaceae grown for its fruits, or berries, of the same name. The blueberry plant possesses oval or elliptical leaves which grow alternately on the stems. The stems, or twigs, are yellow/green in color and turn reddish in winter. Flowers are bell shaped and can be either white or pink, occurring in clusters of 8 to 10 flowers. Berries are blue to black in color and 0.6â€“1.3 cm (0.25â€“0.5 in) in size. Lowbush blueberry plants (including *Vaccinium angustifolium* ) are smaller in stature, reaching heights of 35 to 60 cm (13.8â€“23.6 in) and with proper management can produce fruit for between 40 and 50 years. Lowbush blueberries are also sometimes referred to as Maine, New Hampshire or wild blueberry and are native to eastern/central Canada and northeastern United States. Highbush blueberries (including *Vaccinium corymbosum* ) are generally 2â€“3 m (6.6â€“9.8 ft) in height but can reach up to 5 m (16.4 ft) and may also be referred to as huckleberry or swamp blueberry. Highbush blueberry accounts for most of the commercial production of blueberry fruit and is also native only to North America.

*Fall foliage*

*Blueberry blossoms*

*Flooded blueberry bog*

*Blueberry field*

*Foliage*

*Ripening berries*

## Uses

Blueberries can be eaten fresh or can be dried or baked for further processing. Frozen or pureed berries are commonly used to make jams and preserves and baked goods. Lowbush blueberry is commonly used to make wine.

## Propagation

Lowbush blueberry grows best in well-drained, acidic soils with a pH between 4.5 and 4.8 and should be planted in early Spring as purchased plants or as “plugs” (a small cutting, including root, from an established bush). The newly planted blueberry should be covered in a couple of inches of mulch to conserve moisture in the soil. Any flowers produced by the plants should be removed for at least one year after planting to promote vigor and new growth. Plants should be pruned by cutting close to the ground and a pruned plant will not produce any fruit in the first year, but in the second year subsequent to pruning their should be a good yield. Growth can be stimulated by field-burning, as these plants are very fire-tolerant. Highbush blueberry can be propagated from seeds, cuttings from an established plant or bare root and should be planted in late Fall. Blueberry plants grow best in well drained, highly acidic soils with a pH between 4.5 and 5.8. The plants have a shallow root system and should be planted in a hole at least twice as large as the existing root system and mulched with a 7-10 cm (3-4 in) layer of organic mulch. The first year of blossom should be removed to encourage new growth and it is also recommended to do the same in the second year. Plants should be pruned annually, particularly after the first two years, to promote plant vigour and remove diseased or broken canes. Irrigation is recommended due to the shallow root system and greatly promotes the fruit yield this practice is highly recommended if growing commercially.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

## **Botrytis blossom blight (Gray mold) *Botrytis cinerea***

Blighted blossoms on lowbush blueberry caused by *Botrytis cinerea*

### **Symptoms**

Corollas of expanded blossoms appear blighted; brown lesions on leaves which have come into contact with infected blossoms; infected blossoms do not produce fruit; in large fields, severe infedctions are often visible as brown patches

### **Cause**

Fungus

### **Comments**

Can be very damaging to lowbush blueberries; fungus overwinters in fruits, stems and leaves of plant; disease emergence is favored by wet weather; severe outbreaks can occur after wet periods lasting several days or more

### **Management**

Disease can be controlled by application of appropriate fungicides, if available, at mid-bloom and late bloom stage

## **Mummy berry *Monilinia vaccinii-corymbosi***

Mummified fruit which had dropped from the plant

Mummy berry symptoms on blueberry fruits

Mummy berry symptoms on blueberry fruits

Mummy berry symptoms on blueberry fruits

Infected berries: berry on left has been completely transformed to fungal fruiting body

Infected fruits

### **Symptoms**

Drooping of new leaves and shoots in Spring; rapid browning of upper surface of affected shoots and leaf midribs and veins; death of infected shoots,leaves and flowers 24-72 hours after appearance of brown discoloration; after initial symptoms in Spring, plants become symptomless until fruit development; infected berries are cream or pink in color and turn tan or gray; berries become shriveled and hard; shriveled skin of fruit breaks down to expose black rind of fungal tissue

### **Cause**

Fungus

### **Comments**

Disease affects highbush, lowbush and rabbiteye blueberry varieties; bees can aid the transfer of the fungus from infected to healthy flowers

### **Management**

Plant disease-free, dormant plants; remove or bury mummified fruit, if burying fruit cover with at least an inch of soil; application of appropriate foliar fungicides are very effective at controlling the disease in commercial plantations

## **Powdery mildew *Erysiphe vaccinii***

Powdery mildew symptoms

Lesions caused by powdery mildew on lowbush blueberry foliage

Powdery mildew on rabbiteye blueberry

### **Symptoms**

White fluffy growth on upper surfaces of leaves or lower leaf surface; leaves may be puckered in appearance; leaves may develop chlorotic spots with red borders; leaves may drop from plant

### **Cause**

Fungus

### **Comments**

Disease emergence is favored by warm, dry conditions

### **Management**

Plant resistant highbush blueberry varieties; apply appropriate foliar fungicides, if available

## **Shoestring** Blueberry shoestring virus (BBSSV)

### **Symptoms**

Elongated reddish streaks on green stems; purplish red leaves; cupped leaves; leaves may be elongated or strap-like; reddish-purple fruit

### **Cause**

Virus

### **Comments**

Infected plants do not show symptoms of disease for 4 years or more. During this latent period the virus can be spread to other plants making the removal of visibly infected bushes an ineffective control method; virus is transmitted by aphids

### **Management**

One of the most effective methods of preventing the spread of the virus is to time applications of insecticides to coincide with aphid emergence; the first application is usually made in late May or early June; any equipment used to apply insecticides should be cleaned thoroughly before moving to a new area

## **Stem canker** *Botryosphaeria corticus*

*Red lesions on blueberry stems caused by stem canker infection*

### **Symptoms**

Initial symptoms appear as red lesions on green stems which become swollen and conical; on rabbiteye blueberry varieties lesions are initially brown sunken spots; in susceptible varieties lesions develop into large swollen cankers with deep cracks after 2-3 years of infection; if the variety is very susceptible the cankers may kill the stem

### **Cause**

Fungus

### **Comments**

Infection occurs in late Spring; spores are spread by wind; at lower temperatures the disease may be limited to small red flecks

### **Management**

The most important method of controlling stem canker is to plant resistant varieties in areas where the disease occurs as fungicides are largely ineffective; no varieties of highbush blueberry are resistant to all strains of the disease; infected wood should not be used for propagation

## **Category : Oomycete**

## **Phytophthora root rot** *Phytophthora cinnamomi*

### **Symptoms**

Yellowing leaves; lack of new growth on plants; highbush varieties become stunted and turn red; rabbit eye varieties may become chlorotic and drop leaves

## Cause

Oomycete

## Comments

Disease emergence is favored by water-logged soils and warm temperatures; disease is spread by movement of contaminated water and soil

## Management

The best method of controlling phytophthora root rot is through the use of good cultural practices: plant blueberries in well-draining soils or in raised beds; sanitize all tool sand equipment regularly; avoid transferring soil between sites

# Pests

## Category : Mites

### Blueberry bud mite *Acalitus vaccinii*

*Damage caused by blueberry bud mite*

*Damage caused by blueberry bud mite*

*Damage caused by blueberry bud mite*

## Symptoms

Blistered red scales on buds; misshapen flowers, small leaves and fruit; damage may lead to poor growth and yields; mites are microscopic and difficult to see with the naked eye

## Cause

Arachnid

## Comments

Mite eggs are laid in the bug scales and adult mites migrate down stem to feed

## Management

Control of mites can be difficult as they are protected from pesticides by bud scales; miticides are most effective when applied just after harvest when the buds have not yet formed as they are more exposed to the chemical

## Category : Insects

### Flea beetle (Blueberry flea beetle) *Altica sylvia*

## Symptoms

Small holes or pits in leaves that give the foliage a characteristic “shot hole” appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5–3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance

## Cause

Insect

## Comments

Younger plants are more susceptible to flea beetle damage than older ones; older plants can tolerate infestation; flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year

## Management

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become

a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application on diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied

### **Japanese beetle *Popillia japonica***

*Adult Japanese beetle and damage to blueberry foliage*

*Adult Japanese beetle and damage to blueberry foliage*

#### **Symptoms**

Leaves skeletonized (only veins remaining); flowers and buds damaged; plant damage may be extensive; adult insect is a metallic green-bronze beetle with tufts of white hair protruding from under wing covers on each side of the body; adult beetles are approximately 13 mm in length; larvae are cream-white grubs which develop in the soil

#### **Cause**

Insect

#### **Comments**

One beetle generation every 1-2 years; pheromone traps may actually attract more beetles to home gardens and should generally be avoided; beetle overwinters as larvae in soil; beetle has an extensive range of over 300 host plants

#### **Management**

If beetles were a problem in the previous year, use floating row covers to protect plants or spray kaolin clay; adult beetles can be hand picked from plants and destroyed by placing in soapy water; parasitic nematodes can be applied to soil to reduce the number of overwintering grubs; insecticidal soaps or neem oil can help reduce beetle populations

### **Sharpnosed leafhopper *Scaphytopius magdalensis***

#### **Symptoms**

There are very few outward symptoms of feeding by this insect but they are considered a major pest as they transmit a mycoplasma-like organism that causes blueberry stunt; the adult insect is small and brown reaching approximately 5 mm in length with small cream colored patches on the body and wings; both adult and nymphal stages have a pointed head

#### **Cause**

Insect

#### **Comments**

In Southern regions, the sharpnosed leafhopper may undergo three generations per year; adult insects are capable of flying long distances and will also feed on huckleberry

#### **Management**

Plantations of blueberry can be monitored for sharpnose leafhoppers through the use of yellow sticky traps; insecticides registered for use on blueberry are generally quite effective at reducing leafhopper populations and should be applied to coincide with leafhopper dispersal to limit the spread of blueberry stunt

### **Thrips (Various spp) e.g. *Frankliniella vaccinii***

*Frankliniella tritici* etc.

### Symptoms

Leaves curling around the stem beginning at stem tip; as new leaves emerge, the curling spreads from tip to base of stem; If population is high leaves may be distorted; flowers may be damaged; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color

### Cause

Insect

### Comments

Larvae pupate in soil; the time between egg and adult insect is approximately 3 weeks depending on ambient temperature

### Management

Infested areas can be removed by pruning; in commercial plantations the insecticides registered can be very toxic to bees and should be applied at dusk when bees are not actively flying

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# Brazil nut

## Description

Brazil nut, *Bertholletia excelsa*, is a tropical evergreen in the family Lecythidaceae grown for its edible seeds (nuts). The brazil nut tree is very large with a long straight trunk which is 1–2 m (3.3–6.6 ft) in diameter. The tree only branches in the upper regions and the long branches are covered in large, leathery, oblong shaped leaves which form a spreading canopy. The tree produces large, pale yellow or greenish flowers and a round fruit which is approximately 15 cm (6 in) in diameter. The fruit has a thick hard shell and contains 18 to 24 angular seeds (nuts). The large edible kernel is protected by a thin, woody shell which has a wrinkled appearance. Brazil nut trees can reach a height of 25–56 m (82–184 ft) and can live for well over 500 years. Brazil nut may also be referred to as cream nut or butter nut and originates from the Amazonian rainforest.

*Pile of Brazil nuts in the forest*

*Edible part of brazil nut*

*Brazil nuts drying*

*Image showing the sheer size of the  
brazil nut tree*

*Brazil nut pod showing seeds*

*Brazil nut pod*

*Brazil nut harvest*

*Brazil nut tree*

*Brazil nut trees*

## Uses

Brazil nuts are eaten fresh or may be used to extract oil for cooking or for use in the manufacture of soaps.

## Propagation

**Biology and ecology of the brazil nut** Brazil nut trees grow in areas of tropical rainforests which have a dry period, usually at low altitude. The nuts are harvested almost exclusively from naturally occurring trees although in some parts of the Amazon, plantations are being developed. Brazil nut seedlings develop in the forest understory and require a gap to emerge in the forest canopy to provide the light required to develop to maturity. Trees will flower after 5 or 6 years and only begin to bear fruit after a period of 10–20 years. Flowering occurs at the beginning of the dry season and the flowers are pollinated by a large species of bee. The fruit takes 15 months to reach maturity and is harvested in the wet season by collecting as soon as it falls from the tree. Trees have been successfully propagated from seed and planted into a plantation. A major obstacle to plantation production of Brazil nut is the difficulty of attracting the correct species of pollinator. **Harvesting** Brazil nuts are harvested during the rainy season and the fallen fruits are collected from the forest floor. Collection is usually carried out in the morning to reduce the chance of being hit by falling fruits which can cause severe injury. The fruits are hard and must be hacked open with a machete in order to collect the nuts from inside for further processing.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Brazil nut leaf blight** *Phytophthora heveae*

###### **Symptoms**

Spots on leaves; blighting of young stems

###### **Cause**

Oomycete

###### **Comments**

Brazil nut leaf blight is a soilborne fungus which also affects other crops such as coca, avocado, mango and rubber

###### **Management**

Control of the disease may be achieved by using the fungicides cuprosan after grafting

## Pests

### Category : Mites

#### Cocoa weevil *Araecerus fasciculatus*

*Cocoa weevil*

##### Symptoms

Circular bore holes on nut shells where adult has emerged; kernel destroyed by tunneling or completely hollowed out; adult is a small (3-5 mm) long beetle which is a mottled dark brown in color; larvae are small yellow-white grubs

##### Cause

Insect

##### Comments

Cocoa weevils are potentially devastating post-harvest pests; larvae bore into the kernels to feed and pupate; adults bore an exit hole after pupation and emerge from the kernel

##### Management

The primary method of controlling the cocoa weevil is through the use of fumigants on the stored brazil nuts

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# Broad bean, dry

## Description

Broad bean, *Vicia faba*, is a leguminous plant in the family Fabaceae primarily grown for its edible beans. Broad bean is a an annual vetch reaching between 0.5–1.8 m (1.6–6 ft) tall. There are often multiple stems originating from the base of the plant and the compound leaves are often broad, oval shaped, and come groups of 6 leaflets to a stem. The flowers are white with purple markings. Between 1 and 4 pods develop from each flower cluster. The beans can be greenish black, brown or black in color. *Vicia faba* may also be referred to as bell-bean, fava bean or horsebean and originates from the Mediterranean or in South-West Asia.

*Purple broad bean variety*

*Broad bean pods*

*Broad bean foliage*

*Broad bean pods*

*Broad bean plant in flower*

## Uses

Broad bean is cultivated for both animal and human consumption, soil development, and medicinal uses . It can be served fresh, dried, canned, or as a substitute for meat and skim-milk. Broad bean is often used as either forage (leaves, plant material) or silage (fermented, high-moisture fodder) for animals. Using broad bean as a spring cover crop allows

for protection against erosion, and can be tilled back into the soil as green manure. The taproot also has the added benefit of being able to break-up hard compacted soil.

## Propagation

**Basic requirements** Broad bean is a cool-season crop and should be grown in early Spring or late summer to avoid high summer temperatures. Broad beans will grow best at soil temperatures between 15.5 and 18.3°C (60–65°F) and will not grow well at temperature below below 4.4°C (40°F) or above 23.8°C (75°F). Broad bean is particularly susceptible to high temperatures during the summer which make the plants unproductive. Broad beans will grow best in a fertile, well-draining soil with a pH between 6.0 and 6.75 positioned in full sunlight. **Sowing seeds** Broad beans should be direct seeded in the garden in Spring as soon as the soil is workable and temperature is above 4.4°C (40°F) with the optimum temperature for germination being between 10 and 21°C (50–70°F). A second planting can be made in early Fall in areas with moderate winters. Seeds should be planted 2.5–5.0 (1–2 in) deep allowing 7.5–15 cm (3–6 in) between plants and approximately 0.6 m (2 ft) between rows. **General care and maintenance** Broad bean plants are bush-like but can grow quite tall and will benefit from staking to provide some support and keep them from flopping over due to the weight of the pods. Keep soil moist during flowering to ensure optimum pod development and soak ground thoroughly if plants come into flower during a dry spell. As they are legumes, broad beans generally do not require additional fertilization as long as they have sufficient root nodules. Nodulation can be promoted by inoculating seeds with additional Rhizobacteria prior to planting. **Harvesting** Broad beans are ready to harvest when the pods are fat and full and beginning to droop from the plant due to the weight of the seeds inside. Seeds can be dried either by leaving pods on the plant until they begin to shrivel or by picking and hanging up to dry out.

*Broad beans will benefit from staking to support the weight of the pods*

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## Common Pests and Diseases

### Diseases

#### Category : Bacterial

**Bacterial brown spot** *Pseudomonas syringae*

**Symptoms**

Small, dark brown necrotic spots on leaves which may be surrounded by a zone of yellow tissue; water soaked spots on pods which turn brown and necrotic; pods may twist and distort in area of infection

**Cause**

Bacterium

**Comments**

Bacterium overwinters in crop residue; disease more severe when foliage is wet for extended periods

**Management**

Plant only certified seed; rotate crops regularly; remove crop debris from field after harvest

**Category : Fungal****Chocolate spot** *Botrytis cinerea*

*Botrytis fabae*

**Symptoms**

Symptoms of disease can be aggressive or non-aggressive; symptoms on non-aggressive chocolate spot are small red-brown lesions on leaves of the plant which may also be present on stems and pods; under high humidity the disease moves to the aggressive stage and lesions coalesce and become covered in fluffy mycelium; large patches of tissue can become necrotic and die

**Cause**

Fungus

**Comments**

Long periods of high humidity promote the switch from the non-aggressive phase to the aggressive phase; aggressive phase of the disease favors low levels of potassium and phosphorus in the soil and overcrowded plants

**Management**

Control should be aimed at preventing the aggressive stage of the disease which can be achieved by lowering humidity; use appropriate plant spacings to encourage air circulation around plants; foliar fungicide applications throughout the season will protect the crop from chocolate spot

**Downy mildew** *Peronospora viciae***Symptoms**

Yellow-brown blotches on upper surface of leaves; angular patches of fluffy white-gray fungus on lower side of leaves; plant growth may be stunted or distorted and whole plant may die before flowering; plant may produce

**Cause**

Fungus

**Comments**

Fungus overwinters in soil and on crop debris; fungus can survive in soil for 10-15 years

**Management**

Rotate crops for at least 5 years; till crop debris deeply; avoid sowing in late Autumn at greater soil depths as this can promote severe infections

**Fusarium root rot** *Fusarium solani***Symptoms**

Stunted plant growth; yellowing, necrotic basal leaves; brown-red or black streaks on roots that coalesce as they mature; lesions may spread above the soil line

**Cause**

Fungus

**Comments**

Damage caused by the emergence of the disease is worsened by warm, compacted soils, limited soil moisture and poor

soil fertility

### **Management**

Control relies on cultural practices e.g. do not plant broad in same area more than once in any 5 year span; treat seeds with an appropriate fungicide prior to planting

## **Powdery mildew *Erysiphe pisi***

### **Symptoms**

Yellow spots on upper surface of leaves; powdery gray-white areas which coalesce to cover entire plant; if plant is heavily infected it may appear light blue or gray in color

### **Cause**

Fungus

### **Comments**

Fungus overwinters on plant debris or alternate host; disease emergence is favored by warm, dry weather with cool nights that result in dew formation

### **Management**

Plant resistant varieties, particularly if sowing late; use overhead irrigation (washes fungus from leaves and reduces viability); plant crop as early as possible; frequent applications of sulfur may be required to control heavy infestations

## **Category : Oomycete**

### **Leaf blight *Xanthomonas campestris***

syn. *Xanthomonas axonopodis*

### **Symptoms**

Water-soaked spots on leaves which enlarge and become necrotic; spots may be surrounded by a zone of yellow discoloration; lesions coalesce and give plant a burned appearance; leaves that die remain attached to plant; circular, sunken, red-brown lesion may be present on pods; pod lesions may ooze during humid conditions

### **Cause**

Bacterium

### **Comments**

Disease can be introduced by contaminates seed; bacteria overwinters in crop debris; disease emergence favored by warm temperatures; spread is greatest during humid, wet weather conditions

### **Management**

Plant only certifies seed; plant resistant varieties; treat seeds with an appropriate antibiotic prior to planting to kill off bacteria; spray plants with an appropriate protective copper based fungicide before appearance of symptoms

## **Pests**

## **Category : Insects**

### **Aphids (Pea aphid, Bean aphid, Cowpea aphid, Melon aphid, Peach aphid, etc.)**

*Acyrthosiphon pisum*

*Aphis* spp.

*Myzus persicae*

### **Symptoms**

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plant

**Cause**

Insects

**Comments**

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed; transmit viruses

**Management**

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

**Broad bean rust** *Uromyces viciae-fabae***Symptoms**

Small, powdery dark spots on leaves and stems; dark brown spores on undersides of leaves; severe infestation can cause leaves to collapse and die

**Cause**

Fungus

**Comments**

Emergence of the disease is favored by warm, humid conditions; fungus overwinters on crop debris on the ground

**Management**

Remove all crop debris after harvest; remove any infected leaves from the plant; apply an appropriate foliar fungicide to control the disease; avoid overhead irrigation; make use of trellises to open up the plant canopy and promote good air circulation around foliage; avoid excessive nitrogen fertilization

**Leafminers** *Lyriomyza* spp.**Symptoms**

Thin, white, winding trails on leaves; heavy mining can result in white blotches on leaves and leaves dropping from the plant prematurely; early infestation can cause yield to be reduced; adult leafminer is a small black and yellow fly which lays its eggs in the leaf; larvae hatch and feed on leaf interior

**Cause**

Insects

**Comments**

Mature larvae drop from leaves into soil to pupate; entire lifecycle can take as little as 2 weeks in warm weather; insect may go through 7 to 10 generations per year

**Management**

Check transplants for signs of leafminer damage prior to planting; remove plants from soil immediately after harvest; only use insecticides when leafminer damage has been identified as unnecessary spraying will also reduce populations of their natural enemies

**Mexican bean beetle** *Epilachna varivestis*

Egg cluster

Adult beetle

Mexican bean beetle larva

**Symptoms**

Irregular patches of feeding damage on underside of leaves which causes the top surface of the leaf to dry out, giving the leaves a lacy appearance; insect will also damage flowers and small pods; pods may be damaged so badly that they drop from the plant; adult insect is an orange-brown beetle with black spots; larvae are fat-bodied grubs which taper at the

end and are in rows of conspicuous spines

#### **Cause**

Insect

#### **Comments**

Beetles can decimate bean crops; beetles overwinter as adults and undergo 2-3 generations per year

#### **Management**

Some bean varieties may be less attractive hosts for the beetle, e.g. snapbeans are preferred hosts over lima beans; early varieties may escape damage from beetles beetle populations can be reduced by removing overwintering sites such as brush and leaves on the ground; handpick larvae and adults; brush eggs from leaves and destroy; apply insecticidal soap to leaf undersides if infestation is heavy

### **Thrips (Western flower thrips, Onion thrips, etc.) *Frankliniella occidentalis***

*Thrips tabaci*

#### **Symptoms**

If population is high leaves may be distorted; leaves are covered in coarse stippling and may appear silvery; leaves speckled with black feces; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color

#### **Cause**

Insect

#### **Comments**

Transmit viruses such as Tomato spotted wilt virus; once acquired, the insect retains the ability to transmit the virus for the remainder of its life

#### **Management**

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic

## **Category : Nematodes**

### **Root knot nematode *Meloidogyne* spp.**

#### **Symptoms**

Galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; reduction in plant vigor; yellowing plants which wilt in hot weather

#### **Cause**

Nematode

#### **Comments**

Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or garden with this type of soil is most likely

#### **Management**

Plant resistant varieties if nematodes are known to be present in the soil; check roots of plants mid-season or sooner if symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens

## **Category : Mites**

### **Spider mites (Two-spotted spider mite) *Tetranychus urticae***

#### **Symptoms**

Leaves stippled with yellow; leaves may appear bronzed; webbing covering leaves; mites may be visible as tiny moving dots on the webs or underside of leaves, best viewed using a hand lens; usually not spotted until there are visible symptoms on the plant; leaves turn yellow and may drop from plant

**Cause**

Arachnid

**Comments**

Spider mites thrive in dusty conditions; water-stressed plants are more susceptible to attack

**Management**

In the home garden, spraying plants with a strong jet of water can help reduce buildup of spider mite populations; if mites become problematic apply insecticidal soap to plants; certain chemical insecticides may actually increase mite populations by killing off natural enemies and promoting mite reproduction

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# Broccoli

## Description

Broccoli, *Brassica oleracea*, is an herbaceous annual or biennial grown for its edible flower heads which are used as a vegetable. The broccoli plant has a thick green stalk, or stem, which gives rise to thick, leathery, oblong leaves which are gray-blue to green in color. The plant produces large branching green flower heads covered with numerous white or yellow flowers. Broccoli can be annual or biennial depending on the variety and can grow to 1 m (3.3 ft) in height. Broccoli may also be referred to as sprouting broccoli and likely originates from the Mediterranean although the exact location has not been determined.

*Close-up of broccoli flower head*

*Purple broccoli variety*

*Broccoli plant*

*Broccoli side shoots*

*Broccoli head forming*

*Broccoli*

## Uses

Broccoli heads are consumed after boiling or fresh in salads. It can be processed for freezing and drying.

# Propagation

**Basic requirements** Broccoli is a cool season crop which can be grown both in spring and in fall. The plants thrive in cool climates and should be planted for fall in areas with hot summers. Broccoli grows best in moist, fertile soil with a slightly acidic pH between 6.0 and 7.0 and at temperatures between 15.5 and 18°C (60–65°F). Broccoli has a high nitrogen requirement and due to the reduced activity of soil microbes in late fall and winter, organic matter should be added to the soil throughout the year to ensure an adequate supply of nutrients when broccoli is planted. In addition, broccoli requires regular water, especially during drought, to prevent the plants from going to seed. Plant broccoli in full sun to ensure optimum head size. **Sowing seeds** Broccoli can be direct seeded or started indoors for transplants. Spring plantings should be made 2–3 weeks before the last frost date in your area and Fall plantings should be made approximately 100 days before the first Fall frost. Sow seed 1.3 cm (0.5 in) deep in small groups of 2–3 seeds and about a week after emergence, thin to a final spacing of 30–60 cm (12–24 in) within the row, allowing 90 cm (36 in) between rows. Keep soil evenly moist after planting. If starting indoors, plant seed in peat pots to minimize disturbance to the roots when transplanting. Seedling can be planted outdoors when they are 3–4 weeks old at the same time as seeds are planted using the spacing detailed above. Plant transplants slightly deeper in the ground than they currently are in their pot and keep soil moist to ensure good fertility. **General care and maintenance** Broccoli has a very shallow root system and cultivating the soil around the plants to remove weeds should be avoided. Provide the plants with adequate and even moisture (about 2 in a week) to keep plants fertile and prevent them from bolting and avoid wetting the flower heads as they develop. Mulching around the plants helps to conserve soil moisture and reduces the soil temperature.

**Harvesting** Broccoli is ready to harvest when the flower buds are firm and packed tightly in the head. Harvest before the buds open by cutting the stalk of the head at a 45° angle about 13–20 cm (5–8 in) below the head. Side-shoots will continue to produce after the first harvest.

*Broccoli transplants*

*Broccoli seedlings*

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# Common Pests and Diseases

## Diseases

### Category : Fungal

**Alternaria leaf spot** *Alternaria brassicae*

Lesions may be either round or angular, depending on the leaf veins and shape and site of infection. Some lesions may develop a purplish or black border. Lesions are often concentrically zoned, will develop a target pattern, that will fall out leaving a hole behind.

All above ground parts of host plants (broccoli in this picture) are susceptible to Alternaria leaf spot.

Lesions may also have a chlorotic (yellow) halo around it  
Symptoms of alternaria leaf spot on broccoli leaf

Symptoms of Alternaria leaf spot begin as small dark spots. These spots will grow and become brown to gray in color

### **Symptoms**

Small dark spots on leaves which turn brown to gray; lesions may be round or angular and may possess a purple-black margin; lesions may form concentric rings, become brittle and crack in center; dark brown elongated lesions may develop on stems and petioles

### **Cause**

Fungus

### **Comments**

Disease emergence favored by warm, rainy weather

### **Management**

Plant only pathogen-free seed; rotate crops; applications of appropriate fungicides control disease when present

## **Black rot *Xanthomonas campestris***

### **Symptoms**

Irregularly shaped dull yellow areas along leaf margins which expand to leaf midrib and create a characteristic "V-shaped" lesion; lesions may coalesce along the leaf margin to give plant a scorched appearance

### **Cause**

Bacteria

### **Comments**

Pathogen is spread via infected seed or by splashing water and insect movement; disease emergence favored by warm and humid conditions

### **Management**

Primary method of controlling black rot is through the use of good sanitation practices; rotate crops to non-cruciferous crops every 2 years; plant resistant varieties; control cruciferous weed species which may act as a reservoir for bacteria; plant pathogen-free seed

## **Clubroot *Plasmoidiophora brassicae***

### **Symptoms**

Slow growing, stunted plants; yellowish leaves which wilt during day and rejuvenate in part at night; swollen, distorted roots; extensive gall formation

### **Cause**

Fungus

### **Comments**

Can be difficult to distinguish from nematode damage; fungus can survive in soil for periods in excess of 10 years; can be spread by movement of contaminated soil and irrigation water to uninfected areas

### **Management**

Once the pathogen is present in the soil it can survive for many years, elimination of the pathogen is economically

unfeasible; rotating crops generally does not provide effective control; plant only certified seed and avoid field grown transplants unless produced in a fumigated bed; applying lime to the soil can reduce fungus sporulation

## **Powdery mildew** *Erysiphe cruciferarum*

### **Symptoms**

Small white patches on upper and lower leaf surfaces which may also show purple blotching; patches coalesce to form a dense powdery layer which coats the leaves; leaves become chlorotic and drop from plant

### **Cause**

Fungus

### **Comments**

Disease emergence favored by dry season, moderate temperatures, low humidity and low levels of rainfall

### **Management**

Plant resistant varieties; rotate crops; remove all crop debris after harvest; remove weeds; avoid excessive application of nitrogen fertilizer which encourages powdery mildew growth; powdery mildew can be controlled by application of sulfur sprays, dusts or vapors

## **Sclerotinia stem rot (White mold)** *Sclerotinia sclerotiorum*

The fungus survives in the soil or in crop debris as sclerotia, which act as the primary source of inoculum. Cool moist conditions favor infection.

If stems become infected they will develop white to grayish lesions. Sclerotia will eventually develop inside of infected stems, and if conditions are wet sclerotia will also develop on the outside of the stems also

Wind borne spores will land on petals that have fallen onto leaves and stems. These spores colonize the petals and afterwards will infect the plant itself. Eventually a white fluffy fungal mat can be seen along with sclerotia

### **Symptoms**

Irregular, necrotic gray lesions on leaves; white-gray lesions on stems; reduced pod set; shattering seed pods

### **Cause**

Fungus

### **Comments**

Disease emergence favors moderate to cool temperatures and high humidity

### **Management**

Rotate crop to non-hosts (e.g. cereals) for at least 3 years; control weeds; avoid dense growth by planting in adequately spaced rows; apply appropriate foliar fungicides

## **White rust** *Albugo candida*

### **Symptoms**

White pustules on cotyledons, leaves, stems and/or flowers which coalesce to form large areas of infection; leaves may roll and thicken

### **Cause**

Fungus

### **Comments**

Fungus can survive for long periods of time in dry conditions; disease spread by wind

### **Management**

Rotate crops; plant only disease-free seed; apply appropriate fungicide if disease becomes a problem

## **Category : Bacterial**

## **Black leg** *Phoma lingam*

**Symptoms**

Damping-off of seedlings; round or irregularly shaped gray necrotic lesions on leaves with dark margins; lesions may be covered in pink masses in favorable weather conditions

**Cause**

Fungus

**Comments**

Favors warm, wet conditions; higher temperatures result in the development of more visible symptoms

**Management**

Use disease free seed or treat with hot water to remove fungus prior to planting; remove and destroy crop debris after harvest or plow deeply into soil

**Category : Fungal, Oomycete****Downy mildew *Hyaloperonospora parasitica***

*Downy mildew symptoms on broccoli leaf*

*Downy mildew on broccoli leaf*

*Close-up of downy mildew lesion*

**Symptoms**

Small angular lesions on upper surface of leaves which enlarge into orange or yellow necrotic patches; white fluffy growth on undersides of leaves

**Cause**

Fungus

**Comments**

Disease emergence favored by cool, moist conditions

**Management**

Remove all crop debris after harvest; rotate with non-brassicas; it is possible to control downy mildew with the application of an appropriate fungicide

**Wirestem (Damping-off) *Rhizoctonia solani***

*Constricted stem of broccoli seedling caused by damping-off*

**Symptoms**

Death of seedlings after germination; brown-red or black rot girdling stem; seedling may remain upright but stem is constricted and twisted (wirestem)

**Cause**

Fungus

**Comments**

Disease emergence in seedlings favored by cool temperatures

**Management**

Plant pathogen-free seed or transplants that have been produced in sterilized soil; apply fungicide to seed to kill off any fungi; shallow plant seeds or delay planting until soil warms

**Category : Viral**

## **Ring spot** *Mycosphaerella brassicicola*

*Close-up of ring spot lesions showing concentric pattern*

*Symptoms on ring spot on broccoli leaves*

### **Symptoms**

Small, purple spots surrounded by a ring of water-soaked tissue on leaves which mature to brown spots with olive green borders 1-2 cm across; spots may develop numerous fruiting bodies which give them a black appearance or develop a concentric pattern; heavily infected leaves may dry up and curl inwards

### **Cause**

Fungus

### **Comments**

Ring spot requires cool, moist conditions to survive; disease symptoms typically develop in the fall and the peak of the infection occurs in winter

### **Management**

Refrain from planting in areas known to have had disease previously; rotate crop to non-brassicas; sanitize tools and equipment regularly; apply appropriate fungicide if disease is identified in crop

## **Pests**

### **Category : Insects**

#### **Diamondback moth** *Plutella xylostella*

*Pupa*

*Diamondback moth*

*Larvae*

*Diamondback moth larva feeding on broccoli leaf*

### **Symptoms**

Young larvae feed between upper and lower leaf surface and may be visible when they emerge from small holes on the underside of the leaf; older larvae leave large, irregularly shaped shotholes on leaf undersides, may leave the upper surface intact; larvae may drop from the plant on silk threads if the leaf is disturbed; larvae are small (1 cm/0.3 in) and tapered at both ends; larvae have to prolegs at the rear end that are arranged in a distinctive V-shape

### **Cause**

Insect

### **Comments**

Larvae take between 10 and 14 days to mature and spin a loose, gauze-like cocoon on leaves or stems to pupate

### **Management**

Larvae can be controlled organically by applications of *Bacillus thurengiensis* or Entrust; application of appropriate chemical insecticide is only necessary if larvae are damaging the growing tips of the plants

#### **Flea beetle (Crucifer flea beetle)** *Phyllotreta cruciferae*

*Flea beetles on broccoli leaf*

*Damage to broccoli leaf caused by  
Crucifer flea beetle*

### Symptoms

Small holes or pits in leaves that give the foliage a characteristic “shot hole” appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5–3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance

### Cause

Insect

### Comments

Younger plants are more susceptible to flea beetle damage than older ones; older plants can tolerate infestation; flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year

### Management

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application of diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied

## Large cabbage white (Cabbageworm) *Pieris rapae*

*Broccoli plant damaged by cabbage  
white feeding*

*Cabbage white larva on broccoli  
leaf*

### Symptoms

Large ragged holes in leaves; green-brown frass (insect feces) on leaves; caterpillar is green in color and hairy, with a velvet-like appearance; may have faint yellow to orange stripes down back; slow-moving compared with other caterpillars

### Cause

Insect

### Comments

Butterfly larvae cause damage by feeding on plants; can be distinguished from other caterpillars by its sluggish movement; in large numbers larvae can cause extensive damage very quickly

### Management

Hand pick caterpillars from plants and destroy; scrape eggs from leaves prior to hatching; apply appropriate insecticide if infestation is very heavy

## Thrips (Western flower thrips, Onion thrips, etc.) *Frankliniella occidentalis* *Thrips tabaci*

*Western flower thrips*

## **Symptoms**

If population is high leaves may be distorted; leaves are covered in coarse stippling and may appear silvery; leaves speckled with black feces; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color

## **Cause**

Insect

## **Comments**

Transmit viruses such as Tomato spotted wilt virus; once acquired, the insect retains the ability to transmit the virus for the remainder of its life

## **Management**

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic

## **Category : Nematodes**

### **Root knot nematode *Meloidogyne* spp.**

## **Symptoms**

Galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; reduction in plant vigor; yellowing plants which wilt in hot weather

## **Cause**

Nematode

## **Comments**

Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or garden with this type of soil is most likely

## **Management**

Plant resistant varieties if nematodes are known to be present in the soil; check roots of plants mid-season or sooner if symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens

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# Brussels sprouts

## Description

Brussel sprouts, *Brassica oleracea*, are a cultivar of cabbage in the family Brassicaceae grown for their edible small leafy green buds, which resemble miniature cabbages. The plant has long, smooth and leathery leaves which can be green to purple in color and are arranged alternately on the stem. The sprouts form at the base of each leaf, in a long, spiral stem. The edible portion of the crop is the bud, which is a small cabbage-like head. It is a light green to green/blue in color. The plant is biennial but grown as an annual and can reach 0.6â€“1 m (2â€“3 ft) in height with a spread of 0.5â€“0.6 m (1.5â€“2 ft). Brussel sprouts may also be simply referred to as 'sprouts' and they originated from Northern Europe.

*Developing sprouts*

*Brussels sprout foliage*

*Field of Brussels sprouts*

*Brussels sprout foliage*

*Developing sprouts on the stem of a  
Brussels sprout plant*

*Brussels sprout plants*

## Uses

Brussel sprouts are most commonly eaten cooked as a vegetable. They may also be pickled in vinegar.

## Propagation

**Basic requirements** Brussels sprouts are a cool season crop which can be grown both in Spring and in Fall. The plants thrive in cool climates, maturing in cool or lightly frosty weather. In areas with hot summers, they should be planted for a Fall harvest. Brussels sprouts grow best in moist, fertile, well-draining soil with a slightly acidic pH between 6.0 and 6.5 and at temperatures between 7 and 24°C (45–75°F), with optimum growth occurring at 15–18°C (59–64°F). Brussels sprouts have a high nitrogen requirement and due to the reduced activity of soil microbes in late fall and winter, organic matter should be added to the soil throughout the year to ensure an adequate supply of nutrients when sprouts are planted. Plant Brussels sprouts in an area that receives at least six hours of full sunlight for optimum growth and development. **Sowing seeds** Brussels sprouts can be direct seeded or started indoors for transplants. Spring plantings should be made 2–3 weeks before the last frost date in your area and Fall plantings should be made approximately 4 months before the first Fall frost. Sow seed 1.3 cm (0.5 in) deep in small groups of 2–3 seeds and about a week after emergence, thin to a final spacing of 60 cm (24 in) within the row, allowing 76 cm (30 in) between rows. Keep soil evenly moist after planting. If starting indoors, plant seed in peat pots to minimize disturbance to the roots when transplanting. Seedling can be planted outdoors when they are 3–4 weeks old at the same time as seeds are planted using the spacing detailed above. Plant transplants slightly deeper in the ground than they currently are in their pot and keep soil moist to ensure good fertility. **General care and maintenance** Brussels sprouts are sensitive to boron deficiency which can cause the plants to develop hollow stems and small buds. The deficiency can be corrected by adding boron to the soil. Brussels sprouts should be provided with adequate and even moisture (1.0 to 1.5 inches a week) to keep plants fertile and prevent them from bolting. Mulching around the plants helps to conserve soil moisture and reduces the soil temperature. **Harvesting** Brussels sprouts are generally ready for harvest 90 to 180 days after planting when the heads are firm and green and have reached between 2.5 and 5.0 cm (1–2 in) in diameter. The oldest sprouts are located at the bottom of the stalk and mature upwards. As sprouts are removed, it can be beneficial to remove the leaves which are beginning to yellow. Some people prefer to remove all of the leaves on the stalk to accelerate maturity and harvest in a manner similar to commercial sprout production. The stalks can be removed before the ground freezes over and stored indoors for further harvesting.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

## **Alternaria leaf spot (Black spot, Gray spot) *Alternaria brassicae***

### **Symptoms**

Small dark spots on leaves which turn brown to gray; lesions may be round or angular and may possess a purple-black margin; lesions may form concentric rings, become brittle and crack in center; dark brown elongated lesions may develop on stems and petioles

### **Cause**

Fungus

### **Comments**

May become a problem during cool, wet periods

### **Management**

Plant only pathogen-free seed; rotate crops; applications of appropriate fungicides control disease when present

## **Black rot *Xanthomonas campestris***

### **Symptoms**

Seedlings develop wilted yellow to brown leaves and collapse; yellow, V-shaped lesions on mature leaf margins; dark rings can be found in the cross section of the stem

### **Cause**

Bacteria

### **Comments**

Can be confused with Fusarium wilt; favors warm wet environments

### **Management**

Primary control methods based on good sanitation; plant disease-free seed; rotate crops every 2 years or less to non-brassica; avoid sprinkler irrigation

## **Clubroot *Plasmoidiophora brassicae***

### **Symptoms**

Slow growing, stunted plants; yellowish leaves which wilt during day and rejuvenate in part at night; swollen, distorted roots; extensive gall formation

### **Cause**

Fungus

### **Comments**

Can be difficult to distinguish from nematode damage; fungus can survive in soil for periods in excess of 10 years; can be spread by movement of contaminated soil and irrigation water to uninfected areas

### **Management**

Once the pathogen is present in the soil it can survive for many years, elimination of the pathogen is economically unfeasible; rotating crops generally does not provide effective control; plant only certified seed and avoid field grown transplants unless produced in a fumigated bed; applying lime to the soil can reduce fungus sporulation

## **Downy mildew *Hyaloperonospora parasitica***

### **Symptoms**

Small angular lesions on upper surface of leaves which enlarge into orange or yellow necrotic patches; white fluffy growth on undersides of leaves

### **Cause**

Fungus

### **Comments**

Disease emergence favored by cool, moist conditions

### **Management**

Remove all crop debris after harvest; rotate with non-brassicas; it is possible to control downy mildew on brussel sprouts

with the application of an appropriate fungicide

## **Fusarium wilt (Yellows) *Fusarium oxysporum***

### **Symptoms**

Dull yellow-green discoloration of leaves and stunted plant growth; lower leaves turning yellow-brown necrotic areas and dropping from plant; browning and defoliation spreading upwards from bottom of plant; symptoms more pronounced on one side of leaf than the other

### **Cause**

Fungus

### **Comments**

Fungus can survive for many years in soil and can enter plant through root tips or wounds; disease generally favors warm soil temperatures

### **Management**

Plant resistant varieties; most other control methods are ineffective once disease has emerged; spread can be prevented by disinfecting equipment

## **Powdery mildew *Erysiphe cruciferarum***

### **Symptoms**

Small white patches on upper and lower leaf surfaces which may also show purple blotching; patches coalesce to form a dense powdery layer which coats the leaves; leaves become chlorotic and drop from plant

### **Cause**

Fungus

### **Comments**

Disease emergence favored by dry season, moderate temperatures, low humidity and low levels of rainfall

### **Management**

Plant resistant varieties; rotate crops; remove all crop debris after harvest; remove weeds; avoid excessive application of nitrogen fertilizer which encourages powdery mildew growth; powdery mildew can be controlled by application of sulfur sprays, dusts or vapors

## **Sclerotinia stem rot (White mold) *Sclerotinia sclerotiorum***

### **Symptoms**

Irregular, necrotic gray lesions on leaves; white-gray lesions on stems; reduced pod set; shattering seed pods

### **Cause**

Fungus

### **Comments**

Disease emergence favors moderate to cool temperatures and high humidity

### **Management**

Rotate crop to non-hosts (e.g. cereals) for at least 3 years; control weeds; avoid dense growth by planting in adequately spaced rows; apply appropriate foliar fungicides

## **White rust *Albugo candida***

### **Symptoms**

White pustules on cotyledons, leaves, stems and/or flowers which coalesce to form large areas of infection; leaves may roll and thicken

### **Cause**

Fungus

### **Comments**

Fungus can survive for long periods of time in dry conditions; disease spread by wind

### **Management**

Rotate crops; plant only disease-free seed; apply appropriate fungicide if disease becomes a problem

## Category : Viral

### **Ring spot** *Mycosphaerella brassicicola*

#### **Symptoms**

Small, purple spots surrounded by a ring of water-soaked tissue on leaves which mature to brown spots with olive green borders 1-2 cm across; spots may develop numerous fruiting bodies which give them a black appearance or develop a concentric pattern; heavily infected leaves may dry up and curl inwards

#### **Cause**

Fungus

#### **Comments**

Ring spot requires cool, moist conditions to survive; disease symptoms typically develop in the fall and the peak of the infection occurs in winter

#### **Management**

Refrain from planting in areas known to have had disease previously; rotate crop to non-brassicas; sanitize tools and equipment regularly; apply appropriate fungicide if disease is identified in crop

## Pests

### Category : Insects

### **Cabbage aphid** *Brevicoryne brassicae*

*Cabbage aphids on Brussels sprouts*

#### **Symptoms**

Large populations can cause stunted growth or even plant death; insects visible on the plant leaves or sprouts and are small, grey-green in color and soft bodied and are covered with a white waxy coating; leaves may curl; insect excretes a sticky substance called honedew

#### **Cause**

Insect

#### **Comments**

Cabbage aphids feed only on cruciferous plants but may survive on related weed species

#### **Management**

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

### **Cabbage looper** *Trichoplusia ni*

*Cabbage looper and damage*

## Symptoms

Large or small holes in leaves; damage often extensive; caterpillars are pale green with a white lines running down either side of their body; caterpillars are easily distinguished by the way they arch their body when moving; eggs are laid singly, usually on the lower leaf surface close to the leaf margin, and are white or pale green in color

## Cause

Insect

## Comments

Insects overwinter as pupae in crop debris in soil; adult insect is a dark colored moth; caterpillars have a wide host range

## Management

Looper populations are usually held in check by natural enemies; if they do become problematic larvae can be hand-picked from the plants; an organically acceptable control method is the application of *Bacillus thuringiensis* which effectively kills younger larvae; chemical sprays may damage populations of natural enemies and should be selected carefully

## Diamondback moth *Plutella xylostella*

*Diamondback moth larva*

*Diamondback moth pupae*

## Symptoms

Young larvae feed between upper and lower leaf surface and may be visible when they emerge from small holes on the underside of the leaf; older larvae leave large, irregularly shaped shotholes on leaf undersides, leaving the upper surface intact; larvae may drop from the plant on silk threads if the leaf is disturbed; larvae are small (1 cm/0.3 in) and tapered at both ends; larvae have two prolegs at the rear end that are arranged in a distinctive V-shape

## Cause

Insect

## Comments

Larvae take between 10 and 14 days to mature and spin a loose, gauze-like cocoon on leaves or stems to pupate

## Management

Larvae can be controlled organically by applications of *Bacillus thurengiensis* or Entrust; application of appropriate chemical insecticide is only necessary if larvae are damaging the growing tips of the plants

## Flea beetle *Systema blanda*

*Phyllotreta* spp.

*Flea beetles are often metallic in appearance*

## Symptoms

Small holes or pits in leaves that give the foliage a characteristic "shothole" appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5–3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance

## Cause

Insect

## Comments

Younger plants are more susceptible to flea beetle damage than older ones; older plants can tolerate infestation; flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year

## **Management**

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application on diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied

## **Large cabbage white (Cabbageworm) *Pieris rapae***

*Brussels sprout plant devastated by Cabbageworm and frass  
cabbageworm feeding*

### **Symptoms**

Large ragged holes in leaves or bored into sprouts; green-brown frass (insect feces) on leaves; caterpillar is green in color and hairy, with a velvet-like appearance; may have faint yellow to orange stripes down back; slow-moving compared with other caterpillars

### **Cause**

Insect

### **Comments**

Butterfly larvae cause damage by feeding on plants; can be distinguished from other caterpillars by its sluggish movement; in large numbers larvae can cause extensive damage very quickly

### **Management**

Hand pick caterpillars from plants and destroy; scrape eggs from leaves prior to hatching; apply appropriate insecticide if infestation is very heavy

## **Thrips (Western flower thrips, Onion thrips, etc) *Frankliniella occidentalis***

*Thrips tabaci*

*Western flower thrips*

### **Symptoms**

If population is high leaves may be distorted; leaves are covered in coarse stippling and may appear silvery; leaves speckled with black feces; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color

### **Cause**

Insect

### **Comments**

Transmit viruses such as Tomato spotted wilt virus (see disease entry); once acquired, the insect retains the ability to transmit the virus for the remainder of its life

### **Management**

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic

## **Category : Nematodes**

### **Root knot nematode *Meloidogyne* spp.**

**Symptoms**

Galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; reduction in plant vigor; yellowing plants which wilt in hot weather

**Cause**

Nematode

**Comments**

Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or garden with this type of soil is most likely

**Management**

Plant resistant varieties if nematodes are known to be present in the soil ;check roots of plants mid-season or sooner if symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens

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# Buckwheat

## Description

Buckwheat, *Fagopyrum esculentum*, is an herbaceous annual plant in the family Polygonaceae grown for its seeds which can be utilized in a manner similar to wheat or oats. The buckwheat plant is a fast growing, spindly, broad leaf plant with small heart-shaped leaves and hollow stems. The plant produces many small white or pink flowers which, when pollinated, quickly produce seeds. The seeds are triangular in shape and change from light green in color, to red-brown. The seed consists of a true seed (groat) which is surrounded by a thick hull. Buckwheat plants can grow between 40 and 120 cm (15.7-47.2 in) in height and survive for just one growing season. Buckwheat may also be referred to as qiaomei or ogal and was likely first domesticated from a wild ancestor in China.

*Buckwheat flowering*

*Buckwheat flower*

*Buckwheat field in Japan*

## Uses

Buckwheat can be used in the production of many foods in place of wheat e.g., pancakes, cakes and biscuits. It is also commonly used in breakfast cereals or it may also be blended into flour. The grain may also be used as fodder for animals. Buckwheat is an excellent cover crop, taking only 4–5 weeks from seed to flower and can protect against soil erosion and invasion by weeds.

# Propagation

**Basic requirements** Buckwheat grows optimally in temperate or sub-tropical climates where the temperatures are between 15–25°C but it may also be grown successfully in more tropical climates at higher elevation. Buckwheat will be killed by frost. In addition, the plants require a period of dry weather for harvest. Buckwheat can be grown in poor soils but will produce optimally in well-draining loamy soil. The plants will tolerate a wide pH range from 4.5 down to 7.0. It is a short-season crop and therefore does well when planted in the fall, stimulated by shorter day length. **Sowing** Buckwheat is grown by direct seeding and the seedbed should be properly prepared in advance of sowing. The soil should be fine but firm and dug to a depth of approximately 5 cm (2.0 cm) to aid in seedling emergence. Commercial fields are sown by mechanical drilling in rows spaced approximately 30 cm (12 in) apart but can simply be sown simply by broadcasting in the home garden. Seed should be scattered at a rate of about one pound of seed per 500 square feet of soil. **General care and maintenance** Buckwheat can be grown in nutrient poor soils and it does not require the addition of fertilizer. If growing buckwheat as a cover crop it should be mowed down within 2 weeks of flowering to prevent the plants setting seed. The plant debris can be turned under the soil to decompose as green manure. Allow a few weeks between mowing and planting any new crops to allow the plant matter to decompose.

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# Common Pests and Diseases

## Diseases

### Category : Other

#### Aster yellows

**Aster yellows mycoplasma**  
**Symptoms**  
Flowers small, green, sterile; only a few plants are usually affected in a field

**Cause**

Mycoplasma

**Comments**

Spread by aster leafhoppers

**Management**

No preventative treatment; does not affect buckwheat yields

### Category : Fungal, Oomycete

## **Damping-off (Root rot) *Rhizoctonia* spp.**

### **Symptoms**

Failure of seedling to emerge; light brown, seedlings with light brown to redwater-soaked roots and stems; collapse of plants; plant dry up and die

### **Cause**

Fungus

### **Comments**

Occurs more often in cold temperatures when growth of seedlings is slow and in moist soil

### **Management**

Treat seeds with fungicide prior to planting

## **Category : Fungal**

## **Powdery mildew *Erysiphe polygoni***

### **Symptoms**

Light blotches on leaves; small necrotic areas on foliage near seed fill stage

### **Cause**

Fungus

### **Comments**

Disease favors warm, wet conditions

### **Management**

No treatment possible; infections do not worsen and has no effect on yield

## **Stem rot *Sclerotinia sclerotiorum***

### **Symptoms**

Small brown spots on stems; stems turn pale in color and become dehydrated; seeds fall off easily; stems eventually collapse

### **Cause**

Fungus

### **Comments**

### **Management**

The collapsed plants are hard to spot in a field and the disease may not be discovered

## **Pests**

## **Category : Insects**

## **Aphids Various**

### **Symptoms**

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants

### **Cause**

Insects

### **Comments**

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of

the aphid; will generally not move very quickly when disturbed

### **Management**

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

### **Cutworms** *Agrotis* spp.

*Peridroma saucia*

*Nephelodes minians*

and others

### **Symptoms**

Stems of seedlings may be severed at soil line; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5â€“5.0 cm (1â€“2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed

### **Cause**

Insects

### **Comments**

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato

### **Management**

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically

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# Cabbage (red, white, Savoy)

## Uses

Cabbage is a highly versatile vegetable that can be used in a wide range of dishes and preparations. Whether cooked, fermented, or used in beauty treatments, cabbage offers a wealth of benefits for health and wellness. They are rich in vitamins, minerals, and fiber, and are believed to have anti-inflammatory and antioxidant properties. In cooking, cabbages can be boiled, steamed, roasted, or sautéed, and are a popular ingredient in soups, stews, stir-fries, salads, and slaws. Fermented cabbages, such as sauerkraut, are a traditional and nutritious food, while cabbage juice may be used topically for skin health. Additionally, cabbages can be used as animal feed or for decorative purposes.

## Climatic, soil, and water conditions

Cabbage is a cool-season crop that requires specific climatic, soil, and water conditions to grow successfully, as described below.

**Climatic Conditions :** The crop prefers cool and moist conditions, with an average temperature range of 60 to 65 degrees Fahrenheit (15 to 18 degrees Celsius). Temperatures above 75 degrees Fahrenheit (24 degrees Celsius) can cause the cabbage heads to bolt, which means they will prematurely form seed stalks instead of edible heads. Cabbage requires at least six hours of sunlight per day and does well in regions with a long growing season.

**Soil Conditions :** Cabbage grows well in well-drained soils that are rich in organic matter. The soil should be loose, fertile, and have a pH between 6.0 and 6.8. The soil should be well-aerated and have a good water-holding capacity,

allowing water to infiltrate and drain easily. Adding compost or other organic matter to the soil before planting can help improve its structure and fertility.

**Water Conditions :** The crop requires regular watering, especially during the early stages of growth. The optimal amount of water for cabbages is around 1 to 2 inches (2.5 to 5 centimeters) per week, either from rainfall or irrigation. Soil moisture should be monitored closely to prevent either underwatering or overwatering, as either condition can cause problems with growth, yield, and disease susceptibility.

## Description

### Crops details

Scientific name: *Brassica oleracea*

Order, family, and genus: Brassicales, Brassicaceae, and *Brassica*.

Local names: Kabichi (Swahili)

Other names: Spanish: col, French: chou, German: Kohl, Italian: cavolo, Portuguese: couve, Mandarin Chinese: 莲花白 (lián huā bái), Japanese: かぶ (kabu)

### General Information

Cabbage is a leafy vegetable with a round, compact head or "heart" made up of many layers of thick, sturdy leaves that grow in a tightly packed formation. The outer leaves are usually a darker green, while the inner leaves are lighter in color. The leaves have a smooth, slightly waxy texture and a slightly bitter taste. The densely leafed heads can range in size from 0.5 to 3.6 kg (1–8 lb) depending on variety. Cabbage typically ranges in size from small to large, with smaller heads being more tender and sweeter. The vegetable can also come in different colors, including green, purple, and white, depending on the variety. When cooked, cabbage softens and becomes more tender, but it still retains its distinctive taste and texture.

Cabbage has its roots in the Mediterranean region, but today it is grown in many other countries as well. China is currently the largest producer of cabbage, accounting for more than half of the world's production. Other top producers include India, Russia, and South Korea.

Some of the top cabbage-producing countries in Africa include Ethiopia, Tanzania, Kenya, South Africa, and Zimbabwe. In Ethiopia, cabbage is one of the most widely grown vegetables and is an important crop for small-scale farmers. In Tanzania, the crop is grown in the highlands and is an important source of income for farmers. Kenya is also a major producer, with the crop being grown in areas such as Kiambu and Nyandarua counties. In South Africa, cabbage is grown in several regions, including Limpopo, Mpumalanga, and the Western Cape.

Fields of cabbage

Red cabbage

Cabbage heads ready for harvest

Close-up of cabbage foliage

Field of cabbages

Cabbage leaves

Cabbage head ready for harvest

Cabbage leaves

# Cabbage Varieties

There are many different varieties of cabbage. The main varieties are white and red cabbage (*Brassica oleracea var. capitata*) and savoy cabbage (*Brassica oleracea var. Sabauda*).

Red cabbage has a deep purple-red color and a slightly sweeter flavor than green cabbage, while savoy has crinkly, curly leaves that are a darker shade of green than green cabbage.

There are many other different varieties of cabbage, each with its own unique characteristics:

**Green cabbage** : This variety has a tight head of crisp, green leaves.

**Red cabbage** : This variety has a deep purple-red color and a slightly sweeter flavor than green cabbage.

**Napa cabbage** : Also known as Chinese cabbage, this variety has long, oblong leaves and a milder flavor than other types of cabbage.

**Bok choy** : A type of Chinese cabbage with white stalks and dark green leaves, often used in stir-fries.

**Brussels sprouts** : While technically not a variety of cabbage, Brussels sprouts are a close relative. They grow on a stalk and have small, round heads of tightly packed leaves.

**Conehead cabbage** : This variety has a pointed head and pale green leaves.

**January King cabbage** : This variety has a greenish-blue color and is known for its sweet and nutty flavor.

**Pointed cabbage** : This variety has a pointed head and is similar in flavor to green cabbage.

**Stonehead cabbage** : This variety has a small, tight head and is very dense and heavy.

# Planting procedure

To maximize yield and produce healthy and flavorful cabbages, the following steps should be followed when planting cabbages.

**Soil preparation** : Cabbage prefers well-draining soil with a pH range of 6.0 to 6.8. Before planting, the soil should be tilled and amended with biochar, compost, or other organic matter to improve soil structure and fertility.

**Seed selection** : Choose high-quality cabbage seeds from a reputable seed supplier. There are many different varieties of cabbage, each with different growing requirements and mature sizes. Select a variety that suits your growing conditions and preferences.

**Seed starting** : Cabbage seeds can be started indoors or directly sown in the garden. If starting indoors, sow the seeds in a seed tray or container with a good-quality seed-starting mix. Keep the soil consistently moist and maintain a temperature of around 65 degrees Fahrenheit (18 degrees Celsius). Seeds typically germinate within 7 to 10 days.

**Transplanting** : When the seedlings have grown to about 2 to 3 inches (5 to 7.5 centimeters) tall, they can be transplanted into the garden. Cabbage should be planted at a spacing of 18 to 24 inches (45 to 60 centimeters) apart, with rows spaced 2 to 3 feet (60 to 90 centimeters) apart.

**Planting** : Plant the seedlings in a hole slightly deeper than their root ball and gently firm the soil around them. Water the soil well after planting to help settle it.

**Maintenance** : Cabbage requires consistent moisture, so water regularly to prevent the soil from drying out. Fertilize the plants every two weeks with a balanced fertilizer high in nitrogen. Cabbage plants are also prone to pests and diseases, so monitor the plants regularly for signs of damage or stress and take appropriate measures to control any issues.

*Cabbages can be started in a cold frame and transplanted*

*Cabbage seedlings*

## Harvesting

Harvesting cabbages is an important task in vegetable farming. Cabbage is typically grown for its dense, leafy heads that are used in a variety of culinary dishes. When it's time to harvest, farmers carefully inspect each head of cabbage to determine if it's ready to be picked. They look for the firmness and tightness of the head as well as the size and color of the leaves. Once a cabbage head is deemed ready for harvest, the farmer uses a sharp knife to cut it off at the base. It's important to be careful during this process to avoid damaging the plant or other nearby cabbages. After harvesting, the cabbages are washed and stored in a cool, dry place until they're ready to be sold or used. Overall, harvesting cabbages requires attention to detail and a steady hand, but the end result is a delicious and nutritious vegetable that can be enjoyed in a variety of dishes.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

**Alternaria leaf spot (Black spot, Gray spot)** *Alternaria brassicace*

*Initial symptoms on Chinese cabbage leaf*

*Chinese cabbage leaf showing many lesions caused by *Alternaria brassicicola**

*Chinese cabbage leaf showing many lesions caused by *Alternaria brassicicola**

*Symptoms on lower surface of Chinese cabbage leaf*

*Cabbage infected with black spot (*Alternaria brassicicola*)*

*Concentric black spots on leaf*

*Alternaria (*Alternaria brassicicola*) of cabbage.*

*Black spot (*Alternaria brassicicola*) symptom*

*Black spot infected cabbage leaf*

*Leaf spot on cabbage caused by *Alternaria brassicicola**

*Close-up of Alternaria lesion on cabbage leaf*

*Symptoms of Alternaria leaf spot on cabbage*

## **Symptoms**

Small dark spots on leaves which turn brown to gray; lesions may be round or angular and may possess a purple-black margin; lesions may form concentric rings, become brittle and crack in center; dark brown elongated lesions may develop on stems and petioles.

## **Cause**

Fungus

## **Comments**

May become a problem on cabbage during cool, wet periods.

## **Management**

Plant only pathogen-free seed; rotate crops; applications of appropriate fungicides control disease when present.

## **Anthracnose** *Colletotrichum higginsianum*

*anthracnose (*Colletotrichum higginsianum*) symptoms on turnip leaf*

*Anthracnose symptoms on cabbage leaf*

## **Symptoms**

Small circular or irregularly shaped dry spots which are gray to straw in color on leaves; a high number of spots may cause the leaf to die; lesions may coalesce to form large necrotic patches causing leaves to turn yellow and wilt; lesions may split or crack in dry centers.

## **Cause**

Fungus

## **Comments**

Fungus overwinters on leaf debris and on related weeds; disease emergence is favored by moist, warm conditions.

## **Management**

Control of disease depends on sanitary practices; treat seeds with hot water prior to planting; rotate crops; plant in an area with good soil drainage; remove all cruciferous weeds which may act as a reservoir for the fungus.

## **Black rot** *Xanthomonas campestris*

<i>Bacterial streaming from cut tissue</i>	<i>Initial infection begins as yellow "V" shaped spot on edge of leaf. Black veins eventually appear as infection spreads.</i>	<i>Classic bright yellow lesions at the leaf margins</i>
<i>Symptoms on stem</i>		<i>Typical V-shaped marginal chlorosis and necrosis caused by black rot.</i>
<i>A field with severe infection of black rot</i>	<i>Extreme damage from black rot infection.</i>	
<i>Cabbage leaf with scorched appearance caused by black rot infection</i>	<i>Black rot symptoms include large lesion on the margin of the leaves that causes sever leaf damage and yield losses on cabbage.</i>	<i>The symptoms starts as V-shaped yellow lesions to the margin of the leaves. If the disease infection starts early in the season the entire plant can be severely affected. Blackened veins is another major symptom of black rot on cabbage.</i>
<i>Savoy cabbage infected with black rot</i>		<i>Early symptoms of black rot showing V-shaped lesion on cabbage leaf</i>

## Symptoms

Irregularly shaped dull yellow areas along leaf margins which expand to leaf midrib and create a characteristic "V-shaped" lesion; lesions may coalesce along the leaf margin to give plant a scorched appearance.

## Cause

Bacterium

## Comments

Pathogen is spread via infected seed or by splashing water and insect movement; disease emergence favored by warm and humid conditions.

## Management

Primary method of controlling black rot is through the use of good sanitation practices; rotate crops to non-cruciferous crops every 2 years; plant resistant varieties; control cruciferous weed species which may act as a reservoir for bacteria; plant pathogen-free seed.

## Clubroot *Plasmodiophora brassicae*

<i>Cabbages in field showing symptoms of poor growth due to club root</i>	<i>Distorted roots of cabbage plant caused by infection with club root fungus</i>
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## Symptoms

Slow growing, stunted plants; yellowish leaves which wilt during day and rejuvenate in part at night; swollen, distorted roots; extensive gall formation

## Cause

Fungus

## Comments

Can be difficult to distinguish from nematode damage; fungus can survive in soil for periods in excess of 10 years; can be spread by movement of contaminated soil and irrigation water to uninfected areas

## Management

Once the pathogen is present in the soil it can survive for many years, elimination of the pathogen is economically unfeasible; rotating crops generally does not provide effective control; plant only certified seed and avoid field grown

transplants unless produced in a fumigated bed; applying lime to the soil can reduce fungus sporulation

## Damping-off (Wirestem, Head rot) *Rhizoctonia solani*

*Rotting lesion on cabbage leaf  
caused by infection with Rhizoctonia*

### Symptoms

Death of seedlings after germination; brown or black rot girdling stem; seedling may remain upright but stem is constricted and twisted (wirestem); in older cabbage plants sharply defined brown lesions appear on the underside of leaves; the lesions expand causing leaves to wilt and drop from plant

### Cause

Fungus

### Comments

Disease emergence in seedlings favored by cool temperatures

### Management

Plant pathogen-free seed or transplants that have been produced in sterilized soil; apply fungicide to seed to kill off any fungi; shallow plant seeds or delay planting until soil warms

## Powdery mildew *Erysiphe cruciferarum*

### Symptoms

Small white patches on upper and lower leaf surfaces which may also show purple blotching; patches coalesce to form a dense powdery layer which coats the leaves; leaves become chlorotic and drop from plant

### Cause

Fungus

### Comments

Disease emergence favored by dry season, moderate temperatures, low humidity and low levels of rainfall

### Management

Plant resistant varieties; rotate crops; remove all crop debris after harvest; remove weeds; avoid excessive application of nitrogen fertilizer which encourages powdery mildew growth; powdery mildew can be controlled by application of sulfur sprays, dusts or vapors

## Sclerotinia stem rot (White mold) *Sclerotinia sclerotiorum*

### Symptoms

Irregular, necrotic gray lesions on leaves; white-gray lesions on stems; reduced pod set; shattering seed pods

### Cause

Fungus

### Comments

Disease emergence favors moderate to cool temperatures and high humidity

### Management

Rotate crop to non-hosts (e.g. cereals) for at least 3 years; control weeds; avoid dense growth by planting in adequately spaced rows; apply appropriate foliar fungicides

## Watery soft rot (White rot, Cabbage drop) *Sclerotinia sclerotiorum*

*Cabbage infected with Sclerotinia*

*Cabbage head infected with  
Sclerotinia*

### **Symptoms**

Soft rotting area at base of stem which spreads upwards successively killing leaves by causing them to drop and infect the leaf below; when fungus reaches the head it causes a soft, slimy, watery rot

### **Cause**

Fungus

### **Comments**

Disease emergence is favored by frequent rainfall that keep soil close to saturation

### **Management**

The number of sclerotia in the soil can be reduced by plowing crop debris deep into soil and rotating crops every 3 years with non-host crops; severe infestations may require control through application of appropriate fungicide

## **White rust *Albugo candida***

### **Symptoms**

White pustules on cotyledons, leaves, stems and/or flowers which coalesce to form large areas of infection; leaves may roll and thicken

### **Cause**

Fungus

### **Comments**

Fungus can survive for long periods of time in dry conditions; disease spread by wind

### **Management**

Rotate crops; plant only disease-free seed; apply appropriate fungicide if disease becomes a problem

## **Category : Bacterial**

### **Bacterial soft rot *Erwinia caratovora***

*Infected cabbage Symptoms*

*Cabbage head with decay from soft-rotting, bacterial infection.*

*Bacteria streaming from soft-rotted tissue under dark-field observation.*

*Bacterial soft rot on cabbage*

*Bacterial soft rot on cabbage*

### **Symptoms**

Water-soaked lesions on cabbage head which expand to form a large rotted mass of cream colored tissue which is liquid underneath; surface of lesions usually crack and exude slimy liquid which turns tan, dark brown or black on exposure to air.

### **Cause**

Bacterium

### **Comments**

Bacteria are easily spread on tools and by irrigation water; disease emergence favored by warm, moist conditions.

### **Management**

Chemical treatments are not available for bacterial soft rot, control relies on cultural practices; rotate crops; plant cabbage in well-draining soils or raised beds; only harvest heads when they are dry; avoid damaging heads during harvest.

## **Blackleg *Leptosphaeria maculans***

### **Symptoms**

Damping-off of seedlings; round or irregularly shaped gray necrotic lesions on leaves with dark margins; lesions may be covered in pink masses in favorable weather conditions.

**Cause**

Fungus

**Comments**

Favors warm, wet conditions; higher temperatures result in the development of more visible symptoms.

**Management**

Cabbage does not have high levels of resistance to blackleg and fungicides use is uneconomical; use disease free seed or treat with hot water to remove fungus prior to planting; remove and destroy crop debris after harvest or plow deeply into soil.

**Category : Fungal, Oomycete****Downy mildew *Peronospora parasitica***

*Downy mildew symptoms on cabbage leaf*

*Downy mildew symptoms on cabbage leaf*

**Symptoms**

Irregular yellow patches on leaves which turn light brown in color; fluffy gray growth on the undersides of the leaves

**Cause**

Fungus

**Comments**

Disease emergence favored by cool, moist conditions

**Management**

Remove all crop debris after harvest; rotate with non-brassicas; application of appropriate fungicides may be required if symptoms of disease are present

**Category : Viral****Ring spot *Mycosphaerella brassicicola*****Symptoms**

Small, purple spots surrounded by a ring of water-soaked tissue on leaves which mature to brown spots with olive green borders 1-2 cm across; spots may develop numerous fruiting bodies which give them a black appearance or develop a concentric pattern; heavily infected leaves may dry up and curl inwards

**Cause**

Fungus

**Comments**

Ring spot requires cool, moist conditions to survive; disease symptoms typically develop in the fall and the peak of the infection occurs in winter

**Management**

Refrain from planting in areas known to have had disease previously; rotate crop to non-brassicas; sanitize tools and equipment regularly; apply appropriate fungicide if disease is identified in crop

**Category : Other****Slugs & snails (Gray garden slug, Spotted garden slug, Brown garden snail, European garden snail, etc.) *Decoratus reticulatum***

*Limax maximus*

*Helix aspersa*

*Cornu aspersum*

*European brown snail*

*Gray garden slug*

### Symptoms

Irregularly shaped holes in leaves and stems; flowers and fruit may also be damaged if present; if infestation is severe, leaves may be shredded; slime trails present on rocks, walkways, soil and plant foliage; several slug and snail species are common garden pests; slugs are dark gray to black in color and can range in size from 2.5 to 10 cm (1-4 in); garden snails are generally smaller and possess a rounded or spiral shell

### Cause

Mollusc

### Comments

Slugs and snails prefer moist, shaded habitats and will shelter in weeds or organic trash; adults may deposit eggs in the soil throughout the season; damage to plants can be extensive

### Management

Practice good garden sanitation by removing garden trash, weeds and plant debris to promote good air circulation and reduce moist habitat for slugs and snails; handpick slugs at night to decrease population; spread wood ashes or eggshells around plants; attract molluscs by leaving out organic matter such as lettuce or grapefruit skins, destroy any found feeding on lure; sink shallow dishes filled with beer into the soil to attract and drown the molluscs; chemical controls include ferrous phosphate for organic gardens and metaldehyde (e.g. Buggetta) and carbaryl (e.g Sevin bait) for non-organic growers

## Pests

### Category : Insects

#### Beet armyworm *Spodoptera exigua*

*beet armyworm (*Spodoptera exigua*) larvae on soybean leaf*

*Beet armyworm adult*

*Larva of beet armyworm*

*Young larvae*

*Beet armyworm eggs covered in white hairs*

*Beet armyworm larva*

### Symptoms

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside.

### Cause

Insect

### Comments

Insect can go through 3–5 generations a year.

### Management

Organic methods of controlling the beet armyworm include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that

are available for the home garden do not provide adequate control of the larvae.

## Cabbage aphid *Brevicoryne brassicae*

*Lady beetles feeding on aphids*

*Heavy infestation of cabbage leaves*

*Aphid colony Multiple life stage*

*Dense colony Adult aphid*

*Heavily infested leaf*

*Cabbage aphid colony on a cabbage leaf*

*Cabbage aphid adult*

### Symptoms

Large populations can cause stunted growth or even plant death; insects may be visible on the plant leaves and are small, grey-green in color and soft bodied and are covered with a white waxy coating; prefer to feed deep down in cabbage head and may be obscured by the leaves.

### Cause

Insect

### Comments

Cabbage aphids feed only on cruciferous plants but may survive on related weed species.

### Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use.

## Cabbage looper *Trichoplusia ni*

*Cabbage looper feeding on cabbage leaf*

### Symptoms

Large or small holes in leaves; damage often extensive; caterpillars are pale green with a white lines running down either side of their body; caterpillars are easily distinguished by the way they arch their body when moving; eggs are laid singly, usually on the lower leaf surface close to the leaf margin, and are white or pale green in color

### Cause

Insect

### Comments

Insects overwinter as pupae in crop debris in soil; adult insect is a dark colored moth; caterpillars have a wide host range

### Management

Management may be needed after cabbage heading; biological controls such as spraying with *Bacillus thuringiensis* can be effective at controlling looper numbers; application of appropriate insecticide after heading also controls looper populations; selective insecticides help to protect populations of natural enemies on crop

## Cutworms *Agrotis* spp.

*Peridroma saucia*

*Nephelodes minians*

and others

Cutworm feeding on plant stem

Cutworms will curl up into a characteristic C shape when disturbed

Cutworm larva severing plant stem

### Symptoms

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5â€“5.0 cm (1â€“2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed

### Cause

Insect

### Comments

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato

### Management

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically

## Diamondback moth *Plutella xylostella*

Diamondback moth pupae

Cabbage damaged by  
Diamondback moth larvae

Larva feeding on cabbage leaf

### Symptoms

Young larvae feed between upper and lower leaf surface and may be visible when they emerge from small holes on the underside of the leaf; older larvae leave large, irregularly shaped shotholes on leaf undersides, leaving the upper surface intact; larvae may drop from the plant on silk threads if the leaf is disturbed; larvae are small (1 cm/0.3 in) and tapered at both ends; larvae have two prolegs at the rear end that are arranged in a distinctive V-shape

### Cause

Insect

### Comments

Larvae take between 10 and 14 days to mature and spin a loose, gauze-like cocoon on leaves or stems to pupate

### Management

Larvae can be controlled organically by applications of *Bacillus thurengiensis* or Entrust; application of appropriate chemical insecticide is only necessary if larvae are damaging the growing tips of the plants

## Flea beetle *Phyllotreta* spp.

Crucifer flea beetles and damage on  
cabbage leaf

## Symptoms

Small holes or pits in leaves that give the foliage a characteristic “shot hole” appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5–3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance

## Cause

Insect

## Comments

Younger plants are more susceptible to flea beetle damage than older ones; older plants can tolerate infestation; flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year

## Management

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application of diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied

## Large cabbage white (Cabbageworm) *Pieris rapae*

*Cabbage damaged by cabbageworm*

*Cabbageworm and frass on a cabbage leaf*

## Symptoms

Large ragged holes in leaves or bored into head; green-brown frass (insect feces) on leaves; caterpillar is green in color and hairy, with a velvet-like appearance; may have faint yellow to orange stripes down back; slow-moving compared with other caterpillars

## Cause

Insect

## Comments

Butterfly larvae cause damage by feeding on plants; can be distinguished from other caterpillars by its sluggish movement; in large numbers larvae can cause extensive damage very quickly

## Management

Plant can tolerate quite a lot of damage from caterpillars between transplanting and heading; hand pick caterpillars from plants and destroy; scrape eggs from leaves prior to hatching; apply appropriate insecticide if infestation is very heavy

## Thrips (Western flower thrips, Onion thrips, etc) *Frankliniella occidentalis*

*Thrips tabaci*

*Thrips damage to cabbage head*

*Onion thrips on cabbage*

*Western flower thrips*

## Symptoms

If population is high leaves may be distorted; leaves are covered in coarse stippling and may appear silvery; leaves speckled with black feces; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color

**Cause**

Insect

**Comments**

Transmit several viruses including Tomato spotted wilt virus; once acquired, the insect retains the ability to transmit the virus for the remainder of its life

**Management**

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic

**Category : Nematodes****Root knot nematode *Meloidogyne* spp.****Symptoms**

Galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; reduction in plant vigor; yellowing plants which wilt in hot weather

**Cause**

Nematode

**Comments**

Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or garden with this type of soil is most likely

**Management**

Plant resistant varieties if nematodes are known to be present in the soil ;check roots of plants mid-season or sooner if symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens

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# Cantaloupe

## Description

Cantaloupe, *Cucumis melo*, is a vining plant in the family Cucurbitaceae, grown for its large, sweet fruit of the same name. Cantaloupe vines are trailing and are slightly hairy with simple oval leaves arranged alternately on the stem. The plant produces small yellow flowers which are 1.2–3.0 cm (0.5–1.2 in) in diameter and large oval to round fruit with green to orange flesh. Melon is an annual plant and a vine can grow up to 3 m (9.8 ft) in length. Cantaloupe may be referred to as muskmelon or melon and likely originate from East and Northeast Africa.

*Ripe cantaloupe ready for harvest*

*Cantaloupe flowers*

*Cantaloupe foliage and blossom*

*Cantaloupe vines*

*Cantaloupe*

*Close-up of cantaloupe leaf*

## Uses

Melon is primarily consumed as a fresh fruit. The pulp may be turned into a fresh beverage and the seeds can be roasted and eaten. The unripe fruit of some species are cooked as a vegetable.

# Propagation

**Basic requirements** Cantaloupe is a warm-season crop, requiring lots of sun and good drainage to develop optimally and growing best at temperatures between 18 and 28°C (65–82°F). Melon will yield best if grown in a light, well-draining soil, rich in organic matter and with a pH between 6.0 and 7.0. Cantaloupe should be planted in full sun and are heavy feeders and water users. They need to be provided with ample soil moisture and fertilized regularly. Vining varieties can grow to very large sizes and require a good deal of space. **Sowing seeds** Cantaloupe can be direct seeded in areas with a long, warm growing season but in more Northern climates it should be sown indoors and transplanted. If direct seeding, seeds should be sown after the last frosts and when the soil has warmed to at least 18.4°C (65°F). Allow 90–120 cm (~3–4 ft) between seeds in a row and 150–180 cm (~5–6 ft) between rows. If transplanting, seeds should be sown approximately 3–4 weeks before the last frost date in your area and transplanted after the plants develop their first set of true leaves. Seeds sown both indoors and out require lightly moist soil for germination, care should be taken to avoid overwatering as seeds are prone to rotting. Seeds should germinate in 3–10 days depending on the soil temperature. **Transplanting** Cantaloupe seedlings should be transplanted when all danger of frost has passed and the soil has warmed to at least 18.4°C (65°F). Covering soil with dark plastic or mulch a week prior to planting outdoors can help bring the soil temperature up more quickly in colder regions, allowing earlier planting. Beginning approximately 7–10 days before transplanting, plants should be set outside to harden off (see <https://www.plantvillage.com/posts/264>). The planting site should be prepared by incorporating plenty of organic matter to encourage vegetative growth. When transplanting seedlings, allow 90–120 cm (~3–4 ft) between plants and 150–180 cm (~5–6 ft) between rows. Drip or soaker irrigation is preferred to overhead irrigation and plants should be watered evenly to keep them moist. **General care and maintenance** Cantaloupe vines are sprawling and require plenty space to grow. Vines can be trained to grow on a trellis or fence to save space. Cantaloupe plants also require a regular supply of water while growing, blooming and setting fruit and where drip irrigation is not being used, plants should be watered deeply once per week, providing at least an inch of water. Mulches can be used to conserve soil moisture and black polyethylene mulch has the advantage of warming the soil. **Harvesting** Cantaloupes are ready to be harvested when the surface becomes netted and the color underneath turns from green to yellow. When the melon is ready to be picked the stem will come away easily from the fruit.

*Cantaloupe seedling with first set of true leaves*

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# Common Pests and Diseases

## Diseases

### Category : Fungal

## **Alternaria leaf blight** *Alternaria cucumerina*

*Cracking of fruit due to alternaria leaf blight infestation*

*Brown to black spots with concentric rings observed within the spot. A yellow halo often occurs around a spot or group of spots.*

*Incipient lesions*

*Symptoms on infected leaves*

*Symptoms on infected leaf*

*Symptoms on infected leaf*

*Significantly infected leaves turn brown and brittle.*

*Close-up of alternaria leaf blight*

*Alternaria leaf blight (*Alternaria cucumerina*) symptoms*

*Infected leaf*

*Close-up of multiple spots with concentric rings.*

*Circular spots with concentric rings*

*Alternaria leaf blight infected plant*

*Alternaria leaf blight (*Alternaria cucumerina*) infected leaves*

*Alternaria leaf blight symptoms on cantaloupe leaf*

### **Symptoms**

Small, yellow-brown spots with a yellow or green halo which first appear on the oldest leaves; as the disease progresses, lesions expand and become large necrotic patches, often with concentric patterning; lesions coalesce, leaves begin to curl and eventually die.

### **Cause**

Fungus

### **Comments**

Disease is prevalent in growing areas where temperatures are high and rainfall is frequent.

### **Management**

Cucurbits should be rotated with another crop every 2 years to reduce levels of inoculum; crop debris should be removed from the field as quickly as possible after harvest or plowed deeply into the soil; applications of appropriate protective fungicides can help to slow the development of the disease; water plants from the base rather than from above to reduce periods of leaf wetness which are conducive to the development and spread of disease.

## **Anthracnose (Leaf spot, Fruit rot)** *Colletotrichum orbiculare*

*Infected spots on leaf are often lighter in center with a darker border.*

*Young green-yellow fruit with depressed portions of infected tissue.*

*Anthracnose on honeydew fruit.*

*Anthracnose symptoms on cantaloupe leaf*

*Anthracnose lesions on honeydew melon*

*Fruit with small anthracnose lesions.*

*Symptoms of Cantaloupe anthracnose*

*Single infected area with clumped stromata covered in light tan-orange conidia.*

*Fruit with anthracnose lesions*

*Cantaloupe anthracnose symptoms*

*Anthracnose symptoms on cantaloupe foliage*

*Anthracnose symptoms on cantaloupe leaf*

## **Symptoms**

Lesions on fruit and leaves which may develop salmon pink spore masses during periods of wet weather.

## **Cause**

Fungus

## **Comments**

Favors wet conditions.

## **Management**

Rotate crops with non-cucurbits every 1-2 years to prevent disease build-up; plant only disease free, treated seed.

## **Cercospora leaf spot** *Cercospora citrullina*

*Foliage with low level of Cercospora leaf spot*

*Cercospora leaf spot*

*Lower side of infected leaf*

*Close up of Cercospora leaf spot infected leaf*

*Close up of diseased leaf*

## **Symptoms**

Initial symptoms of disease occur on older leaves as small spots with light to tan brown centers; as the disease progresses, the lesions enlarge to cover large areas of the leaf surface; lesions may have a dark border and be surrounded by a chlorotic area; the centers of the lesions may become brittle and crack.

## **Cause**

Fungus

## **Comments**

Fungus survives on plant debris; spread by wind and water splash; occurs mainly in tropical and subtropical growing regions.

## **Management**

Any diseased plants should be removed and destroyed to prevent further spread; crop debris should be removed after harvest or plowed deeply into the soil to reduce inoculum.

## **Charcoal rot** *Macrophomina phaseolina*

charcoal rot (*Macrophomina phaseolina*)

infected fruit

Charcoal rot

Charcoal rot of cantaloupe fruit.

Stem lesions caused by charcoal rot

### Symptoms

yellowing, dying leaves; water-soaked lesion on stem at soil line; stems oozing amber gummy substance; stem drying and turning tan brown in color; lesion may girdle stem and kill plant;

### Cause

Fungus

### Comments

Primarily affects fall season melons.

### Management

Rotate crop to a non-host for 2-3 years to reduce disease build-up; avoid water stress to plants; plow crop debris deep into soil or remove and destroy after harvest.

## Fusarium wilt *Fusarium oxysporum*

### Symptoms

Yellowing and wilting of runners; lesions on the runner extend from crown to tips; lesions on roots and stems; internal red to brown discoloration.

### Cause

Fungus

### Comments

Disease emergence favored by warm, wet soil.

### Management

Plant in well draining soils and avoid waterlogging; plant fungicide treated seed; rotate crops on 4 year rotation.

## Gummy stem blight *Didymella bryoniae*

gummy stem blight (vine decline)

gummy stem blight (vine decline)

Gummy stem blight on cantaloupe leaf.

Large gummy stem blight lesions on cantaloupe leaf

Rotted lower cantaloupe stem.  
Dark areas have abundant pseudothecia.

Infected fruit

Infected melons

Large gummy stem blight lesions on cantaloupe leaf

Large gummy stem blight lesions on cantaloupe leaf.

Pycnidia of *Didymella bryoniae* and gumming

Symptoms of gummy stem blight on cantaloupe fruit

Symptoms of gummy stem blight on cantaloupe leaves

### Symptoms

Circular brown or tan spots of various sizes on leaves; leaves covered with lesions; stems splitting and forming cankers; wounds exude a brown, gummy substance; wilting vines; death of stems; small water-soaked lesions on fruit which enlarge and exude gummy substance; black fruiting bodies often present in lesions.

**Cause**

Fungus

**Comments**

Disease may be seed-borne.

**Management**

Use disease free seed; treat seeds prior to planting; rotate crops every 2 years.

## **Monosporascus vine decline** *Monosporascus cannonballus*

*Monosporascus* root rot

Research plots show dark green plants tolerating *Monosporascus* root rot

Early symptoms of *Monosporascus* root rot. Note yellow patches in the field.

Root lesion caused by *M. cannonballus*

Cantaloupe tap root with large numbers of perithecia (black dots) of *Monosporascus cannonballus*.

Cantaloupe root with large numbers of perithecia (black dots) of *Monosporascus cannonballus*.

Perithecia of *Monosporascus cannonballus* embedded in outer layer of cantaloupe secondary root tissue.

*Monosporascus* root rot (*Monosporascus cannonballus*) of cantaloupe kills vines late in the season and leaves fruit to sunburn.

*Monosporascus cannonballus* of cantaloupe kills vines late in the season and leaves fruit to sunburn.

Black fruiting bodies visible on root of cantaloupe

Black fruiting bodies visible on root of cantaloupe

**Symptoms**

Leaves turning chlorotic; sudden collapse of plant canopy 1-2 weeks before harvest; root lesions generally become evident several days after plant death; lesions become covered in black dots (fungal fruiting bodies).

**Cause**

Fungus

**Comments**

Symptoms may not appear until the vines are mature with ripening fruit.

**Management**

Fumigate soil prior to planting; remove and destroy plant roots immediately following harvest.

## **Powdery mildew** *Podosphaera xanthii*

*Erysiphe cichoracearum*

Powdery mildew lesions caused by *Podosphaera xanthii*

Powdery mildew lesions caused by *Podosphaera xanthii* nearly cover the entire leaf surface

Powdery mildew (*Podosphaera xanthii*) on cantaloupe leaf

Powdery mildew lesions caused by *Podosphaera xanthii*.

White sporulation of *Podosphaera xanthii* on cantaloupe leaves

Powdery mildew on cantaloupe leaf

**Symptoms**

White powdery growth on the upper surfaces of leaves and stems; infected areas stunted and distorted.

**Cause**

Fungus

**Comments**

Disease emergence favored by dry weather and high relative humidity.

**Management**

Plant in sites with good air circulation and sun exposure; do not overcrowd plants; sanitize equipment regularly.

**Septoria leaf spot** *Septoria cucurbitacearum***Symptoms**

Initial symptoms of disease are small dark water-soaked spots on the leaves which turn beige to white in dry conditions; lesions develop thin brown borders and the centers may become brittle and crack; small white spots may erupt on the surface of infected butternut and acorn squash and pumpkin fruit.

**Cause**

Fungus

**Comments**

Pathogen can survive on crop debris for periods in excess of 1 year.

**Management**

Scout plants during cool wet conditions for any sign of spots; early application of an appropriate protective fungicide can help limit the development of the disease if spots are found' cucurbits should be rotated with other crops every 2 years to prevent the build-up of inoculum; crop debris should be removed and destroyed after harvest.

**Southern blight (Stem and fruit rot)** *Sclerotium rolfsii*

*Fruit with fungus colonizing ground scar*

*Fruit with fungus colonizing ground scar*

*Fruit with fungus colonizing ground scar.*

*Southern blight symptoms on cantaloupe vines*

*Rotting stem of cantaloupe infected with Southern blight*

*Symptoms of Southern blight on cantaloupe fruit*

**Symptoms**

Sudden wilting of leaves; yellowing foliage; browning stem above and below soil; browning branches; stem may be covered with fan-like mycelial mat.

**Cause**

Fungus

**Comments**

Fungus can survive in soil for long periods; disease emergence favored by high temperatures, high humidity and acidic soil; disease found mainly in tropical and subtropical regions, including the southern United States.

**Management**

Remove infected plants; avoid overcrowding plants to promote air circulation; rotate crops with less susceptible plants; plow crop debris deep into soil; provided a barrier to infection by wrapping lower stems of plant with aluminum foil covering below ground portion of stem and 2-3 in above soil line.

**Verticillium wilt** *Verticillium dahliae***Symptoms**

Symptoms generally appear after fruit set; chlorotic leaves which develop necrotic areas; leaves collapsing; symptoms only on one side of vine; discoloration of vascular tissue in roots.

**Cause**

Fungus

## Comments

Fungus can survive in soil for many years; disease emergence favored by cool or mild weather in Spring.

## Management

Do not plant in areas where other susceptible crops have been grown previously; delay planting until temperatures are warmer.

## Category : Bacterial

### Angular leaf spot *Pseudomonas syringae*

Symptoms of angular leaf spot on cantaloupe leaf

Symptoms of angular leaf spot on cantaloupe leaf

Symptoms of angular leaf spot on cantaloupe leaf

## Comments

Small water-soaked lesions on leaves which expand between leaf veins and become angular in shape; in humid conditions, lesions exude a milky substance which dries to form a white crust on or beside lesions; as the disease progresses, lesions turn tan and may have yellow/green edges; the centers of the lesions dry and may drop out leaving a hole in the leaf.

## Cause

Bacterium

## Comments

Spread through infected seed, splashing rain, insects and movement of people between plants; bacterium overwinters in crop debris and can survive for 2.5 years.

## Management

Use disease-free seed; do not grow plants in field where cucurbits have been grown in the previous 2 years; protective copper spray may help reduce incidence of disease in warm, humid climates; plant resistant varieties.

### Bacterial wilt *Erwinia tracheiphila*

Wilted plant

Wilted vine of a single plant.

Wilting plant

Cross section through cantaloupe stem showing xylem vessels plugged with *Erwinia tracheiphila*

Wilted vine of Korean melon plant.

Wilted vine of Korean melon plant

Field diagnosis of bacterial wilt can be done by cutting a stem where the wilt has occurred.

Positive bacterial slime string test.  
Note the slime strings stretching between cut stems.

Cantaloupe plant suffering from bacterial wilt

## Comments

Wilting of individual runners or entire plant; leaves and stems of affected parts turn dark green; wilting is irreversible; affected parts turn necrotic.

## Cause

Bacterium

## Comments

Spread by striped or spotted cucumber beetles; disease can be confirmed by cutting the stem and slowly pulling the two ends apart - infected plants will ooze strings of bacterial exudate.

## **Management**

Control cucumber beetle populations on plants; hand pick adult beetles and destroy; soil and foliar application of appropriate insecticides may help to control populations.

## **Category : Other**

### **Aster yellows** Aster yellows phytoplasma

#### **Symptoms**

Foliage turning yellow; secondary shoots begin growing prolifically; stems take on a rigid, upright growth habit; leaves are often small in size and distorted, may appear thickened; flowers are often disfigured and possess conspicuous leafy bracts; fruits are small and pale in color.

#### **Cause**

Phytoplasma

#### **Comments**

Disease is transmitted by leafhoppers and can cause huge losses in cucurbit crops.

#### **Management**

Remove any infected plants from the field to reduce spread; control weeds in and around the field that may act as a reservoir for the phytoplasma; protect plants from leaf hopper vectors with row covers.

## **Category : Viral**

### **Cucumber mosaic** Cucumber mosaic virus (CMV)

*Typical symptoms of mosaic virus on cantaloupe.*

*Symptoms of mosaic viruses on cantaloupe leaf*

*Symptoms of mosaic viruses on cantaloupe leaves*

#### **Symptoms**

Plants are severely stunted; foliage is covered in distinctive yellow mosaic; leaves of plant curl downwards and leaf size is smaller than normal; flowers on infected plants may be deformed with green petals; fruits become distorted and are small in size; fruit is often discolored.

#### **Cause**

Viruses

#### **Comments**

Transmitted by aphids; virus has an extensive host range; can be mechanically transmitted via tools etc.

#### **Management**

Control of the virus is largely dependant on the control of the aphid vectors; reflective mulches can deter aphid feeding; aphid outbreaks can be treated with mineral oils or insecticidal soap applications; some resistant varieties are available.

### **Cucurbit yellow stunting disorder virus** Cucurbit yellow stunting disorder virus (CYSDV)

Genus: Crinivirus

Group: "Positive sense ssRNA viruses"

*Infected honeydew melon plants*

#### **Symptoms**

The symptoms generally appear on the older leaves first. Initially the symptom appears as chlorotic spotting which leads to interveinal chlorosis and followed by severe yellowing. The infected leaves may roll upward and become brittle. Also the infected plant may appear stunted.

## **Cause**

Virus

## **Comments**

The virus is mainly transmitted by whitefly *Bemisia tabaci*. The host range is restricted to the Cucurbitaceae (watermelon, melon, cucumber, squash, courgette etc.).

## **Management**

Grow virus free and whiteflies free seed materials. During the growing season use yellow sticky traps to monitor and control whiteflies. Remove the infected plants and burn them. Keep the field free from weeds. In case severe infestation of whiteflies, use suitable insecticides. After a growing season remove the crop debris, volunteer plants and destroy them.

## **Squash mosaic** Squash mosaic virus (SqMV)

*Symptoms on a melon seedling following seed transmission.*

## **Symptoms**

Symptoms vary with variety being grown but plants can show symptoms which include green veinbanding, mottled leaves, blisters, ring spots or protruding veins at leaf margins; some squash varieties may develop leaf enations; infected plants are often stunted and fruits may be malformed with mottled skin.

## **Cause**

Virus

## **Comments**

Virus can be transmitted through infected seed and spread by striped cucumber beetles.

## **Management**

Use only certified disease-free seed.

## **Watermelon mosaic** Watermelon mosaic virus (WMV)

## **Symptoms**

Symptoms vary widely depending on species, cultivar, virus strain and environmental conditions; symptoms on leaves may include green mosaic patternation, green vein-banding, chlorotic rings and disfigured leaves.

## **Cause**

Virus

## **Comments**

Virus is found in almost all Cucurbit growing regions in the world; virus is spread by over 20 aphid species.

## **Management**

Treatments that control populations of aphid vectors can also reduce the incidence of the virus; spraying plants with mineral oils or insecticidal soaps can help to reduce aphid numbers.

## **Zucchini yellow mosaic** Zucchini yellow mosaic virus (ZYMV)

## **Symptoms**

Infected plants are severely stunted and leaves can exhibit a variety of symptoms including yellow mosaic patternation, severe deformation, blistering, reduced size and necrosis; fruits are deformed.

## **Cause**

Virus

## **Comments**

Disease can cause devastating epidemics when present.

## **Management**

Use of resistant varieties, where available, is usually the most effective method of controlling the virus; control of aphid populations on the plants can be achieved through the use of mineral oils and insecticidal soaps but is rarely effective at controlling the virus.

## Category : Fungal, Oomycete

### Downy mildew *Pseudoperonospora cubensis*

Downy mildew on canteloupe

Downy mildew symptoms on cantaloupe foliage

Downy mildew symptoms on cantaloupe foliage

Downy mildew symptoms on cantaloupe foliage

Symptoms of downy mildew on underside of cantaloupe leaf

Symptoms of downy mildew on melon leaf

#### Symptoms

Dead or dying leaves; yellow to brown lesions on the upper side of leaves; purple growth developing on the underside of leaves.

#### Cause

Fungus

#### Comments

Favors heavy rains and moving water.

#### Management

Do not overcrowd plants; avoid overhead irrigation, water plants from base; apply appropriate fungicide.

## Pests

### Category : Insects

### Aphids (Peach aphid, Melon aphid) *Myzus persicae*

*Aphis gossypii*

cotton aphid (*Aphis gossypii*) adults  
and nymphs

Cotton aphid (*Aphis gossypii*) adult

Green peach aphid (*Myzus persicae*)  
adult

Colony of peach aphids on a leaf

Adult green peach aphid (*Myzus persicae*) with deformed wings.

#### Symptoms

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants.

#### Cause

Insect

#### Comments

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed.

### Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use.

## Cabbage looper *Trichoplusia ni*

*Cabbage looper adult*

*Cabbage looper egg*

*Cabbage looper larvae*

*Cabbage looper*

### Symptoms

Large or small holes in leaves; damage often extensive; caterpillars are pale green with a white lines running down either side of their body; caterpillars are easily distinguished by the way they arch their body when moving; eggs are laid singly, usually on the lower leaf surface close to the leaf margin, and are white or pale green in color.

### Cause

Insect

### Comments

Insects overwinter as pupae in crop debris in soil; adult insect is a dark colored moth; caterpillars have a wide host range.

### Management

Looper populations are usually held in check by natural enemies; if they do become problematic larvae can be hand-picked from the plants; an organically acceptable control method is the application of *Bacillus thuringiensis* which effectively kills younger larvae; chemical sprays may damage populations of natural enemies and should be selected carefully.

## Cucumber beetles (Western striped cucumber beetle, Western spotted cucumber beetle, Banded cucumber beetle) *Acalymma vittata*

*Diabrotica undecimpunctata*

*Diabrotica balteata*

*Striped cucumber beetles adult scarring of vine*

*striped cucumber beetle adult scarring of fruit skin*

*striped cucumber beetle (*Acalymma vittatum*) on larvae in Cantaloupe rind*

*External symptoms of striped cucumber beetle larval tunneling at plant crown and adult scarring of vine*

*Extensive tunneling by striped cucumber beetle larvae at plant base producing plant collapse*

*Striped cucumber beetles and checkered melon beetle feeding on ripe muskmelon*

*Banded cucumber beetle*

*Western spotted cucumber beetle*

*Western striped cucumber beetle*

### Symptoms

Stunted seedling; damaged leaves, stems and/or petioles; reduced plant stand; plants may exhibit symptoms of bacterial wilt; scars on fruit caused by beetle feeding damage; adult beetles are brightly colored with either a green-yellow background and black spots or alternating black and yellow stripes

#### Cause

Insect

#### Comments

Beetles overwinter in soil and leaf litter and emerge from soil when temperatures begin to reach and exceed 12.7°C (55°F)

#### Management

Monitor new planting regularly for signs of beetle; floating row covers can be used to protect the plants from damage but will need to be removed at bloom to allow bees to pollinate plants; applications of kaolin clay can be effective for management of small beetle populations; application of appropriate insecticides may be necessary

#### Cutworms *Agrotis* spp.

*Peridroma saucia*

*Nephelodes minians*

and others

bronzed cutworm (*Nephelodes minians*) larvae

variegated cutworm (*Peridroma saucia*)

bronzed cutworm (*Nephelodes minians*) adult

Colorful larva of the variegated cutworm (*Peridroma saucia*)

Cutworm

#### Symptoms

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5–5.0 cm (1–2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed.

#### Cause

Insect

#### Comments

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato.

#### Management

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically.

#### Flea beetles *Epitrix* spp.

flea beetles (*Epitrix* spp.)

#### Symptoms

Small holes or pits in leaves that give the foliage a characteristic “shot hole” appearance; young plants and

seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5â€“3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance.

### Cause

Insects

### Comments

Younger plants are more susceptible to flea beetle damage than older ones; older plants can tolerate infestation; flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year.

### Management

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application on diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied.

## Squash bug *Anasa tristis*

squash bug (*Anasa tristis*) adult

Egg mass shortly after hatch on squash.

Adult ovipositing on squash leaf.

Squash bug (*Anasa tristis*) nymph

Mating pair of squash bugs (*Anasa tristis*).

Squash bug nymphs

### Symptoms

Speckled leaves which turn yellow and brown; wilting plants; dieback of runners; blemished fruit; fruit death; adult squash bugs are often misidentified as stink bugs; they are grey-black in color with orange and black stripes on the edges of their abdomen; nymphs are greenish gray in color and often covered in white powder; female squash bugs lay conspicuous copper colored eggs on the undersides of the leaves.

### Cause

Insect

### Comments

Squash bugs overwinter in crop debris or under rocks and stones.

### Management

Destroy all crops residue as soon as possible after harvest or on plant death; apply row covers at planting; apply insecticidal soap or appropriate insecticide.

## Stinkbugs (Various) Various

Green stink bug

### Symptoms

Dark colored pinpricks on fruit surrounded by a lighter area that turns yellow or remains light green; stink bugs often carry pathogens in their mouthparts which can cause secondary infections and decay of fruit; adult insect is shield-shaped and brown or green in color; may have pink, red or yellow markings; eggs are drum shaped and laid in clusters on the leaves; larvae resemble the adults but are smaller

## Cause

Insect

## Comments

Adult insects overwinter under leaves, on legumes, blackberries or on certain weeds such as mustard or Russian thistle

## Management

Remove weeds around crop which may act as overwintering sites for stink bugs and practice good weed management throughout the year; organically accepted control methods include the use of insecticidal soaps, kaolin clay and preservation of natural enemies; chemical treatments are not recommended for tomatoes that are to be processed for paste or canning unless secondary infections with other pathogens are a concern

## Thrips (Western flower thrips, others) *Frankliniella occidentalis*

*Western flower thrips*

## Symptoms

If population is high leaves may be distorted; leaves are covered in coarse stippling and may appear silvery; leaves speckled with black feces; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color

## Cause

Insect

## Comments

Transmit viruses such as Tomato spotted wilt virus; once acquired, the insect retains the ability to transmit the virus for the remainder of its life

## Management

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic

## Category : Nematodes

### Root knot nematode *Meloidogyne* spp.

Dug-up cantaloupe (cv. Athena) root system full of nodules caused by *Meloidogyne incognita*.

Washed cantaloupe root system full of nodules caused by *Meloidogyne incognita*.

Washed cantaloupe root full of nodules caused by *Meloidogyne sp.*

Washed cantaloupe root full of nodules caused by *Meloidogyne sp.*

Cantaloupe (cv. Athena) root system full of nodules caused by *Meloidogyne incognita*

Cantaloupe (cv. Athena) root system full of nodules caused by *Meloidogyne incognita*

cantaloupe (cv. Athena) root system full of nodules caused by *Meloidogyne incognita*.

Roots from cantaloupe (right) and pepper (left) showing the relative size of root nodules.

root-knot nematode (*Meloidogyne* spp.) damaged cantaloupe roots

## Symptoms

Galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; reduction in plant vigor; yellowing plants which wilt in hot weather.

## Cause

Nematode

## **Comments**

Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or garden with this type of soil is most likely.

## **Management**

Plant resistant varieties if nematodes are known to be present in the soil ;check roots of plants mid-season or sooner if symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens.

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# Cardamom

## Description

Cardamom, *Ellettaria cardamomum*, is an herbaceous perennial in the family Zingiberaceae grown for its fruits which are used as a spice. Cardamom is a clumping plant with between 10 and 20 leafy shoots arising from the rhizome. The shoots are actually pseudostems composed of overlapping leaf sheaths. There are several additional flowering shoots. The leaves are lanceolate and dark green in color. The plant produces flowers on a long drooping panicle and a capsule-like fruit which is triangular in cross section and initially pale green or yellow in color but dries to brown. The fruit contains 15–20 small aromatic seeds. Cardamom can reach a height of 5 m (16.4 ft) and has an economic lifespan of 10–15 years. Cardamom may also be referred to as green cardamom, black cardamom, brown cardamom, red cardamom or white cardamom and originates from southern India and Sri Lanka.

*Cardamom pods*

*Cardamom pods*

*Cardamom pods*

*Cardamom flower*

*Cardamom plant*

*Cardamom plants*

## Uses

The cardamom fruit or seeds are used dried as a culinary spice. The seeds are used whole or ground. Cardamom may

also be used as a flavoring in drinks, baked goods and confection.

## Propagation

**Basic requirements** Cardamom originates from mountainous forests and can be grown in a variety of soils ranging from forest loam to quartz gravels. It can be grown in the home garden in areas with tropical climates and elsewhere can be grown as a container plant and moved indoors when the temperature drops in the Fall. The optimum annual mean temperature for the growth of the plant is 22°C (71.6°F) and the plant will not grow below 17°C (62.6°F). As a consequence of their forest origins, cardamom plants thrive in shaded areas with indirect sunlight. **Propagation** Cardamom seeds can be collected from the mature capsules (pods) by gently pressing the capsules until they pop open. The seeds should be left to dry for a couple of days before planting in a container or outdoors in a prepared bed. For large scale production, they are commonly sown in nursery beds and transplanted to the field when they are 1–2 years old. Propagation from rhizomes is achieved by dividing the rhizome of plants that have at least three shoots. Plants are usually spaced 1.5–3 m (5–10 ft) apart allowing a further 1.5–3 m (5–10 ft) between rows.

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## Common Pests and Diseases

### Diseases

#### Category : Oomycete

##### Azhukal (Capsule rot) *Phytophthora* spp.

###### Symptoms

Water-soaked lesions on rachis; plant dries up beyond point of infection; rotting capsules with a foul odor which fall from plant; water-soaked spots on leaves which enlarge and coalesce

###### Cause

Oomycete

###### Comments

Disease emergence favored by wet, poorly-draining soils; fungus persists in the soil and becomes active during the monsoon season

###### Management

Plants must be protected during pre-monsoon period by removing all crop debris including diseased plants and burning; try to reduce the amount of shade on the plantation and promote good drainage

#### Category : Fungal

##### Damping-off (Rhizome rot) *Pythium vexans*

## *Rhizoctonia solani*

### **Symptoms**

Pale leaves and yellowing of plant; collapse of seedlings in nursery; more mature plants may exhibit a discoloration and decay of the rhizome; decay causes death of plants

### **Cause**

Fungi

### **Comments**

Fungus can survive in soil for long periods of time

### **Management**

Soil drenches with appropriate fungicides may be used to treat the disease prior to planting nurseries; all infected clumps, including rhizomes must be removed and destroyed; plant cardamom in well-draining soils

## **Category : Viral**

### **Katte disease (Mosaic)** Cardamom mosaic virus (CdMV)

#### **Symptoms**

Thin chlorotic flecks on youngest leaves of stem which develop into pale green stripes running from midrib to leaf margin parallel to veins; all leaves emerging subsequently have stripes; symptoms then spread to all tillers

#### **Cause**

Virus

#### **Comments**

Transmitted by banana aphids

#### **Management**

Check plantation for symptoms of disease at least twice each year; remove and destroy affected plants; replant with healthy material; avoid planting close to diseased gardens; do not use volunteer or tillers from infected plants as planting material

## **Pests**

## **Category : Insects**

### **Cardamom thrips** *Sciothrips cardamomi*

#### **Symptoms**

Silvery sheen or discoloration on young leaf sheaths and unopened flower bracts; damaged areas developing white, yellow and brown blotches and/or streaks

#### **Cause**

Insect

#### **Comments**

Damaged caused by feeding adults and nymphs; cardamom thrips found in Hawaii and India

#### **Management**

Regulate shade in plantation; applications of appropriate insecticide may be required

## **Category : Nematodes**

### **Nematodes** *Meloidogyne* spp.

#### **Symptoms**

Stunted, yellowing plants; galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; reduction in

plant vigor; yellowing plants which wilt in hot weather

**Cause**

Nematodes

**Comments**

Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or garden with this type of soil is most likely

**Management**

Check roots of plants mid-season or sooner if symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens

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# Carrot

## Description

Carrot, *Daucus carota*, is an edible, biennial herb in the family Apiaceae grown for its edible root. The carrot plant produces a rosette of 8–12 leaves above ground and a fleshy conical taproot below ground. The plant produces small (2 mm) flowers which are white, red or purple in color. The root can grow to between 5 and 50 cm (2.0–20 in) long and reach 5 cm (2.0 in) in diameter. The foliage of the plant can reach a height of 150 cm (59.1 in) when in flower. The carrot plant can be annual or biennial and may also be referred to as wild carrot. The plant is believed to have originated in Europe or the Western Mediterranean.

*Carrot flowers*

*Carrot foliage*

*Carrot taproot emerging from the soil*

*Freshly harvested carrots*

*Carrot foliage*

*Harvested carrots*

## Uses

Carrot roots are eaten as a vegetable and can be consumed fresh or cooked. Carrot juice is consumed as a beverage. The leaves of the plant can be used as feed for animals.

## Propagation

**Basic requirements** Carrots are cool-season crops which can be planted in early Spring and left in the ground all summer for harvest in the fall. Carrots grow best in a well-draining, loose, sandy soil which is free of large rocks and has a pH between 5.5 and 7.0. They require full sun for optimum development but will tolerate some very light shade. The optimum temperature for their growth is between 16 and 24°C (61–74°F). Carrot seedlings are very sensitive to extremes of temperature, very hot weather may kill the plant whereas temperatures below 10°C (50°F) tend to cause the development of longer, paler roots. The plants also require plenty moisture and organic matter. Carrots do very well in raised beds and can also be grown in containers. **Sowing seeds** Carrot is usually direct seeded and should be planted 3–5 weeks before the least frost date in your area. Soil should be prepared prior to planting by removing rocks and breaking up any hard lumps of soil down to a depth of at least 30 cm (12 in). It is also beneficial to work some compost into the soil prior to planting. Avoid using fresh manure as it can cause forking of the roots. Sow seeds 6 mm (0.25 in) deep, leaving 5 cm (2 in) between seeds and approximately 30 cm (1 ft) apart. When seedlings reach 2.5 cm (1 in) in height, thin them to a final spacing of 7.5 cm (3 in) between plants by snipping with scissors - this avoids damaging plant roots. **General care and maintenance** Carrots benefit from a plentiful moisture supply and should be provided with 2.5 cm (1 in) of water each week. Mulching around the plants helps to conserve moisture and reduce weeds. Any weeds growing around the plants should be carefully removed. The plants should be fertilized 5–6 weeks after the seeds are sown. **Harvesting** Carrots are generally ready to harvest after around 2–3 months when the roots have reached 1.3 cm (0.5 in) in diameter. Allowing the carrots to stay in the ground for at least one frost makes them sweeter but care should be taken to harvest before the ground freezes or to cover the plants to prevent freezing. Carrots are harvested by gently digging around the plant to expose the top of the root and gently, but firmly pulling the root from the soil by grasping the top of the carrot just above the root. Carrot tops should be twisted off and the roots washed prior to refrigeration in airtight bags. Carrots may also be stored in moist sand to keep them fresh prior to use.

Gently pull the carrot from the soil  
by grasping the top at the base

Dig around the plant to expose the  
root

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

## **Alternaria leaf blight** *Alternaria dauci*

*Symptoms of Alternaria leaf blight  
on carrot foliage*

### **Symptoms**

Green-brown water-soaked lesions on leaves which enlarge and turn dark brown or black; lesions may coalesce causing leaves to yellow and die; lesions may be present on petioles

### **Cause**

Fungus

### **Comments**

Disease emergence favored by wet foliage and warm weather; rain and fog enhance the development of the disease; fungus survives in soil on crop debris but is killed when the debris decomposes

### **Management**

Disease can be difficult to control in wet, warm conditions; apply appropriate fungicides when first symptoms appear or as a protective measure in humid areas; treat seeds with fungicide or hot water prior to planting; apply gibberellic acid to carrot foliage to promote upright growth and promote air circulation through canopy

## **Black rot** *Alternaria radicina*

### **Symptoms**

Damping-off of seedlings; root and crown necrosis; blighted foliage; lower portion of petioles black and necrotic; black ring around petiole attachment black, sunken lesions on taproot

### **Cause**

Fungi

### **Comments**

Disease is spread through infected seed and can survive in soil for up to 8 years

### **Management**

Black rot is difficult to control and can survive in the soil for long periods of time: practice long crop rotations ; plow crop residue into soil immediately after harvest; plant resistant varieties; plant only pathogen-free seed; treat seeds with hot water prior to planting

## **Cercospora leaf blight** *Cercospora carotae*

*Necrotic flecks on carrot foliage*

### **Symptoms**

Small, necrotic flecks on leaves which develop a chlorotic halo and expand into tan brown necrotic spots; lesions coalesce and cause leaves to wither, curl and die

### **Cause**

Fungus

### **Comments**

Disease can be introduced through infested seed and spread by wind or water splash; symptoms usually occur on younger foliage first

### **Management**

Plant only pathogen-free seed; rotate crops; plow crop debris into soil after harvest; apply appropriate fungicide sprays

## **Cottony rot (Sclerotinia rot)** *Sclerotinia sclerotiorum*

*Carrot field infected with Sclerotinia*

*Carrot covered in white mold caused by Sclerotinia infection*

### **Symptoms**

Small, water-soaked, soft lesions on crown and roots; white fluffy fungal growth all over affected tissues; soft and decaying tissue developing

### **Cause**

Fungus

### **Comments**

Fungus can survive in soil for up to 10 years; disease emergence is favored by soils that are held close to saturation for periods in excess of 2 weeks

### **Management**

Cultural practices play an important role in the control of cottony rot as there are no resistant carrot varieties: in carrot fields, the use of drip irrigation 5-8 cm below the soil surface can provide good control; deep plowing of soil and trimming back carrot foliage to promote air circulation can also be useful; fungicides may be warranted in periods of extended cool, damp weather

## **Downy mildew *Peronospora umbellifarum***

### **Symptoms**

Yellow spots on upper surface of leaves; white fluffy growth on underside of leaves; lesions become darker as the mature

### **Cause**

Fungus

### **Comments**

Disease affects young, tender leaves; disease emergence and spread is favored by prolonged leaf wetness

### **Management**

Plant pathogen-free seed; do not overcrowd plants; rotate crops with non-umbelliferous varieties

## **Powdery mildew *Erysiphe heraclei***

### **Symptoms**

Powdery growth on leaves, petioles flowers stalks and bracts; leaves becoming chlorotic; severe infections can cause flowers to become distorted

### **Cause**

Fungus

### **Comments**

Fungus can spread long distances in air; disease emergence is favored by high humidity and moderate temperatures; infection is most severe in shaded areas

### **Management**

Plant tolerant varieties; avoid excess fertilization; protective fungicide applications provide adequate protection; sulfur application can be used if infection occurs early in season

## **Category : Bacterial**

## **Bacterial leaf blight *Xanthomonas campestris***

### **Symptoms**

Small, angular, yellow spots on leaves which expand into irregularly shaped, brown, water-soaked lesions with a yellow halo; centers of lesions dry out, become brittle; leaves may become curled or distorted; flower stalks may develop elongated lesions that exude a bacterial ooze; infected umbels may be blighted

**Cause**

Bacterium

**Comments**

Bacteria can be spread by splashing irrigation water or rain or on contaminated equipment

**Management**

Plant pathogen-free seed; avoid using sprinkler irrigation; apply appropriate bactericides if available

**Soft rot** *Erwinia carotovora*

*Erwinia chrysanthemi*

*Pseudomonas marginalis*

**Symptoms**

Sunken dull orange lesions on taproot which causes tissue to collapse and become soft

**Cause**

Bacteria

**Comments**

Bacteria thrive in oxygen depleted plant tissue; disease emergence requires long periods of water saturated soil; bacteria enter plants through wounds

**Management**

Control relies on the avoidance of conditions conducive to bacterial infection: plant carrots in well-draining soils; allow plants to dry before irrigating again; avoid wounding plants during harvest to prevent post harvest development of disease; disinfect all equipment regularly

**Category : Oomycete****Cavity spot** *Pythium* spp.**Symptoms**

Sunken, elliptical, gray lesions across the root; outer layer of root ruptures and develops dark, elongated lesions; small vertical cracks may form on the cavities

**Cause**

Fungi

**Comments**

Fungi can persist in soil for several years and disease outbreaks are associated with wet soils; flooded soil increases the number of cavities formed

**Management**

Some cultural practices can control the disease: avoid planting in fields/areas known to previously had carrot spot; do not over-fertilize plants; application(s) of appropriate fungicide can provide adequate control

**Category : Fungal, Oomycete****Damping-off** *Pythium* spp.

*Rhizoctonia solani*

**Symptoms**

Soft, rotting seeds which fail to germinate; rapid death of seedling prior to emergence from soil; collapse of seedlings after they have emerged from the soil caused by water-soaked reddish lesions girdling the stem at the soil line

**Cause**

Fungi

**Comments**

Damping-off diseases favor conditions which slow seed germination; fungi can be spread in water, contaminated soil or on equipment

## **Management**

Avoid planting carrots in poorly draining, cool, wet soil; planting in raised beds will help with soil drainage; plant high quality seed that germinates quickly; treat seeds with fungicide prior to planting to eliminate fungal pathogens

# **Pests**

## **Category : Insects**

### **Aphids (Willow-carrot aphid) *Cavariella aegopodii***

*Willow-carrot aphid colony*

#### **Symptoms**

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants

#### **Cause**

Insect

#### **Comments**

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed; willow-carrot aphid will also attack parsnip, parsley and celery

#### **Management**

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

### **Carrot rust fly *Psila rosae***

*Damage to carrot surface caused by Carrot rust fly larvae tunneling*

#### **Symptoms**

Surface scarring of taproot caused by tunnels; tunnels are filled with a rust colored mush; adult insect is a small, dark colored fly; larvae are white maggots approximately 1 cm (0.3 in) long

#### **Cause**

Insect

#### **Comments**

Carrot rust fly also attacks parsnip, celery and other Umbelliferous crops which will also need to be protected if carrot rust fly is a problem

#### **Management**

Use of row covers will help to protect plants from damage but they must be installed before adult fly lays eggs on plants; harvest carrots in blocks; do not leave any carrots in the ground over winter to reduce overwintering sites

## **Carrot weevil** *Listronotus oregonensis*

*Close-up of weevil damage*

*Carrot weevil damage*

*Carrot weevil damage*

*Adult carrot weevil*

*Damage to carrots and weevil larvae*

*Carrot damaged by carrot weevil*

### **Symptoms**

Irregular dark grooves in zig-zag pattern on roots; leaves of plant may yellow; adult insect is a dark colored beetle; larvae are white to pinkish white C-shaped grubs with a yellow-brown head

### **Cause**

Insect

### **Comments**

Adult weevils overwinter in crop debris remaining in the ground; larvae feed for approximately 2 weeks before pupating in the soil; insect undergoes several generations each year

### **Management**

Remove all debris from Umbelliferous crops (e.g. parsley, dill, celery etc.) to reduce sites where weevil can survive and persist; try to rotate Umbelliferous crops to different areas of the home garden each year to reduce survival of larvae in soil

## **Flea beetle** *Systema blanda*

*Palestriped flea beetle*

### **Symptoms**

Small holes or pits in leaves that give the foliage a characteristic "shot-hole" appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5–3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance

### **Cause**

Insect

### **Comments**

Younger plants are more susceptible to flea beetle damage than older ones; older plants can tolerate infestation; flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year

### **Management**

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application of diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied

## **Category : Nematodes**

**Root-knot nematodes (Stubby root nematodes, Needle nematodes)** *Meloidogyne* spp.

*Paratrichodorus* spp.

*Longidorus africanus*

*Root knot nematode symptoms on carrots*

*Reduced stand due to nematode damage*

*Forked and stunted carrot taproots caused by stubby root nematodes*

### Symptoms

Forked, distorted or stunted taproots; reduced stand; reduced yield

### Cause

Nematodes

### Comments

Root-knot nematodes are most damaging to carrot; nematodes are microscopic and not visible to the naked eye

### Management

Leaving land to fallow when not planting can be effective at reducing nematode numbers; solarizing soil for 4-6 week period to a depth of 6 inches can temporarily reduce nematode populations; new carrot varieties are currently being developed that are resistant to nematodes

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# Cashew nuts

## Scientific Clarification

The following are the crop details for Cashew Nuts

Scientific name: *Anacardium occidentale*

Local names: Mkorosho / mkanju (Swahili)

Order: Sapindales

Family: Anacardiaceae

Genus: *Anacardium*

*Cashew fruits developing*

*Cashew fruits forming*

*Cashew fruits developing*

*Cashew fruits ripening*

*Cashew growing wild in Panama*

*Cashew fruits and flowers*

*Cashew tree*

*Cashew foliage*

*Cashew apples*

## **General Information**

Cashew is an evergreen tree with deep tap roots, grown for its edible fruits (nuts). The cashew tree has a branching main trunk and characteristic domed crown. The thin foliage of the tree is limited to the ends of the branches and is made up of oval-oblong leathery, shiny dark green leaves.

The leaves are smooth with pronounced veins and midrib and possess petioles that are swollen at their base. The tree produces numerous pinkish-white flowers on drooping panicles and a kidney-shaped true fruit (nut) which is approximately 3 cm (1.2 in) long with a grey-brown shell and develops from a fleshy accessory fruit, sometimes referred to as the 'cashew apple'. The cashew apple is pear-shaped and red to yellow.

Cashew trees can reach a height of 12 m (39.4 ft) and have an economic lifespan of 25 years after which time they are replaced in commercial plantations.

Cashew originates from Brazil. The Portuguese introduced cashew to Mozambique in the 16th century where it flourished, forming extensive forests; eventually, it also became dispersed in East Africa along the coastal plains of Kenya and Tanzania.

## **Cashew Varieties in Kenya**

Recommended varieties of cashew nuts by KALRO are A75/83, A100, A81, and A82.

## **Climate Conditions, Soil, and Water Management**

Cashew trees are usually grown at altitudes of between 0-500 m above sea level (asl) but can grow up to 1000 m asl. They can be very drought resistant provided their roots penetrate deeply into the soil and draw water from the subsoil. For mature trees 500 mm of rainfall per year is adequate, but seedlings should be watered until properly established. If rainfall is below 900 mm per year plant at the widest spacing indicated. Cashew nut trees tolerate a wide range of soils provided they are deep and well-drained. They can grow quite well on infertile soils but do not do well on coral outcrops at the coast.

## **Uses**

The kernels or nuts have a high nutritional as well as commercial value and are used for human consumption either raw or roasted. The cashew nut apple is rich in Vitamin C (about 5 times higher than the orange) and is used for the production of juice, wines, spirits, jam, pickles, and chutneys. The liquid of the shell is used for brake linings, heatproof and waterproof paints, and protective varnishes. Cashew nut wood is of poor quality but can be used as firewood if mixed with other types of wood.

# Planting Procedure

Cashew nuts should be planted at the beginning of the rainy season. In the Coastal lowlands, the best time for planting is between April to June.

Cashew nuts are usually propagated through seed or grafted seedlings. In propagation by direct seeding 3 seeds are planted in the planting hole and two months after germination the weak seedlings are uprooted leaving the strong ones to grow.

The holes should be 60 cm by 60cm so that they can be able to collect water during the rainy season which will be used during the dry season.

Cashew trees are generally planted with a spacing of 7.5 m X 7.5 m (175 plants/ ha) or 8 m X 8 m (156 plants/ ha) is recommended. High-density planting of cashew at a closer spacing of 4 m X 4 m (625 plants/ ha) in the beginning and thinning out in stages to maintain a final spacing of 8 m X 8 m in the tenth year is also recommended.

Proper seed selection from healthy, high-yielding trees is important, and it can be done by sorting out seeds by the water density method:

Place the seeds in a bucket of seawater (100 g salt per 5 liters of water) and select the seeds that sink for planting. Those that float have poor germination and growth potential.

Sundry seeds for planting for several weeks to prevent mold and rotting.

Do not plant seeds that are more than one year old.

Intercropping can be done before the canopies close. Most annual crops can be used apart from cotton and sweet potatoes, which are host plants for Helopeltis bugs, major pests of cashew. Do not interplant young trees with pasture because of the high competition for water during the dry season.

## Planting using grafted seedlings

Propagation through grafting starts by raising rootstock propagated from local cashew nut varieties. The first step is a visual selection of seeds to remove diseased or deformed seeds. The selected seeds are taken through a flotation test in water. Seeds that sink are planted in pre-germination beds.

The pre-germinated seeds are transplanted into potting bags when the radicals (tap root) are 2.5 " 3cm after 7-10 days. The recommended soil media for cashew nut seedlings is in the ratio of 2:1:150 where: 2 is two buckets of soil, 1 is one bucket of well-decomposed farmyard manure, and 150gms of DAP. The seedlings are transplanted in potting bags (6" x 9"). This composition can sustain the plant for an average of three months after transplanting the pre-germinated seeds in them.

Seedlings are ready for grafting when they attain more than two functional leaves and the cotyledons are still attached to the young stem. Grafting is done 3-4 weeks after transplanting into potting bags.

Scions for grafting are harvested from select mother plants. The following procedure for grafting is recommended:

- a. Cut and remove the actively growing part of the rootstock, leaving two functional leaves.
- b. Vertically cut down the stock between the two leaves to a depth of 2.5 " 3.0cm.
- c. Make a wedge cut of the scion of a similar length of 2.5-3.0 cm and sharpen it.
- d. Insert the scion into the rootstock and tie them together.
- e. Cover the scion and the rootstock by wrapping them with grafting tape.
- f. Wait for 2-3 weeks and unwrap the scion.

## Husbandry

No fertilizer is required, but well-rotted manure at planting is beneficial. The area around the tree should be 1½ times the size of the canopy and should be kept clean of weeds for the first 2 years to avoid competition.

If planted on a slope the tree should have a U-shaped mound of soil below it to collect rainwater for improved growth. Seeds germinate within 2-4 weeks. Thin after 3-4 months leaving only the strongest plant at each site.

Mulching with black polythene is beneficial to increase the growth and yield of cashew. However, locally available materials like green or dry grass or weeds can be utilized for mulching the basins. Small pebbles or stones can also be used for mulching the basin.

Plastic or stone mulch does not improve soil health but ensures better moisture retention in the soil and also prevents the attack of soil-borne insects and pests.

The topsoil and sub-soil are kept separately and allowed to wither under the sun. It helps in the migration of termites and ants(this is in the planting process).

Weeding with light digging should preferably be done before the end of the rainy season. Hoeing, cutting the weeds off underground is more effective than slashing.

Cashew plants start bearing after three years of planting and reach full bearing during the tenth year and continue giving remunerative yields for another 20 years(so they can yield up to 45 years after being planted).

Protect seedlings from monkeys, rodents, and bucks by placing wire cages or thorns around the seedlings. Support plants with a stick and trim off side shoots up to 60-90 cm from ground level. When trees are mature, prune dead wood or any borer-damaged or intergrowing branches to give the canopy air and light.

## Harvesting and Postharvest Handling

Cashew nuts planted using seeds begin bearing 3 to 4 years after transplanting the seedlings. The nuts should be harvested as soon as possible, especially under wet conditions, and should be dried before storage.

Grafted seedlings begin bearing within 2 years of transplanting. Depending on the age and maturity of the plant, a tree yields between 10 to 100 kilograms of unshelled nuts per year. One hectare can thus produce between 2,000 to 5,000 kilograms of unshelled nuts per year. Although trees are produced for 40 to 50 years, commercial harvesting is for 35 years.

The cashew nuts do not mature at the same time. The duration of harvest extends from 45-75 days and the nuts should be collected daily during this period. November to May is the harvesting period, with the peak harvest period from November to January. The nuts are collected at weekly intervals from the farm during the harvesting season. During that period the land should be clean to facilitate the collection of cashew. To get good quality nuts, clear the area beneath the tree, collect fallen fruits, detach the nut from the apple, and dry the nuts under the sun for about 2 hours.

The nuts can be graded into Fair Average Quality (FAQ) and Under Grade (UG). FAQ are well-matured nuts and they should be full and well-dried (12% moisture content). The color should be grey or pale brown. They should neither be wrinkled nor spotted.

UG are well-dried and mature nuts. They can be spotted but not wrinkled.

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## Common Pests and Diseases

### Diseases

#### Category : Bacterial

##### **Angular leaf spot** *Septoria anacardii*

###### **Symptoms**

Angular cream colored lesions with dark-brown margins on leaves of seedlings; angular black lesions with chlorotic halos on mature trees; defoliated seedlings

###### **Cause**

Fungus

###### **Comments**

Some dwarf types of cashew are resistant to this disease; disease is widespread in cashew growing regions of Brazil

###### **Management**

Currently no control measures are used

#### Category : Fungal

##### **Anthracnose** *Colletotrichum gloeosporioides*

###### **Symptoms**

Water-soaked lesions on leaves, twigs, flowers or young apples which develop into orange-brown or red lesions;

###### **Cause**

Fungus

###### **Comments**

Disease emergence favored by rainfall and high humidity

###### **Management**

A protective coating of copper-based fungicide on susceptible parts of plant can prevent the disease; fungicide should be applied when buds begin to expand through to fruit set but are not required during dry periods

##### **Black mould** *Pilgeriella anacardii*

###### **Symptoms**

Chlorotic spots on upper surface of leaves which spread to lower surface as infection progresses; dark-brown to black fungal patches on leaves; leaves shrivelling and dropping from plant

###### **Cause**

Fungus

###### **Comments**

Damage most severe on dwarf cashew varieties

# Pests

## Category : Insects

### Cashew weevil *Mecicorynus loripes*

#### Symptoms

Brown-black gummy frass (insect excrement) on trunk and branches; girdling of branches; plants dying

#### Cause

Insect

#### Comments

Adults large and gray-brown with knobbly appearance; larvae legless grubs which are white with a brown head

#### Management

Remove bark from infested areas and destroy any larvae or pupae found, this process should be repeated every month for up to six months; severely infested trees should be removed and destroyed; remove all adult weevils from tree prior to destruction and also remove bark and kill all larvae and pupae

### Coconut bug *Pseudotheraptus wayi*

#### Symptoms

Necrotic lesions on fruit which develop into hard lumps; pockmarks of fruit; spotting on kernels

#### Cause

Insect

#### Comments

Adults are red-brown in color; nymphs are red-brown to green in color

#### Management

Conserve natural enemies by avoiding unnecessary applications of insecticides

### Helopeltis bugs *Helopeltis schoutedeni*

*Helopeltis anacardii*

#### Symptoms

Deformed leaves with angular lesions along veins; leaves may drop from plant; elongated green lesions on young shoots which may exude gummy substance; dieback of shoots

#### Cause

Insects

#### Comments

Helopeltis bugs are slender with long legs and antennae; antennae twice as long as body; females are red; males brown; nymphs are yellowish in color

#### Management

Monitor crop regularly for signs of damage; conserve populations of natural enemies, weaver ants can reduce populations; avoid interplanting cashew with other crops which are hosts for helopeltis bugs such as tea and cotton

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# Cassava (manioc)

## Uses

Cassava root is eaten as a vegetable and is considered to be toxic in raw form which is why it must be cooked before being consumed. The root has a variety of applications, some of which include the production of flour, starch, or ethanol. Cassava leaves can supply a good source of vitamins and protein which can also be consumed after cooking. Cassava hay is used as animal feed and it plays a role in the production of adhesives, textiles, and cosmetics.

## Description

Cassava, *Manihot esculenta*, is a perennial shrub in the family Euphorbiaceae grown primarily for its storage roots which are eaten as a vegetable. The cassava plant is a woody plant with erect stems and spirally arranged simple lobed leaves with petioles (leaf stems) up to 30 cm in length. The plant produces petal-less flowers on a raceme. The edible roots of the plant are usually cylindrical and tapered and are white, brown or reddish in color. Cassava plants can reach 4 m in height and is usually harvested 9-12 months after planting. Cassava may also be referred to as Brazilian arrowroot, manioc, yuca or tapioca and the origins of the plant are unknown. The plant is not known to occur wild but may have first been cultivated in Brazil. Cassava is the third-largest source of food carbohydrates in the tropics, after rice and maize. It is a major staple food in the developing world, providing a basic diet for over half a billion people. It is

one of the most drought-tolerant crops, capable of growing on marginal soils.

*Harvested cassava roots*

*Researcher working in cassava field*

*Cassava leaf*

*Cassava plants*

*Cassava leaves*

*Cassava plants*

## Propagation

**Basic requirements** Cassava thrives in tropical and subtropical regions of the world as it requires warm temperatures for optimal growth. The plants require at least 8 months of warm weather, thriving in regions with warm, moist climates with regular rainfall. Cassava can be grown in many types of soil, producing even in poor soil but will be optimally productive in well-draining, sandy clay loam with a pH between 5.5 and 6.5. Cassava is drought resistant but will not tolerate water-logging. Root production is maximized when temperatures are between 25 and 32°C (77–90°F). Cassava should be planted in full sun and is very sensitive to shading, which leads to low yields. **Cuttings** Cassava is propagated from stem cuttings as the tubers do not produce buds. Stem cuttings should only be taken from plants which are free from disease, are at least 10 months old and have borne tubers. The cuttings should be taken from hardened stems leaving at least 30 cm (11.8 in) of stem intact in the ground. The stem can be severed using a sharp knife, secateurs or saw and each cutting should have 1-2 nodes and be approximately 20 cm (7.9 in) long. **Presprouting** It is a good idea to dip the stem cuttings in an appropriate fungicide prior to planting to help prevent the development of diseases. The cuttings can then either be planted directly into a nursery bed or presprouted in trays or polyethylene bags. To presprout the stems, plant in a cell tray or bag which is filled with good quality soil. Plant one stem in each cell or bag by pushing it into the soil in the direction in which it was growing on the mother plant (oldest part of stem first). The trays should be kept in partial shade until the stems begin to sprout. If planting stem cuttings in a nursery bed (best for cuttings taken from higher up the stems where the wood is not mature), select a site with good quality soil in partial shade and prepare a bed at least 1 m (3.3 ft) wide. The stems can be planted horizontally in a nursery bed and this encourages the growth of multiple stems. Space the cuttings 10 x 10 cm (4 x 4 in) grid. Stem cutting should be watered immediately after planting and on a regular basis thereafter. Aim to keep the soil moist but not wet. Stems should begin to sprout 7-10 days after planting. **Transplanting** Plants propagated from stem cuttings are ready to be transplanted after approximately 4-6 weeks. Prepare the field for planting by cultivating the soil and removing weeds. Space transplants 75–100 cm (2.5–3.2 ft) apart in rows spaced 1–5 m (3.2–16.4 ft) apart. Fertilize the plants as appropriate. Manure or poultry droppings can be used. Cultivate the soil to remove weeds and break up the soil around the plants. **Harvesting** Cassava is ready to harvest about a year after planting depending on the variety being grown. Some early maturing varieties may be ready to harvest in around nine months. In colder regions, cassava tubers can remain in the ground for up to 2 years before harvesting but can become fibrous so this is not recommended where cassava is being grown for consumption. Cassava tubers are harvested by digging. The roots should be dug up carefully to prevent damage.

*Cassava plantation in the Democratic Republic of Congo*

*Planting cassava stem cuttings*

*Cutting cassava stems*

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Anthracnose** *Colletotrichum gloeosporioides*

*Symptoms of a severe anthracnose infection on cassava stem*      *Anthracnose canker on cassava stem*

##### **Symptoms**

Cankers on stems and leaf petioles; leaves drooping downwards; wilting leaves which die and fall from plant leading to plant defoliation; death of shoots; soft parts of plant become twisted and distorted

##### **Cause**

Fungus

##### **Comments**

Disease emerges at the beginning of wet season (Africa) and worsens; spores spread by wind

##### **Management**

Anthracnose usually does not cause large-scale economic damage to cassava and control is usually not necessary; avoid planting cuttings with cankers; if disease does occur crop debris should be removed and destroyed after harvest

##### **Cassava Brown Leaf Spot** *Cercosporidium henningsii*

*Brown Leaf Spot on cassava leaf in Chambezi, Tanzania*

##### **Symptoms**

Circular or irregular brown spots with darker margin between leaf veins on older leaves; centers of lesions may drop out giving leaves a shothole appearance; if infection is severe, leaves may turn yellow, dry out and drop from the plant

##### **Cause**

Fungus

##### **Comments**

Disease emergence favored by high temperature and humidity

## **Management**

Remove leaves and crop debris from around plants to prevent disease spreading; remove weeds from around crop

## **White leaf spot** *Cercospora vicosae*

### **Symptoms**

Large, diffuse white spots on upper surface of leaves; spots with grey center on underside of leaves in humid weather

### **Cause**

Fungus

### **Comments**

Prevalent in wetter, warmer regions where cassava is grown e.g. Brazil and Colombia; common in West Africa

## **Management**

Remove leaves and crop debris from around plants to prevent disease spreading; remove weeds from around crop

## **Witches' broom** Cassava witches'-broom phytoplasma

*Cassava cuttings infected with  
witches broom disease*

*Shortened internodes*

*Witches' broom symptom*

*Symptoms of the disease include  
change in color of the stem and  
oozing from the stem*

### **Symptoms**

Plants are stunted with an excessive proliferation of branches; shoots have small leaves and shortened internodes; no chlorosis is present; cuttings from the shoots are weak but show no visible symptoms; few shoots successfully grow from cuttings.

### **Cause**

Phytoplasma

### **Comments**

Disease has been detected in Vietnam, Thailand, Cambodia, Laos, Indonesia, and the Philippines. The disease will cause yield loss from 30 to 80 percent.

## **Management**

Remove and destroy plants suspected of being infected; remove all cassava debris from field after harvest; disinfect all tools and equipment between cuttings.

## **Category : Viral**

## **Bud necrosis** Unknown

### **Symptoms**

Patches of dark brown or gray fungal growth on stems; necrotic areas covering buds on the stem

### **Cause**

Fungus

### **Comments**

Disease most commonly found on cassava grown in humid regions (e.g. humid forest zones) and is less common in drier savanna areas; fungal spores are carried by wind to new plants and farms

## **Management**

Only plant cassava cuttings taken from healthy plants which are free from necrotic lesions; space plants widely to allow good air circulation around plants and reduce disease incidence; remove weeds around plants; if disease is present,

burn all necrotic stems and crop debris immediately after harvest to prevent spread

## Cassava Brown Streak Disease

Cassava brown streak virus (CBSV)

*CBSD on lower leaf of cassava plant in Chambezi, Tanzania*

*B. tabaci feeding on the underside of cassava leaf*

*Root symptoms of CBSD*

*CBSD symptoms on the lower leaves of a cassava plant, Kenya*

*Root symptoms of CBSD*

*CBSD symptoms*

*Rotting tuber caused by Cassava brown streak*

*Tuber necrosis caused by Cassava brown streak*

*Mottled leaves infected with Cassava brown streak*

### Symptoms

Leaves:

- chlorotic or necrotic vein banding in mature leaves which may merge later to form large yellow patches

Stems:

- Brown elongated necrotic lesions on young stems

Tubers:

- necrosis of tubers

- roots develop knots

- internal tissues of roots and tubers stained brown and may rot due to secondary fungus infection

1. yellowing along veins on lower/older leaves ~3 months after planting
2. dark brown spots on upper green portion of stem ~6 months after planting
3. Severe cases- leaf drying, shoot die-back
4. In Tuber - Brown and hard rot when you cut into it. Causes malformation and root constriction ~10 months after planting

### Cause

Virus

### Comments

Histroy and origin: Disease is prevalent in East Africa (Tanzania, Uganda and Kenya). It was first reported in 1930's in Tanzania and become endemic in later years. It is currently travelling from East Africa westwards and has been reported in the DRC. There is considerable concern that it will appear in the major West African growing regions, notably Nigeria. The virus is transmitted through whiteflies and stem cuttings. The origin of CBSD is suspected to have arisen from the viruses that are already present on the indigenous African flora. Virus structure and properties: The microscopic studies revealed that the virus is 650 nm long and earlier it was believed to be carlavirus. But further studies associate the virus to Ipomovirus. Cassava Brown Streak Disease is caused by two distinct species of single-stranded RNA (ssRNA) viruses, Cassava brown streak virus (CBSV) and Ugandan cassava brown streak virus (UCBSV), belonging to the genus Ipomovirus of the family Potyviridae. Economic loss: Cassava is an important staple crop in Africa and the continent produces an estimated 54% of the world's cassava production. As such the threat from CBSD seems inevitable due to its presence in many eastern African countries and its rate of transmission westwards to the major growing regions in Nigeria (which produced 30.8% of the world's supply). Though the economic loss from brown streak virus depends on region, cultivars and environment conditions, in general it is estimated up to 70% yield loss in susceptible variety is common with losses as high as 100% being observed in some regions. If the disease is unchecked it may cause 2 billion dollar in loss in Nigeria alone and lead to increase widespread poverty and malnutrition in West and Central Africa.

## **Management**

Disease diagnosis: The first and foremost important aspect is to identify the disease correctly. Cassava brown streak disease varies in symptoms which made it difficult to identify in the field. It makes further complicated if both cassava brown streak and cassava mosaic diseases occur together. There are few techniques like serological and molecular methods are used to identify the virus in laboratory but have their limitations. Planting materials: Use only healthy and disease free cuttings for planting. Resistant cultivars: Plant cassava varieties that are more tolerant of brown streak virus such as Garukunsubire and Seruruseke. Roguing and sanitation: Remove and destroy any plants which are symptomatic of the disease including alternative hosts. Early Harvesting of tubers: Harvest crop early to avoid severe losses due to necrosis of tubers. Follow proper plant quarantine practices to avoid spread of virus to new region. Control insect vector: Whiteflies can be controlled by encouraging beneficial insects in the field like spiders, ladybird beetles etc. Use yellow sticky traps to monitor infestation of whiteflies. Spraying insecticidal soaps under leaf surface to kill flies.

## **Cassava Mosaic Disease** African cassava mosaic virus (ACMV)

Severe CMD symptoms on leaf in Chambezi, Tanzania

Cassava farmer showing severe damage to cassava roots infected with CMD

Field in Kwindwa, Mwanza Region, Tanzania devastated by CMD in the space of one season

Whiteflies on cassava leaf

Severe CMD symptoms on cassava leaf in Namulonge, southern Uganda

Whitefly nymphs on cassava leaf

Cassava leaves showing typical mottling caused by ACMV

ACMV-infected cassava plant

Resistant cassava variety beside a traditional susceptible variety with symptoms of ACMV

## **Symptoms**

Discolored pale green, yellow or white mottled leaves which may be distorted with a reduced size; in highly susceptible cassava cultivars plant growth may be stunted, resulting in poor root yield and low quality stem cuttings. Note that infected plants can express a range of symptoms and the exact symptoms depend on the species of virus and the strain as well as the environmental conditions and the sensitivity of the cassava host.

1. Patches of discolouration (chlorosis) in the leaves that vary from yellow to green.
2. The leaves display size variation and are often severely distorted.
3. Leaf blades sometimes fold depending on severity shrivel.

## **Cause**

Virus

## **Comments**

Disease is spread by infected cuttings and by whiteflies. The leaves are yellow, mottled and distorted. If leaves are yellow all over but are a normal size or there brown leaves that does not indicate disease. Wild cassava (kisamvu cha mpira in Kiswahili) also hosts the disease. The disease was first observed in the late 19th Century in what is now Tanzania. It was not until work in 1938 that the disease transmission was confirmed to occur via grafting as well as vectored by the White fly.

## **Management**

Varieties of cassava resistant to the virus are available in many countries, most traditional varieties of cassava grown in Africa are susceptible to the virus, seek advice from an agricultural extension on suitable varieties for your region (see below). Do not plant cuttings from plants with symptoms of disease; inspect plants regularly for symptoms of disease and remove and destroy any showing symptoms. Infected plants should be uprooted ('rouged'). Replace with disease resistant varieties such as 'Rwizihiza', 'Ndamirabana', 'Cyizere', 'Seruruseke', 'Mavoka', 'Garukunsubire' and 'Mbakungahaze'. There is no agrochemical agent or organic treatment for this disease. There are both control strategies for the whitefly vector.

## **Category : Bacterial**

### **Cassava Bacterial Blight** *Xanthomonas manihotis*

#### **Symptoms**

Small, angular, brown, water-soaked lesions between leaf veins on lower surfaces of leaves; leaf blades turning brown as lesion expands; lesions may have a yellow halo; lesions coalesce to form large necrotic patches; defoliation occurs with leaf petioles remaining in horizontal position as leaves drop; dieback of shoots; brown gum may be present on stems, leaves and petioles

#### **Cause**

Bacterium

#### **Comments**

Most important bacterial disease of cassava; spread by water splash and infected tools; disease more severe in wet conditions; particularly destructive in South America and Africa; most important method of spread is probably through exchange of infected plant cuttings

#### **Management**

Rotate cassava crop with non-host; plow crop debris into soil after harvest or remove and burn it; prune infected parts from plant; propagate cuttings only from healthy plants; intercrop cassava with corn (maize) and melon

## **Category : Other**

### **Cassava Healthy**

#### **Symptoms**

#### **Cause**

#### **Comments**

### **Cassava Nutritional Deficiency**

#### **Symptoms**

#### **Cause**

#### **Comments**

### **No Diagnosis**

#### **Symptoms**

#### **Cause**

#### **Comments**

### **Category :**

### **Cassava Mites**

#### **Symptoms**

#### **Cause**

#### **Comments**

### **CBLS**

#### **Symptoms**

#### **Cause**

#### **Comments**

## **CBSD**

**Symptoms**

**Cause**

**Comments**

## **CGM**

**Symptoms**

**Cause**

**Comments**

## **CMD**

**Symptoms**

**Cause**

**Comments**

## **CRM**

**Symptoms**

**Cause**

**Comments**

## **Healthy**

**Symptoms**

**Cause**

**Comments**

## **Late Blight**

**Symptoms**

**Cause**

**Comments**

## **Potato Virus**

**Symptoms**

**Cause**

**Comments**

## **Category : Bacterial, Fungal**

### **Cassava root rot disease** *Macrophomina phaseolina*

*Botryodiplodia theobromae*

*Fusarium spp.*

*Fusarium rot-infected cassava roots*

*Cassava roots infected with  
botryodiplodia root rot disease*

*Fusarium-infected cassava stems*

*Discoloration on tuber surface  
caused by root rot*

*White fungal structures visible on  
stem*

*Dark tuber discoloration caused by  
Botryodiplodia*

*Rotting tubers cut open to reveal  
discoloration*

### **Symptoms**

Leaves on affected plants turning brown and wilting and plant has a scorched appearance; leaves may remain attached to the plant or drop to the ground; plant death will occur; examination of roots reveals root dieback and swelling of tubers; tubers may have light brown, dark gray, blue or pink discoloration; rotting roots may be soft and produce a foul odor; infection by Botryodiplodia fungi may cause the appearance of white fungal structures at the base of the stem, particularly during the wet season

### **Cause**

Fungi

### **Comments**

Root rot disease emergence is often favored by waterlogged, poorly-draining soils

### **Management**

Plant cassava in well-draining soils; remove and destroy all crop debris by burning; sanitize all tools after use

## **Pests**

### **Category : Insects**

#### **African root and tuber scale *Strictococcus vayssierrei***

*Scales on cassava stem*

*Scales on cassava tubers*

### **Symptoms**

Oval shaped scales on stems, roots and/or tubers; infections which occur at an early age kill plants and prevent the production of tubers; plant becomes shriveled and discolored at feeding sites

### **Cause**

Insect

### **Comments**

Insect is indigenous to Africa and is particularly prevalent in forest areas of Ghana and Congo

### **Management**

Improve soil by adding organic matter to make soil more fertile; remove and destroy infested stems; do not plant cuttings with scale

#### **Cassava scale *Aonidomytilus albus***

### **Symptoms**

Stem surfaces covered with white waxy substance; leaves wilting and dropping from plant; severe infestations may result in stunted plants and poor tuber yields; cutting from infected plants do not sprout; insect is a flattened oval scale with an elongated white cover

### **Cause**

Insect

### **Comments**

Using pesticides to control scale insects reduces populations of beneficial insects such as natural enemies

### **Management**

Plant material that is completely free of scale insects; remove and destroy infested stems from existing plantations; apply organic matter to soil to improve fertility

#### **Cassava whitefly *Bemisia tabaci***

**Symptoms****Cause****Comments**

**Grasshoppers (Variegated grasshopper, Elegant grasshopper)** *Zonocerus variegatus*  
*Zonocerus elegans*

*Grasshoppers feeding on cassava leaves*

*Variegated grasshopper*

**Symptoms**

Defoliated plants; bark removed from stems; insects are large brightly colored grasshoppers

**Cause**

Insect

**Comments**

Grasshoppers have a wide host range and mainly attack seedlings; cooperation between neighboring farms can help with grasshopper control as the insect tends to lay its eggs outwith the plantation with nymphs migrating to the crop to feed

**Management**

Hand pick any grasshoppers found on plants; locate any egg pods around cassava field and destroy to reduce grasshopper populations; biopesticides such as "Green Muscle" are available in South and West Africa which are very effective at reducing the grasshopper population; products containing neem have also given good control of variegated grasshoppers

**Category : Mites**

**Cassava Green Mite** *Mononychellus tanajoa*

*Mononychellus progresivus*

*Cassava green mite infested cassava leaves*

*Cassava green mite infestation*

*Predatory mites feeding on the eggs of cassava green spider mite on the under surface of cassava leaf.*

**Symptoms**

Yellow stippling of leaves; chlorotic spots on leaves; chlorosis of entire leaves; if infestation is very high then leaves may be stunted and deformed; terminal leaves may die and drop from plant; pest responsible is a tiny green mite

1. Chlorosis (yellowing of leaves).
2. Leaves become shrivelled, mottled in serious cases
3. Check for the presence of mites on the underside of leaves
4. Yellow speckles evenly distributed on young leaves usually near the top " of the plant

**Cause**

Arachnid

**Comments**

Green spider mites are very common pests in most African growing regions and become problematic during the dry season; can cause significant tuber losses

## **Management**

Plant tolerant cassava varieties where possible; plant at the beginning of the rainy season to encourage vigorous growth which allows plant to tolerate attack; intercropping with crops such as cowpea may reduce damage; introductions of the predatory mite *Typhlodromalus arioi* have been very successful at controlling the green spider mite in many regions of Africa

## **Cassava Red Mite Damage**

### **Symptoms**

### **Cause**

### **Comments**

## **Two-spotted spider mite *Tetranychus* spp.**

*Two females with an egg of the green form of the spider mite *Tetranychus urticae*.*

*Male of the green form of the spider mite *Tetranychus urticae**

### **Symptoms**

Leaves stippled with yellow; leaves may appear bronzed; webbing covering leaves; mites may be visible as tiny moving dots on the webs or underside of leaves, best viewed using a hand lens; usually not spotted until there are visible symptoms on the plant; leaves turn yellow and may drop from plant

### **Cause**

Arachnid

### **Comments**

Spider mites thrive in dusty conditions; water-stressed plants are more susceptible to attack

### **Management**

Spraying plants with a strong jet of water can help reduce buildup of spider mite populations; if mites become problematic apply insecticidal soap to plants; certain chemical insecticides may actually increase mite populations by killing off natural enemies and promoting mite reproduction

## **Category : Nematodes**

## **Root knot nematode *Meloidogyne* spp.**

### **Symptoms**

Galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; reduction in plant vigor; yellowing plants which wilt in hot weather

### **Cause**

Nematode

### **Comments**

Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or garden with this type of soil is most likely

### **Management**

Plant resistant varieties if nematodes are known to be present in the soil ;check roots of plants mid-season or sooner if symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens

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# Cauliflower

## Description

Cauliflower, *Brassica oleracea* var. *botrytis*, is an herbaceous annual or biennial vegetable plant in the family Brassicaceae grown for its edible head. The head is actually a mass of abortive flowers (flowers which are unable to produce fruit or seed as they possess only female reproductive organs; the male organs are either underdeveloped or totally lacking). Cauliflower plants are shallow rooted with a small, thickened stem. The ribbed leaves branch off the top of the stem and are light green in color. The plant can reach a height of 1–1.5 m (3.3–4.9 ft) and is most commonly grown as an annual, harvested between 60 and 100 days after planting. The origin of cauliflower has not been definitively determined but its ancestor, wild cabbage, is thought to have originated in ancient Asia Minor.

*Cauliflower leaves*

*Cauliflower*

*Close-up of cauliflower florets*

*Harvested cauliflower heads*

*Cauliflower head developing*

*Cauliflower plant*

## Uses

Cauliflower is grown for consumption as a vegetable, either fresh or cooked. May be processed for freezing or pickling.

# Propagation

**Basic requirements** Cauliflower is a cool season crop and grows best in well draining, organic soil at a pH of 6.5 or above. A high amount of organic matter in the soil will help to hold moisture. The plant requires consistent cool temperatures to prevent “buttoning” - the formation of several small heads instead of one large one. Cauliflower is less cold hardy than its relatives and it should be planted after the last frost as sub-freezing temperatures are likely to damage the plant. It is best grown as a Fall crop in cooler areas. Only mature plants will survive frost in the Fall.

**Transplants** Cauliflower is most successfully grown from transplants started in the glasshouse or indoors. Peat pots work well for growing seedlings as damage to the roots during transplanting can be avoided. Plant seeds in a sterile seed starting mix to a depth of 0.6-1.3 cm (0.25-0.5 in) deep and keep moist. Seedlings can be transplanted when they are approximately 6 weeks old after hardening. Plant spacing will greatly affect the final size of the cauliflower head and the plants should be spaced at least 46 cm (18 in) apart leaving approximately 75 cm (30 in) between rows.

**General care and maintenance** Cauliflower requires consistent moisture during the growing season in order to produce large, tender heads. Do not let the soil dry out. The plants also require ample nitrogen and this should be applied as a side-dressing of fertilizer about half way through the growing season. Cauliflower heads can be discolored by sunlight and when the cauliflower head has reached 2.5–5.0 cm (1–2 in) the plant requires 'blanching', a process that ensures that the head remains white. This is achieved by gathering the longest outer leaves together at the head and tying them with twine. Remove the twine periodically to check on the progress of the head, check for pests and to allow the head to dry out after rain. Self blanching varieties are available which grow leaves which naturally cover the head.

**Harvesting** Cauliflower heads are ready for harvest when the head reaches 15 to 20 cm in diameter (6-8 in), usually about 7 to 12 days after blanching begins. Harvest the head by cutting the main stem with a sharp knife, including some of the central leaves which will protect the head. The heads can quickly become overmature, leading to reduced quality. Be sure to harvest the heads while they are still firm, before individual florets can be distinguished.

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# Common Pests and Diseases

## Diseases

### Category : Bacterial

#### Bacterial soft rot *Erwinia caratovora*

## *Bacterial soft rot of cauliflower*

### **Symptoms**

Water-soaked lesions on leaves and flower heads which expand to form a large rotted mass; surface of lesions usually crack and exude slimy liquid which turns tan, dark brown or black on exposure to air

### **Cause**

Bacterium

### **Comments**

Bacteria are easily spread on tools and by irrigation water; disease emergence favored by warm, moist conditions

### **Management**

Chemical treatments are not available for bacterial soft rot, control relies on cultural practices; rotate crops; plant in well-draining soils or raised beds; only harvest heads when they are dry; avoid damaging heads during harvest

## **Blackleg** *Leptosphaeria maculans*

### **Symptoms**

Damping-off of seedlings; round or irregularly shaped gray necrotic lesions on leaves with dark margins; lesions may be covered in pink masses in favorable weather conditions

### **Cause**

Fungus

### **Comments**

Favors warm, wet conditions; higher temperatures result in the development of more visible symptoms

### **Management**

Use disease free seed or treat with hot water to remove fungus prior to planting; remove and destroy crop debris after harvest or plow deeply into soil

## **Category : Fungal**

## **Black rot** *Xanthomonas campestris*

### **Symptoms**

Irregularly shaped dull yellow areas along leaf margins which expand to leaf midrib and create a characteristic "V-shaped" lesion; lesions may coalesce along the leaf margin to give plant a scorched appearance

### **Cause**

Bacterium

### **Comments**

Pathogen is spread via infected seed or by splashing water and insect movement; disease emergence favored by warm and humid conditions

### **Management**

Primary method of controlling black rot is through the use of good sanitation practices; rotate crops to non-cruciferous crops every 2 years; plant resistant varieties; control cruciferous weed species which may act as a reservoir for bacteria; plant pathogen-free seed

## **Clubroot** *Plasmoidiophora brassicae*

### **Symptoms**

Slow growing, stunted plants; yellowish leaves which wilt during day and rejuvenate in part at night; swollen, distorted roots; extensive gall formation

### **Cause**

Fungus

## **Comments**

Can be difficult to distinguish from nematode damage; fungus can survive in soil for periods in excess of 10 years; can be spread by movement of contaminated soil and irrigation water to uninfected areas

## **Management**

Once the pathogen is present in the soil it can survive for many years, elimination of the pathogen is economically unfeasible; rotating crops generally does not provide effective control; plant only certified seed and avoid field grown transplants unless produced in a fumigated bed; applying lime to the soil can reduce fungus sporulation

## **Downy mildew** *Hyaloperonospora parasitica*

### **Symptoms**

Small angular lesions on upper surface of leaves which enlarge into orange or yellow necrotic patches; white fluffy growth on undersides of leaves

### **Cause**

Fungus

### **Comments**

Disease emergence favored by cool, moist conditions

## **Management**

Remove all crop debris after harvest; rotate with non-brassicas; it is possible to control downy mildew with the application of an appropriate fungicide

## **Powdery mildew** *Erysiphe cruciferarum*

### **Symptoms**

Small white patches on upper and lower leaf surfaces which may also show purple blotching; patches coalesce to form a dense powdery layer which coats the leaves; leaves become chlorotic and drop from plant

### **Cause**

Fungus

### **Comments**

Disease emergence favored by dry season, moderate temperatures, low humidity and low levels of rainfall

## **Management**

Plant resistant varieties; rotate crops; remove all crop debris after harvest; remove weeds; avoid excessive application of nitrogen fertilizer which encourages powdery mildew growth; powdery mildew can be controlled by application of sulfur sprays, dusts or vapors

## **Sclerotinia stem rot (White mold)** *Sclerotinia sclerotiorum*

*White mold infections usually begin near the base of the plant. It will form water soaked lesions on the stem which will eventually produce white cottony fungal mats. Severe infections may cause stem to break*

### **Symptoms**

Irregular, necrotic gray lesions on leaves; white-gray lesions on stems; reduced pod set; shattering seed pods

### **Cause**

Fungus

### **Comments**

Disease emergence favors moderate to cool temperatures and high humidity

## **Management**

Rotate crop to non-hosts (e.g. cereals) for at least 3 years; control weeds; avoid dense growth by planting in adequately

spaced rows; apply appropriate foliar fungicides

### **White rust** *Albugo candida*

#### **Symptoms**

White pustules on cotyledons, leaves, stems and/or flowers which coalesce to form large areas of infection; leaves may roll and thicken

#### **Cause**

Fungus

#### **Comments**

Fungus can survive for long periods of time in dry conditions; disease spread by wind

#### **Management**

Rotate crops; plant only disease-free seed; apply appropriate fungicide if disease becomes a problem

### **Category : Viral**

#### **Cauliflower mosaic** Cauliflower mosaic virus (CaMV)

#### **Symptoms**

Mosaic patterns on leaves; vein clearing and or veinbanding; stunted plant growth; reduced head size

#### **Cause**

Virus

#### **Comments**

Transmitted by various species of aphid including the cabbage aphid, and peach aphid

#### **Management**

Control cruciferous weeds which can act as a reservoir for the virus; control aphid populations on plants by applying an appropriate insecticide

#### **Ring spot** *Mycosphaerella brassicicola*

#### **Symptoms**

Small, purple spots surrounded by a ring of water-soaked tissue on leaves which mature to brown spots with olive green borders 1-2 cm across; spots may develop numerous fruiting bodies which give them a black appearance or develop a concentric pattern; heavily infected leaves may dry up and curl inwards

#### **Cause**

Fungus

#### **Comments**

Ring spot requires cool, moist conditions to survive; disease symptoms typically develop in the fall and the peak of the infection occurs in winter

#### **Management**

Refrain from planting in areas known to have had disease previously; rotate crop to non-brassicas; sanitize tools and equipment regularly; apply appropriate fungicide if disease is identified in crop

### **Category : Fungal, Oomycete**

#### **Wirestem (Damping-off)** *Rhizoctonia solani*

#### **Symptoms**

Death of seedlings after germination; brown-red or black rot girdling stem; seedling may remain upright but stem is constricted and twisted (wirestem)

#### **Cause**

Fungus

#### **Comments**

Disease emergence in seedlings favored by cool temperatures

### Management

Plant pathogen-free seed or transplants that have been produced in sterilized soil; apply fungicide to seed to kill off any fungi; shallow plant seeds or delay planting until soil warms

## Pests

### Category : Insects

#### Beet armyworm *Spodoptera exigua*

Young larvae

Beet armyworm eggs covered in white hairs

Beet armyworm larva

### Symptoms

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside

### Cause

Insect

### Comments

Insect can go through 3–5 generations a year

### Management

Organic methods of controlling the beet armyworm include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae

#### Cabbage aphid *Brevicoryne brassicae*

Cabbage aphid colony

### Symptoms

Large populations can cause stunted growth or even plant death; insects may be visible on the plant leaves and are small, grey-green in color and soft bodied and are covered with a white waxy coating; prefer to feed deep down in cabbage head and may be obscured by the leaves

### Cause

Insect

### Comments

Cabbage aphids feed only on cruciferous plants but may survive on related weed species

### Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally

tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

## **Cabbage looper** *Trichoplusia ni*

*Cabbage looper*

### **Symptoms**

Large or small holes in leaves; damage often extensive; caterpillars are pale green with a white lines running down either side of their body; caterpillars are easily distinguished by the way they arch their body when moving; eggs are laid singly, usually on the lower leaf surface close to the leaf margin, and are white or pale green in color

### **Cause**

Insect

### **Comments**

Cabbage looper can be identified by their characteristic "looping" movement in which they arch their body and bring the back portion of the body forward to meet the front

### **Management**

Looper populations are usually held in check by natural enemies; if they do become problematic larvae can be hand-picked from the plants; biological controls such as spraying with *Bacillus thuringiensis* can be effective at controlling looper numbers; application of appropriate insecticide also controls looper populations; selective insecticides help to protect populations of natural enemies on crop

## **Cucumber beetles (Western spotted cucumber beetle)** *Diabrotica undecimpunctata*

*Spotted cucumber beetle*

### **Symptoms**

Stunted seedlings; damaged leaves, stems and/or petioles

### **Cause**

Insect

### **Comments**

Beetles overwinter in soil and leaf litter

### **Management**

Monitor new planting regularly for signs of beetle; apply appropriate insecticides

## **Cutworms** *Agrotis* spp.

*Peridroma saucia*

*Nephelodes minians*

and others

*Cutworm feeding on plant stem*

*Cutworms larva severing plant stem*

*Cutworms will curl up into a characteristic C shape when disturbed*

### **Symptoms**

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5â€“5.0 cm (1â€“2 in) in length; larvae may exhibit a

variety of patterns and coloration but will usually curl up into a C-shape when disturbed

#### Cause

Insect

#### Comments

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato

#### Management

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically

### Diamondback moth *Plutella xylostella*

Larva feeding on cabbage leaf

Diamondback moth pupae

#### Symptoms

Young larvae feed between upper and lower leaf surface and may be visible when they emerge from small holes on the underside of the leaf; older larvae leave large, irregularly shaped shotholes on leaf undersides, may leave the upper surface intact; larvae may drop from the plant on silk threads if the leaf is disturbed; larvae are small (1 cm/0.3 in) and tapered at both ends; larvae have to prolegs at the rear end that are arranged in a distinctive V-shape

#### Cause

Insect

#### Comments

Larvae take between 10 and 14 days to mature and spin a loose, gauze-like cocoon on leaves or stems to pupate

#### Management

Larvae can be controlled organically by applications of *Bacillus thurengiensis* or Entrust; application of appropriate chemical insecticide is only necessary if larvae are damaging the growing tips of the plants

### Flea beetles *Phyllotreta cruciferae*

Crucifer flea beetles

#### Symptoms

Small holes or pits in leaves that give the foliage a characteristic "shot-hole" appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5–3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance

#### Cause

Insects

#### Comments

Flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year

#### Management

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles

to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application on diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied

## **Large cabbage white (Cabbageworm) *Pieris rapae***

*Cabbage white caterpillar*

### **Symptoms**

Large ragged holes in leaves or bored into head; green-brown frass (insect feces) on leaves; caterpillar is green in color and hairy, with a velvet-like appearance; may have faint yellow to orange stripes down back; slow-moving compared with other caterpillars

### **Cause**

Insect

### **Comments**

Larvae cause damage by feeding on plants; can be distinguished from other caterpillars by its sluggish movement; in large numbers larvae can cause extensive damage very quickly

### **Management**

Plant cHand-pick caterpillars from plants and destroy; scrape eggs from leaves prior to hatching; apply appropriate insecticide if infestation is very heavy

## **Thrips (Western flower thrips, Onion thrips, etc.) *Frankliniella occidentalis***

*Thrips tabaci*

*Western flower thrips*

### **Symptoms**

If population is high leaves may be distorted; leaves are covered in coarse stippling and may appear silvery; leaves speckled with black feces; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color

### **Cause**

Insect

### **Comments**

Transmit viruses such as Tomato spotted wilt virus; once acquired, the insect retains the ability to transmit the virus for the remainder of its life

### **Management**

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic

## **Category : Nematodes**

### **Root knot nematode *Meloidogyne* spp.**

#### **Symptoms**

Galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; reduction in plant vigor; yellowing plants which wilt in hot weather

**Cause**

Nematode

**Comments**

Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or garden with this type of soil is most likely

**Management**

Plant resistant varieties if nematodes are known to be present in the soil ;check roots of plants mid-season or sooner if symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens

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# Celery

## Description

Celery, *Apium graveolens*, is an aromatic biennial plant in the family Apiaceae grown primarily for its stalk and taproot which are used as vegetables. The rhombic leaves of the celery plant grow in a rosette and are 3â€“6 cm (1.2â€“2.4 in) long and 2â€“4 cm (0.8â€“1.6 in) broad on a branched central stem which is highly ribbed. The plant produces creamy white flowers in dense umbels (an umbrella of short flower stalks) and produces broad oval seeds 1.5â€“2 mm (<0.1 in) long and wide. Celery is a biennial plant that is commonly grown as an annual and it can reach a height of about 1 m. Celery may also be referred to as celeriac which is the name given to the root and is believed to have originated in the Eastern Mediterranean.

*Celery root (celeriac)*

*Celery root (celeriac)*

*Harvested celery stalks*

*Celery blossoms*

*Celery plant*

*Celery plant*

## Uses

Celery is eaten around the world as a vegetable. Both the taproot and leaves are often used. Temperate countries grow celery for its seeds, which are often mixed with salt to make celery salt for seasoning.

# Propagation

**Basic requirements** Celery is a cool season vegetable which grows best in cool climates in well-draining, fertile soils with a pH between 6.0 and 6.8.. Celery plants grow optimally in cool, moist locations and will tolerate some shade but will not tolerate heat. The plants require constant moisture and can tolerate temperatures between 5 and 27°C (41–80.6°F) with the optimum for growth being between 15–21°C (59–69.8°F). If temperatures drop below 12.7°C (55°F) then the plants will benefit from protective coverings to prevent the plants from bolting (going to seed).

**Sowing seeds** For best results celery should usually be started indoors or in a glasshouse and transplanted to the garden or field. Germination of celery seeds is slow and the seeds should be planted 10 to 12 weeks before the last Spring frost. Soaking seeds in warm water overnight prior to planting can increase germination success. Plant seeds in seedling flats containing a good quality sterile seed starting mix by lightly sprinkling a pinch of seeds across the soil surface and covering with a thin layer of starting mix or vermiculite. Place trays in a warm location inside the house or in the glasshouse and keep well-watered. Do not allow the trays to dry out. It is important to keep the soil at the temperature between 12.7 and 21°C (55 and 70°F). The optimum temperature for germination is 60° to 70° (15° to 21°C) and the seedlings should emerge within 2–3 weeks. The seedlings can be potted into individual pots when they are about 5 cm (2 in) tall. **Transplanting** Seedlings are ready to transplant when they are 15 cm (6 in) tall and have been hardened off. Prepare the transplant site in advance of planting by working fertilizer or compost into the soil and plant the seedlings when the weather has settled after the last frost. Seedlings should be planted at the same depth as their previous container and should be spaced 15–20 cm (6–8 in) apart in rows spaced 60–90 cm (2–3 ft) apart.

**General care and maintenance** Celery is a very heavy feeder and should be fed every 10–14 days with a balanced fertilizer. The plants require constant moisture and should be provided with at least 1 inch of water per week. A layer of mulch spread around the plants helps to conserve the moisture in the soil and prevents weeds. Any weeds should be gently removed from around the plants. If temperatures are forecast to drop below 12.7°C (55°F) then the plants should be protected with cloches to prevent them developing weak stalks. Prolonged exposure to temperatures below this threshold will result in bolting. **Blanching** Blanching is the act of deliberately covering plant parts to prevent photosynthesis, thus keeping the parts pale in color. Many people choose to blanch celery stalks to prevent them becoming bitter. Self-blanching varieties are also available. To blanch celery, the soil can simply be mounded around the stalks to just below the leaves. This can be done gradually as the plants grow, or about two weeks prior to harvest. Alternatively, newspaper or cardboard can be tied around the stalks or boards can be erected around the plants to block out sunlight. **Harvesting** Celery can begin to be harvested when the stalks are about 20 cm (8 in) tall. Unblanched celery can be harvested as needed by cutting stalks from the outside in. Blanched celery can be harvested by cutting the plant just below the soil line. The plants can be kept in the garden until Fall and will tolerate a light frost but not continuous heavy frosts. If uncovered, the stalks will grow darker in color and the resultant texture will be more fibrous than the young stalks.

A layer of mulch spread around the plants helps to conserve moisture

For best results, celery should be started indoors

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## Common Pests and Diseases

### Diseases

#### Category : Bacterial

##### **Bacterial blight and brown stem** *Pseudomonas cichorii*

###### **Symptoms**

Small water-soaked spots on leaf blades which become necrotic and either circular or angular in shape and may develop a chlorotic halo; lesions become dry and rust colored; brown stem symptoms include the development of a brown discoloration of petioles and brown streaks along petioles

###### **Cause**

Bacterium

###### **Comments**

Close plant spacing favors bacterial spread between plants; bacterium causes severe disease symptoms at temperatures above 30°C (86°F)

###### **Management**

Control of disease is difficult and usually involve the application of copper sprays in commercial plantations; some control can be achieved by planting less susceptible celery varieties; mechanical transmission can be reduced by only trimming leaves when foliage is dry

##### **Soft rot** *Erwinia carotovora*

*Erwinia chrysanthemi*

*Pseudomonas marginalis*

###### **Symptoms**

Small water-soaked lesions near base of petioles which become soft, sunken and brown

###### **Cause**

Bacteria

###### **Comments**

Bacteria thrive in oxygen depleted plant tissue; disease emergence requires long periods of water saturated soil; bacteria enter plants through wounds

###### **Management**

Control relies on the avoidance of conditions conducive to bacterial infection: plant celery in well-draining soils; allow plants to dry before irrigating again; avoid wounding plants during harvest to prevent post harvest development of disease; disinfect all equipment regularly

#### Category : Viral

##### **Celery mosaic** Celery mosaic virus (CeMv)

###### **Symptoms**

Vein clearing and mottling in areas of leaves between veins; leaves may be twisted, curled or cupped; dark green mottling on petioles; young plants may be stunted

###### **Cause**

**Virus**

**Comments**

Virus is transmitted by several species of aphid; aphids can successfully transmit virus to plants within 30 seconds of feeding and virus symptoms typically develop within 10 days of primary infection

**Management**

Control relies on the implementation of a 'celery-free' period of 1-3 months and controlling umbelliferous weeds that can act as a source of inoculum

**Category : Fungal, Oomycete**

**Damping-off** *Pythium* spp.

*Rhizoctonia solani*

**Symptoms**

Soft, rotting seeds which fail to germinate; rapid death of seedling prior to emergence from soil; collapse of seedlings after they have emerged from the soil caused by water-soaked reddish lesions girdling the stem at the soil line

**Cause**

Fungi

**Comments**

Damping-off diseases favor conditions which slow seed germination; fungi can be spread in water, contaminated soil or on equipment

**Management**

Avoid planting celery in poorly draining, cool, wet soil; planting in raised beds will help with soil drainage; plant high quality seed that germinates quickly; treat seeds with fungicide prior to planting to eliminate fungal pathogens

**Category : Fungal**

**Downy mildew** *Peronospora umbellifarum*

**Symptoms**

Yellow spots on upper surface of leaves; white fluffy growth on underside of leaves; lesions become darker as they mature

**Cause**

Fungus

**Comments**

Disease affects young, tender leaves; disease emergence and spread is favored by prolonged leaf wetness

**Management**

Plant pathogen-free seed; do not overcrowd plants; rotate crops with non-umbelliferous varieties

**Early blight (Cercospora leaf spot, Cercospora blight)** *Cercospora apii*

*Symptoms of Cercospora on celery*

**Symptoms**

Small yellow flecks on upper and lower leaf surfaces which enlarge to brown-gray spots with no defined border; lesions develop a papery texture; leaves with many lesions may turn necrotic and die

**Cause**

Fungus

## **Comments**

Fields become infected through infested seed; disease emergence is favored by warm temperatures and prolonged leaf wetness; disease can be differentiated from late blight by the absence of black fungal fruiting bodies embedded in leaves and the typically larger lesions

## **Management**

In areas where warm temperatures and high humidity favor the emergence of early blight, control must rely on a number of different methods: plant pathogen-free seed; rotate crops; avoid overcrowding plants; plant tolerant or resistant celery varieties when conditions are favorable to early blight emergence; apply appropriate fungicides where available

## **Fusarium yellows** *Fusarium oxysporum*

### **Symptoms**

Yellowing plants that are severely stunted; roots brown and water-soaked; discoloration of vascular tissue in the stems

### **Cause**

Fungus

### **Comments**

Fungus can persist indefinitely in soil once introduced and is usually introduced via infected transplants or contaminated equipment; disease emergence is favored by a soil pH which is close to 7

## **Management**

The most effective method of controlling Fusarium yellows is to prevent its introduction by regularly sanitizing tools and equipment, planting in pathogen-free soil and planting resistant or tolerant varieties of celery

## **Late blight (Septoria leaf blight)** *Septoria apicola*

*Septoria blight symptoms on celery*

*Necrotic lesions on celery foliage caused by infection with Septoria fungus*

*Necrotic lesions on celery foliage caused by infection with Septoria fungus*

### **Symptoms**

Irregularly shaped chlorotic spots on leaves and petioles which turn necrotic and coalesce to form large necrotic areas, blighting of leaves and leaf death; black fungal fruiting bodies are visible embedded in leaf tissue and resemble peppercorns

### **Cause**

Fungus

### **Comments**

Fungus can survive on seed for up to 2 years in storage; emergence of disease is favored by heavy rainfall and dense leaf canopies which prevent air circulation; fungus can be spread via rainfall or contaminated irrigation water and by the movement of people, tools or machinery

## **Management**

Plant pathogen-free seed; treat seed with fungicide or hot water prior to planting; if disease is present, avoid working in area when plants are wet; apply appropriate foliar fungicides where available

## **Pink rot** *Sclerotinia sclerotiorum*

### **Symptoms**

Soft, brown lesions on base of stalks with pink margin which cause the entire stalk to rot, turn brown and collapse; large black fungal fruiting bodies are visible on infected tissue; when young seedlings are infected, the fungus causing damping-off with a watery rot visibly on the seedling stems near the soil line

### **Cause**

Fungus

## **Comments**

Fungus can survive in soil for up to 10 years; disease emergence is favored by soils that are held close to saturation for periods in excess of 2 weeks

## **Management**

Cultural practices play an important role in the control of pink rot: the use of drip irrigation 5-8 cm below the soil surface can provide good control; deep plowing of soil and trimming back foliage to promote air circulation can also be useful; fungicides may be warranted in periods of extended cool, damp weather

## **Powdery mildew** *Erysiphe heraclei*

### **Symptoms**

Powdery growth on leaves, petioles flowers stalks and bracts; leaves becoming chlorotic; severe infections can cause flowers to become distorted

### **Cause**

Fungus

### **Comments**

Fungus can spread long distances in air; disease emergence is favored by high humidity and moderate temperatures; infection is most severe in shaded areas

## **Management**

Plant tolerant varieties; avoid excess fertilization; protective fungicide applications provide adequate protection; sulfur application can be used in infection occurs early in season

## **Pests**

### **Category : Insects**

## **Aphids (Carrot-willow aphids, Peach aphid, Hawthorn aphid, Melon aphid)** *Cavariella aegopodii*

*Myzus persicae*

*Dysaphis apiifolia*

*Aphis gossypii*

*Carrot-willow aphid colony*

### **Symptoms**

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants.

### **Cause**

Insects

### **Comments**

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed; aphids can build up to several thousand per celery plant.

## **Management**

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids

from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use.

## **Armyworm** *Pseudaletia unipuncta*

*Armyworm*

### **Symptoms**

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside

### **Cause**

Insect

### **Comments**

Insect can go through 3–5 generations a year

### **Management**

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae

## **Category : Nematodes**

### **Root knot nematode** *Meloidogyne* spp.

*Celery roots damaged by root knot nematodes*

### **Symptoms**

Galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; reduction in plant vigor; yellowing plants which wilt in hot weather

### **Cause**

Nematode

### **Comments**

Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or garden with this type of soil is most likely

### **Management**

Plant resistant varieties where available if nematodes are known to be present in the soil; check roots of plants mid-season or sooner if symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens

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# Chard

## Description

Chard, *Beta vulgaris* var *cicla*, is an herbaceous biennial plant in the family Chenopodiaceae grown for its edible leaves and leaf stalks. The chard plant has an erect growth habit with a basal rosette of leaves with long fleshy petioles which can be red or white in color. The leaves are large and wrinkled with a pronounced midrib and prominent veins. The chard plant can reach 30–40 cm (12–16 in) in height and is usually grown as an annual, harvested after one growing season. Chard may also be referred to as Swiss chard or silverbeet and likely originates from the Mediterranean.

*Chard stalks*

*Harvested leaves*

*Harvested stalks*

*Colorful stems*

*Chard foliage*

*Chard leaf*

*Chard seedlings*

*Chard leaves*

*Chard leaf*

## Uses

All parts of the chard plant are edible. The leaves and petioles (leaf stalks) are usually consumed after cooking with the former being eaten in a similar way to spinach and the latter similar to asparagus.

## Propagation

**Basic requirements** Chard is best grown in moist, fertile, and organically rich soils. The soil should be light to sandy, and well drained with a pH between 6.0 and 7.0. The plants should be positioned in full sun or light shade. Chard grows best in cool climates and can tolerate moderate frosts although prolonged freezing will cause some varieties to bolt. The optimum temperature for growth is between 15.5 and 18.3°C (60–65°F). **Planting** Seed may be sown in the ground 30 days prior to the last spring frost as the seedlings are tolerant to moderate frost. Plant one seed every 2.5 cm (1 in) at a depth of 13 mm (0.5 in) in rows spaced 30–40 cm (12–16 in) apart. Keep the seedbed well watered. Seedling should emerge in 5 to 17 days at temperatures between 10 and 24°C (50–75°F). When seedlings have reached between 7 and 10 cm (3–4 in) in height, thin to a final spacing of 7–10 cm (3–4 in) between plants. If planning to harvest entire plants at one time, plant seeds every 2–3 weeks to ensure a continuous supply. **General care and maintenance** Chard requires plenty of moisture to develop optimally. Even watering will promote the development of good quality roots. Soil moisture can be conserved by applying a layer of mulch around the plants. In addition to moisture, chard benefits from an adequate supply of nutrients. Apply a complete fertilizer at planting to ensure optimum development. Remove any weeds around plants by cultivating shallowly to avoid damaging the developing roots. **Harvesting** Leaves can be cut from the plant at any point after they develop but if plant is to reach maturity then it is best to remove the outer leaves that have fully developed first.

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## Common Pests and Diseases

### Diseases

#### Category : Bacterial

##### Bacterial soft rot *Erwinia* spp.

###### Symptoms

Water-soaked, brown lesions on the leaves; center of leaves breaking down

###### Cause

Bacteria

###### Comments

Bacteria is common in most soils, particularly if area is frequently planted with susceptible crops

###### Management

Remove and destroy infected plants; avoid planting in poorly draining soil; rotate crops with corn, small grains or grasses where possible; treat soil with an insecticide prior to planting to reduce damage caused by grubs and larvae which promotes bacterial soft rot

### **Damping-off** *Pythium* spp.

*Rhizoctonia solani*

#### **Symptoms**

Dark and withered lesions on seedling stems; lesions may be black and greasy; death of seedlings

#### **Cause**

Fungi

#### **Comments**

Warm, wet weather favors disease emergence; beet very susceptible

#### **Management**

Treat seeds with fungicide prior to planting; plant in well draining soil; do not plant until soil is sufficiently warm

## **Category : Viral**

### **Curly top** Beet curly top virus (BCTV)

#### **Symptoms**

Slow plant growth; shortened leaf stems; small, curled, yellowed leaves with swollen veins

#### **Cause**

Virus

#### **Comments**

Transmitted by beet leaf hoppers

#### **Management**

Plant only healthy transplants; remove and destroy any infected plants to limit spread; use floating row covers to protect plants from leafhoppers in the home garden

## **Pests**

## **Category : Insects**

### **Darkling beetle (Rove beetle)** *Blapstinus* spp.

*Staphylinid* spp

#### **Symptoms**

Feeding damage on stems; death of seedlings; seeds dug up; insect is a dull blue-black or brown beetle about 0.6 cm (0.52 in) long; tips of antennae are often enlarged, resembling a club

#### **Cause**

Insect

#### **Comments**

Beetles are generally active at night; during the day beetles hide in organic debris

#### **Management**

Ditches filled with water can prevent spread of beetle to/from adjacent fields; remove all weeds from garden borders; if beetle is problematic then appropriate insecticides can provide control; insecticides are usually in the form of baits

### **Flea beetles** *Epitrix cucumeris*

*Phyllotreta striolata*

*Phyllotreta pusilla*

## *Phyllotreta ramosa*

### **Symptoms**

Small holes or pits in leaves that give the foliage a characteristic “shot hole” appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5–3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance

### **Cause**

Insect

### **Comments**

Younger plants are more susceptible to flea beetle damage than older ones; older plants can tolerate infestation; flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year

### **Management**

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application of diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied

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# Cherry (including sour)

## Description

The wild cherry tree, *Prunus avium*, is a perennial tree in the family Rosaceae grown for its fruit, the cherry. Cherry trees have alternating simple oval leaves which often have serrated margins and approximately eight pairs of veins, 5â€“13 cm (2â€“5 in) long. The flowers are white and appear in clusters of about 3â€“5. They appear in early spring and are about one inch long. The fruit is dark red, about half an inch to a full inch, matures in early to mid summer. The bark is gray-brown, smooth and glossy and it often peels. Cherry trees can live up to 60 years, growing to a height of over 15 m (50 ft). Cherry may also be referred to as sweet cherry, gean, mazzard or wild cherry and originates from the Caspian-Black Sea region and Asia. Sour cherry, *Prunus cerasus*, is closely related to *Prunus avium* but with fruit that is more acidic. The tree has twiggy branches with bright red to near black cherries. The tree reaches a height of 4â€“10 m (13.1â€“16.4 ft) and is believed to have originated as a natural hybrid of wild cherry (*Prunus avium*) and ground cherry (*Prunus fruticosa*) somewhere in the Caucasus Mountains, Turkey or Eastern Europe where the two species' geographic ranges overlap.

*Cherry orchard*

*Cherry blossoms*

*Cherry blossom*

*Buds on cherry tree*

*Ripe cherries*

*Cherries*

## Uses

Cherries are mainly consumed as a fresh fruit or processed into jellies and juices. The wood of the cherry tree is a distinctive honey color and is used in furniture making and for musical instruments. Sour cherries are used mainly for canning and processing.

## Propagation

**Basic requirements** Cherries grow optimally in mild, dry climates and also have a chilling requirement to break dormancy so require cold winters. Because of the cold weather requirement, none of the *Prunus* family, including cherries, can grow in tropical climates. Cherry trees will grow in a variety of soils provided that they are well-draining. Soils which remain wet for prolonged periods of time and soils that become excessively dry should be avoided. Trees will perform best if planted in sandy soil with a pH of 5.5–7.5. Planting on a gentle slope is beneficial for cherry as cold air can drain away from the trees to lower areas, helping to prevent damage. Sweet cherries bloom earlier than sour cherries and can be susceptible to damage from late frosts. **Propagation** Cherry nurseries are mainly propagated by budding and grafting onto 1–2 year old seedling grown from seed. In order to grow from seed, pits should be planted in the fall (after first being chilled) and seedlings will emerge in the spring. A cherry tree will take three-four years to produce its first crop of fruit and seven years to attain full maturity. **Planting** Cherry trees should be planted in the Spring when all danger of frost has passed and the soil has warmed. If bare root plants have been purchased, be sure to keep the root ball moist prior to planting. The tree should be planted in a hole which is large enough to accommodate the root ball without bending any of the roots. Broken or damaged roots can be removed but try to avoid pruning the roots. Place the tree in the planting hole and carefully backfill with soil. The tree should be planted at the same depth as it was in the nursery. Carefully firm or tamp the soil to prevent air pockets and when the planting hole is about 2/3 filled, water the roots thoroughly before filling the remainder of the hole with top soil. The tree should be watered as needed throughout the first year of growth. **Training and pruning** Cherry trees are usually trained to a modified central leader system where the lateral limbs branch from a central trunk. Sweet cherries have a more upright growth habit than sour cherries which tend to have a more open and spreading canopy. Trees should only be pruned lightly while the tree matures and reaches maximum productivity. Any dead or damaged branches should be removed. **General care and maintenance** The area around the base of the tree should be kept free from weeds either by cultivating or using a chemical weed control. In the home garden, trees are usually surrounded by turf with only a small area of soil around the trunk which is easy to keep weed free by hand. Unless grown in fertile soils, cherry trees may require the addition of some nitrogen fertilizer, the volume of which will vary with the age of the tree. The fertilizer should be applied in a band around the trunk of the tree.

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## Common Pests and Diseases

# Diseases

## Category : Bacterial

### Bacterial canker *Pseudomonas syringae*

#### Symptoms

Cankers on twigs at bases of flower and leaf buds, in pruning wounds or at the base of spurs which exude amber colored gum; cankers spread upwards and form sunken areas in winter; if pathogen enters dormant buds they may be killed or open normally in Spring before collapsing in early Summer; infected buds may be symptomless

#### Cause

Bacterium

#### Comments

Disease emergence favors high moisture and low temperatures in the spring; young trees particularly susceptible; trees grown in sandy soils that drain poorly are also susceptible

#### Management

Ensure that a suitable cherry variety and rootstock is chosen based on geographic location and environmental conditions to prevent stress to tree which predisposes tree to canker disease; apply protective copper spray to trees before flowering; prune trees in early summer to decrease likelihood of infection

## Category : Fungal

### Black knot *Apiosporina morbosa*

*Black knot symptoms on cherry*

*Black knot on black cherry stem*

*Black knot symptoms on cherry*

#### Symptoms

Elongated swellings (knots) on woody parts of tree which can reach up to 30 cm (12 in) long; knots are initially olive green in color with a corky texture but turn black in color and become hard and brittle; knots grow in length each year

#### Cause

Fungus

#### Comments

Infections occur on new shoots after rainfall and knots develop rapidly in second year

#### Management

Prune knots on twigs and branches 8-10 cm (3-4 in) below the swelling and remove the pruned branches from the orchard; remove knots on older branches by removing the knot plus 2 cm (0.8 in) of surrounding tissue; removal of knots is most effective when done in midsummer; disease can be controlled by application of appropriate fungicides, if available, during shoot elongation

### Brown rot *Monilinia fructicola*

*Cherry fruits infected with brown rot fungus*

#### Symptoms

Brown discoloration of fruit skin and inner tissue; fruit skin wrinkled; collapsed flowers exuding sap from their bases; tan cankers with dark edges on twigs; gray-brown spore masses may be present on cankers

#### Cause

Fungus

### Comments

Fungus survives in mummified fruit on the tree, blighted blossoms, cankers and infected twigs; blossom and twig blights are promoted by periods of wet weather

### Management

The currently most effective method of controlling brown rot is through the application of appropriate protective fungicides timed so that they are applied when the susceptible flower parts are exposed or after a wet period; avoiding sprinkler irrigation protects the leaves and flowers from wetness that promotes the disease. Cultural control methods include: removing mummified fruit from tree, pruning infected twigs and reducing plant stress by providing adequate levels of water and fertilizer

## Cherry leaf spot *Coccomyces hiemalis*

*Cherry leaf spot lesions on sweet cherry leaf*

*Cherry leaf spot lesions on sweet cherry leaf*

### Symptoms

Small, red-purple spots on upper surfaces of leaves which turn brown and may coalesce; leaves may become chlorotic if there are a few lesions present; if tree becomes severely defoliated fruit may fail to develop properly and remain light in color and watery in texture

### Cause

Fungus

### Comments

Fungus overwinters on infected leaves on the ground; disease development is promoted by warm temperatures and high humidity

### Management

Disease can be controlled through applications of appropriate fungicides, Bordeaux mixture is also effective; no cherry varieties are resistant to leaf spot, plant less susceptible varieties if available

## Powdery mildew *Podosphaera spp.*

### Symptoms

Light colored circular lesions on leaves inside tree canopy which develop a powdery appearance; lesions may coalesce to cover leaf; if infection is severe, leaves may blister and infected shoots may be distorted and stunted; infected fruits may have slightly depressed areas on the surface containing fungal hyphae (filamentous fungal structures)

### Cause

Fungus

### Comments

Infection of fruit is more likely if there are rainfalls close to harvest

### Management

Management of powdery mildew in cherry is reliant on the application of appropriate fungicides and cultural practices which promote good air circulation around tree canopies to lower humidity

## Rust *Tranzschelia discolor*

### Symptoms

Pale yellow-green spots on both upper and lower leaf surfaces which are angular in shape and turn bright yellow in color; spots on lower leaf surface develop orange-red spores

### Cause

Fungus

## **Comments**

Fungus overwinters in twigs or in leaves which remain attached to the tree

## **Management**

Rust can be prevented by spraying trees with protective fungicides; application is usually carried out one, two and three months before harvest in areas prone to early season outbreaks of the disease and after harvest in areas where disease is less problematic or emerges later in the season

## **Silver leaf** *Chondrosterum pupureum*

### **Symptoms**

Leaves have a silvery appearance; if infection is severe the leaves may curl upwards and become necrotic; death of individual limbs or entire tree may occur; fungal fruiting bodies appear on the surface of the dead bark

### **Cause**

Fungus

### **Comments**

Pathogen is spread via spores released after rainfall during periods of high humidity and can enter trees through pruning wounds; risk of infection is increased if tree is pruned during late winter or early spring; trees also susceptible when they are heavily pruned

## **Management**

Control of silver leaf disease is difficult and infection can be widespread after rainfall in areas where the disease is present; strategies to reduce the incidence of the disease include: removing all plant debris e.g. pruning waste, stumps, and logs; pruning tree during dry periods and treating large pruning wounds with fungicidal dressing

## **Verticillium wilt** *Verticillium dahliae*

*Symptoms of Verticillium wilt on sweet cherry tree*

### **Symptoms**

Withering of leaves on one or more spurs on 1 year old wood; leaves are dull and stunted; fruit small; older cherry trees do not recover from disease

### **Cause**

Fungus

### **Comments**

Disease is more severe in wet soils

## **Management**

Plant cherry in soil with no history of disease; keep trees adequately fertilized and watered

## **Category : Viral**

## **Cherry rasp leaf** Cherry rasp leaf virus (CRLV)

*Cherry leaves infected with cherry rasp leaf*

### **Symptoms**

Leaf like growths (enations) on underside of leaves near center; symptoms spread from lower parts of tree upwards; defoliation of limbs; decline of tree

### **Cause**

Virus

#### Comments

Distinguished from PNRSV by the leaves remaining green; virus is transmitted by nematodes and through grafting

#### Management

Fumigants to control nematodes may control cherry rasp leaf

### Sour cherry yellows Prune dwarf virus (PDV)

#### Symptoms

Chlorotic rings or mottled pattern on newly expanded leaves of sour cherry which become necrotic and may drop out of leaves, giving them a shot hole appearance; leaves that expand after the initial symptoms have become visible display lesser and lesser symptoms; one or more years later leaves on infected trees become yellow with green mottle and drop from tree; fruit yield may be reduced by up to 50%; sweet cherry trees develop chlorotic spots or rings with some shot holes; fruiting spurs decrease in later years as the disease progresses; fruit on infected trees are generally firmer and larger than on uninfected

#### Cause

Virus

#### Comments

Virus can infect a wide range of *Prunus* species

#### Management

No control strategies are currently known; always purchase certified, disease-free material

### Category : Oomycete

#### Crown and root rot *Phytophthora* spp.

#### Symptoms

Poor new growth; leaves chlorotic, small in size and sparse; fruit may be small, brightly colored and susceptible to sunburn; shoots may suffer from dieback and tree will often die within weeks or months of first signs of infection or decline gradually over several seasons; root crown may show signs of decay which develops into a canker; bark of infected crown tissue turns dark brown; cankers may occur on aerial parts of plant

#### Cause

Oomycete

#### Comments

Symptoms can be similar to those of bacterial infections or mechanical damage; severity of disease is linked to soil moisture content; water-saturated soils promote development of disease

#### Management

Management of phytophthora is reliant on good management of water: cherry trees should be planted in well-draining soil to minimize the frequency and duration of water saturated soil; trees should be propagated from resistant rootstock and application of appropriate systemic fungicides may provide some protection from the disease

### Category : Bacterial, Fungal

#### Crown gall *Agrobacterium* spp

#### Symptoms

Galls on root and/or crown of tree which can range in size from so small they are not visible to the naked eye up to 10 cm (4 in) in diameter; galls first become visible as white, fleshy swellings that grow rapidly and become tan to brown in color; galls typically develop at the site of a wound and new galls form adjacent to old ones the next year

#### Cause

Bacterium

#### Comments

Infection with crown gall begins at the site of plant wounds; disease emergence is favored by poorly-drained, alkaline soils and previous feeding damage by nematodes

### **Management**

Chemical control of the disease is generally ineffective; an effective bacterial biological control is available for commercial production; cultural control methods include: planting only certified, disease-free material, planting cherry in well-draining soil, rotating infected fields with a non-host before peach is planted and also using good sanitation practices

## **Category : Other**

### **X-disease** X-disease mycoplasma-like organism (MLO)

*Graft union on a Bing cherry tree (on mahaleb rootstock) infected with X-disease*

*Delayed fruit maturity caused by X-disease*

### **Symptoms**

Rapid or slow decline of tree depending on rootstock; in hypersensitive rootstocks such as *Prunus mahaleb* cherry scion is rapidly girdled; cherry grafted on susceptible rootstocks exhibit a slow decline over a number of years; leaves on infected limbs are small with a red tinge; fruit may mature late and color development may be incomplete; limbs experience dieback and the tree is killed

### **Cause**

Mycoplasma-like organism

### **Comments**

Disease is transmitted by cherry leafhoppers

### **Management**

Most practical control method for X-disease is to remove infected trees and other plant sources which act as a disease reservoir e.g. chokeberry

## **Pests**

### **Category : Insects**

### **Aphids (Black cherry aphid)** *Myzus cerasi*

*Aphid colony on sour cherry*

*Black cherry aphids*

### **Symptoms**

Small soft bodied insects on underside of leaves and/or stems of plant which are shiny and black in color; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants

### **Cause**

Insect

### **Comments**

Aphids overwinter as eggs on trees and young nymphs hatch and feed at growing tips; winged aphids will migrate to plants in the mustard family during the summer months

## **Management**

Remove any mustard volunteers growing in proximity to cherry; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use; aphids are best treated when cherry is dormant and insect is at the egg stage; if population has not been controlled by the treatment during dormancy then it should be reapplied at petal fall

## **Peach twig borer** *Anarsia lineatella*

*Peach twig borer*

### **Symptoms**

Death of shoot tips; feeding damage to fruit, usually at stem end; larvae are dark brown and white with a black head; adult insect is a gray-brown moth

### **Cause**

Insect

### **Comments**

Peach twig borers overwinter as larvae in a specialized cell known as a hibernaculum; overwintering sites are located in rough areas of bark on 1 to 4 year old wood in crotch of limbs

### **Management**

Most effective method of treatment is well-timed applications of insecticide around time of bloom; organically acceptable insecticides include *Bacillus thuringiensis* or Entrust; infestations can also be treated with appropriate organophosphate or pyrethroid insecticides

## **Western cherry fruit fly** *Rhagoletis indifferens*

### **Symptoms**

Fruit mushy and contains a single white maggot; adult insect is a fly with a black body and white bands on the abdomen and a distinctive dark banded pattern on their wings

### **Cause**

Insect

### **Comments**

Western cherry fruit flies are a potentially damaging pest in all western states of the US; high populations can result in a maggot being found in every single fruit

### **Management**

In commercial cherry plantations, western cherry fruit flies should be monitored using yellow sticky traps, the most effective being one with an ammonium carbonate lure; the insect is a quarantine pest and if a single fruit is found to be infested, treatment is warranted - even if no adults have been found on sticky traps; chemical treatments should be timed to target mature, egg-laying females in your particular region; recommended chemicals include spinosad, carbaryl, malathion, and acetamiprid; home growers should also treat trees to help control this damaging pest

## **Category : Mites**

## **Spider mites (e.g. Two-spotted spider mite)** *Tetranychus urticae*

### **Symptoms**

Leaves stippled with yellow; leaves may appear bronzed; webbing covering leaves; mites may be visible as tiny moving dots on the webs or underside of leaves, best viewed using a hand lens; usually not spotted until there are visible symptoms on the plant; leaves turn yellow and may drop from plant

### **Cause**

Arachnid

### **Comments**

Spider mites thrive in dusty conditions; water-stressed plants are more susceptible to attack

### **Management**

In the home garden, spraying plants with a strong jet of water can help reduce buildup of spider mite populations; if mites become problematic apply insecticidal soap or 1% horticultural oil to plants; certain chemical insecticides may actually increase mite populations by killing off natural enemies and promoting mite reproduction

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# Chestnut

## Description

Chestnut (*Castanea* spp.) is a deciduous tree in the family Fagaceae grown for its edible seeds (nuts). The chestnut tree has a thick trunk covered in gray bark. The trunk has an erect growth habit and can grow 2 m (6.6 ft) in diameter. When the tree stands alone, the canopy can spread 15 m (49 ft) across and is made up of glossy leaves with serrated margins and pointed tips. The leaves are hairy with visible glands on the underside. The chestnut tree produces flowers on long catkins and the seeds are produced in clusters of 1–3. The seeds are covered by a thick, spiny bur which is approximately 10 cm (4 in) in diameter. The kernel within is protected by a thin, dark brown shell. Chestnut trees can reach 40–60 m (131–198 ft) in height and can live for in excess of 150 years. Chestnut may also be referred to by variety and includes European, American, Japanese and Spanish chestnut. The tree originates from Asia.

*Chestnut*

*Chestnuts*

*Chestnut on tree*

*Chestnut tree*

*Chestnut leaves*

*Chestnut burs on the tree split to reveal the kernel*

## Uses

Chestnuts are commonly consumed after roasting or may be processed to produce chestnut creams and purees or for canning.

## Propagation

**Basic requirements** Chestnuts are hardy trees which will grow in a variety of conditions. The trees grow best in well-draining, acid loam soils and require a pH between 4.5 and 6.5. The trees perform well when planted on a gentle slope which allows cold air to drain to a lower area as well as aiding in soil drainage. Chestnuts should be planted in full sunlight and open fields are preferred for maximum nut production. Chestnut has poor self compatibility and at least 2 trees are required for nut production. **Propagation** Chestnut trees can be grown from seeds or can be propagated by grafting onto a seedling rootstock. Seedlings grown for use as a rootstock for grafting are usually ready to receive a scion when they are two years old. The seedling must have reached a suitable thickness in order to receive a graft (usually when it reaches a thickness similar to that of a pencil). **Germinating seeds** Chestnut seeds germinate readily but not all will produce a seedling suitable for planting and/or grafting. Seeds can be obtained from breeders or collected from chestnut trees in the Fall. Seeds should be kept refrigerated until planting and can then be direct-seeded outdoors or grown in containers inside. Seeds should be planted in early Spring as soon as the soil can be worked. The seed should be planted in a hole 7.5 to 15.0 cm (3-6 in) deep with the radicle (embryo emerging from the seed) facing downwards. If planting in a container, be sure to choose one that is at least 30 cm (12 in) deep and 10 cm (4 in) in diameter. The seeds can be planted earlier if the containers are to be kept indoors. **Planting seedlings** Seedlings started in containers can be transplanted after all danger of frost has passed and after hardening. The seedling should be planted in a hole that is at least 1.5 times the size of the existing root ball. Gently remove the remnants of the nut from the roots and place the seedling in the hole. Backfill the hole with soil and tamp to remove air pockets. Seedlings should be planted 10–12 m (33–39 ft) apart, allowing an additional 10–12 m (33–39 ft) between rows. After planting, the seedlings should be watered thoroughly. Continue watering the seed for the first month after planting to help the seedling establish.

**General care and maintenance** After planting, the areas around the trees should be kept free from weeds. A layer of mulch spread around the trunks will help suppress weeds and conserve soil moisture. You may have to protect the young trees from pests such as deer which can cause severe damage to the trees. The most effective method of protecting trees is to erect an 8 ft high metal deer fence around the area where the new trees have been planted.

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## Common Pests and Diseases

### Diseases

**Category : Fungal**

## **Blight** *Cryphonectria parasitica*

### **Symptoms**

Sunken or swollen, yellow-brown, oval cankers on branches or trunk; cankers may girdle stems and result in yellow-brown leaves which remain attached; water may be visible below cankers

### **Cause**

Fungus

### **Comments**

American and European chestnuts are susceptible to the disease; Japanese chestnuts have some resistance; the fungus was introduced to the US via imported chestnuts and completely devastated the population of chestnut on the east coast

### **Management**

Infected trees must be removed and destroyed to prevent spread

## **Leaf spot** *Marssonina ochroleuca*

### **Symptoms**

Small, circular, yellow-brown spots on leaves which may have concentric rings; holes in leaves as lesions dry and drop out; premature leaf fall

### **Cause**

Fungus

### **Comments**

### **Management**

No control methods are currently recommended

## **Pests**

### **Category : Insects**

## **Chestnut weevil (Lesser chestnut weevil, Larger chestnut weevil)** *Curculio sayi*

*Curculio caryatrypes*

### **Symptoms**

Nuts on ground with small circular hole bored from the inside; adult insects are dark brown beetles with protruding snouts; larvae are creamy white grubs

### **Cause**

Insect

### **Comments**

Female weevil lays her eggs in the shell of the nut and larvae hatch and feed inside; larvae exit the nut through a small hole bored in the shell and enter the soil when the nut falls to the ground; most larvae pupate after one year

### **Management**

Chestnuts should be picked daily and, after curing, should be heated to 60°C (140°F) for 30 minutes to kill off any larvae inside nuts; collecting the nuts promptly after they have fallen prevents larvae from leaving the nut and entering the soil

## **Japanese beetle** *Popillia japonica*

*Adult Japanese beetle*

### **Symptoms**

Leaves skeletonized (only veins remaining); flowers and buds damaged; plant damage may be extensive; adult insect is a

metallic green-bronze beetle with tufts of white hair protruding from under wing covers on each side of the body; adult beetles are approximately 13 mm in length; larvae are cream-white grubs which develop in the soil

### **Cause**

Insect

### **Comments**

One beetle generation every 1-2 years; pheromone traps may actually attract more beetles to home gardens and should generally be avoided; beetle overwinters as larvae in soil; beetle has an extensive range of over 300 host plants

### **Management**

If beetles were a problem in the previous year, use floating row covers to protect plants or spray kaolin clay; adult beetles can be hand picked from plants and destroyed by placing in soapy water; parasitic nematodes can be applied to soil to reduce the number of overwintering grubs; insecticidal soaps or neem oil can help reduce beetle populations

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# Chickpea (gram pea)

## Description

The chickpea, *Cicer arietinum*, is a leguminous annual plant in the family Fabaceae grown for its edible seeds. The plant has a branched, straight or bending stem with small feathery leaves arranged alternately on the stem. The leaves are composed of 11–15 individual leaflets which are oval in shape. The flowers are produced singly or in pairs and can be white, pink, purple or blue in color. The seed pod is rhomboid or ellipsoid and contains 4 cream, brown, green or black seeds. The chickpea plant can range in height from 20 cm (7.9 in) up to 100 cm (39.4 in) and as an annual, grows over only one growing season. Chickpea may also be referred to as gram pea, garbanzo bean or ceci bean and originate from south-eastern Turkey.

*Chickpea pods*

*White chickpea flower*

*Commercially grown chickpea*

*Chickpea seedling*

*Chickpea plant*

*Purple chickpea flower*

## Uses

Chickpea is primarily consumed as a dry pulse. The shelled peas are eaten as snack or vegetable. The seed husks can be used as a feed for animals. Chickpeas are also commonly cooked and ground into a paste to produce the popular dish,

hummus.

## Propagation

**General requirements** Chickpeas are cool-season legumes which are best grown as a winter crop in the tropics or as a spring or summer crop in temperate regions. Chickpeas are classified into two distinct types based on seed characteristics. Desi chickpeas have a thick, colored seed coat and the surface of the seed is rough and angular whereas the Kabuli type have white or beige seeds with a smooth surface. Kabuli chickpeas are best grown in temperate areas whereas Desi chickpeas are best suited to semi-arid areas of the tropics. Chickpeas will grow optimally at temperatures between 15 and 29°C (59–84.2°F) with extremes of temperature above 35°C (95°F) and below 15°C (59°F) causing flowers to drop, reducing production. Plants will perform best when planted in well-draining sandy loam soils with a pH between 5.0 and 7.0 in areas where the annual rainfall is between 600 and 1000 mm. **Planting** Chickpeas are propagated directly from seed with timing of planting depending on the variety being grown and geographic location. Spring crops should be planted when the soil has warmed to at least 5°C (41°F). Chickpeas are leguminous and when planting in a site which has not previously been used for chickpea cultivation, seed should be inoculated with an appropriate type of Rhizobacteria prior to planting. Seed is usually spread by broadcasting or by drilling in rows. Desi types require a seed rate of 30 to 40 kg per hectare whereas Kabuli types require 80 to 100 kg per hectare. The seed should be planted 2 to 12 cm (0.8–4.7 in) deep and when planting in rows, seed should be spaced 10 cm (4 in) apart allowing 25 to 60 cm (9.8 to 23.6 in) between rows. Seedlings usually emerge between 7 and 15 days after sowing depending on temperature. **General care** In the home garden, chickpea seedlings will benefit from the addition of a layer of mulch after they have emerged to suppress weeds and conserve soil moisture. Plants should be provided with additional irrigation during periods of dry weather but care should be taken not to overwater as this can cause the plants to drop their flowers and/or pods. Application of fertilizer is generally not necessary as chickpeas are leguminous and fix their own nitrogen with the aid of micro-organisms but requirements vary from field to field and management should be based on the results of a soil test. Like other pulses, chickpeas require phosphorus, potassium and micronutrients for growth and application should be based on the results of soil testing. Suppression of weeds in commercial fields is important as chickpeas do not compete well and weed will reduce productivity. Pre- and post-emergence herbicide applications can be helpful for managing weed. If a field has a history of weed problems then it is not suitable for chickpea production. **Harvesting** Chickpeas are ready to harvest approximately 100 days after planting. In the home garden, chickpeas can be collected and eaten when green but for dried seeds, the leaves should be allowed to turn brown before collecting the pods. The pods should be allowed to dry and split open before collecting seeds. In commercial production, chickpeas can be harvested by swathing and/or combine.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Ascochyta blight** *Ascochyta rabiei*

*Ascochyta blight lesion close-up*

*Ascochyta blight lesion on chickpea flower*

*Ascochyta blight symptoms on chickpea stem*

*Ascochyta blight symptoms on chickpea leaf*

*Stem lesion caused by Ascochyta blight*

*Leaf lesions caused by Ascochyta blight*

*Ascochyta blight in chickpea field*

*Chickpea plants infected with Ascochyta blight*

*Ascochyta blight on chickpea pods*

#### Symptoms

Water-soaked pale spots on young leaves which enlarge rapidly under cool, wet conditions and coalesce to cause blighting of leaves; elongated lesions often cause girdling of the stems which break off; new shoots may form at the breakage points; if pods become infected it can lead to reduced seed set; if infected seeds are planted, the seedlings will develop dark brown lesions at the base of the stem and may dry up and die

#### Cause

Fungus

#### Comments

Disease emergence is favored by wet weather; spores are carried to new plants by wind and water splash

#### Management

Grow more resistant varieties such as PBA Slasher or Genesis® 090; even resistant varieties require fungicide application at early podding to ensure high quality seed; more susceptible varieties may require a first fungicide application approximately 4-6 weeks after sowing

#### **Fusarium wilt** *Fusarium oxysporum*

#### Symptoms

Weak and wilting leaf stems, leaves and flowers; lower leaves drying out and dying; leaves turning brown or pale yellow; splitting the stem reveals discoloration of the inner tissue; leaves turn dull yellow in color and collapse

#### Cause

Fungus

#### Comments

Disease emergence favors warm, moist soils; disease can be spread by water splash, movement of infected soil and plants and by infected seed

#### Management

The primary method of controlling the disease is to use resistant varieties; damage can be reduced by application of appropriate fungicides; crop debris should be removed or plowed deeply into the soil after harvest; if disease is present in the soil then a rotation to a non-host for a period of three years can reduce the levels of inoculum in the soil

#### **Sclerotinia stem rot (White mold)** *Sclerotinia sclerotiorum*

*Sclerotinia stem rot symptoms on chickpea*

### **Symptoms**

Plants rapidly wilting and dying, often without turning yellow; as plants dry out they may turn straw yellow in color; small black fungal bodies (sclerotia) may be present on the surface of the root just below the soil line together with white fluffy mycelium; water soaked lesions may be present on the stem in Spring; infected tissues dry out and may become covered in white mycelium

### **Cause**

Fungus

### **Comments**

Disease emergence favors very wet weather conditions; disease is usually introduced to non-infected areas by infected seed

### **Management**

Plant only certified seed; if disease is known to present rotate crops with non-hosts such as cereals; if problem is severe then a 4 year rotation away from susceptible plants may be required; there are no seed treatments or fungicides available to treat the disease

## **Category : Fungal, Oomycete**

### **Damping-off *Pythium* spp.**

#### **Symptoms**

Failure of seedling to emerge; light brown, seedlings with light brown to redwater-soaked roots and stems; collapse of plants; plant dry up and die; stunted plant growth; rotting taproot with few lateral roots

#### **Cause**

Fungus

#### **Comments**

Occurs more often in cold temperatures when growth of seedlings is slow and in moist soil

#### **Management**

Treat seeds with fungicide prior to planting

## **Category : Oomycete**

### **Dry root rot *Macrophomina phaseolina***

#### **Symptoms**

Leaves and leaf stems wilting; dark, rotten tap roots; gray fibrous fungal threads on the tap root

#### **Cause**

Fungus

#### **Comments**

Favors high temperature and low moisture

#### **Management**

No fungicides provide effective control of the disease and management therefore relies on cultural practices; utilize adequate plant spacing to avoid overcrowding and competition for water which can promote the disease; crop rotation to a non-host may help reduce the population in the soil

### **Phytophthora root rot *Phytophthora megasperma***

#### **Symptoms**

Leaves of plants turning yellow and drying out; decaying roots; small brown lesions on roots which enlarge and create necrotic patches; lesions may girdle stem

#### Cause

Oomycete

#### Comments

Favors warm, wet soil

#### Management

Varieties with resistance to the disease are available in most areas where root rot is a problem

## Pests

### Category : Insects

#### Beet armyworm *Spodoptera exigua*

##### Symptoms

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; larvae are dark green to brown caterpillars with banding patterns

##### Cause

Insect

##### Comments

Beet armyworm is a serious pest of chickpea in India and Mexico; Insect can go through 3–5 generations a year

##### Management

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae

#### Chickpea leafminer *Liriomyza cicerina*

##### Symptoms

Leaves may have a stippled appearance from females puncturing leaf with ovipositor to feed on exudate; female lays eggs under leaf surface and newly hatched larvae damage the leaf by feeding on the inner tissues; feeding damage from larvae causes the development of winding white trails of the leaf surface; if feeding damage is extensive, the entire leaf may dry out and drop from the plant; damage to young seedlings may result in the death of the plant; crop yield may be reduced

##### Cause

Insect

##### Comments

Chickpea leafminers can cause heavy losses in North Africa, West Asia and Northern Europe

##### Management

Cultural control methods include planting chickpeas in early winter instead of Spring when the populations of the insects are at less damaging levels; crop debris should be plowed deeply into the soil to destroy overwintering pupae; chickpea cultivars with smaller leaf sizes are less attractive to leafminers; insects may be controlled through the application of appropriate chemical insecticides

#### Cowpea aphid (Black aphid) *Aphis craccivora*

##### Symptoms

Deformed leaves and shoots; curled leaves; if infestation is severe then plants may be killed; seed fill and yield may be reduced; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants; adult insect is small and soft bodied and is easily distinguished from other aphids by its shiny-black color

## Cause

Insect

## Comments

Black aphids can cause severe damage when infestation is high but more commonly cause problems in chickpea crops through the transmission of several plant viruses

## Management

Plants should be monitored for signs of aphids; if insects are present then control measures should be implemented; some chickpea cultivars are more susceptible to aphid infestation than others - cultivars with a low density of trichomes (leaf hairs) are more susceptible than others; chemical control may be warranted although aphids have developed resistance to several insecticides in India; cultural control methods include early planting which promotes early closure of the plant canopy and reduced the spread of viruses; aphid infestations tend to be worse when broad plant spacing is employed

## Cutworms (Black cutworm, Winter cutworm) *Agrotis ipsilon*

*Agrotis segetum*

## Symptoms

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5â€“5.0 cm (1â€“2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed

## Cause

Insect

## Comments

Favors late tillage and planting; major pest for corn and will start attacking everything else after corn is rotated out

## Management

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically

## Pod borers ( Cotton bollworm, Australian bollworm ) *Helicoverpa armigera*

*Helicoverpa punctigera*

Large *Helicoverpa punctigera* (left) and *H. armigera* (right) larvae showing the distinguishing dark and pale hairs behind their heads

Medium *Helicoverpa armigera* (12 mm) showing the distinctive "saddle" on 4th and 5th body segments (top), and *H. punctigera* without saddle (bottom)

## Symptoms

Young larvae feed on foliage initially; young chickpea plants may be completely destroyed; older larvae bore into seed pods and consume seeds; insect frass (feces) may be present outside the feeding holes

## Cause

Insects

## Comments

*Helicoverpa armigera* is widely distributed in Asia, Africa, Australia, and the Mediterranean; also a pest of cotton, pigeonpea, sunflower, tomato, maize, sorghum, pearl millet, okra, beans, tobacco, linseed and a number of fruit trees; *Helicoverpa punctigera* is a major pest of chickpea in Australia

## **Management**

The insect can be very damaging in the areas where it occurs and plants should be monitored carefully for presence of larvae; identifying the species of *Helicoverpa* present can be important for management decisions as *H. armigera* is resistant to some insecticides (particularly synthetic pyrethroids), while *H. punctigera* is susceptible to all insecticides; small larvae should be distinguished with the use of a hand lens or microscope; young *H. armigera* larvae have a distinctive saddle on the fourth body segment which is absent from the larvae of *H. punctigera* (see image); older larvae can be distinguished by the color of the hairs behind the head - *H. armigera* possess white hairs, while *H. punctigera* have black hairs; both types of larvae may also be controlled organically via release of natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*

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# Chicory

## Description

Common chicory, *Cichorium intybus*, is a perennial herb in the family Asteraceae grown for use as a salad green. Generally, chicory plants have an erect growth habit with numerous lanceolate (lance shaped) leaves branching off of the erect stems. The basal leaves can reach 25 cm (9.8 in) in length and are spatulate (spoon-shaped) and may be green or red in color. There are two rows of bracts (modified leaves) on the stems, the inner are longer and erect and the outer are shorter and spreading. The foliage is commonly covered in hairs. The plant produces bright blue or sometimes pink or white flowers which are 2–4 cm (0.79–1.6 in) in diameter. Chicory can grow to a height of 0.6–1.2 m (2.0–3.9 ft) and is usually grown as a biennial. Chicory may also be referred to by variety and these include Common chicory, Italian dandelion, Witloof, Belgian endive and radicchio. Chicory likely originates from the Mediterranean.

*Chicory foliage*

*Radicchio*

*Belgian endive*

## Uses

Chicory is predominantly grown for its leaves which are used as salad greens or cooked. The witloof variety is also grown for its root which can be ground and used as a coffee substitute.

# Propagation

**Basic requirements** Many types of chicory are available for the home garden and the chosen variety depends ultimately on its desired use. Radicchio types are grown for their leaves whereas witloof types may be grown for their roots and leaves. Chicory is a cool season crop and radicchio varieties require cool temperatures to produce heads. Plants will grow best in fertile, well draining soils with a pH between 6.5 and 7.2 and should be positioned in full sun.

**Planting** Chicory can be direct seeded or started indoors for transplanting. If started indoors, seeds should be sown in a sterile seed starting mix by planting to a depth of 0.6 cm (0.25 in). Thin the seedlings when they have 3 to 4 sets of true leaves. The seedlings are ready for transplanting when they are about 5 to 6 weeks old and have 5 or six mature leaves. Seedlings should be hardened prior to transplanting by gradually increasing their exposure to outdoor conditions. Space seedlings 20 to 23 cm (8-9 in) apart allowing 20 cm (8 in) between rows. Directly seeded plants should be thinned to this spacing. **General care and maintenance** Plants should be protected from frosts with row covers or fabric to prevent damage. The plants will benefit from a layer of organic mulch such as grass clippings or leaves which will help to suppress weeds while conserving moisture in the soil. Plants should be kept moist during growth to prevent the development of bitter tasting leaves. Chicory generally requires 1 to 2 inches of water a week but this will depend on the type of soil and the prevailing climatic conditions. **Harvesting** Radicchio varieties should be harvested when the leaves have reached their full size. Harvesting should not be delayed as it results in the leaves developing a bitter flavor. Cut the head from the plant using a sharp knife to cut through the stem just below the head. Witloof varieties grown for leaves should be harvested while the leaves are young and tender. If the plants are being grown for their roots then they should be pulled from the soil just before the last frost date. The leaves should be trimmed to about 2.5 cm from the crown and the roots should be trimmed to a uniform size. Store the trimmed plants at 0°C (32°F) for 5 to 7 weeks before forcing.

**Forcing** Forcing is the term used to describe the process by which witloof chicory varieties are forced to produce new growth in winter. The forcing process is commonly carried out by transplanting the plants into sand filled boxes or buckets which are then stored in a frost free place such as a glasshouse, shed or basement where temperatures are between 10 and 15.55°C (50-60°F). The chicory plants should be planted in the sand, leaving the crown exposed and then either kept in darkness if in a basement or covered if in a glasshouse. It is important that no light is able to reach the plants. The plant will begin to produce a tightly packed head of leaves called a chicon. Chicons are ready for harvest within 3-5 weeks.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Anthracnose** *Microdochium panttonianum*

###### **Symptoms**

Small circular or irregularly shaped dry spots which are gray to straw in color on leaves; a high number of spots may cause the leaf to die; lesions may coalesce to form large necrotic patches causing leaves to turn yellow and wilt; lesions may split or crack in dry centers

**Cause**

Fungus

**Comments**

Fungus overwinters on leaf debris and on related weeds; disease emergence is favored by moist, warm conditions

**Management**

Control of disease depends on sanitary practices; treat seeds with hot water prior to planting; rotate crops; plant in an area with good soil drainage; remove all cruciferous weeds which may act as a reservoir for the fungus

**Downy mildew** *Bremia lactucae***Symptoms**

Young leaves drying up and dropping off; older leaves developing a papery texture; white fuzzy mold on the underside of leaves

**Cause**

Fungus

**Comments**

Disease favors cool, moist conditions; can be spread via infected seed; fungus survives in plant debris and in wild lettuce plants

**Management**

Disease is controlled primarily by planting resistant varieties and/or by applying appropriate fungicides

**Fusarium wilt** *Fusarium* spp.**Symptoms**

Small water soaked lesions on foliage; drooping and yellowing of leaves

**Cause**

Fungi

**Comments**

High temperatures and rainfall promote spread

**Septoria blight** *Septoria lactucae***Symptoms**

Small, irregularly shaped chlorotic spots on oldest plant leaves which enlarge and turn brown and dry out; lesions may fall out of leaves creating holes; leaf spots may have chlorotic halos; if plant is severely infected, lesions may coalesce forming large necrotic patches, wilting leaves and plant death

**Cause**

Fungus

**Comments**

Fungus survives in infected seed and in crop debris; disease spreads in humid or wet conditions; can be spread by splashing water; wild lettuce is an important overwintering site for the fungus

**Management**

Plant pathogen free seed; plant in areas where Septoria is uncommon; ideal planting sites are in regions with low rainfall; hot water treatment of seeds prior to planting may help reduce levels of disease

**White mold** *Sclerotinia sclerotiorum***Symptoms**

Abundant white mycelium (thread-like fungal structures) on any part of plant; Wilting of outside leaves which spreads inwards until whole plant is affected; soft watery lesions on leaves; leaves collapse and lie on soil surface; black fungal structures on infected leaf tissue and soil surface

**Cause**

Fungi

## **Comments**

Common in cool moist regions on a variety of crops; fungus can survive in soil for 8-10 years

## **Management**

Rotate crop to non-hosts (e.g. cereals) for at least 3 years; control weeds; avoid dense growth by planting in adequately spaced rows; disease significantly reduced by application of fungicides immediately after thinning plants; plow soil deeply

## **Category : Bacterial**

### **Bacterial soft rot *Erwinia* spp.**

#### **Symptoms**

Water-soaked lesions which expand to form a large rotted mass of cream colored tissue which is liquid underneath; surface of lesions usually crack and exude slimy liquid which turns tan, dark brown or black on exposure to air

#### **Cause**

Bacteria

#### **Comments**

Bacteria are easily spread on tools and by irrigation water; disease emergence favored by warm, moist conditions; bacteria enter plant through wounds

#### **Management**

Chemical treatments are not available for bacterial soft rot, control relies on cultural practices; rotate crops; plant cabbage in well-draining soils or raised beds; only harvest heads when they are dry; avoid damaging heads during harvest

## **Category : Other**

### **Bottom rot *Rhizoctonia solani***

#### **Symptoms**

Small red to brown spots on lower leaves, usually on underside of midrib which may expand rapidly causing the leaves to rot; amber colored liquid may ooze from leaf lesions; as stems rot, head of lettuce becomes slimy and brown and collapse; a tan or brown mycelial growth may be visible in infected tissue

#### **Cause**

Fungus

#### **Comments**

Fungus survives on crop debris in soil; disease emergence favored by warm, wet weather

#### **Management**

Disease is most effectively managed by combining cultural control with fungicide application; plow soil before planting; rotate crops regularly; avoid irrigation close to harvest; plant varieties with an erect growth habit to reduce leaf contact with soil; apply appropriate foliar fungicides

### **Slugs & snails (Gray garden slug, Spotted garden slug, Brown garden snail, European garden snail, etc.) *Decoratus reticulatum***

*Limax maximus*

*Helix aspersa*

*Cornu aspersum*

Gray garden slug

European brown snail

#### **Symptoms**

Irregularly shaped holes in leaves and stems; flowers and fruit may also be damaged if present; if infestation is severe,

leaves may be shredded; slime trails present on rocks, walkways, soil and plant foliage; several slug and snail species are common garden pests; slugs are dark gray to black in color and can range in size from 2.5 to 10 cm (1-4 in); garden snails are generally smaller and possess a rounded or spiral shell

#### Cause

Mollusc

#### Comments

Slugs and snails prefer moist, shaded habitats and will shelter in weeds or organic trash; adults may deposit eggs in the soil throughout the season; damage to plants can be extensive

#### Management

Practice good garden sanitation by removing garden trash, weeds and plant debris to promote good air circulation and reduce moist habitat for slugs and snails; handpick slugs at night to decrease population; spread wood ashes or eggshells around plants; attract molluscs by leaving out organic matter such as lettuce or grapefruit skins, destroy any found feeding on lure; sink shallow dishes filled with beer into the soil to attract and drown the molluscs; chemical controls include ferrous phosphate for organic gardens and metaldehyde (e.g. Buggeta) and carbaryl (e.g. Sevin bait) for non-organic growers

## Category : Fungal, Oomycete

### Damping-off *Pythium* spp.

*Rhizoctonia solani*

#### Symptoms

Poor seedling germination and emergence; dark lesions on stems; withered stem; stems collapsing; brown rotting roots

#### Cause

Fungi

#### Comments

Disease emergence in seedlings favored by cool temperatures and waterlogged soils

#### Management

Plant pathogen-free seed or transplants that have been produced in sterilized soil; apply fungicide to seed to kill off any fungi; shallow plant seeds or delay planting until soil warms

## Pests

## Category : Insects

### Aphids (Green peach aphid, Lettuce aphid, Plum aphid) *Myzus persicae*

*Nasonovia ribisnigri*

*Brachycaudus helichrysi*

*Green peach aphid colony*

#### Symptoms

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants

#### Cause

Insect

## **Comments**

Aphids will be visible on the leaves; small, rounded green to pink insects; distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed

## **Management**

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

## **Darkling beetles** *Eleodes sp.*

*Blapstinus* spp.

*Caelus* spp.

*Darkling beetle, Eleodes hispilabrus*

## **Symptoms**

Feeding damage on stems; death of seedlings; seeds dug up; insect is a dull blue-black or brown beetle about 0.6 cm (0.52 in) long; tips of antennae are often enlarged, resembling a club

## **Cause**

Insect

## **Comments**

Beetles are generally active at night; during the day beetles hide in organic debris

## **Management**

Ditches filled with water can prevent spread of beetle to/from adjacent fields; remove all weeds from garden borders; if beetle is problematic then appropriate insecticides can provide control; insecticides are usually in the form of baits

## **Flea beetles** *Epitrix* spp.

*Phyllotreta* spp.

*Flea beetles and damage*

## **Symptoms**

Small holes or pits in leaves that give the foliage a characteristic "shot hole" appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5–3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance

## **Cause**

Insect

## **Comments**

Younger plants are more susceptible to flea beetle damage than older ones; older plants can tolerate infestation; flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year

## **Management**

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become

a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application on diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied

### **Leafminers** *Liriomyza* spp

*Typical leafminer damage*

#### **Symptoms**

Thin, white, winding trails on leaves; heavy mining can result in white blotches on leaves and leaves dropping from the plant prematurely; early infestation can cause fruit yield to be reduced; adult leafminer is a small black and yellow fly which lays its eggs in the leaf; larvae hatch and feed on leaf interior

#### **Cause**

Insect

#### **Comments**

Mature larvae drop from leaves into soil to pupate; entire lifecycle can take as little as 2 weeks in warm weather; insect may go through 7 to 10 generations per year

#### **Management**

Check transplants for signs of leafminer damage prior to planting; remove plants from soil immediately after harvest; only use insecticides when leafminer damage has been identified as unnecessary spraying will also reduce populations of their natural enemies

### **Loopers (Cabbage looper, Alfalfa looper)** *Trichoplusia ni*

*Autographa californica*

*Cabbage looper*

#### **Symptoms**

Large or small holes in leaves; damage often extensive; caterpillars are pale green with a white line running down either side of their body; caterpillars are easily distinguished by the way they arch their body when moving; eggs are laid singly, usually on the lower leaf surface close to the leaf margin, and are white or pale green in color

#### **Cause**

Insect

#### **Comments**

Insects overwinter as pupae in crop debris in soil; adult insect is a dark colored moth; caterpillars have a wide host range

#### **Management**

Looper populations are usually held in check by natural enemies; if they do become problematic larvae can be hand-picked from the plants; an organically acceptable control method is the application of *Bacillus thuringiensis* which effectively kills younger larvae; chemical sprays may damage populations of natural enemies and should be selected carefully

### **Thrips (Western flower thrips, Onion thrips)** *Frankliniella occidentalis*

*Thrips tabaci*

### **Symptoms**

If population is high leaves may be distorted; leaves are covered in coarse stippling and may appear silvery; leaves speckled with black feces; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color

### **Cause**

Insect

### **Comments**

Transmit viruses such as Tomato spotted wilt virus; once acquired, the insect retains the ability to transmit the virus for the remainder of its life

### **Management**

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic

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# Chilli Pepper

## Crop details

### Scientific Name

Capsicum spp. (C. annuum, C. frutescens)

### Order / Family

Solanales: Solanaceae

### Local Names

Pilipili (Swahili)

### Common Names

Sweet pepper, Bell pepper, Chilli, Hot pepper

### General Information

All chilli peppers are varieties of several plant species in the genus *Capsicum*, including *Capsicum annuum* (e.g. jalapeños and cayennes), *C. frutescens* (e.g. tabasco and piri piri), *C. chinense* (e.g. habaneros and Scotch bonnet), *C. pubescens* (e.g. rocoto and locoto) and *C. baccatum* (e.g. aji peppers) and their hybrids which include some of the hottest peppers known. Unsurprisingly, the plants are most commonly grown for the harvest of their fruits, which are used as a spice. Hot peppers are perennial plants with varying structure. They can be herbaceous or shrub-like but are generally branching with green-brown stems and simple oval leaves. The plants produce flowers with five teeth (petals) which are usually white in color. Chilli pepper plants can reach heights in the range of 0.5 to 1.5 m (1.6–4.9 ft) tall and although they are perennial species, they are commonly grown as annuals, with fruit being harvested for one growing season.

Chilli peppers may also be referred to as hot peppers or hot chillis. *C. annuum* species are believed to have originated from Mexico, while the others are all likely to have originated from South America.

Chilli pepper flower

Habaneros

Pepper flower buds

Thai chilli peppers

Habanero fruits ripening on the plant

Cayenne pepper fruit

## climatic conditions, soil and water management

Capsicum peppers tend to tolerate shade conditions up to 45% of prevailing solar radiation, although shade may delay flowering. Capsicum peppers grow best on well-drained loamy soils at pH 5.5-6.8. They grow at a wide range of altitudes, with rainfall between 600- and 1250-mm. Severe flooding or drought is injurious to most cultivars. Seeds germinate best at 25-30°C. Optimal temperatures for productivity are between 18 and 30°C. *C. frutescens* are more tolerant to high temperatures. Cooler night temperatures down to 15°C favor fruit setting, although flowering will be delayed as temperatures drop below 25°C. Flower buds will usually abort rather than develop to maturity if night temperatures reach 30°C. Pollen viability is significantly reduced at temperatures above 30°C and below 15°C.

### Chillie paper varieties

Cultivars commonly grown in Kenya:

#### Sweet pepper (*C. annuum*):

California Wonder

Yolo wonder

Emerald Giant

Ruby Giant

#### Hot pepper (*C. frutescens*)

Anaheim

Fresno

Jalapeno

Long Red Cayenne

Rocket

Short Bullet

## Nutrition Value

Chili peppers have amazingly high levels of vitamins and minerals. Just 100 g provides (in % of recommended daily allowance):

240% of vitamin-C (Ascorbic acid),

39% of vitamin B-6 (Pyridoxine),

32% of vitamin A,

13% of iron,

14% of copper,

7% of potassium,

## Uses

Hot peppers can be eaten fresh or cooked as a vegetable, seasoning or garnish.

## Propagation

### Basic requirements

Peppers are warm-season crops and grow best at temperatures between 18 and 30°C (65–86°F). They can be grown in many soil types although sandy soils warm faster in Spring and are good for early planting. The soil should have a pH between 6 and 7. Peppers will not tolerate water saturated soil and should be planted in a well draining soil or raised bed. Peppers should be planted in an area that receives full sun for most of the day.

### Sowing seeds

In most cases, pepper seeds should be started indoors 8–10 weeks before the last Spring frost. Pepper should only be direct seeded in areas with a long, warm growing season, otherwise seeds should be sown indoors in flats or cell trays using a sterile seedling mix. Plant seeds to a depth of 1.3 cm (1/2 in) and water lightly. Seeds should not be allowed to dry out as there will be a negative impact on germination rates. Trays should be positioned in a warm, bright, South facing window or under fluorescent lighting. The optimum soil temperature for germination is 21–29°C (70–85°F). A heat mat can be used to warm the flats if required. Seedlings will emerge within 8–25 days and after the seedlings has developed two sets of true leaves then they can be moved to a larger (3-4 in) pot. Seedlings should be provided with ample light and adequate fertilizer.

### Transplanting

Peppers are usually transplanted 2–3 weeks after the last frost when the soil temperature has reached a minimum of 15.5°C (60°F). Covering soil with dark plastic or mulch a week prior to planting outdoors can help bring the soil temperature up more quickly in colder regions, allowing earlier planting. Beginning approximately 7–10 days before transplanting, plants should be set outside to harden off (see <https://www.plantvillage.com/posts/264>). The hardening off process is very important as peppers are very susceptible to transplant shock. The planting site should be prepared by incorporating plenty of organic matter to encourage vegetative growth. When transplanting seedlings, allow 30–45 cm (12–18 in) between plants and 60–76 cm (24–30 in) between rows. Side dress plants with a nitrogen fertilizer at planting. Drip or soaker irrigation is preferred to overhead irrigation and plants should be watered evenly to keep them moist. Mulching around the plants can also help to conserve soil moisture.

### General care and maintenance

Peppers will benefit from applications of fertilizer to keep them supplied with essential nutrients. A timed release fertilizer can be applied at bloom or the plants can be fed with a liquid fertilizer at planting and every two weeks thereafter. In addition, pepper plants can produce a heavy load of fruit and it can be helpful to provide the plants with some support using stakes or cages to prevent branches from breaking under the weight. Use a soft material to tie plants to stakes or cages.

*Caged hot peppers*

*Jalapeno seedlings*

*Pepper seedlings*

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## Common Pests and Diseases

### Diseases

#### Category : Bacterial

##### **Bacterial spot** *Xanthomonas vesicatoria*

*Lesions on capsicum fruit*

*Symptoms of bacterial spot on red chili foliage*

*Symptoms of bacterial spot on red chili foliage*

*Symptoms of bacterial spot on red chili foliage*

#### Symptoms

Water-soaked lesions that dry out and turn brown forming on the underside of the leave; raised brown cankers on stems; cracked brown lesions on fruit.

#### Cause

Bacterium

#### Comments

Disease emergence favored by warm, wet conditions.

#### Management

Use disease free planting material; remove and destroy all crop debris after harvest, or plow material deeply under soil.

#### Category : Fungal

##### **Damping-off** *Pythium* spp.

*Rhizoctonia solani*

*Shriveled stem of pepper seedling caused by damping-off*

### Symptoms

Seeds did not germinate; seedlings collapsing and dying; dark stems which are shriveled near the soil line; water-soaked lesions on the stem; water-soaked discolored roots.

### Cause

Fungi

### Comments

Disease can be spread in infected soil and irrigation water; disease emergence favored by overcrowded plants and excessive nitrogen fertilization.

### Management

Avoid planting in poorly draining, cool, wet soil; planting in raised beds will help with soil drainage; plant high quality seed that germinates quickly; treat seeds with fungicide prior to planting to eliminate fungal pathogens.

## **Fusarium wilt** *Fusarium oxysporum* most likely

### Symptoms

Yellowing of foliage and wilting upper leaves; wilting spread to all parts of plant; leaves remain attached to plant and are dark green in color; red-brown discoloration of vascular tissue; plant death.

### Cause

Fungus

### Comments

Disease emergence favors high soil moisture content.

### Management

Plant pepper in well draining soils and avoid water logging.

## **Powdery mildew** *Leveillula taurica*

*Powdery mildew symptoms on pepper leaf*

*Powdery mildew symptoms on pepper leaf*

*Powdery mildew symptoms on pepper leaf*

### Symptoms

White, powdery growth on underside of leaves which starts in patches but starts to spread across whole leaves, including the top surface; yellow-brown discoloration on underside of leaves; leaves curling.

### Cause

Fungus

### Comments

Disease can occur in both humid and dry conditions; disease spreads most rapidly in humid conditions; disease commonly affects older leaves.

### Management

Apply appropriate fungicide if disease is severe.

## **Southern blight** *Sclerotium rolfsii*

<i>Yellow patches in the field of sweet pepper where the disease has struck</i>	<i>Southern blight girdles the lower stem and causes the plant to die</i>	<i>Cross-section through the lower stem of sweet pepper shows the degree of tissue discoloration</i>
<i>Pepper plant infected with southern blight disease</i>	<i>Ropey mycelium of <i>Sclerotium rolfsii</i> on the lower stem</i>	<i>Browning sweet pepper stem above and below soil due southern blight disease</i>
<i>Symptoms of southern blight (<i>Sclerotium rolfsii</i>) on pepper plant</i>	<i>Infected lower stem showing mustard seed-sized sclerotia.</i>	<i>Stem of sweet pepper plant covered with fan-like mycelial mat</i>

## Symptoms

Sudden wilting of leaves; yellowing foliage; browning stem above and below soil; browning branches; stem may be covered with fan-like mycelial mat.

## Cause

Fungus

## Comments

Fungus can survive in soil for long periods; disease emergence favored by high temperatures, high humidity and acidic soil; disease found mainly in tropical and subtropical regions, including the southern United States.

## Management

Remove infected plants; avoid overcrowding plants to promote air circulation; rotate crops with less susceptible plants; plow crop debris deep into soil; provide a barrier to infection by wrapping lower stems of plant with aluminum foil covering below ground portion of stem and 2-3 in above soil line.

## Category : Viral

### Mosaic

Cucumber mosaic virus (CMV)

Potato virus Y (PVY)

*Symptoms on pepper leaves*

*Cucumber mosaic virus symptoms on pepper foliage*

## Symptoms

Alternating light and green areas or mosaic patterns on the leaves; leaves distorted and curled; slow plant growth.

## Cause

Virus

## Comments

Transmitted by aphids; weeds can act as a source of inoculum; insecticides are not effective due to the speed with which aphids can transmit the virus.

## Management

Remove weeds around crop; use reflective mulches to deter aphids from plants.

## Category : Oomycete

### Phytophthora blight

*Phytophthora capsici*

The xylem of a pepper plant infected with Phytophthora wilt caused by *Phytophthora capsici*.

A field of pepper plants infected with Phytophthora wilt caused by *Phytophthora capsici*.

An uprooted pepper plant infected with Phytophthora wilt caused by *Phytophthora capsici*.

Pepper infected with Phytophthora blight

### Symptoms

Black lesions on stems; wilting plant; circular gray-brown lesions on leaves; dark lesions on fruit which may be covered in white sporangia.

### Cause

Oomycete

### Comments

Disease highly water dependent and spores can be spread by water splash; disease can move root to root to infect a row of plants.

### Management

Plant disease free transplants; manage water carefully as pathogen depends on water for survival; rotate crops; apply appropriate fungicide.

## Pests

### Category : Insects

#### Aphids *Myzus persicae*

Potato aphid (*Macrosiphum euphorbiae*) on chilli pepper leaves

Aphids (and ladybug larva) on pepper leaf

### Symptoms

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants.

### Cause

Insect

### Comments

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed.

### Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use.

## **Beet armyworm** *Spodoptera exigua*

*Beet armyworm egg mass hatching*

*Damage caused by beet armyworm*

*Late stage beet armyworm larva feeding on pepper leaf*

### **Symptoms**

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside.

### **Cause**

Insect

### **Comments**

Insect can go through 3â€“5 generations a year.

### **Management**

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae.

## **Flea beetles** Various

*Adult flea beetle on a leaf*

*Flea beetles are often metallic in appearance*

### **Symptoms**

Small holes or pits in leaves that give the foliage a characteristic â€œshot holeâ€ appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5â€“3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny and metallic in appearance.

### **Cause**

Insects

### **Comments**

Younger plants are more susceptible to flea beetle damage than older ones; older plants can tolerate infestation; flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year.

### **Management**

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application of diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied.

## **Leafminers** *Lyriomyza* spp.

## *Leafminer trails on pepper leaves*

### **Symptoms**

Thin, white, winding trails on leaves; heavy mining can result in white blotches on leaves and leaves dropping from the plant prematurely; early infestation can cause fruit yield to be reduced; adult leafminer is a small black and yellow fly which lays its eggs in the leaf; larvae hatch and feed on leaf interior.

### **Cause**

Insects

### **Comments**

Mature larvae drop from leaves into soil to pupate; entire lifecycle can take as little as 2 weeks in warm weather; insect may go through 7 to 10 generations per year.

### **Management**

Check transplants for signs of leafminer damage prior to planting; remove plants from soil immediately after harvest; only use insecticides when leafminer damage has been identified as unnecessary spraying will also reduce populations of their natural enemies.

## **Leafroller (Omnivorous leafroller) *Platynota stultana***

*Larvae of omnivorous leafroller  
(Platynota stultana)*

*Adult omnivorous leafroller  
(Platynota stultana)*

### **Symptoms**

Leaves of plant rolled and tied together with silk webbing; feeding damage to rolled leaves; defoliation of plant; silk webbing may also be present on fruits and fruits may have substantial scarring from feeding damage; larvae wriggle vigorously when disturbed and may drop from plant on a silken thread.

### **Cause**

Insect

### **Comments**

Adult insect is a moth which can fly over several miles to find suitable hosts; alfalfa and sugar beet are good hosts.

### **Management**

Monitor plants regularly for signs of infestation; remove weeds from plant bases as they can act as hosts for leafrollers; avoid planting pepper in areas where sugarbeet or alfalfa are grown nearby; *Bacillus thuringiensis* or Entrust SC may be applied to control insects on organically grown plants; apply sprays carefully to ensure that treatment reaches inside rolled leaves.

## **Pepper weevil *Anthonomus eugenii***

*Pepper weevil larvae*

*Adult pepper weevil*

### **Symptoms**

Feeding damage to foliage, buds and tender young fruit pods; larvae feed within buds and fruit; older fruit misshapen and discolored; buds and fruit may drop from plant; adult weevil is a small black beetle; larvae are small cream-white grubs with brown heads which can reach 0.6 cm (0.25 in) in length when mature.

### **Cause**

Insect

### **Comments**

Weevil will go through multiple generations per year; pepper preferred host but weevil will feed on other plants in the nightshade family also.

### Management

Remove any nightshade plants growing in close proximity to pepper; immediately remove any dropped fruit from soil surface; if pepper weevil becomes problematic, rotate crop the following year; organically acceptable control methods include sprays of pyrethrin; destroy pepper crop residue immediately after harvest.

## Thrips (Western flower thrips, Onion thrips, etc.) *Frankliniella occidentalis*

*Thrips tabaci*

Chilli thrips (*Scirtothrips dorsalis*)  
damaged plant

Thrips infestation in a pepper  
blossom

### Symptoms

If population is high leaves and buds may be distorted; leaves appear silvery and are speckled with black feces; insects will feed on and damage flowers; most damage occurs through the transmission of Tomato spotted wilt virus (TSWV); insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color.

### Cause

Insect

### Comments

Insect transmits Tomato spotted wilt virus; once acquired, the insect retains the ability to transmit the virus for the remainder of its life.

### Management

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic.

## Tomato fruit worm (Corn earworm) *Helicoverpa zea*

Adult cornworm

Cornworm on chilli pepper

Early instar larva feeding on pepper  
bud

Mixture of larvae showing range of  
colors

### Symptoms

Larvae burrowing into fruit near stem end and feeding on fruit interior causing decay; fruit turn red prematurely and fall from plant causing reduced yield; young caterpillars are cream-white in color with a black head and black hairs; older larvae may be yellow-green to almost black in color with fine white lines along their body and black spots at the base of hairs; eggs are laid singly on both upper and lower leaf surfaces and are initially creamy white but develop a brown-red ring after 24 hours and darken prior to hatching.

### Cause

Insect

### Comments

Adult insect is a pale green to tan, medium sized moth; can be one of the most damaging pests of tomato; insect overwinters as pupae in the soil; the insect is also a damaging pest of corn and is also referred to as the corn ear worm.

### Management

Early treatment of tomato fruitworms is necessary as once they enter the fruit they are protected from sprays; monitor

plants for eggs and young larvae and also natural enemies that could be damaged by chemicals; *Bacillus thuringiensis* or Entrust SC may be applied to control insects on organically grown plants; appropriate chemical treatment may be required for control in commercial plantations.

## Category : Mites

### Spider mites (Two spotted spider mite) *Tetranychus urticae*

*Close-up view of two-spotted spider mites (*Tetranychus urticae*)*

*Spider mite damage on under surface of pepper leaves*

#### Symptoms

Leaves stippled with yellow; leaves may appear bronzed; webbing covering leaves; mites may be visible as tiny moving dots on the webs or underside of leaves, best viewed using a hand lens; usually not spotted until there are visible symptoms on the plant; leaves turn yellow and may drop from plant.

#### Cause

Arachnid

#### Comments

Spider mites thrive in dusty conditions; water-stressed plants are more susceptible to attack.

#### Management

In the home garden, spraying plants with a strong jet of water can help reduce buildup of spider mite populations; if mites become problematic apply insecticidal soap to plants; certain chemical insecticides may actually increase mite populations by killing off natural enemies and promoting mite reproduction.

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# Chinese cabbage

## Description

Chinese cabbage can refer to two subspecies of cabbage belonging to the family Brassicaceae, *Brassica rapa pekinensis* (napa cabbage) and *Brassica rapa chinensis* (bok-choy). Napa cabbage has a barrel shaped, elongated rosette of overlapping leaves which point inwardly and can grow 25â€“51 cm (10â€“20 in) tall, with a diameter of 15â€“20 cm (6â€“8 in). Napa cabbage may also be called Chinese leaf or wong-bok and originates from the Beijing region of China. The bok choy type cabbage is made up of about 30 individual leaves arranged into a loose, spiral head and are dark green and shiny. The petioles, or stalks, are white or light green and thick and fleshy. Bok choy can reach a height of 15â€“60 cm (0.5 to 2 ft) and spread outwards by 15â€“46 cm (0.5â€“1.5 ft). Bok choy may also be referred to as pak choi, Chinese chard, Chinese mustard, celery mustard or spoon cabbage and also originates from China

*Bok-choy (subspecies chinensis)*

## Uses

Napa cabbage and bok choy are used in similar ways. The inner leaves of napa cabbage are eaten raw or cooked in stir fries and other dishes while the tougher outer leaves are often used in soups. Both the leaves and stems of bok choy are edible and can be eaten raw or can be cooked in stir fries and other dishes.

## Propagation

Napa cabbage is a cool season annual plant and as such will grow best in temperatures averaging between 13 and 21°C (55–70°F), with optimum growth occurring between 15–18°C (59–64°F). Seed should be planted in the fall, 1.5 cm (0.6 in) deep in a well draining soil with a pH between 5.5 and 7.0. Transplants can be taken from a 4–5 week old plant if a spring crop is desired. The plants can be grown on flat or raised beds and positioned in rows 50–60 cm (20–24 in) apart. Each plant should be spaced 50 cm (20 in) from its neighbor for optimum growth. Bok choy is most successfully grown in regions that experience cool summers and mild winters, growing optimally in temperatures between 15 and 20°C (59–68°F). Bok choy can be planted in early spring if the required climatic conditions are met, producing a crop in early summer or they can be planted in early summer for a late summer crop. The seeds will germinate quickly and seedlings are fast growing. Transplants may also be used. Seed should be sown at a depth of 15 to 20 mm (0.6–0.7 in) in soil with a pH between 5.5 and 7.0 and plant should be spaced approximately 20 cm (8 in) from one another.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

#### **Alternaria leaf spot (Black spot, Gray spot) *Alternaria brassicae***

*Alternaria lesions on Chinese cabbage leaf*

*Close-up of Alternaria lesions on chinese cabbage leaf*

#### Symptoms

Small dark spots on leaves which turn brown to gray; lesions may be round or angular and may possess a purple-black margin; lesions may form concentric rings, become brittle and crack in center; dark brown elongated lesions may develop on stems and petioles

#### Cause

Fungus

**Comments**

May become a problem during cool, wet periods

**Management**

Plant only pathogen-free seed; rotate crops; applications of appropriate fungicides control disease when present

**Anthracnose** *Colletotrichum higginsianum*

**Symptoms**

Small circular or irregularly shaped dry spots which are gray to straw in color on leaves; a high number of spots may cause the leaf to die; lesions may coalesce to form large necrotic patches causing leaves to turn yellow and wilt; lesions may split or crack in dry centers

**Cause**

Fungus

**Comments**

Fungus overwinters on leaf debris and on related weeds; disease emergence is favored by moist, warm conditions

**Management**

Control of disease depends on sanitary practices; treat seeds with hot water prior to planting; rotate crops; plant in an area with good soil drainage; remove all cruciferous weeds which may act as a reservoir for the fungus

**Black rot** *Xanthomonas campestris*

**Symptoms**

Irregularly shaped dull yellow areas along leaf margins which expand to leaf midrib and create a characteristic "V-shaped" lesion; lesions may coalesce along the leaf margin to give plant a scorched appearance

**Cause**

Bacterium

**Comments**

Pathogen is spread via infected seed or by splashing water and insect movement; disease emergence favored by warm and humid conditions

**Management**

Primary method of controlling black rot is through the use of good sanitation practices; rotate crops to non-cruciferous crops every 2 years; plant resistant varieties; control cruciferous weed species which may act as a reservoir for bacteria; plant pathogen-free seed

**Clubroot** *Plasmoidiophora brassicae*

*Distorted roots of chinese cabbage  
plant caused by infection with club  
root fungus*

**Symptoms**

Slow growing, stunted plants; yellowish leaves which wilt during day and rejuvenate in part at night; swollen, distorted roots; extensive gall formation

**Cause**

Fungus

**Comments**

Can be difficult to distinguish from nematode damage; fungus can survive in soil for periods in excess of 10 years; can be spread by movement of contaminated soil and irrigation water to uninfected areas

**Management**

Once the pathogen is present in the soil it can survive for many years, elimination of the pathogen is economically unfeasible; rotating crops generally does not provide effective control; plant only certified seed and avoid field grown transplants unless produced in a fumigated bed; applying lime to the soil can reduce fungus sporulation

### **Downy mildew** *Peronospora parasitica*

*Symptoms of downy mildew on Chinese cabbage foliage*

#### **Symptoms**

Irregular yellow patches on leaves which turn light brown in color; fluffy gray growth on the undersides of the leaves

#### **Cause**

Fungus

#### **Comments**

Favors cool, humid weather; damage to the cabbage head may not be seen until the cabbage is cut open

#### **Management**

Remove all crop debris after harvest; rotate with non-brassicas; application of appropriate fungicides may be required if symptoms of disease are present

### **Powdery mildew** *Erysiphe cruciferarum*

#### **Symptoms**

Small white patches on upper and lower leaf surfaces which may also show purple blotching; patches coalesce to form a dense powdery layer which coats the leaves; leaves become chlorotic and drop from plant

#### **Cause**

Fungus

#### **Comments**

Disease emergence favored by dry season, moderate temperatures, low humidity and low levels of rainfall

#### **Management**

Plant resistant varieties; rotate crops; remove all crop debris after harvest; remove weeds; avoid excessive application of nitrogen fertilizer which encourages powdery mildew growth; powdery mildew can be controlled by application of sulfur sprays, dusts or vapors

### **Watery soft rot (White mold, Cabbage drop)** *Sclerotinia sclerotiorum*

#### **Symptoms**

Soft rotting area at base of stem which spreads upwards successively killing leaves by causing them to drop and infect the leaf below; when fungus reaches the head it causes a soft, slimy, watery rot

#### **Cause**

Fungus

#### **Comments**

Disease emergence is favored by frequent rainfall that keep soil close to saturation

#### **Management**

The number of sclerotia in the soil can be reduced by plowing crop debris deep into soil and rotating crops every 3 years with non-host crops; severe infestations may require control through application of appropriate fungicide

### **White leaf spot** *Mycosphaerella capsellae*

#### **Symptoms**

Small, necrotic, brown spots on leaf tips or margins that matures to light gray or white with the original dark spot in center; margins of lesions may be darker; lesions may coalesce to form large chlorotic areas and cause defoliation

#### **Cause**

Fungus

#### Comments

Symptoms easily confused with downy mildew; disease emergence favored by wet leaves and cool temperatures

#### Management

No known plant resistance to white leaf spot so control relies on cultural practices such as rotating crops and removing weeds; application of appropriate fungicide may help control the disease

### Category : Bacterial

#### Bacterial soft rot *Erwinia caratovora*

##### Comments

Water-soaked lesions on cabbage head which expand to form a large rotted mass of cream colored tissue which is liquid underneath; surface of lesions usually crack and exude slimy liquid which turns tan, dark brown or black on exposure to air

##### Cause

Bacterium

##### Comments

Bacteria are easily spread on tools and by irrigation water; disease emergence favored by warm, moist conditions

#### Management

Chemical treatments are not available for bacterial soft rot, control relies on cultural practices; rotate crops; plant cabbage in well-draining soils or raised beds; only harvest heads when they are dry; avoid damaging heads during harvest

#### Blackleg *Leptosphaeria maculans*

##### Comments

Damping-off of seedlings; round or irregularly shaped gray necrotic lesions on leaves with dark margins; lesions may be covered in pink masses in favorable weather conditions

##### Cause

Fungus

##### Comments

Favors warm, wet conditions; higher temperatures result in the development of more visible symptoms

#### Management

Cabbage does not have high levels of resistance to blackleg and fungicides use is uneconomical; use disease free seed or treat with hot water to remove fungus prior to planting; remove and destroy crop debris after harvest or plow deeply into soil

### Category :

#### Cabbage aphid *Brevicoryne brassicae*

##### Comments

Large populations can cause stunted growth or even plant death; insects may be visible on the plant leaves and are small, grey-green in color and soft bodied and are covered with a white waxy coating; prefer to feed deep down in cabbage head and may be obscured by the leaves

##### Cause

Insect

## **Comments**

Cabbage aphids feed only on cruciferous plants but may survive on related weed species

## **Management**

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

## **Cabbage aphid** *Brevicoryne brassicaea*

*Cabbage aphid colony on a cabbage leaf*

## **Symptoms**

Large populations can cause stunted growth or even plant death; insects may be visible on the plant leaves and are small, grey-green in color and soft bodied and are covered with a white waxy coating; prefer to feed deep down in cabbage head and may be obscured by the leaves

## **Cause**

Insect

## **Comments**

Cabbage aphids feed only on cruciferous plants but may survive on related weed species

## **Management**

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

## **Category : Fungal, Oomycete**

### **Damping-off** *Rhizoctonia solani*

## **Symptoms**

Death of seedlings after germination; brown or black rot girdling stem; seedling may remain upright but stem is constricted and twisted (wirestem); in older cabbage plants sharply defined brown lesions appear on the underside of leaves; the lesions expand causing leaves to wilt and drop from plant

## **Cause**

Fungus

## **Comments**

Disease emergence in seedlings favored by cool temperatures

## **Management**

Plant pathogen-free seed or transplants that have been produced in sterilized soil; apply fungicide to seed to kill off any fungi; shallow plant seeds or delay planting until soil warms

## **Pests**

## Category : Insects

### Beet armyworm *Spodoptera exigua*

Young larvae

Beet armyworm eggs covered in white hairs

Beet armyworm larva

#### Symptoms

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside

#### Cause

Insect

#### Comments

Insect can go through 3–5 generations a year

#### Management

Organic methods of controlling the beet armyworm include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae

### Cabbage looper *Trichoplusia ni*

Cabbage looper and damage

#### Symptoms

Large or small holes in leaves; damage often extensive; caterpillars are pale green with a white lines running down either side of their body; caterpillars are easily distinguished by the way they arch their body when moving; eggs are laid singly, usually on the lower leaf surface close to the leaf margin, and are white or pale green in color

#### Cause

Insect

#### Comments

Insects overwinter as pupae in crop debris in soil; adult insect is a dark colored moth; caterpillars have a wide host range

#### Management

Looper populations are usually held in check by natural enemies; if they do become problematic larvae can be hand-picked from the plants; an organically acceptable control method is the application of *Bacillus thuringiensis* which effectively kills younger larvae; chemical sprays may damage populations of natural enemies and should be selected carefully

### Cutworms *Agrotis* spp.

*Peridroma saucia*

*Nephelodes minians*

and others

*Cutworm feeding on plant stem*

*Cutworms will curl up into a characteristic C shape when disturbed*

*Cutworm larva severing plant stem*

### Symptoms

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5â€“5.0 cm (1â€“2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed

### Cause

Insects

### Comments

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato

### Management

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically

## Diamondback moth *Plutella xylostella*

*Diamondback moth pupae*

*Larva feeding on cabbage leaf*

### Symptoms

Young larvae feed between upper and lower leaf surface and may be visible when they emerge from small holes on the underside of the leaf; older larvae leave large, irregularly shaped shotholes on leaf undersides, may leave the upper surface intact; larvae may drop from the plant on silk threads if the leaf is disturbed; larvae are small (1 cm/0.3 in) and tapered at both ends; larvae have to prolegs at the rear end that are arranged in a distinctive V-shape

### Cause

Insect

### Comments

Larvae take between 10 and 14 days to mature and spin a loose, gauze-like cocoon on leaves or stems to pupate

### Management

Larvae can be controlled organically by applications of *Bacillus thurengiensis* or Entrust; application of appropriate chemical insecticide is only necessary if larvae are damaging the growing tips of the plants

## Large cabbage white (Cabbageworm) *Pieris rapae*

*Cabbageworm and frass on a cabbage leaf*

### Symptoms

Large ragged holes in leaves or bored into head; green-brown frass (insect feces) on leaves; caterpillar is green in color and hairy, with a velvet-like appearance; may have faint yellow to orange stripes down back; slow-moving compared

with other caterpillars

#### Cause

Insect

#### Comments

Butterfly larvae cause damage by feeding on plants; can be distinguished from other caterpillars by its sluggish movement; in large numbers larvae can cause extensive damage very quickly

#### Management

Hand-pick caterpillars from plants and destroy; scrape eggs from leaves prior to hatching; apply appropriate insecticide if infestation is very heavy

### Thrips (Western flower thrips, Onion thrips, etc.) *Frankliniella occidentalis*

*Thrips tabaci*

*Western flower thrips*

#### Symptoms

If population is high leaves may be distorted; leaves are covered in coarse stippling and may appear silvery; leaves speckled with black feces; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color

#### Cause

Insect

#### Comments

Transmit viruses such as Tomato spotted wilt virus; once acquired, the insect retains the ability to transmit the virus for the remainder of its life

#### Management

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic

### Category : Mites

### Flea beetle *Phyllotreta* spp.

*Flea beetle damage on Chinese cabbage*

*Severe damage to Chinese cabbage leaf by flea beetles*

#### Symptoms

Small holes or pits in leaves that give the foliage a characteristic "shot hole" appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5–3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance

#### Cause

Insect

#### Comments

Younger plants are more susceptible to flea beetle damage than older ones; older plants can tolerate infestation; flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year

#### Management

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application on diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied

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# Chives

## Description

Chives, *Allium schoenoprasum*, are perennial herbs in the family Liliaceae grown for their leaves which are used as culinary herbs. The chive plant is a member of the onion family and forms small bulbs from the roots. The leaves of the plant are tapering, hollow and cylindrical and have a soft texture. The chive plant grows in clumps and produces large pale purple flowers in a dense clusters of 10–30 individual inflorescences. Chives grow to approximately 46 cm (18 in) in height and can live for many years in favorable conditions. The exact origin of the chive plant is disputed but it grows wild in Europe, Australia and North America.

*Chive flowers*

*Flower heads beginning to open*

*Chive flower heads*

*Chives*

*Chive plant*

*Chive plant*

## Uses

Chives are consumed fresh as a culinary herb in a variety of dishes.

# Propagation

**Basic requirements** Chives are easy to grow and tolerate a range of soil types and conditions. Chives will grow best in a well-draining soil, rich in organic matter with a pH of 6-7 and will perform optimally when positioned in full sunlight but will tolerate partial shade. **Propagation Starting from seeds** Chives can be grown directly from seed or new plants can be produced by dividing an established plant. Seeds can be started indoors approximately 4 weeks prior to the last frost date and should be planted in flat trays containing sterile seed starting mix. Plant seeds to a depth of 1.3 cm (0.5 in). The seeds are slow to germinate, emerging after about 7 days but the seedlings develop quickly and are ready to be transplanted when they are about 4 weeks old and after they have been hardened. **Dividing plants** Established plants should be divided in the Spring. Start by watering the plants a few hours before dividing to soften the soil and ensure the plants are turgid. Identify individual groups of plants and plant to take 3 to 4 of these together to form a new clump. Cut the chives back to a height of approximately 10 cm (4 in) and carefully extract the existing plant from the soil. Break the clump by dropping the plant from a gentle height to break it apart into separate plants. **Transplanting** Individual plants or seedlings should be planted 20 to 30 cm (8-12 in) apart. Plant divided plants about 1.25 cm (0.5 in) deeper than they were previously. Keep the plants moist to aid in the establishment of the root system. **Harvesting** Chives can be harvested at any time once plants are established. To harvest leaves simply snip them with a pair of scissors leaving about 3 cm (2 in) of green on the plant. Begin harvesting from the outside leaves inwards as required. The plants will quickly produce new growth. **General care and maintenance** Chives benefit from the application of a layer of mulch in the Spring, grass clipping or leaves are ideal and help to conserve soil moisture and suppress weeds. When plants flower, remove the flower head when it starts to dry out and die in order to divert energy to the production of leaves. Chives require the application of fertilizer at regular intervals throughout the growing season unless they were planted in composted manure. A liquid fertilizer should be applied every 4 to 6 weeks.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Damping-off** *Pythium* spp.

*Fusarium* spp.

*Rhizoctonia* spp.

#### **Symptoms**

Seeds water-soaked, mushy and decomposing; infected roots are gray and water-soaked; seedlings that have already

emerged prior to infection collapse and die; older plants that become infected become severely stunted

#### Cause

Fungi

#### Comments

Disease emergence favors high soil moisture and cool temperatures

#### Management

Control of disease is dependent on minimizing soil moisture: break up compacted soil; plant in well-draining areas or raised beds; treat seeds with appropriate fungicides prior to planting

### Downy mildew *Puccinia destructor*

#### Symptoms

Pale spots or elongated patches on leaves; gray-purple fuzzy growth on leaf surface; leaves turning pale then yellow; leaf tips collapsing

#### Cause

Fungus

#### Comments

Disease emergence favored by cool temperatures and leaf wetness

#### Management

Avoid planting infected sets; rotate crops to non-allium species for 3-4 years; plant in well-draining areas and do not overcrowd plants; destroy all infected crop debris; apply appropriate foliar fungicides taking care to apply thoroughly to waxy leaves

### Category : Oomycete

### Pink root *Phoma terrestris*

#### Symptoms

Light pink roots which darken and turn purple; roots become transparent and water soaked; plant may look like it has a nutrient deficiency; infected seedling may die; stunted plants with shriveled bulbs

#### Cause

Fungus

#### Comments

Fungus colonizes plant through root tips; fungus can survive in soil down to a depth of 45 cm (17.7 in)

#### Management

Disease is most severe where onions have been planted continuously; avoid planting on sites where onion has been planted recently, especially if they were diseased; plant more resistant varieties; solarization and/or fumigation can help reduce the levels of pathogen in the soil

## Pests

### Category : Insects

### Onion maggot *Delia antiqua*

#### Symptoms

Stunted or wilting seedlings; plant will commonly break at soil line if an attempt is made to pull it up; if infestation occurs when plants are bulbing, bulbs will be deformed and susceptible to storage rots after harvest; adult insect is a greyish fly which lays white, elongate eggs around the base of the plant; the larvae that emerge from the eggs are tiny and white and bore into the bulbs; mature larvae are about 1 cm (0.4 in) long with feeding hooks

**Cause**

Insect

**Comments**

Females can lay several hundred eggs during their 2-4 week lifespan; insect overwinters as pupae in the soil

**Management**

Management of onion maggots is heavily reliant on good sanitation; all chive bulbs should be removed at the end of the season as maggots will die without a food source; commercial growers must often rely on the application of appropriate granular insecticides and, in some cases, insecticide sprays are also required; home gardeners should try to remove any volunteer wild onion and chive plants as these can act as an infection source; floating row covers may provide protection by preventing females from laying eggs around the plants

**Thrips (Onion thrips, Western flower thrips) *Thrips tabaci***

*Frankliniella occidentalis*

**Symptoms**

Discolored, distorted tissue; scarring of leaves; severely infected plants may have a silvery appearance

**Cause**

Insect

**Comments**

Both onion thrips and western flower thrips have an extensive host range and can be introduced to chives from other plants

**Management**

Natural enemies include some species of predatory mite, pirate bugs and lacewings; avoid planting onion in close proximity to grain fields as thrips populations build up on these plants in the spring; overhead irrigation of plants may help reduce thrips numbers; apply appropriate insecticides at first sign of thrips damage

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# Cinnamon

## Description

Cinnamon is the collective name given to several plant species in the genus *Cinnamomum* (family Lauraceae), including *Cinnamomum verum* (syn. *Cinnamomum verum*; Ceylon cinnamon) and *Cinnamomum burmanni* (Indonesian cinnamon), grown for their inner bark which is used as a flavoring. Cinnamon trees are small evergreens with aromatic bark and leaves. The leaves of the tree are thick and oval or lanceolate in shape, growing on smooth gray branches. The tree produces small yellow or green flowers on panicles and a berry fruit. Cinnamon trees can reach heights of up to 20 m (66 ft) in the wild but are usually coppiced to smaller bushes under cultivation. Cinnamon trees have an economic lifespan of approximately 10 years. Cinnamon may be referred to as cassia and originates from Asia.

*Cinnamomum verum* foliage

Harvested cinnamon bark

*Cinnamomum verum* foliage

Indonesian cinnamon foliage

Ceylon cinnamon leaves

Indonesian cinnamon flower

Ceylon cinnamon foliage and inflorescences

Indonesian cinnamon foliage

Cinnamon tree

## Uses

Pieces of dried cinnamon bark (quills) or ground cinnamon are used a flavoring in baked goods, confection or savory dishes. Oil extracted from the bark and leaves is used as a flavoring or scent in perfumes.

## Propagation

**Basic requirements** Cinnamon is a tropical plant and grows best in warm areas with high humidity where average temperatures reach approximately 27°C (80.6°F). Cinnamon can be grown in a wide range of soils but the highest quality bark is obtained when trees are grown in sandy soils rich in humus. Cinnamon grows best when planted in full sun but as a forest tree it will tolerate some shading. Trees require an average annual rainfall of between 1250 and 2500 mm.

**Propagation** Cinnamon can be grown from seed or vegetatively propagated. Fruits often have to be bagged in order to save the seeds as they are often consumed by birds. Planting material should be selected from trees showing the desired bark characteristics which are healthy and vigorous regardless of the propagation method used. Cinnamon trees are usually cultivated commercially through cutting or by air layering due to the seeds exhibiting a wide genetic variability.

*Propagation from seed* Seeds should be collected from the pulp of the fruit, washed and dried. Seeds should be planted as soon as possible after extraction as they do not remain viable for long. Seeds should be planted in prepared nursery beds or in polyethylene bags filled with good quality potting soil or aged compost or composted manure. The seedbed or bags should be provided with shading to protect the seedlings and seeds should be kept moist with frequent irrigation.

Germination usually occurs after approximately 20 days. Seedlings can be transplanted to the field after about 3 months. *Vegetative propagation* Cinnamon can be propagated vegetatively from cuttings, by layering or by dividing the root ball. A cutting is usually taken by removing a partially mature shoot with at least one node from an established mother plant. The shoot should then be planted in a polyethylene bag to establish its own root system, thus creating a new tree.

Cuttings are usually grown under the protection of a polyethylene covering which is removed gradually to harden the seedlings for field planting. Seedling are ready to be transplanted to the field when they are 12 to 18 months old. **Transplanting** Seedlings should be planted in a pre-dug hole large enough to accommodate the root ball and backfilled with topsoil. Adding rock phosphate to the planting hole aids in root development. Trees are often grown in small groups to produce a single clump or are planted individually. For commercial production, field spacings of between 0.9 m (3 ft) to 1.2 m (4 ft) per tree are recommended.

*Cinnamon bark drying in the sun*

*Scraping bark from cinnamon branches, Sri Lanka*

*Cinnamon farmer carries harvested bark in Lempur, Indonesia*

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## Common Pests and Diseases

### Diseases

## **Category : Bacterial**

### **Leaf spot and dieback** *Colletotrichum gloeosporioides*

#### **Symptoms**

Small brown specks on leaves; lesions coalesce to form irregular shaped brown patches; lesions may drop out of leaves leaving a shot hole; dieback of stems

#### **Cause**

Fungus

#### **Comments**

#### **Management**

Infected branches should be pruned out; applications of 1% Bordeaux mixture can help to control the disease

## **Category : Oomycete**

### **Phytophthora dieback (Stripe canker)** *Phytophthora cinnamomi*

#### **Symptoms**

Dieback of plants and plant death; sudden wilting; elongated sections of dead bark extending vertically up tree, usually near ground level; dieback of roots

#### **Cause**

Fungus

#### **Comments**

Fungus is established in many regions of the world; fungus can survive for prolonged periods of time in the soil

#### **Management**

Use only disease free seed and planting material; if disease is present in the soil then crop should be rotated to a non-susceptible host for a period of four years; avoid planting in water saturated soils; soil drenches with appropriate systemic fungicide may give a measure of control

## **Category : Fungal**

### **Seedling blight** *Diplodia* spp.

#### **Symptoms**

Light brown patches which girdle stem of young seedlings; death of seedlings

#### **Cause**

Fungi

#### **Comments**

#### **Management**

Disease can be controlled by application of 1% Bordeaux mixture

## **Pests**

### **Category : Insects**

### **Cinnamon butterfly** *Chilasa clytia*

#### **Symptoms**

New growth damaged; entire tree defoliated with only leaf veins remaining; adult insect is a large swallowtail butterfly with black-brown wings and white markings; young larvae are dark green or black, velvety caterpillars which mature to pale yellow with dark stripes

**Cause**

Insect

**Comments**

Adults large butterflies with black-brown wings and white markings; larvae pale yellow caterpillars with black markings

**Management**

Larvae and pupae should be handpicked from trees where possible; application of appropriate foliar insecticide may be required to control heavy infestations

**Leafminers** *Acrocercops* spp.

*Phyllocnistis chrysophthalma*

**Symptoms**

Thin, white, winding trails on leaves; heavy mining can result in blisters on leaves and leaves dropping from the plant prematurely; adult insect is a small, silver-gray moth; larvae are pale gray initially and mature to pink

**Cause**

Insect

**Comments**

Leafminer damage is most common during the monsoon season and nursery seedlings are most seriously affected

**Management**

Applications of appropriate foliar insecticides may be required to control heavy infestations;

**Category : Mites****Cinnamon gall mite** *Aceria doctersi***Symptoms**

Irregular galls on undersides of leaves, leaf stalks and/or new stems; galls are roughly conical in shape and are caused by damage from tiny mites which are difficult to see with the naked eye

**Cause**

Arachnid

**Comments**

May be several generations of mite per year

**Management**

Monitor for the presence of gall mites by regularly checking the undersides of leaves; in large trees, damage is often limited and does not require control; appropriate miticides need to be applied in a protective manner as once the mites have entered the leaves, chemical control is ineffective

**Category : Nematodes****Root knot nematode** *Meloidogyne* spp.**Symptoms**

Galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; reduction in plant vigor; yellowing plants which wilt in hot weather

**Cause**

Nematode

**Comments**

Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or garden with this type of soil is most likely

**Management**

Plant resistant varieties, where known, if nematodes are known to be present in the soil; check roots of plants mid-season or sooner if symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels

of inoculum of many other pathogens

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# Clove

## Description

Clove, *Syzygium aromaticum*, is a monoecious (both male and female flowers on the same plant) evergreen tree in the family Myrtaceae grown for its aromatic flowers. The many branches of the tree are semi-erect with smooth oval shaped leaves. The branches end with a 3â€“4 flowers near the tip with one terminal flower and the others opening below it. The leaves, flowers and bark all have a distinct smell. The clove is the unopened flower buds. The tree grows 8â€“15 m (26â€“50 ft) tall and can live to be more than 100 years old. The clove tree may also be referred to as tropical myrtle and are native to the Molucca Islands.

Dried buds

Clove leaves

Clove fruits on the tree

Clove flowering

Clove fruits

Clove foliage

Clove buds

Clove buds

Clove tree

## Uses

The vast majority of commercially cultivated cloves are used by the tobacco industry to flavor cigarettes. Cloves are also used commonly as spices, either in their whole form or after first grinding into powder.

## Propagation

**Basic requirements** Clove trees require a warm, tropical climate with an average rainfall of at least 1500 mm per year. Clove trees are very susceptible to stress. Areas that undergo a dry season are good for flowering but the tree must be planted in an area with deep, fertile soil to limit water stress. Clove trees grow optimally at temperatures between 16 and 27°C (65–80°F) in rich loamy, well draining soil. **Propagation** Clove is commercially propagated from seeds which are planted soon after harvest. Seeds should be collected and extracted from the fruits of healthy mother plants exhibiting desirable characteristics. The seeds are extracted by soaking the fruits in water and peeling the skin from the fruit. The seeds can be planted in prepared nursery beds or polyethylene bags containing a mixture of soil and aged manure and should be planted to a depth of 2 to 5 cm (0.8–2.0 in) and spaced 12 to 15 cm (4.7–5.9 in) apart. Germination usually occurs within 1 to 6 weeks. The seedlings should be shaded to protect them from harsh sunlight. The seedlings should be kept moist through regular watering and can be transplanted when they reach at least 30 cm (11.8 in) in height. The seedlings should be hardened off by exposing them to increasing amounts of sunlight before they are transplanted to the field. **Transplanting** Young clove trees should be planted in pre-dug pits which are approximately 60–60 cm (24–24 in), or large enough to accommodate the root ball. The recommended spacing for clove trees is 8 m (26 ft) but closer spacings are commonly used. Trees planted in the field should be provided with temporary shading to alleviate stress. Shade can be provided through intercropping with other crops such as banana, cassava or coconut but trees such as Gliricidia are also used as these can be pruned to alter the amount of light reaching the cloves throughout the year. **General care and maintenance** Once the temporary shade plants are removed, the plantation should be kept free from weeds by weeding once or twice each year or by applying a layer of mulch around the trees. Mulch helps prevent the roots being damaged by the physical removal of the weeds. Trees may require additional irrigation during dry periods to prevent them becoming stressed which harms their production. The trees should also be provided with nutrients in the form of fertilizer or manure. The composition and amount of fertilizer required is dependent on the region and soil type. **Harvesting** The complete inflorescence (flower) should be picked just before the first buds open to ensure maximum size and oil content of the buds. The harvest is often conducted over 3 to 8 pickings during the season as buds mature. After harvesting, the buds are laid out to dry in the sun for several days.

*Cloves laid out to dry, Bali, Indonesia*

*Cloves laid out to dry, Bali, Indonesia*

*Cloves laid out to dry, Bali, Indonesia*

*Clove nursery bed*

*Clove nursery*

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### Dieback (**Eucalyptus canker**) *Cryphonectria cubensis*

##### Symptoms

Once fungus enters a wound on a branch it moves downward until it reaches the branch junction; all branches above the junction die back

##### Cause

Fungus

##### Comments

Fungus attacks wounded areas of the plant

##### Management

Avoid causing damage to trees with machinery and tools; protect pruning wounds with appropriate fungicide; infected parts of trees should be pruned out and burned; any resultant wounds should be treated with fungicide paste

### Category : Bacterial

#### Sumatra disease *Ralstonia syzygii*

##### Symptoms

Dieback of trees which begins in the crown and leads to tree death within 3 years of initial infection; leaves turn chlorotic and drop from the tree or may wilt and remain attached; discoloration of vascular tissues evident as gray-brown streaks in new wood; bacterial exudate may ooze out of tissue when cut

##### Cause

Bacterium

##### Comments

Bacteria are limited to the water-carrying vessels in the tree (xylem); the disease is thought to be transmitted by *Hindola striata* and *Hindola fulva*, both sucking insect species

##### Management

An antibiotic - oxytetracycline - can be injected into the tree to slow the decline of infected trees but there is currently no known cure for the disease; several insecticides can give control of *Hindola* insect species which are believed to spread the disease

## Pests

### Category : Insects

#### Coconut scale *Aspidiotus destructor*

##### Symptoms

Pale yellow spots on leaves; entire leaves yellowing; leaves turning brown and dropping prematurely; adult insect is a flattened oval, resembling a scale, which is red-brown in color

##### Cause

Insect

##### Comments

Insect also attacks other crops such as coconut, tea and mango

**Management**

May be possible to control coconut scale by pruning infested parts of trees and destroying by burning; chemical control may be necessary

**Oriental fruit fly *Bactrocera dorsalis*****Symptoms**

Dark brown to black lesions on foliage; adult insect is a small fly with a bright yellow abdomen with a distinctive dark "T-shape" pattern; larvae are cream-white maggots which burrow into fruit

**Cause**

Insect

**Comments**

Oriental fruit flies are serious pests of many crops including mango, avocado, guava, pineapple and papaya

**Management**

One of the most effective methods of controlling the oriental fruit fly on many crops is to bag the fruit in paper bags or polythene sleeves to prevent oviposition by female flies; chemical sprays are most effective when combined with a protein bait to attract the insect

**Soft scale *Ceroplastes floridensis*****Symptoms**

Reduction in plant vigor and viability; wilting leaves with abnormal coloration; stick residue on leaves; insect is a rounded scale covered in white or pink-white waxy substance

**Cause**

Insect

**Comments**

Large populations of soft scale promote the development of sooty mold

**Management**

Natural enemies of the soft scale can generally provide good control of the pest; application of horticultural oil may be applied if scales become problematic; healthy plants are less susceptible to scale damage than those which are stressed so adequate irrigation and fertilization are important in scale management

**Category : Nematodes****Nematodes (Ring nematode, Reniform nematode, Common spiral nematode)**

*Criconemoides* spp.

*Rotylenchulus reniformis*

*Helicotylenchus dihystera*

**Symptoms**

Dark lesions on roots; stunted plant growth; yellow leaves; slow growth and low yield

**Cause**

Nematode

**Comments**

Damage from nematodes often promotes root infection by bacteria and fungi

**Management**

Solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens

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# Clover

## Description

Clover is the common name given to a group of approximately 300 leguminous plants in the genus *Trifolium*, in the family Fabaceae. Several species are cultivated specifically for fodder. The most commonly cultivated is white clover, *Trifolium repens*. Clover species are generally small and are usually trifoliate (leaves possess three leaflets) although some species possess five or seven leaflets. The clover plant has smooth stems and produces small red, purple, white, or yellow flowers made up of many florets. Clover species can be annual, biennial or short-lived perennials. White clover may live for 3–5 years, and can reach a height of 20–30 cm (8–12 inches). Clover may also be referred to as Ladino clover, Dutch clover or trefoil and it originates from Europe.

*Clover flower being visited by a honey bee*

*Clover leaflets*

*White clover flowers*

*Clover flowering*

*White clover*

*Clover leaflet*

## Uses

Clover is mainly cultivated to provide pasture or to protect soil. It may be harvested and used as forage, hay or silage.

## Propagation

**Basic requirements** White clover is the most widely grown clover in the world, growing best in a cool, moist, temperate climate. It can be grown on a wide range of soils but performs best in well-draining clay or loam as opposed to sandy soils. The plant will grow optimally at a soil pH of 5.5 and 7.0. Dry soils are not recommended due to the shallow root system. Clover tolerates shade, repeated mowing and field traffic very well making it well suited to use as a cover crop.

**Planting** Clover is direct seeded either by drilling or broadcasting. When growing clover as a commercial crop, a higher yield will be obtained in warmer areas if the seed is inoculated with Rhizobacteria before planting. Inoculation is not necessary if an inoculated clover crop was grown in the same field within the past 3 years or in colder regions where nitrogen-fixing bacteria can persist in the soil. If broadcasting seed, spread 5–14 lb (2.25–6.35 kg) of seed per acre and cover. When drilling seed, 3–9 lb (1.4–4 kg) of pure seed should be planted per acre to a depth of 6–12 mm (1/4 – 1/2 in). Clover is also commonly sown into an existing grass pasture or with grass seed to establish a mixed pasture. Seeding rates into an existing grass pasture should be 2–4 lb (0.9–1.8 kg) per acre. The soil should be kept moist after seeding to promote germination. **General care and maintenance** If grown as a forage crop mixed with grass, management should be aimed at maintaining clover at 40 to 50% of the total cover. Grazing to a stubble height of 5 cm (2 in) favors the growth of the clover, whereas lighter grazing will favor the growth of grass. The pasture should be fertilized with nitrogen and phosphorous depending on the needs of the particular soil. When grown as a living mulch, clover should be mowed as required and killed off when no longer needed. Clover can be killed by rototilling, undercutting or moldboard plowing. White clover can be persistent and it is necessary to kill off the root system to effectively kill the plants.

Clover seeds

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## Common Pests and Diseases

### Diseases

#### Category : Viral

**Alfalfa mosaic** Alfalfa mosaic virus (AMV)

**Symptoms**

Yellow streaks parallel to leaf veins; yellow-green mottling of leaves; distorted leaves; stunted plant growth

#### Cause

Virus

#### Comments

Virus overwinters on many perennial plants; transmitted by aphids; also spread via infected seed and pollen

#### Management

Plant resistant varieties; control aphid populations on plants; use virus free seed

### **Red clover mosaic** Red clover vein mosaic virus (RCVMV)

#### Symptoms

Yellow leaf veins and/or yellow tissue adjacent to leaf veins

#### Cause

Virus

#### Comments

Transmitted by aphids; symptoms evident in cool weather on young leaves; renders clover plant more susceptible to secondary infections with other diseases and drought.

#### Management

Plant resistant cultivars; control aphid populations on plants; use virus free seed

## **Category : Fungal**

### **Aphanomyces root rot** *Aphanomyces* spp.

#### Symptoms

Infected seedlings have yellow cotyledons (seed leaves) with other leaflets beginning to turn yellow; seedlings dying back, seedlings with stunted growth; decaying roots in established plants leading to symptoms resembling nitrogen deficiency

#### Cause

Oomycete

#### Comments

Disease is more easily spread in moist soils and over a wide range of temperatures

#### Management

Maintaining soil potassium, phosphorous and an optimum soil pH can help protect plants from disease; follow recommended harvest schedule; if disease is present in soil a rotation away from legumes for a period of at least three years is desirable

### **Clover rot** *Sclerotinia trifoliorum*

#### Symptoms

Small brown to black lesions on leaves which coalesce and cause the leaves to dry out and drop, fungus may also affect stems, causing the plant to wither and die; dead plant material on the ground may be covered in white mold

#### Cause

Fungus

#### Comments

Fungus can survive in soil for up to 5 years; severely infected pastures can be reduced to masses of rotting plants on the ground

#### Management

Allowing close grazing or cutting of the stand reduces humidity around plants which in turn will slow the progression of the disease; plow plant material deeply into soil; rotation to a non-susceptible host for a period of 4-5 years is recommended if disease is present

## **Common leaf spot** *Pseudopeziza trifolii*

### **Symptoms**

Small circular brown-black spots with uneven margins on leaves; leaves turning yellow and dropping from plant

### **Cause**

Fungus

### **Comments**

Favors cool, wet weather; over winters on crop debris; more common during periods of high rainfall

### **Management**

Harvest infected early to avoid severe infections; rotating crops may reduce incidence of disease

## **Category : Bacterial, Fungal**

### **Root rot** *Fusarium* spp.

### **Symptoms**

Plant stunted and yellow; some roots show tan to red coloration; infected seedlings die quickly; poor plant stand

### **Cause**

Fungi

### **Comments**

Disease spreads more rapidly in the presence of unfavorable growing conditions (e.g. drought or harsh winter)

### **Management**

Maintaining soil potassium, phosphorous and an optimum soil pH can help protect plants from disease; follow recommended harvest schedule; if disease is present in soil a rotation away from legumes for a period of at least three years is desirable

## **Pests**

### **Category : Insects**

### **Alfalfa weevil** *Hypera postica*

#### **Symptoms**

Leaves skeletonized and appear bronzed; plants may be completely defoliated; adult insect is a dark gray beetle 0.5 cm (0.2 in) in length; larvae are pale green grubs with a thin white line down the center of their back and a brown head; larvae spin a cocoon and pupate on leaves or in soil

#### **Cause**

Insect

#### **Comments**

Weevils overwinter in crop debris and emerge in Spring; both adult insects and larvae damage plants

#### **Management**

Treatment of alfalfa weevils should be focused on the period before the first cutting; cutting the crop before budding is organically acceptable and can prevent serious damage and kill off most weevils; other control methods include the application of appropriate insecticide

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# Cocoa (cacao)

## Description

**Cocoa**

**Scientific name:** *Theobroma cacao*

**Rank:** Species

**Higher classification:** *Theobroma*

**Family:** *Malvaceae*

**Kingdom:** Plantae

**Order:** *Malvales*

### Local Names

English (Mother of cocoa, Mexican lilac, quikstick)

Cocoa may also be referred to as cacao, koko or Kacao and originates from upper Amazon region of South America.

### General information.

Cocoa is an evergreen tree in the Malvaceae family that is grown for its seeds (beans), which are primarily used in the production of chocolate.

A cocoa tree is a branching tree with simple, pointed (lanceolate) leaves that can reach up to 10 cm in width and 61 cm in length. The tree bears clusters of pale-yellow flowers with five petals and sepals each. Cocoa pods (drupes) can be green-white, yellow, purplish, or red in color, with 20-50 seeds arranged in five distinct rows.

### **How do cocoa fruits look?**

The ripe cocoa fruits are yellow, greenish, yellow-red, and red to red-brown.

They have the shape of American football balls. They grow to be about 25 cm long and have a thick shell. In the center is a white, sweet pulp with 25 to 50 seeds arranged in five rows. Each one is about 2-3 cm long. They are encased in white mucus. Criollo cocoa fruit.

We have three main varieties of cocoa:

-Criollo.

-Forastero.

-Trinitario.

#### **i). Criollo**

Criollo is a noble and extremely rare group of many varieties. It now accounts for less than 1% of global production, despite dominating 200 years ago. It is indigenous to Colombia and Venezuela.

It is also grown commercially in Peru, Mexico, Sri Lanka, Colombia, Madagascar, and the Caribbean region.

#### **Types of Cocoa Criollo example from Venezuela**

##### *Criollo guasare*

It is grown south of Lake Maracaibo. Its plantations are currently quite small. It is distinguished by a green fruit with a thin, slightly rough shell. This is a high-quality cocoa.

##### *Criollo chacao*

It's among the most famous type cocoa grown in the world, it is mainly grown in the Chacao region of Aragua state. It is classed as fine cocoa.

##### *Criollo porcelain*

It is grown in the southern regions of Lake Maracaibo. It has a distinct flavor and is considered extremely fine cocoa by experts. It is thought to have the highest genetic quality of all Venezuelan cocoa trees.

#### **ii). Forastero**

Forastero is native to the Amazon basin, which is why it is also known as Cacao Amazonico. Because of its high yield, this cocoa is also known as Cacao Corriente or ordinary cocoa. It is currently grown in many regions, primarily in Africa (Ghana and Côte d'Ivoire). The Spaniards first brought this cocoa from Venezuela. According to various sources, it accounts for 85-95% of global production. The relatively low requirements and ease of cultivation account for such a large share. It is relatively resistant to diseases and pests. It grows faster and produces more than the other groups.

The appearance of individual Forastero varieties varies. There are numerous subspecies, including Cundeamor, Calabacillo and Amelonado.

#### **iii). Trinitario**

Trinitario cocoa has a delicate flavor. It is a cross between the two varieties mentioned above. It was chosen during the seventeenth century. The trees were brought to Trinidad from Venezuela. It was a big hit. Trinidad produced the best cocoa beans for several decades.

Trinitario's global market share is currently less than 10%. The aroma of Trinitario is forastero, and the flavor is delicate criollo.

*Red cocoa pods*

*Cocoa flower*

*Red cocoa pods*

*Ripe cocoa pod*

*Cocoa pods*

*Cocoa tree and pods*

## Uses

Cocoa seeds have a high fat content and thus provide an energy-rich and delicious food. Cocoa is grown in all humid and tropical countries. Côte d'Ivoire (the world's largest cocoa producer) is the leading cocoa producer in Africa, followed by Ghana, Nigeria, and Cameroon.

Chocolate, cocoa powder, and butterfat are the main products made from cocoa beans which are all consumed by humans. Butterfat is also used in cosmetics and pharmaceutical products, but the amount used is insignificant in comparison to that used in chocolate production. Raw cocoa (dried cocoa seeds) is the most sought-after product on the international market, and it is used to make cocoa butter, cocoa powder, and chocolate.

*Dried and fermented cocoa beans*

*Cocoa beans in a cacao pod*

## Climatic condition soil and water.

Cocoa grows in the so-called under-storey of primary forests and is associated with a number of palm species as well as a number of other tree species. For example, in rain forests, tree varieties from the upper storey, primarily single trees overtopping the forest canopy, lose their foliage during the months of shorter daylight hours. The increased light encourages the development of cocoa blossoms, and the falling leaves provide organic material enrichment.

The plantations can survive on 1250 mm of rainfall per year if the annual distribution is even (100 mm per month). Heavy clouds and high humidity can compensate for short drought periods. The annual average temperature should be around 25°C. Harvesting periods are reduced to a few months per year in regions with extensive wet periods or large seasonal temperature fluctuations. Cocoa produces fruit almost all year in regions with a balanced climate and only minor temperature and rainfall fluctuations. As a result, cocoa is a typical crop of the tropical lowlands. If other conditions are favorable, it can also be grown at higher altitudes.

Cocoa has shown to develop more quickly in areas without a dry season than in the major production areas of West Africa, where growth is slowed by drought during certain months of the year.

Cocoa plantations should have deep, well-drained soil with adequate water retention. Soils with a high available moisture-storage capacity can compensate for lack of rain. The pH of the solution should be between 4.0 and 7.5. It is critical to ensure that there is enough organic material available. Cocoa trees can live for more than a century. Naturally occurring cocoa crops reproduce through lateral shoots that can appear at any height on the trunk. Natural vegetative proliferation occurs when small rodents and apes spread the seeds.

### Propagation and planting

The natural site requirements of cocoa should be followed when selecting a location for a new plantation. Sites with alluvial soils that are resistant to waterlogging are ideal. Other appropriate locations include irrigated form wells and hollows. Steep and convex slopes are unsuitable locations. When establishing a new plantation, take care to replicate the natural structure of forests as closely as possible. This means that in the agroecosystem, all of the varieties that will be cultivated alongside cocoa should be planted at the same time (or even before) the cocoa.

The best method is to leave an area open for natural growth and plant tall-growing trees that will quickly provide cover, such as bananas and manioc, and then plant cocoa in between them later. The biological activity of the soil is maintained in this manner, and the cocoa mycorrhiza can begin to develop immediately.

Cocoa is typically planted as seedlings, which are simple and inexpensive to produce. To establish seed gardens, vegetative propagation via rooted cuttings or budding is used. In a shaded nursery, seedlings are typically raised in polythene bags.

At the age of 4 - 6 months, young plants are planted in the field 3 - 4 m apart. Young trees require shade to reduce irradiance, buffer the microenvironment, and promote proper tree shape and habit. The need for shade is reduced when a closed canopy is formed. Cocoa can only be grown without shade under the most favorable soil and nutrient conditions.

In order to extend the economic life of plantations, some shade is usually required to reduce moisture stress and the incidence of insect damage.

Shade can be obtained by either thinning the forest or planting shade trees. Shade trees are common in South-East Asia, where they are mostly seedless and Mother of cocoa.

Hedges of leguminous shrubs are frequently used for temporary side protection between rows as well as a source of mulch. Cocoa can also be grown as an intercrop with coconuts.

## Main varieties grown are

### **Trinitario**

- This variety is a hybrid of Criollo and Forastero.
- The pods can be long or short, and red or yellow.
- It produces reasonably high-quality cocoa.

### **Forastero (Amelonado) (Amelonado)**

- The pods are short, yellow, smooth, and have shallow furrows.
- This variety yields well, but the quality is not as high as that of Criollo. It is widely grown in Africa.

### **Criollo**

- When Criollo pods are ripe, they are long, yellow or red, with deep furrows and large warts.
- This variety does not produce as much as the others, but the cocoa is of very high quality.
- It is mostly grown in the United States.

### **Harvesting**

The most vital characteristics of cocoa are dependent on proper processing, which begins with harvesting and ends with storage. Pod development takes about 6 months from seed to maturity. When the pods are completely ripe, harvesting can begin. An orange discoloration of the shell distinguishes many Trinitario types with their red and dark violet pods. When other varieties are ripe, they turn yellow.

Depending on the region and weather conditions, there are usually one or two harvesting phases that last several months. It is best to harvest all of the ripened pods every 2-3 weeks to ensure uniform ripeness of the harvested pods. Each week during peak

production, pods are harvested.

To avoid damaging the bark, use a sharp knife or other suitable instrument to cut off the pods at the base of the blossom.

## **POST-HARVEST PROCESSES**

After harvest, the cocoa fruit is fermented, dried, and stored. Farmers remain vulnerable to production losses during these processes and the quality and flavor of the product is defined by the environment and the methods used.

### **Fermentation**

There are various ways in which farmers can engage in the process of cocoa fermentation. After the cocoa beans and pulp are removed from the husk, smallholders typically cover the heaps of cocoa with plantain or banana leaves and let them ferment for approximately five days. This traditional approach to fermentation, however, is susceptible to environmental risk factors. Periods of intense rainfall increase the time required for fermentation. Temperature changes, droughts, and prolonged dry seasons affect the flavor and overall quality of the product. Unlike farmers in West Africa, cocoa farmers in Latin America tend to ferment the cocoa pulp surrounding the beans using wooden boxes. In Indonesia, farmers rarely take part in the fermentation process because their production is valued mostly for cocoa butter which is unaffected by fermentation.

### **Drying**

The next step after fermentation is the drying of the cocoa beans. Under inadequate methods and circumstances, drying can result in production losses and loss of quality. Farmers may either sun dry their beans or use an artificial drying technique. The former is common in countries that have a significant dry period during which to carry out drying and it involves placing the cocoa seeds on a surface exposed to the sun either on mats, trays, or concrete. Artificial drying involves the use of an artificial source of heat such as fires. Intensive rainfall can cause molding of cocoa beans and reduce quality. While temperature changes alter the time required for drying, droughts and dry periods will increase the speed at which cocoa dries. CSC recommends the use of solar dryers, which are easy to build using wood and clear plastic. Solar dryers avoid the GHG emissions of artificial drying and protect cocoa from excessive humidity.

### **Storage**

In temperate climates, cocoa can be safely stored for years. High temperatures and humidity, on the other hand, cause a rapid infestation of storage pests and infection with mould fungi in the moist tropics. Because cocoa is highly hygroscopic, even a well-dried product can increase in moisture content by up to 10% in areas with 80-90% humidity, reducing its storage capacity. For storage, the critical moisture content is 8%.

Cocoa should be stored in air-permeable sacks for a short period of time on the production site, and the sacks should be stacked on wooden planks or boards.

Sacks made of organic material that have been treated with pesticides should be avoided since the cocoa butter component of the cocoa shell is an excellent solvent for chlorinated hydrocarbons, which can diffuse through the outer shell and into the cocoa seed when they come into contact with it. In such cases, tests have revealed that limits for certain agricultural poisons were exceeded despite the fact that no pesticides had ever been used on the site.

The storage area should be well-ventilated at all times, with the inside temperature remaining below the outside temperature.

It is common practice on conventional plantations to gas the cocoa with methyl bromide to protect it from storage pests. However, the use of methyl bromide is no longer permitted.

Tetraline soap, hydrogen phosphide, and prussic acid are also employed. It is not permitted to use insecticides against storage pests or to gas the beans on organic cocoa plantations. Cocoa beans should be stored at low temperatures in dark, dry, well-ventilated rooms. Short-term storage temperature: approximately 16°C; relative humidity: 55% Long-term storage temperature: 11°C; relative humidity: 55

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## Common Pests and Diseases

### Diseases

#### Category : Oomycete

##### **Black pod (*Phytophthora* pod rot)** *Phytophthora palmivora*

*Phytophthora megakarya*

*Phytophthora capsici*

*Pods of Theobroma cacao in central Costa Rica display symptoms of the fungal disease black pod. This disease causes pods to rot on the cacao tree during the last stages of ripening.*

*Symptoms of black pod of cocoa*

#### Symptoms

Translucent spots on pod surface which develop into a small, dark hard spots; entire pod becomes black and necrotic with 14 days of initial symptoms; white to yellow downy growth on black areas; internal tissues become dry and shriveled resulting in mummified pods

#### Cause

Oomycete

#### Comments

Disease occurs in all cocoa growing areas; *P. megakarya* is most destructive in Central and West Africa whereas *P. capsici* is most common in Central and South America

#### Management

Protective sprays of copper containing fungicides in combination with systemic fungicides are often recommended to control the disease; cocoa plants should be well spaced to allow good air circulation through the plantation; mummified pods should be removed and destroyed to reduce spread

#### Category : Viral

##### **Cocoa swollen shoot** Cocoa swollen shoot virus (CSSV)

*Cacao (Theobroma cacao L.) showing swollen shoot diseased stem.*

*Cocoa Swollen Shoot Virus symptoms*

*Symptoms of swollen shoot of cocoa*

*Symptoms of swollen shoot of cocoa*

### **Symptoms**

Swelling of leaves and shoots; red leaf veins, notably in young leaves; chlorotic patches next to leaf veins; chlorotic spots or flecks on leaves mottled, smooth pods with reduced beans; mottled coloration on pods; stems may develop swellings at nodes or internodes and shoot tips; progressive defoliation may occur ultimately leading to the death of the tree.

### **Cause**

Virus

### **Comments**

Only occurs in West Africa. Major problem in Togo, Ghana, Cote d'Ivoire and Nigeria; transmitted by mealybugs. The Swollen Shoot Virus is not native to cocoa but jumped into the cocoa from trees that grew in the rain forests of W. Africa (e.g. *Cola chlamydanta*, *Ceiba pentandra*, *Adansonia digitata*, *Cola gigantea* and *Sterculia tragacantha*). The virus is a badnavirus within the family Caulimoviridae.

### **Management**

Infected trees and those surrounding them should be removed and destroyed (up to 5 m from infected tree if less than 10 trees are infected and up to a distance of 15 m if greater than 100 trees are infected) to prevent further spread; a gap should be placed between cocoa plantations of at least 10 m (33 ft) and it may be possible to isolate cocoa plantations using a non-host crop such as oil palm growing between plantations.

## **Category : Fungal**

### **Frosty pod (Monilia pod rot, Watery pod rot) *Moniliophthora roreri***

*Frosty pod rot, external fruit symptoms & sporulation*

*Comparison of external and internal fruit symptoms (*Phytophthora* on left, *Moniliophthora* on right)*

*Frosty pod symptoms on cocoa*

### **Symptoms**

Spots on surface of immature pods; spots turning brown and rapidly enlarging to cover entire pod surface; disease affects only actively growing pods.

### **Cause**

Fungus

### **Comments**

Causes serious losses in South-Western parts of South America; spores are dry and powdery and are spread easily by

water movement, wind or movement of pods; disease spread is highest during periods of high rainfall.

### Management

Planting cocoa varieties that produce pods during the dry season allows the pod to avoid the disease; pods showing symptoms of disease should be removed to prevent spread; application of copper containing fungicides will help reduce disease incidence.

## Witches' broom *Moniliophthora perniciosa*

Spores released from the fan-shaped basidiocarp of this inch-wide *Crinipellis perniciosa* mushroom can infect cacao trees and drastically reduce yields of the beans from which cocoa and chocolate products are made.

A branch of a cacao tree in western Ecuador killed by witches' broom disease. Protruding from some leaf midveins are whitish fungal structures that send thousands of spores onto other trees.

Pathogenic fungi that cause witches' broom on cacao tree limbs and trunks also attack pods, destroying the valuable beans inside.

### Symptoms

Characteristic proliferation of shoots and brooms from bud; production of branches which do not produce fruit; distorted pods with green patches which give an appearance of uneven ripening.

### Cause

Fungus

### Comments

One of the most devastating cocoa diseases in South America; disease is widespread throughout South America, the Caribbean and Panama; spread of disease greatly influenced by humidity with emergence favored by high temperature and high humidity (>80%).

### Management

Good sanitation is the most effective method of controlling the disease; material known to be infected should be removed and destroyed; removal of infected material can be difficult as there may be no visible symptoms; new fungicides and resistant cocoa varieties are being developed to help control the disease.

## Pests

### Category : Insects

#### Cocoa mealybugs *Planococcus* spp.

*Pseudococcus* spp.

Cocoa mealybugs being tended by ants

### Symptoms

Flattened oval to round disc-like insect covered in waxy substance on tree branches; insects attract ants which may also be present; insect colony may also be associated with growth of sooty mold due to fungal colonization of sugary honeydew excreted by the insect; symptoms of direct insect damage not well documented but trees may exhibit symptoms of cocoa swollen shoot (see disease entry)

### Cause

Insect

### Comments

Insects have a wide host range; often tended by ants which farm them for their sugary honeydew secretions; transmit Cocoa swollen shoot virus

### Management

Mealybugs can potentially be controlled by natural enemies such as lady beetles but are commonly controlled using chemicals; chemical pesticides may also decrease populations of natural enemies leading to mealybug outbreaks

### Cocoa mirid *Distantiella theobroma*

*Sahlbergella singularis*

*Helopeltis* spp.

*Monalonion* spp.

The picture shows pods attacked by  
*Helopeltis* pest.

Cocoa mirid feeding on cocoa pod

Comparison between healthy pods  
and ones attacked by cocoa mirid.

*Helopeltis* sp. (cocoa mirid)

Cocoa mirid and damage to pod

### Symptoms

First symptoms appear as tiny puncture wounds on young stems and pods; these punctures quickly turn necrotic, creating black patches which may develop into cankers; discolored bark; terminal leaves and branches dying back; trees unproductive; adult insect is a slender red or brown insect with long legs and antennae; adults are typically between 7 and 10 mm long.

### Cause

Insect

### Comments

Adult females lay their eggs in the bark of the tree and can lay between 30 and 40 eggs.

### Management

In African countries, the insect is usually controlled by chemical eradication programs consisting of two sprays conducted one month apart to target different stages of the insects development; mirids have been shown to be attracted to trees positioned in direct sunlight and providing shade cover in the form of forest to cocoa trees can be used as part of an integrated control method; do not interplant with other hosts such as cashew, tea, sweet potato, guava, cotton or mango - the trees used must be non-hosts; some species of ant, e.g black ants, can be used as a biological control agent.

### Cocoa pod borer *Conopomorpha cramerella*

#### Symptoms

Holes in cocoa pod husk caused by insect larvae entering and exiting the pod; uneven and premature ripening of pods; seeds sticking together inside pod due to insect eating surrounding tissue; harvested cocoa beans clump together and can be very difficult to remove from the pod; adult insect is a small brown moth; larvae are cream in color and approximately 1 cm (0.4 in) long; larvae change color to green when they emerge from the pod to pupate.

#### Cause

Insect

#### Comments

Female moth lives for approximately 5-7 days and can lay 100-200 eggs; eggs are laid on the surface of cocoa pods; larvae develop for 14-18 days before pupating.

#### Management

Sleeving pods in plastic bags while they mature prevents the insect from reaching the pods, sleeves should be applied when pods are 8-10 cm (3-4 in) long; borer populations can be held in check by black ants and weaver ants; chemical control is often economically unfeasible due to the high price of pesticides compared with the low price of cocoa but,

where available, small amounts of contact pyrethroid or carbamate applied to underside of cocoa leaves can keep borers below an economically damaging level.

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# Coconut

## Crop details

Scientific Name *Cocos nucifera*

Order / Family Arecales: Arecaceae

Local Names Mnazi (Swahili)

### General information

The coconut palm, *Cocos nucifera*, is an erect palm in the family Arecaceae which is grown for its fruits, used primarily for the extraction of coconut oil for use in cooking. The coconut palm has an erect or slightly curved stem which grows from a swollen base. The stem is smooth, light gray in color and has prominent leaf scars. The stem is topped with a crown of 60–70 spirally arranged leaves. The leaves are long (up to 7 m/23 ft), pinnately divided and composed of 200–250 tapering leaflets. The inflorescence is a spike produced at the leaf axil with 20–60 branches, each with a female flower at the base and many male flowers. The fruit is a drupe containing a single seed. It is ovoid in shape with three sides divided by ridges. The exocarp and the mesocarp make up the husk of the coconut. The seed is protected by a thick, stony shell, or endocarp, and is partially filled with a liquid known as coconut water. The edible endosperm is white and meaty and can be between 1.0 and 2.5 cm (0.4–1.0 in) thick. Coconut palms can reach a height of 30 m (98 ft), produce up to 75 fruits a year, and live for up to 90 years. The origin of the coconut is unknown although the center of genetic diversity lies in Southeast Asia.

*Coconut propagation*

*Harvested coconut drupes*

*Coconut seed cut open to reveal flesh*

*Coconut inflorescence*

*Coconut drupes*

*Coconut seedling*

*Close-up image of coconut palm leaf*

*Coconut palms can reach 30 m (98 ft)*

*Coconut palms with coconuts*

## **climatic conditions, soil and water management**

Coconut needs a continuous supply of water, which can be provided by regular rainfall of about 1250 mm per annum, or from ground water (at a depth of 1-3 m). It can not tolerate water logging. The northern Kenya coast receives only a rainfall of 750-1000 mm and this restricts production. Coconut grows best at average temperatures of around 26-27°C. Because of its temperature requirements, the coconut palm cannot normally grow above 750 m. However, near to the equator and in areas where other conditions are favourable for coconut development, it is possible to grow the crop up to about 1300 m. Growth is stimulated by a sufficient supply of chlorine in the soil. The coconut palm can withstand up to 1% salt in the soil.

These conditions are generally found in tropical and subtropical coastal regions with little rainfall. Coconut palms can also grow on deep, water-logging free, alluvial soil, away from the coast - yet low chlorine content in the soil could have negative effects. Consider these conditions when choosing a site.

Depending on the site, coconut palms can be cultivated on agroforestry systems. As a plant of the upper storey, with essential light requirements, the coconut palm towers above such crops as citrus, cacao and others

## **coconut varieties**

### **West Coast Tall Coconut**

This tall coconut tree bears fruit in 6-7 years and produces around 60-80 coconuts per palm, each year. It is drought-tolerant, and the color of the fruits varies from green to yellow and orange to brown.

### **The East Coast tall coconut**

East coast tall produces around 60-70 coconuts on each palm every year and takes 6-8 years to yield fruits. This tall coconut tree needs well-drained, loamy soil to thrive.

### **Maypan Coconut**

Hybrid of Malayan and Panama; Maypan is a cold-hardy variety, producing medium to large-sized coconuts. Growing up to 20-meters, this variety is also resistant to lethal yellowing disease.

### **Tiptur Tall Coconut**

Leathery fronds of tiptur tree produce 6-12 inches long fruits. It starts bearing fruits in 6-7 years from the planting and produces 70-80 coconuts on each palm, every year. It is one of the best coconut tree variety to grow.

### **Orange Dwarf Coconut**

Producing fruits in 3-4 years, this dwarf variety can yield around 50-70 drupes per palm each year. Each crown of this tree consists of 20-28 leaves. Avoid growing this palm tree in the wind prone areas, as it may get damaged due to strong winds.

### **Green Dwarf Coconut**

This palm tree yields around 60-70 coconuts per palm and begins fruiting in 3-4 years. Its drupes are dark green and resistant to root wilt disease.

### **Malayan Yellow Dwarf Coconut**

This palm has a yield of 50-60 coconuts on each palm per year and starts bearing fruits after 3-4 years. It is native to Indonesia and is resistant to lethal yellowing disease.

### **Fiji Dwarf Coconut**

This tropical ornamental tree is popular for its long fronds and a swollen trunk base. Its unique leaf arrangement makes it different from others and has a large bulb at its lower stem. Thanks to its durable nature, it has earned the name- Tough nut.

Other coconut varieties include, VHCl coconut, Macapuno coconut and King coconut

## **Uses**

Coconuts are primarily cultivated for their oil. The oil is extracted from the endosperm and is used in cooking. Low grade oils are used in the production of soaps. The endosperm can be consumed fresh or dry and is commonly grated for use in baking. Young coconuts, termed waternuts, are commonly sold in tropical resorts, where the liquid is drunk directly from the shell. Coconuts may also be used to produce coconut milk by squeezing the liquid from the grated endosperm. Coconut milk is popularly used in many dishes from Southeast Asia.

## **coconut growing areas**

### ***coconut growing in Kenya***

In Kenya, a majority of the coconut trees are found in the Coastal Counties of Kwale, Mombasa, Kiifi, Tana River and Lamu. Taita-Taveta, a Coastal highland County also has a small population of coconut trees; with the area under production continually increasing on a yearly basis. Other areas with potential for coconut production include Busia and Homa Bay in the Lake Victoria region and Tharaka-Nithi in the Eastern region. The total area under coconut farming in Kenya is estimated to be 200,000 acres. Many (92%) of the trees are in the ages of 20 to 60 years. The rest (8%) of the coconut tree population is beyond the economic age limit of 60 years, and are either low nut producers or non productive at all.

### ***coconut growing in Tanzania***

In Tanzania coconut is grown along the eastern parts of the country including Tanga, Morogoro, Lindi, Coast Region and Dar es Salaam as well as Mtwara and all regions of Zanzibar and other potential regions including Mbeya particularly in Kyela, Kigoma, Mwanza and Musoma.

About 95 per cent of the crop is grown and produced by small-scale farmers who own an average of a hectare. Medium and large-scale producers account for only 5 per cent of the coconut production in Tanzania.

### ***Coconut growing in Uganda***

Their varieties of coconut are based on place of origin, shape, and size of the palms. Some of the coconut palm varieties include; the dwarf coconut palms like Malayan dwarf.

## Coconut nutrition value

Coconut is generally regarded as a source of healthy fat. The meat contains protein and fiber, as well as some essential minerals such as:

Two tablespoons of fresh, shredded coconut contain the following nutrients:

35 calories

Less than 1 gram of protein

3 grams of fat

2 grams of carbohydrates

1 gram of fiber

1 gram of sugar

One piece of fresh coconut meat measuring 2" x 2" x 1/2 (45g) provides 159 calories, 1.5g of protein, 6.8g of carbohydrates, and 15.1g of fat. Coconut is an excellent source of, fibre potassium, manganese, and selenium.

Calories 160

Fat 15g

Sodium 9mg

Carbohydrates 6.8g

Fiber 4g

Sugars 2.8g

Protein 1.5g

Potassium 160mg

Manganese 0.68mg

Selenium 4.5mcg

## Propagation

### Basic requirements

The coconut palm is a tropical plant and is generally grown in humid, tropical regions. It grows optimally in areas with an annual mean temperature of 27°C (80.6°F) with in excess of 2000 hours of sunlight per year. The palm will thrive in a wide range of soils from sand to clay as long as they are well draining and well aerated with a pH between 4.3 and 8.0. Although palms are often found growing on sandy beaches, they can be successfully grown inland but will not tolerate freezing temperatures.

### Propagation

Coconut palms are propagated exclusively from seed. The seeds are ready for planting when the coconut milk can be heard sloshing around inside the seed when it is shaken. Seeds are germinated by planting in seed beds before

transferring to a polythene bag or nursery beds after germination. Seeds should be planted on their sides in a shallow hole with enough soil to cover about one third of the seed. The seed should be watered regularly to prevent it drying out. Germination usually occurs after about 3 months but may take up to 6 months.

### **Transplanting**

Coconut seedling can be transplanted from 6 months onwards or transferred to pots and grown further in the nursery. Trees require a wide spacing and are typically planted 8–9 m (26–30 ft) apart allowing a further 8–9 m (26–30 ft) between rows. Dwarf varieties can be spaced closer together and are typically planted 7.5 m (25 ft) apart allowing another 7.5 m (25 ft) between rows

### **Crop monitoring**

The nuts ripen during the entire year. As a rule, a harvest is carried out every 1-2 months, when the ripened coconuts are harvested directly from the tree - farmers should not wait until the nuts fall from the tree. The nuts are fully ripened when the coconut water can be clearly heard sloshing against the inside when they are shaken. Harvesting too early can unfavorably affect the quality of the copra.

### **Harvesting**

Stock plants that are suitable seed providers produce 100 nuts per year and up to 180 g copra per nut. In drier areas yields are usually 15-20 nuts/tree/year. Harvest fully-ripened nuts intended to provide seeds after 11-12 months. Cut down nuts and lower them carefully (e.g. by rope). Do not allow the nuts to fall down. Following the harvest, store nuts for a short break in a covered, well-ventilated place.

### **drying**

#### **Sun drying**

Remove the husk first. Dry nuts on a clean surface to reduce moisture from 45% to 6%. In fine weather this takes about 5 days. Turn the pieces occasionally and cover them at night and in rainy weather.

#### **Kiln drying**

Make a fire in the pit of the kiln. Use the coconut shells as fuel as they heat well and smoke little. Put the copra on a wire mesh platform over the fire and protect it from the rain. This takes about 4 days.

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## **Common Pests and Diseases**

# Diseases

## Category : Fungal

### Bud rot and nutfall *Phytophthora* spp.

*Fusarium solani*

*Fusarium moniliforme*

*Graphium* spp.

Coconut tree infected with bud rot  
pathogen *Phytophthora palmivora*

#### Symptoms

Chlorosis of youngest open leaves; leaves rapidly turning necrotic; necrotic spots on leaf bases; unopened spear leaves can be pulled away from the plant easily; removal of unopened spear leaves reveals soft, pink-red tissue with foul smell; leaf necrosis spreading through central crown leaves; woody parts of plant may have water-soaked, pink lesions with dark borders; infected inflorescences abort nuts.

#### Cause

Oomycete

#### Comments

Palms between 14 and 40 years old most susceptible; disease occurs in all coconut growing regions; diseases emergence favored by high rainfall.

#### Management

Control of the disease is reliant on good sanitation practices and the use of appropriate systemic fungicides; remove all infected debris and dead trees from plantation and destroy; irrigate trees early in the day to allow surfaces to dry off during the day.

### Ganoderma butt rot *Ganoderma* spp.

Fruiting bodies

Close-up of *Ganoderma* root and  
butt rot fruiting bodies

*Ganoderma* root and butt rot  
(*Ganoderma australe*) fruiting  
bodies

#### Symptoms

Older fronds turning yellow and gradually wilting and drooping; fronds collapsing and dying; internal tissue of lower stem discolored; overall reduction in vigor.

#### Cause

Fungi

#### Comments

Fungi may enter through wounds on trunk or pruning wounds.

#### Management

Spacing trees widely limits the chance of infection through root grafts; avoid damaging tree trunks with tools and machinery; remove any dead or severely damaged trees from plantation immediately, including any that have been killed by natural processes; if a site is known to be infected with the disease, the ground should be fallowed for at least 1 year prior to a new plantation being established.

### Gray leaf blight *Pestalotiopsis palmarum*

Symptom	<i>Pestalotiopsis</i> leaf spot ( <i>Pestalotiopsis palm arum</i> ) sign
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### Symptoms

Small, yellow-brown spots on leaflets which develop gray centers and dark green borders; lesions coalesce to form large necrotic patches; tips of leaflets turning gray; canopy has blighted appearance.

### Cause

Fungus

### Comments

Fungi will colonize young, wounded or weakened tissues; disease emergence favored by high rainfall and high humidity.

### Management

Disease usually only merits control in coconut nurseries as infection of mature coconut palms are rare; appropriate broad spectrum protective fungicides should be applied.

## Lethal bole rot *Marasmiellus cocophilus*

### Symptoms

Oldest leaves of palm turning yellow and wilting; reddish-brown rot in bole tissue; destruction of root system

### Cause

Fungus

### Comments

Some grasses such as Bermuda grass have been reported as alternative hosts fro the fungi

### Management

Any infected trees must be uprooted and burned; area can only be replanted once soil is treated for the disease

## Stem bleeding disease *Chalara paradoxa* (syn. *Thielaviopsis paradoxa*, *Ceratocystis paradoxa* )

The canopy of the coconut in the center is wilted and necrotic due to a trunk infection by *Thielaviopsis paradoxa*.

Only one side of this trunk has significant rot due to *Thielaviopsis paradoxa*. The fungus rots the trunk tissue from the outside to the inside.

The three coconuts on the left have died from *Thielaviopsis* trunk rot. The palm in the foreground exhibits trunk collapse.

The trunk of this coconut was just beginning to exhibit "stem bleeding", but the large rusty-brown area at the top was already soft.

Trunk collapse due to stem bleeding disease

Stem bleeding on a coconut trunk. The top of the blackened area was very soft and could be easily pushed in with the fingers.

### Symptoms

Soft, yellow rot on trunk; affected areas are dark and turn black as they mature; a reddish-brown liquid may ooze from rotting regions and spill down trunk.

### Cause

Fungus

### Comments

Fungi enter the trunk through wounds.

### Management

Avoid wounding palms with machinery and tools to reduce disease incidence; disease can be controlled with applications of the fungicide benomyl where registered; infected trees should be removed and destroyed as soon as possible.

## **Category : Viral**

### **Cadang-cadang** Coconut cadang-cadang viroid (CCCVd)

*Area with cadang-cadang disease showing trees in the early, medium and late stages of the disease.*

#### **Symptoms**

Newly formed nuts more rounded than in previous years; nuts exhibit scarring on the surface; chlorotic spots on leaves; stunted inflorescences with tip necrosis; leaves begin to decline in size and number; death of palm.

#### **Cause**

Viroid

#### **Comments**

No vector has been identified.

#### **Management**

There is currently no known method of controlling the disease.

### **Coconut foliar decay** Coconut foliar decay virus (CFDV)

#### **Symptoms**

Some varieties which have the disease may show no symptoms, others exhibit partial yellowing of leaves which begins to spread to leaf tip; necrosis of petioles causing leaves to die and hang from palm canopy

#### **Cause**

Virus

#### **Comments**

Transmitted by leaf hoppers

## **Category : Other**

### **Lethal yellowing (Palm lethal yellowing)** *Candidatus Phytoplasma palmae* (PLY)

*Infected trees*

*Infected coconut trees*

*Lethal yellowing damaged tree*

*Damage due to lethal yellowing*

*Lethal yellowing infected palm*

*Cocos nucifera spear leaf is dying just as the last leaves are discoloring due to lethal yellow phytoplasma*

*Lethal yellowing infected coconut trees*

*Symptoms of lethal yellowing on coconut palm*

*Symptoms of lethal yellowing on coconut palm*

#### **Symptoms**

Premature dropping of fruit; fruit with brown-black water-soaked appearance; necrosis of inflorescences; flower stalks turn black; lower, older leaves turning yellow; entire crown turning yellow; yellow leaves turn brown, dry out and hang from canopy.

#### **Cause**

Phytoplasma

## Comments

May be transmitted by leaf hoppers.

## Management

The most effective method of managing the disease is to plant resistant coconut varieties such as Malayan dwarf or Maypan; antibiotic treatment is effective but not usually practical for large scale plantings.

# Pests

## Category : Insects

### Coconut bug *Pseudotheraptus wayi*

#### Symptoms

Damaged and/or aborted flowers; sunken necrotic lesions and scars on nuts; young nuts may exude gum (gummosis) and die; many nuts fall from tree; adult insect is a brown-red with well-developed wings; nymphs are brown-red or green in color with long antennae and feed at the calyx of the nut

#### Cause

Insect

#### Comments

The coconut bug is one of the most damaging pests of coconut in Africa; just two bugs per palm can cause severe damage

#### Management

Natural enemies of the coconut bug include weaver ants, conserve bushes and trees around plantation which are habitats for weaver ants or intercrop with mango, guava or citrus which are attractive to weaver ants; connect canopy with ropes or sticks to allow weaver ants to move between trees

### Coconut leafroller *Omiodes blackburni* (earlier *Hedylepta blackburni*)

*Coconut leafroller (Hedylepta blackburni)* damage to coconut plant

Damage due to coconut leafrollers

Coconut leafroller larvae

*Coconut leafroller (Hedylepta blackburni)* adult

*Coconut leafroller (Hedylepta blackburni)* larvae damage to coconut leaves.

Coconut leafroller pupae and frass

*Coconut leafroller feeding on leaves*

*Coconut leafroller pupa, larva and frass.*

*Coconut leafroller rolls leaf near midrib of frond*

#### Symptoms

The larvae feeds on under surface of leaves. Usually they found protected by silken web. Initially they feed on the lower epidermis leaving the upper epidermis intact. The larvae often fold two sides of leaflets by a silken thread and feed inside. The later stage larvae feeds on both upper and lower epidermis of leaves. Severe infestation leads to skeletonization of fronds.

#### Cause

Insect

#### Comments

The insect is quite common in high wind areas.

#### Management

Encourage natural enemies in the orchard.

## Coconut rhinoceros beetle *Oryctes rhinoceros*

Damaged coconut frond      coconut rhinoceros beetle (*Oryctes rhinoceros*) pupae      coconut rhinoceros beetle (*Oryctes rhinoceros*) injured trees

coconut rhinoceros beetle (*Oryctes rhinoceros*) adult      Damage due to coconut rhinoceros beetle      Damage due to rhinoceros beetle

Lure and trap for Coconut Rhinoceros Beetle      Rhinoceros beetle damage      Coconut Rhinoceros Beetle (CRB)

coconut rhinoceros beetle injury to young coconut tree      Coconut rhinoceros beetle larvae      The Asiatic rhinoceros beetle or coconut rhinoceros beetle (*Oryctes rhinoceros*) damage to coconut

### Symptoms

V-shaped cuts in palm fronds or holes in leaf midribs caused by beetles boring into crown to feed; adult insect is a large black beetle with a curved spine on its head; larvae are creamy white grubs with brown heads and 3 sets of prolegs at the anterior (head) end.

### Cause

Insect

### Comments

Beetles are nocturnal and fly at night; also a damaging pest of oil palm.

### Management

Destroy any decaying logs in plantation by chopping and burning to kill any larvae that may be inside; remove any dead trees from plantation and destroy by burning; plant a cover crop to deter egg laying by females as they do not lay eggs in areas covered by vegetation; hooked wire can be used to extract larvae that are boring into young crowns.

## Coconut scale *Aspidiotus destructor*

coconut scale (*Aspidiotus destructor*) infestation      Coconut scale (*Aspidiotus destructor*) adults      coconut scale (*Aspidiotus destructor*) adults and early instars

coconut scale (*Aspidiotus destructor*)      Coconut scale infestation      coconut scale (*Pinnaspis buxi*)

Scale on coconut foliage      Coconut scale damage      Coconut scale damage

### Symptoms

Pale yellow spots on leaves; entire leaves yellowing; leaves turning brown and dropping prematurely; adult insect is a flattened oval, resembling a scale, which is red-brown in color.

### Cause

Insect

### Comments

Insect also attacks other crops such as tea and mango.

## **Management**

May be possible to control coconut scale by pruning infested parts of trees and destroying by burning; chemical control may be necessary.

## **Mealybugs (Pineapple mealybug, Striped mealybug, Cocoa mealybug, etc.)** *Dysmicoccus brevipes*

*Ferrisia virgata*

*Planococcus lilacinus*

Coconut (*Cocos nucifera*): Mealybugs and scales on leaflet

Coconut mealybugs (*Nipaecoccus nipae*)

Colony of coconut mealybugs (*Nipaecoccus nipae*)

coconut mealybugs (*Nipaecoccus nipae*) tended by ants

Coconut mealybug (*Nipaecoccus nipae*) adult

Adults of coconut mealybug (*Nipaecoccus nipae*)

Coconut mealybug damage

## **Symptoms**

Flattened oval to round disc-like insect covered in waxy substance on tree branches; insects attract ants which may also be present; insect colony may also be associated with growth of sooty mold due to fungal colonization of sugary honeydew excreted by the insect; symptoms of direct insect damage not well documented but trees may exhibit symptoms of cocoa swollen shoot (see disease entry).

## **Cause**

Insect

## **Comments**

Insects have a wide host range; often tended by ants which farm them for their sugary honeydew secretions; transmit Cocoa swollen shoot virus.

## **Management**

Mealybugs can potentially be controlled by natural enemies such as lady beetles but are commonly controlled using chemicals; chemical pesticides may also decrease populations of natural enemies leading to mealybug outbreaks.

## **Category : Mites**

### **Eriophyid coconut mite** *Aceria guerreronis*

Coconut: Eriophyid mites injury to nuts

Mite damage

Mite feeding injury

Coconut mite damage coconut fruits

Scarring of coconut fruits due to coconut mites

Symptoms due to coconut mite infestation

Coconut mite feeding injury

Eriophyid mites feeding injury to coconut

Coconut mite damage on fruits of coconut

## **Symptoms**

The mites suck sap from young nuts. Generally they feed on meristematic zone, i.e., the area which is covered by perianth. The infestation starts very early. As the nut develops the feeding leaves brown fissures that extending down

from the perianth. The nut becomes small and distorted.

#### **Cause**

Mites

#### **Comments**

The mites spread through the wind. It causes yield loss from 30 to 60 per cent.

#### **Management**

Provide proper fertilizer and water for trees to withstand mite damage. Encourage natural enemies of mite in the orchard. If infestation is severe, apply suitable insecticide by root feeding or stem injection.

### **Category : Nematodes**

#### **Red ring nematode (Coconut palm nematode) *Bursaphelenchus cocophilus***

#### **Symptoms**

Nuts falling prematurely; withering inflorescences; yellowing leaves which then turn brown; orange to red-brown ring of discoloration when a cross section is taken of lower stem.

#### **Cause**

Nematode

#### **Comments**

Nematode spread to palms via American palm weevils and sugarcane weevils.

#### **Management**

If a tree becomes infected it should be removed and destroyed; control of the disease is currently limited to efforts to control the weevil which transmits the nematode to the palms.

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# Cocoyam

## Description

Cocoyams are herbaceous perennial plants belonging to the family Araceae and are grown primarily for their edible roots, although all parts of the plant are edible. Cocoyams that are cultivated as food crops belong to either the genus *Colocasia* or the genus *Xanthosoma* and are generally comprised of a large spherical corm (swollen underground storage stem), from which a few large leaves emerge. The petioles of the leaves stand erect and can reach lengths in excess of 1 m (3.3 ft). The leaf blades are large and heart-shaped and can reach 50 cm (15.8 in) in length. The corm produces lateral buds which give rise to tubers or cormels and suckers or stolons. Cocoyams commonly reach in excess of 1 m (3.3 ft) in height and although they are perennials, they are often grown as annuals, harvested after one season. *Colocasia* species may also be referred to as taro, old cocoyam, arrowroot, eddoe, macabo or dasheen and originates from Southeast or Central Asia. *Xanthosoma* species may be referred to as tannia, yautia, new cocoyam or Chinese taro and originates from Central and South America.

*Mature cocoyam roots for sale at a market in Nigeria*

*Taro leaf close-up*

*Colocasia esculenta*

*Aerial view of taro fields in French Polynesia*

*Young taro plants in French Polynesia*

*Cocoyam corms*

*Xanthosoma plant*

*Cocoyam*

*Colocasia plant*

## Uses

Cocoyam is most commonly grown for its starchy edible roots. *Colocasia* is grown for its corm which is consumed after boiling, frying or roasting. The corms can be dried and used to make flour or sliced and fried to make chips. The leaves of the plant are also edible and are usually consumed as a vegetable after cooking in dishes such as stews. *Xanthosoma* species produce tubers much like potato and are boiled, baked, steamed or fried prior to consumption. The corm of some varieties is also consumed. Young leaves are eaten as a vegetable.

*Colocasia corms*

## Propagation

**Basic requirements** Cocoyam grows best in fertile, well-draining, sandy loam soil with a pH between 4.2–7.5. It can be grown in a wide variety of conditions including paddies in wetland areas using a system similar to that of rice.

*Xanthosoma* species require temperatures above 21°C (69°F) to grow properly. Unlike *Colocasia* spp, they will not tolerate waterlogging and grow best in deep, well-draining loams with a pH between 5.5 and 6.5 in partial shade.

Cocoyam will thrive when planted in full sunlight or partial shade. The plants can survive for short periods at temperatures of 10°C (50°F) but will be damaged or killed by lower temperatures. **Propagation** Cocoyam is vegetatively propagated from headsets (â€œetopsâ€) or suckers which establish quickly and give the highest rate of survival. Larger headsets and suckers tend to produce larger corms and bigger yields but the size of the planting material may be determined by the particular cultivar being grown e.g. some varieties will produce two heads from the same corm if the sucker that is planted is too big and therefore medium sized suckers are selected when growing tubers for export. Headsets and suckers should only be taken from healthy plants in order to protect yields and prevent the spread of diseases. **Planting** Cocoyam is planted in such a way as to encourage sucker growth e.g. the use of larger plant spacing and shallow planting depths. The planting material (sucker or headset) is set in furrows or ridges and plant spacing can be anywhere between 30 to 100 cm (11.8â€“39.4 in) between plants depending on the prevailing soil and climatic conditions. A narrow spacing helps to control weeds whereas a wider spacing is preferred for good growth.

*Cocoyam plantation in Cameroon*

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## Common Pests and Diseases

### Diseases

#### Category : Viral

##### **Alomae-bobone** Colocasia bobone disease virus (CBDV)

*Symptoms of Colocasia bobone disease virus (CBDV)*

#### Symptoms

Leaves thickened, rolled and often brittle; leaf veins are prominent and develop enations; leaf petioles are shortened and also develop enations; plant may recover (bobone disease) Leaves thickened and dark green in color; distorted areas may develop on leaves and leaves may be cupped (but not rolled as in bobone disease); usually only one to three leaves affected (alomae disease)

#### Cause

Virus

#### Comments

Taro plants have been traditionally classified as 'male' or 'female' based on their susceptibility to two diseases, both of which are caused by Colocasia bobone disease virus (CBDV), which are known as bobone and alomae; 'male' plants are susceptible to alomae and die as a result of the infection, but are resistant to bobone; 'female' plants are resistant to alomae but susceptible to bobone from which they recover; the virus is transmitted by leafhoppers

#### Management

Remove any plants showing symptoms of disease and destroy by burning; removal of outer leaf sheaths may control the disease by reducing the number of leafhopper eggs

##### **Dasheen mosaic** Dasheen mosaic virus (DsMV)

*Dasheen mosaic virus symptoms on taro foliage*

*Mosaic pattern and leaf distortion caused by Dasheen mosaic virus*

*Leaf curling caused by infection with Dasheen mosaic virus*

*Dasheen mosaic virus symptoms on taro leaf*

*Dasheen mosaic virus symptoms on taro leaf*

## **Symptoms**

Mosaic pattern on leaves; mild to moderately distorted leaves

## **Cause**

Virus

## **Comments**

Transmitted by aphids; symptoms more pronounced in cooler temperatures; infected plants may show no symptoms of disease for several months after infection

## **Management**

The best method of control appears to be planting resistant varieties

## **Category : Fungal**

### **Phyllosticta leaf spot *Phyllosticta colocasiophila***

#### **Symptoms**

Oval or irregular beige to reddish brown spots on leaves; dark brown spots with chlorotic area around lesion; holes in leaves where lesion centers have dried and dropped out

#### **Cause**

Fungus

#### **Comments**

Disease emergence favored by cloudy, rainy weather

#### **Management**

No control is needed unless the disease is causing severe defoliation of the plants; remove and destroy any diseased leaves

## **Category : Oomycete**

### **Phytophthora leaf blight *Phytophthora colocasiae***

*Symptoims of leaf blight on taro foliage*

*Water-soaked lesion caused by taro leaf blight*

*Symptoims of leaf blight on taro foliage*

#### **Symptoms**

Small purple or dark brown, circular, water-soaked lesions on leaves which enlarge, turn purple-brown and may coalesce; lesions may exude clear amber fluid from center; lesions may form concentric pattern and develop white fuzz on both sides of leaves; holes may form in leaves where lesions have dried and dropped out; leaves collapse and die; disease may occur as a post-harvest rot of corms and causes large areas of dark gray to blue rot with indistinct margins

#### **Cause**

Oomycete

#### **Comments**

Disease emergence favored by rainy overcast weather with low night temperatures; disease spread primarily by splashing rain water

#### **Management**

Planting resistant varieties is the most effective method of controlling the disease; if plants do become infected, symptomatic leaves should be removed and destroyed to reduce the level of inoculum; plant cocoyam in well-draining

soils; disease may also be controlled by protective sprays of appropriate systemic or non-systemic fungicides where available

### **Pythium root and corm rot** *Pythium* spp.

#### **Symptoms**

Soft, mushy rot on corm with foul odor; root system may be completely destroyed; plants stunted with shortened leaf stalks; leaves curled, crinkled and yellowish in color; when corm is cut open rotted area is sharply delineated from healthy tissue

#### **Cause**

Fungi

#### **Comments**

Disease emergence appears to favor the presence of warm, stagnant water where cocoyam is grown in wetlands; poor field sanitation practices aid in the spread of the disease

#### **Management**

Some varieties are more resistant to the disease than others (e.g. Hawaiian varieties Kai Kea and Kai uliuli) and should be planted if disease is known to be a problem in the area; root rot severity can be reduced in acid soils by the addition of the fungicide Captan prior to planting

## **Pests**

### **Category : Insects**

#### **Pink hibiscus mealybug** *Maconellicoccus hirsutus*

*Pink hibiscus mealybug nymphs*

#### **Symptoms**

Stunted growth of plants at growing tips; leaves may be distorted; insects are soft bodied elongated ovals which are pink in color and covered in a white waxy substance; adults are approximately 2-4 mm in length

#### **Cause**

Insect

#### **Comments**

Pink hibiscus mealybugs have a very wide host range and may also be found on other crops such as cassava and mango as well as leguminous plants

#### **Management**

Pesticides are often largely ineffective at controlling the insects as they hide in crevices on the plants and avoid contact with the chemical; in the Caribbean, predatory beetles have been very successful at controlling populations of mealy bugs

#### **Taro beetle** *Papuana* spp.

*Eucopidocaulus* spp.

#### **Symptoms**

Tunnels bored in corms; tunnels may join together to form large cavities; large populations of insects may because the plants to wilt and die; adult insect is a shiny black scarab beetle

#### **Cause**

Insect

#### **Comments**

Beetle is a major pest of taro in Papua New Guinea and Fiji

### **Management**

The lack of chemical pesticides registered for use on taro beetles means that control relies largely on populations of natural enemies and cultural control methods; taro gardens in Papua New Guinea are often flooded in an attempt to control the pest; farmers may also apply wood ash to the crop

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# Coffee

## Description

### Crop details

Scientific name: Coffea

Family: Coffea

Genus: Coffea

Local names: Kahawa (Swahili)

Other names:

Spanish: cafÃ©

French: cafÃ©

German: Kaffee

Italian: caffÃ“

Portuguese: cafÃ©

Dutch: koffie

Swedish: kaffe

Norwegian: kaffe

Danish: kaffe

Finnish: kahvi

Russian: Кофе (kofe)

Arabic: قهوة (qahwah)

Turkish: kahve

Japanese: コーヒー (kōhī)

Chinese: 咖啡 (kāfēi)

Korean: 커피 (keopi)

## General Information

Coffee is grown in over 60 countries in the world, with the majority of the crop being produced in Brazil, Vietnam, Colombia, Indonesia, and Ethiopia. Other major African coffee-producing countries include Uganda, Ivory Coast, Tanzania, and Kenya, with the crop serving as a significant source of income for many farmers and an export commodity for many countries.

The coffee plant has a woody perennial evergreen shrub or small tree that can grow up to 30 feet (9 meters) tall in the wild, although it is usually pruned to a height of 6–10 feet (1.8–3 meters) to make it easier to manage for cultivation. The plant has a straight trunk, elliptical leaves, and small, fragrant white flowers that bloom in clusters. After the flowers are pollinated, the fruit, known as a coffee cherry, develops. Each cherry usually contains two seeds, which are the coffee beans that are harvested and roasted to make the coffee beverage. It takes 2 to 3 years for a coffee plant to mature and start producing berries, and it can continue to produce coffee berries for up to 25 years under good conditions.

*Coffee berries*

*Coffee plantation*

*Flower close-up*

*Coffee flowers*

*Coffee plant*

*Berries and foliage*

## Coffee Varieties

The two main coffee varieties are Arabica (**Coffea arabica**) and Robusta (**Coffea canephora**).

Arabica is the most widely consumed and accounts for approximately 60% of the world's coffee production. Arabica coffee is grown at high altitudes, typically above 2,000 feet (600 meters) above sea level, and is known for its delicate and complex flavor profile. Its berries have a smoother, sweeter taste, with notes of fruit, berries, chocolate, and nuts. They also have a lower caffeine content compared to robusta beans, which makes them a popular choice among coffee

enthusiasts.

On the other hand, robusta coffee beans are known for their strong and bitter taste, higher caffeine content, and lower acidity. The plants can grow at lower altitudes, typically between 900 and 1200 feet above sea level, and are generally more disease-resistant and easier to cultivate compared to arabica. It has a shallow root system and grows as a shrub tree to almost 10 meters tall and has evenly distributed flowers. It takes 10 to 11 meters for the cherries to ripen, though this ripening is determined by the rainfall distribution. Robusta beans are commonly used in espresso blends and instant coffees due to their strong flavor profile and affordability.

In Uganda, a number of varieties have been developed by the National Agricultural Research Organization (NARO), and close to 10 varieties of coffee that are high-yielding and resistant to coffee wilt have been released. These run from KR1 to KR10 (KR is an abbreviation for Kituza Robusta).

Other coffee varieties include:

**Liberica** : A coffee variety that is grown primarily in West Africa and Southeast Asia. Liberica beans have a unique flavor profile that is often described as smoky and woody with a floral aftertaste. They are known for their large size and irregular shape.

**Excelsa** : A coffee variety that is grown primarily in Southeast Asia. Excelsa beans have a tart and fruity flavor with hints of dark chocolate and a floral aroma. They are often used to add complexity to coffee blends.

**Maragogype** : A coffee variety that is grown primarily in Central and South America. Maragogype beans are very large and have a distinctive flavor that is often described as mild and nutty.

**Catuai** : A hybrid coffee variety that is a cross between Caturra and Mundo Novo. Catuai beans are grown primarily in Central and South America and are known for their high yield and balanced flavor profile.

**Bourbon** : A coffee variety that is grown primarily in Central and South America and Africa. Bourbon beans have a sweet and fruity flavor with a bright acidity and are often used in specialty coffee blends.

These are just a few examples of the many different coffee varieties that exist. Each variety has its own unique flavor profile and characteristics, and they are often used in different ways in the coffee industry.

## Uses

Coffee has a variety of uses beyond being a popular beverage. It is often used as an ingredient in cooking and baking, adding a rich and complex flavor to dishes. Coffee is also commonly used in the production of chocolate and is a key ingredient in espresso-based drinks like lattes and cappuccinos. In addition to its culinary uses, coffee has non-culinary uses as well. For example, coffee grounds can be used as a natural exfoliant in beauty products or as a deodorizer in the home. The caffeine in coffee is also used in some medications and cosmetics, as it has stimulating properties. Furthermore, coffee has been shown to have a variety of health benefits, including improving cognitive function and reducing the risk of certain diseases. Overall, coffee is a versatile and valuable commodity that has a range of uses beyond just being a beverage.

## Climatic, soil, and water conditions

Growing coffee requires specific climatic, soil, and water conditions. It is a tropical crop that thrives in areas with warm temperatures, abundant rainfall, and well-drained soil. The ideal temperature range for coffee growth is between 60-70°F (15-24°C). Heat stress can be caused by temperatures above 86°F (30°C), while temperatures below 50°F (10°C) can damage the coffee cherries. In terms of rainfall, coffee plants require a lot of water but also need well-drained

soil to prevent root rot. The ideal rainfall range for coffee growth is between 1200mm and 1800mm, well distributed over a period of nine months, with consistent rainfall throughout the growing season.

The soil type and quality are also important factors in coffee production. Coffee plants require nutrient-rich soil with good drainage, a slightly acidic pH level (between 5.5 and 6.5), and good aeration. The soil should also be deep enough to allow the roots to penetrate and access water and nutrients. Additionally, coffee plants grow best in areas with high levels of organic matter, which can be provided through the use of compost or other organic fertilizers.

Water is also a critical factor in coffee production. Coffee plants require consistent access to water throughout the growing season, with frequent watering during dry spells. However, the soil must also be well-drained to prevent waterlogging, which can cause root rot and other diseases. In some areas, irrigation systems may be necessary to ensure that the plants receive adequate water.

Overall, the climatic, soil, and water conditions for growing coffee must be carefully managed to ensure a successful harvest and high-quality cherries.

## Planting Procedure

The coffee planting procedure typically involves the following steps:

**Land preparation :** The land must be cleared of any existing vegetation, rocks, and other debris. The soil should then be tilled to a depth of at least 30 cm to loosen and aerate it.

**Selection of seedlings :** High-quality coffee seedlings should be selected from a reputable nursery or developed from seeds. Seedlings should be healthy, disease-free, and at least six months old.

**Digging of holes :** Holes should be dug at least 60 cm (2 feet) deep and 60 cm (2 feet) wide enough to accommodate the root ball of the seedling. The holes should be 3 meters apart.

**Planting of seedlings :** The seedlings should be carefully placed in the center of the hole. The soil in the hole should be uniformly mixed with well decomposed manure to boost growth and root establishment. Pest and disease-free seedlings should be selected.

**Mulching :** This is the covering of topsoil between the coffee trees. A layer of organic mulch, such as dry leaves or grass, coffee husks, composted manure, maize stalks, and rice stalks, should be applied around the base of the seedling to help retain moisture and suppress weed growth. Mulching regulates soil moisture, controls soil erosion, and helps retain water.

**Watering :** The newly planted seedlings should be watered immediately and regularly to ensure that the soil remains moist but not waterlogged. In dry spells or when the rains aren't regular, water bottle irrigation should be used, as this is the cheapest of all.

**Pruning :** At a later stage, when the plant has grown, pruning should be done to remove any weak, dead, unproductive, diseased, and broken branches and promote the growth of a strong central stem. Pruning reduces competition for nutrients and sunlight on the stem or plant and removes unproductive parts to help the plant grow vigorously. It should be carried out at the end of the harvesting season, just before flowering takes place.

**Fertilization :** Regular fertilization is necessary to provide the coffee plants with the nutrients they need to grow and produce high-quality cherries.

**Pest and disease control :** Pests and diseases lead to reduced production, reduced quality, and losses to the farmer. Some of the pests include the Coffee Twin borer (BCTB), Coffee Berry Borer (CBB), Coffee Mealybug, Coffee Leaf Miner, Coffee Leaf Skeletonizer, tailed caterpillars and Tailed Ant. Some of the Disease of Coffee include, Coffee Wilt Disease also known as "Fusarium wilt" or "Tracheomycosis spp" (CWD), Coffee Leafrust , Red blister (*Cercospora caffelcola*) and Root rot or Collar Crack Disease (*Armillaria mella*). Pests and diseases can be managed to reduce the rate of infection by doing

different practices, consulting government extension officers, PlantVillage field extension officers, or seeking knowledge through the PlantVillage Nuru application, which can be downloaded for free from the Google Playstore.

**Other maintenance practices :** Coffee plants require regular maintenance, including pest and disease control weeding, planting shade trees around the garden, planting cover crops within the plantation, irrigation, and thinning to ensure healthy growth and optimal yields.

The specific planting procedures may vary depending on the location, climate, and soil conditions, but the above steps provide a general overview of the process.

*Shaded coffee nursery*

*Coffee seedlings in polyethylene bags*

*Coffee nursery beds*

## Harvesting

Coffee is typically harvested by hand, which involves picking the ripe coffee cherries from the coffee plants. This can be accomplished through the use of either selective or strip-picking methods.

**Selective picking :** This involves going through the coffee fields and picking only the ripe coffee cherries. This is typically done in several phases, as the coffee cherries do not all ripen at the same time. The picker will gently pull the ripe cherry from the tree, taking care not to damage the surrounding branches or unripe cherries.

**Strip picking :** Also known as "milking," this is the complete removal of all the berries from the coffee tree at once. It can be done manually with hands or with machinery that shakes the tree and knocks off all of the cherries. However, strip picking is discouraged since it involves mixing mature and ripe cherries with immature and unripe ones, leading to ununiform drying and eventually reducing the taste and quality of the final product.

After harvesting, the coffee cherries are processed to remove the outer layers and reveal the coffee cherries inside. There are two main processing methods, which are dry processing and wet processing.

**Dry processing :** This is the drying of harvested coffee cherries under the sun. Solar dryers, cement floors, tarpaulins, and raised tables are used. In Uganda, for example, this process takes 2–4 weeks, depending on the weather conditions. The dried coffee is now called "kiboko," and it should be free of dust, mold, and a bad smell with a recommended moisture content of 13–14% before being taken to the milling machine. At the machine, the outer cover is removed from the inner beans. The outer cover is now coffee husks, and the dried beans are now called "clean coffee" or "FAQ," which means fair to average quality. This is then graded to different screen sizes and packed for storage, export, or value addition.

**Wet Processing :** Coffee processed using this method usually fetches high prices because it's of a higher quality than the one under dry harvesting; however, this process is more complicated and requires specific tools to run it. The processing can be a full wash or a semi-wash. In a full wash, the skin of the freshly harvested berries is removed either manually or using a pulling machine with the addition of water. Mucilage (the sugary coating) is fermented for 2–3 days, and the parchment is washed to remove all the fermented mucilage. The parchment is dried to attain the recommended 12–13% moisture content. To dry 1 kg of fresh berries, 5 to 10 liters of water are required, as well as good management in washing and fermenting to ensure that the flavor is not lost in the process. In a semi-wash, the fresh skin is physically removed using a pulling machine with the addition of water to avoid damaging the fabric. The mucin is then immediately removed with a mucin machine. No fermentation is done here. Once the mucilage is removed, the berries are now ready for drying to attain a moisture content of 12 to 13%. This process is faster than the full wash and uses less water—usually 0.5 to 1 liter for 1 kg of fresh cherries. However, it is not commonly used since a lot of expensive machines are used. It usually takes 7–12 days to dry the parchment coffee. This must be properly dried to avoid the growth of mold, rotting, and aflatoxins. Usually,

farmers under this system use raised wire meshes under a shade to avoid direct sunlight from cracking the beans. 12–13% moisture content should be maintained, and the coffee shouldn't be put in bare grounds or dirty environments.

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## Common Pests and Diseases

### Diseases

#### Category : Bacterial

##### **Bacterial blight** *Pseudomonas syringae*

###### **Symptoms**

Water-soaked spots on leaves which dry out and become brown and necrotic with yellow halos; necrosis of shoot tips which spreads rapidly down branches; leaves turn black and die off but remain attached to tree

###### **Cause**

Bacterium

###### **Comments**

Disease can be spread long distance by the movement of infected seedlings or within the field by water splash; bacteria can enter the plant through wounds

###### **Management**

Protective sprays of copper should be applied to the plants just before the onset of the rainy season and should be continued right through to the short rains

#### Category : Fungal

##### **Cercospora leaf spot (Brown eye spot, Berry blotch)** *Cercospora coffeicola*

*Cercospora leaf spot symptoms on coffee*

*Cercospora leaf spot symptoms on coffee*

*Cercospora leaf spot symptoms on coffee*

*Berry blotch caused by Cercospora infection*

*Cercospora leaf spot symptoms on coffee*

*Berry blotch caused by Cercospora infection*

*Berry blotch caused by Cercospora infection*

*Cercospora lesions on coffee leaves*

*Cercospora lesion on coffee*

*Cercospora symptoms on coffee plant*

*Cercospora lesions on coffee leaves*

## Symptoms

Brown spots on foliage which enlarge and develop gray-white center and a red-brown margin; lesions may also be surrounded by a yellow halo or may have a burned appearance if lesions are very numerous; infected leaves may drop from plant prematurely; lesions on green berries are brown and sunken and may have a purplish halo; infected red berries may have large black sunken areas

## Cause

Fungus

## Comments

Disease can be spread by wind, water-splash and through human movement through fields, particularly when plants are wet

## Management

Ensure crop is adequately fertilized as nutrient deficient plants are more susceptible to the disease; remove all crop debris from field after pruning to prevent build up of inoculum; good plant spacing and pruning to open up the canopy promotes good air circulation around foliage and protects against disease; if disease does occur then it can be controlled with the use of copper fungicides where available

## Coffee berry disease (CBD) *Colletotrichum kahawae*

*Lesions on coffee berries*

## Symptoms

Dark sunken lesions on green berries; berries dropping from plant; mummified berries

## Cause

Fungus

## Comments

Very serious disease; can destroy up to 80% of crop

## Management

Protective sprays of copper containing fungicides can help to control the disease; any diseased berries should be removed from plants; resistant varieties are available and should be planted in areas where disease is present

## Coffee leaf rust *Hemileia vastatrix*

*Coffee rust symptoms on leaves*

*Coffee rust symptoms on leaves*

*Coffee rust symptoms on leaves*

*Uredinium showing arrangement of spores; bar = 20 Åµm*

*Urediniospores; bar = 10 Åµm*

*Defoliation caused by coffee rust*

*Coffee rust pustules, bar = 0.5 cm*

*Coffee rust symptoms on leaves*

*Coffee rust symptoms, bar = 0.5 cm*

## Symptoms

Small, pale yellow spots on upper leaf surfaces followed by powdery orange-yellow lesions on the undersides of leaves; symptoms commonly develop on lower leaves of plant first and then spread; infected leaves drop from the plant and twigs and branches become defoliated

## Cause

Fungus

## Comments

**History** *Origins and spread* Coffee originates from high altitude regions of Ethiopia, Sudan and Kenya and the rust pathogen is believed to have originated from the same mountains. The earliest reports of the disease hail from the 1860s. It was reported first by a British explorer from regions of Kenya around Lake Victoria in 1861 from where it is believed to have spread to Asia and the Americas. Rust was first reported in the major coffee growing regions of Sri Lanka (then called Ceylon) in 1867 and the causal fungus was first fully described by the English mycologist Michael Joseph Berkeley and his collaborator Christopher Edmund Broome after an analysis of specimens of a ‘coffee leaf disease’ collected by George H.K. Thwaites in Ceylon. Berkeley and Broome named the fungus *Hemileia vastatrix*, *Hemileia* referring to the half smooth characteristic of the spores and *vastatrix* for the devastating nature of the disease. It is unknown exactly how the rust reached Ceylon from Ethiopia but over the years that followed, the disease was recorded in India in 1870, Sumatra in 1876, Java in 1878, and the Philippines in 1889. During 1913 it crossed the African continent from Kenya to the Congo, where it was found in 1918, before spreading to West Africa, the Ivory Coast (1954), Liberia (1955), Nigeria (1962–63) and Angola (1966). *The collapse of the coffee industry in Ceylon* In the nineteenth century, Ceylon was one of the largest coffee producing regions in the world, responsible for the export of approximately 42 million kilos of coffee per year. In the 28 years following the arrival of rust, export ceased and production was reduced to less than 3 kg/year. It wasn’t until 1879 that the government of Ceylon set up a commission to investigate the crisis and the British government sent Harry Marshall Ward to the plantations. Ward’s work on the coffee rust fungus would establish him as one of the most important figures in the field of plant pathology. Ward was able to link the collapse of the coffee crop to the *Hemileia vastatrix* fungus and, identify characteristics of both the fungal spore and agricultural practices that caused such a catastrophic loss. Unfortunately the investigation came too late and the rust epidemic was too far advanced. Ward could do little other than document the complete collapse of the coffee crop, as has been recounted in many histories of the disease (Large, 1940, Carefoot and Sprott 1967, Money 2007). Ward’s observations however, would provide the crucial basis for the development of future control strategies, discussed below.

**Biology and ecology of coffee rust** The collapse of the Sri Lankan coffee industry and Ward’s investigation of the agricultural practices being employed highlighted the problems created by planting coffee at such high densities. The proximity of the plants to one another created optimal conditions for rust transmission over short distances while the reduced genetic diversity resulting from the practice of monoculture meant that once the rust pathogen broke down the inherent host resistance, little could be done to prevent its spread. The pathogen, *Hemileia vastatrix*, evolved within the forest and adapted to the widely dispersed nature of the wild host by producing highly mobile spores that are capable of travelling large distances via wind currents, water splash and on the bodies of insects. The practice of removing native trees to plant coffee side by side, removed a natural barrier to the movement of the rust spores and helped compound the catastrophic crop losses witnessed in Ceylon. **Rust transmission and infection** Coffee leaf rust is an obligate parasite and is transmitted when urediniospores (spores produced from the brown-red rust pustules) disperse from one part of the plant to another, or to a new, uninfected plant. The spores are produced on the underside of the leaf from uredinia which make up part of the red/orange pustules on the undersides of the leaves. When the spores erupt, they enter the air current where they can

travel a few centimeters to the next leaf, or hundreds of kilometers to another site (spores have been recorded travelling 1,000 m up in the high altitude air streams). The spores are also known to travel over shorter distances by rain-splash, which is a common way for plant pathogens to travel from leaf to leaf of the same tree. There are also documented cases of spores being transported to new sites by small insects such as *Thrips* and parasitoid wasps. When the spores reach a leaf, they attach to the surface using the spines on their rough side. In order for the spores to germinate, they require the presence of liquid water on the leaves and a temperature of 17 to 25°C (62.6 to 77°F), with 22°C (71.6°F) being optimal. Heavy rains can wash the spores from the leaves and prevent infection occurring. When conditions are favorable, the spores produce a long tubes known as germ tubes which move over the leaf searching for a stomata (tiny openings in the leaf surface where plants breathe and release water). The germ tubes produce appressoria (flattened fungal structures that produce ~ pegs™ to puncture through host tissues) on, or close to the stomata, from which infection hyphae grow and puncture the host cells. The entire infection process is completed in 24 to 48 hours and new urediniospores erupt from the stomatal openings after 10 to 14 days. One rust lesion will produce 4–6 spore crops over a 3–5 month period releasing 300–400,000 spores into the environment to repeat the process. **The 2012 Coffee leaf rust epidemic** In 2012 there was a major increase in coffee rust across ten Latin American and Caribbean countries. The disease became an epidemic and the resulting crop losses pushed coffee prices to an all time high amid concerns for supply. The reasons for the epidemic remain unclear but an emergency rust summit meeting in Guatemala in April 2013 compiled a long list of shortcomings. These included a lack of resources to control the rust, the dismissal of early warning signs, ineffective fungicide application techniques, lack of training, poor infrastructure and conflicting advice. In a keynote talk at the ‘Let’s Talk Roya’ meeting (El Salvador, November 4th 2013), Dr Peter Baker, a senior scientist at CAB International, raised several key points regarding the epidemic including the proportional lack of investment in research and development in such a high value industry and the lack of investment in new varieties in key coffee producing countries such as Colombia.

## Management

**Resistant varieties** Commercially grown coffee has, through the practice of monocultures, lost much of the genetic diversity of its wild ancestors. Sadly, due to the effects of deforestation, wild coffee has also lost much of its genetic diversity outside of its evolutionary center in Ethiopia. The breeding of crop varieties which are resistant to key pathogens has proven to be a very successful method of controlling diseases and in the late 1950s, a natural coffee hybrid was discovered growing wild in East Timor. The plant was found to be a hybrid of *C. arabica* and *C. canephora* and was named Hibrido de Timor (HDT). The plant was found to possess full or partial resistance to all known races of the rust pathogen and five genes were subsequently elucidated from the hybrid and from other coffee varieties that were responsible for conferring the resistance. Varieties expressing some of these genes have been grown commercially but the resistance was broken-down after a few years when new virulent races of the rust pathogen emerged. Crosses of the hybrid with other commercial cultivars produced the ‘Colombia’™ cultivar which is now widely planted. Colombia managed to reduce its losses during the 2012/13 epidemic because of new plantings. Many Colombian farmers are now replanting with Castillo or Colombia varieties. **Fungicides** Copper-containing fungicides Copper-containing fungicides remain one of the most effective and economical methods of controlling the rust pathogen in susceptible coffee varieties and during conditions which are favorable to the development of rust. They have the added advantage of being active against a number of other fungal pathogens and have also been shown to increase coffee yields. Examples of copper-containing fungicides used in coffee include copper oxychloride and cuprous oxide which have largely replaced the use of Bordeaux mixture in most commercial plantations. These chemicals are applied protectively with plants being sprayed in advance of infection and work by adhering to the plant and producing a toxic barrier to invading fungal pathogens. They pose limitations due to their need to be reapplied at regular intervals to protect new growth flushes and also pose environmental concerns over the accumulation of copper to toxic levels in the soil. Copper-containing fungicides can be alternated with systemic fungicides to reduce the amount of copper build-up. **Systemic fungicides** Systemic fungicides used in coffee include pyracarbolid such as triadimefon and propiconazole and strobilurins such as azoxystrobin. Systemic fungicides are transported around the plant in the vascular tissue after application thus requiring lower doses and less frequent application than copper-based fungicides. They can be applied after infection has occurred to treat the symptoms of the disease and eradicate it from the host plant. Systemic fungicides tend to be more expensive and some have been shown to induce severe defoliation of the coffee plant. They have been shown to be very effective at controlling rust when used in combination with copper-containing fungicides. **Organic fungicides** Only one organic fungicide is widely used in coffee - triadimefon. Triadimefon is a systemic fungicide which is applied to the foliage and works to inhibit the rust infection. It can be alternated or combined with other

chemicals and is generally very effective at controlling rust infections. **Organically certified control methods** Most commercially grown coffee varieties are susceptible to coffee rust fungus and because organic farmers cannot use chemical approaches controlling the rust is extremely hard. (note that in some growing regions copper based fungicides are allowed). Here we discuss a few methods and we encourage others to share knowledge by [emailing PlantVillage](#) or answering questions on the forum.

- i) Planting spore traps. The fungal spore has a rough side that attaches to plant tissue. Wind-break trees can be used to reduce the spore load. Organic coffee is often grown using shade trees which may act to reduce inoculum reaching the coffee plants.
- ii) Spraying organic formulations that impacts the ability of the spore to germinate or of new spores to be produced. We have heard that some farmers had success with this strategy but we do not know the details. Dr Peter Baker of CABI has reported to us that some farmers are using lime sulphur because of the expense of copper. We will try and find more information. Please [contact PlantVillage](#) if you have information.
- iii) Spraying water. It is feasible that high pressure water can wash the spores from the leaves and reduce the spore load. Heavy rains may also have the same effect. As humidity on the leaves actually promotes fungal growth then washing is best done when the water is likely to evaporate.

**Biological control** Concepts Biological control is the use of one living organism to control another living organism that is considered a pest species. In addition to breeding new and better genetic material and the use of good crop husbandry, the development of an effective biological control strategy could provide another tool to manage coffee rust which would allow for organic certification and the continued use of heirloom varieties. If a suitable agent(s) can be identified in the short term, then this approach would be available in significantly less time than that needed to develop a new variety. CBC of fungi exploits the ability of coevolved fungal natural enemies in order to produce massive quantities of inoculum on the host plant and allow them to spread and propagate continuously within the host population. It offers a sustainable control method but has and has, surprisingly, never been used for crop pathogens (diseases). The concept is simple and follows the enemy-release hypothesis whereby an exotic or alien species increases its fitness, and hence its invasiveness, because it arrives without its guild of co-evolved natural enemies.

*Examples*

- i) Bacteria Bacteria such as *Bacillus* and *Pseudomonas* are known to produce compounds that negatively affect fungal pathogens of plants. Such bacteria evolved in the soil and utilize antifungal compounds to compete with soil dwelling fungi. A number of studies have shown how coffee rust development in greenhouse settings or in the lab can be retarded by *Bacillus* and *Pseudomonas*. For example, a study by Haddad et al, 2009 showed for the first time that certain strains of *Bacillus* and *Pseudomonas* reduced coffee rust on organic farms in Brazil. In follow up work the same team (Haddad et al 2014) found 17 different bacterial isolates collected from leaves, leaf debris, and soil reduced both the infection frequency and the number of *H. vastatrix* urediniospores produced per leaf by more than 70%.
- ii) Other fungi White halo fungus, *Lecanicillium lecanii*, has been suggested as a potential biological control agent of coffee rust by Prof. John Vandermeer and collaborators at the University of Michigan (Vandermeer et al 2009). White halo fungus has been shown to be hyperparasitic on *Hemileia vastatrix* in laboratory conditions and it has also been observed attacking the fungus in the field. White halo fungus often infects green coffee scale which feed on coffee. These insects are frequently tended by ants which collect the sugar that they excrete. The ants often create clusters of scale insects on the plants which are infected with white halo disease. It is postulated that white halo fungus may attack and kill the coffee leaf rust fungus or may simply reduce its abundance due to crowding effects or produce chemicals to attack it. Currently, the fungus does not appear to be a viable biological control agent because it has not evolved to parasitize the fungi, rather it evolved to infect insects. Promising attempts have been made to culture the fungus and apply it as a topical spray to control the rust fungus.

**Future prospects** Currently, no CBC program has focused explicitly on controlling coffee rust but pathogenic rusts have themselves been used to control other pests. For example, rubber vine is considered to be a major pest plant in Australia as it is highly invasive and causes millions of dollars of damage to agriculture and massive ecological damage. A team led by Dr. Harry Evans, a scientific officer with CAB International, identified a rust called *Maravalia* (which is taxonomically close to coffee rust) in the center of genetic origin for rubber vine in Madagascar which showed potential for use as a CBC agent. Before the rust could be released in the environment in Australia, it had to be quarantined. This process removed the rust from its natural enemies and had the effect of making the rust fungus extremely pathogenic. Dr. Evans' stated that the rust went "berserk" and when it was eventually deployed in Australia, it was extremely successful at controlling the rubber vine, even killing off young seedlings. In 2014, another team led by Dr. Evans and Dr. Roberto Barreto of the Federal University of Vicosa in Brazil will begin to explore genetic centers of origin of Arabica coffee with the aim of identifying similar co-evolved natural enemies of *Hemileia vastatrix*. It is believed that CBC holds great promise for the future control of coffee rust.

## Category : Other

## **Coffee Red Blister**

Symptoms

Cause

Comments

**Category :**

## **Coffee Rust Leaf**

Symptoms

Cause

Comments

## **Coffee Rust Leaf (underside)**

Symptoms

Cause

Comments

## **Coffee Rust Symptom**

Symptoms

Cause

Comments

## **Coffee Rust Symptom (underside)**

Symptoms

Cause

Comments

## **Healthy Coffee Berry**

Symptoms

Cause

Comments

## **Unknown**

Symptoms

Cause

Comments

## **Pests**

**Category : Insects**

### **Black twig borer *Xylosandrus compactus***

*Damage to coffee by black twig borer*

*"Flagging" coffee leaves caused by black twig borer injury*

**Symptoms**

Wilting and yellowing of foliage, often at end of twigs and branches (termed "flagging"); a pin sized hole can often be found on the underside of the flagging stems or twigs where the insect has entered the plant; twigs and stems are hollowed out and can be seen by cutting open the affected tissue; the adult beetle is small and black, approx. 2 mm in length and is rarely seen; eggs and pupae are creamy white in color

#### **Cause**

Insect

#### **Comments**

Damage caused by the beetles promotes secondary infestation by bacteria and other fungi; adult beetles overwinter in the plant

#### **Management**

Prune out infested twigs and stems and destroy; flagging branches should be pruned back a few inches from the beginning of symptomatic areas; adequate fertilizer and irrigation to ensure vigorous plants can speed recovery from pruning injury

### **Coffee berry borer** *Hypothenemus hampei*

#### **Symptoms**

Fruit dropping from plants; small holes may be evident on red cherries; when the insect is feeding, debris is pushed out of the hole and forms a brown or grey deposit on top of the hole; adult beetle can be found by cutting open the berry; adult is a tiny black beetle approx. 1.5-2.5 mm in length; larvae are white grubs with brown heads

#### **Cause**

Insect

#### **Comments**

Female beetle lays clusters of eggs inside the berries; insect undergoes up to 5 generations per year

#### **Management**

Removal of dropped berries and debris on plantation floor can help reduce sources of new infections; remove any berries remaining on plants after harvest; insecticide application is only effective if applied when the female beetle is still in the entry tunnel and has not yet penetrated deep into the berry

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# Collard greens

## Description

Collards, *Brassica oleracea* var *viridis* are herbaceous annual or biennial plants in the family Brassicaceae grown for their edible leaves which are consumed as a vegetable. Collards are erect, branched plants with thick stems and irregularly lobed dark green leaves with long petioles. The plant produces clusters of small yellow flowers on racemes. Collards can reach 1 m (3.3 ft) in height and are usually grown as annuals, harvested after one growing season. Collards may also be referred to as collard greens or tree cabbage and likely originated from a wild ancestor in ancient Asia minor.

*Collards and mustard greens*

*Harvested collard greens ready for sale*

*Collard plant*

*Harvested collard leaves*

*Collards*

## Uses

Collards leaves are usually consumed after cooking and are eaten as a leafy green vegetable.

# Propagation

**Basic requirements** Collard greens are a cool season crop that grow best in cool, moist conditions. The plant will grow best at temperatures between 4 and 21°C (40–50°F) allowing it to be grown in both Spring and Fall. Collards are very hardy and will tolerate frost. The plants will grow optimally in a rich, moist, well draining soil with a pH of 6.5. Collard greens require at least six hours of direct sunlight every day. **Sowing seeds** Collard greens can be direct seeded or started indoors for transplants. The optimum soil temperature for germination is between 12 and 24°C (55–75°F). Collard seeds should be planted after any danger of hard frost or in a cold frame for transplanting to their final location. For Fall harvest, plant collard seeds in July so that the plants develop in cooler weather. Prepare the soil for planting through the addition of nitrogen in the form of bone meal or composted manure. Plant seeds 6 mm (0.25 in) deep allowing 3.5 cm (1 in) between plants in the row, allowing 0.6–1.2 m (2–4 ft) between rows. Thin seedlings to a final within row spacing of 30–60 cm (12–24 in). Keep soil moist during germination to prevent a crust from forming on the soil surface as this will cause uneven germination. **Transplanting** Seedlings started indoors or in a cold frame are ready to be transplanted when they have 5–6 true leaves. Seedlings should be planted at the final spacing for seeds (30–60 cm/12–24 in between plants and 0.6 to 1.2 m/2–4 ft between rows). Plant each seedling slightly deeper than it was previously. The plantings can be staggered in 2 week intervals to prolong the harvest. **General care and maintenance** Collards should be kept evenly watered, application of mulch around plants helps to conserve soil moisture. The plants have shallow roots and in order to avoid damaging them, it is preferable to hand pull any weeds growing around the plants. Collards are heavy feeders, requiring plentiful nitrogen to meet their growth requirements and develop optimally. Apply an appropriate complete fertilizer when thinning seedlings. **Harvesting** Collard greens can be harvested about 2 months after planting. Harvest the outer leaves to avoid damaging the growing tip of the plant. Collard leaves are sweeter when they are harvested after frost..

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Alternaria leaf spot** *Alternaria* spp.

##### **Symptoms**

Brown to tan concentric rings with yellow edges on leaves; centers of lesions developing gray to brown soft fungal mold; brown to black lesions with a black border on roots

##### **Cause**

Fungus

**Comments**

Disease emergence favors warm, wet conditions

**Management**

Plant only pathogen-free seed; rotate crops; applications of appropriate fungicides control disease when present

**Anthracnose** *Colletotrichum higginsianum***Symptoms**

Small circular or irregularly shaped dry spots which are gray to straw in color on leaves; a high number of spots may cause the leaf to die; lesions may coalesce to form large necrotic patches causing leaves to turn yellow and wilt; lesions may split or crack in dry centers; dry sunken spots on roots which enlarge and turn gray or brown

**Cause**

Fungus

**Comments**

Fungus overwinters on leaf debris and on related weeds; disease emergence is favored by moist, warm conditions

**Management**

Control of disease depends on sanitary practices; treat seeds with hot water prior to planting; rotate crops; plant in an area with good soil drainage; remove all cruciferous weeds which may act as a reservoir for the fungus

**Black rot** *Xanthomonas campestris***Symptoms**

Seedlings develop wilted yellow to brown leaves and collapse; yellow, V-shaped lesions on mature leaf margins; dark rings can be found in the cross section of the stem

**Cause**

Bacterium

**Comments**

Disease emergence favors warm, wet conditions

**Management**

Primary control methods based on good sanitation; plant disease-free seed; rotate crops every 2 years or less to non-brassica; avoid sprinkler irrigation

**Cercospora leaf spot (Frogeye leaf spot)** *Cercospora brassicola***Symptoms**

Angular or circular green to gray spots with brown borders on leaves; plant defoliation may occur in the case of a severe infestation

**Cause**

Fungus

**Comments**

Disease emergence favors cool temperatures and wet weather

**Management**

Plant only certified disease-free seed; avoid overhead irrigation; rotate crops to non-brassica species for 2-3 years; apply appropriate fungicide if disease emerges

**Clubroot** *Plasmodiophora brassicae***Symptoms**

Slow growing, stunted plants; yellowish leaves which wilt during day and rejuvenate in part at night; swollen, distorted roots; extensive gall formation

**Cause**

Fungus

**Comments**

Can be difficult to distinguish from nematode damage; fungus can survive in soil for periods in excess of 10 years; can be spread by movement of contaminated soil and irrigation water to uninfected areas

### **Management**

Once the pathogen is present in the soil it can survive for many years, elimination of the pathogen is economically unfeasible; rotating crops generally does not provide effective control; plant only certified seed and avoid field grown transplants unless produced in a fumigated bed; applying lime to the soil can reduce fungus sporulation

## **Downy mildew** *Peronospora parasitica*

*Downy mildew symptoms on collards*      *Downy mildew symptoms on collards*

### **Symptoms**

Gray to white fluffy mold on the underside of leaves; tan to yellow dry spots on upper surface of leaves; leaves dropping

### **Cause**

Fungus

### **Comments**

Disease emergence favors cool temperatures; disease spreads quickly in wet conditions

### **Management**

Remove all crop debris after harvest; rotate with non-brassicas; application of appropriate fungicides may be required if symptoms of disease are present

## **White leaf spot** *Pseudocercosporella capsellae*

### **Symptoms**

Small, necrotic, brown spots on leaf tips or margins that matures to light gray or white with the original dark spot in center; margins of lesions may be darker; lesions may coalesce to form large chlorotic areas and cause defoliation

### **Cause**

Fungus

### **Comments**

Disease emergence favors cool and wet conditions

### **Management**

No known plant resistance to white leaf spot so control relies on cultural practices such as rotating crops and removing weeds; application of appropriate fungicide may help control the disease

## **Wirestem (Damping-off)** *Rhizoctonia solani*

### **Symptoms**

Death of seedlings after germination; brown-red or black rot girdling stem; seedling may remain upright but stem is constricted and twisted (wirestem)

### **Cause**

Fungus

### **Comments**

Disease emergence favors slow growing, deeply seeded plants and cool, wet soils

### **Management**

Plant pathogen-free seed or transplants that have been produced in sterilized soil; apply fungicide to seed to kill off any fungi; shallow plant seeds or delay planting until soil warms

## **Pests**

## Category : Insects

### Beet armyworm *Spodoptera exigua*

Young larvae

Beet armyworm eggs covered in white hairs

Beet armyworm larva

#### Symptoms

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside

#### Cause

Insect

#### Comments

Insect can go through 3–5 generations a year

#### Management

Organic methods of controlling the beet armyworm include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae

### Cabbage aphid *Brevicoryne brassicae*

Cabbage aphid colony

#### Symptoms

Large populations can cause stunted growth or even plant death; insects may be visible on the plant leaves and are small, grey-green in color and soft bodied and are covered with a white waxy coating; prefer to feed deep down in cabbage head and may be obscured by the leaves

#### Cause

Insect

#### Comments

Cabbage aphids feed only on cruciferous plants but may survive on related weed species

#### Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

### Cabbage looper *Trichoplusia ni*

Cabbage looper and damage

## Symptoms

Large or small holes in leaves; damage often extensive; caterpillars are pale green with a white lines running down either side of their body; caterpillars are easily distinguished by the way they arch their body when moving; eggs are laid singly, usually on the lower leaf surface close to the leaf margin, and are white or pale green in color

## Cause

Insect

## Comments

Insects overwinter as pupae in crop debris in soil; adult insect is a dark colored moth; caterpillars have a wide host range

## Management

Looper populations are usually held in check by natural enemies; if they do become problematic larvae can be hand-picked from the plants; an organically acceptable control method is the application of *Bacillus thuringiensis* which effectively kills younger larvae; chemical sprays may damage populations of natural enemies and should be selected carefully

## Cutworms *Agrotis* spp.

*Peridroma saucia*

*Nephelodes minians*

and others

*Cutworms will curl up into a characteristic C shape when disturbed*

*Cutworm feeding on plant stem*

*Cutworm larva severing plant stem*

## Symptoms

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5–5.0 cm (1–2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed

## Cause

Insects

## Comments

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato

## Management

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically

## Diamondback moth *Plutella xylostella*

*Larva feeding on cabbage leaf*

*Diamondback moth pupae*

## Symptoms

Young larvae feed between upper and lower leaf surface and may be visible when they emerge from small holes on the underside of the leaf; older larvae leave large, irregularly shaped shotholes on leaf undersides, may leave the upper surface intact; larvae may drop from the plant on silk threads if the leaf is disturbed; larvae are small (1 cm/0.3 in) and

tapered at both ends; larvae have to prolegs at the rear end that are arranged in a distinctive V-shape

#### **Cause**

Insect

#### **Comments**

Larvae take between 10 and 14 days to mature and spin a loose, gauze-like cocoon on leaves or stems to pupate

#### **Management**

Larvae can be controlled organically by applications of *Bacillus thurengiensis* or Entrust; application of appropriate chemical insecticide is only necessary if larvae are damaging the growing tips of the plants

### **Flea beetles** *Phylotreta* spp.

*Crucifer flea beetle damage on broccoli leaf*

#### **Symptoms**

Small holes or pits in leaves that give the foliage a characteristic “holey” appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5–3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance

#### **Cause**

Insects

#### **Comments**

Younger plants are more susceptible to flea beetle damage than older ones; older plants can tolerate infestation; flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year

#### **Management**

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application of diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied

### **Large cabbage white (Cabbageworm)** *Pieris rapae*

*Cabbageworm and frass*

#### **Symptoms**

Large ragged holes in leaves or bored into head; green-brown frass (insect feces) on leaves; caterpillar is green in color and hairy, with a velvet-like appearance; may have faint yellow to orange stripes down back; slow-moving compared with other caterpillars

#### **Cause**

Insect

#### **Comments**

Larvae can be distinguished from other caterpillars by their sluggish movement; in large numbers larvae can cause extensive damage very quickly

## **Management**

Hand-pick caterpillars from plants and destroy; scrape eggs from leaves prior to hatching; apply appropriate insecticide if infestation is very heavy

## **Thrips (Western flower thrips, Onion thrips, etc.)** *Frankliniella occidentalis*

*Thrips tabaci*

*Western flower thrips*

### **Symptoms**

If population is high leaves may be distorted; leaves are covered in coarse stippling and may appear silvery; leaves speckled with black feces; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color

### **Cause**

Insect

### **Comments**

Transmit viruses such as Tomato spotted wilt virus; once acquired, the insect retains the ability to transmit the virus for the remainder of its life

## **Management**

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic

## **Category : Nematodes**

### **Root knot nematode** *Meloidogyne* spp.

#### **Symptoms**

Galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; reduction in plant vigor; yellowing plants which wilt in hot weather

#### **Cause**

Nematode

#### **Comments**

Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or garden with this type of soil is most likely

## **Management**

Plant resistant varieties if nematodes are known to be present in the soil ;check roots of plants mid-season or sooner if symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens

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# Coriander (Cilantro)

## Description

Coriander, *Coriandrum sativum*, is an erect annual herb in the family Apiaceae. The leaves of the plant are variable in shape, broadly lobed at the base of the plant, and slender and feathery higher on the flowering stems. It is a soft, hairless plant. The flowers are produced in small umbels and are white or very pale pink in color with the petals pointing away from the centre of the umbel longer than those pointing towards it. The plant produces an oval shaped fruit which is yellow-brown in color and contains two seeds. Coriander is an annual plant, surviving only one growing season and reaches up to 50 cm (19.7 in). Coriander may also be referred to as cilantro, chinese parsley or dhania and originates from the Near East.

*Coriander foliage*

*Coriander fruits*

*Honey bee on coriander flower*

*Coriander flowers*

*Coriander foliage*

## Uses

All parts of the coriander plant are edible, but the fresh leaves and the dried seeds are most commonly used. Leaves and seeds are used fresh or dried as a herb in cooking.

Dried coriander seeds are used as a spice

## Propagation

**Basic requirements** The plant grows optimally in areas with damp, cool springs and hot, dry summers at temperatures between 17 and 27°C (62.6–80.6°F) depending on the variety. The plant can tolerate light frost but hot temperatures will cause the plants to bolt. Coriander grows best in well-draining soil and can be grown in sandy loam, loam and clay soils as long as there is sufficient drainage. The plants will grow best when positioned in full sun. **Propagation** Coriander is propagated directly from seeds and should be sown after the last frost. The seeds should be planted in a prepared bed by planting seeds 0.6 to 1.2 cm (0.25–0.5 in) deep allowing 5cm (2 in) between seeds and 30 to 38 cm (12–15 in) between rows. Plantings can be staggered to ensure a continuous harvest. The seeds should be kept moist. **General care and maintenance** Once the young coriander plants are established they require little water as the plants do not perform well in damp conditions. The plants should be kept free of weeds, particularly when they are young to prevent competition for nutrients. The plants will benefit from the addition of fertilizer during the growing season. Phosphorous and potassium often limit the growth of coriander whereas the demand for nitrogen is not very high. **Harvest** Coriander can be harvested 45 to 70 days after planting. Leaves can be removed from the outside of the plant when they have reached 10 to 15 cm (4–6 in) in length. Commercially grown coriander is harvested by cutting the entire plant at soil level or 4 to 5 cm (1.5–2.0 in) above the crown, The bunches are then secured with a rubber band or tied together with a twist tie.

Harvested bunches of coriander

Coriander seedlings

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## Common Pests and Diseases

### Diseases

#### Category : Bacterial

##### Bacterial leaf spot *Pseudomonas syringae*

#### Symptoms

Very small water-soaked spots between leaf veins which enlarge and turn dark brown to black; stems may have elongated dark streaks; inflorescences yellowing and turning brown and blighted; water-soaked lesions on fruit

#### Cause

Bacterium

#### Comments

Disease is transmitted through infected seed and can be spread by splashing irrigation water and rain

#### Management

Bacterial leaf spot is difficult to control; plant pathogen-free seed; avoid overhead irrigation; do not work with plants when they are wet

#### Soft rot *Erwinia carotovora*

*Erwinia chrysanthemi*

*Pseudomonas marginalis*

#### Symptoms

Small water-soaked lesions near base of petioles which become soft, sunken and brown

#### Cause

Bacteria

#### Comments

Bacteria thrive in oxygen depleted plant tissue; disease emergence requires long periods of water saturated soil; bacteria enter plants through wounds

#### Management

Control relies on the avoidance of conditions conducive to bacterial infection: plant coriander in well-draining soils; allow plants to dry before irrigating again; avoid wounding plants during harvest to prevent post harvest development of disease; disinfect all equipment regularly

### Category : Viral

#### Carrot motley dwarf (CMD)

Carrot redleaf virus (CRLV)

+ Carrot mottle virus (CMoV)

#### Symptoms

Yellow and red leaves; stunted plant growth

#### Cause

Viruses

#### Comments

Disease transmitted by aphids; both viruses must be present to cause carrot motley dwarf

#### Management

Avoid planting coriander in close proximity to overwintered carrot fields

### Category : Fungal

#### Damping-off *Pythium* spp.

*Rhizoctonia solani*

#### Symptoms

Soft, rotting seeds which fail to germinate; rapid death of seedling prior to emergence from soil; collapse of seedlings after they have emerged from the soil caused by water-soaked reddish lesions girdling the stem at the soil line

#### Cause

Fungi

#### Comments

Damping-off diseases favor conditions which slow seed germination; fungi can be spread in water, contaminated soil or

on equipment

### **Management**

Avoid planting in poorly draining, cool, wet soil; planting in raised beds will help with soil drainage; plant high quality seed that germinates quickly; treat seeds with fungicide prior to planting to eliminate fungal pathogens

### **Powdery mildew *Erysiphe heraclei***

#### **Symptoms**

Powdery growth on leaves, petioles flowers stalks and bracts; leaves becoming chlorotic; severe infections can cause flowers to become distorted

#### **Cause**

Fungus

#### **Comments**

Fungus can spread long distances in air; disease emergence is favored by high humidity and moderate temperatures; infection is most severe in shaded areas

### **Management**

Plant tolerant varieties; avoid excess fertilization; protective fungicide applications provide adequate protection; sulfur application can be used in infection occurs early in season

## **Pests**

### **Category : Insects**

#### **Aphids (Willow-carrot aphid) *Cavariella aegopodii***

*Carrot-willow aphid*

#### **Symptoms**

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants

#### **Cause**

Insect

#### **Comments**

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed; willow-carrot aphid will also attack parsnip, carrot and celery

#### **Management**

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

#### **Armyworm *Pseudaletia unipuncta***

## Armyworm

### Symptoms

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside

### Cause

Insect

### Comments

Insect can go through 3–5 generations a year

### Management

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae

### Cutworms *Agrotis* spp.

*Peridroma saucia*

*Nephelodes minians*

and others

*Cutworm severing plant stem*

### Symptoms

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5–5.0 cm (1–2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed

### Cause

Insects

### Comments

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato

### Management

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically

## Category : Nematodes

### Root knot nematode *Meloidogyne* spp.

#### Symptoms

Galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; reduction in plant vigor; yellowing

plants which wilt in hot weather

**Cause**

Nematode

**Comments**

Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or garden with this type of soil is most likely

**Management**

Plant resistant varieties if nematodes are known to be present in the soil ;check roots of plants mid-season or sooner if symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens

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# Maize (corn)

## Description

### Crop Details

The following are the crop details for maize (corn)

Scientific name: Zea mays

Local names: "Mahindi" in Swahili, "maíz" in Spanish, "maïs" in French, "Mais" in German, "grano" or "mais" in Italian, "milho" in Portuguese, "玉米" (yǐmǐ) in Chinese, "मक्का" (makkā) in Hindi, "ذرة" (dhira) in Arabic, and "кукуруза" (kukuruza) in Russian

Order: Poales

Family: Poaceae

Subfamily: Panicoideae

Genus: Zea

### General Information

Maize is a staple food for almost half the population of sub-Saharan Africa and is important for its carbohydrate, proteins, iron, vitamin B, and minerals. The produce is consumed as maize meal (ugali), porridge, pastes, and beer, and can be boiled or roasted as fresh as it comes from the farm. Maize is also processed to produce oils for cooking. It is also

an important crop for animal feed.

Smallholder farmers are the largest producers of maize in sub-Saharan Africa. The maize is produced through subsistence farming as part of mixed agricultural systems which lack inputs such as fertiliser, irrigation, improved seeds and efficient labor.

In 2017, Africa produced 7.4% of the 1,135 million tonnes produced worldwide in 40 million hectares, according to data by the Food and Agriculture Organization (FAO).

*Maize field*

*Ripened maize*

*Harvested maize*

*Maize field*

*Maize ear*

*Maize ears*

*Maize silks*

*Maize tassel*

*Maize foliage*

## Maize Varieties

The history of maize varieties in the continent spans way back in 1500 AD when the crop was introduced in Africa and spread in every corner of the continent. Today, there are about 50 species with different texture, color, grain sizes and shapes. White and yellow maize are the most commonly cultivated, and production of seed varieties depends on the region's soil and climatic conditions.

PlantVillage recommends use of certified seeds suitable for appropriate soil and climatic conditions.

Here are some of the maize varieties grown in Kenya:

H614: this is a white maize variety that is popular in Kenya due to its high yield potential, good grain quality, and tolerance to diseases such as maize streak virus.

H6213: a yellow maize variety is planted for its high yield potential, good grain quality, and tolerance to drought and pests such as the maize stem borer.

DH01: this is a hybrid maize variety popular for its high yield potential, good drought tolerance, and resistance to diseases such as maize lethal necrosis disease.

PH4: this is a yellow maize variety that is popular in Kenya due to its high yield potential, good resistance to diseases such as leaf rust, and tolerance to drought.

DK8031: this hybrid maize variety is popular in Kenya for its high yield potential, good grain quality, and tolerance to diseases such as grey leaf spot.

Longe 5H: this is a white maize variety grown for its high yield potential, good drought tolerance, and tolerance to diseases such as maize streak virus.

The following are some of the maize varieties grown in Tanzania:

Staha: for low to medium altitude (1-900 m); maturity of 110-130 days; tolerant to drought and also humid conditions  
Kilima, UCA (OPV): for medium to slightly high altitude (900-1700 m); maturity of 110-130 days; yield potential of 45-65 bags of 90 kg / ha

Situka (OPV): for medium altitude (500-1600 m); maturity of 110-120 days; yield potential of 45-65 bags of 90 kg / ha; tolerant to low nitrogen; resistant to cob rots, grey leaf spot and maize streak virus

TMV-1 (OPV): for low to medium altitude (1-900 m); maturity of 110-120 days

Kito: for low to medium altitude (1-750 m); maturity of 90 days; yield potential of 22-30 bags of 90 kg / ha; drought tolerant

These are some of the maize varieties grown in Uganda:

Longe 4 (OPV): for low land to mid altitude areas; maturity of 100-115 days; yield potential of 40-55 bags of 90 kg / ha; tolerant to maize streak virus, rust and grey leaf spot.

Longe 8 H: for mid-altitude; maturity of 120-125 days; potential yield of 88--10 bags of 90 kg / ha; excellent husk cover; tolerant to cob rots, drought and poor soil; resistant to maize streak virus, northern leaf blight and grey leaf spot; a very popular hybrid in Uganda.

Longe 5 (Nalongo) (QPM Maize): for low land to mid altitude areas; maturity of 115 days; potential yield of 40-50 bags of 90 kg / ha; quality protein maize with lysine and tryptophan amino acids; drought tolerant; resistant to maize streak virus, grey leaf spot; moderately resistant to northern leaf blight.

## Climatic conditions, soils, and water management

Maize is a versatile crop that can grow in different varieties of soil, water, and climatic conditions. The crop has a wide range of tolerance to temperature conditions but grows well in warm regions where moisture is sufficient. The crop flourishes in regions with rainfall ranging from 1200mm to 2500mm but can adapt to regions receiving rainfall of up to 400 mm. The crop requires warm temperatures of between 15°C and 30°C and thrives in a range of zones with altitudes ranging from 100 m to 2900 m ASL, depending on the variety.

The crop is sensitive to moisture stress around tasseling time and during cob formation. Growth is favorable under a pH ranging from 5-8 with 5.5-7 being optimal because it is sensitive to salinity.

## Planting Procedure

The planting procedure for maize is as follows:

### Choice of seed

The first step to getting maximum yield is ensuring you plant healthy, certified seeds. Apart from the varieties shown above, H614, H626, and H627 for attitudes ranging from 1500 to 2100 M ASL; KATUMANI, DH O2, DH O4, and Drought TEGO for attitudes ranging from 600 to 1300 M ASL; H 513, H 511, and H 516 for attitudes ranging from 800 to 1500 M ASL; and

PH1, PH4 for attitudes ranging from 0 to 1200 M ASL are some of the other seed varieties planted in East Africa.

### **Land Preparation**

The piece of land for planting maize should be prepared early, before the onset of rains, for weeds to decompose before planting. The following procedure for planting can be followed:

Spray weeds with the appropriate chemicals.

Plough the land and make it level with a fine tilth. Considering the size of the land, machines like tractors or ox-drawn ploughs can be used, observing the correct spacing.

Mix soil with manure and biochar for efficient and improved nutrient uptake as well as stabilizing soil pH.

Make holes at a spacing of  $90 \times 30$  cm if soil fertility is low or  $75 \times 25$  cm if soil fertility is relatively high.

Place 1 or 2 seeds per hole, or alternate 1 and 2 seeds at a depth of about 4 cm if the soil is moist and about 10 cm if the soil is dry.

Cover the seeds with loose soil.

## **Planting Time**

It is important to plant maize early in the season because late planting adversely affects yield. Plant within two weeks of the onset of rainfall in the highlands and before the onset of rainfall in the lowlands to make use of the scarce rainfall.

## **Field Operations**

### **Thinning and Gapping**

Gapping is done to replace seeds that did not germinate after others germinated completely. Thinning is done when maize has grown to about 15 cm in height by removing weak and deformed seedlings to make space for healthy seedlings in a hole.

### **Fertilizer application**

To achieve maximum yield, fertilizer should be applied on time. Manure and biochar can also be added to soil with little or no organic matter.

When planting manually, thoroughly mix soil with a teaspoonful of fertilizer into each planting hole to ensure that it doesn't burn the seeds. Place the seeds on top of the soil and feel for softness.

DAP is recommended for planting because it contains phosphorous, which helps in root development.

### **Top dressing**

Maize can be top dressed with CA 2-3 weeks after planting or when it is 45 cm (1 ft) high. One teaspoon of fertilizer should be applied to the base of each plant, 15 cm away from the plant in a ring or along the row.

Top dress in two stages in areas with heavy rainfall: the first six weeks after sowing and the second 10-15 days later, or just before tussling.

In areas experiencing low rainfall, topdressing is done only once at a rate of 50-100 kg per acre.

Using CAN and urea for topdressing is good because it fixes nitrogen in the soil. Nitrogen increases the green color of the leaves to make food for the plant.

### **Weeding**

Remove weeds mechanically, manually, or by using herbicides to prevent them from competing with the crops for nutrients, water, and light.

First weeding, if done manually, should be done three weeks after planting, depending on the intensity of weeds in the field.

Herbicides can be applied in two phases: pre-emergence, which is used before the maize germinates and weeds appear, and post-emergence, which is applied after the maize and weeds germinate.

## Harvesting

Normally, each maize stalk should yield one large ear of maize, but in ideal conditions, the stalk can yield a second, slightly smaller ear that matures slightly later than the first. Maize is ready for harvesting when the kernels within the husks are well packed and produce a milky substance when the kernel is punctured.

*Maize should be planted in blocks rather than a single row*

*Partially filled ears are usually a result of poor pollination*

## Physiological Diseases

**Nitrogen deficiency** The typical symptom of nitrogen deficiency is the plant turns pale green; a "V" shaped yellow coloration on leaves. This pattern starts from leaf end to leaf collar. The symptom begins from lower to upper leaves.

**Phosphorous deficiency** The deficient plants are dark green and lower leaves show reddish-purple discoloration.

**Potassium deficiency** The leaf margins turn yellow and brown which appears like firing or drying. The symptoms progress from lower leaves to upper leaves.

**Sulfur deficiency** Symptom appears on younger leaves where we will see yellow color striping(interveinal chlorosis).

**Zinc deficiency** Upper leaves shows broad bands of yellow coloration and later turn pale brown or gray necrosis(dead-spots). The symptom first appears in the middle of leaves and progress outward.

*Zinc deficiency*

*Symptoms of Phosphorous deficiency*

*Field maize plant, the bottom leaf of which is showing symptoms of nitrogen deficiency.*

*Zinc deficiency. Shortening of internodes and light streaking of leaves followed by a broad stripe of bleached tissue on each side of the midrib. Occasionally the leaf edges and interior of the stalks at the nodes appear purplish.*

*Leaves of maize showing characteristic "V" coloration indicating nitrogen deficiency.*

## Common Pests and Diseases

### Diseases

#### Category : Fungal

## **Anthracnose** *Colletotrichum graminicola*

<i>Stalk rot symptom</i>	<i>Stalk rot symptom due to anthracnose disease (<i>Colletotrichum graminicola</i>)</i>	<i>Symptoms of anthracnose on leaves (<i>Colletotrichum graminicola</i>)</i>
<i>Anthracnose leaf blight on maize</i>	<i>Anthracnose lesion on maize leaf</i>	<i>Anthracnose lesions on maize leaves</i>

### **Symptoms**

Anthracnose symptoms vary widely depending on numerous factors such as genotype, age of plant and environmental conditions.

- Small oval or elongated water-soaked spots which enlarge up to 15 mm long appear on leaves
- Lesions develop a tan center and red-brown or orange border
- Lesions may coalesce to form large necrotic(dead) patches
- Severely infected leaves on susceptible hybrids may wither and die
- Fungal fruiting bodies develop on dead tissues and may produce pink or orange spore masses
- Top dieback and stalk rot

### **Cause**

Fungus

### **Comments**

Fungus survives the winter on crop debris. Emergence of disease is favored by high temperatures and extended periods of wet and cloudy weather - seedlings and mature plants are most susceptible to the disease.

### **Management**

Plant hybrids resistant to anthracnose; rotating crops and plowing crop debris into soil may help reduce incidence of early season infections.

## **Cercospora leaf spot (Gray leaf spot)** *Cercospora zaeae-maydis*

<i>Gray leaf spot</i>	<i>Small necrotic(dead) spots with chlorotic halos on leaves which expand to rectangular lesions 1-6 cm in length and 2-4 mm wide</i>	<i>Gray leaf spot (<i>Cercospora zaeae-maydis</i>)</i>
<i>Symptoms on maize leaf</i>		<i>Close up view of gray leaf spot with white sporulation</i>
<i>Gray leaf spot on maize</i>	<i>Symptoms</i>	
<i>Maize leaf showing characteristic rectangular Cercospora lesions</i>	<i>Leaf completely blighted by Cercospora</i>	<i>Cercospora lesions</i>
		<i>Severely blighted leaf caused by Cercospora infection</i>

### **Symptoms**

Small necrotic spots with chlorotic halos on leaves which expand to rectangular lesions 1-6 cm in length and 2-4 mm wide; as the lesions mature they turn tan in color and finally gray; lesions have sharp, parallel edges and are opaque; disease can develop quickly causing complete blighting of leaves and plant death.

1. Brown Spots with yellow rings throughout the leaf during the growing period of the Cassava

2. Lesions that are 0.15-0.2 cm in diameter
3. Serious cases can lead to holes throughout the lesions on the leaf

#### Cause

Fungus

#### Comments

Disease emergence is favored in areas where a corn crop is followed by more corn with no rotation; severity and incidence of disease is likely due to continuous corn culture with minimum tillage and the use of susceptible hybrids in the midwestern corn belt of the USA; prolonged periods of foggy or cloudy weather can cause severe Cercospora epidemics.

#### Management

Plant corn hybrids with resistance to the disease; crop rotation and plowing debris into soil may reduce levels of inoculum in the soil but may not provide control in areas where the disease is prevalent; foliar fungicides may be economically viable for some high yielding susceptible hybrids.

### Charcoal rot *Macrophomina phaseolina*

*Inside the infected stalk*

*Damaged stalk*

*Black fruiting body of fungus on infected corn stalk*

*Infected stalk*

*Charcoal rot infected stalk*

*Charcoal stalk rot of field corn (*Macrophomina phaseolina*)*

*Corn stalk infected with charcoal rot*

*Corn stalk infected with charcoal rot*

#### Symptoms

Symptoms are usually first apparent at the tasseling stage; plant stalks become shredded and pith is completely rotted with stringy strands of vascular tissue left intact; small, black fungal fruiting bodies are visible in the vascular strands and give the tissue a gray coloration; fungus grows into internodes of the stalk causing the plant to ripen early and causing the stalk to weaken; plant may break.

#### Cause

Fungus

#### Comments

Emergence of the disease is favored by warm soils with a low moisture content; fungus overwinters in the soil and can also survive on other host plants which include sorghum and soybean.

#### Management

There are currently no available fungicides to treat the disease; avoid stressing plants by practicing good water management; rotating crops with small grains may help reduce disease incidence.

### Common rust *Puccinia sorghi*

*Common corn rust*

*Common rust infected corn leaf*

*Common corn rust*

*common corn rust (*Puccinia sorghi*)*

*Corn rust (*Puccinia sorghi*)*

*common corn rust (*Puccinia sorghi*)*

*Rust symptoms on corn foliage*

*Rust symptoms on corn foliage*

*Rust symptoms on corn foliage*

*Close-up of rust pustules on corn leaf*

*Rust symptoms on corn foliage*

*Rust pustules on corn leaf*

## Symptoms

Oval or elongated cinnamon brown pustules on upper and lower surfaces of leaves; pustules rupture and release powdery red spores; pustules turn dark brown-black as they mature and release dark brown powdery spores; if infection is severe, pustules may appear on tassels and ears and leaves may begin to yellow; in partially resistant corn hybrids, symptoms appear as chlorotic or necrotic flecks on the leaves which release little or no spore.

## Cause

Fungus

## Comments

Disease is spread by wind-borne spores; some of the most popularly grown sweet corn varieties have little or no resistance to the disease.

## Management

The most effective method of controlling the disease is to plant resistant hybrids; application of appropriate fungicides may provide some degree of control and reduce disease severity; fungicides are most effective when the amount of secondary inoculum is still low, generally when plants only have a few rust pustules per leaf.

## Common smut (Boil smut, Blister smut) *Ustilago zea*

*Signs and symptoms of common smut (*Ustilago maydis*) on a corn plant.*

*Smut galls on corn tassels*

*Comparison of two corn tassel infected with common smut (center), *Ustilago maydis*, and head smut (right), *Sphacelotheca reiliana*.*

*Common smut gall on corn stalk*

*Common smut on sweet corn cv. White Delight*

*Kernels replaced by smut galls in corn ear*

*Kernels replaced by smut galls in corn ear*

*Galls on corn caused by common smut*

*Galls on corn caused by common smut*

## Symptoms

Tumor-like galls on plant tissues which are initially green-white or silvery white in color; interior of galls darken and turn into masses of powdery dark brown or black spores (with the exception of galls on leaves which remain greenish in color); galls may reach up to 15 cm in diameter and are common on ears, tassels, shoots or midrib of leaves; galls on leaves remain small and do not burst open.

## Cause

Fungus

## Comments

Fungus overwinters on crop debris or in the soil and can survive for several years; fungus usually enters the plant through

wounds; application of nitrogen fertilizer increases incidence of disease, while application of phosphorous fertilizer decreases infection.

### Management

Although many practices may be recommended for the control of common smut, the only method that is completely effective is to grow resistant corn hybrids.

### Downy Mildew disease *Peronosclerospora sorghi* (*Sorghum downy mildew*)

*P. maydis* (*Java downy mildew*)

*P. philippinensis* (*Philippine downy mildew*)

*P. sacchari* (*Sugarcane downy mildew*)

*Sclerotophthora rayssiae* var. *zeae* (*Brown stripe downy mildew*)

*Sclerospora graminicola* (*Graminicola downy mildew or green ear*)

*Sclerophthora macrospora* (*crazy top*)

*Brown stripe downy mildew on maize*

*Sorghum downy mildew on maize*

*Underside of maize leaf showing sorghum downy mildew*

*Philippine downy mildew on maize*

*Sugarcane downy mildew on maize*

*Java downy mildew on maize*

### Symptoms

Symptoms of all maize downy mildew pathogens are similar although may vary depends on cultivar, age and climate. The disease appear as early from two weeks after sowing resulting in chlorosis and stunting. In older plants the leaves shows mottling, chlorotic streaking and lesions and white striped leaves. Usually the leaves are narrower and more erect when compare to healthy plants and are covered with a white, downy growth on both surfaces.

### Cause

Fungus

### Comments

The disease is both air and seed born. The pathogen have several alternative hosts.

### Management

Grow available resistant varieties and hybrids. Follow crop rotation with non host crops. Use suitable systemic fungicide for both seed treatment and foliar spray. Keep the fields free from weeds. Drying seeds before sowing reduces the disease incidence.

### Giberella stalk and ear rot *Giberella zaeae*

*Bluish black perithecia of Giberella zaeae superficial near nodes*

*Ear infected with Giberella ear rot*

*Ear infected with Giberella ear rot*

*Ear infected with Giberella ear rot*

*Ear rot caused by Giberella fungus*

*Small black fungal fruiting bodies visible on corn stalk*

*Pink mold caused by Giberella ear rot*

### Symptoms

Plants wilting and leaves changing color from light to dull green; lower stalk turns straw yellow; internal stalk tissue breaks down; interior of stalk has a red discoloration; black fungal fruiting bodies may be visible on the stalk, often at internodes, and can be easily scraped off; if fungal infection affects the ears, it produces a red mold at the tips of the ear

which spreads down; early infection may result in the ear being covered in pink mycelium which causes the corn husk to adhere to the ear.

### Cause

Fungus

### Comments

Fungus can enter through wounds to stalk or ear; ear rot is caused by the fungus infecting silks and moving down through the ear; fungus survives on corn debris in soil and on debris of other host plants such as wheat.

### Management

Stressed plants are more susceptible to Gibberella - providing adequate fertilization and irrigation can help reduce incidence of disease; control insects, especially stem and ear borers; hybrids differ in their susceptibility to the disease and further information is required in order to develop specific control measures.

## Northern Leaf Blight *Exserohilum turcicum*

Symptoms	Symptoms on leaves	Infected field	Infected leaf	Northern corn leaf blight ( <i>Exserohilum turcicum</i> )
Blight across the leaf axil areas			Small, tan to brown, somewhat round spots. May completely cover the leaf	Symptoms on leaves
Close up of leaves demonstrating typical tan-colored, cigar-shaped lesions	Elliptical gray-green lesions on leaves			Long, narrow lesions which are unrestricted by veins
				Lesions become pale gray to tan color

### Symptoms

In the beginning we will notice elliptical gray-green lesions on leaves. As the disease process this lesions become pale gray to tan color. Later stage the lesions looks dirty due to dark gray spores particularly under lower leaf surface. The disease can be easily identified in the field due to its long, narrow lesions which are unrestricted by veins.

### Cause

Fungus

### Comments

The disease mainly spread through rain splash and wind.

### Management

Follow proper tillage to reduce fungus inoculum from crop debris. Follow crop rotation with non host crop. Grow available resistant varieties. In severe case of disease incidence apply suitable fungicide.

## Southern corn leaf blight *Bipolaris maydis*

<i>Bipolaris maydis</i> sporulation	<i>Southern blight</i> infected cob	<i>Young plant infected with southern blight</i>
Infected field	Corn field infected by Southern corn leaf blight	<i>Southern corn leaf blight and stalk rot (<i>Bipolaris maydis</i>) symptoms</i>
Long, irregular shaped, tan to white lesions. Lesions will appear along the leaf vein	Plant in field infected with Southern corn leaf blight	<i>Southern corn blight lesions on corn leaf</i>
Various symptoms of Southern corn leaf blight	Elongated lesions on corn leaf caused by Southern corn leaf blight	

## Symptoms

Foliar symptoms vary with hybrid and different fungal isolate; lesions on leaves may be tan and elongated and run between leaf veins; lesions may have a buff or brown colored margin; another race of the fungus causes tan, spindle shaped or elliptical lesions with a water-soaked margin that turns into a yellow halo.

## Cause

Fungus

## Comments

Fungus overwinters in corn debris in soil; disease occurs worldwide but is emergence favors areas with a warm, damp climate.

## Management

The most effective method of controlling the disease is to plant resistant hybrids; cultural control methods include plowing crop debris into soil after harvest and rotating crops.

## Category : Bacterial

### Bacterial leaf blight/stripe *Pseudomonas rubrilineans*, syn. *Pseudomonas avenae*, *Acidovorax avenae* subsp. *avenae*

Maize plant showing tassel rotting, caused when dead leaves enclose the tassel due to severe damage to the top leaves by bacterial leaf stripe (*Acidovorax avenae*).

Bacterial leaf stripe (*Acidovorax avenae* subsp. *avenae*) symptoms. Leaves develop several small, pale-green lesions which expand along veins producing a conspicuous striping, mainly in the youngest leaves.

Bacterial leaf blight and stalk rot (*Acidovorax avenae*) symptom

## Symptoms

Water-soaked linear lesions on leaves as they emerge; lesions turn brown and may subsequently turn gray or white; lesions may have a red border; after the leaves are mature, lesions do not tend to extend any further; no new lesions tend to appear after tasseling; if corn variety is susceptible, mature leaves may shred after maturity.

## Cause

Bacterium

## Comments

Bacteria can also cause disease in oats, barley, wheat, some millets and sorghum.

## Management

Resistant hybrids should be planted in areas where the disease is prevalent; plowing crop debris into soil and rotating crop may not be effective at controlling the disease due to its extensive host range.

## **Bacterial Leaf Streak disease** *Xanthomonas vasicola* pv. *vasculorum* (syn *Xanthomonas campestris* pv. *zeae*)

*Initial symptoms*

*Symptoms on corn leaf*

### **Symptoms**

The infected leaves initially shows narrow stripes between the veins. The initial symptoms are generally confused with gray leaf spot disease. But the lesions from bacteria appear brown, orange, and/or yellow when you infected leaves are back-lit. Also in Bacterial Leaf Streak disease the lesions show slightly wavy edges when compared to the smooth, linear lesion margins of gray leaf spot.

### **Cause**

Bacterium

### **Comments**

The bacteria causes gumming disease on sugarcane in several part of the world. First reported on corn in South Africa. Currently this disease is reported in Nebraska (Aug. 26, 2016), Colorado, Illinois, Iowa, and Kansas on corn.

### **Management**

Use healthy and disease free seeds. Remove the infected plant debris and burn them. Follow crop rotation.

## **Bacterial stalk rot/soft rot** *Erwinia chrysanthemi*

*Erwinia carotovora*

*Close-up view of the damage caused by bacterial soft rot (*Erwinia carotovora*) on a stalk of corn*

*Bacterial soft rot (*Erwinia carotovora*) on a corn stalk*

*Bacterial soft rot (*Erwinia carotovora*) on the leaf sheath of a corn stalk.*

*Bacterial stalk rot symptoms*

*Bacterial stalk rot symptoms*

*Mushy stalk tissue caused by bacterial stalk rot*

### **Symptoms**

Plants suddenly beginning to lodge (bend to lie along the ground) midway through season; one or more internodes above soil line turning brown, water-soaked, soft and slimy; tissue has foul odor and mushy appearance;

### **Cause**

Bacterium

### **Comments**

Disease is most commonly found in plantations which have overhead irrigation systems or in areas with high rainfall; disease emergence is favored by high temperatures and high humidity.

### **Management**

Plow all crop debris into soil in Fall; plant corn in well-draining soil to prevent waterlogged plants.

## **Goss's bacterial blight** *Clavibacter michiganensis*

*Lesions on corn leaf showing symptoms of Goss's wilt (*Clavibacter michiganensis* subsp. *nebraskensis*).*

*Symptoms of Goss's bacterial blight on corn leaves*

*Corn leaves showing symptoms of Goss's bacterial blight*

*Stalks of field corn split in half to show vascular plugging caused by Goss's wilt (*Clavibacter michiganensis* subsp. *nebraskensis*).*

*Corn plant infected with Goss's bacterial blight*

*Stalk of field corn split to show vascular plugging*

*Goss' bacterial wilt infected leaf*

## **Symptoms**

Gray or yellow stripes with irregular margins on leaf surfaces; stripes follow leaf veins and contain characteristic dark green to black water-soaked spots; if infection occurs early then plant may become wilted or withered; it is common to find a crystalline residue on leaves caused by dried bacterial exudate.

## **Cause**

Bacteria

## **Comments**

Disease overwinters in diseased crop debris on, or close to, the soil surface; temperatures below 12°C (53.6°F) and above 40°C (104°F) bacterium grows more slowly and may even be killed off.

## **Management**

Plant resistant sweetcorn hybrids; rotate crop; plow crop debris into soil immediately after harvest.

## **Holcus spot** *Pseudomonas syringae*

### **Symptoms**

Circular or elliptical spots 2-10 mm across near the tips of lower leaves which are dark green and water soaked initially but become cream to tan before turning dry and brown; lesions may have red-brown margins; large lesions may have a yellow halo.

## **Cause**

Bacterium

## **Comments**

Disease can occur anywhere where corn is grown but is not usually very damaging.

## **Management**

Disease is usually not severe but if it does become a problem crops should be rotated and any debris should be plowed into the soil after harvest.

## **Stewartâ€™s wilt** *Erwinia stewartii*

*syn Pantoea stewartii*

*Infected young plant* *Infected plant*

*Stewart's wilt infected stalk*

*Stewart's wilt infected plant*

*Typical symptoms on maize*

*Leaf symptoms in maize caused by *Erwinia stewartii* showing long chlorotic streaks with irregular margins*

*Stewart's wilt (*Erwinia stewartii*) on sweet corn*

## **Symptoms**

The main symptoms are appearance of water soaked lesions initially. As the disease progress the lesions become long and turn pale yellow with irregular margins running in the length. The pathogen may infect the stem and causes stunting, wilting and death of plant.

**Cause**

Bacterium

**Comments**

The pathogen is mainly transmitted by maize flea beetles and to lesser extent by infected seeds.

**Management**

Grow available resistant varieties. Use certified healthy seeds. Remove the crop debris and burn them. Use suitable insecticide to control flea beetle.

**Category :**

**Fall armyworm - IPM** Fall armyworm - IPM

**Symptoms**

**Cause**

**Comments**

**Fall armyworm Open Access Knowledge** FAW\_Open Access Knowledge

**Symptoms**

**Cause**

**Comments**

**Fall armyworm Pesticides** Fall armyworm\_Pesticides

**Symptoms**

**Cause**

**Comments**

**Fall armyworm Remote sensing** Fall armyworm\_Remote sensing

**Symptoms**

**Cause**

[https://plantvillage.psu.edu/diseases/fall-armyworm\\_remote-sensing](https://plantvillage.psu.edu/diseases/fall-armyworm_remote-sensing)

**Comments**

**Category : Viral**

## **Maize dwarf mosaic** Maize dwarf mosaic virus (MDMV)

*Maize Dwarf Mosaic Virus (Potyvirus  
MDMV)*      *MDMV infected plant*      *Symptoms on leaf*

*Maize dwarf mosaic virus infected  
plant*      *Maize dwarf mosaic symptoms on  
corn*      *Corn plant infected with Maize  
dwarf mosaic*

### **Symptoms**

Chlorotic spots and streaks on leaves which develop into a mottled or mosaic pattern; susceptible plants may be stunted; ear formation and development cease; mosaic and mottling with no red discoloration are characteristic symptoms of the disease.

### **Cause**

Virus

### **Comments**

Virus is transmitted by more than 15 different species of aphid and is passed to the plant from the insect in seconds to minutes of feeding; sorghum is also a major host of the virus.

### **Management**

Many commercial corn hybrids are highly tolerant of the disease and no control is needed; control aphid populations on plants and remove any Johnson grass growing in the vicinity as it can act as a reservoir for the virus.

## **Maize Lethal Necrosis Disease (MLND) or Corn Lethal Necrosis (CLN)** Maize Chlorotic Mottle Virus (MCMoV) + Sugarcane Mosaic Virus (SCMV)/ Wheat Streak Mosaic Virus (WSMV)/Maize Dwarf Mosaic Virus (MDMV)

*Chlorotic mottling of entire leaf*      *Young infected plant*      *MLND infected plant*

*Chlorotic mottling which starts from  
base of leaf and extends towards tip*      *MLND infected leaf*      *Necrosis of leaf margin (2)*

*Necrosis of leaf margin*

### **Symptoms**

The disease occurs at all stages of crop. The main symptoms includes appearance of chlorotic mottling on leaves which starts from base and extends upwards. Also the leaves shows necrosis at margins which later extends to mid rib and results in drying of entire leaf. The necrosis of young leaves in the whorl causes dead heart symptom. Other symptoms are premature plant death, shortened male inflorescences with few spikes, and/or shortened, malformed, partially filled ears.

### **Cause**

Virus

### **Comments**

The virus mainly spread by vectors (maize thrips, aphids, rootworms and leaf beetles) and infected seeds. The first report of this disease in Africa continent was in Kenya (2011). And later the disease spreads to other countries like Tanzania, Uganda and South Sudan.

### **Management**

Use healthy, disease free certified seeds. Keep the fields free from weeds. Remove the infected plants and burn them. Control vectors by treating seed and/ foliar spray with suitable insecticide. Follow crop rotation with non cereals at least for two seasons. Plant maize only in main rainy season instead of short rainy season. Grow available resistant varieties.

## Category : Oomycete

### Pythium root rot *Pythium* spp.

Damping-off of seedlings caused by  
*Pythium* infection

#### Symptoms

Above-ground, plants may be yellow and stunted; roots have obvious lesions and roots are discolored; root cortex will come away when pulled gently, exposing the white stele; can also cause damping-off of seedlings.

#### Cause

Fungus

#### Comments

Fungus overwinters in soil and crop debris; disease emergence is favored by high soil moisture and low temperatures leading to low soil oxygen levels.

#### Management

Control of the disease relies on improving soil drainage or planting corn in areas where the soil is well-draining; systemic fungicides can be used to treat seed prior to planting to protect seedlings from disease.

## Category : Other

### Slugs Various

European brown snail (*Cornu aspersum*)

Yellow-spotted slug (*Limax flavus*)

Spanish slug (*Arion lusitanicus*)

Dusky slug (*Arion subfuscus*)

Orange-banded slug (*Arion fasciatus*)

Gray garden slug (*Deroceras reticulatum*) damage symptoms

#### Symptoms

Irregularly shaped holes in leaves and stems; leaves may be shredded; slime trails present on rocks, walkways, soil and plant foliage; several slug species are common garden and field pests; slugs are dark gray to black in color and can range in size from 2.5 to 10 cm (1-4 in).

#### Cause

Mollusc

#### Comments

Slugs prefer moist, shaded habitats and will shelter in weeds or organic trash; adults may deposit eggs in the soil throughout the season; damage to plants can be extensive.

#### Management

Practice good garden sanitation by removing garden trash, weeds and plant debris to promote good air circulation and reduce moist habitat for slugs and snails; handpick slugs at night to decrease population; spread wood ashes or eggshells around plants; attract molluscs by leaving out organic matter such as lettuce or grapefruit skins, destroy any found feeding on lure; sink shallow dishes filled with beer into the soil to attract and drown the molluscs; chemical controls include ferrous phosphate for organic gardens and metaldehyde (e.g. Buggetta) and carbaryl (e.g Sevin bait) for

non-organic growers.

## Pests

### Category : Insects

#### Aphids (Corn leaf aphid, Peach Aphid) *Rhopalosiphum maidis*

*Myzus persicae*

*Aphids infestation*

*Corn leaf aphid (*Rhopalosiphum maidis*) infestation on tassel*

*Close-up view of the corn leaf aphid (*Rhopalosiphum maidis*).*

*Maize tassel infested with aphids*

*Aphid infestation on maize*

*Aphids on maize tassel*

*Infestation of corn leaf aphids*

*Heavy aphid infestation and growth of sooty mold on corn*

#### Symptoms

Heavy infestations can result in curled leaves and stunted plants; honeydew secretions promote growth of sooty mold; corn leaf aphids are blue-green in color, peach aphids are green-yellow in color; aphids may transmit viruses when feeding.

#### Cause

Insects

#### Comments

Grassy weeds also serve as hosts for corn-leaf aphids; peach aphids have a wide host range.

#### Management

It is rare for aphids to reach levels that are damaging to the plant and no control is generally warranted as insecticide sprays will not prevent transmission of viruses.

#### Corn earworm *Helicoverpa zea*

*Larvae feeding on the cob*

*Larva(e) feeding on leaf*

*Corn earworm larva (*Helicoverpa zea*) near tip of an ear of field corn.*

*Trap set for adult corn earworm moths (*Helicoverpa zea*).*

*Corn earworm (*Helicoverpa zea*) feeding on an ear of sweet corn.*

*Adult of *Helicoverpa zea*.*

*Larvae feeding on sweetcorn tip*

*Leaf damage caused by corn earworm*

*Corn earworm feeding on ear*

#### Symptoms

Feeding damage to leaves, tassel and leaf whorls; preferred feeding site is the ear and insect produces extensive excrement at the tip of the ear; younger larvae feed on silks, severing them from the plant; young caterpillars are cream-white in color with a black head and black hairs; older larvae may be yellow-green to almost black in color with fine white lines along their body and black spots at the base of hairs; eggs are laid singly on both upper and lower leaf surfaces and are initially creamy white but develop a brown-red ring after 24 hours and darken prior to hatching.

## Cause

Insect

## Comments

Adult insect is a pale green to tan, medium sized moth; can be a very damaging pest of corn; insect overwinters as pupae in the soil.

## Management

Corn earworms are most problematic on sweet corn varieties and treatment should be applied at egg hatch; monitor plants for eggs and young larvae and also natural enemies that could be damaged by chemicals; *Bacillus thuringiensis* or Entrust SC may be applied to control insects on organically grown plants; appropriate chemical treatment may be required for control in commercial plantations.

## Cutworms (Black cutworm, Variegated cutworm) *Agrotis ipsilon*

*Peridroma saucia*

*Black cutworm (Agrotis ipsilon)* adult

*Black cutworm larva (Agrotis ipsilon)* lying next to the damage it caused to a young corn plant.

*Fall armyworm (Spodoptera frugiperda)* feeding on corn

*Armyworm (Mythimna unipuncta)* crawling on a corn leaf. They tend to hide down in the corn whorl.

*Black cutworm (Agrotis ipsilon)* larvae may feed on young corn, and pull the stalk down into the ground from below. Damage shows up as gaps in the normal corn rows. Stalks may also be simply cut off and fall to the side.

Cutworms will curl up into a characteristic C shape when disturbed

Young corn plant severed by cutworm

## Symptoms

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5–5.0 cm (1–2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed.

## Cause

Insects

## Comments

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato.

## Management

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically.

## Fall armyworm *Spodoptera frugiperda*

## Symptoms

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to

skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside.

1. Leaf damage is usually characterized by ragged feeding, and moist sawdust-like frass near the funnels and upper leaves of the plant.
2. Leaf damage is usually scattered in rows across the leaf
3. Younger larvae usually eat tissue from one side, leaving the other side in tact. This is what creates windows in the leaf
4. Deep feeding may destroy maize tassels.
5. Caterpillars enter through the side of the ear and feed on developing kernels

#### Cause

Insects

#### Comments

Insect can go through 3–5 generations a year.

#### Management

Organic methods of controlling the armyworm include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae.

### Flea beetles *Chaetocnema pulicaria*

*Altica spp.*

Corn flea beetles

corn flea beetle feeding on leaf

corn flea beetle (*Chaetocnema pulicaria*) adult

corn flea beetle (*Chaetocnema pulicaria*)

Flea beetle on corn leaf

Damaged corn foliage

#### Symptoms

Small holes or pits in leaves that give the foliage a characteristic “shot hole” appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5–3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance.

#### Cause

Insects

#### Comments

Flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year.

#### Management

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application of diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied.

### Thrips (Various spp.) Various

*Thrips damage on corn leaf*

*The damaged plants with small, silver streaks on the leaves, and the plant looks as though it has been sandblasted.*

*Western flower thrips*

### Symptoms

If population is high leaves and may be distorted and curl upwards; edges of leaves may dry up and are speckled with black feces; insects are small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color.

### Cause

Insects

### Comments

May be found on corn at any time during the growing season.

### Management

Avoid planting next to onions, garlic where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic; young plants will recover from damage and treatment is not often necessary as the thrips are beneficial for controlling mites.

## Category : Nematodes

### Root knot nematode *Meloidogyne incognita*

*M. arenaria*

*M. javanica*

*Root-knot nematode infected barley seedlings*

*Root-knot nematode female and egg mass of the root-knot nematode, *Meloidogyne* sp.*

### Symptoms

Below ground we can see galls on the roots due to female nematode feeding. Above ground the plants are stunted, yellow and patchy in growth. Severely infested plant may die before harvest.

### Cause

Nematode

### Comments

The galls are formed by female nematode feeding resulting in formation of giant cells.

### Management

Deep summer ploughing helps in reducing nematode population. Follow crop rotation with nematode antagonistic plants. Grow resistant varieties. In severely infected field follow soil fumigation with suitable nematicide.

## Category : Mites

### Spider mites (Various spp.) Various

*Twospotted spider mite damage*

*Twospotted spider mite  
(Tetranychus urticae) infected leaf*

*Twospotted spider mite  
(Tetranychus urticae) damaged leaf*

*Tetranychus urticae infected plant*

*Spider mite damage to a corn field --  
plants in a treated (controlled) field  
on the left, damaged field on the  
right.*

*Severe damage to corn plants due  
to an infestation of spider mites.*

*Corn leaves discolored by spider  
mite feeding*

*Banks grass mite (Oligonychus  
pratensis) adults with eggs on corn  
leaf*

*Banks grass mite (Oligonychus  
pratensis) damage*

*Banks grass mite (Oligonychus  
pratensis) damage to sweet corn  
husk*

*Banks grass mites (Oligonychus  
pratensis).*

*Corn field infested with spider mite*

*Banks grass mite (Oligonychus  
pratensis) infested field*

*Stippled corn leaf*

## Symptoms

Leaves stippled with yellow; leaves may appear bronzed; webbing on underside of leaves; small kernel size; mites may be visible as tiny moving dots on the webs or underside of leaves, best viewed using a hand lens; usually not spotted until there are visible symptoms on the plant; leaves turn yellow and may drop from plant;

## Cause

Arachnid

## Comments

Spider mites thrive in dusty conditions; water-stressed plants are more susceptible to attack.

## Management

In the home garden, spraying plants with a strong jet of water can help reduce buildup of spider mite populations; if mites become problematic apply insecticidal soap to plants; certain chemical insecticides may actually increase mite populations by killing off natural enemies and promoting mite reproduction.

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# Cotton

## Description

Cotton is the collective name given to four species of plants in the genus *Gossypium*, *Gossypium hirsutum*, *Gossypium barbadense*, *Gossypium arboreum* and *Gossypium herbaceum* which are perennial shrubs in the family Malvaceae grown for the fluffy fiber which protects the seeds of the plant. *G. hirsutum* accounts for approximately 90% of world wide cotton production today. Cotton plants possess a main stem giving rise to several branches at the top. The leaves of the plant are spirally arranged on the branches, have long petioles and have 3–5 triangular lobes. The plant produces a single flower on each axillary branch which can be red-purple, yellow or white in color and forms a leathery, oval seed capsule, or 'boll' which is 2–6 cm (0.8–2.4 in) long. Mature bolls will usually split open to reveal the characteristic white cotton fibers and the seed. The cotton plant can reach heights of 1–1.5 m (3.3–4.9 ft) and is usually cultivated as an annual, surviving only one growing season. Cotton may also be referred to as tree cotton and its center of origin is unknown although the plant has diversified from Mexico, north-east Africa and Arabia and Australia.

*Cotton field ready for harvest*

*Cotton field*

*White cotton fibers*

*Cotton*

*Cotton boll*

*Gossypium barbadense flower*

*Gossypium hirsutum* flower

Cotton boll beginning to split open

Cotton field

## Uses

The major use of cotton today is in the textile industry, the fibers or 'lints' of the cotton plant are harvested and woven into fabric for the production of clothing, towels, bed sheets and many other textiles. Cotton fiber may also be used in the production of yarn and twine. The cotton seeds can be used to extract oil for use in the production of shortening or cooking oil and the manufacture of soaps and lubricants. The seed may be used as a feed for livestock. The fuzz produced as a byproduct of the ginning process can be used in the upholstery industry.

## Propagation

**Basic requirements** Cotton is best grown in desert conditions using irrigation. The seeds will germinate optimally at 34°C (93.2°F), while the seedlings require a temperature between 24 and 29°C (75.2–84.2°F) to grow and develop properly. Cotton will grow on a variety of soils including sandy soil and heavy clay as long as it is water permeable and will grow optimally in a soil with a pH of 5.5–8.5. In addition cotton has a high tolerance for salt. **Planting** Cotton is propagated from seed by planting directly in a prepared field when growing conditions are favorable (suitable temperature, adequate rainfall etc). Cotton should only be planted when the soil has warmed to at least 18.3°C (65°F). Generally, seeds should be sown at a depth of 0.25 cm (1 in), with 3–6 seeds sown in each hole. Ridging the soil is recommended as it helps to drain the plant in wet conditions and also to conserve water in dry conditions. Plant spacing depends on the variety but generally 20–100 cm (7.9–39.4 in) should be left between plants. **General care and maintenance** The cotton field should be kept free from weeds and where the crop does not receive an adequate amount of water from rainfall, additional irrigation should be provided. Demand for nutrients is dependent on the type of soil on which the cotton is being grown. Cotton growing in acidic soils the plants will have a greater demand for nitrogen and phosphorus, whereas in sandy soil, potassium will be of greater importance. It is not recommended to grow cotton in the same field for more than three years and the crop should be rotated to prevent the build-up of diseases in the soil.

**Harvesting** Cotton is still picked by hand in many areas of the world where the crop is grown. In the US cotton is machine harvested. Cotton is ready to harvest approximately 4 months after sowing when the bolls split open to reveal the white cotton fibers. Fields are usually picked once every 3 to 4 weeks to prevent the fibers remaining in the field too long where they are susceptible to pests. The entire field is usually harvested with 2 to 3 pickings.

Machine harvested cotton

Machine harvest of cotton

Women carry harvested cotton to be  
deseeded in Burkina Faso, Africa.

Cotton harvesting in Madagascar

Harvesting cotton by hand, India

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Alternaria leaf spot** *Alternaria macrospora*

###### **Symptoms**

Small, circular brown lesions on cotyledons and seedling leaves which expand and develop a concentric pattern; necrotic areas coalesce and often have a purple margin; centers of lesions may dry out and drop from the plant creating a "shot-hole" appearance on the leaves.

###### **Cause**

Fungus

###### **Comments**

Plants stressed by drought, nutrient deficiency and other pests are more susceptible to the disease; fungus spreads rapidly in dense canopies, especially during periods of warm, wet weather.

###### **Management**

Plow crop residue into the soil to reduce inoculum levels; provide plants with adequate irrigation and nutrients, particularly potassium; applications of appropriate foliar fungicides may be required on susceptible cultivars.

##### **Asochyta blight** *Asochyta gossypii*

*Symptoms on lower leaf surface*

*Damage to cotton seedling.*

*Ascochyta blight of cotton*

*Symptoms of Asochyta blight on cotton foliage*

*Symptoms of Asochyta blight on cotton foliage*

*Symptoms of Asochyta blight on cotton foliage*

###### **Symptoms**

Brown or gray spots on leaves surrounded by a red halo; elongated red-purple cankers on stems cause the wilting and death of leaves above.

###### **Cause**

Fungus

###### **Comments**

Disease emergence is favored by cool, wet weather.

###### **Management**

No fungicides are currently registered for use in cotton; plow crop debris into soil after harvest; crop rotation has little to no effect of control of disease.

##### **Cercospora leaf spot** *Cercospora gossypina*

###### **Symptoms**

Circular red lesions on leaves which enlarge and turn white or gray in the center; lesions often have a pattern of concentric rings and possess a red margin; dark gray spore masses form in the centers of the lesions making them appear dark gray.

#### **Cause**

Fungus

#### **Comments**

Fungus overwinters in crop debris from previous growing season; commonly found alongside Alternaria leaf spot and other foliar disease.

#### **Management**

Plow crop residue into the soil to reduce inoculum levels; provide plants with adequate irrigation and nutrients; applications of appropriate foliar fungicides may be required on susceptible cultivars.

### **Fusarium wilt *Fusarium oxysporum***

*Infected plant*

*Discoloration of vascular tissue caused by Fusarium wilt*

*Discoloration of vascular tissue caused by Fusarium wilt*

#### **Symptoms**

Wilting of cotyledons and seedling leaves; cotyledons become chlorotic at the edges and then necrotic; older plants exhibit symptoms of wilting and leaf chlorosis; wilting is usually gradual but may be pronounced after heavy summer rain; if infection is severe plants become stunted and may be killed; vascular system of infected plants becomes discolored and can be seen by cutting the stem.

#### **Cause**

Fungus

#### **Comments**

Disease emergence is favored by warm temperatures; fungus may be introduced to field through infected seed or by contaminated equipment and human movement.

#### **Management**

Use on certified, disease-free seed; plant varieties with higher resistance to the disease in areas with a history of Fusarium diseases; fumigating the soil may reduce disease incidence.

### **Target spot *Corynespora cassiicola***

*Symptoms on infected leaf*

*Circular to irregular spot with target markings*

*Corynespora leaf spot (*Corynespora cassiicola*)*

*Infected leaf*

*Spots on infected leaves*

*Target leaf spot*

#### **Symptoms**

The symptoms can be found on leaves, boll bracts and on bolls. Initially the appearance of small chocolate brown spots which later enlarge to become circular to irregular spot with target markings. The symptoms are mainly seen in the lower canopy. Typically the infected leaves retain their green color or green yellow color. Under severe conditions leaf and flower drop may occur.

#### **Cause**

Fungus

#### **Comments**

The pathogen also infects cucumber, sweet potato, soybean and tomato. It will cause severe loss if pathogen infect at

flowering stage. The disease is common in Southeastern cotton producing states of USA. The target spot is confused with leaf spot caused by Cercospora spp. Stemphyllium spp. or Alternaria spp. But this spot is surrounded by reddish to purplish margin.

#### **Management**

Use available resistant varieties. Follow crop rotation. Spray suitable fungicide.

#### **Category : Bacterial**

##### **Bacterial blight/angular leaf spot of cotton *Xanthomonas axonopodis* pv. *malvacearum***

Earlier *Xanthomonas citri* ssp. *malvacearum*

*Lower surface of infected leaf*

*Symptoms Infected leaf*

*Spots on infected leaf*

*Angular leaf spot of cotton symptoms*

*water soaked spot*

#### **Symptoms**

Water-soaked spots on leaves which are delimited by leaf veins, giving them an angular appearance; lesions increase in size and turn black and necrotic; leaves drop from the plant; disease may also cause elongated gray-black lesions extending from the leaves to petioles and stem which are known as the "blackarm" phase; severe blackarm symptoms may cause the stem to be girdled; water-soaked lesions may be present on bolls; boll lesions enlarge and become sunken and brown-black in color.

#### **Cause**

Bacterium

#### **Comments**

Disease is often introduced to cotton fields by infested seeds.

#### **Management**

The use of resistant cotton varieties is the most effective method of controlling the disease; cultural practices such as plowing crop residue into soil after harvest can also limit disease emergence.

#### **Pests**

#### **Category : Insects**

##### **Aphids (Cotton aphid) *Aphis gossypii***

<i>Leaf curling downward due to feeding</i>	<i>Adult winged form</i>	<i>Cotton aphids nymphs and adults</i>
<i>Infestation on tender shoot</i>	<i>Biological Control: Aphids with lady beetle larva predator</i>	<i>Infestation cotton aphid infestation</i>
<i>Aphids on cotton leaves</i>	<i>Aphids are eating by lady bird beetle larvae</i>	<i>Honeydew on leaves due to aphid infestation</i>
<i>Cotton aphid (<i>Aphis gossypii</i>)</i>	<i>Honeydew and damage</i>	<i>Sooty mold on open cotton resulting from aphid infestation</i>
<i>Cotton aphid infestation</i>	<i>Cotton aphid (<i>Aphis gossypii</i>) infestation</i>	

### **Symptoms**

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants.

### **Cause**

Insect

### **Comments**

Honeydew excreted by aphids promotes growth of mold. This honeydew also attracts ants which then protect the aphids from natural enemies and even move aphids to other parts of the plants and even other plants.

### **Management**

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use.

### **Armyworm *Spodoptera exigua***

Larva(e) damage to foliage	Beet armyworm feeding on square	Larva(e) feeding on square
Beet armyworm feeding on cotton	Beet armyworm larvae	Beet armyworm damage
Braconid wasp parasitizing beet armyworm larva	Beet armyworm egg mass	Beet armyworm larvae
Beet armyworm ( <i>Spodoptera exigua</i> ) adult moth	A biological control agent, nuclear polyhedrosis virus, killed the beet armyworm at top.	Several early instar beet armyworm larvae feeding in the under side of a cotton leaf.
Beet armyworm, <i>Spodoptera exigua</i> , on a cotton leaf	Early instar beet army worm damage	Early instar beet armyworm ( <i>Spodoptera exigua</i> ) feeding under leaf surface

### Symptoms

Holes in bracts associated with bolls; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside.

### Cause

Insect

### Comments

Insect can go through 3–5 generations a year.

### Management

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae.

### Cotton bollworm *Helicoverpa zea*

Adult moth of <i>Helicoverpa zea</i>	Late instar larvae feeding	Larvae Damage due to bollworm
Egg of cotton bollworm	Feeding on boll	Cotton bolls damage by the cotton bollworm
Egg of bollworm on cotton leaf	Cotton bollworm feeding on a cotton bloom	Numerous cotton bolls and squares damage by an overwhelming population of cotton bowlwoms
Bollworm larvae feeding on cotton bloom	Late instar larvae feeding on cotton square	Larvae feeding on cotton square
Hole under cotton bloom due to bollworm	Hole due to larvae feeding	

## Symptoms

Holes chewed in bases of bolls and insect frass around holes; young caterpillars are cream-white in color with a black head and black hairs; older larvae may be yellow-green to almost black in color with fine white lines along their body and black spots at the base of hairs; eggs are laid singly on both upper and lower leaf surfaces and are initially creamy white but develop a brown-red ring after 24 hours and darken prior to hatching.

## Cause

Insect

## Comments

Adult insect is a pale green to tan, medium sized moth; insect is also very damaging pests of corn; insect overwinters as pupae in the soil.

## Management

Monitor plants for eggs and young larvae and also natural enemies that could be damaged by chemicals; *Bacillus thuringiensis* or Entrust SC may be applied to control insects on organically grown plants; appropriate chemical treatment may be required for control in commercial plantations.

## Cutworms (Black cutworm, Variegated cutworm) *Agrotis ipsilon*

*Peridroma saucia*

Adult black cutworm

Larvae of black cutworm

Black cut worm larvae

Black cutworm (*Agrotis ipsilon*) adult

Larvae of variegated cutworm

variegated cutworm (*Peridroma saucia*) adult

Adult variegated cutworm

Variegated cutworm (*Peridroma saucia*) larvae

## Symptoms

Stems of young seedlings may be severed at soil line; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5–5.0 cm (1–2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed.

## Cause

Insect

## Comments

Insects outbreak favored by a cool, wet spring following a mild winter; cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato.

## Management

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically.

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# Cowpea

## Description

Cowpea, *Vigna unguiculata*, is a climbing annual in the family Fabaceae grown for its edible seeds and pods. The cowpea plant is usually erect and possess ribbed stems and smooth trifoliate leaves which are arranged alternately on the stems. The plant produces clusters of flowers at the end of a peduncle (flower stalk) and 2–3 seed pods per peduncle. The seed pods are smooth, cylindrical and curved, reaching up to 35 cm (10 in) in length, with distinctive coloration, usually green, purple or yellow. As the seeds reach maturity the pod changes color to tan or brown. The seeds can be white, cream, green, red brown or black in color or be a mottled combination. The seed may also possess an “eye” where a lighter color is surrounded by one that is darker. Cowpea can reach in excess of 80 cm (31.5 in) in height and, as an annual plant, lives for only one growing season before harvest. Cowpea may also be referred to as black-eyed pea, southern pea, crowder pea or field pea and originates from Africa.

*Field of cowpea*

*Cowpea plants*

*Cowpea flower*

*Cowpea with pods*

*Cowpea with pods*

## Uses

Cowpea is an important grain legume in Africa, parts of the Americas and in Asia. The seeds can be consumed fresh along with the pods and leaves as a vegetable. Dried seeds are consumed after cooking. The plant can be used as a forage or for hay or silage.

*Cowpea may also be referred to as  
'black-eyed pea'*

## Propagation

**Basic requirements** Cowpea is a warm season crop and thrives in hot, moist conditions. Cowpeas have similar growth requirements to soybeans and should not be planted until after the last frost and only when the soil temperature has reached 18.3°C (65°F) to prevent seeds rotting in the ground. The plants will be killed by frost. Cowpeas can be planted in a wide range of soils, from acidic (to pH 4) to neutral, as long as they are well-draining but the plants are not well adapted to alkaline soil. For best results, plant cowpeas in a well draining sandy loam with a pH between 5.5 and 6.5 in an area that receives full sun. Cowpeas are drought resistant and very heat tolerant which means they can be grown successfully in many areas. **Planting** Cowpeas should be direct seeded when the soil temperature is consistently above 18.3°C (65°F). Seeds should be sown to a depth of 2.5–5.0 cm (1–2 in) at a density of 4-8 plants per foot of row. An additional 76 cm (30 in) should be left between rows. Seeds germinate quickly and the plants should produce pods in approximately 60 days. **General care and maintenance** Cowpea is fast growing and should quickly suppress any competing weeds. Some perennial grass species may colonize the spaces between rows and should be removed by cultivation. Cowpeas can grow in poor quality soils and do not require the addition of nitrogen fertilizers. In addition, the plants can grow a taproot which is often in excess of 2.4 m (8 ft) which allows the plant to access moisture deep down in the soil. This makes cowpea extremely resistant to drought, requiring little or no irrigation after the plants have become established.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Anthracnose** *Colletotrichum* spp.

###### **Symptoms**

Tan to brown sunken lesions on leaves; lesions merging to girdle stems and petioles; lesions may become covered in pink spore masses during periods of wet weather

**Cause**

Fungi

**Comments**

Disease causes economically important losses to crops in Africa, Latin America and Asia

**Management**

The best method of controlling the fungus is to plant resistant varieties if available; plant only certified disease-free seed; practice good field sanitation such as removing crop debris from field after harvest to reduce levels of inoculum

**Asochyta blight** *Asochyta phaseolorum***Symptoms**

Severe defoliation of plants; extensive lesions on stems and pods; if infection is severe then plants may be killed

**Cause**

Fungus

**Comments**

Major disease in Africa; disease transmitted by infected seed and from infected plant debris; secondary spread by rain splash and wind

**Management**

Plant disease-free seed; applications of appropriate foliar fungicides, where available, may help to control the disease

**Brown rust** *Uromyces* spp.**Symptoms**

Raised brown to black pustules on both sides of leaves; wilting plants; drying leaves dropping from plant

**Cause**

Fungi

**Comments**

Major disease in parts of West Africa and in areas of medium elevation in East Africa

**Management**

Sprays of sulphur or potassium carbonate can help to control the disease

**Cercospora and Pseudocercospora leaf spot** *Cercospora canescens*

*Pseudocercospora cruenta*

**Symptoms**

Chlorotic spots on upper surfaces of leaves; necrotic spots on leaves; masses of spores on lesions which resemble black mats on lower leaf surface; defoliation of plants; yellowing of leaves; circular, red lesions on leaves

**Cause**

Fungi

**Comments**

Pseudospore an important disease in China; both diseases occur in Africa

**Management**

Remove all crop residue from field after harvest; plant disease-free seed

**Charcoal rot** *Macrophomina phaseolina***Symptoms**

Discoloration of stem at soil line; cankers on stem may spread upwards; leaves may wilt and drop from plant; numerous small black sclerotia (fungal fruiting bodies) develop in affected tissues and can be used to diagnose the disease

**Cause**

Fungus

**Comments**

Fungus had a wide host range and affects beans, tobacco, soybean, pigeon pea and many other crops; disease is

primarily spread via microsclerotia in the soil

### **Management**

Organic soil amendments such as the addition of manure or neemcake can be used to reduce levels of inoculum in the soil

## **Fusarium wilt** *Fusarium oxysporum*

### **Symptoms**

Stunted plant growth; yellowing, necrotic basal leaves; brown-red or black streaks on roots that coalesce as they mature; lesions may spread above the soil line

### **Cause**

Fungus

### **Comments**

Damage caused by the emergence of the disease is worsened by warm, compacted soils, limited soil moisture and poor soil fertility

### **Management**

Control relies on cultural practices e.g. do not plant in same area more than once in any 5 year span or treating seeds with an appropriate fungicide prior to planting

## **Powdery mildew** *Erysiphe polygani*

*Sphaerotheca fuliginea*

### **Symptoms**

White powdery fungal growth on upper surfaces of leaves; chlorotic or brown patches on leaves; leaves dropping from plant

### **Cause**

Fungi

### **Comments**

*E. polygani* occurs in all areas where cowpea is grown; *S. fuliginea* only reported in India

### **Management**

Plant resistant varieties if available; use adequate plant spacing to avoid overcrowding and promote good air circulation around plants

## **Rhizoctonia seedling blight** *Rhizoctonia solani*

### **Symptoms**

Water-soaked sunken, red-brown lesions on hypocotyls (germinating shoot below seed leaves) and epicotyls (shoot above seed leaves); small, circular brown spots on leaves; large irregular lesions with zonate banding on leaves; lesions with water-soaked borders; leaves that look like they are covered in sand (sclerotia)

### **Cause**

Fungus

### **Comments**

Can cause complete destruction of canopy

### **Management**

Crop rotation helps to reduce the build up of the fungus in the soil; reduce soil compaction; do not plant seeds too deep

## **Southern blight** *Sclerotium rolfsii*

### **Symptoms**

Sudden wilting of leaves; yellowing foliage; browning stem above and below soil; browning branches; stem may be covered with fan-like mycelial mat

### **Cause**

Fungus

## **Comments**

Fungus can survive in soil for long periods; disease emergence favored by high temperatures, high humidity and acidic soil; disease found mainly in tropical and subtropical regions, including the southern United States

## **Management**

Remove infected plants; avoid overcrowding plants to promote air circulation; rotate crops with less susceptible plants; plow crop debris deep into soil; provide a barrier to infection by wrapping lower stems of plant with aluminum foil covering below ground portion of stem and 2-3 in above soil line

## **Category : Bacterial**

### **Bacterial blight** *Xanthomonas campestris*

#### **Symptoms**

Water-soaked spots on leaves which enlarge and become necrotic; spots may be surrounded by a zone of yellow discoloration; lesions coalesce and give plant a burned appearance; leaves that die remain attached to plant; circular, sunken, red-brown lesion may be present on pods; pod lesions may ooze during humid conditions

#### **Cause**

Bacterium

#### **Comments**

Disease can be introduced by contaminated seed; bacteria overwinters in crop debris; disease emergence favored by warm temperatures; spread is greatest during humid, wet weather conditions

## **Management**

Plant only certified seed; plant resistant varieties; treat seeds with an appropriate antibiotic prior to planting to kill off bacteria; spray plants with an appropriate protective copper based fungicide before appearance of symptoms

### **Brown blotch** *Colletotrichum capsici*

*Colletotrichum truncatum*

#### **Symptoms**

Seeds not germinating; death of seedlings; post emergence symptoms include sunken oval lesions on stems, red-brown lesions on leaves, flowers aborting and/or mummified pods; severe defoliation can occur during prolonged periods of wet weather

#### **Cause**

Fungi

#### **Comments**

Disease particularly important in rainforest zone, southern Guinea savannas and the southernmost part of northern Guinea savannas

## **Management**

The best method of controlling the fungus is to plant resistant varieties if available; plant only certified disease-free seed; practice good field sanitation such as removing crop debris from field after harvest to reduce levels of inoculum

### **Soft stem rot** *Pythium aphanidermatum*

#### **Symptoms**

Gary to green water-soaked rot girdling stem; plant death; white mycelial growth on stem during high humidity

#### **Cause**

Fungus

#### **Comments**

Important in warm, humid tropical conditions of southern Guinea, West Central Africa and subtropical India

## **Management**

Plant in well-draining soils or raised bed to reduce soil moisture content; solarizing soil can help reduce levels of inoculum in the soil; soil drenches or seed treatment with appropriate fungicides can help to control the disease

# Pests

## Category : Insects

### Aphids (Cowpea aphid, Pea aphid, etc.) *Aphis craccivora*

*Acyrthosiphon pisum*

#### Symptoms

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants

#### Cause

Insect

#### Comments

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed

#### Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

### Armyworms (Beet armyworm, Western striped armyworm) *Spodoptera exigua*

*Spodoptera praefica*

#### Symptoms

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside

#### Cause

Insect

#### Comments

Insect can go through 3–5 generations a year

#### Management

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae

### Corn earworm *Helicoverpa zea*

#### Symptoms

Larvae damage leaves, buds, flowers, pods and beans; young caterpillars are cream-white in color with a black head and black hairs; older larvae may be yellow-green to almost black in color with fine white lines along their body and black spots at the base of hairs; eggs are laid singly on both upper and lower leaf surfaces and are initially creamy white but develop a brown-red ring after 24 hours and darken prior to hatching

#### Cause

Insect

### Comments

Adult insect is a pale green to tan, medium sized moth; insect is also very damaging pests of corn; insect overwinters as pupae in the soil

### Management

Monitor plants for eggs and young larvae and also natural enemies that could be damaged by chemicals; *Bacillus thuringiensis* or Entrust SC may be applied to control insects on organically grown plants; appropriate chemical treatment may be required for control in commercial plantations

## Mexican bean beetle *Epilachna varivestis*

### Symptoms

Irregular patches of feeding damage on underside of leaves which causes the top surface of the leaf to dry out, giving the leaves a lacy appearance; insect will also damage flowers and small pods; pods may be damaged so badly that they drop from the plant; adult insect is an orange-brown beetle with black spots; larvae are fat-bodied grubs which taper at the end and are in rows of conspicuous spines

### Cause

Insect

### Comments

Beetles can decimate bean crops; beetles overwinter as adults and undergo 2-3 generations per year

### Management

Some bean varieties may be less attractive hosts for the beetle, e.g. snapbeans are preferred hosts over lima beans; early varieties may escape damage form beetles beetle populations can be reduced by remove overwintering sites such as brush and leaves on the ground; handpick larvae and adults; brush eggs from leaves and destroy; apply insecticidal soap to leaf undersides if infestation is heavy

## Category : Nematodes

### Root knot nematode *Meloidogyne* spp.

#### Symptoms

Galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; reduction in plant vigor; yellowing plants which wilt in hot weather

#### Cause

Nematode

#### Comments

Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or garden with this type of soil is most likely

#### Management

Plant resistant varieties if nematodes are known to be present in the soil ;check roots of plants mid-season or sooner if symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens

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# Cranberry

## Description

Cranberry is the name given to a group of long-lived woody perennial shrubs or trailing vines in the genus *Vaccinium*, including *Vaccinium macrocarpon*, the most popular commercial species, grown for their edible berries. The cranberry bush possesses a slender, wiry stems with small elliptical waxy evergreen leaves 7–10 mm (0.28–0.45 in) in length. The plant produces distinctive dark pink flowers with reflexed petals that leave the style and stamens exposed. The fruit is produced on the new plant growth produced that season and are initially white and ripen to dark red, waxy berries measuring 9–14 mm (0.4–0.6 in) in diameter. The cranberry plant can reach 5–20 cm (2.0–7.9 in) in height, with the vines stretching up to 2 m (6.6 ft) long. The cranberry may also be referred to as bearberry and originates from North America.

*Cranberry bog*

*American cranberry foliage*

*American cranberry flowers and fruit*

*American cranberry flowers*

*American cranberry*

## Uses

Cranberries are usually processed into juice, sauce, jam and sweetened dried cranberries. They may also eaten raw. Cranberries have long been used as a remedy to prevent recurrent urinary tract infections, research has demonstrated the benefit to women, but the effect on other groups is less clear.

## Propagation

**Basic requirements** Cranberries are wetland plants which grow best in bogs, swamps and poorly draining soils. The plants grow best in acidic, organic or sandy soils with a pH between 4.0 and 5.5 where there is a plentiful water supply. The bed should have a base material which is impermeable to water such as clay or peat. Commercially grown cranberries are grown in large beds surrounded by dykes that hold water in the beds when flooded for harvest. Cranberry is very susceptible to frost and flooding is also used to protect the plants along with sprinkler irrigation. This means that it is the water that will freeze and the resultant heat produced by the change of liquid to solid (latent heat of fusion) protects the plants from freezing themselves. It is common for cranberry beds to be covered with up to 25 cm (9.8 in) of ice. **Propagation** Cranberries are usually propagated vegetatively by moving vines to a new bed. Cuttings are obtained as a by product of the practice of mowing the beds. Mowing helps to prevent the vines from becoming matted and leads to greater productivity by promoting new growth. Cuttings are pushed into a layer of fresh sand approximately 15 cm (5.9 in) deep and the sand is kept moist to allow the new vines to establish and produce new growth. Fruit will be produced on the new vine within 2–3 years and full productivity should be reached within 4 to 6 years of planting. Rooted plants are available for planting in home gardens and are less labor intensive option. **General care and maintenance** One of the most important aspects of caring for cranberry plants is to protect them from frosts. Growers use irrigation systems to help prevent damage and are able to flood the beds to protect the plants. In the home garden, cranberry plants can be protected by covering with plastic sheets or blankets in the event of a frost. Cranberry beds should be kept moist through irrigation. Cranberries benefit from the addition of fertilizers with nitrogen being the most common requirement. Cranberries utilize nitrogen in the ammonium form as they lack the ability to reduce the nitrogen to nitrate. Phosphorus may also be required but should not be applied to the soil in excess amounts as acid soils bind large quantities of the element and it is unavailable to the plants. **Harvest** Cranberries can be dry or wet harvested. Berries are dry harvested with the use of a machine which combs berries from the plants. Wet harvesting of berries occurs in many major cranberry growing regions and involves flooding the beds and using machinery to remove the berries from the vines. The beds are flooded with water sufficient to cover the vines and a piece of machinery called a water reel, or ‘beater’, is driven through the bed to dislodge the berries from the plants. More water is then added to the beds to allow the berries to float free from the plants and they are then moved with the use of booms to one corner of the bed where they are removed by conveyor belts or pumps for transport and processing.

The berries are pumped from the bed for transporting

Booms are used to move the berries to one corner of the bed

Booms are used to move the berries to one corner of the bed

Water is added to float the berries away from the plants

Water is added to float the berries away from the plants

Machinery is driven through flooded beds to 'pick' the cranberries

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Botryosphaeria fruit rot and berry speckle** *Botryosphaeria vaccinii*

###### **Symptoms**

Small, light colored lesions on skin of fruit; epidermis surrounding lesion turns red; on green fruit lesions appear as red ring spots; fruit may develop a watery rot postharvest

###### **Cause**

Fungus

###### **Comments**

Occurs in all major cranberry growing regions of the US but causes little economic damage

###### **Management**

No specific control measures; application of fungicides for other fruit rots usually sufficient to control this particular disease; removing plant debris from beds during flooding may reduce levels of inoculum

##### **Proventuria Early Leaf Spot** *Proventuria barriae*

###### **Symptoms**

Red circles or rings on upper surfaces of leaves which darken as the fungus multiplies; symptoms of early leaf spot can appear as early as March

###### **Cause**

Fungus

###### **Comments**

###### **Management**

No control measures currently recommended

##### **Red leaf spot** *Exobasidium rostrupii*

###### **Symptoms**

Circular Albright red spots on upper leaf surfaces; spots may also be present on young berries

###### **Cause**

Fungus

###### **Comments**

Fungus overwinters on infected leaves and stems; disease emergence is favored by periods of high humidity such as rainfall and fogs

###### **Management**

Spraying with Bordeaux mixture after bud break protects new leaves from becoming infected; avoid over fertilizing vines; fungicide applications are ineffective if disease outbreak is severe

#### Category : Other

##### **End rot** *Godronia cassandrae*

###### **Symptoms**

Soft watery rot which can start at either end of berry with clear boundaries between rotting area and unaffected tissue; rot progresses to affect entire berry which becomes soft to touch; upper surface of leaves may become infected and develop red-brown spots which develop tan or gray centers and black borders; areas of leaves outside black borders turn bright red; leaves may drop from plant

#### Cause

Fungus

#### Comments

Fungus overwinters in bark, dead leaves and rotting fruit; disease incidence is increased when raking is used during wet harvest of cranberries

#### Management

Disease usually manifests as a post harvest berry rot and only requires control if berries are for soft market; fungicides are available in some US states; end rot development can be slowed by refrigerating berries after harvest

### Category : Oomycete

#### Phytophthora root and runner rot *Phytophthora* spp.

#### Symptoms

Discrete patches in a bed which are devoid of vines; other symptoms of disease include: weak and unproductive vines; stunted shoots; small leaves which turn red prematurely in the Fall; reduced flower and fruit production; olive green to dark brown discoloration of root tissue under periderm

#### Cause

Oomycete

#### Comments

Disease is most severe in water logged or poorly drained soils

#### Management

Control of the disease is most effective when an integrated management strategy is implemented, control strategies include: managing water to avoid water saturated soil; increasing soil drainage through digging of ditches or installing drains; stimulating root production and plant growth by fertilizing, particularly unproductive plants; application of appropriate fungicides if available

## Pests

### Category : Insects

#### Blackheaded fireworm *Rhopobota naevana*

#### Symptoms

Several leaves webbed together at growing tips of fresh growth; insects feed on lower leaf surface, creating holes which remain covered by the upper leaf surface; upper leaf surface turns red-brown and dies; insect may also wound fruit and encourage secondary infections with fungi and/or bacteria; adult insect is a gray-brown moth; larvae are cream to gray-green caterpillars shiny dark brown or black head

#### Cause

Insect

#### Comments

Insect overwinters as eggs on the foliage; insect typically undergoes 2 generations per year but there may be a third generation in warmer years when there is an early spring; insect can cause substantial damage if populations are left unchecked

#### Management

Reflooding the beds for between 24 and 48 hours after eggs have hatched will kill off a high number of larvae; application of *Bacillus thurengiensis* may reduce the populations of larvae on the plants

## **Cottonball** *Monilinia oxyocci*

### **Symptoms**

Tip blight on new shoots (shriveled tip resembles a shepherd's crook); masses of white powdery spores on tips just before plant bloom; brown V- or U-shaped lesions on leaf midveins

### **Cause**

Fungus

### **Comments**

Fungus overwinters in dried up remains of fruit

### **Management**

Primary method of controlling cottonball is the application of appropriate fungicides if available; cultural practices that reduce incidence of the disease have not yet been investigated

## **Cranberry blossomworm** *Epigaea apiata*

*Cranberry blossomworm larva*

*Cranberry blossomworm - adult moth*

### **Symptoms**

Feeding damage to leaves; holes bored in buds; buds and blossoms dropping from plant; adult insect is a dark brown moth; young larvae are green caterpillars which turn reddish-brown as they mature

### **Cause**

Insect

### **Comments**

Insect overwinters as eggs on crop debris in the soil; blossomworms undergo one generation per year

### **Management**

Insecticide application is recommended for commercial production if the number of blossomworm larvae reaches the threshold of 4.5 larvae per 25 sweep net samples (sweep netting must be done at night as the insect is nocturnal);

## **Cranberry fruitworm** *Acrobasis vaccinii*

*Cranberry fruitworm (berry pictured is blueberry)*

### **Symptoms**

Berries turning red prematurely; fruit shriveling and drying up; fruit is hollowed out and filled with insect frass; entry and exit holes may be visible on the berry - exit holes are significantly larger than entry holes; adult insect is a gray-brown moth which lays its eggs near the calyx end of the berry; newly hatched larvae are very small and are pale yellow in color; larvae are the damaging stage and they burrow into the berries to consume the pulp inside

### **Cause**

Insect

### **Comments**

One fruitworm larva can consume 3 to 8 berries prior to pupation; insect undergoes only one generation per year; insect is also a pest of blueberry

### **Management**

Predation by natural enemies does occur but is not enough to keep the cranberry fruitworm under control; late flooding

of the cranberry plantation (30 day reflood before the end of dormancy) has been shown to successfully reduce the activity of the fruitworm; chemical control option include several broad spectrum insecticides for commercial use but must be applied at the egg stage in order to be effective as larvae which have already entered the fruit are shielded from the chemical

### **Cranberry tipworm** *Dasineura oxycoccana*

#### **Symptoms**

Cupping and whitening of terminal leaves; death of growing tips of plants; plants will compensate by creating a new branch at a lateral bud, these new branches may produce only vegetative growth and no fruit, resulting in reduced yield the following year; adult insect is a tiny (2 mm) fly which only lives a few days; larvae are maggots which are initially clear but change to white and finally orange as they mature

#### **Cause**

Insect

#### **Comments**

Damage from the insect is most apparent the year following attack in the form of reduced yield; the fly can undergoe between 3 and 5 generations per year

#### **Management**

Because cranberry tipworm larvae and adults are so small, they are difficult to monitor; sarding the cranberry bushes is an effective method of controlling insect emergence as it prevent that adults emerging from pupae in the soil; sarding should be conducted on continuous blocks as there is potential for the insect to recolonize from unsanded areas; natural enemies include hoverflies and some species of parasitic wasp

### **Cranberry weevil** *Anthonomus musculus*

#### **Symptoms**

Flowers are orange instead of pink due to feeding damage and do not produce fruit; numerous holes in berries; feeding damage to underside of leaves results in small black crescent-shaped spots; damage to the base of runners by adult insect may cause damage similar to frost; adult insect is a reddish brown beetle with elongated snout; larvae are yellow-white grubs

#### **Cause**

Insect

#### **Comments**

Weevils overwinter as adults under the winter flooded beds; the insect undergoes only one generation per year

#### **Management**

Cranberry weevil populations usually remain low and little is known about their natural enemies and cultural control methods; chemicals registered for use in commercial plantations on the East coast of the US include azinphosmethyl and chlorpyrifos which should be applied if weevil population has reached the threshold (on average 4.5 weevils per 25 sweep net samples)

### **Gypsy moth** *Lymantria dispar*

*Gypsy moth larva*

#### **Symptoms**

Feeding damage to cranberry foliage and terminal buds and new growth; adult insect is a brown (male) or white (female) moth; larvae are black caterpillars which are covered in hair-like structures called setae; as the caterpillars mature they develop five pairs of raised blue spots and six pairs of raised red spots along their backs

#### **Cause**

Insect

#### **Comments**

Gypsy moths are serious forest pests and can find their way into cranberry plantations by dropping from nearby trees; outbreaks are cyclic in nature and serious outbreaks in the US have tended to occur every 9-10 years; eggs can overwinter on the bed of the bogs and cause a new infestation in spring

### **Management**

Larvae are easily controlled with insecticides or by reflooding the beds for a period of 24 hours

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# Cress

## Description

Garden cress, *Lepidium sativum*, is an herbaceous annual in the family Brassicaceae grown for its edible shoots and leaves which are grown as a salad green. Garden cress is a fast growing plant with many branches and narrow, oval leaves. The plant produces small pink to white flower which are 2 mm (1/12 in) in diameter and form a highly clustered inflorescence. It can reach a height of 60 cm (23.6 in) and although classed as an annual it can behave as a perennial as it may drop seeds before harvest that will grow the next year. Garden cress may also be referred to as pepper cress or Persian broadleaf cress and it originates from Persia (Iran).

*Cress flowers*

*Cress flowers*

*Cress*

*Cress leaves*

*Garden cress plants*

*Potted cress plants*

## Uses

The shoots and leaves of garden cress are used as a salad green or seasoning as they has a peppery taste. The seeds may also be ground and used as a seasoning.

# Propagation

**Basic requirements** Garden cress is a cool season annual and can grow in almost any type of soil as long as it is moist and rich in nutrients. Cress will grow best in a well-draining loam soil with a pH between 6.0 and 6.7. The plants should be grown in full sun or partial shade in areas where temperatures get very high. Cress plants will tolerate some frost.

**Planting** Garden cress is propagated by seed and can be sown as soon as the soil is workable in the Spring. The seeds are sown either by broadcasting or arranging the plants in rows. Rows should be spaced 7-10 cm (3-4 in) apart. The seeds should be covered with a light layer of soil and kept moist. Cress will germinate in 2 to 7 days and the plants do not usually require thinning. The plants will grow best if the soil is kept moist. **General care and maintenance** Cress is very easy to grow and care for. The plants will grow best if kept moist so the plants should be watered regularly. Keep beds weed free to prevent competition with the developing plants. Due to its short growing period, cress has a low fertilizer requirement. Container grown plants can be fertilized with a liquid fertilizer if required. **Harvesting** Cress can be harvested 2 to 3 weeks after the seedlings emerge once the leaves have reached 3 cm (2 in) in length. Harvest older plants first by snipping with a pair of scissors and leave the younger ones to develop fully.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Alternaria leaf spot (Brown spot)** *Alternaria brassicae*

##### **Symptoms**

Brown lesions on leaves; brown or yellow concentric rings developing from lesions

##### **Cause**

Fungus

##### **Comments**

Favors warm, wet weather

#### **Anthracnose** *Colletotrichum higginsianum*

##### **Symptoms**

Small circular or irregularly shaped dry spots which are gray to straw in color on leaves; a high number of spots may cause the leaf to die; lesions may coalesce to form large necrotic patches causing leaves to turn yellow and wilt; lesions may split or crack in dry centers

##### **Cause**

Fungus

##### **Comments**

Fungus overwinters on leaf debris and on related weeds; disease emergence is favored by moist, warm conditions

### **Management**

Control of disease depends on sanitary practices; treat seeds with hot water prior to planting; rotate crops; plant in an area with good soil drainage; remove all cruciferous weeds which may act as a reservoir for the fungus

### **Clubroot *Plasmodiophora brassicae***

#### **Symptoms**

Slow growing, stunted plants; yellowish leaves which wilt during day and rejuvenate in part at night; swollen, distorted roots; extensive gall formation

#### **Cause**

Fungus

#### **Comments**

Can be difficult to distinguish from nematode damage; fungus can survive in soil for periods in excess of 10 years; can be spread by movement of contaminated soil and irrigation water to uninfected areas

### **Management**

Once the pathogen is present in the soil it can survive for many years, elimination of the pathogen is economically unfeasible; rotating crops generally does not provide effective control; plant only certified seed and avoid field grown transplants unless produced in a fumigated bed; applying lime to the soil can reduce fungus sporulation

### **Damping-off *Pythium* spp.**

*Rhizoctonia solani*

#### **Symptoms**

Death of seedlings after germination; brown or black rot girdling stem; seedling may remain upright but stem is constricted and twisted

#### **Cause**

Fungi

#### **Comments**

Disease emergence in seedlings favored by cool temperatures

### **Management**

Plant pathogen-free seed or transplants that have been produced in sterilized soil; apply fungicide to seed to kill off any fungi; shallow plant seeds or delay planting until soil warms

### **Downy mildew *Peronospora parasitica***

#### **Symptoms**

White, fluffy mold on the underside of leaves; yellowing of the top side of the leaf; black lesions on leaves

#### **Cause**

Fungus

#### **Comments**

Disease favors cool, humid weather

### **Management**

Remove all crop debris after harvest; rotate with non-brassicas; application of appropriate fungicides may be required if symptoms of disease are present

## **Category : Bacterial**

### **Blackleg *Phoma lingam***

#### **Symptoms**

Damping-off of seedlings; round or irregularly shaped gray necrotic lesions on leaves with dark margins; lesions may be covered in pink masses in favorable weather conditions

**Cause**

Fungus

**Comments**

Disease favors warm, wet weather; water splash contaminated tools can spread the disease

**Management**

Use disease free seed or treat with hot water to remove fungus prior to planting; remove and destroy crop debris after harvest or plow deeply into soil

**Black rot *Xanthomonas campestris*****Symptoms**

V-shaped yellow or orange discoloration spreading from leaf edge to the center; black leaf veins; leaves falling off

**Cause**

Bacteria

**Comments**

Pathogen is spread via infected seed or by splashing water and insect movement; disease emergence favored by warm and humid conditions

**Management**

Primary method of controlling black rot is through the use of good sanitation practices; rotate crops to non-cruciferous crops every 2 years; plant resistant varieties; control cruciferous weed species which may act as a reservoir for bacteria; plant pathogen-free seed

## Pests

### Category : Insects

**Flea beetles *Phyllotreta* spp.****Symptoms**

Small holes or pits in leaves that give the foliage a characteristic "shot hole" appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5–3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance

**Cause**

Insect

**Comments**

Younger plants are more susceptible to flea beetle damage than older ones; older plants can tolerate infestation; flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year

**Management**

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application of diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied

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# Cucumber

## Description

Cucumber, *Cucumis sativus*, is a warm season, vining, annual plant in the family Cucurbitaceae grown for its edible cucumber fruit. The cucumber plant is a sprawling vine with large leaves and curling tendrils. The plant may have 4 or 5 main stems from which the tendrils branch. The leaves of the plant are arranged alternately on the vines, have 3–7 pointed lobes and are hairy. The cucumber plant produces yellow flowers that are 4 cm (1.6 in) in diameter. The cucumber fruit varies in shape but is generally a curved cylinder rounded at both ends that can reach up to 60 cm (24 in) in length 10 cm (3.9 in) in diameter. Cucumber plants are annual plants, surviving only one growing season and the vines can reach up to 5 m (16.4 ft) in length. Cucumber may also be referred to as gherkin and originates from the foothills of the Himalayas, likely in India.

*Cucumbers beginning to develop from flower*

*Close-up cucumber flower*

*Cucumber flower*

*Cucumber foliage*

*Cucumber fruit*

*Cucumber fruit on the vine*

## Uses

Although technically a fruit, cucumbers are used as a fresh vegetable, consumed fresh in salads. Some varieties are grown specifically for pickling. Yellow varieties are generally cooked before consumption.

## Propagation

**Basic requirements** Cucumbers require warm, dry conditions to develop optimally, preferring both warm days and warm nights and growing best at a temperature of 30°C (86°F). Cucumbers will yield best if grown in a fertile, well-draining soil, rich in organic matter and with a pH between 6.5 and 7.5. Cucumbers are very sensitive to cold and should be planted in full sun and provided with ample soil moisture due to their shallow root system. **Cucumber varieties** One of the biggest considerations when choosing a cucumber variety is whether or not it requires pollinating. Many newer cucumber varieties are gynoecious which means that they produce only, or mostly, female flowers. Some gynoecious varieties require pollinating with male flowers, in which case a proportion of the seeds in the packet will be pollinator plants which produce the male flowers. Some gynoecious varieties are parthenocarpic which means that they do not need the male plants to produce fruit. These types are recommended for growing in glasshouses as they do not require the presence of insect pollinators. **Sowing seeds** Direct seeding is the preferred method for sowing cucumbers as they do not transplant well. Seeds should be sown after the last frosts and when the soil has warmed to at least 15.6°C (60°F). Sow seeds 1.3–2.5 cm (0.5–1.0 in) deep, thinning to a spacing of at least 30 cm (12 in) between plants after germination. Cucumbers can also be seeded on hills or mounds of soil to encourage warm soil and better drainage. In this instance, seeds should be sown on hills in groups of 4–6 seeds, allowing 1.2 m (4 ft) between each group in all directions. After emergence, thin the seedlings to 1 or 2 plants per hill. Cucumber seeds should germinate in 4–13 days depending on the soil temperature. **General care and maintenance** Cucumber vines are sprawling and require plenty space to grow. Vines can be trained to grow on a trellis or fence. Providing burpless varieties with vertical support allows the fruits to hang loose and grow straight. Cucumbers also require a continuous supply of water and where drip irrigation is not being used, plants should be watered deeply once per week, providing at least an inch of water. Shallow watering or watering less frequently will reduce fruit yields. Mulches can be used to conserve soil moisture and black plastic mulch has the advantage of warming the soil. **Harvesting** Cucumbers should be harvested from the plant when they are still immature and green in color. Mature fruits are yellow and the flesh is often tough with woody seeds. The size of cucumbers at harvest depends on the variety of the cucumber being grown and what it is to be used for. Cucumbers for pickling are generally picked when they are less than 5 cm (2 in) long whereas burpless cucumbers for slicing should be allowed to reach approximately 4 cm (~1.5 in) in diameter. It is important to remove any fruits nearing maturity to ensure the plant remains productive. Their rapid growth means that cucumbers may need harvested every couple of days.

Cucumber growing vertically in cage

Cucumber trellis

Vertical support allows the fruits to hang loose and grow straight

Cucumber seedlings with black plastic mulch and trellis

Cucumber seedlings should emerge in 4–13 days

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Alternaria leaf blight** *Alternaria cucumerina*

*Alternaria leaf blight (Alternaria cucumerina) symptoms on cantaloupe leaf*

*Infected cantaloupe plant*

*Infected cucumber leaf*

*Symptoms of alternaria leaf blight on cucumber leaf*

#### Symptoms

Small, yellow-brown spots with a yellow or green halo which first appear on the oldest leaves; as the disease progresses, lesions expand and become large necrotic patches, often with concentric patterning; lesions coalesce, leaves begin to curl and eventually die.

#### Cause

Fungus

#### Comments

Disease is prevalent in growing areas where temperatures are high and rainfall is frequent.

#### Management

Cucurbits should be rotated with another crop every 2 years to reduce levels of inoculum; crop debris should be removed from the field as quickly as possible after harvest or plowed deeply into the soil; applications of appropriate protective fungicides can help to slow the development of the disease; water plants from the base rather than from above to reduce periods of leaf wetness which are conducive to the development and spread of disease.

##### **Anthracnose** *Colletotrichum orbiculare*

Diseased leaf	Diseased leaf	Lesion on fruit	Anthracnose lesions
Anthracnose symptoms on cucumber foliage		Close up of anthracnose symptom on leaf	Lesions on fruit with pink sporulation
Anthracnose lesions on cucumber foliage		Anthracnose lesions on cucumber foliage	Anthracnose lesions on cucumber foliage
		Anthracnose symptoms on cucumber foliage	Post-harvest anthracnose symptoms on cucumber fruit

## Symptoms

Brown roughly circular lesions with yellow edges on leaves on leaves, petioles, stems and/or fruit; lesions on resistant varieties appear tan with green edges; lesions dry out and drop out of leaves.

## Cause

Fungus

## Comments

Disease favors warm temperatures.

## Management

Plant resistant varieties; use only certified seed; apply appropriate protective fungicides; rotate crops every year.

## Belly rot (Fruit rot, Damping-off) *Rhizoctonia solani*

Early infection	Symptoms of belly rot	Belly rot lesions are watersoaked initially, but quickly dry and become scabby.
Cucumber belly rot symptom	Water-soaked lesion on cucumber fruit caused by belly rot	Symptoms of belly rot on cucumber fruit
Symptoms of belly rot on cucumber fruit	Symptoms of belly rot on cucumber fruit	Symptoms of belly rot on cucumber fruit

## Symptoms

Yellow/brown discoloration on fruit; water soaked spots on side of fruit in contact with soil; brown mold growing on rotting areas; collapse of seedlings.

## Cause

Fungus

## Comments

Disease favors warm, humid conditions.

## Management

Till soil deeply prior to planting; use plastic mulch to create a barrier between fruit and soil; plant in sites with good drainage to avoid wet soils; apply appropriate protective fungicides when plants begin to vine.

## **Cercospora leaf spot** *Cercospora citrullina*

Diseased melon leaf

Close-up of cercospora lesion on melon

Cercospora leaf spot (*Cercospora citrullina*) symptoms on melon leaf

Lower side of infected melon leaf

### **Symptoms**

Initial symptoms of disease occur on older leaves as small spots with light to tan brown centers; as the disease progresses, the lesions enlarge to cover large areas of the leaf surface; lesions may have a dark border and be surrounded by a chlorotic area; the centers of the lesions may become brittle and crack.

### **Cause**

Fungus

### **Comments**

Fungus survives on plant debris; spread by wind and water splash; occurs mainly in tropical and subtropical growing regions.

### **Management**

Any diseased plants should be removed and destroyed to prevent further spread; crop debris should be removed after harvest or plowed deeply into the soil to reduce inoculum.

## **Downy mildew** *Pseudoperonospora cubensis*

Purplish gray coloration of downy mildew sporangia on cucumber

Advanced stage of downy mildew on cucumber.

Close-up of downy mildew symptom

Downy mildew symptom

Young cucumber plants with downy mildew. Notice that individual leaf spots have a slight orange/yellow hue and are often angular.

Cucumber leaves showing various stages of downy mildew lesion development.

Downy mildew symptoms in cucumber field

Downy mildew symptoms on cucumber foliage

Downy mildew symptoms on cucumber foliage

Downy mildew symptoms on cucumber foliage

Symptoms of downy mildew on underside of cucumber leaf

Symptoms of downy mildew on cucumber leaf

### **Symptoms**

Fluffy purplish mildew on underside of leaves; yellow spots on the upper side of leaves.

### **Cause**

Oomycete

### **Comments**

Disease favors cool, humid conditions.

### **Management**

Do not overcrowd plants; avoid overhead irrigation, water plants from base; apply appropriate fungicide.

## **Fusarium wilt (Cucumber wilt, Foot-rot)** *Fusarium oxysporum*

## Symptoms

Rotting of seedling stems at soil line; brown lesions on one side of stem; discoloration of tissue inside vine.

## Cause

Fungus

## Comments

Disease favors warm, moist soil.

## Management

Plant fungicide treated seed; rotate crops on 4 year rotation.

## Gummy stem blight (vine decline, GSB) *Didymella bryoniae*

*Leaf spotting caused by gummy stem blight*

*Gummy stem blight typically starts at leaf margins.*

*Fruiting bodies (pycnidia) of the pathogen are evident in the lesion as tiny black dots.*

*Diseased leaf blighted leaf*

*Severely blighted leaf Infected leaf*

*Symptoms on stem*

*Close up of foliar lesion showing black pycnidia embedded in necrotic tissue on adaxial surface.*

*Late foliar symptoms with marginal necrosis.*

*Foliar lesion showing black pycnidia embedded in necrotic tissue on adaxial surface.*

*Lesions caused by gummy stem blight on cucumber leaf (smaller lesions; large lesion in center caused by target leaf spot)*

## Symptoms

Gray/green lesions between veins of leaves; tan or gray lesions on stems.

## Cause

Fungus

## Comments

Disease may be seed-borne.

## Management

Use disease free seed; treat seeds prior to planting; rotate crops every 2 years.

## Powdery mildew *Erysiphe cichoracearum*

*Sphaerotheca fuliginea*

<i>Infected plant</i>	<i>Powdery mildew symptoms</i>	<i>Powdery mildew of cucumber (Cucumis melo) caused by Erysiphe cichoracearum.</i>
<i>white powdery spots on the upper surfaces of leaf</i>	<i>Diseased leaf</i>	<i>Powdery mildew infected leaf</i>
<i>Conidia produced on leaf surface</i>	<i>Typical powdery white appearance of affected foliage</i>	<i>A cucumber plant showing signs of powdery mildew infection in the field.</i>
<i>Powdery mildew of cucumber</i>	<i>White fungal growth on leaf surface</i>	<i>Symptoms on cucumber leaves</i>

## **Symptoms**

The appearance of white powdery spots on the upper surfaces of leaves, stems and fruits. As the disease progress, white fungal growth covers whole leaves and stem. The infected leaves become yellow, distorted and may drop prematurely.

## **Cause**

Fungus

## **Comments**

The spores are carried by wind from one plant to another. The disease is favored by moderate temperature and shady conditions.

## **Management**

Grow available resistant varieties. If the disease is severe, spray suitable fungicide.

## **Septoria leaf spot** *Septoria cucurbitacearum*

<i>Dark pycnidia, extruding spore tendrils, evident in leaf spot</i>	<i>Septoria leaf spot symptoms- Dark pycnidia evident in leaf spot</i>
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## **Symptoms**

Initial symptoms of disease are small dark water-soaked spots on the leaves which turn beige to white in dry conditions; lesions develop thin brown borders and the centers may become brittle and crack; small white spots may erupt on the surface of infected butternut and acorn squash and pumpkin fruit.

## **Cause**

Fungus

## **Comments**

Pathogen can survive on crop debris for periods in excess of 1 year.

## **Management**

Scout plants during cool wet conditions for any sign of spots; early application of an appropriate protective fungicide can help limit the development of the disease if spots are found' cucurbits should be rotated with other crops every 2 years to prevent the build-up of inoculum; crop debris should be removed and destroyed after harvest.

## **Target leaf spot** *Corynespora cassiicola*

*Corynespora melonis*

<i>Micrograph of target spot lesion at 30X magnification. Dark flecks are conidia of <i>Corynespora cassiicola</i>.</i>	<i>Note the angular shape of lesions.</i>	<i>Symptoms</i>
<i>Infected leaf</i>	<i>The angular shape of lesions due to <i>Corynespora</i></i>	<i>Close-up image of target spot lesion on cucumber</i>
<i>Target leaf spot symptoms on cucumber</i>	<i>Target leaf spot symptoms on cucumber foliage</i>	<i>Lesions on cucumber leaf caused by target leaf spot</i>

### **Symptoms**

Angular yellow spots appear on older leaves; as the disease progresses, the spots enlarge and become circular with light brown centers and dark margins; as lesions mature, they turn gray and drop out leaving holes in the leaves; if fruits become infected early in their growth then the blossom end may darken and become shriveled.

### **Cause**

Fungus

### **Comments**

Fungus can survive on plant debris for periods in excess of 2 years; disease emergence favored by periods of high humidity and temperature.

### **Management**

Plant resistant varieties; apply appropriate protective fungicide; sanitize equipment regularly.

## **Verticillium wilt** *Verticillium dahliae*

### **Symptoms**

Symptoms generally appear after fruit set; chlorotic leaves which develop necrotic areas; leaves collapsing; symptoms only on one side of vine; discoloration of vascular tissue in roots.

### **Cause**

Fungus

### **Comments**

Fungus can survive in soil for many years; disease emergence favored by cool or mild weather in Spring.

### **Management**

Do not plant in areas where other susceptible crops have been grown previously; delay planting until temperatures are warmer.

## **Category : Bacterial**

### **Angular leaf spot** *Pseudomonas syringae*

<i>Severe foliar symptoms</i>	<i>Symptoms</i>	<i>Initial symptom</i>	<i>Infected field</i>
<i>Angular leaf spot symptoms on cucumber leaf</i>	<i>Notice that lesions are delimited by veins in the leaf.</i>		<i>Initial symptoms of angular leaf spot of cucumber (<i>Pseudomonas syringae</i> pv. <i>lachrymans</i>)</i>
<i>Angular leaf spot symptoms on cucumber leaf</i>	<i>Angular leaf spot symptoms on cucumber foliage</i>		<i>Angular leaf spot symptoms</i>
	<i>Angular leaf spot symptoms on cucumber foliage</i>		<i>Symptoms of angular leaf spot on cucumber leaves</i>

## **Symptoms**

Small water-soaked lesions on leaves which expand between leaf veins and become angular in shape; in humid conditions, lesions exude a milky substance which dries to form a white crust on or beside lesions; as the disease progresses, lesions turn tan and may have yellow/green edges; the centers of the lesions dry and may drop out leaving a hole in the leaf.

## **Cause**

Bacteria, Bacterium

## **Comments**

Spread through infected seed, splashing rain, insects and movement of people between plants; bacterium overwinters in crop debris and can survive for 2.5 years.

## **Management**

Use disease-free seed; do not grow plants in field where cucurbits have been grown in the previous 2 years; protective copper spray may help reduce incidence of disease in warm, humid climates; plant resistant varieties.

## **Bacterial leaf spot** *Xanthomonas campestris*

### **Symptoms**

Initial symptoms of the disease are the appearance of small water-soaked lesions on the undersides of the leaves which lead to the development of yellow patches on the upper leaf surface; the lesions become round and angular and may be mistaken for angular leaf spot; the centers of the lesions become thin and translucent and lesions become surrounded with a wide yellow halo.

## **Cause**

Bacterium

## **Comments**

Bacteria is spread via infected seeds.

## **Management**

Use disease-free seed; do not grow plants in field where cucurbits have been grown in the previous 2 years; avoid overhead irrigation, water plants from the base instead to reduce the spread of bacteria.

## **Bacterial wilt** *Erwinia tracheiphila*

<i>Bacterial stringing between vascular elements of the stem.</i>	<i>Severely affected plants will die.</i>	<i>Wilting vine</i>
<i>In diseased stems, slime strings form between cut stem sections as they're pulled apart.</i>	<i>Bacterial wilt (<i>Erwinia tracheiphila</i>) of cucumber.</i>	<i>Symptoms of bacterial wilt of cucumber</i>
<i>Cucumber plant infected with bacterial wilt</i>	<i>Cucumber plant infected with bacterial wilt</i>	<i>Wilting cucumber vines caused by bacterial wilt</i>

### **Symptoms**

Individual runners or whole plant begins to wilt and rapidly die; infected runners appear dark green in color but rapidly become necrotic as the disease progresses.

### **Cause**

Bacterium

### **Comments**

Can result in crop losses of 75%; spread by striped or spotted cucumber beetles; disease can be confirmed by cutting the stem and slowly pulling the two ends apart - infected plants will ooze strings of bacterial exudate.

### **Management**

Control cucumber beetle populations on plants; hand pick adult beetles and destroy; soil and foliar application of appropriate insecticides may help to control populations.

## **Category : Other**

### **Aster yellows** Aster yellows phytoplasma

<i>May be phytoplasma disease on melon</i>	<i>Proliferation of shoot may be due to phytoplasma</i>	<i>Possible symptom</i>
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*Symptoms*

*Possible symptoms phytoplasma disease (Close up of vine terminal showing bunching of leaves & blossoms)*

### **Symptoms**

Foliage turning yellow; secondary shoots begin growing prolifically; stems take on a rigid, upright growth habit; leaves are often small in size and distorted, may appear thickened; flowers are often disfigured and possess conspicuous leafy bracts; fruits are small and pale in color.

### **Cause**

Phytoplasma

### **Comments**

Disease is transmitted by leafhoppers and can cause huge losses in cucurbit crops.

### **Management**

Remove any infected plants from the field to reduce spread; control weeds in and around the field that may act as a reservoir for the phytoplasma; protect plants from leaf hopper vectors with row covers.

## **Category : Viral**

## **Cucumber green mottle mosaic** Cucumber green mottle mosaic virus (CGMMV)

### **Symptoms**

Early symptoms on young plants include vein-clearing and the development of crumpled leaves; older plants develop bleached and/or chlorotic leaves. As the infection progresses, leaves develop mottling and become blistered and distorted. Leaf symptoms are very difficult to distinguish from other mosaic viruses of Cucurbits. Severity of symptoms varies depending on the strain of the virus.

### **Cause**

Virus

### **Comments**

All Cucurbit species are susceptible to the virus, some cucumber varieties have been developed which have some resistance to the disease and are available in Canada and Europe.

### **Management**

As the virus is spread primarily by infected seed, only disease-free seed from a reputable supplier should be planted. Seedlings and plants infected with the virus should be removed and destroyed to prevent spread. All seedlings/plants within a 3-5 ft radius of the infected plant should also be destroyed. The virus can be spread mechanically via tools and on hands, good sanitation should be practiced at all times to prevent virus transmission - disinfect all tools and equipment between uses by dipping in a solution of bleach or using a commercially available disinfectant such as Virkon.

## **Cucumber mosaic** Cucumber mosaic virus (CMV)

*Greenhouse cucumbers infected with cucumber mosaic virus*

*Cucumber mosaic symptoms*

*Cucumber mosaic symptoms*

*Cucumber mosaic symptoms on fruit*

*Cucumber mosaic symptoms on cucumber leaf*

*Cucumber mosaic virus symptoms on cucumber foliage*

### **Symptoms**

Plants are severely stunted; foliage is covered in distinctive yellow mosaic; leaves of plant curl downwards and leaf size is smaller than normal; flowers on infected plants may be deformed with green petals; fruits become distorted and are small in size; fruit is often discolored.

### **Cause**

Virus

### **Comments**

Transmitted by aphids; virus has an extensive host range; virus can be mechanically transmitted via tools etc.

### **Management**

Control of the virus is largely dependant on the control of the aphid vectors; reflective mulches can deter aphid feeding; aphid outbreaks can be treated with mineral oils or insecticidal soap applications; some resistant varieties are available.

## **Squash mosaic** Squash mosaic virus (SqMV)

*Leaves appear with yellow and green mosaic pattern. Leaves may be puckered and distorted.*

*A zucchini squash leaf showing symptoms of the squash virus infection.*

### **Symptoms**

Symptoms vary with variety being grown but plants can show symptoms which include green veinbanding, mottled leaves, blisters, ring spots or protruding veins at leaf margins; some squash varieties may develop leaf enations; infected

plants are often stunted and fruits may be malformed with mottled skin.

#### Cause

Virus

#### Comments

Virus can be transmitted through infected seed and spread by striped cucumber beetles.

#### Management

Use only certified disease-free seed.

### Watermelon mosaic Watermelon mosaic virus (WMV)

#### Symptoms

Symptoms vary widely depending on species, cultivar, virus strain and environmental conditions; symptoms on leaves may include green mosaic patterning, green vein-banding, chlorotic rings and disfigured leaves.

#### Cause

Virus

#### Comments

Virus is found in almost all Cucurbit growing regions in the world; virus is spread by over 20 aphid species.

#### Management

Treatments that control populations of aphid vectors can also reduce the incidence of the virus; spraying plants with mineral oils or insecticidal soaps can help to reduce aphid numbers.

## Category : Oomycete

### Phytophthora blight *Phytophthora capsici*

Vine blight symptom

Wilted foliage is the first symptom of  
*Phytophthora* blight.

Diseased leaf

Squash plants lying flat were  
infected by *P. capsici* at the crown.

Blighted foliage Diseased fruit

*Phytophthora* blight foliar symptom

Abundant sporulation occurs on the  
surface growth. *Phytophthora* Fruit  
Rot

Diseased fruit with sporulating  
lesions.

Water soaked lesion of fruit

*Phytophthora* blight (*Phytophthora*  
*capsici*) infected fruits

Healthy and *phytophthora* fruit rot  
infected cucumbers

#### Symptoms

The disease can be found in all stages and all parts of the crop. On seedlings, the pathogen causes damping off symptoms where hypocotyl exhibit watery rot or rotting of the stem near the soil line, resulting in plant death. The mature plants exhibit crown rot symptoms. The post-emergence infection leads to wilting and death of the plant. During the growing season, vine exhibit dark olive water soaked lesion which later become brown resulting in girdling of the stem that leads to quick collapse and death of foliage (vine blight). On leaves shows necrotic spots with chlorotic to olive-green borders. As the disease progress, this spot merges and cover entire leaf. On fruits, disease can occur from fruit set to harvest and storage. The appearance of water soaked lesions on fruit, particularly near the surface which is touching the soil. Later these lesions expand, resulting in rotting. The infected fruit is covered with white mold numerous sporangia.

#### Cause

Oomycete

### Comments

Rain and overhead irrigation helps in spreading pathogen from plant to plant.

### Management

Use disease free seed materials. Follow crop rotation. Spray suitable fungicide.

## Pythium fruit rot (Cottony leak) *Pythium* spp.

Infected fruit

symptoms Cottony leak

In a moist chamber *Pythium* spp will form extensive, cottony, mycelial growth.

*Pythium* cottony leak on cucumber fruit. White, cotton like mass that may cover the entire fruit. Jelly or liquid may ooze from within the fruit.

*Pythium* cottony leak

Heavy growth of white fungal mass which resembles the tufts of cotton

Cross section of cucumber fruit infected with *Pythium* cottony leak.

*Pythium* cottony leak of cucumber

### Symptoms

The symptoms first appear in the area of fruit which is in contact with soil as small, water-soaked spots. These spots spread very fast to a large portion of fruit resulting in soft and necrotic area. If the condition is favorable, heavy growth of white fungal mass which resembles the tufts of cotton can be seen on infected area.

### Cause

Fungus

### Comments

The disease is favored by wet condition. The pathogen spreads via water and soil particles.

### Management

Avoid excessive soil moisture. Mulching with suitable materials help in preventing the disease.

## Category : Bacterial, Fungal

## Scab *Cladosporium cucumerinum*

Damaged fruit Symptoms on leaf

Scab symptoms on cucumber

Infected fruit

Symptoms on leaves, partial and stem

Infected fruits

Stem lesion with fungal sporulation

### Symptoms

The leaves exhibit small water-soaked or pale green spots which later turn white to gray and become angular. A yellowish halo may surround the lesion. The damaged leaves may appear ragged due to tearing and cracking of dead tissue. Symptoms can also be seen on petiole and stem. On fruits, the appearance of small, gray, slightly sunken, oozing, gummy spots which later enlarge, and finally become distinct sunken cavities. Under favorable condition, the pathogen produces dark, olive green, velvety layer of spores on the cavities.

### Cause

Fungus

## Comments

The pathogen overwinters on the seed, in crop debris and in soil.

## Management

Remove and destroy the infected leaves and plant debris. Keep the field free from weeds. Use disease free seeds. Grow available resistant varieties. Follow crop rotation. Spray with suitable fungicides.

# Pests

## Category : Insects

### Aphids (Peach aphid, Melon aphid) *Myzus persicae*

*Aphis gossypii*

*Aphis gossypii*

Winged form of *Myzus persicae* aphid on squash leaf

Larvae of lady bird beetle feeding on aphid

Wingless form of *Myzus persicae* aphid on squash leaf

Infestation of *Myzus persicae* on lower surface of leaf

## Symptoms

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants.

## Cause

Insects

## Comments

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed.

## Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use.

### Cabbage looper *Trichoplusia ni*

Cabbage looper adult

Cabbage Looper cocoon with pupa

Cocoon and pupa of the cabbage looper (*Trichoplusia ni*) from which the moth has emerged.

cabbage looper (*Trichoplusia ni*) larvae

Later stage larvae

Cabbage Looper

## Symptoms

Large or small holes in leaves; damage often extensive; caterpillars are pale green with a white lines running down either side of their body; caterpillars are easily distinguished by the way they arch their body when moving; eggs are laid singly, usually on the lower leaf surface close to the leaf margin, and are white or pale green in color.

### Cause

Insect

### Comments

Insects overwinter as pupae in crop debris in soil; adult insect id a dark colored moth; caterpillars have a wide host range.

### Management

Looper populations are usually held in check by natural enemies; if they do become problematic larvae can be hand-picked from the plants; an organically acceptable control method is the application of *Bacillus thuringiensis* which effectively kills younger larvae; chemical sprays may damage populations of natural enemies and should and should be selected carefully.

## **Cucumber beetles (Western striped cucumber beetle, Western spotted cucumber beetle, Banded cucumber beetle) *Acalymma vittata***

*Diabrotica undecimpunctata*

*Diabrotica balteata*

Banded cucumber beetle

Banded cucumber beetle feeding on leaf

The spotted cucumber beetle

striped cucumber beetle (*Acalymma vittatum*)

Striped cucumber beetles and checkered melon beetle feeding on ripe muskmelon

Adult striped cucumber beetle

Banded cucumber beetle

Western striped cucumber beetle

Western spotted cucumber beetle

### Symptoms

Stunted seedling; damaged leaves, stems and/or petioles; reduced plant stand; plants may exhibit symptoms of bacterial wilt; scars on fruit caused by beetle feeding damage; adult beetles are brightly colored with either a green-yellow background and black spots or alternating black and yellow stripes.

### Cause

Insect

### Comments

Beetles overwinter in soil and leaf litter and emerge from soil when temperatures begin to reach and exceed 12.7°C (55°F).

### Management

Monitor new planting regularly for signs of beetle; floating row covers can be used to protect the plants from damage but will need to be removed at bloom to allow bees to pollinate plants; applications of kaolin clay can be effective for management of small beetle populations; application of appropriate insecticides may be necessary.

## **Cutworms *Agrotis* spp.**

*Peridroma saucia*

*Nephelodes minians*

and others

*Cutworm adult insect*

*bronzed cutworm (*Nephelodes minians*) adult*

*Bronzed cutworm larvae*

*Larva feeding on leaf*

*Cutworm feeding on leaves*

*Cutworm severing plant stem*

## Symptoms

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5â€“5.0 cm (1â€“2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed.

## Cause

Insects

## Comments

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato.

## Management

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically.

## Flea beetles *Epitrix* spp.

*potato flea beetle (*Epitrix cucumeris*) injury to potato leaf*

*copper leafy spurge flea beetle (*Aphthona flava*)*

*Tobacco flea beetle (*Epitrix hirtipennis*)*

## Symptoms

Small holes or pits in leaves that give the foliage a characteristic â€œshot holeâ€ appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5â€“3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance.

## Cause

Insects

## Comments

Younger plants are more susceptible to flea beetle damage than older ones; older plants can tolerate infestation; flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year.

## Management

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application of diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied.

## Stinkbugs (Various) Various

*Stink bug on cucumber leaf*

*southern green stink bug (*Nezara viridula*)*

*Stink bug*

### Symptoms

Dark colored pinpricks on fruit surrounded by a lighter area that turns yellow or remains light green; stink bugs often carry pathogens in their mouthparts which can cause secondary infections and decay of fruit; adult insect is shield-shaped and brown or green in color; may have pink, red or yellow markings; eggs are drum shaped and laid in clusters on the leaves; larvae resemble the adults but are smaller.

### Cause

Insect

### Comments

Adult insects overwinter under leaves, on legumes, blackberries or on certain weeds such as mustard or Russian thistle.

### Management

Remove weeds around crop which may act as overwintering sites for stink bugs and practice good weed management throughout the year; organically accepted control methods include the use of insecticidal soaps, kaolin clay and preservation of natural enemies; chemical treatments are not recommended for tomatoes that are to be processed for paste or canning unless secondary infections with other pathogens are a concern.

## Thrips (Western flower thrips, Onion thrips, etc.) *Frankliniella occidentalis*

*Thrips tabaci*

*Smaller, tan thrips on left is the onion thrips (*Thrips tabaci*). Larger yellowish thrips on the right is the western flower thrips (*Frankliniella occidentalis*).*

*First instar nymph of onion thrips (*Thrips tabaci*).*

*Close-up of thrips injury to cucumber fruit*

*Thrips damage to cucumber leaf*

*Thrips damage to cucumber leaf*

*Thrips damage on cucumber leaves: *Frankliniella occidentalis* with coarser pattern (left); *Thrips tabaci* on right, for comparison.*

### Symptoms

If population is high leaves may be distorted; leaves are covered in coarse stippling and may appear silvery; leaves speckled with black feces; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color.

### Cause

Insect

### Comments

Transmit viruses such as Tomato spotted wilt virus; once acquired, the insect retains the ability to transmit the virus for the remainder of its life.

### Management

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic.

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# Dates

## Description

The date palm, *Phoenix dactylifera*, is an erect palm tree in the family Arecaceae grown for its edible fruit, the date. The trunk of the tree is covered in upward-pointing, overlapping, woody leaf bases and terminates in a crown of 20–30 leaves. The leaves are feather-like with spiny petioles and thick midrib. The leaf blades are pinnately divided and are blue-green in color. The uppermost leaves of the crown stand more erect while the lower ones droop and recurve toward the trunk. The tree produces small, fragrant cream-white flowers and the inflorescence may possess as many as 10,000 flowers. The fruits are produced in clusters and are oblong to ovoid berries with single stones and red-brown flesh. Date palms can grow to a height of 30 m (98 ft) and can live for up to 150 years, although they are usually replaced in commercial plantations when their productivity begins to decline. The date palm is believed to originate from Western Asia.

*Date cluster*

*Dates*

*Date palm*

*Red dates*

*Date palm*

*Date palm with clusters of dates*

## Uses

Dates are consumed as a fresh or dry fruit. They are considered a staple in the deserts of North Africa and the Middle East. The fruit may also be used to make juice concentrates, fermented products (e.g. wines) or pastes for use in baking and confection.

*Dates for sale at a bazaar in Morocco*

## Propagation

**Basic requirements** Date palms grow best in semi-arid climates close to water bodies such as rivers or oases, with an annual average temperature of 12–27°C (53.6–80.6°F) in regions where there is a long hot summer and mild winter. A mean temperature of 21–30°C (69.8–86°F) for at least one month is necessary for fruit production in addition to a period of no rainfall during flowering to prevent damage to the flowers. Date palms grow well in a wide range of soils provided they are well-draining, have a pH between 5.2 and 8 and are in close proximity to a body of water. Fruit production is highest when grown in sandy loams. **Propagation** Date palms for commercial cultivation are usually propagated from suckers removed from the base of mature trees to allow desirable characteristics to be maintained. The suckers should be between 3 and 6 years old and are separated from the mother along with some root. Separating of suckers is usually carried out in late summer or Fall. The newly detached suckers are planted to a depth of 80 cm (31.5 in) leaving 9–10 m (30–33 ft) between plants. The newly planted suckers should be watered daily for the first week to aid in establishment and once weekly thereafter. **Pollination** Date palms are protandric which means that the male flowers are produced before the females. In order for successful pollination to be guaranteed, commercial date palms are pollinated by hand or with the use of machinery. Hand pollination is achieved by cutting the male inflorescence from the palm and joining strands to the female inflorescence. Alternatively, the pollen is extracted and mixed with flour and the mixture is then applied mechanically to the female flowers. Mechanical pollination is conducted with the aid of a small insecticide duster known as a “puffer”. **General care and maintenance** Date development is aided by removing dead leaves and thorns from the trees, thinning of fruit and bunches and also the removal of bunches if the number per palm is too high. Allowing palms to over produce will reduce yield the following year. Each of these practices also aims to maximize fruit size and promote regular fruit production. When bunches begin to develop, they are pulled down and tied to lower leaves in order to protect them from damage from wind. Dates require dry and hot conditions to ripen in combination with the large amount of irrigation of the soil. **Harvesting** Harvesting of ripe dates requires reaching the top of the palm tree. This is achieved through the use of ladders which may be permanently fixed to the tree or through the use of machinery that can raise the worker on a platform. In the Northern Hemisphere, harvest begins at the end of the summer into early Fall and ends around November depending on the variety. Some varieties continue to be harvested after the onset of the rainy season but rain can damage the fruit and reduce its quality so the fruits are usually protected with the use of waxed paper or nylon sleeves.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Bayoud disease** *Fusarium oxysporum*

*Symptoms of Bayoud disease on date palm*

##### **Symptoms**

Leaflets of mature leaves becoming chlorotic at the base on one side; leaf death progressively to the leaf tip; brown or white lesions on underside of leaves

##### **Cause**

Fungus

##### **Comments**

Soil-borne disease; currently restricted to Morocco and Algeria where it can be devastating; the popularity of susceptible cultivars means it has a massive potential to continue to spread

##### **Management**

Cultural control is not recommended for the control of the disease as conditions which favor high yield of dates also favors growth of the fungus; if disease is confirmed then infected tree should be uprooted and burned to prevent spread; soil should be treated with methyl bromide or chloropicrin and the area closed off

#### **Black scorch disease** *Ceratocystis paradoxa*

##### **Symptoms**

Dark brown-black, hard lesions on leaves; foliage with scorched appearance

##### **Cause**

Fungus

##### **Comments**

Palms may recover from disease; fungi can enter through pruning wounds

##### **Management**

Prune out infected fronds, leaf bases and inflorescences and burn the material immediately; pruning wounds should be protected by spraying with Bordeaux mixture

#### **Diplodia disease** *Diplodia phoenicum*

##### **Symptoms**

Death of suckers either while still attached to mother or after planting

##### **Cause**

Fungus

##### **Comments**

Fungus usually enters through cutting or pruning wounds

##### **Management**

Disinfect all tools and equipment regularly; protect pruning wounds and cuts with Bordeaux mixture or other appropriate copper based fungicides

## **Graphiola leaf spot** *Graphiola phoenicis*

*Graphiola leaf spot symptoms on date palm frond*

### **Symptoms**

Small spots on both sides of leaves; yellow spore masses on leaves; black crater-like lesions on leaves

### **Cause**

Fungus

### **Comments**

Disease emergence favored by high humidity

### **Management**

Infected leaves should be pruned out and destroyed; disease can be controlled by sprays of Bordeaux mixture or other appropriate broad spectrum fungicide

## **Khamedj disease** *Mauginiella scattae*

### **Symptoms**

Brown or rust colored area on unopened spathes; partial or complete destruction of flowers

### **Cause**

Fungus

### **Comments**

Disease emergence favored by hot, humid conditions in neglected plantations

### **Management**

Good sanitation practices and maintenance of the plantation helps to control the disease; infected spathes and inflorescences should be removed and burned; diseased palms should be treated with Bordeaux mixture or appropriate copper based fungicide after harvest and approximately 1 month before emergence of spathes

## **Category : Other**

### **Lethal yellowing** Lethal yellowing phytoplasma

*Symptoms of lethal yellowing on date palm*

### **Symptoms**

Fronds drying out and turning gray-brown; growing tip rotting and turning into a slimy mass with foul smell; crown collapses from trunk leaving a naked trunk

### **Cause**

Phytoplasma

### **Comments**

Disease is transmitted by planthoppers

### **Management**

Disease severity can be reduced by injecting the antibiotic oxytetracycline HCl into the trunk; antibiotics can also be administered as a protective measure if the disease is known to be in the area; control of the disease long term relies on planting resistant or tolerant varieties

# Pests

## Category : Insects

### Coconut rhinoceros beetle *Oryctes rhinoceros*

#### Symptoms

V-shaped cuts in palm fronds or holes in leaf midribs caused by beetles boring into crown to feed; adult insect is a large black beetle with a curved spine on its head; larvae are creamy white grubs with brown heads and 3 sets of prolegs at the anterior (head) end

#### Cause

Insect

#### Comments

Beetles are nocturnal and fly at night; also a damaging pest of oil palm

#### Management

Destroy any decaying logs in plantation by chopping and burning to kill any larvae that may be inside; remove any dead trees from plantation and destroy by burning; plant a cover crop to deter egg laying by females as they do not lay eggs in areas covered by vegetation; hooked wire can be used to extract larvae that are boring into young crowns

### Parlatoria date scale *Parlatoria blanchardi*

#### Symptoms

Discolored areas on leaflets where insects are feeding; leaflets turning yellow and fronds dying; discolored fruits; insect is a circular-oval scale

#### Cause

Insect

#### Comments

Insect is a serious pest in Algeria, Kuwait, Libya, Mauritania, Morocco and Tunisia; attacks by the scale are very serious on young palms

#### Management

Population of natural enemies coupled with pruning of palms usually keeps scales under control; mineral based oils are effective against nymphs

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# Dill

## Description

Dill, *Anethum graveolens*, is an herbaceous annual in the family Apiaceae grown for its leaves which are used as a herb. Dill is a very aromatic plant with an erect growth habit. It possess branching stems and fine, soft, fibre-like leaves which are arranged into an open cone and are blue-green in color. The plant produces yellow flowers on umbels which can be up to 16 cm (6 in) in diameter. Dill can grow up to 1.5 m (5 ft) in height and is an annual plant, surviving only one growing season. Dill may also be referred to as garden dill and its origin is no known, although it is believed to be native to the Mediterranean.

*Dill foliage*

*Young dill plant*

*Dill seedhead*

*Dill cultivation in Montana, USA*

*Dill stem and flowerhead*

*Dill flower umbels*

*Dill flower umbels*

*Dill flower umbels*

*Dill foliage*

## Uses

Dill leaves are used fresh or dry as a culinary herb. The leaves may be used to make tea. The seeds of the plant may be used as a spice.

## Propagation

**Basic requirements** Dill grows best in full sun in temperatures averaging 16°–18°C (60°–64°F). Dill can be grown in a range of soils but the plants will grow optimally in well-draining sandy loam which is rich in organic matter and has a pH between 5.6 and 6.5. Dill should be planted in an area that receives 6 to 8 hours of direct sunlight every day and that is sheltered from strong winds which can easily damage the hollow stalks of the plant. **Planting** Dill does not transplant well and it is therefore recommended to direct seed. Seeds should be planted in early Spring after all danger of frost has passed. Sow seeds 1.9 to 2.5 cm (0.75 to 1.0 in) deep, allowing 30 to 38 cm (12-15 in) between plants and 45 cm (18 in) between rows. It is common for dill to be grown between other plants such as onions. Stagger plantings by 2 to 3 weeks for a continuous harvest. Seeds usually germinate within 7 to 21 days depending on the soil temperature. **General care and maintenance** Dill is a hardy plant and can tolerate temperatures down to -3.8°C (25°F) once established, Dill plants require little water, usually irrigating once or twice a week is sufficient and one light application of fertilizer late in the Spring should be enough to sustain the plant for the entire growing season. If the plant is not sufficiently sheltered from wind, the plants will benefit from staking to prevent the hollow stems from snapping. **Harvesting** Dill is ready to harvest approximately 90 days after planting. Foliage can be harvested anytime but is most flavorful just before flowering. To harvest the leaves simply cut the leaves at the stem or cut the stem a few inches from the soil line. Seedheads should be harvested 2-3 weeks after bloom before the seeds begin to change color. The seedheads can be hung up to finish drying.

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## Common Pests and Diseases

### Diseases

#### Category : Viral

##### **Carrot motley dwarf (CMD)** Carrot redleaf virus (CRLV)

+ Carrot mottle virus (CMoV)

##### Symptoms

Yellow and red leaves; stunted plant growth

##### Cause

Viruses

## **Comments**

Disease transmitted by aphids; both viruses must be present to cause carrot motley dwarf

## **Management**

Avoid planting dill in close proximity to overwintered carrot fields

## **Category : Fungal**

### **Cercospora leaf blight *Cercosporidium punctum***

Necrotic spots on dill stems

Leaf blight symptoms on dill

Leaf blight symptoms on dill

## **Symptoms**

Small, necrotic flecks on leaves which develop a chlorotic halo and expand into tan brown necrotic spots; lesions coalesce and cause leaves to wither, curl and die

## **Cause**

Fungus

## **Comments**

Disease can be introduced through infested seed and spread by wind or water splash; symptoms usually occur on younger foliage first

## **Management**

Plant only pathogen-free seed; rotate crops; plow crop debris into soil after harvest; apply appropriate fungicide sprays

### **Damping-off *Pythium* spp.**

*Rhizoctonia solani*

## **Symptoms**

Soft, rotting seeds which fail to germinate; rapid death of seedling prior to emergence from soil; collapse of seedlings after they have emerged from the soil caused by water-soaked reddish lesions girdling the stem at the soil line

## **Cause**

Fungus

## **Comments**

Damping-off diseases favor conditions which slow seed germination; fungi can be spread in water, contaminated soil or on equipment

## **Management**

Avoid planting dill in poorly draining, cool, wet soil; planting in raised beds will help with soil drainage; plant high quality seed that germinates quickly; treat seeds with fungicide prior to planting to eliminate fungal pathogens

### **Downy mildew *Peronospora umbellifarum***

## **Symptoms**

Yellow spots on upper surface of leaves; white fluffy growth on underside of leaves; lesions become darker as they mature

## **Cause**

Fungus

## **Comments**

Disease affects young, tender leaves; disease emergence and spread is favored by prolonged leaf wetness

## **Management**

Plant pathogen-free seed; do not overcrowd plants; rotate crops with non-umbelliferous varieties

### **Powdery mildew *Erysiphe heraclei***

## **Symptoms**

Powdery growth on leaves, petioles flowers stalks and bracts; leaves becoming chlorotic; severe infections can cause flowers to become distorted

#### Cause

Fungus

#### Comments

Fungus can spread long distances in air; disease emergence is favored by high humidity and moderate temperatures; infection is most severe in shaded areas

#### Management

Plant tolerant varieties; avoid excess fertilization; protective fungicide applications provide adequate protection; sulfur application can be used in infection occurs early in season

## Pests

### Category : Insects

#### Aphids (Willow-carrot aphid) *Cavariella aegopodii*

*Carrot-willow aphid damage on dill*

*Carrot-willow aphid colony on dill*

#### Symptoms

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants

#### Cause

Insect

#### Comments

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed; willow-carrot aphid will also attack parsnip, carrot and celery

#### Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

#### Armyworm *Pseudaletia unipuncta*

*Armyworm*

#### Symptoms

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body

and a pink or yellow underside

### **Cause**

Insect

### **Comments**

Insect can go through 3–5 generations a year

### **Management**

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae

## **Cutworms** *Agrotis* spp.

*Peridroma saucia*

*Nephelodes minians*

and others

*Cutworm severing plant stem*

### **Symptoms**

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5–5.0 cm (1–2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed

### **Cause**

Insects

### **Comments**

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato

### **Management**

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically

## **Category : Nematodes**

### **Root knot nematode** *Meloidogyne* spp.

#### **Symptoms**

Galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; reduction in plant vigor; yellowing plants which wilt in hot weather

#### **Cause**

Nematode

#### **Comments**

Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or garden with this type of soil is most likely

#### **Management**

Plant resistant varieties if nematodes are known to be present in the soil; check roots of plants mid-season or sooner if

symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens

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# Eggplant

## Description

Eggplant, *Solanum melongena*, is a tropical, herbaceous, perennial plant, closely related to tomato, in the family Solanaceae which is grown for its edible fruit. The plants has a branching stem and simple, long, flat, coarsely lobed leaves which are green in color and are arranged alternately on the branches. The leaves can measure 10 to 20 cm (4â€“8 in) long and 5 to 10 cm (2â€“4 in) broad. The plant produces purple flowers which are 3â€“5 cm (1.2â€“2.0 in) in diameter. The fruit is a large, fleshy ovoid berry which can reach 40 cm (15.7 in) in length, with glossy smooth skin and numerous small seeds. The color of the fruit is variable and can be white, green, yellow, purple or black. Eggplants can reach up to 1.5 m (4.9 ft) in height and although they are perennial plants, they are most commonly grown as annuals. Eggplant may also be referred to as aubergine or guinea squash and originates from the Indian subcontinent.

*Different eggplant varieties*

*Eggplant flower bud*

*Eggplant flower*

*Eggplant*

*Eggplant*

*Eggplant*

## Uses

Eggplant is usually cooked before consumption and is eaten as a vegetable.

# Propagation

**Basic requirements** Eggplants are warm-season crops which require a long growing season. They grow best in regions where the daytime temperature is between 26 and 32°C (80–90°F) and night time temperatures around 21°C (70°F). In addition, eggplant is a sun loving plant and should be positioned in an area that receives full sunlight. Plants will perform best when planted in a fertile soil with a pH between 6.3 and 6.8. **Sowing seeds** In cold areas and regions with a short growing season it is necessary to start eggplant indoors or in a glasshouse. In addition, eggplant will often perform much better in colder areas if planted in containers or grown under row covers as this helps to keep the soil warm. Seeds should be sown indoors 6 to 8 weeks before the last frost date. Sow seeds thickly in seed trays containing good quality sterile seed starting mix to a depth of 6 mm (0.25 in). Keep the trays moist and provide bottom heat by placing on a heat mat or in a warm area of the house. Seedling should be potted into larger pots when they have two sets of true leaves. **Transplanting** Eggplant seedlings can be transplanted after hardening-off and when all danger of frost has passed in your area. Seedlings should be spaced 45–60 cm (18–24 in) apart, depending on variety, allowing a further 60–90 cm (24–36 in) between rows. **General care and maintenance** Eggplant may benefit from the addition of mulch to conserve soil moisture and maintain a higher soil temperature. Row covers will help to increase the temperature around the plants in cooler climates and during cool spells in otherwise warm areas. The row covers should be removed to allow pollinators to access the plants during flowering. Eggplant should be provided with a steady water supply for optimum development of fruit and the soil around the plants should not be allowed to dry out but should also not be wet. Plants can be laden with numerous fruit and the use of stakes and supports can help to support the plants before harvest. **Harvesting** Eggplant fruits are ready to harvest while the flesh is still firm and seeds are small and tightly packed. The skin of the fruit should be firm, glossy and dark purple. Over ripe fruit will contain darker seeds and will taste bitter. Harvest the fruit as soon as it is ripe to ensure maximum productivity. The fruit should be removed from the plant by cutting the calyx (green stem above the fruit) with a sharp knife.

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# Common Pests and Diseases

## Diseases

### Category : Other

#### Blossom-end rot n/a

##### Symptoms

Small water-soaked area on end of fruit where the blossom was occurring on unripe fruit; lesion enlarges and turns sunken, black and leathery in appearance.

##### Cause

Physiological disorder

## **Comments**

Caused by low calcium concentration in fruit; may result from competition from other competitive ions in soil e.g. potassium, drought stress; fluctuations in soil moisture or application of excessive amounts of nitrogen fertilizer which promotes rapid vegetative growth.

## **Management**

Maintain soil pH at 6.5; lime soil to increase the concentration of calcium in soil and decrease competition with other ions; use mulch to reduce drought stress; avoid ammonium fertilizers as they may increase competition with calcium by increasing ammonium ions in soil, use nitrate instead; avoid over fertilizing.

## **Category : Fungal**

### **Cercospora leaf spot *Cercospora melongenae***

*Cercospora leaf spot symptoms on eggplant*

*Cercospora leaf spot on eggplant foliage*

## **Symptoms**

Symptoms appear first on lower part of plant and move upwards; initial symptoms are small circular or oval chlorotic spots on leaves which develop light to dark brown centers; as the lesions expand, they may develop concentric zones; severely infested leaves may dry out and curl then drop from the plant.

## **Cause**

Fungus

## **Comments**

Fungus can survive over winter on crop debris in soil.

## **Management**

Irrigate plants in the morning to allow plenty time for plants to dry out during the day; irrigate at base of plant to avoid leaf wetness; use adequate plant spacings to decrease humidity in the plant canopy; applications of appropriate protective fungicides can protect plants from disease.

### **Colletotrichum fruit rot *Colletotrichum melongenae***

## **Symptoms**

Sunken lesions on the fruit filled with pinkish fungal ooze; severely infected plants drop to the ground with the pedicel still attached.

## **Cause**

Fungus

## **Comments**

Disease favors warm, wet conditions; exacerbated by overhead irrigation.

## **Management**

Avoid sprinkler irrigation when fruit is ripening; rotate crops with other non-solanaceous plants; applications of appropriate protective fungicides may be required if disease is in the area.

### **Damping-off *Fusarium***

*Pythium* spp.

*Rhizoctonia* spp.

### Symptoms

Failure of seedling to emerge; light brown, seedlings with light brown to redwater-soaked roots and stems; collapse of plants; plant dry up and die; stunted plant growth; rotting taproot with few lateral roots

### Cause

Fungi

### Comments

Disease favors warm weather and very wet soil with poor drainage

### Management

Plant pathogen-free seed or transplants that have been produced in sterilized soil; apply fungicide to seed to kill off any fungi; shallow plant seeds or delay planting until soil warms

## Early blight *Alternaria solani*

### Symptoms

Premature dropping of lower leaves; brown-black spots on leaves; spots covering leaf surface; alternating rings of light and dark on leaves; yellowing dry leaves; large sunken area of concentric rings and black velvety texture at stem end of fruit

### Cause

Fungus

### Comments

Disease can spread rapidly after plants have set fruit

### Management

Apply fungicide at first sign of disease; destroy any volunteer solanaceous plants (tomato, potato, nightshade etc); practice crop rotation

## Phomopsis fruit rot *Phomopsis vexans*

*Phomopsis* fruit rot lesion on eggplant

### Symptoms

Circular brown spots with lighter centers on fruits; infested leaves may turn yellow and drop from plant; dark cankers may form on stems; symptoms on fruit begin as pale sunken areas which are oval in shape, these area grow bigger and become depressed; lesions may coalesce to cover all or most of the fruit

### Cause

Fungus

### Comments

Fungus survives in crop debris in the soil; emergence of the disease if favored by hot, humid weather conditions; fungus spreads primarily by splashing water

### Management

Destroy infected plant material to reduce levels of inoculum; plant only disease free seed and clean transplants; applications of appropriate fungicides may be required to control the disease

## Powdery mildew *Leveillula taurica*

### **Symptoms**

White, powdery spots on leaves, shoots, flowers and fruit; yellow, twisted leaves; leaves dropping

### **Cause**

Fungus

### **Comments**

Disease favors shady conditions and poor air circulation

### **Management**

Avoid stressing plants by providing them with adequate irrigation and fertilizer; use adequate spacings when planting to avoid overcrowding

## **Verticillium wilt** *Verticillium spp.*

### **Symptoms**

Symptoms appear first on lower leaves and spread upwards; symptoms include yellow blotches on lower leaves, rapid yellowing and the edges of leaves rolling inward; leaves on severely infested rats turn brown and dry

### **Cause**

Fungus

### **Comments**

Can survive in soil indefinitely; disease has a broad host range; emergence is favored by cool temperatures

### **Management**

Plant resistant varieties; sanitize all equipment on a regular basis; rotate with non-susceptible crops; fumigation of soil can reduce levels of inoculum; solarizing soil is also effective but must be done in the middle of summer when the eggplants are usually grown

## **Category : Oomycete**

## **Phytophthora blight** *Phytophthora capsici*

*Symptoms of Phytophthora blight on eggplant fruit*

### **Symptoms**

Wilting plants; plant death; water soaked root; few secondary roots; brown discoloration on roots; water-soaked brown lesions on stem at soil line

### **Cause**

Oomycete

### **Comments**

Disease emergence is favored by water saturated soils; disease is commonly spread by infected transplants and contaminated water

### **Management**

Rotate crops away from susceptible plants for a period of 2 years if disease is present; avoid excessive overhead irrigation; only plant in well-draining soils

## **Pests**

## **Category : Insects**

## **Aphids (Peach aphid, Potato aphid)** *Myzus persicae*

## *Macrosiphon euphorbiae*

*Green peach aphid nymph*

*Green peach aphid (Myzus persicae)*

### **Symptoms**

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or be distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants.

### **Cause**

Insect

### **Comments**

Distinguishing features of aphids include the presence of cornicles (tubular structures) which project backwards from the insect's body; aphids will generally not move very quickly when disturbed; aphids may also transmit plant viruses to the plant when they feed.

### **Management**

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use.

## **Colorado potato beetle** *Leptinotarsa decemlineata*

*Colorado potato beetle nymphs and damage to eggplant*

*Colorado potato beetle nymphs feeding on eggplant leaf*

*Colorado potato beetle on eggplant leaf*

### **Symptoms**

Feeding damage to foliage; if infestation is severe or if left untreated plants can be completely defoliated; adult insect is a black and yellow striped beetle; larvae are bright red with black heads when they first hatch and change color to pink; larvae have two rows of black spots.

### **Cause**

Insect

### **Comments**

Adult beetles emerge in spring; female beetles lay eggs in batches of up to two dozen; eggs are orange-yellow and are laid on undersides of leaves; a female can lay 500 or more eggs over a four to five week period.

### **Management**

Control of Colorado potato beetle can be challenging as they have developed high levels of insecticide resistance; in the home garden planting early maturing varieties of potato allows the plants to escape from most damage; adults and larvae should be hand picked from plants and destroyed in soapy water; applications of *Bacillus thuringiensis* can be effective at controlling larvae but should be applied frequently; some insecticides, including spinosad, are still effective against adult beetles.

### **Cutworms** Various species including:

*Agrotis* spp.

*Peridroma saucia*

*Nephelodes minians*

etc.

### Symptoms

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5â€“5.0 cm (1â€“2 in) in length; larvae may exhibit a variety of patterns and coloration but are usually dirty gray or brown to black with dark spots or lines and will curl up into a characteristic C-shape when disturbed

### Cause

Insect

### Comments

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato

### Management

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically

### Flea beetles *Epitrix fuscula*

*Epitrix hirtipennis*

*Flea beetle damage to eggplant foliage*

*Flea beetle damage to eggplant foliage*

### Symptoms

Small holes or pits in leaves that give the foliage a characteristic â€œshot holeâ€ appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; feeding damage may also occur on the fruit; the pest responsible for the damage is a small (1.5â€“3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance

### Cause

Insect

### Comments

Flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year

### Management

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application of diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied

### Hornworms (Tomato hornworm, Tobacco hornworm) *Manduca quinquemaculata*

*Manduca sexta*

*Tomato hornworm and damage on eggplant*

### **Symptoms**

Feeding damage to leaves or leaves stripped from plant; heavy infestation may result in damage to fruit appearing as large open scars; large green caterpillars may be spotted on plant; caterpillars may reach in excess of 7.5 cm (3 in) in length and possess a spike at the end of their body; most common species have 7 diagonal stripes on sides or 8 v-shaped markings on each side; single eggs may be present on leaves and measure approx 1.3 mm in diameter; eggs are initially light green in color and turn white prior to hatching

### **Cause**

Insect

### **Comments**

Insect overwinters as pupa in soil; typically undergoes 2 generations per year; heavy infestations are more common in warm areas

### **Management**

Hand pick larvae from plants leaving any parasitized larvae behind to promote populations of natural enemies (these larvae can be distinguished by the presence of white, oblong-shaped cocoons on their backs); sprays of *Bacillus thuringiensis* are organically acceptable and highly effective

## **Stinkbugs (Various)** Various

### **Symptoms**

Dark colored pinpricks on fruit surrounded by a lighter area that turns yellow or remains light green; stink bugs often carry pathogens in their mouthparts which can cause secondary infections and decay of fruit; adult insect is shield-shaped and brown or green in color; may have pink, red or yellow markings; eggs are drum shaped and laid in clusters on the leaves; larvae resemble the adults but are smaller

### **Cause**

Insect

### **Comments**

Several types of stink bug can cause damage to tomatoes; adult insects overwinter under leaves, on legumes, blackberries or on certain weeds such as mustard or Russian thistle

### **Management**

Remove weeds around crop which may act as overwintering sites for stink bugs and practice good weed management throughout the year; organically accepted control methods include the use of insecticidal soaps, kaolin clay and preservation of natural enemies; chemical treatments are not recommended for tomatoes that are to be processed for paste or canning unless secondary infections with other pathogens are a concern

## **Category : Mites**

### **Mites (Carmine mite, Two-spotted spider mite)** *Tetranychus cinnabarinus*

*Tetranychus urticae*

*Spider mite damage to eggplant leaves*

### **Symptoms**

Leaves stippled with yellow; leaves may appear bronzed; webbing covering leaves; mites may be visible as tiny moving dots on the webs or underside of leaves, best viewed using a hand lens; usually not spotted until there are visible

symptoms on the plant; leaves turn yellow and may drop from plant

**Cause**

Arachnid

**Comments**

Spider mites thrive in dusty conditions; water-stressed plants are more susceptible to attack

**Management**

In the home garden, spraying plants with a strong jet of water can help reduce buildup of spider mite populations; if mites become problematic apply insecticidal soap to plants; certain chemical insecticides may actually increase mite populations by killing off natural enemies and promoting mite reproduction

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# Endive

## Description

Endive, *Cichorium endivia*, is an annual or biennial herbaceous plant in the family Asteraceae grown as a salad green. The plant is a short stemmed herb with a rosette of leaves which are arranged alternately on the stem. The leaves become smaller toward the top of the stem. The leaves can be broad and flat, curly or frizzy depending in the variety and are generally 10–25 cm (3.9–9.8 in) in length. The endive plant produces an inflorescence consisting of 1–3 blue flowers. Endive plants can grow to 1.5 m (4.9 ft) in height and are typically grown as an annual with only one growing season. Endive may also be referred to as Ceylon spinach, escarole or chicory and originates from the Mediterranean.

A frizzy variety of endive

## Uses

Endive leaves are eaten fresh as a salad green.

## Propagation

**Basic requirements** Endive is a cool season plant and grows best in short days and cool temperatures. The optimum

temperature for the plants growth is between 15 and 18°C (59–64.4°F). The plants will grow best in a loose, fertile soil or well draining loam with a pH of 6.5–7.8 and should be positioned in full sun or partial shade. Endive will tolerate light frost and harvesting after frost will improve the flavor of the leaves. **Growing from seed** Endive can be direct seeded or started indoors to produce transplants. Seeds germinate at temperatures between 1.7 and 29.4°C (35–85°F), with 23.8°C (75°F) being optimal. Seeds should be sown to a depth of 0.6 cm (0.25 in) in high quality potting soil or, if direct seeding, a finely prepared bed. Seeds can be sown outdoors 2 to 4 weeks before the last frost date. Sow seeds 5–10 cm (2–4 in) apart, leaving approximately 45 cm (18 in) between rows. **General care and maintenance** Endive is prone to bolting in warm weather. If the temperature rises above 24°C (75°F) then care should be taken to keep the plants well watered and shaded from strong sunlight. About a week before harvest, the outer leaves of heading varieties should be tied up around the head to blanch the plant to prevent it developing a bitter flavor. The plants can also be blanched by covering the entire plant with a pot or box to exclude light. **Harvest** The entire head should be cut at ground level after blanching using a sharp knife. Harvest the plants early if very hot weather or a hard frost is expected.

## References

Anderson, C. R. Endive-Escarole. University of Arkansas Division of Agriculture. Available at: <http://www.uaex.edu/publications/pdf/FSA-6068.pdf>. [Accessed 01 December 14]. Free to access . CABI Crop Protection Compendium. (2013). *Cichorium endivia* datasheet. Available at: <http://www.cabi.org/cpc/datasheet/13408>. [Accessed 01 December 14]. Paid subscription required .

## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Anthracnose** *Microdochium panttonianum*

###### **Symptoms**

Small circular or irregularly shaped dry spots which are gray to straw in color on leaves; a high number of spots may cause the leaf to die; lesions may coalesce to form large necrotic patches causing leaves to turn yellow and wilt; lesions may split or crack in dry centers

###### **Cause**

Fungus

###### **Comments**

Fungus overwinters on leaf debris and on related weeds; disease emergence is favored by moist, warm conditions

###### **Management**

Control of disease depends on sanitary practices; treat seeds with hot water prior to planting; rotate crops; plant in an area with good soil drainage; remove all cruciferous weeds which may act as a reservoir for the fungus

##### **Bottom rot** *Rhizoctonia solani*

###### **Symptoms**

Small red to brown spots on lower leaves, usually on underside of midrib which may expand rapidly causing the leaves to rot; amber colored liquid may ooze from leaf lesions; as stems rot, head of lettuce becomes slimy and brown and collapse; a tan or brown mycelial growth may be visible in infected tissue

###### **Cause**

Fungus

## **Comments**

Fungus survives on crop debris in soil; disease emergence favored by warm, wet weather

## **Management**

Disease is most effectively managed by combining cultural control with fungicide application; plow soil before planting; rotate crops regularly; avoid irrigation close to harvest; plant varieties with an erect growth habit to reduce leaf contact with soil; apply appropriate foliar fungicides

## **Damping-off *Pythium* spp.**

*Rhizoctonia solani*

## **Symptoms**

Poor seedling germination and emergence; dark lesions on stems; withered stem; stems collapsing; brown rotting roots

## **Cause**

Fungi

## **Comments**

Disease emergence in seedlings favored by cool temperatures

## **Management**

Plant pathogen-free seed or transplants that have been produced in sterilized soil; apply fungicide to seed to kill off any fungi; shallow plant seeds or delay planting until soil warms

## **Downy mildew *Bremia lactucae***

## **Symptoms**

Young leaves drying up and dropping off; older leaves developing a papery texture; white fuzzy mold on the underside of leaves

## **Cause**

Fungus

## **Comments**

Disease favors cool, moist conditions; can be spread via infected seed; fungus survives in plant debris and in wild lettuce plants

## **Management**

Disease is controlled primarily by planting resistant varieties and/or by applying appropriate fungicides

## **Sclerotinia blight (Sclerotinia drop) *Sclerotinia sclerotiorum***

## **Symptoms**

Wilting of outside leaves which spreads inwards until whole plant is affected; soft watery lesions on leaves; leaves collapse and lie on soil surface; black fungal structures on infected leaf tissue and soil surface

## **Cause**

Fungus

## **Comments**

Fungi can survive in soil for 8-10 years

## **Management**

Rotate crop to non-hosts (e.g. cereals) for at least 3 years; control weeds; avoid dense growth by planting in adequately spaced rows; disease significantly reduced by application of fungicides immediately after thinning plants; plow soil deeply

## **Septoria blight *Septoria lactucae***

## **Symptoms**

Small, irregularly shaped chlorotic spots on oldest plant leaves which enlarge and turn brown and dry out; lesions may fall out of leaves creating holes; leaf spots may have chlorotic halos; if plant is severely infected, lesions may coalesce forming large necrotic patches, wilting leaves and plant death

**Cause**

Fungus

**Comments**

Fungus survives in infected seed and in crop debris; disease spreads in humid or wet conditions; can be spread by splashing water; wild lettuce is an important overwintering site for the fungus

**Management**

Plant pathogen free seed; plant in areas where Septoria is uncommon; ideal planting sites are in regions with low rainfall; hot water treatment of seeds prior to planting may help reduce levels of disease

**Category : Bacterial****Bacterial soft rot** *Erwinia* spp.**Symptoms**

Water-soaked lesions which expand to form a large rotted mass of cream colored tissue which is liquid underneath; surface of lesions usually crack and exude slimy liquid which turns tan, dark brown or black on exposure to air

**Cause**

Bacteria

**Comments**

Bacteria are easily spread on tools and by irrigation water; disease emergence favored by warm, moist conditions; bacteria enter plant through wounds

**Management**

Chemical treatments are not available for bacterial soft rot, control relies on cultural practices; rotate crops; plant cabbage in well-draining soils or raised beds; only harvest heads when they are dry; avoid damaging heads during harvest

**Category : Other****Slugs & snails (Gray garden slug, Spotted garden slug, Brown garden snail, European garden snail , etc.)** *Decoratus reticulatum*

*Limax maximus*

*Helix aspersa*

*Cornu aspersum*

*European brown snail*

*Gray garden slug*

**Symptoms**

Irregularly shaped holes in leaves and stems; flowers and fruit may also be damaged if present; if infestation is severe, leaves may be shredded; slime trails present on rocks, walkways, soil and plant foliage; several slug and snail species are common garden pests; slugs are dark gray to black in color and can range in size from 2.5 to 10 cm (1-4 in); garden snails are generally smaller and possess a rounded or spiral shell

**Cause**

Mollusc

**Comments**

Slugs and snails prefer moist, shaded habitats and will shelter in weeds or organic trash; adults may deposit eggs in the soil throughout the season; damage to plants can be extensive

**Management**

Practice good garden sanitation by removing garden trash, weeds and plant debris to promote good air circulation and reduce moist habitat for slugs and snails; handpick slugs at night to decrease population; spread wood ashes or

eggshells around plants; attract molluscs by leaving out organic matter such as lettuce or grapefruit skins, destroy any found feeding on lure; sink shallow dishes filled with beer into the soil to attract and drown the molluscs; chemical controls include ferrous phosphate for organic gardens and metaldehyde (e.g. Buggeta) and carbaryl (e.g Sevin bait) for non-organic growers

## Pests

### Category : Insects

#### Aphids (Green peach aphid, Lettuce aphid, Plum aphid) *Myzus persicae*

*Nasonovia ribisnigri*

*Brachycaudus helichrysi*

*Green peach aphid colony*

#### Symptoms

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants

#### Cause

Insect

#### Comments

Aphids will be visible on the leaves; small, rounded green to pink insects; distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed

#### Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

#### Darkling beetles *Eleodes sp*

*Blapstinus* spp.

*Caelus* spp.

*Darkling beetle, Eleodes hispilabrus*

#### Symptoms

Feeding damage on stems; death of seedlings; seeds dug up; insect is a dull blue-black or brown beetle about 0.6 cm (0.52 in) long; tips of antennae are often enlarged, resembling a club

#### Cause

Insect

#### Comments

Beetles are generally active at night; during the day beetles hide in organic debris

## **Management**

Ditches filled with water can prevent spread of beetle to/from adjacent fields; remove all weeds from garden borders; if beetle is problematic then appropriate insecticides can provide control; insecticides are usually in the form of baits

## **Flea beetles** *Epitrix* spp.

*Phyllotreta* spp.

*Flea beetles and damage*

## **Symptoms**

Small holes or pits in leaves that give the foliage a characteristic “holey” appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5–3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance

## **Cause**

Insect

## **Comments**

Younger plants are more susceptible to flea beetle damage than older ones; older plants can tolerate infestation; flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year

## **Management**

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application of diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied

## **Leafminers** *Liriomyza* spp

*Typical leafminer damage*

## **Symptoms**

Thin, white, winding trails on leaves; heavy mining can result in white blotches on leaves and leaves dropping from the plant prematurely; early infestation can cause fruit yield to be reduced; adult leafminer is a small black and yellow fly which lays its eggs in the leaf; larvae hatch and feed on leaf interior

## **Cause**

Insect

## **Comments**

Mature larvae drop from leaves into soil to pupate; entire lifecycle can take as little as 2 weeks in warm weather; insect may go through 7 to 10 generations per year

## **Management**

Check transplants for signs of leafminer damage prior to planting; remove plants from soil immediately after harvest; only use insecticides when leafminer damage has been identified as unnecessary spraying will also reduce populations of their natural enemies

## **Loopers (Cabbage looper, Alfalfa looper)** *Trichoplusia ni*

*Autographa californica*

## *Cabbage looper*

### **Symptoms**

Large or small holes in leaves; damage often extensive; caterpillars are pale green with a white lines running down either side of their body; caterpillars are easily distinguished by the way they arch their body when moving; eggs are laid singly, usually on the lower leaf surface close to the leaf margin, and are white or pale green in color

### **Cause**

Insect

### **Comments**

Insects overwinter as pupae in crop debris in soil; adult insect is a dark colored moth; caterpillars have a wide host range

### **Management**

Looper populations are usually held in check by natural enemies; if they do become problematic larvae can be hand-picked from the plants; an organically acceptable control method is the application of *Bacillus thuringiensis* which effectively kills younger larvae; chemical sprays may damage populations of natural enemies and should be selected carefully

## **Thrips (Western flower thrips, Onion thrips) *Frankliniella occidentalis***

*Thrips tabaci*

### *Western flower thrips*

### **Symptoms**

If population is high leaves may be distorted; leaves are covered in coarse stippling and may appear silvery; leaves speckled with black feces; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color

### **Cause**

Insect

### **Comments**

Transmit viruses such as Tomato spotted wilt virus; once acquired, the insect retains the ability to transmit the virus for the remainder of its life

### **Management**

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic

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# Fennel

## Description

Fennel, *Foeniculum vulgare*, is an herbaceous perennial plant in the family Apiaceae grown for use as a herb or flavoring. The fennel plant is an erect herb with 4–5 hollow stems and distinctly divided feathery foliage. The leaves are simple and linear and are 2–15 cm in length. The plant produces flowers on flat umbels which can be 20 cm (7.9 in) in diameter and possess 20-50 tiny yellow flowers. The plant may reach 2 m (6.6 ft) in height. Fennel is a short-lived plant and is almost always grown as an annual. Fennel may also be referred to as wild fennel or sweet fennel depending on variety and originates from southern Europe and the Mediterranean.

*Fennel flower umbel*

*Fennel*

*Fennel stems and flowers*

*Fennel flowering*

*Fennel bulb*

*Fennel flower bud*

*Fennel flowerheads*

*Feathery foliage of the fennel plant*

*Fennel plant*

## Uses

Fennel leaves can be used fresh or dried as a spice in cooking. The bulb of some varieties is also edible and is usually consumed after cooking. The seeds can be dried and used as a spice.

## Propagation

**Basic requirements** Fennel is a perennial plant which is commonly grown as an annual. It grows best in cool weather at temperatures between 21 and 24°C (70–75°F). Hotter temperatures tend to induce bolting. Fennel will grow best if grown in full sun in a well draining, fertile loam soil with a pH between 6.3 and 8.3. **Planting** Fennel is usually propagated directly from seed and requires an ambient temperature between 15 and 20°C (59–68°F) to germinate. It should be planted in early Spring or Fall when temperatures are suitable. Seed should be sown at a depth of 1–3 cm (0.4–1.2 in) leaving 15–50 cm (5.9–19.7 in) between plants and 60 cm (24 in) between rows. **General care and maintenance** Fennel should be kept free from weeds which will easily out compete the plant for light and nutrients. Plants will benefit from the addition of nitrogen fertilizer but care should be taken not to overfeed the plants as it will result in a disproportionate amount of vegetative mass developing. Fennel should be provided with regular irrigation to prevent the stalks from splitting. **Harvesting** Fennel stalks should be cut just before flowering. Stalks are usually ready for harvest between 5 and 7 months after planting. Seed heads should be collected promptly before they shatter. The seed heads are ready to harvest when they turn brown in color. Once the stalks have been harvested, the bulb can also be cleaned and stored.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Cercospora leaf blight** *Cercosporidium punctum*

###### **Symptoms**

Small, necrotic flecks on leaves which develop a chlorotic halo and expand into tan brown necrotic spots; lesions coalesce and cause leaves to wither, curl and die

###### **Cause**

Fungus

###### **Comments**

Disease can be introduced through infested seed and spread by wind or water splash; symptoms usually occur on

younger foliage first

#### **Management**

Plant only pathogen-free seed; rotate crops; plow crop debris into soil after harvest; apply appropriate fungicide sprays

### **Downy mildew** *Peronospora umbellifarum*

#### **Symptoms**

Yellow spots on upper surface of leaves; white fluffy growth on underside of leaves; lesions become darker as they mature

#### **Cause**

Fungus

#### **Comments**

Disease affects young, tender leaves; disease emergence and spread is favored by prolonged leaf wetness

#### **Management**

Plant pathogen-free seed; do not overcrowd plants; rotate crops with non-umbelliferous varieties

### **Powdery mildew** *Erysiphe heraclei*

#### **Symptoms**

Powdery growth on leaves, petioles, flowers, stalks and bracts; leaves becoming chlorotic; severe infections can cause flowers to become distorted

#### **Cause**

Fungus

#### **Comments**

Fungus can spread long distances in air; disease emergence is favored by high humidity and moderate temperatures; infection is most severe in shaded areas

#### **Management**

Plant tolerant varieties; avoid excess fertilization; protective fungicide applications provide adequate protection; sulfur application can be used if infection occurs early in season

#### **Rust** *Puccinia* spp.

*Uromyces* spp.

*Nyssopsora* spp.

#### **Symptoms**

Light green discolored lesions on leaves which become chlorotic; yellow-orange pustules on underside of leaves; stems bend and become swollen or distorted; plants may be stunted

#### **Cause**

Fungi

#### **Comments**

Some species infect only parsley while others have alternative hosts which may provide a reservoir for the disease; disease emergence is favored by high humidity

#### **Management**

Plant in well-draining soils to reduce humidity around plants; apply appropriate systemic fungicide

## **Pests**

### **Category : Insects**

#### **Aphids (Willow-carrot aphid)** *Cavariella aegopodii*

*Carrot-willow aphid*

### **Symptoms**

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants

### **Cause**

Insect

### **Comments**

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed; willow-carrot aphid will also attack parsnip, carrot and celery

### **Management**

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

## **Armyworm *Pseudaletia unipuncta***

*Armyworm*

### **Symptoms**

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside

### **Cause**

Insect

### **Comments**

Insect can go through 3–5 generations a year

### **Management**

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae

## **Cutworms *Agrotis* spp.**

*Peridroma saucia*

*Nephelodes minians*

and others

*Cutworm severing plant stem*

## **Symptoms**

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5â€“5.0 cm (1â€“2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed

## **Cause**

Insects

## **Comments**

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato

## **Management**

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically

## **Category : Nematodes**

### **Root knot nematode *Meloidogyne* spp.**

## **Symptoms**

Galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; reduction in plant vigor; yellowing plants which wilt in hot weather

## **Cause**

Nematode

## **Comments**

Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or garden with this type of soil is most likely

## **Management**

Plant resistant varieties if nematodes are known to be present in the soil ;check roots of plants mid-season or sooner if symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens

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# Fenugreek

## Description

Fenugreek, *Trigonella foenum-graecum*, is an herbaceous annual plant in the family Fabaceae grown for its leaves and seeds which are used as a herb or spice. The fenugreek plant may have a single stem or may be branched at the stem base. The plant has an erect growth habit and a strong, sweet aroma. The leaves of the plant are small and trifoliate with oval leaflets which are green to purple in color. The plant produces solitary pale white or purplish flowers and a straight or occasionally curved yellow pod which houses the seeds. Between 10 and 20 seeds are produced per pod and they are small, smooth and brown, each divided into two lobes. Fenugreek can reach a height of 60 cm (23.6 in) and as an annual, survives only one growing season. The origin of fenugreek is unknown but it is indigenous to the western Mediterranean.

*Fenugreek foliage*

*Fenugreek foliage*

*Fenugreek*

## Uses

Fenugreek leaves can be used fresh or dried as a culinary herb. The seeds are used as a spice or flavoring.

## Propagation

**Basic requirements** Fenugreek is a sun-loving plant which is usually grown as a cool season crop. It grows optimally in well draining loams or sandy loams with a pH between 5.8 and 8.2. it will not grow well in heavy clay. Fenugreek is moderately drought resistant and can be grown in areas with low amounts of rainfall. In areas where the summer temperatures are high it is grown as a cool season crop but can be grown over summer in more temperate climates. The plants can withstand light frost. **Propagation** Fenugreek is propagated from seed and it does not withstand transplanting. It should be direct seeded to a depth of 1–2 cm (0.4–0.8 in) allowing 7.5 cm (3 in) between individual plants and 20–45 cm (8–18 in) between rows. It may also be spread by broadcasting. **General care and maintenance** The most important aspect of fenugreek cultivation is keeping the bed free from weeds. Beds should be weeded regularly to prevent competition with the developing plants. The plants will benefit from additional irrigation if rainfall is not adequate. In addition, productivity of fenugreek grown for seed will be increased with the addition of potash and phosphate fertilizer. **Harvesting** Fenugreek grown for seed is ready to harvest within 3 to 5 months after planting. The plants are harvested by uprooting and are then hung up to dry to allow seeds to be collected. In India, where the plant is grown as a vegetable crop, young shoots and leaves are harvested earlier and the plant is allowed to regrow before harvesting again.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Cercospora leaf spot** *Cercospora traversiana*

###### **Symptoms**

Circular sunken lesions with chlorotic halos on leaves; necrotic areas on leaves; discolored areas on pods

###### **Cause**

Fungus

###### **Comments**

Spread via infected seed

##### **Charcoal rot** *Macrophomina phaseolina*

###### **Symptoms**

Discoloration of vine at soil line; cankers on stem may spread upwards; leaves may wilt and drop from plant; numerous small black sclerota (fungal fruiting bodies) develop in affected tissues and can be used to diagnose the disease

###### **Cause**

Fungus

###### **Comments**

Fungus had a wide host range and affects beans, tobacco, soybean, pigeon pea and many other crops; disease is primarily spread via microsclerotia in the soil

## **Management**

Organic soil amendments such as the addition of manure or neemcake can be used to reduce levels of inoculum in the soil

## **Powdery mildew** *Leveillula taurica*

### **Symptoms**

White, powdery spots on leaves which expand over time; yellow spots may be visible on leaf underside

### **Cause**

Fungus

### **Comments**

Disease favors shady conditions and poor air circulation

## **Management**

Avoid stressing plants by providing them with adequate irrigation and fertilizer; use adequate spacings when planting to avoid overcrowding

# **Pests**

## **Category : Insects**

### **Aphids (Pea aphid, Cowpea aphid)** *Acyrthosiphon pisum*

*Aphis craccivora*

### **Symptoms**

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants

### **Cause**

Insect

### **Comments**

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed

## **Management**

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

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# Fig

## Description

The Common Fig, *Ficus carica*, is a deciduous tree or shrub in the family Moraceae grown for its edible fruits. The fig tree has numerous spreading branches and palmate leaves. The leaves are deeply lobed and thick with a rough upper surface and hairy lower surface. They have irregular teeth on the margins. The fig fruit is not technically a fruit, but a syconium, a flesh, hollow receptacle with tiny flowers on the inside walls. The fig is roughly oval or pear-shaped and can be yellow-green, bronze or dark purple in color. Fig trees can range in height from 3 to 9 m (10â€“30 ft) and can live for 50â€“75 years depending on conditions. Fig trees are believed to originate from Western Asia.

*Fig leaves*

*Foliage and fruit*

*Fig fruit*

*Fig fruit*

*Fig leaf buds and young fruit developing*

*Fig fruit ripening on the tree*

## Uses

Fig fruits are consumed fresh or dried or may be processed to produce jams or fig paste.

# Propagation

**Basic requirements** Fig trees grow in both mild temperate climates and in the tropics, where it grows as an evergreen. The tree is not generally very cold hardy and new growth in Spring can be damaged by temperatures of -1°C (30.2°F). Fig trees can be successfully grown on many types of soil but will grow optimally in deep sandy-clay loams with a pH between 6 and 8. Very light soils are not conducive to fig production and should be amended prior to planting through the addition of organic matter. Fig trees should be planted in full sun. In the home landscape, planting the to the South or East of a building can help protect them during cold spells in winter. **Propagation** Fig trees are generally vegetatively propagated from cuttings which are rooted in a nursery. Cuttings should be taken from the previous years growth in winter when the tree is dormant and should be 25 to 30 cm (10-12 in) in length. The cuttings should be severed at the nodes and planted in prepared nursery beds or pots to the tips to allow a strong root system to develop before transplanting. The rooted cuttings should be ready for transplant the following winter. **Transplanting** Fig trees are traditionally planted as dormant rooted cuttings in winter or early spring. A hole should be dug that is deeper and wider than the existing root system as the cuttings perform well if planted a few inches deeper than in the nursery. Position the tree at the correct depth and carefully crumble the soil around the roots, tamping gently several times as the hole is filled. The newly planted tree should be watered to help settle the soil around the roots. It is not necessary to fertilize fig at time of planting. Once planted, the tree should be cut back by about 1/3 to counteract the effect of root loss during transplanting. If planting more than one tree, they should be positioned at least 6 m (20 ft) apart. **General care and maintenance** Figs are typically grown as rain-fed trees in Mediterranean climates but the trees grow best when they have access to constant moisture as water stress can cause early leaf drop. Soil moisture can be conserved by mulching around the trees. Organic mulches also have the benefit of providing the tree with nutrients. Fig trees do benefit from the addition of fertilizer and the type and amount varies with the variety being grown. **Pruning** In sub-tropical areas, figs are commonly grown as a single trunk tree, however, in more temperate climates, it is common for fig to exist as a multi-trunked vase-shaped trees. This is encouraged through pruning to three or four primary branches from the trunk and two to three secondary branches stemming from the primary branches. For the first few years, fig trees are pruned severely but after the shape has been formed pruning is limited to the removal of branches which are growing upright, touching the ground or those interfering with the growth of other branches.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

**Alternaria rot (Surface mold)** *Alternaria* spp.

*Cladosporium herbarum*

*Ulocladium altum*

**Symptoms**

Small, olive-green specks or sunken yellow-olive lesions covered in green spores on fruit; water-soaked areas on fruit surface where figs touch;

**Cause**

Fungi

**Comments**

Fungi over winter in plant debris. *C. herbarum* usually more common on green fruit, *Alternaria* spp. primarily a problem on ripe fruit.

**Management**

Rot can be minimized by picking fruit before it becomes overripe; reducing dust in orchards may also help to reduce the incidence of rot.

**Aspergillus rot** *Aspergillus* spp.

**Symptoms**

Internal tissue of figs bright yellow in color; part or all of the interior turned to powdery mass of spores.

**Cause**

Fungi

**Comments**

Disease emergence favors water-stressed trees.

**Management**

Avoid stressing trees by providing adequate irrigation; reducing dust in the orchard may help to reduce incidence of rots.

**Botrytis limb blight** *Botrytis cinerea*

**Symptoms**

Cankers above and below fruit; shoots dying back; buff colored spores on shoots in late winter or early spring; blighted shoots; foliage on infected shoots wilting and turning light green or brown.

**Cause**

Fungus

**Comments**

Disease emergence favors wet, cool springs.

**Management**

Infected areas of trees should be pruned out beginning just below the canker.

**Smut** *Aspergillus* spp.

**Symptoms**

Internal sections of fruit or entire inside of fruit discolored; infected areas turn black and are covered with powdery black spores.

**Cause**

Fungi

**Comments**

Fungus is transferred to fruit by some species of fly, thrips and beetle; fig varieties with smaller ostioles (pores) on the fruit are less susceptible to the disease than those with large ostioles.

**Management**

Remove all old fruit and crop debris from orchard; try to reduce dust around trees.

**Category : Viral**

## **Fig mosaic** Fig mosaic virus (FMV)

*Fig mosaic* -This symptom is associated with one or more of several plant-pathogenic viruses known to infect fig in Hawaii.

*Mosaic* This symptom is associated with one or more of several plant-pathogenic viruses known to infect fig in Hawaii.

*Edible fig: Mosaic* This symptom is associated with one or more of several plant-pathogenic viruses known to infect fig in Hawaii.  
Location: Honolulu, Oahu, Hawaii

*Fig mosaic*

*Fig mosaic virus symptoms*

*Fig-mosaic virus infected leaf*

*Fig Mosaic Virus symptoms*

*Symptoms of Fig Mosaic Virus  
(Emaravirus FMV)*

*Fig Mosaic Virus (Emaravirus FMV)  
symptoms*

### **Symptoms**

Yellow spots and mottling on foliage; margins of spots are diffuse and blend gradually back into the green of the leaf; spots may be distributed uniformly across the leaf surface or as irregular patches; mature lesions develop a brown-red band around their margin.

### **Cause**

Virus

### **Comments**

Transmitted by fig mites or by grafting from infected tree.

### **Management**

Do not collect propagation material from any trees showing symptoms of disease; controlling fig mites may help to reduce incidence of disease.

## **Pests**

### **Category : Mites**

#### **Fig blister mites** *Aceria ficus*

##### **Symptoms**

Blisters on surface of leaves which cause leaves to be russetted; twigs may be stunted and leaves may drop from trees.

##### **Cause**

Arachnid

##### **Comments**

Blister mites transmit fig mosaic virus; mites undergo several generations per year.

##### **Management**

Applications of horticultural oils or sulfur sprays are effective at controlling blister mites and should be applied if the mites were a problem the previous year; chemical treatments should be applied before bloom.

### **Category : Others**

#### **Fig rust** *Cerotelium fici* (earlier *Physopella fici* )

*Infected plant*

*Rust symptoms on the leaf*

*Fig rust* *Rust infected fig leaf* *Fig rust*

*Upper and lower surface of rust infected fig leaf*

*Rust infected fig fruit*

*Premature defoliation of a susceptible fig variety due to fig rust.*

*Uredinia on underside of leaf*

*Lower surface of infected leaf*

*Pustules of fig rust on the lower leaf surface.*

*Symptoms of fig rust visible on the upper leaf surface.*

## **Symptoms**

The first symptom appears as small, yellowish spots on the upper surface of leaves which later enlarge and become reddish brown in color. As the disease progress the numerous spots may appear on leaves. The lower surface of the lesions shows reddish-brown color and have a slightly raised, blister-like appearance. Severely infected leaves may turn yellow or brown and fall off prematurely.

## **Cause**

Fungus

## **Comments**

The pathogen spreads by splashing water.

## **Management**

Collect and burn the fallen leaves and other plant debris. Avoid overhead application of water and leaf wetting. Provide proper air circulation around the plant. Keep the plant healthy by providing proper mulching and fertilizers. If the disease is sever, spray suitable fungicides.

## **Category : Insects**

### **June beetle (fig beetle or fig eater) *Cotinis nitida***

*Larvae of Green June Beetle*

*Green June beetle adult*

*Green June Beetle on peach fruit*

*Green June beetle (*Cotinis nitida*) larvae*

*Green June beetle (*Cotinis nitida*) larvae*

*green June beetle (*Cotinis nitida*) pupae*

*Green June beetle (*Cotinis nitida*) cocoon*

*Adult Green June beetle*

*Green June beetle (*Cotinis nitida*) adult*

## **Symptoms**

Holes in fruit; staining of fruit surface from insect excrement; adult insect is a moderate sized green beetle reaching approx. 3 cm (1.2 in in length) which has a distinct horn on its head; larvae are cream colored grubs with a brown head.

## **Cause**

Insect

## **Comments**

Larvae pupate in cells in the soil in late spring; insect undergoes one generation per year.

## **Management**

Remove dead leaves and other crop debris from the orchard floor; allowing the orchard floor to dry out and harden prevents the adults emerging in the Spring; saturating the soil with water for a period of 2 days will kill off any eggs and larvae.

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# Finger Millet

## Description

Finger millet, *Eleusine coracana*, is an annual grass in the family Poaceae which is grown for its grain which can be used for food or for brewing. Finger millet is a robust tillering grass which grows in tufts. It has erect, light green stems. The leaves of the plant are dark green, linear and mainly smooth with some hair along the leaf edges. The inflorescence of the plant is a cluster of 3–26 “fingers” composed of dense spikelets where the grain, or seed, is produced. Finger millet can reach 1.7 m (5.6 ft) in height and is an annual plant, harvested after one growing season. Finger millet may also be referred to as African finger millet, goosegrass or millet and originates from the highlands of Eastern Africa.

*Finger millet plants*

*Finger millet*

*Finger millet*

## Uses

Finger millet grains are commonly cooked and made into a porridge to accompany other foods. Grain may also be used in the brewing of alcoholic beverages. Millet straw can be used as an animal feed.

## Propagation

**Basic requirements** Finger millet requires warm temperatures to develop optimally and as such is mainly grown in the tropics. The optimum temperature for the growth of the plants is between 18°C (64.4°F) and 27°C (80.6°F) and the plants require an average of 750 mm of rainfall over the course of the growing season. Finger millet can be grown in a wide range of soils but a fertile, well-draining sandy loam with a pH between 6.5 and 5.8 is optimal. Finger millet will not tolerate drought and will not grow well in areas with heavy rainfall. **Planting** If being grown as a rain-fed crop, finger millet is directly seeded in the field by broadcasting. Seeds should be sown to a depth of 2.5 cm (1.0 in) allowing 25 cm (10 in) between rows and 10–12 cm (4–5 in) between plants. The soil is commonly ridged to promote drainage in wet soils. When adequate irrigation is not available, the seeds are grown in nurseries to create transplant which are transferred to the field later. Finger millet is commonly intercropped with sorghum, maize or legumes such as pigeon pea or cowpea. **General care and maintenance** The seedbed should be kept free from weeds as the plants develop to prevent competition for light and nutrients. The plants should be provided with additional irrigation during dry periods. Finger millet benefits from the addition of chemical fertilizers. In Africa, farmers fertilize using ash, while in India it is common for farmers to spread cow or sheep manure on the crop. **Harvesting** Finger millet is usually ready to harvest between 3.5 and 5 months after sowing depending on the variety. The crop is usually harvested by hand by cutting the seed heads or by cutting the entire plant.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Blast** *Pyricularia grisea*

###### **Symptoms**

Elliptical or diamond shaped lesions on leaves; centers of lesions are grey and water-soaked; lesions surrounded by chlorotic halo; appearance of concentric rings on leaves

###### **Cause**

Fungus

###### **Comments**

Occurs in all areas of Africa and Asia where millet is grown

###### **Management**

Plant resistant varieties where available; treat seeds with appropriate fungicide; sprays of appropriate fungicides may also be required to control the disease in the field; good sanitary practices are essential to limit the spread of the disease

##### **Cercospora leaf spot** *Cercospora penniseti*

###### **Symptoms**

Small dark lesions on leaves which are usually oval in shape but may be oblong to rectangular; centers of lesions are gray to tan in color with visible black dots; lesions may be covered in spores during wet weather; lesions may also be present on the stems and are slightly longer than those on the leaves

###### **Cause**

Fungus

## **Comments**

Disease emergence occurs when high temperatures coincide with periods of high humidity

## **Management**

Avoid planting millet varieties that are highly susceptible to Cercospora fungi; control weeds in field; rotate crops and practice good sanitation; no chemical control is needed to treat the disease

## **Downy mildew** *Sclerospora graminicola*

### **Symptoms**

Chlorosis of leaves beginning at base of the infected leaf beginning lower down on the plant and progressing upwards; downy white to gray fungal growth on undersides of leaves; brown, necrotic leaves; distinct margin between diseased leaf tissue at base of leaf and healthy tissue towards tip

### **Cause**

Fungus

### **Comments**

Disease is of great economic importance in India and several countries in Africa

## **Management**

Rogue infected plants when found in the field; treat seeds with an appropriate systemic fungicide prior to planting and continue to spray the crop at least once every 25 days after sowing

## **Rust** *Puccinia substriata*

### **Symptoms**

Small yellow or white raised spots on upper and lower leaf surfaces; spots tend to be more numerous on lower leaf surface; spots enlarge and develop into red-brown pustules which may be surrounded by a yellow halo

### **Cause**

Fungus

### **Comments**

Spores can be spread via wind and survive in crop debris in the soil

## **Management**

Plant resistant varieties of millet if rust is a persistent problem; avoid the use of overhead irrigation; do not plant millet in close proximity to eggplant or other Solanaceous crops; there are no recommended chemical controls for rust

## **Seedling and leaf blight** *Helminthosporium nodulosum*

### **Symptoms**

Death of seedlings before they breach soil surface; light brown, oval lesions on seedlings; large dark brown patches on seedlings; withering of plants; well defined lesions on junction between leaf blade and sheath; tissue necrosis; death of plant above lesions; dropping of leaf tips, spikelets, fingers or entire head

### **Cause**

Fungus

### **Comments**

Disease occurs in India, Japan and Africa; fungus attacks other millet species; disease spread through infected seed

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# Fonio

## Description

White fonio, *Digitaria exilis*, is an annual grass in the family Poaceae grown for its grain which is commonly used to make porridge. Fonio is an erect, tillering grass with delicate stems and alternate leaves. The leaves are blade like or linear and tapering and can reach up to 15 cm (6 in) in length. The plant produces spikelets, where the grain is produced, on branched, spike-like panicles. A single inflorescence possesses 2–5 racemes with spikelets arranged in pairs or in threes or fours, giving it a lacy appearance. White fonio can reach a height of 30–80 cm (11.8–31.5 in) depending on variety and is an annual plant, harvested after one growing season. White fonio may also be referred to fonio, hungry rice or hungry millet and originates from West Africa.

*Harvested fonio*

## Uses

The fonio grain is consumed after cooking, either as a porridge or couscous. The grain may also be ground and mixed with other cereals. Fonio grain may be used to brew beers and the straw can be used as animal fodder.

# Propagation

**Basic requirements** Fonio is a tropical plant and requires a dry season to grow properly. The plant grows optimally at temperatures between 25 and 30°C (77–86°F) and in areas where the average rainfall is between 900 and 1000 mm. Fonio can be grown on a range of soils and it is generally grown in soils that are considered too nutrient poor for other crops. The plants will grow best in light, sandy soils and it is often planted in rotation with rice, sorghum or millet.

**Planting** Fonio is direct seeded by broadcasting in the field and germinates and grows rapidly, out-competing weeds and negating the need for weeding the field. The soil is roughly loosened prior to planting and seed is generally broadcast at a rate of 10 to 30 kg of seed/ha. The seeds are then lightly dug into the soil or covered using a hoe and allowed to germinate. **General care and maintenance** Fonio requires little maintenance after planting and is highly adapted to drought conditions. **Harvesting** Fonio is harvested using traditional methods, The plants are cut using a knife or sickle and gathered into sheaths for drying. Processing the grain is a laborious process that requires beating the dried plants to extract the grain and then dehulling the grain using a mortar.

Harvesting fonio

Harvesting fonio

Harvested fonio

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### Pangola stunt

Pangola stunt virus (PaSV)

##### Symptoms

Stunted plants; slow growth of plants after mowing or grazing; yellowing, twisting or kinking of young leaves and inflorescences; swelling of small leaf veins; excessive tillering; leaf margins turning purple

##### Cause

Virus

##### Comments

Widespread in warm regions all over the world including USA, Africa, Central and South America and Asia; transmitted by the whitebacked planthopper *Sogatella furcifera*

##### Management

Insecticidal soaps can help to control young planthoppers but may not be effective at preventing virus transmission; in areas where disease is a problem other grass species should be considered

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# Garlic (*Allium Sativum*)

## Description

**Garlic (*Allium Sativum*)**

### Crop details

The following are the crop details for garlic

Scientific name: *Allium Sativum*

Local names: Kitungu saumu (Swahili)

Order: Asparagales

Family: Amaryllidaceae

Subfamily: Allioideae

Genus: Allium

*Harvested garlic*

*Garlic flowerhead*

*Garlic flowerhead*



## General information

Garlic is one of the most used crops among the cultivated *Allium* species. It is a perennial flowering plant that grows from a bulb that contains outer layers of thin, whitish sheaths or skin that enclose various lobes known as cloves. One garlic bulb may contain 10 to 20 edible cloves that are asymmetrical in shape, except for the small ones, which are close to the center. Cloves, which are also covered by protective whitish skin, have a distinctive smell.

Garlic, either in fresh or powdered form, is mainly used as a seasoning or condiment for flavoring food. It also has nutritional value, as raw garlic contains protein, starch, small amounts of fat and sugar, and high levels of potassium and vitamin C. Furthermore, garlic is widely valued for its medicinal importance as it contains bioactive constituents that are believed to help the body fight viral, fungal, and bacterial infections, among other health benefits such as lowering blood sugar and cholesterol levels, among others.

In addition, garlic extracts have pesticide properties that play a vital role in protecting plants from some pests and diseases like African armyworm, downy mildew, and rice bugs, among others. While it is beneficial in organic farming, its use as a pesticide should be moderated as it can kill beneficial soil bacteria and insects due to its broad-spectrum effects.

### Origin.

Garlic is believed to have originated in Central Asia (China). It then spread to the Mediterranean region in ancient times and was already known in Egypt by 3000 BC. Today, garlic is cultivated across the globe at latitudes ranging from 5 to 50 in both the northern and southern hemispheres.

### Nutritive value

The table below is a summary of the nutrition value per 100g of an edible portion of garlic

## Uses

Garlic is primarily used for flavoring food and can be dried, ground or powdered for this purpose

## Garlic Varieties

It is difficult to identify the wild primogenitor of common garlic due to the presence of numerous cultivars (clones). This makes it difficult to classify the clones. Despite this, there are two well-known garlic varieties, namely, cv. group *Ophioscorodon*, also known as hard-necked garlic, and cv. group Common Garlic, commonly referred to as soft-necked garlic (CABI, 2019).

While the cv. group Common Garlic has a straight stalk, the cv. group *Ophioscorodon*, on the other hand, has a curvy scape. In addition, hard-necked garlic is best suited for the northern climate, while soft-necked garlic flourishes in southern

climates. The two varieties do well in Kenya, although the soft-necked is more commonly planted.

## Climatic condition soil and water.

Temperature, and length of day are important factors in bulbing and bolting. Garlic is grown in a temperature-limited range of 9–28 °C. It is required that the propagules be exposed to 10–15 °C for 2 months to allow proper bulbing. Moreover, lower temperatures ranging from -2 to 6 °C are necessary for vernalization. Day length (>12 hours), on the other hand, stimulates clove formation. Garlic growth is easily adapted to all latitudes due to its wide genetic variation in response to temperature and day length. For instance, it is grown in the highlands around the equator to increase its growth. Also, garlic growth is recommended during the prevailing long-day season and at high altitudes in the tropics. In areas that experience long seasons of sub-freezing temperatures, mulching is advised to protect the plants from the cold. Mulching also conserves moisture and control weed growth.

Garlic requires fertile, well-drained, non-crusting mineral soil, in organic matter to increase yields. It should also be planted in raised beds to allow good soil drainage, which is essential.

Garlic plants perform well in areas with low rainfall since excess rain and humidity are bad for their growth. Regular irrigation during dry seasons is advised, where moisture in the top 30 cm of the soil should be maintained during the entire growth period to attain maximum yields. However, in some areas, stopping irrigation three weeks before harvest is recommended to prevent rotting and skin color loss.

*Garlic curing*

*Harvested garlic*

*Garlic sprout emerging*

## Planting procedures

### i) Cultivation and planting

Prepare the soil a few weeks before planting for aeration; remove rocks and loosen the soil. While garlic can grow in soil with high organic matter, it can also grow in a variety of soil conditions and pH levels. A basal dressing of 200 kg/ha of triple superphosphate is recommended during soil tillage.

Garlic is usually grown as an annual crop. It is normally cultivated using cloves as seeds. To have quality and maximum yields, a farmer needs to plant healthy cloves. During seed selection, it is recommended that cloves planted should be of about equal weight (depending on cultivar) for uniformity purposes. The quantity of planting material is dependent on the size of the clove and the density of the plants.

During planting, place selected cloves 8–10 cm apart within the rows and 15–20 cm between rows to leave enough space for bulbs to grow and mature well. The cloves should be planted with the pointed side up and the base down. Garlic plants are best grown as sole crops on raised beds alternated with furrows. Protect the garlic cloves through mulching.

### ii) Field operations

Planting, watering, weeding, and harvesting are all done by hand.

Avoid under-watering or over-watering the plants to allow optimal bulb formation. In cases where there is no rain, light watering (one inch deep) is enough. Dripline irrigation is recommended during the dry season.

Remove weeds that might hinder the crops from accessing maximum light, water, and nutrients. This can be done by

mulching, hand hoeing, or spraying herbicides.

80 kg/ha of ammonium sulphate is mixed with 50 kg/ha of potassium chloride and 80 kg/ha of urea and then applied as side dressings at 15, 30, and 45 days after planting.

### iii) Harvesting and storage

Garlic grows about 60 cm (2 feet) tall. The duration of subsequent growth and development phases strongly depends on the prevailing conditions. The total growing period varies depending on the area, where harvesting takes place 3–4 months after planting (in the tropics) to about 9 months (for winter garlic in temperate regions). Harvesting is done once the leaves start turning yellow and begin to dry up. Once ready, the farmer pulls the bulbs out of the soil using their hands. They are then tied in bunches for drying and later stored in a dry place with good ventilation to inhibit growth or decay.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Downy mildew** *Peronospora destructor*

###### **Symptoms**

Pale spots or elongated patches on leaves; gray-purple fuzzy growth on leaf surface; leaves turning pale then yellow; leaf tips collapsing

###### **Cause**

Fungus

###### **Comments**

Disease emergence favored by cool temperatures and leaf wetness

###### **Management**

Avoid planting infected sets; rotate crops to non-allium species for 3-4 years; plant in well-draining areas and do not overcrowd plants; destroy all infected crop debris; apply appropriate foliar fungicides taking care to apply thoroughly to waxy leaves

## Purple blotch *Alternaria porri*

### Symptoms

Small water-soaked lesions on leaves or stalk with white centers; which enlarge to become zonate and brown to purple in color with red or purple margin surrounded by yellow zone; large lesions may coalesce and girdle leaf, killing any tissue between the lesions and the leaf tip; severely infected foliage may die

### Cause

Fungi

### Comments

Disease emergence favored by wet foliage, with sporulation occurring during the night during periods of high humidity

### Management

Cultural controls include long rotations with non-hosts and the reduction of leaf wetness by planting in well-draining soil and timing irrigation to allow plants to dry adequately during the day; some fungicides are effective at controlling the disease but should be rotated for optimal control

## Rust *Puccinia porri*

*Rust pustules on garlic leaf*

*Cultivated garlic plant suffering from rust*

### Symptoms

Small white flecks on leaves and stems which develop into circular or elongated orange pustules; severe infestations can cause leaves to yellow and die

### Cause

Fungus

### Comments

Favors high humidity but low rainfall; spores can be transported over long distances by wind

### Management

No resistance known; use only disease-free seed and plant in well-draining soil; control weeds around crop; apply appropriate protective fungicide

## White rot *Sclerotium cepivorum*

*Close up of white rot on base of garlic stem*

*Yellowing leaves of garlic plant caused by white rot infection*

### Symptoms

Older leaves yellowing; stunted growth; death of all leaves; fluffy white growth on base of bulb which spreads up bulb to storage leaves

### Cause

Fungus

### Comments

Once disease is established the field is unusable for garlic production; fungus can survive in soil for 20 years and is one of the most damaging diseases of Allium crops worldwide, causing major crop losses

### Management

Fungicide treatment may not be effective at controlling white rot under conditions which are favorable to the fungi's development and control may have to rely on cultural methods: avoid transferring soil or plant material between sites; treat seeds with hot water prior to planting; use a long term rotation with non-allium crops; apply appropriate

fungicides if available

## Category : Viral

### Mosaic Garlic mosaic virus (GarMV)

#### Symptoms

Mosaic patterns on leaves; chlorotic mottling or streaks on leaves; stunted plant growth and reduced bulb size

#### Cause

Virus

#### Comments

Transmitted by aphids; infections can be latent and produce no symptoms; infection in garlic are often found alongside other viruses such as onion yellow dwarf

#### Management

Plant virus-free cloves that were produced from meristem tip culture in virus-free conditions

## Pests

### Category : Mites

#### Bulb mites *Rhizoglyphus* spp.

*Tyrophagus* spp.

#### Symptoms

Stunted plant growth; reduced stand; bulbs rotting in ground or in storage; pest is a cream-white, bulbous mite <1 mm in length, which resembles a pearl with legs

#### Cause

Arachnid

#### Comments

Damage to plants by bulb mites allows secondary invasion by other pathogens and can cause bulb rots

#### Management

Do not plant successive crops of onion or garlic in same location; allow field to fallow to ensure that any residual organic matter decomposes completely - crop residues can harbor mite populations; treating garlic seed cloves with hot water prior to planting may help reduce mite populations

### Category : Insects

#### Leafminers *Lyriomyza* spp.

*Example of typical leafminer damage (onion leaf)*

#### Symptoms

Thin, white, winding trails on leaves; heavy mining can result in white blotches on leaves and leaves dropping from the plant prematurely; early infestation can cause yield to be reduced; adult leafminer is a small black and yellow fly which lays its eggs in the leaf; larvae hatch and feed on leaf interior

#### Cause

Insects

#### Comments

Mature larvae drop from leaves into soil to pupate; entire lifecycle can take as little as 2 weeks in warm weather; insect may go through 7 to 10 generations per year

### **Management**

Check transplants for signs of leafminer damage prior to planting; remove plants from soil immediately after harvest; only use insecticides when leafminer damage has been identified as unnecessary spraying will also reduce populations of their natural enemies

## **Onion maggot *Delia antiqua***

### **Symptoms**

Stunted or wilting seedlings; plant will commonly break at soil line if an attempt is made to pull it up; if infestation occurs when plants are bulbing, bulbs will be deformed and susceptible to storage rots after harvest; adult insect is a greyish fly which lays white, elongate eggs around the base of the plant; the larvae that emerge from the eggs are tiny and white and bore into the plant; mature larvae are about 1 cm (0.4 in) long with feeding hooks

### **Cause**

Insect

### **Comments**

Females can lay several hundred eggs during their 2-4 week lifespan; insect overwinters as pupae in the soil

### **Management**

Management of onion maggots is heavily reliant on good sanitation; all onion bulbs should be removed at the end of the season as maggots will die without a food source; commercial onion growers must often rely on the application of appropriate granular insecticides and, in some cases, insecticide sprays are also required; home gardeners should try to remove any volunteer wild onion and chive plants as these can act as an infection source; floating row covers may help to protect plants and prevent females from laying eggs around plants

## **Thrips (Onion thrips, Western flower thrips) *Thrips tabaci***

*Frankliniella occidentalis*

*Western flower thrips*

### **Symptoms**

Discolored, distorted tissue; scarring of leaves; severely infected plants may have a silvery appearance; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color

### **Cause**

Insect

### **Comments**

Onion thrips and western flower thrips have an extensive host range and can be introduced to garlic from other plants

### **Management**

Natural enemies include some species of predatory mite, pirate bugs and lacewings; avoid planting onion in close proximity to grain fields as thrips populations build up on these plants in the spring; overhead irrigation of plants may help reduce thrips numbers; apply appropriate insecticides at first sign of thrips damage

## **Category : Nematodes**

### **Lesion nematode *Pratylenchus penetrans***

#### **Symptoms**

Stunted plants; root system lacks fine roots; round or irregular lesions on roots

#### **Cause**

Nematode

## **Comments**

Lesion nematode has one of the widest host ranges of any nematode; nematode enters the plant through the root epidermis and consumes cell contents

## **Management**

Hot water dips can be used to control nematodes in bulbs; crop rotation is not usually very effective at controlling lesion nematodes due to its extensive host range

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# Ginger

## Description

Ginger, *Zingiber officinale*, is an erect, herbaceous perennial plant in the family Zingiberaceae grown for its edible rhizome (underground stem) which is widely used as a spice. The rhizome is brown, with a corky outer layer and pale-yellow scented center. The above ground shoot is erect and reed-like with linear leaves that are arranged alternately on the stem. The shoots originate from a multiple bases and wrap around one another. The leaves can reach 7 cm (2.75 in) in length and 1.9 cm (0.7 in) broad. Flowering heads are borne on shorter stems and the plant produces cone shaped, pale yellow flowers. The ginger plant can reach 0.6–1.2 m in height (2–4 ft) and is grown as an annual plant. Ginger may also be referred to as true ginger, stem ginger, garden ginger or root ginger and it is believed to have originated in the Southeast Asia.

*Ginger plant*

*Ginger rhizomes with buds*

*Ginger plant with flower*

*Ginger foliage*

*Ginger foliage*

*Ginger plant*

## Uses

Ginger is popularly used as a spice in cooking and can be used either fresh, dried or powdered. The fresh rhizome can be

used to extract ginger essential oil. Ginger may also be used to flavor beverages. Ginger continues to be a popular folk remedy in China and India.

## Propagation

**Basic requirements** As a tropical plant, ginger grows best in warm and sunny climates in a deep but well draining soil loam that is high in organic matter. The optimum soil pH for growth of ginger is between 6.0 and 6.5 and the plant requires a minimum temperature of 15.5°C (59.9°F). Ginger plants require an average annual rainfall of between 250 and 300 cm for optimal growth and development and require additional irrigation where rainfall is not adequate. Ginger plants will not tolerate waterlogged soils. **Propagation** Ginger is vegetatively propagated from small sections of the rhizome, called sets. Sets are produced by cutting a small 3–6 cm from a living rhizome. Each piece should possess at least one living bud which will produce shoots. The ginger sets can be pre-sprouted in pots or nursery seed beds by covering with a layer of soil or they can be planted directly at the final planting location. The bed should be prepared for planting by digging to soil to a fine tilth and removing any weeds that are present. The addition of lime to the soil adjusts the pH while helping to provide the calcium required by the plants during their growth. Lime should be added to the soil in appropriate amounts in the Fall prior to planting. The sets should then be planted in early Spring at a depth of 5–12 cm, leaving 15–35 cm between plants and 25–30 cm between rows. For optimal growth, the soil temperature at planting should not fall below 25°C (77°F). **General care and maintenance** Ginger has a tendency to grow horizontally and the soil can be hilled around the growing stems to force a more vertical growth habit. Soil should be hilled 3 to 5 times during the growing season. Any exposed rhizomes should be covered with soil and weeds should be removed from the bed. Ginger will benefit from the addition of a complete fertilizer as well as phosphorous, calcium and organic matter prior to planting. During the growing season, additional fertilizer can be applied as a side dressing. The side dressing should be made 25 to 30 cm (10-12 in) from the row of plants due to ginger being easily damaged by fertilizer applications. Side dressings should be made every 2 to 3 weeks during the growing season to ensure the ginger is supplied with adequate nutrients. **Harvesting** Ginger is usually harvested after the leaves senesce, dry out and the stem falls over. Ginger roots are harvested by digging. Commercially produced ginger is harvested with the use of cutter bar which is pulled by a tractor. After harvest, the ginger should be cured for 3 to 5 days to prevent the development of mildew on the rhizomes.

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## Common Pests and Diseases

### Diseases

#### Category : Bacterial

**Bacterial wilt** *Ralstonia solanacearum*

*Discolored ginger root due to bacterial wilt*

*Bacterial streaming from diseased rhizome of edible ginger (ooze test)*

*Rotting of rhizome*

*Internal necrosis root rot*

*Rotting of root*

*necrosis and rot of edible root*

*plant chlorosis and wilting*

*internal necrosis and rot of edible root*

*internal necrosis and rot of edible root.*

*Bacterial wilt of ginger*

*rot of edible root*

*plant wilting and dieback.*

*Yellowing ginger foliage caused by bacterial wilt*

*Bacterial wilt of ginger*

*Bacterial wilt of ginger*

*Yellowing ginger foliage caused by bacterial wilt*

## Symptoms

Green leaves infected with the pathogen roll and curl ("green wilt"); leaves turn yellow then necrotic; plants become stunted and die; rhizomes are discolored and water-soaked and may be rotting inside.

## Cause

Bacteria

## Comments

Disease is spread via movement of infested soil; bacteria survive in the soil on plant debris.

## Management

Plant ginger in well draining soils where ginger had not previously been grown; plant only pathogen free seed; plant ginger on hills to aid soil drainage and promote air flow around the rhizome; rotate ginger with non-hosts of bacterial wilt.

## Category : Fungal

### Dry rot *Fusarium and Pratylenchus complex*

#### Symptoms

Initially the lower leaves exhibit yellow tips followed by complete yellowing. As the disease progresses, the upper leaves become yellow. Later the leaves become dry and whole plant appears stunted. Infected rhizome shows brownish ring particularly at cortical region.

#### Cause

Fungus and Nematode

#### Comments

Favors waterlogged fields. Always occurs in patches. When comparing to soft rot the dry rot infected stem won't come off with a gentle pull.

#### Management

Treating seed with Bordeaux mixture prior to planting and solarizing the soil can help to reduce the incidence of the disease.

## Category : Oomycete

## Rhizome rot/Soft rot/Pythium rot *Pythium aphanidermatum*

*P. vexans*  
*P. myriotylum*  
*Fusarium* sp.

### Symptoms

Stunted plant growth; yellow leaves and stems; brown discoloration of water conducting tissue within stem; root system rotted, mushy and turning black; rotted rhizome gives off a foul odor.

### Cause

Fungi

### Comments

Disease favors warm, moist soils; spread primarily through use of infected seed pieces which may not show any outward signs of disease.

### Management

Plant ginger in well-draining soils or on hills created by tilling; do not plant any seed pieces which show symptoms of disease; seed pieces can be treated with hot water (50°C/122°F for 10 min) or appropriate fungicides prior to planting; destroy all crop debris after harvest; keep fields weed free; do not grow ginger for more than one year in same area.

## Pests

### Category : Insects

#### Chinese rose beetle *Adoretus sinicus*

*Chinese rose beetles (Adoretus sinicus) and their feeding injury (windowing) on a leaf.*

*Chinese rose beetle feeding injury on Cacao*

*Adult Chinese rose beetles*

*Chinese rose beetle (Adoretus sinicus)*

### Symptoms

"Shot-hole" appearance of leaves; entire leaf consumed with the exception of the leaf veins; adult insect is a reddish-brown beetle which feeds on plants at night.

### Cause

Insect

### Comments

Chinese rose beetles are nocturnal.

### Management

Chinese rose beetles are attracted to dim light and repelled by bright light, shining bright light on plants may help deter them from feeding; covering young plants with e.g. floating row covers can help to protect plants until they are old enough to withstand attacks by the beetle.

### Category : Nematodes

#### Root-knot nematode and Burrowing nematode *Meloidogyne* spp.

*Radopholus similis*

*Burrowing nematode (*Radopholus similis*) damage*

*Damage due to burrowing nematode*

*Symptoms on rhizome caused by burrowing nematode*

### **Symptoms**

Root knot nematode: Water soaked lesions on roots; Galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; reduction in plant vigor; yellowing plants which wilt in hot weather. Burrowing nematode: The appearance of small, water-soaked shallow lesions on rhizome which later turn brown. This lesion merges together and leads to rotting. Infected plants show yellow leaves with less number of shoots and stunted growth.

### **Cause**

Nematode

### **Comments**

Galls or lesions can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in the areas of the field or garden with this type of soil is most likely.

### **Management**

Plant resistant varieties if nematodes are known to be present in the soil ;check roots of plants mid-season or sooner if symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens. Treating rhizome with hot water (51°C for 10 minutes) before planting reduces burrowing nematode problem.

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# Gooseberry

## Description

Gooseberry (*Ribes* spp.) is a small spiny bush in the family Rosaceae which is grown for its edible fruit of the same name. The gooseberry bush is a spiny shrub with deeply lobed, dark green leaves and produce bell shaped flowers and green/yellow to red berries approximately 1 inch long containing many tiny seeds. If managed properly, gooseberry bushes can be very long lived, growing to 0.9–3.0 m (3–10 ft) tall and up to 1.8 m (6 ft) wide and producing a crop of fruit each spring. The gooseberry has been derived mainly from two species, the European gooseberry *Ribes grossularia*, native to North Africa, and the American gooseberry (*Ribes hirtellum*), native to Northeast and central US and parts of Canada. The American gooseberry tends to be smaller than the species grown in Europe, with weeping stems that will rot easily if they are allowed to be in contact with the ground.

*Developing fruits*

*Gooseberry fruits*

*Gooseberry flowers*

*Gooseberry flowers*

*Gooseberry bush*

*Gooseberry fruit*

## Uses

Gooseberries can be eaten fresh or used as an ingredient in other foods such as desserts, jams and preserves or drinks

such as tea. The fruit can also be used as an ingredient for pickling. They are also used to flavor beverages such as sodas, flavored waters, or milk, and can be made into fruit wines and teas. They can be preserved in the forms of jams or dried fruit.

## Propagation

**Basic requirements** Gooseberries grow best in cool, moist locations and can be damaged by intense summer heat. Gooseberry can be grown in partial shade but it is essential that the plants have a good air circulation around them to help prevent the development of disease. Gooseberry has a chilling requirement of between 1000 to 1200 hours between 1.7 and 7.2°C (35–45°F) to break dormancy. Plants can tolerate cold and light frosts but temperatures below -2°C (28°F) can cause damage to the flower buds. Gooseberries can be grown successfully in a range of soils but perform optimally in well-draining sandy loams which are rich in organic matter with a pH between 5.5 and 6.5. **Propagation** Gooseberry plants can be planted as rooted plants obtained from a nursery or from cuttings from established plants. Cuttings should be taken in winter or early spring when the plant is dormant. Cuttings should be 15–20 cm (6–8 in) in length and taken from the previous years growth. The cuttings should be stored in sand or peat moss in a refrigerator or other cold location until early spring. **Planting** Gooseberry plants and cuttings should be planted out in early spring. Plants obtained from a nursery should have a strong root system. Remove any damaged roots prior to planting and cut the stems back so that they are between 15 and 25 cm (6–10 in) depending on the size of the root system. Plant the gooseberries in prepared soil a little deeper than they were in the nursery and gently tamp the soil around the plants. Spacing depends on the variety being grown but generally gooseberries should be spaced 0.9–1.5 m (3–5 ft) apart, allowing 2.4–3.0 m (8–10 ft) between rows. Closer spacings can be used if a hedgerow is desired. Cuttings should be similarly spaced. The tips of the cuttings can be dipped in rooting hormone prior to planting to encourage root development. **Pruning** Gooseberries should be pruned in the winter while dormant. Damaged or drooping canes should be removed as well as any which shade the center of the plant. After the first year of growth, the plant should be cut to leave 6 to 8 vigorous canes. After the second growing season all but 4 or 5 one year old shoots and 3 or 4 two year old canes should be removed. after the third growing season, retain 3–4 each of 1-, 2- and 3- year old wood. After the fourth growing season, all of the four year old wood should be removed and the plants should be pruned annually following the directions for after the third growing season.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### American gooseberry mildew *Sphaerotheca mors-uvae*

###### Symptoms

Powdery, white patches on young leaves, stems and branch tips which kill patches of the leaf and cause leaf curling and

deformation; fungal fruiting bodies may be visible in the patches as black dots; white patches may also appear on fruit and turns dark brown in color with a rough texture

#### **Cause**

Fungus

#### **Comments**

Disease favors cool, humid, rainy environments; prevalent in the early spring and fall

#### **Management**

Reduce humidity around plants by keeping area free from weeds, using recommended plant spacings and pruning plants; plant gooseberry varieties that are resistant to powdery mildew

### **Anthracnose *Drepanopeziza ribis***

#### **Symptoms**

Brown to black lesions on leaves which enlarge over time and may develop a purple margin; leaves turning yellow and dropping from plant; dark flecks on berries; berries may split and drop from plant

#### **Cause**

Fungus

#### **Comments**

Disease emergence is favored by wet weather in Spring; spores are spread by splashing water

#### **Management**

Remove all leaf debris from around plants as soon as they fall from plants; applications of appropriate fungicide may be necessary

### **Botrytis dieback (Gray mold berry rot) *Botrytis cinerea***

#### **Symptoms**

Gray fuzzy mould covering leaves and fruit; branches turning dark at tips and dying back; unripe fruit dropping from plant

#### **Cause**

Fungus

#### **Comments**

Disease favors wet and humid environments with poor air circulation; fungus overwinters on plant debris in the soil

#### **Management**

Plant gooseberry in a location with good air circulation; remove weeds from around plants to aid drying of foliage; harvest fruit in a timely manner before it becomes overripe; applications of appropriate fungicides may be necessary and should be applied during bloom

### **Currant cane blight *Botryosphaeria ribis***

#### **Symptoms**

Sudden wilting and dying of scattered canes or whole bush; pith of cane discolored tan to black; canes may become hollow and snap from plant

#### **Cause**

Fungus

#### **Comments**

Fungus likely overwinters in infected canes

#### **Management**

Prune out infected branches in Spring and any wilting canes in Summer; remove plants that are severely infected or dead; protective sprays of appropriate fungicides can help protect uninfected plants from disease

### **Septoria leaf spot *Mycosphaerella ribis***

#### **Symptoms**

Symptoms on leaves are similar to anthracnose (see entry) but lesions develop a lighter center and the leaves drop from the plant

**Cause**

Fungus

**Comments**

Fungus survives on leaf debris on the ground

**Management**

Try to reduce leaf wetness by removing weeds around plants, using adequate plant spacings etc.; application of appropriate fungicides can help control the disease

**White pine blister rust** *Cronartium ribicola*

**Symptoms**

Yellow spots that develop into brown lesions on leaves; yellow fungal fruiting bodies on undersides of leaves; fibrous growth on infection sites.

**Cause**

Fungus

**Comments**

Plants become infected by spores released from white pine

**Management**

Avoid planting near white pine

## Pests

### Category : Insects

**Aphids (Currant aphid)** *Cryptomyzus ribis*

**Symptoms**

Small soft bodied insects on underside of leaves and/or stems; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants; stunted growth and distorted leaves; sticky residue on leaves

**Cause**

Insect

**Comments**

Aphids overwinter as eggs on stems

**Management**

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

**Currant borer** *Synanthedon tipuliformis*

**Symptoms**

Withered, yellow leaves; pith of cane dark and hollow; canes may die; adult insect is a small moth with clear wings; larvae are white with a brown head

**Cause**

Insect

### Comments

Adult female lays her eggs on the canes, larvae hatch out and tunnel into the cane, boring through the pith

### Management

Prune damaged branches below damaged area and destroy; appropriate insecticides must be applied before larvae enter canes in order to be effective

## Stinkbugs (Brown marmorated stink bug) *Halyomorpha halys*

### Symptoms

Dark colored pinpricks on fruit surrounded by a lighter area that turns yellow or remains light green; stink bugs often carry pathogens in their mouthparts which can cause secondary infections and decay of fruit; adult insect is shield-shaped and brown or green in color; may have pink, red or yellow markings; eggs are drum shaped and laid in clusters on the leaves; larvae resemble the adults but are smaller

### Cause

Insect

### Comments

Adult insects overwinter under leaves, on legumes, blackberries or on certain weeds such as mustard or Russian thistle

### Management

Remove weeds around crop which may act as overwintering sites for stink bugs and practice good weed management throughout the year; organically accepted control methods include the use of insecticidal soaps, kaolin clay and preservation of natural enemies; chemical treatments are not recommended for tomatoes that are to be processed for paste or canning unless secondary infections with other pathogens are a concern

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# Gourd

## Description

Gourds are annual trailing or climbing vines in the family Cucurbitaceae grown for their fruit of the same name. The two most commonly grown types of gourd are *Lagenaria* species and *Cucurbita* species. Gourd plants produce long vines with long-stemmed, large, oval or triangular lobed leaves. The *Cucurbita* gourds produce yellow flowers and unusually shaped fruit which can be smooth or warty, plain or patterned. The *Lagenaria* gourds produce white flowers and smooth, knobly or ridged fruit which can range in size from 7 cm (3 in) up to 1 m (3 ft). Gourd vines are capable of climbing over 3.5 m (12 ft) and as annual plants, survive only one growing season. Gourds may also be referred to as dudi, cucuzzi, spaghetti squash or calabash and are believed to have originated in Africa.

*gourd flower*

*Bottle gourd (*Lagenaria siceraria*)  
plant growing on a frame*

*A colorful selection of gourds*

## Uses

Young gourds can be cooked and eaten as a vegetable while the mature gourds are used to make decorative items such as bottles, containers and utensils. In the US, gourds have become a very popular household decoration in the Fall.

# Propagation

**Basic requirements** Gourds are warm-season crops, requiring lots of sun and good drainage to develop optimally. Plants will grow best at temperatures between 18 and 25°C (65–75°F) in a fertile, well-draining soil, rich in organic matter and with a pH between 6.5 and 7.5. Gourd plants should be planted in full sun and provided with ample soil moisture. Vining varieties can grow to very large sizes and require a good deal of space. **Sowing seeds** Gourds can be direct seeded or sown indoors and transplanted. If direct seeding, seeds should be sown after the last frosts and when the soil has warmed to at least 15.6°C (60°F). Sow 1–2 seeds 1.3–2.5 cm (0.5–1.0 in) deep, at least 90 cm (~3 ft) apart if growing bush varieties and 120–150 cm (4–5 ft) apart if growing vining varieties. Allow a further 1–3 m (6–10 ft) between rows depending on the variety. If transplanting, seeds should be sown 3–4 weeks before the last frost date in your area and transplanted before the plants develop their second set of true leaves. Sowing seeds in 3–4 inch pots help to minimize disturbance to the roots prior to transplanting. Peat pots can be transplanted with the seedlings eliminating the need to disturb the roots entirely. Seeds sown both indoors and out require lightly moist soil for germination, care should be taken to avoid overwatering. Seeds should germinate in 5–10 days depending on the soil temperature. **General care and maintenance** Gourd plants sprawl and require plenty space to grow. Vines can be trained to grow on a trellis or fence. Plants also require a continuous supply of water and where drip irrigation is not being used, plants should be watered deeply once per week, providing at least an inch of water. Shallow watering or watering less frequently encourages a shallow root system. Mulches can be used to conserve soil moisture and black polyethylene mulch has the advantage of warming the soil. Gourds produce both male and female flowers (monoecious) and are pollinated by insects such as bees. Poor fruit set is often caused by poor pollination.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Alternaria leaf blight** *Alternaria cucumerina*

###### **Symptoms**

Small, yellow-brown spots with a yellow or green halo which first appear on the oldest leaves; as the disease progresses, lesions expand and become large necrotic patches, often with concentric patterning; lesions coalesce, leaves begin to curl and eventually die

###### **Cause**

Fungus

###### **Comments**

Disease is prevalent in growing areas where temperatures are high and rainfall is frequent

###### **Management**

Cucurbits should be rotated with another crop every 2 years to reduce levels of inoculum; crop debris should be removed

from the field as quickly as possible after harvest or plowed deeply into the soil; applications of appropriate protective fungicides can help to slow the development of the disease; water plants from the base rather than from above to reduce periods of leaf wetness which are conducive to the development and spread of disease

### **Anthracnose** *Colletotrichum orbiculare*

#### **Symptoms**

Tan to brown lesions with dark spots inside on leaves and petioles, main stem and fruit

#### **Cause**

Fungus

#### **Comments**

Disease favors warm weather

#### **Management**

Plant resistant varieties; use only certified seed; apply appropriate protective fungicides; rotate crops every year

### **Cercospora leaf spot** *Cercospora citrullina*

#### **Symptoms**

Initial symptoms of disease occur on older leaves as small spots with light to tan brown centers; as the disease progresses, the lesions enlarge to cover large areas of the leaf surface; lesions may have a dark border and be surrounded by a chlorotic area; the centers of the lesions may become brittle and crack

#### **Cause**

Fungus

#### **Comments**

Fungus survives on plant debris; spread by wind and water splash; occurs mainly in tropical and subtropical growing regions

#### **Management**

Any diseased plants should be removed and destroyed to prevent further spread; crop debris should be removed after harvest or plowed deeply into the soil to reduce inoculum

### **Downy mildew** *Pseudoperonospora cubensis*

*Symptoms of downy mildew on underside of a gourd leaf*

#### **Symptoms**

Angular brown lesions on upper side of leaves; purple to gray spores and gray mold on underside of leaves; brown leaves; dead leaves that remain attached

#### **Cause**

Fungus

#### **Comments**

Disease favors cool, humid weather

#### **Management**

Do not overcrowd plants; avoid overhead irrigation, water plants from base; apply appropriate fungicide

### **Gummy stem blight** *Plectosporium tabacinum*

#### **Symptoms**

V-shaped yellow to brown areas on stem; cracked dry areas on stem; lesions leaking a sappy material

#### **Cause**

Fungus

## **Comments**

Disease may be seed-borne

## **Management**

Use disease free seed; treat seeds prior to planting; rotate crops every 2 years

## **Powdery mildew** *Sphaerotheca fuliginea*

### **Symptoms**

Powdery, white spots on the undersides of leaves; yellowing leaves

### **Cause**

Fungus

### **Comments**

Disease emergence favored by dry weather and high relative humidity

## **Management**

Plant in sites with good air circulation and sun exposure; do not overcrowd plants; sanitize equipment regularly

## **Scab** *Cladosporium cucumerinum*

*Scab symptoms on gourd fruit*

### **Symptoms**

Angular brown lesions on leaves confined by small veins; pale green and water soaked lesions; holes in leaves from dried out lesions; lesions may also be present on petioles, stems and fruit

### **Cause**

Fungus

### **Comments**

Fungus survives in soil on crop debris; may be seedborne; disease emergence favored by wet weather and temperatures below 21°C (69.8°F)

## **Management**

Rotate cucurbits with non-susceptible crops for a period of at least 2 years; plant only in well-draining soils; spray plants with appropriate protective fungicides

## **Septoria leaf spot** *Septoria cucurbitacearum*

### **Symptoms**

Initial symptoms of disease are small dark water-soaked spots on the leaves which turn beige to white in dry conditions; lesions develop thin brown borders and the centers may become brittle and crack; small white spots may erupt on the surface of infected butternut and acorn squash and pumpkin fruit

### **Cause**

Fungus

### **Comments**

Pathogen can survive on crop debris for periods in excess of 1 year

## **Management**

Scout plants during cool wet conditions for any sign of spots; early application of an appropriate protective fungicide can help limit the development of the disease if spots are found' cucurbits should be rotated with other crops every 2 years to prevent the build-up of inoculum; crop debris should be removed and destroyed after harvest

## **Verticillium wilt** *Verticillium dahliae*

### **Symptoms**

Symptoms generally appear after fruit set; chlorotic leaves which develop necrotic areas; leaves collapsing; symptoms only on one side of vine; discoloration of vascular tissue in roots

**Cause**

Fungus

**Comments**

Fungus can survive in soil for many years; disease emergence favored by cool or mild weather in Spring

**Management**

Do not plant in areas where other susceptible crops have been grown previously; delay planting until temperatures are warmer

## Category : Bacterial

### Angular leaf spot *Pseudomonas syringae*

**Symptoms**

Small water-soaked lesions on leaves which expand between leaf veins and become angular in shape; in humid conditions, lesions exude a milky substance which dries to form a white crust on or beside lesions; as the disease progresses, lesions turn tan and may have yellow/green edges; the centers of the lesions dry and may drop out leaving a hole in the leaf

**Cause**

Bacterium

**Comments**

Spread through infected seed, splashing rain, insects and movement of people between plants; bacterium overwinters in crop debris and can survive for 2.5 years

**Management**

Use disease-free seed; do not grow plants in field where cucurbits have been grown in the previous 2 years; protective copper spray may help reduce incidence of disease in warm, humid climates; plant resistant varieties

### Bacterial leaf spot *Xanthomonas campestris*

**Symptoms**

Dark, angular lesions on leaves; leaf lesions may coalesce and cause severely blighted foliage; water-soaked lesions which enlarge and develop into tan scabs, or blisters, on the fruit; blisters eventually flatten as they reach their full size

**Cause**

Bacterium

**Comments**

Disease can spread rapidly in a field; disease can be introduced through contaminated seed

**Management**

Avoid overhead irrigation; rotate crops away from cucurbit species to prevent disease building up; use new seed each planting as saved seed is more likely to carry bacteria; apply appropriate protective fungicides; copper containing fungicides generally provide good control

## Category : Other

### Aster yellows Aster yellows phytoplasma

**Symptoms**

Foliage turning yellow; secondary shoots begin growing prolifically; stems take on a rigid, upright growth habit; leaves are often small in size and distorted, may appear thickened; flowers are often disfigured and possess conspicuous leafy bracts; fruits are small and pale in color

**Cause**

Phytoplasma

**Comments**

Disease is transmitted by leafhoppers and can cause huge losses in cucurbit crops

### **Management**

Remove any infected plants from the field to reduce spread; control weeds in and around the field that may act as a reservoir for the phytoplasma; protect plants from leaf hopper vectors with row covers

## **Category : Viral**

### **Cucumber mosaic** Cucumber mosaic virus (CMV)

#### **Symptoms**

Plants are severely stunted; foliage is covered in distinctive yellow mosaic; leaves of plant curl downwards and leaf size is smaller than normal; flowers on infected plants may be deformed with green petals; fruits become distorted and are small in size; fruit is often discolored

#### **Cause**

Virus

#### **Comments**

Transmitted by aphids; virus has an extensive host range; can be mechanically transmitted via tools etc.

### **Management**

Control of the virus is largely dependant on the control of the aphid vectors; reflective mulches can deter aphid feeding; aphid outbreaks can be treated with mineral oils or insecticidal soap applications; some resistant varieties are available

### **Squash mosaic** Squash mosaic virus (SqMV)

#### **Symptoms**

Symptoms vary with variety being grown but plants can show symptoms which include include green veinbanding, mottled leaves, blisters, ring spots or protruding veins at leaf margins; some squash varieties may develop leaf enations; infected plants are often stunted and fruits may be malformed with mottled skin

#### **Cause**

Virus

#### **Comments**

Virus can be transmitted through infected seed and spread by striped cucumber beetles

### **Management**

Use only certified disease-free seed

### **Watermelon mosaic** Watermelon mosaic virus (WMV)

#### **Symptoms**

Symptoms vary widely depending on species, cultivar, virus strain and environmental conditions; symptoms on leaves may include green mosaic patterning, green vein-banding, chlorotic rings and disfigured leaves

#### **Cause**

Virus

#### **Comments**

Virus is found in almost all Cucurbit growing regions in the world; virus is spread by over 20 aphid species

### **Management**

Treatments that control populations of aphid vectors can also reduce the incidence of the virus; spraying plants with mineral oils or insecticidal soaps can help to reduce aphid numbers

## **Category : Oomycete**

### **Phytophthora fruit and crown rot** *Phytophthora capsici*

#### **Symptoms**

Sudden wilting of plants; brown lesions on stems and roots; rotting fruit; stunted plant growth; downy growth may be

present on lesions during periods of high humidity

#### Cause

Oomycete

#### Comments

Disease emergence favored by heavy rainfall and poorly draining, waterlogged soils

#### Management

Do not plant in poorly draining soils; avoid over-watering plants; rotate cucurbits with non-susceptible plants for a period of at least 3 years

## Pests

### Category : Insects

#### Squash vine borer *Melittia cucurbitae*

##### Symptoms

Plant or runner wilting suddenly; entry holes in vines; sawdust like material at the base of the plant; may be yellow to brown feces coming out of holes

##### Cause

Insect

##### Comments

Insect overwinters in soil as larvae or pupae and adults emerge in spring; adults lay eggs on leaves and larvae burrow into stems to feed

##### Management

Apply appropriate insecticide if eggs are found on leaves; plow plants into soil after harvest

#### Western striped cucumber beetle (Western spotted cucumber beetle, Banded cucumber beetle) *Acalymma vittata*

*Diabrotica undecimpunctata*

*Diabrotica balteata*

*Western spotted cucumber beetle*

*Banded cucumber beetle*

*Western striped cucumber beetle*

##### Symptoms

Feeding damage to leaves, blossoms and stems

##### Cause

Insect

##### Comments

Beetles overwinter in soil and leaf litter and can transmit bacterial wilt

##### Management

Monitor new planting regularly for signs of beetle; apply appropriate insecticides

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# Grape

## Description

The Common or European grapevine (*Vitis vinifera*) is a long stemmed, woody vine (liana) which produces high value berries, or grapes. The vines can reach lengths in excess of 30 m and can live for many years with proper management. The leaves of the grape vine are alternately arranged on the stem and are long and broad with 5–7 lobes, typically reaching sizes of 5–20 cm (2.0–7.9 in). Flowers are produced in clusters and fruit. The fruit is a berry known as a grape and grows in clusters from the vine. In wild species, the fruit is 6 mm (1/5 in) in diameter and ripens to dark purple to black with a pale wax bloom. In cultivated plants, the berry is usually much larger, up to 3 cm (1.2 in) long and can be green, red or purple. *Vitis vinifera* is native to the Mediterranean region, central Europe, and southwestern Asia but is cultivated on every continent except Antarctica. Most grape cultivation centers on the use of *Vitis vinifera*, however, in North America the related species *Vitis labrusca*, *Vitis riparia* and *Vitis rotundifolia* are also grown. *Vitis amurensis* is native to Asia and has been hybridized with *Vitis vinifera* to produce cold tolerant grapevine varieties.

*Vineyard in Italy*

*Young grapes*

*Grape vine and trellis*

*Grape buds*

*Nebbiolo grapes*

*Cultivated purple grape*

## Uses

Grapes are the most widely produced commercial fruit crop in the world. They are often eaten fresh but are also commonly used to produce wine. Grapes can also be processed into jams, and preserves, juices, grape seed oil, grape seed extract, raisins and vinegar.

## Propagation

**Requirements** The first consideration when attempting to cultivate grape is to select a variety based on the prevailing local climate, with the best production occurring in hot, dry regions. American varieties tend to be the most cold hardy while the European hybrids perform best in hotter, drier regions. Generally, vines should be grown in full sun, in a well draining soil and in a location where there is good circulating air to reduce incidence of disease. Low lying areas should be avoided when selecting a planting site as this can lead to water accumulation during periods of wet weather. Vines prefer a soil with a slightly acidic to neutral pH between 6.0 and 7.0 and require a trellis system to support the weight of the fruit on the vines. **Preparation** Grape vines are usually planted as dormant bare root vines in Spring. Young plants can be purchased from nurseries and garden centres for planting in the home garden. Grape vines require a trellis and this should be built before the vines are planted in the ground. For information on constructing a suitable trellis see: <https://www.plantvillage.com/posts/192-grape-how-to-build-a-trellis-for-grape-vines?locale=en>. The trellis helps support the weight of the fruit and protects the vines from damage while also increasing air circulation and reducing diseases in the canopy. You may also consider a more decorative method of supporting the vines, such as an arbor.

**Planting** New vines should be planted out in Spring after all danger of frost has passed. Dig a hole for each plant approximately 30 cm (12 in) deep and 30 cm (12 in) wide, spaced 1.8–3.0 m (6–10 ft) apart and plant the vine at the same level as the nursery. It is important not to cover the graft union in soil. Tamp the soil around the plants and add any remaining soil. The newly planted vines should be cut back to have only 2 or 3 new buds and watered lightly. **Training** In order for grape vines to develop strong root systems and support heavy loads of fruit, new vines should not be allowed to produce fruit for the first 2–3 years after planting. The vine will produce new shoots, of which several should be allowed to grow while the others are cut back. This allows the vine to fill out with leaves which provide energy for an extensive root system. The new shoots should be attached to the trellis. At the beginning of the second year of growth, select 2–3 of the strongest canes on each plant and cut back the rest. Allow 3 or 4 shoots to develop on each cane and attach to the trellis. Remove any flower clusters that form. **Pruning** Pruning is an essential component of healthy grape production and should be carried out annually in early Spring while the vines are still dormant and before the buds begin to swell. From the third year onwards, most of the previous year's growth should be removed. The more buds that are left on each shoot, the more fruit it will produce but care must be taken to ensure that too many are not left as the fruit may not ripen as a result. Fruit clusters can be removed as required throughout the growing season.

Grape trellis schematic for French grapes

Grapes can be grown on arbors or porches

Grape trellis schematics

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Anthracnose (Birdâ€™s eye rot) *Elsinoe ampelina***

Grape anthracnose symptoms on leaves - not that leaf galls are caused by mites

Grape anthracnose symptoms on fruit

Grape anthracnose symptoms on fruit

#### Symptoms

Dark red lesions on grapes; sunken gray lesions with a darker edge on grapes; lesions on the leaves causing leaf to curl; lesions on shoots may cause a ring of damage which will kill parts of the plant; lesions may also be present on tendrils, fruit stems, and leaf stems

#### Cause

Fungus

#### Comments

Disease favors warm weather

#### Management

Plant less susceptible cultivars; application of Bordeaux mixture or other appropriate fungicide while vines are dormant may be necessary

##### **Armillaria root rot *Armillaria mellea***

#### Symptoms

Weak, short shoots; white fungal mats under the bark at the soil line; unproductive vines; rapid wilting

#### Cause

Fungus

#### Comments

No known Armillaria resistant grape varieties

#### Management

Fumigation may be necessary in soils known or suspected to have carried the disease

##### **Botrytis bunch rot (Gray mold) *Botrytis cinerea***

Bunch rot symptoms on fruit

Bunch rot symptoms on fruit

#### Symptoms

Brown lesions on the stem early in the season; grapes covered with a gray to tan powder; stems and grape clusters shrivel

#### Cause

Fungus

## **Comments**

Disease favors high levels of moisture and high temperatures.

## **Management**

Plant less susceptible varieties; reduce amount of vegetative growth on vines; do not over fertilize; use suitable trellises to increase air circulation in canopy and expose grape clusters to sun; disease usually merits chemical control

## **Dieback (*Eutypa dieback.*) *Eutypa lata***

### **Symptoms**

Stunted, withered leaves curled into a cup shape; dark cankers on wood; cross section of wood reveals wedge-shaped discoloration

### **Cause**

Fungus

### **Comments**

Affects older vines that are five to six years old

## **Management**

No resistant varieties known; disease practically impossible to control without chemicals in areas where alternative hosts are available; use of an appropriate fungicide on pruning wounds can prevent the fungus from entering the plant; fungicide should be applied at time of pruning

## **Esca (Black Measles or Spanish Measles) *Phaeomoniella aleophilum*, *Phaeomoniella chlamydospora***

### **Symptoms**

Symptom appears on leaves, trunk, canes and berries. On leaves we will see interveinal striping looks like tiger strips. White cultivars shows chlorotic and necrotic strips whereas red cultivars shows red areas and necrotic strips. On berries we will see superficial spots and later may coalesce making berries appear black. Trunk/arm/cordons shows dark brown black vascular streaking and oozes dark sap when we cut trunk. Some time this measles is associate with numerous secondary wood rotting fungi which decorate the vineyard completely.

### **Cause**

Fungus

### **Comments**

The leaf and berry symptoms may occur together in single cane or may show symptom on only one parts. The severe infestation of measles kill grapevine in a single year which is commonly called apoplexy. The symptoms are common in 5 to 7 year old vineyard. The prune wounds helps in pathogen entrance and establishment.

## **Management**

Till date there is no effective method to control this disease. Remove the infected berries, leaves and trunk and destroy them. Protect the prune wounds to minimize fungal infection using wound sealant (5% boric acid in acrylic paint) or essential oil or suitable fungicides.

## **Leaf blight (Isariopsis Leaf Spot) *Pseudocercospora vitis***

### **Symptoms**

On leaf surface we will see lesions which are irregularly shaped (2 to 25 mm in diameter). Initially lesions are dull red to brown in color turn black later. If disease is severe this lesions may coalesce. On berries we can see symptom similar to black rot but the entire clusters will collapse.

### **Cause**

Fungus

### **Comments**

Common in tropical and subtropical grapes. The disease appear late in the season. Cynthiana and Cabernet Sauvignon are susceptible to this pathogen.

## **Management**

Fungicides sprayed for other diseases in the season may help to reduce this disease.

## **Leaf spot (*Phomopsis* cane)** *Phomopsis viticola*

*Phomopsis cane and leaf spot symptoms*

*Phomopsis cane and leaf spot symptoms*

*Phomopsis cane and leaf spot symptoms*

### **Symptoms**

Dark lesions with yellow edges on canes and leaves; canes appear bleached and may have dark discoloration; small distorted leaves; lesions in shoots cause cracking

### **Cause**

Fungus

### **Comments**

Disease emergence favorable with rain directly following budbreak

### **Management**

Use pathogens free planting material; if disease is present prune out dead and infected wood and plow under soil; apply an appropriate fungicide

## **Powdery mildew** *Erysiphe necator*

*Powdery mildew symptoms on fruit*

*Powdery mildew symptoms on cane*

*Powdery mildew symptoms on leaf*

*Powdery mildew symptoms on fruit*

### **Symptoms**

Red patches on canes; yellow patches on top surface of leaves; white powdery growth on leaves; white powdery growth on fruit

### **Cause**

Fungus

### **Comments**

Disease favors mild temperatures and high humidity

### **Management**

Plant vines in sites with good air circulation and sun exposure; use a training system that promotes air circulation through the canopy; apply sulfur or copper based fungicide

## **Category : Bacterial**

## **Black rot** *Guignardia bidwellii*

*Black rot symptoms on fruit*

*Black rot symptoms on fruit*

### **Symptoms**

Brown lesions on the leaves that develop black dots (pycnidia); grapes have light spots that eventually form pycnidia; grapes harden and turn black, while still remaining on the vine

### **Cause**

Fungus

### **Comments**

Disease favors rainy weather; spores may ooze out during rain

### **Management**

Remove all mummified fruit from vines during dormant pruning; cultivate soil during bud break to bury mummies and reduce inoculant; application of appropriate fungicides can help control the disease

## **Crown gall** *Agrobacterium vitis*

*Galls on grape vine caused by crown gall*

*Galls on grape vine caused by crown gall*

### **Symptoms**

Galls on vines; wilting and yellowing of canopy; drying grapes; collapsing plants

### **Cause**

Bacterium

### **Comments**

Bacteria enter via wounded areas; spread from infected rootstock

### **Management**

Sanitize all equipment regularly; avoid injuring plants; plant disease free stock, heat treatment of planting material can help eliminate pathogens prior to planting

## **Pierce's disease** *Xylella fastidiosa*

*Glassy-winged sharpshooter: a vector of Pierce's disease*

### **Symptoms**

Yellow to red leaf edges; dry leaves with leaf death in concentric rings; leaves dropping but petiole remaining attached to vine; fruit dry and shriveled

### **Cause**

Bacteria

### **Comments**

Disease transmitted by sharpshooters and spittlebugs

### **Management**

Application of appropriate insecticide in areas adjacent to plantation can help reduce the number of sharpshooters reaching vines in spring; remove symptomatic vines while dormant; monitor vines with mild symptoms and remove when symptoms become pronounced

## **Category : Other**

### **Young vine decline** *Phaeoacremonium* spp.

*Togninia minima*,

*Togninia californica*

### **Symptoms**

Small yellow spots between leaf veins; leaves dropping; round brown or purple lesions on fruit; dry cracked fruit

### **Cause**

Fungi

### **Comments**

Fungus can enter the plant through propagation wounds

## **Management**

Avoid stressing vines; provide adequate irrigation and do not over-fertilize; do not harvest fruit until vines are at least 3 years old

# **Pests**

## **Category : Insects**

### **Black vine weevil *Otiorhynchus sulcatus***

*Black vine weevil*

#### **Symptoms**

Feeding damage to stems, leaves, buds and/or flowers; loss of plant vigor

#### **Cause**

Insect

#### **Comments**

Larvae live in soil and feed on roots

#### **Management**

Consider growing a cover crop such as red fescue

### **Grape cane girdler *Ampeloglypterus ater***

#### **Symptoms**

Holes encircling cane; punctures in cane

#### **Cause**

Insect

#### **Comments**

Greatest injury to vines during establishment

#### **Management**

Prune out infested shoots below girdle before adult insects emerge in summer; spraying may be required to control adult populations

### **Grape mealybug *Pseudococcus maritimus***

*Grape mealybugs on fruit*

*Grape mealybug damage to fruit cluster*

#### **Symptoms**

Sooty mold growing on fruit

#### **Cause**

Insect

#### **Comments**

Sporadic pest; sugary secretions by the insect drop onto fruit and encourage growth of mold

#### **Management**

Control ant populations to encourage populations of mealybug natural enemies; apply appropriate insecticide

## **Japanese beetle** *Popillia japonica*

*Adult Japanese beetle*

### **Symptoms**

Leaves skeletonized (only veins remaining); flowers and buds damaged; plant damage may be extensive; adult insect is a metallic green-bronze beetle with tufts of white hair protruding from under wing covers on each side of the body; adult beetles are approximately 13 mm in length; larvae are cream-white grubs which develop in the soil

### **Cause**

Insect

### **Comments**

One beetle generation every 1-2 years; pheromone traps may actually attract more beetles to home gardens and should generally be avoided; beetle overwinters as larvae in soil; beetle has an extensive range of over 300 host plants

### **Management**

If beetles were a problem in the previous year, use floating row covers to protect plants or spray kaolin clay; adult beetles can be hand picked from plants and destroyed by placing in soapy water; parasitic nematodes can be applied to soil to reduce the number of overwintering grubs; insecticidal soaps or neem oil can help reduce beetle populations

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# Grapefruit

## Description

Grapefruit, *Citrus Á—paradisi*, is a large evergreen tree in the family Rutaceae grown for its edible fruit. The tree has a spreading canopy with a rounded top and densely packed dark green, long and thin leaves with winged petioles. The tree produces white flowers singly or in clusters and large spherical fruits, usually in clusters. The fruits are 8â€“12 cm (3â€“5 in) in diameter with yellow-orange skin and segmented white, red or pink flesh. Grapefruit trees can reach heights between 10 and 15 m (33â€“50 ft) and live for many years if well maintained. Grapefruit likely originated in the West Indies as a hybrid of pomelo and sweet orange or mandarin.

*Sliced grapefruit with pink flesh*

*Grapefruit blossoms*

*Grapefruit tree*

*Unripe fruits*

*Grapefruits ripening on the tree*

*Grapefruits*

## Uses

Grapefruit can be eaten fresh and is commonly eaten as a breakfast fruit. It can also be used to make juice or processed for canning of segments or pulp. Grapefruit essential oils are used in perfumery.

# Propagation

**Requirements** Grapefruit is a tropical to subtropical plant and the trees grow best in areas with hot daytime temperatures and warm to hot night time temperatures. Grapefruit is less hardy than orange but continual exposure to cooler temperatures will induce a certain degree of cold tolerance. Mature trees can tolerate short exposures to temperatures below freezing but ice will begin to form in fruit after 2-3 hours at -3°C (27°F). Young trees may be killed by these temperatures. young trees will be killed. Fruit will also be damaged by freezing conditions. The trees will tolerate drought conditions but perform poorly in water-logged soil. Trees will grow best when planted in a well-draining sandy loam with a pH between 6.0 and 7.5. Soil must be deep enough to permit adequate root development. Grapefruit trees will grow best when planted in full sun. **Grapefruit propagation** Grapefruit seedlings are usually produced by grafting or budding to an appropriate rootstock as seeds will not produce fruit true to type. Grafting is the process by which a scion from plant is joined to the rootstock of another to produce a new tree. Budding is a special type of grafting where the scion that is joined to the rootstock consists of a single bud. Budding is commonly used in citrus propagation as it is the easier of the two processes and works very well. Common rootstocks for grafting and budding of citrus trees include sour orange and rough lemon. **Budding** Budding should be carried out when seedling stems have reached roughly the diameter of a pencil (6–9 mm/0.25–0.36 in) and at a time when the bark of the rootstock tree is slipping (this is the term used to describe a period of active growth when the bark can be easily peeled from the plant). Twigs (budwood) should be collected from the previous growth flush or the current flush so long as the twig has begun to harden. The twigs should have well developed buds and should be as close as possible to the diameter of the rootstock onto which it will be joined. It is extremely important to only collect budwood from disease-free trees. The use of diseased budwood can cause the spread of many serious citrus diseases which can kill trees. The budwood to be used for propagation should be trimmed to create budsticks which are 20–25 cm (8–10 in) by removing any unwanted wood and leaves. These budsticks can be stored for 2–3 months under the correct conditions but it is best to use them as soon as possible after cutting. The simplest way to join the budwood to the rootstock is by T-budding. The area to be joined should be pruned to remove any thorns or twigs and the cut made approximately 15 cm (6 in) from the ground. Using a sharp knife, a 2.5–3.8 cm (1–1.5 in) vertical cut should be made in the stem of the rootstock, through the bark. A horizontal cut should be made at either the top or the bottom of the vertical cut to produce a ‘T-shape’. The horizontal cut should be made a slightly upward-pointing angle and should reach through the bark. Remove a bud from a budstick by slicing a thin, shield-shaped piece of bark and wood from the stem, beginning about 1.25 cm (0.5 in) above the bud. This piece should measure 1.9–2.5 cm (0.75–1.0 in) in length. Immediately insert the piece of bud into the cut on the rootstock by sliding it under the opened bark so that the cut surface lies flat against the wood of the rootstock plant. Finish the join by wrapping the bud with budding tape. After the union has formed and the tape is removed, the bud is forced to grow by cutting the rootstock stem 2.5–3.9 cm (1.0–1.5 in) above the join about 2/3 of the way through the stem on the same side as the join. The top of the seedling should then be pushed over towards the ground. This process, known as ‘clopping’ allows all of the nutrients to be diverted to the bud. Once the bud begins to grow and reaches several inches in length, the lop can be removed completely from the seedling. **Planting seedlings** Grapefruit trees can be purchased as seedlings which have already been grafted and only require planting in the garden or orchard. The best time to plant citrus trees is in Spring after all danger of frost has passed in your area. Trees should be planted at or higher than the level of the nursery pot. Once the tree is positioned in the planting hole, backfill the soil by about half and water to allow the soil to settle around the lower roots before filling in the hole. The newly planted tree should be watered every few days. **General care** Newly planted trees require proper irrigation to ensure they become established. During the first year, water should be applied at the base of the trunk so that the root ball is kept moist to allow the roots to establish in the soil. Newly planted trees should be provided with water every 3–7 days. The soil should be moist, but not wet. Trees planted in sandy soils will require water more frequently. Young trees will also require a light application of fertilizer every month in the first year. Grapefruit trees will need protected from cold temperatures to prevent damage. Soil can be mounded up around the trunk during the winter and removed in the Spring. Young trees can also be protected from frosts by covering them with tarps or blankets as required.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Anthracnose** *Colletotrichum gloeosporioides*

*Anthracnose symptoms on grapefruit*

*Anthracnose symptoms on grapefruit*

##### **Symptoms**

Dieback of twigs; premature leaf drop; dark staining on fruit; leaves and twigs covered in dark spores

##### **Cause**

Fungus

##### **Comments**

Disease common during wet Springs or long periods of wet weather late in season

##### **Management**

If disease is damaging then appropriate fungicides should be applied to whole tree

##### **Blast** *Pseudomonas syringae*

##### **Symptoms**

Water-soaked or black lesions on leaf petioles; which rapidly expand along the leaf midrib; cankers on twigs and branches; twigs may be girdled and die; leaves turning black and dying; black lesions may be present on fruit

##### **Cause**

Bacterium

##### **Comments**

Symptoms most severe on south facing side of tree exposed to winds

##### **Management**

In areas where disease is severe, copper fungicides should be applied in Fall and Winter prior to the first rains

#### Category : Bacterial

##### **Brown rot** *Phytophthora* spp.

##### **Symptoms**

Water-soaked lesions on fruit close to maturation; leather tan to dark brown lesions on fruit; lesions with a pungent smell; leaves, twigs and flowers may be turning brown

**Cause**

Oomycete

**Comments**

Disease emergence favored by cool, wet conditions

**Management**

Cultural control methods should focus on reducing leaf wetness e.g. mowing around trees to prevent grasses growing too long, proper irrigation management, pruning branches hanging low to the ground etc.; if fruit become infected, harvest should be delayed to allow all infected fruit to drop to the ground and minimizing contamination in the harvest; applications of copper fungicides to foliage can help protect the trees

**Citrus canker *Xanthomonas axonopodis***

*Citrus canker on grapefruit*

**Symptoms**

Raised lesions on leaves, often at leaf margin or tip; lesions may also be present on twigs and fruits; young lesions are usually surrounded by yellow halo; depressed brown craters formed from collapse of lesions

**Cause**

Bacterium

**Comments**

Can cause serious economic losses to grapefruit crop; bacteria survive in lesions; the main method of spread is via wind driven rain; bacteria may enter through pruning wounds

**Management**

If the disease is introduced to an area, all infected trees should be removed and destroyed; in areas where disease is endemic, windbreaks can help to reduce disease severity; cultural control of the disease should focus on controlling leaf miner populations, utilizing wind breaks and applications of copper sprays

**Huanglongbing (Citrus greening, Yellow dragon disease) *Candidatus Liberibacter asiaticus***

*Candidatus Liberibacter africanus*

*Candidatus Liberibacter americanus*

*Symptoms of huanglongbing on grapefruit leaves*

**Symptoms**

Yellowing of one limb or one area of canopy; yellowing of leaf veins; blotchy mottling on leaf blades; twig and limb dieback; fruits dropping prematurely; small upwardly pointing leaves; small, misshapen fruit; fruit very bitter

**Cause**

Bacteria

**Comments**

**History** *Origins and spread* Huanglongbing, or citrus greening, was first reported from Southern China in 1919 by American botanist Otto August Reinking who described a “yellow shoot” disease of citrus while evaluating diseases of economic plants in Southern China. A subsequent field survey conducted between 1941 and 1955 on citrus plants in the provinces of Guangdong, Fujian and Jiangxi by Chinese plant pathologist Lin Kongxiang (Kung Hsiang) determined that the disease likely originated in Chaozhou county in Guangdong as early as the 1870s. Lin adopted the name the local farmers had given to the disease of “huang long bing”, which translates to “yellow dragon disease”, a reference to the yellow coloration of new shoots on the infected trees. By 1936 Huanglongbing was considered a serious disease of citrus in China and it subsequently spread across Southeast Asia reaching Indonesia in 1948 and Taiwan in

1950 before spreading to the Philippines, Thailand and Malaysia in the 1950s, 60s and 70s respectively. The disease has been known by various names in different countries - 'greening' in South Africa, 'mottle leaf' in the Philippines, 'dieback' in India and 'vein phloem degeneration' in Indonesia - but in 1995 the disease was officially named Huanglongbing by the International Organization of Citrus Virologists (IOCV) and this name is now widely used to describe the disease in Africa, America and Asia. **Biology and ecology** The organism that causes Huanglongbing is a Gram-negative bacterium that is limited to the plant phloem - the plant system responsible for the delivery of sugars from the leaves to the growing parts of the plant. The bacteria involved have so far not been isolated and cultured but the disease is believed to be caused by bacteria belonging to the genus *Candidatus Liberibacter*. It is believed that there are at least two different forms of the disease, an African heat-sensitive form, *L. africanus* which survives in cool areas with temperatures below 30-32°C, and an Asian heat-tolerant form which occurs in areas where temperatures greatly exceed 30°C. A third species, *L. asiaticus*, found in .A third species, *L. americanus* was detected in citrus trees in São Paulo, Brazil but there is presently little information on its climatic requirements. As this species is found in the same areas as *L. asiaticus* it seems likely that it has similar requirements. **Transmission** Huanglongbing can be transmitted by citrus psyllids or by grafting. The Asian citrus psyllid, *Diaphorina citri* is responsible for the spread of the disease in Asia and Oceania, Brazil and North America whereas the African citrus psyllid, *Trioza erytreae* is the main vector in Africa and Madagascar. Both psyllid species are present the Indian Ocean islands of Reunion and Mauritius, *Citrus psyllids* Citrus psyllids are tiny (3-4 mm) sap-sucking insects that excrete a sticky, sugary substance called honeydew. Both the Asian and African citrus psyllids are mottled brown in color but the Asian citrus psyllid possesses a brown head and the African species has a black head. Adult citrus psyllids will jump and/or fly for a short distance when they are disturbed. They are usually found on the undersides of leaves, often in high numbers. When a psyllid feeds on an infected plant, it acquires the disease after 15 to 30 minutes and feeding and is able to transmit the disease to new hosts after a period of 21 days. In order to transmit the disease successfully, the psyllids need only feed on a new host for a period of 15 minutes in order for successful transmission to occur. It is hypothesized that the bacterium multiplies within the body of the psyllid prior to transmission but this theory requires validation through experiments. **Grafting** Although the primary method of spread of the Huanglongbing bacterium is via the movement of citrus psyllids, the disease can also be transmitted through grafting practices. The ability of Huanglongbing to be transmitted by grafting was first demonstrated by Lin Kongxiang through experimental work which was published in 1956. The disease is not transmitted at high rates through grafting as not all buds on infected trees contain the bacterium.

## Management

**Control (i)** Cultural control Once a tree becomes infected with HLB, it cannot be cured. Control is therefore reliant on preventing the disease occurring in the first place and this is achieved through strict quarantining to prevent the introduction of citrus psyllids to areas which are currently free of the pest. Areas which are subject to quarantine have restrictions placed on the movement of citrus plants, fruit, equipment and items made from citrus. Infected trees should be removed as quickly as possible from plantations and destroyed. Identification of infected trees should be achieved through several surveys to ensure that infected trees which are not yet showing symptoms are identified. In Florida, the recommendation is to scout groves at least 4 times a year for disease symptoms. **(ii)** Control of citrus psyllids Citrus psyllid populations can be controlled through the application of chemical sprays. Insecticides have proved very effective at controlling *T. erytreae* in South Africa where systemic insecticides are applied to the tree at the base of the trunk. In areas of the USA, Citrus health management areas (CHMAs) have been created to encourage neighbouring growers to work together to prevent the disease. Control strategies which have been implemented by the program include scouting, mapping and large-scale spraying to control citrus psyllids.

## Stubborn disease *Spiroplasma citri*

### Symptoms

Stunted trees; leaves shorter and broader, cupped and upright; may be chlorotic or have a mottled appearance; stunted, malformed fruits and low yield

### Cause

Bacterium

### Comments

Transmitted by leafhoppers; can cause serious losses in hot, dry conditions

## Management

Plant only material from disease-free budwood; if disease is endemic to the area then nursery trees should be grown in an enclosure to protect the trees from vectors; if a young orchard becomes infected, it should be removed and replanted with healthy material

## Category : Oomycete

### **Phytophthora gummosis** *Phytophthora* spp.

#### **Symptoms**

Sap oozing from cracks in bark; bark cracking, drying and falling off; lesions girdling trunk; severely infected trees have pale green leaves with yellow veins

#### **Cause**

Oomycete

#### **Comments**

Disease can develop rapidly in moist, cool conditions; spread by water splash

#### **Management**

Only plant disease-free nursery stock; plant trees in well-draining soil and avoid injuries to bark on trunk; trunk wraps can provide protection from freezing

## Category : Viral

### **Tristeza disease** Citrus tristeza virus (CTV)

Pits in branch of grapefruit tree  
infected with tristeza disease

Pits in trunk of grapefruit tree  
infected with tristeza disease

#### **Symptoms**

Light green foliage; poor new growth; leaves may be dropping from tree; young trees blooming early; severely infected trees are stunted and bushy in appearance with chlorotic leaves and brittle twigs; some strains of the virus cause elongated pits in the trunk and branches which give the wood a rope-like appearance

#### **Cause**

Virus

#### **Comments**

Disease spread from infected grafting material or by aphids

#### **Management**

Quarantine procedures are used to control tristeza and prevent the pathogen from entering areas which are currently free of the disease

## Pests

## Category : Insects

### **Citrus leaf miner** *Phyllocnistis citrella*

#### **Symptoms**

Thin, winding trails on leaves; heavy infestation can result in curled and distorted leaves; adult leafminer is a tiny moth which lays its eggs in the leaf; larvae hatch and feed on leaf interior

#### **Cause**

Insect

## **Comments**

Leaf miners attack flushes of young growth and are unable to enter leaves once they harden

## **Management**

Insecticide application are rarely warranted in mature orchards as yields are unaffected; young trees should be treated with appropriate insecticides to prevent retarded growth; cultural control methods include removal of water sprouts from trees and refraining from pruning live branches more than once a year to encourage uniform growth flushes which are short in duration

## **Soft scales (Black scale, Brown soft scale , Citricolla scale) *Saissetia oleae***

*Coccus hesperidum*

*Coccus pseudomagnoliarum*

## **Symptoms**

Leaves covered in sticky substance and may have growth of sooty mold; reduced tree vigor; leaves and/or fruit dropping from plants; presence of black, brown or gray flattened scales on leaves, twigs and/or branches

## **Cause**

Insects

## **Comments**

Insects can produce several overlapping generations per year

## **Management**

Organically acceptable methods of control include the application of horticultural oils and preservation of natural enemies

## **Thrips *Scirtothrips citri***

## **Symptoms**

Insect feeds under sepals of young fruit and causes a ring of scarred tissue as the rind expands; adult thrips are orange-yellow in color

## **Cause**

Insect Citrus thrips

## **Comments**

Insects overwinter on trees as eggs and can undergo multiple generations per year

## **Management**

Insecticide application is rarely required as healthy trees can withstand heavy feeding damage; insecticides can actually promote thrips populations by stimulating reproduction

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# Guava

## Description

Guava, *Psidium guajava*, is an evergreen shrub or small tree in the family Myrtaceae grown for its edible fruits. Guava has a slender trunk with smooth green to red-brown bark. The trunk may be branched at the base and the branches droop low to the ground. The plant possesses oval or elliptical leaves which are smooth on the upper surface and hairy on the lower surface. Guava produces solitary white flowers and a berry fruit. The fruit is oval in shape and green to yellow in color. The flesh inside can be white, yellow, pink or red in color and contains numerous yellowish seeds. Guava can reach grow to 10 m (33 ft) in height and lives for approximately 40 years. Guava may also be referred to as common guava and its origin is unknown although it grows native in parts of tropical America.

*Fruits*

*Flesh of guava fruit*

*Fruits*

*Developing guava fruits*

*Bee visiting guava flower*

*Guava flower*

*Guava leaves*

*Guava plant*

*Guava fruits growing on the tree*

## Uses

Guava fruits may be eaten fresh or processed to produce paste, jellies or preserves. Dehydrated fruit is used to make guava powder.

## Propagation

**Basic requirements** Guava is mainly grown in the tropics and will tolerate temperatures between 15 and 45°C (59–113°F). Guava will grow optimally between 23 and 28°C (73–82°F) but established trees can tolerate short periods at -3 to -2°C (27–28°F) although temperatures below 15°C (60°F) can cause the tree to cease producing fruit. Guava is also amenable to a wide range of soils and will grow in both sandy or rocky soils in addition to loams, preferring a pH of 4.5–7 but tolerating alkaline soil to pH 8.5. Guava is more resistant to drought than most tropical fruits and can withstand long periods of dry weather by ceasing vegetative growth until conditions improve. **Propagation** Guavas grown for processing can be grown from seed as approximately 70% of the seedlings will retain the genetic characteristics of the parent tree. Guavas that are grown for fresh fruit are usually vegetatively propagated by air layering or budding. *Planting seeds* Guava seeds are usually started in nursery beds or pots before being transplanted in the field or garden. Only seeds from healthy, vigorous trees with the desired characteristics should be planted. Seeds should be planted in flats containing sandy soil and covered to a depth of 6 mm (0.25 in). Seeds usually germinate within 15 to 20 days of planting. When the seedlings reach 3.8 cm (1.5 in) in height they should be transplanted into individual pots. Seedling are ready to be moved to the field after about 6 to 7 months when they have reached approximately 30.5 cm (12 in) in height. *Transplanting seedlings* Guava trees should be planted in full sun and should be spaced 4.5–7.5 m (15–25 ft) away from other trees and buildings to prevent shading. A hole should be dug which is slightly larger than the existing root ball and the addition of a layer of compost or rotted manure at the bottom of the planting hole. The tree should be planted at the same depth as it was in the nursery by placing the seedling upright into the planting hole and backfilling the soil around the plant. The soil should be tamped by hand around the tree to eliminate any air pockets. Water the newly planted seedlings immediately unless the soil is already damp. **General care and maintenance** Newly planted guava trees should be watered every two days after planting for the first week and then once a week for the following few months to allow the root system to develop and become established. A 0.6 to 1.5 m (2.0–5.0 ft) area around the trunk should be maintained to be free from grass and weeds. Guava trees benefit from the application of a layer of organic mulch such as bark or wood chips around the base. This helps to suppress weeds and conserve moisture in the soil. Do not mound the mulch around the trunk, allow a gap of 20 to 30 cm (8–10 in) between the trunk and the mulch layer. Young trees benefit from fertilizer application with the type and amount varying with area and soil type. **Pruning** Young trees should be pruned to encourage the development of laterals. This is achieved by cutting back existing laterals at 30 to 60 cm (1 to 2 ft). During the first year of growth, 3 to 4 of the lateral branches should be allowed to grow 60 to 90 cm (24–36 in) before the tips are cut to encourage further branching. Any new shoots formed by this process should also be tipped when they reach 60 to 90 cm (24–36 in). Pruning of established trees should be carried out to retain a manageable height and to open out the canopy. **Harvesting** Trees grown from seed may not come into production for anywhere between 3 to 8 years. Guava does not ripen off the tree and it can be difficult to distinguish when the fruits are ready for harvest. The best indication is a color change from dark to light green and the development of some yellowing on the fruits. Fruit should be harvested every 2–3 days to prevent fruit becoming overripe.

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## Common Pests and Diseases

### Diseases

#### Category : Other

##### Algal leaf spot *Cephaleuros virescens*

green alga (*Cephaleuros virescens*)  
on pineapple-guava

Algal leaf spot lesions on guava  
foliage and fruit

Algal leaf spot lesions on guava  
foliage

#### Symptoms

Orange, rust-colored, dense, silky tufts on both upper and lower surfaces of leaves which turn reddish-purple in color as they mature; if tufts are scraped away, a thin gray-white or dark-colored necrotic spot remains on the leaf; bark on twigs and branches may be cracked; young stems and fruit may also be attacked.

#### Cause

Alga

#### Comments

Wet, humid conditions promote spread of the disease; zoospores can be spread by splashing water.

#### Management

Ensure trees receive adequate fertilization, irrigation and are properly pruned to avoid stress on the plants and promote air circulation through the canopy; periodic applications of a copper based fungicide is usually enough to control the disease.

#### Category : Fungal

##### Anthracnose *Colletotrichum gloeosporioides*

Symptoms of anthracnose on guava  
fruit

Symptoms of anthracnose on guava  
fruit

#### Symptoms

Sunken, dark colored lesions on mature fruit which may become covered in pink spores; lesions coalesce to form large necrotic patches on surface of fruit

#### Cause

Fungus

#### Comments

Disease emergence favors warm, wet weather; spread easily during wet weather by water splash

#### Management

The primary method of controlling the disease is to plant resistant guava cultivars; both systemic and non-systemic fungicides are effective at controlling the disease and are usually applied shortly before flowering and during fruit development.

### **Pseudocercospora leaf spot** *Pseudocercospora psidii*

#### **Symptoms**

Small irregularly shaped or roughly circular dark brown lesions with darker brown border on upper surface of leaves; lesions may also be present on stems and fruit; under humid conditions, fungus may sporulate and gray tufts of mycelium may be visible in the center of lesions; lesions may coalesce to form large necrotic patches.

#### **Cause**

Fungus

#### **Comments**

Infection of leaves occurs during wet conditions when temperatures are between 13 and 25°C (55-77°F); disease can be spread by splashing water.

#### **Management**

In areas where environmental conditions are conducive to the development of the disease, chemical control using appropriate fungicides is necessary to control the disease; copper-containing fungicides are most effective.

### **Rust** *Puccinia psidii*

*Symptoms on fruit*

*Symptom on buds*

*Infected fruit*

*Rust symptoms on lower surface of leaves*

*Rust pustules on guava fruit*

*Guava rust*

#### **Symptoms**

Orange to red pustules appearing on leaves, young shoots, flowers and/or fruit; leaves distorted; defoliation of tree; reduced growth; circular lesions on fully expanded leaves with dark borders and yellow halos.

#### **Cause**

Fungus

#### **Comments**

Disease emergence favored by warm temperatures and high humidity.

#### **Management**

Primary method of controlling disease is usually the application of appropriate fungicides; cultural practices that may reduce the incidence of the disease include good sanitation practices and adequate fertilization, irrigation and pruning of trees.

## **Pests**

### **Category : Insects**

#### **Fruit flies (Guava fruit fly, Caribbean fruit fly)** *Bactrocera* spp.

*Anastrepha suspensa*

The fruit pulp becomes soft and discolored

Guava (*Psidium guajava*): Fruit fly injury  
The fruit pulp becomes soft and discolored

*Bactrocera correcta* adult

Fruit fly injury to guava fruit.

Fruit fly damage on guava fruit

Fruit fly damage on guava fruit

Fruit fly damage on guava fruit

Caribbean fruit fly

Guava fruit fly

## Symptoms

Depressions in fruit with dark colored puncture wounds; soft, mushy areas on fruit caused by larvae feeding on fruit; development of secondary rots often cause fruit to drop from tree; insects are small flies - the guava fruit fly is approximately 5 mm in length and is black and yellow in color; the Caribbean fruit fly may reach 12-14 mm in length and is yellow-brown with long patterned wings.

## Cause

Insect

## Comments

Guava fruit flies are widespread in Southern Asia while Caribbean fruit flies are damaging pests in Cuba, Jamaica, Hispaniola, Puerto Rico and Florida.

## Management

Infested fruit should be removed and destroyed; plowing around bases of trees infested with guava fruit flies exposes pupae to damaging heat from the sun and to natural enemies; pheromone traps are used successfully in some regions to control guava fruit flies; millions of sterile Caribbean fruit flies are introduced yearly in Florida to control populations on citrus.

## Guava Weevil *Conotrachelus psidii*

*Conotrachelus dimidiatus*

Guava weevil (*Conotrachelus psidii*) damage

Guava weevil (*Conotrachelus psidii*) adults on guava fruit

Guava weevil (*Conotrachelus psidii*) adult

Guava weevil larvae inside the fruit

Guava weevil (*Conotrachelus psidii*) larva

## Symptoms

The adult females lay eggs in small unripe fruits. After hatching, the larva enters the fruit. Once inside, the larva feeds on pulp and seeds, causing petrification and premature maturity of fruit. Larva excrement deposited inside fruit causes fermentation. Mature larvae abandon the ripe fruits and pupate underground.

## Cause

Insect

## Comments

The insect can cause up to 70 to 100 % yield loss.

## Management

Collect and burn the damaged fruits. Soil application of entomopathogenic nematodes (EPN) like genus *Heterorhabditis* and *Steinernema* as biological control agents against 4th larval instar, pre-pupa and pupa weevil stages.

## Scale insect (green scale, green shield scale) *Coccus viridis*

## *Pulvinaria psidii*

green shield scale (*Pulvinaria psidii*) adult      Multiple stages of green shield scale (*Pulvinaria psidii*)      Green scales on lower side of guava leaf

Young and adult green scale on fruit      Green scales (*Coccus viridis*) feeding on stalk attached to fruits of guava (*Psidium guajava*).      Green scales (*Coccus viridis*) in various states of life in guava fruit (*Psidium guajava*).

### Symptoms

Leaves covered in sticky substance and may have growth of sooty mold; reduced tree vigor; leaves and/or fruit dropping from plants; presence of green or gray flattened scales on leaves, twigs and/or branches.

### Cause

Insect

### Comments

Insects can produce several overlapping generations per year. Also they have wide host range.

### Management

Collect and burn the fallen plant materials. Organically acceptable methods of control include the application of horticultural oils and preservation of natural enemies.

## **Thrips (Redbanded thrips) *Selenothrips rubrocinctus***

Redbanded thrips pupae      Redbanded thrips adult      Redbanded thrips damaged mango leaves

Redbanded thrips larvae      Redbanded thrips larvae adults and larvae      Immatures and fecal spots

### Symptoms

If population is high leaves may be distorted; leaves are covered in coarse stippling and may appear silvery; leaves speckled with black feces; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult are dark brown to black in color and female has red pigmentation on abdominal segments.

### Cause

Insect

### Comments

Insect is tropical to subtropical insect; lifecycle is approximately 3 weeks allowing for several generations per year.

### Management

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic.

## **Category : Nematodes**

### **Root knot nematode *Meloidogyne* spp.**

Infected root      root-knot nematode (*Meloidogyne enterolobii*) damage      root-knot nematode (*Meloidogyne enterolobii*) damaged guava root

## **Symptoms**

Galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; reduction in plant vigor; yellowing plants which wilt in hot weather.

## **Cause**

Nematode

## **Comments**

Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or garden with this type of soil is most likely.

## **Management**

Plant resistant varieties if nematodes are known to be present in the soil; check roots of plants mid-season or sooner if symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens.

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# Hazelnut (filbert)

## Description

Hazelnut, belongs to the family *Corylus*, which includes *C. avellana* (Common or European hazelnut) and the closely related species *C. maxima* (filbert). Hazels are deciduous trees or shrubs in the family Betulaceae grown for their edible nuts. Hazelnuts are large multi-stemmed shrubs or small trees with rounded leaves which possess a doubly serrated margin (each tooth bears another tooth). They produce flowers very late in the winter prior to the emergence of any leaves. The female flowers are small and only the bright red stigmas are visible protruding from the bud. The male flower is a catkin which is pale yellow in color and measures 6–12 cm (2–5 in) in length. The fruit of the hazelnut is a classic nut which grows in clusters of 1–5, each protected by a leafy husk which covers most (common) or all of the nut (filbert). The nut is oval in shape and yellow to brown in colour. Each has a pale scale at its base. When ripe, the nut falls from the husk to the ground. Hazelnut can reach a height of 3–8 m (10–26 ft) and can live for many years, although its commercial lifespan is usually about 40 years. Hazelnut originates from Europe and South East Asia.

*Hazelnut catkins*

*Hazelnut shrubs*

*Young hazelnut trees*

*Hazelnut*

*Hazelnuts on the tree*

*Hazelnuts*

## Uses

The kernel of the hazelnut is edible and can be eaten raw or toasted. The kernels can be processed to produce praline or as an ingredient in confectionery and baked goods.

## Propagation

**Basic requirements** Filberts are hardy plants which can survive adverse growing conditions. They should be grown in a soil which is at least 2.4 to 3 m (8-10 ft) deep and will grow optimally in well-draining, fertile loams with a pH between 5.5 and 7.5 in full sun or partial shade. Filberts will grow well in areas where wild hazel grows large and vigorous.

**Propagation methods** While it is possible to propagate filberts from cuttings, the success rate for obtaining rooted cuttings is usually only between 20 and 50%. The most successful method of propagating filberts is by layering. The most successful and widely used method of layering for commercial filbert production is tip layering. Tip layering involves bending shoots into a V-shape and burying the lower parts in the soil to a depth of 20 to 25 cm (8-10 in) while the tips of the shoot, which will form the new tree tops, are kept upright. The soil is kept moist to promote root development above the V bend on the tip and roots should ideally be congregated in a 5 to 10 cm (2-4 in) section of the shoot. **Planting** Trees should be planted in early winter while dormant. The trees should be planted at least 6 m (20 ft) apart. Before planting, remove as much as possible of the old layered shoot and prune back the ends of any broken roots. Plant the tree in a hole large enough to accommodate the roots but avoid deep planting. Fill in the hole around the roots with fine soil, pressing down with your hands to eliminate any air pockets around the roots. Add soil on top of the roots and tamp down to set the tree. Fill in the remainder of the hole with loosely packed soil. Once planted, the tree should be headed back in order to compensate for reduced water uptake. The tree should be cut back to a height of 45 to 76 cm (18-30 in). **Suckering** Hazelnut trees produce suckers which should be removed from the tree at, or close to, their point of origin on the trunk. This can be achieved by gently removing the soil from around the sucker. While the trunk is exposed, any other buds which are beginning to show should also be removed. Cutting the sucker at or just below the soil line will encourage more suckers so it is important to make the cut as close to the trunk as possible. **Harvesting** Newly planted trees usually bear nuts within two to three years after planting although full production may not be reached until twenty five years after planting. The nuts are usually harvested two to three times over the season. The nuts can be spread out on the ground to dry or, as with commercially produced nuts, dried artificially at a temperature of 90 to 100°C (176-212°F).

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

## **Armillaria root rot (Oak root fungus) *Armillaria mellea***

### **Symptoms**

Small, discolored leaves which drop early; death of branches; death of plant; clusters of honey-colored mushrooms may sprout at base of plant

### **Cause**

Fungus

### **Comments**

Disease emergence favored by wet soils

### **Management**

Armillaria root rot cannot be effectively controlled once it has become established in an orchard; diseased or dead plants should be uprooted and removed; planting resistant rootstocks is the most effective method of preventing the disease

## **Eastern filbert blight *Anisogramma anomala***

### **Symptoms**

Initial symptom of disease is the presence of cankers, usually on branches near the top of the tree; blossoms; cankers can appear subsequently on any part of the plant causing leaves to rapidly wilt and dieback of branches

### **Cause**

Fungus

### **Comments**

Disease spread during wet weather; disease is a serious problem on European hazelnut varieties

### **Management**

Prune out branches and twigs with cankers where possible; cuts should be made 0.6 to 0.9 m below the canker; pruning waste should be destroyed; destroy any volunteer hazelnut trees from abandoned orchards

## **Powdery mildew *Phyllactinia guttata***

### **Symptoms**

Small powdery white patches on leaves and fruit which can expand to cover the entire leaf or fruit surface; small black fungal fruiting bodies are often visible in the white patches

### **Cause**

Fungus

### **Comments**

Disease emergence favored by moderate temperature, poor air circulation around plant and shady conditions

### **Management**

Disease does not cause severe damage to hazelnut and control is not warranted

## **Category : Bacterial**

## **Bacterial blight *Xanthomonas campestris***

### **Symptoms**

Dieback of young twigs and branches; necrosis of buds and twigs; small, angular or round water-soaked which turn red-brown in color; stems may be girdled by cankers and leaves are killed but remain attached to the tree

### **Cause**

Bacterium

### **Comments**

Disease is introduced to orchards from infected nursery trees; bacteria overwinter in lesions on the trunk or on large branches; disease is particularly serious in the Pacific Northwest

### **Management**

Diseased areas of tree should be pruned out by making cuts 0.6 to 0.9 m below the diseased area; avoid planting hazelnut

in water-logged or poorly draining soils; providing trees with irrigation to reduce water stress for the first 3 years after planting can greatly reduce mortality; applications of copper-based bactericide is recommended to control the disease

### **Bacterial canker** *Pseudomonas syringae*

#### **Symptoms**

Buds fail to break in Spring and new growth is withered and dying; leaves become chlorotic and die; dead leaves remain attached to the tree after leaves drop from the tree in Fall; if infection begins at the base of the tree, cankers are formed in the bark and are visible as light gray areas

#### **Cause**

Bacterium

#### **Comments**

Disease occurs in Europe, causes severe losses in orchards in Greece

#### **Management**

Plant only certified, disease-free nursery stock; prune out infected stems; applications of copper-based chemicals such as Bordeaux mixture during leaf drop can help to control the disease

## **Category : Viral**

### **Hazelnut mosaic** Apple mosaic virus (ApMV)

#### **Symptoms**

Yellowing of leaves which may occur as rings, lines, flecks or vein banding; young hazelnut trees may exhibit a reduction in new growth and reduced yield if disease occurs in conjunction with other viruses; infected plants may have no outward symptoms

#### **Cause**

Virus

#### **Comments**

Disease may be caused by different viruses such as Prunus necrotic ringspot virus (PNRSV)

#### **Management**

Only plant trees derived from virus-free stock; there is no known resistance to the virus

## **Pests**

### **Category : Insects**

### **Filbertworm and Acorn moth** *Cydia latiferreana*

*Valentinia glandulella*

#### **Symptoms**

Tunnels in nuts; kernels completely destroyed; whitish larvae may be present in tunnels; nuts may become infected with secondary pathogens such as bacteria and fungi; adult is a small coppery-brown moth; larvae are light brown to whitish grubs with a brown head

#### **Cause**

Insects

#### **Comments**

Insect overwinters in silk cocoon in leaf debris on the ground or in crack and crevices

#### **Management**

Application of appropriate insecticides may be required to control the insects

### **Nut weevil** *Curculio occidentis*

**Symptoms**

Holes in nut shells; larvae inside nuts surrounded with frass; damaged buds and flowers

**Cause**

Insect

**Comments**

Larvae feed on nut, adult beetles feed on buds and leaves

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# Hop

## Description

Hop, *Humulus lupulus*, is a climbing perennial plant in the family Cannabaceae that is grown for its flowers which are used extensively in the brewing industry. The hop plant is a climbing plant with grasping hooks that help it grasp the substrate. The plant climbs upwards in a clockwise direction and has opposing pairs of leaves which are covered in hairs. The plant produces flowers called 'burrs' which develop into scaly cones, or 'hops'. The hop plant vine can grow 6–9 m (20–30 ft) in length and can be harvested for many years. Hop may also be referred to as common hop and likely originated from Central Asia but now grows native in many areas in the Northern Hemisphere.

*Hop plants*

*Hop vine*

*Hop plant*

*Hop leaf*

*Hop flowers*

*Hop cones*

## Uses

Hop cones are usually dried and used in the brewing of beer to impart bitterness and aroma.

# Propagation

**Basic requirements** Hop plants can grow in a wide variety of soils as long as there is adequate drainage, but a loose loam or sandy loam with a high organic content and a pH between 6.0 and 7.5 will produce optimal growth. Hop plants are perennial and can be harvested for many years, they should be provided with adequate vertical space to allow the vines to spread. Hop plants should be grown in full sun and require a tall trellis or fence which is large enough to support 6 to 9 m (20-30 ft) of vine growth. The plants require a period of approximately 8 weeks at low temperature in order to break dormancy. **Propagation** Hop plants are vegetatively propagated from the pieces of rhizome which should be obtained from a reputable breeder. Only female rhizomes should be planted as it is the female flower that is harvested. Plants grown from seed exhibit highly variable characteristics and are not suitable for commercial production. **Planting** Hops should be planted as soon as the soil can be worked in the Spring. The plants can survive a frost but will not tolerate the ground freezing over. Rhizomes should be kept refrigerated until the soil is ready for planting. Rhizomes should be planted horizontally in trenches approximately 30 cm (12 in) deep, leaving 1.5–2.5 m (5–8.2 ft) between plants. Hop plant require a trellis system in order to train the long vines. The support system usually consists of a supporting pole and wire with strings for the plant to grow on. There may be up to four strings per plant which are fixed from the ground to the wire. **General care and maintenance** After the first year of growth, the plants will produce an excessive amount of shoots which need to be cut back once several shoots have been selected and trained to grow on the supporting structure. Unwanted shoots can also be defoliated using chemicals. Mounding earth around the base of the plants will help to reduce the amount of unwanted shoots. The soil around the hop vines should be amended with compost every spring and the vines will also benefit from a side dressing of nitrogen fertilizer later in the growing season. **Harvesting** Hop cones should be harvested before the first frost. Generally, cones are harvested in mid-August to mid-September. The cones will have a papery texture when they are ready and will produce a fine yellow powder and strong aroma when crushed. The lower bracts of the cone may also be beginning to turn brown. The vines should be lowered to the ground and the cones removed from the plant. the cones should be dried prior to storage by threading them out thinly on a screen and allowing to air dry. The cones are fully dry when the inner stem becomes brittle.

*Commercial hop production*

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# Common Pests and Diseases

## Diseases

### Category : Fungal

**Black root rot** *Phytophthora citricola*

**Symptoms**

Blackened and water-soaked areas on the roots; yellowing leaves; wilting stems; blackened leaves which remain attached to the stem

**Cause**

Oomycete

**Comments**

Disease favors poorly drained soils which are regularly wet; easily mistaken for Verticillium wilt or Fusarium canker

**Downy mildew** *Pseudoperonospora humuli***Symptoms**

Stunted, brittle, and light colored shoots; flowers turning brown; curled and/or cup shaped leaves; brown lesions with yellow halos on underside of leaves

**Cause**

Fungus

**Comments**

Symptoms resemble damage caused by early frost

**Fusarium canker (Cone tip blight)** *Fusarium* spp.**Symptoms**

Cankers on the base of the climbing stem (bine); sudden wilting of bines at flowering or in high temperatures; leaves at the tips of the cone turning brown; inner supporting portion of the hop cone is brown and dead

**Cause**

Fungi

**Comments****Gray mold** *Botrytis cinerea***Symptoms**

Lesions on the tips of leaves associated with the cones (bracts) turning tan to dark brown; discoloration may spread from the bracts to the entire cone; gray fuzzy growth on the tip of the cones

**Cause**

Fungus

**Comments**

Disease favors high moisture and high temperature; symptoms are not evident in dry weather

**Powdery mildew** *Podosphaera macularis***Symptoms**

Pale green to yellow spots on top side of leaves; white lesions developing from spots on the leaves, stems, or cones; lesions developing white, powdery fungal masses; slow growth of shoots; shoots covered with white fungal powder

**Cause**

Fungi

**Comments**

May cause the hops to dry early; disease favors high wind and little sunlight

**Red crown rot** *Phomopsis tuberivora***Symptoms**

Red to orange discoloration of the inner tissue of the plant; uneven root growth; yellow lower leaves; climbing stems developing little side branching

**Cause**

Fungus

## Comments

**Sooty mold** *Cladosporium* spp.

*Fumago* spp.

## Symptoms

Flat layer of black mold on the leaves (including bracts), and cones; reduced cone quality; wilting of the climbing vines; rapid death of leaves

## Cause

Fungal complex

## Comments

Mold can develop on sticky residue left behind by aphids

**Verticillium wilt** *Verticillium albo-atrum*.

*Verticillium dahliae*

## Symptoms

Yellowing of leaf tissue between the veins; swollen climbing vines with brown discoloration of the inner tissue

## Cause

Fungus

## Comments

Disease favors nitrogen rich soil

**White mold. (Sclerotinia wilt)** *Sclerotinia sclerotiorum*

## Symptoms

Water-soaked lesions on the stem just below the soil line; tan to gray lesions develop out of the water-soaked region; white fluffy fungus and hard black specks on diseased tissue; yellowing leaves

## Cause

Fungus

## Comments

Disease favors poor air circulation and wet, cool environments

## Category : Viral

**Mosaic virus** Hop mosaic virus (HpMV)

Hop latent virus (HpLV)

American hop latent virus (AHLV)

## Symptoms

Yellow and green mottling between the leaf veins; reduced plant growth

## Cause

Virus

## Comments

Hop mosaic virus causes the most damage; yield losses between 15-62%; transmitted by hop aphid

## Pests

## Category : Insects

**California prionus beetle** *Prionus californicus*

## Symptoms

Wilting and yellowing of the climbing vines

**Cause**

Insect

**Comments****Hop aphid** *Phorodon humuli***Symptoms**

Curling and/or wilting leaves; brown wilting cones

**Cause**

Insect

**Comments**

Aphids feed on the underside of hop leaves; aphids transmit a variety of viruses; sugary residue that they excrete promotes sooty fungal growth

**Japanese beetle** *Popillia japonica***Symptoms**

Leaves stripped down to skeleton of veins

**Cause**

Insect

**Comments****Potato leafhopper** *Empoasca fabae***Symptoms**

Parts of leaves withering and turning brown in a V-shape; reduced plant growth

**Cause**

Insect

**Comments****Category : Mites****Two-spotted spider mite** *Tetranychus urticae***Symptoms**

Small light colored spots on leaves; brown leaves that shrivel and die

**Cause**

Mite

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# Horseradish

## Description

Horseradish, *Armoracia rusticana*, is an herbaceous perennial plant in the family Brassicaceae that is cultivated for its large, edible root. The leaves of the plant grow in a distinctive rosette pattern sprouting from single or multiple stems. The leaves have long petioles and can be smooth or crinkled, reaching 30–100 cm (12–40 in) in length. The taproot is thick and fleshy and cylindrical in shape and can reach 50 cm (20 in) in length. The plant produces many white flowers on racemes. Horseradish plants are usually grown as annuals, surviving only one growing season and can reach a height of 1.5 m (5 ft). Horseradish may also be referred to as red cole or pepper rod and originates from south-eastern Europe and western Asia.

*Flowering horseradish plant*

*Horseradish plant*

*Harvested horseradish root*

*Horseradish leaves*

*Horseradish flowers*

*Horseradish flowers*

## Uses

Horseradish is grown as a vegetable and can be eaten fresh or cooked. Due to its bitter taste, it is commonly used to make sauces which accompany meat or fish.

## Propagation

**Basic requirements** Horseradish grows best in temperate climates in full sun or partial shade at temperatures between 15.5 and 28°C (60–65°F). If grown as an annual, the plant requires a long growing season with a warm summer and cooler temperatures in late summer and fall to allow the flavor to develop in the root. Horseradish can be grown in most soils as long as they are well draining but will grow optimally in a deep, fertile, well-draining soil with a pH between 6.0 and 7.5. **Propagation** Horseradish is usually vegetatively propagated by dividing crowns or from root cuttings. It can be grown from supermarket bought root as it is not treated with any chemicals that affect growth. The disadvantage is that the variety and characteristics may not be known. Root pieces are small, pencil size pieces of root which grow from the main root. They are referred to as sets and as the horseradish root exhibits polarity, it is important to make a note of which end of the set is the top and which is the bottom in order to plant the piece the correct orientation. A good way of doing this is to use a straight cut across the top end of the set and an oblique cut at the bottom. If planting by dividing an established crown, the plant should be carefully dug from the soil and split into four equal pieces each with some leaf and root. **Planting** Horseradish sets should be planted as soon as the soil is workable in the spring. The soil should be prepared for planting by double digging and incorporating composted organic matter and all purpose fertilizer. The root sets can be planted in shallow trenches which are approximately 10 to 12 cm (4–5 in) allowing 45–60 cm (18–24 in) between individual plants and deep and at least 30 cm (1 ft) between rows. The sets should be planted at a 45° angle so that the top of the set is higher in the soil than the bottom end. **General care and maintenance** Horseradish should be provided with approximately 1 to 2 inches of water each week. Additional irrigation may be required during dry spells. Care should be taken not to overwater the plants or allow them to become too dry as this will affect the flavor of the harvested root. An additional dose of fertilizer high in potassium and phosphorous but low in nitrogen should be applied 4 to 8 weeks after planting. Excess nitrogen should be avoided as it will encourage too much top growth on the plants and will also cause the roots to branch. Horseradish plants will benefit from the addition of a layer of organic mulch which will help to suppress weed growth. If no mulch is added then any weeds around young horseradish should be removed by gently cultivation the soil around the plants. Many growers make use of the practice of lifting and suckering their horseradish plants. Once the plant has begun to grow, it is gently lifted to expose the crown and any branching roots are removed. This focusses the plants energy on growing the main root. **Harvesting** Horseradish should be harvested when the tops have been frozen back in the fall. In commercial fields, the tops of the plants are mowed back to facilitate mechanical digging. In the home garden, the roots can be dug up with a fork and the tops removed after harvest. The roots should be scrubbed clean before storing. Leaving some small pieces of root in the ground will allow the plant to regrow the following year. If regrowth is not desired then all pieces of root should be dug up and removed to prevent the horseradish becoming a weed in the garden.

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## Common Pests and Diseases

### Diseases

## **Category : Bacterial**

### **Bacterial leaf spot** *Phytoponas campestris armoraciae*

#### **Symptoms**

Small translucent spot on leaves which turn black and are scattered over the leaf surface between the veins; spots may enlarge after periods of rainfall; leaves may curl and dry up

#### **Cause**

Bacterium

#### **Comments**

Bacteria overwinter on plant debris; disease emergence is favored by wet weather

#### **Management**

Remove plant debris from around plants and after harvest to reduce overwintering inoculum

## **Category : Fungal**

### **Brittle root** *Spiroplasma citri*

#### **Symptoms**

Poor growth of plants; chlorotic leaves which collapse and dry out; roots are brittle and discolored dark brown with a dark ring when snapped in two

#### **Cause**

Bacteria

#### **Comments**

Disease is transmitted by beet leafhoppers; disease is one of the most destructive of horseradish

#### **Management**

Brittle root can be reduced or eliminated by controlling the insect vector; plants should be scouted for beet leafhoppers and appropriate insecticides should be applied

### **Cercospora leaf spot** *Cercospora armoraciae*

#### **Symptoms**

Round or angular tan spots with lighter centers on leaves; leaves dying and plants becoming defoliated

#### **Cause**

Fungus

#### **Comments**

Emergence of the disease is favored by periods of cool, wet weather; fungus is spread by splashing water

#### **Management**

Infected plant should be removed and destroyed to prevent spread; remove any volunteer plants and weeds; avoid working with plants when they are wet; seeds can be treated with hot water to eliminate the fungus prior to planting

### **Ramularia leaf spot** *Ramularia cynarae*

#### **Symptoms**

Disease initially appears as yellow-green circular patches between leaf veins which become distinct lesions with irregular margins; centers of lesions may dry out and drop from plant producing a shot hole appearance; if infection is severe, the entire leaf may dry out

#### **Cause**

Fungus

#### **Comments**

Fungus overwinters on plant debris

#### **Management**

Remove weeds and any horseradish debris from around plants; avoid the use of sprinklers for irrigation; remove and destroy any infected plants to prevent spread; rotate crops away from horseradish for a period of 3 years; if disease is problematic it may be necessary to treat with appropriate fungicides

### **White rust *Albugo candida***

#### **Symptoms**

Pale yellow areas on upper leaf surfaces followed by the appearance of creamy white pustules on leaf undersides; if infection is severe then leaves may become curled and distorted with pustules covering the entire leaf surface

#### **Cause**

Fungus

#### **Comments**

Spores are spread by wind; fungus overwinters in plant debris or on perennial plants; disease development is favored by cool weather and periods of extended rainfall

#### **Management**

Remove weeds and any horseradish debris from around plants; avoid the use of sprinklers for irrigation; remove and destroy any infected plants to prevent spread; rotate crops away from horseradish for a period of 3 years; if disease is problematic it may be necessary to treat with appropriate fungicides

### **Category : Viral**

#### **Mosaic Turnip mosaic virus (TuMV)**

#### **Symptoms**

Green and yellow mottling on leaves; crinkled, underdeveloped leaves; black streaks on petioles

#### **Cause**

Virus

#### **Comments**

Plant can tolerate low levels of infection

## **Pests**

### **Category : Insects**

#### **Cabbage looper *Trichoplusia ni***

#### **Symptoms**

Large or small holes in leaves; damage often extensive; caterpillars are pale green with a white lines running down either side of their body; caterpillars are easily distinguished by the way they arch their body when moving; eggs are laid singly, usually on the lower leaf surface close to the leaf margin, and are white or pale green in color

#### **Cause**

Insect

#### **Comments**

Insects overwinter as pupae in crop debris in soil; adult insect is a dark colored moth; caterpillars have a wide host range

#### **Management**

Horseradish can tolerate a large amount of damage; looper populations are usually held in check by natural enemies; if they do become problematic larvae can be hand-picked from the plants; an organically acceptable control method is the application of *Bacillus thuringiensis* which effectively kills younger larvae; chemical sprays may damage populations of natural enemies and should be selected carefully

#### **Flea beetles (Horseradish flea beetle) *Phyllotreta armoraciae***

## **Symptoms**

Small holes or pits in leaves that give the foliage a characteristic “shot hole” appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5–3.0 mm) dark colored beetle which jumps when disturbed

## **Cause**

Insects

## **Comments**

Flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year

## **Management**

Horseradish can tolerate a large amount of early feeding damage before the root is affected; application of a thick layer of mulch may help prevent beetles reaching surface; application of diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied

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# Kale

## Crop details

Kale ( *Brassica oleracea* )

**Variety** (acephala)

**Local name** :sukumawiki

### General information

Kale, *Brassica oleracea* variant *acephala*, is a leafy herbaceous biennial or perennial plant in the family Brassicaceae grown as a leafy green vegetable. The kale plant is a non-heading, cabbage like plant with curly or straight, loose blue-green or purple leaves. Kale is usually grown as an annual plant, harvested after one growing season and can reach a height of 1 m (3.3 ft). Kale may also be referred to as borecole or non-heading cabbage or broccoli and its exact origins are unknown, although it grows native in regions of the eastern Mediterranean and Asia.

*Harvested curly kale*

*Young kale leaves*

*Kale foliage*

*Close-up view of kale leaf*

*Curly kale variety*

*Kale*

## Kale Nutrition

Kale is a nutritious food rich in antioxidants, vitamin C, vitamin K, and beta-carotene. It also contains nutrients that can support eye health, weight management and heart health. Loaded with important micronutrients and antioxidants, kale is one of the most nutritious leafy greens available.

In fact, kale contains a variety of beneficial compounds, some of which have powerful medicinal properties. It's versatile and boasts a nutty, earthy flavour that works well in a wide range of recipes.

### uses

Kale is used as a green vegetable and is usually cooked before consumption. Some varieties of kale are grown as decorative ornamental plants due to their attractive, brightly colored foliage.

## Kale Variety

### "Thousand Headed"

This is a continuous growing and hardy crop that is tolerant to cold temperatures. It can stay in the field for a long time, therefore, giving a higher yield. It has a thick stem with big leaves that are dark green, smooth and attractive. It matures between 90-100 days. It can also be used as fodder for animals. It is easily digestible and easy to cook.

### "Southern Georgia"

It is a very popular seed variety grown across Africa. It has been developed to give high yields while up to 6 months before flowering thus profitable to farmers. The leaves are well flavored and easy to cook. It is popular in the local market. It is adapted to hot areas. It is hardy and resistant to black rot.

### "Marrow Stem"

The variety has dark green leaves and flavor and little fiber. It is vigorous, medium tall with finely curled leaves which are less prone to bird damage.

## Kale growing in Kenya

In Kenya, kale is mainly grown in the highlands, which are located in the central, western, and parts of the eastern regions of the country. These regions have a cool climate, and the soil is rich in nutrients, which is ideal for growing kale. Examples of these regions include the Mount Kenya region, the Aberdares, and the Elgeyo Marakwet .

## Propagation

### Climatic conditions and soil type

Kale is cool season crop that grows best in cool, moist conditions. The plant will grow best at temperatures between 4 and 21°C (40°F-50°F) allowing it to be grown in both Spring and Fall. Kale is a hardy plant, tolerating frost, and will grow optimally in a rich, moist, well draining soil with a pH of 6.5. Kale requires at least six hours of direct sunlight every

day.

## Sowing seeds

Kale can be direct seeded or started indoors for transplants. The optimum soil temperature for germination is between 12 and 24°C (55–75°F). Kale seeds should be planted after any danger of hard frost or in a cold frame for transplanting to their final location. For a Fall harvest, try to time seeding so that the plants will mature in cool weather. This often means sowing in July but may be as late as October in warmer Southern regions. Prepare the soil for planting through the addition of nitrogen in the form of bone meal or composted manure. Plant seeds 12 mm (0.5 in) deep allowing 3.5 cm (1 in) between plants in the row. Thin seedlings to a final within row spacing of 45–60 cm (18–24 in). Keep soil moist during germination to prevent a crust from forming on the soil surface as this will cause uneven germination.

## Transplanting

Seedlings started indoors or in a cold frame are ready to be transplanted when they have 3–4 leaves and the daytime temperature has reached 10°C (50°F). Seedlings should be planted at the final spacing for seeds (45–60 cm/18–24 in between plants and 0.6 to 1.2 m/2–4 ft between rows). Plant each seedling slightly deeper than it was previously. The plantings can be staggered in 2 week intervals to prolong the harvest. **General care** Kale should be kept evenly watered, application of mulch around plants helps to conserve soil moisture. The plants have shallow roots and in order to avoid damaging them, it is preferable to hand pull any weeds growing around the plants. Kale plants are heavy feeders, requiring plentiful nitrogen to meet their growth requirements and develop optimally. Apply an appropriate complete fertilizer when thinning seedlings.

## Harvesting

Kale leaves can be harvested when they are 20–25 cm (8–10 in) long. Harvest the outer leaves to avoid damaging the growing tip of the plant. Kale leaves are sweeter when they are harvested after frost.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

**Alternaria leaf spot (Black spot, Gray spot)** *Alternaria brassicaceae*  
*Alternaria brassicicola*

*Alternaria* as a secondary invader of  
kale stem tissue.

Black spot of collard and kale

Alternaria black molds / stem  
cankers (*Alternaria spp.*) on kale

Black spot of collard and kale  
caused by *Alternaria brassicae* or *A.  
brassicicola*

### Symptoms

Small dark spots on leaves which turn brown to gray; lesions may be round or angular and may possess a purple-black margin; lesions may form concentric rings, become brittle and crack in center; dark brown elongated lesions may develop on stems and petioles.

### Cause

Fungus

### Comments

May become a problem on cabbage during cool, wet periods.

### Management

Plant only pathogen-free seed; rotate crops; applications of appropriate fungicides control disease when present.

## **Anthracnose** *Colletotrichum higginsianum*

### Symptoms

Small circular or irregularly shaped dry spots which are gray to straw in color on leaves; a high number of spots may cause the leaf to die; lesions may coalesce to form large necrotic patches causing leaves to turn yellow and wilt; lesions may split or crack in dry centers

### Cause

Fungus

### Comments

Fungus overwinters on leaf debris and on related weeds; disease emergence is favored by moist, warm conditions

### Management

Control of disease depends on sanitary practices; treat seeds with hot water prior to planting; rotate crops; plant in an area with good soil drainage; remove all cruciferous weeds which may act as a reservoir for the fungus

## **Damping-off (Wirestem)** *Rhizoctonia solani*

*Rhizoctonia* damping-off of *Brassica*

*Rhizoctonia* damping-off, blight and  
rot (*Rhizoctonia solani*) J.G. KÄ½hn  
on *Brassica*.

### Symptoms

Death of seedlings after germination; brown or black rot girdling stem; seedling may remain upright but stem is constricted and twisted (wirestem).

### Cause

Fungus

### Comments

Disease emergence in seedlings favored by cool temperatures.

### Management

Plant pathogen-free seed or transplants that have been produced in sterilized soil; apply fungicide to seed to kill off any fungi; shallow plant seeds or delay planting until soil warms.

## **Downy mildew** *Peronospora parasitica*

*Symptoms of downy mildew (Peronospora parasitica) on brassica*

*Yellow spots on top of leaf, whitish mold on the bottom of the leaf.  
Lesions on undersides of leaf are often restricted by veins*

*Downy mildew (Peronospora parasitica) on brassica*

### **Symptoms**

Irregular yellow patches on leaves which turn light brown in color; fluffy gray growth on the undersides of the leaves.

### **Cause**

Fungus

### **Comments**

Disease emergence favored by cool, moist conditions.

### **Management**

Remove all crop debris after harvest; rotate with non-brassicas; application of appropriate fungicides may be required if symptoms of disease are present.

## **Category : Bacterial**

### **Black rot (Leaf spot)** *Xanthomonas campestris*

*Black rot symptoms on kale*

*Symptoms on kale*

### **Symptoms**

V-shaped brown lesions originating from edge of leaves; black leaf stems and drop from the plant; black discoloration of stem; brown spots on leaves.

### **Cause**

Bacteria

### **Comments**

Pathogen is spread via infected seed or by splashing water and insect movement; disease emergence favored by warm and humid conditions.

### **Management**

Primary method of controlling black rot is through the use of good sanitation practices; rotate crops to non-cruciferous crops every 2 years; plant resistant varieties; control cruciferous weed species which may act as a reservoir for bacteria; plant pathogen-free seed.

## **Pests**

### **Category : Insects**

### **Beet armyworm** *Spodoptera exigua*

*Young larvae*

*Beet armyworm eggs covered in white hairs*

*Beet armyworm larva*

## Symptoms

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside.

## Cause

Insect

## Comments

Insect can go through 3–5 generations a year.

## Management

Organic methods of controlling the beet armyworm include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae.

## Cabbage aphid *Brevicoryne brassicae*

Colony with parasitized aphid

Cabbage aphid colony on *Brassica* spp.

Cabbage aphid colony

## Symptoms

Large populations can cause stunted growth or even plant death; insects may be visible on the plant leaves and are small, grey-green in color and soft bodied and are covered with a white waxy coating; prefer to feed deep down in cabbage head and may be obscured by the leaves.

## Cause

Insect

## Comments

Cabbage aphids feed only on cruciferous plants but may survive on related weed species.

## Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use.

## Cabbage looper *Trichoplusia ni*

Cabbage loopers egg

Cabbage looper

cabbage looper feeding on leaves

Cabbage looper adult

Cabbage looper (*Trichoplusia ni*)

Cabbage looper and damage

## Symptoms

Large or small holes in leaves; damage often extensive; caterpillars are pale green with a white lines running down either side of their body; caterpillars are easily distinguished by the way they arch their body when moving; eggs are laid singly, usually on the lower leaf surface close to the leaf margin, and are white or pale green in color.

## Cause

## Insect

### Comments

Insects overwinter as pupae in crop debris in soil; adult insect is a dark colored moth; caterpillars have a wide host range.

### Management

Looper populations are usually held in check by natural enemies; if they do become problematic larvae can be hand-picked from the plants; an organically acceptable control method is the application of *Bacillus thuringiensis* which effectively kills younger larvae; chemical sprays may damage populations of natural enemies and should be selected carefully.

### Cutworms *Agrotis* spp.

*Peridroma saucia*

*Nephelodes minians*

and others

Army cutworm (*Euxoa auxiliaris*)

Bronzed cutworm (*Nephelodes minians*) adult

Greasy cutworm (*Agrotis ipsilon aneituma*) adult

Cutworm feeding on plant stem

Cutworms will curl up into a characteristic C shape when disturbed

Cutworm larva severing plant stem

### Symptoms

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5–5.0 cm (1–2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed.

### Cause

Insects

### Comments

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato.

### Management

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically.

### Diamondback moth *Plutella xylostella*

Diamondback moth early instar larva

Diamondback moth egg

Diamondback moth feeding on Brassicaceae

Diamondback moth adult

Larva feeding on cabbage leaf

Diamondback moth pupae

### Symptoms

Young larvae feed between upper and lower leaf surface and may be visible when they emerge from small holes on the underside of the leaf; older larvae leave large, irregularly shaped shotholes on leaf undersides, may leave the upper surface intact; larvae may drop from the plant on silk threads if the leaf is disturbed; larvae are small (1 cm/0.3 in) and tapered at both ends; larvae have to prolegs at the rear end that are arranged in a distinctive V-shape.

### Cause

Insect

### Comments

Larvae take between 10 and 14 days to mature and spin a loose, gauze-like cocoon on leaves or stems to pupate.

### Management

Larvae can be controlled organically by applications of *Bacillus thurengiensis* or Entrust; application of appropriate chemical insecticide is only necessary if larvae are damaging the growing tips of the plants.

## Flea beetles *Phylloptreta* spp.

*Adult flea beetle on a leaf*

*Adults and associated damage on cabbage*

*Shothole" damage on chinese cabbage due to crucifer flea beetle*

*crucifer flea beetle (*Phylloptreta cruciferae*) on Chinese cabbage.*

*Crucifer flea beetle damage on broccoli leaf*

### Symptoms

Small holes or pits in leaves that give the foliage a characteristic "shothole" appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5–3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance.

### Cause

Insects

### Comments

Younger plants are more susceptible to flea beetle damage than older ones; older plants can tolerate infestation; flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year.

### Management

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application of diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied.

## Large cabbage white (and Cross-Striped Cabbageworm) *Pieris rapae*

*Evergestis rimosalis*

cabbage white (*Pieris rapae*) eggs

Cabbage white adult

cabbage white (*Pieris rapae*) early instar larvae

cross-striped cabbageworm on cabbage

cabbage white (*Pieris rapae*) adult

cross-striped cabbageworm on brassica

Cross striped cabbage worm

cross-striped cabbageworm (*Evergestis rimosalis*) feeding on leaves

Cabbage white (*Pieres rapae*): Pupa of imported cabbageworm (left) and southern cabbageworm (right).

Cabbageworm and frass

## Symptoms

Large ragged holes in leaves or bored into head; green-brown frass (insect feces) on leaves; caterpillar is green in color and hairy, with a velvet-like appearance; may have faint yellow to orange stripes down back; slow-moving compared with other caterpillars.

## Cause

Insect

## Comments

Larvae can be distinguished from other caterpillars by their sluggish movement; in large numbers larvae can cause extensive damage very quickly.

## Management

Hand-pick caterpillars from plants and destroy; scrape eggs from leaves prior to hatching; apply appropriate insecticide if infestation is very heavy.

## Thrips (Western flower thrips, Onion thrips, etc.) *Frankliniella occidentalis*

*Thrips tabaci*

Second instar nymph (and damage to leaf) of the onion thrips (*Thrips tabaci*).

First instar nymph of onion thrips (*Thrips tabaci*).

Onion thrips (*Thrips tabaci*)

Western flower thrips

## Symptoms

If population is high leaves may be distorted; leaves are covered in coarse stippling and may appear silvery; leaves speckled with black feces; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color.

## Cause

Insect

## Comments

Transmit viruses such as Tomato spotted wilt virus; once acquired, the insect retains the ability to transmit the virus for the remainder of its life.

## Management

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic.

## Category : Mites

## **Root-knot nematode** *Meloidogyne* spp

*Galling on lettuce roots from root-knot nematode*

*Southern root-knot nematode (*Meloidogyne incognita*) on cantaloupe root*

*Root-knot nematode female and egg mass of the root-knot nematode, *Meloidogyne* sp.*

### **Symptoms**

Areas of irregular growth on plant; stunted plant growth; plants wilt during hot afternoons during periods of water-stress; galls on roots

### **Cause**

Nematode

### **Comments**

Root-knot nemtodes are easily spread via movement of infected soil; root-knot nematodes have a wide host range which includes many weed species which can act as reservoirs for infection

### **Management**

Rotate crops every 1-2 years to non-host; avoid transferring soil from infested fields; soil fumigation with nematacide or application of non-fumigant nematicide may be required to manage heavy infestations

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# Kiwi

## Description

Kiwi, *Actinidia deliciosa*, is a deciduous climbing vine or shrub in the family Actinidiaceae grown for its edible fruits. The plant is vigorous and woody with nearly circular leaves which have long petioles and are alternately arranged on the stems. Young leaves and shoots are covered in tiny red hairs, while mature leaves are smooth and dark green on the upper surface and white and downy on lower surface. The kiwi plant produces fragrant white-yellow flowers singly or in clusters of 3 at the leaf axils (area between leaf and stem). The fruit is oval or ovoid in shape with green-brown skin covered in stiff brown hairs. The flesh of the fruit is bright green and juicy with many tiny black seeds. Kiwi plants can reach a height of 9 m (30 ft) and have an economic lifespan of 3 years, after which time fruit production begins to decline. Kiwi may also be referred to as kiwifruit or Chinese gooseberry and originates from China.

*Kiwi vines*

*Kiwi leaf*

*Kiwi fruit*

*Developing leaves*

*Kiwi flowers*

*Kiwi plant*

## Uses

Kiwis are primarily consumed as a fresh fruit.

# Propagation

**Basic requirements** Kiwi plants are native to warm, forest regions of China and require a long growing season with 8 to 9 months with no frost. The optimal temperature during the growing season is between 14 and 24°C (57.2–75.2°F). The plant can tolerate cold but is damaged by temperatures below -8°C (17.6°F). Some varieties of *A. deliciosa*, such as the Hayward cultivar will tolerate temperatures down to -10°C (14°F). In general, kiwifruit vines will grow best when planted in deep, well-draining, sandy loams as they are extremely sensitive to standing water. The optimum pH for the soil is between 5.5 and 6.0. In addition, kiwifruits require a plentiful supply of water during production and the vines require the support of a trellis to support the weight of the growing fruit. Kiwi should be planted in full sunlight to ensure optimal productivity. **Propagation** Kiwis can be propagated by a variety of methods, including growing from seed or from hard or softwood cuttings or root cuttings. The easiest method of propagation is the use of softwood cuttings. The cuttings should be taken during the summer months when the tree is actively growing. Each cutting should be taken from the current season's growth and should possess 2-3 nodes (leaves). The leaves must be fully expanded in order for the cutting to be successful, cuttings should not be taken from immature growth such as at the end of shoots. Once the cuttings have been obtained, they should be stripped of all but the top-most leaf. Rooting hormone can be used to aid the cuttings in developing new roots. Those containing indole-3-butyric acid have been shown to be most effective in kiwi propagation. After treatment with rooting hormone, the kiwi cuttings should be planted in beds or small pots, preferably in a glasshouse, and kept moist. When the cuttings have begun to develop new shoots, they should be transferred into 1 gallon pots containing a high quality potting soil and watered daily. The potted plants should be fed with a slow release fertilizer at least twice over the growing season. **Planting** If the kiwi vines are to be grown on a trellis or pergola, this should be constructed prior to planting. Kiwi should be planted by digging a planting hole which is at least three times the width of the current pot that the plant is in. Individual plants should typically be spaced 5 m (16.4 ft) apart when using a T-trellis system but can be planted closer together when vines are managed by pruning. Approximately 6 m (19.6 ft) should be left between rows. This distance is again dependent on the training system being utilized. Almost all kiwi species are dioecious and require the presence of both a male and female tree in order to set fruit. The recommended planting ratio is 1 male to every 8 females but a higher density of male trees will increase productivity. **General care and maintenance** Kiwis have a high nutrient demand, particularly for nitrogen and potassium. After the first year of planting, plants should be fertilized in the Spring and as required throughout the growing season with the type and amount of fertilizer depending on the particular soil type and the age of the vines.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Armillaria root rot** *Armillaria mellea*

##### Symptoms

Vines may completely collapse; whit mycelial mats may be present under bark close to the soil line; cortical tissue has a dark discoloration and white mycelial strands are present; root-like rhizomorphs extend from roots into soil

#### Cause

Fungus

#### Comments

Disease emergence favored by continually damp soil

#### Management

Ensure that land to be used for new kiwi plantings is completely cleared of roots which are greater than 1 inch in diameter; ensure kiwi vines are adequately irrigated but not overwatered

### Category : Bacterial

#### Bacterial blight *Pseudomonas* spp.

##### Symptoms

Brown, sunken lesions on petals covering flower buds; yellow-orange discoloration of petals; small yellow spots may appear on leaves after periods of rain

##### Cause

Bacteria

##### Comments

Bacteria enter plants through wounds

##### Management

Control of the disease relies on the avoidance of injuries to the plant which allow bacteria to enter; there are currently no recommended chemical control strategies for the disease

#### Bleeding canker *Pseudomonas syringae*

##### Symptoms

Wilting plants; blighting of canes; red, rust colored cankers on branches which may exude red colored discharge

##### Cause

Bacterium

##### Comments

Disease has a wide host range; bacteria overwinter on vines

##### Management

Infected areas should be pruned by cutting 1 foot below the edge of the canker; disease severity can be reduced by protecting plants from freeze injuries over winter

#### Crown gall *Agrobacterium tumefaciens*

##### Symptoms

Reduced plant vigor; small leaves; poor growth; open canopy; reduced yield; galls may be too small to see

##### Cause

Bacterium

##### Comments

Bacteria enter the plant through wounds

##### Management

Control of the disease relies on the avoidance of injury to kiwi vines; existing galls can be surgically removed

### Category : Oomycete

#### Phytophthora root and crown rot *Phytophthora* spp.

**Symptoms**

Reduced shoot growth; small, chlorotic leaves; vines may collapse suddenly or show a gradual decline in productivity over several seasons; red-brown discoloration of roots and root crowns which is visible when root is cut in two

**Cause**

Oomycete

**Comments**

Disease emergence favored by poorly drained soils and flood irrigation

**Management**

Control of the disease is reliant on good water management and application of appropriate fungicides; kiwi should be planted in well-draining soils where water does not pool after rain or irrigation; plants should be allowed to dry out between irrigations

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# Kohlrabi

## Description

Kohlrabi, *Brassica oleracea* var. *gongylodes*, is an herbaceous biennial grown for its edible stem. The kohlrabi plant has an erect stem which is swollen at the bottom, close to the soil. The swelling resembles a turnip in appearance, can reach up to 10 cm (4 in) in diameter and may be green, white or purple in color depending on the variety. The leaves of the plant grow from the stem and have long petioles and a waxy appearance. Kohlrabi can grow to a height of 40–50 cm (16–20 in) and although biennial, is commonly grown as an annual. Kohlrabi may also be referred to as turnip-rooted cabbage or German cabbage and originates from Europe.

*Kohlrabi*

*Kohlrabi leaf*

*Kohlrabi plant*

*Kohlrabi close-up*

*Kohlrabi plant*

*Kohlrabi stem and leaves*

## Uses

The kohlrabi stem is consumed after cooking as a vegetable. The leaves of the plant are also edible and are eaten after cooking similar to spinach or kale.

# Propagation

**Basic requirements** Kohlrabi a cool season crop which can be grown both in Spring and in Fall. The plants thrive in cool climates, maturing in cool or lightly frosty weather. In areas with hot summers, they should be planted for a Fall harvest. Kohlrabi will grow best in moist, fertile, well-draining soil with a slightly acidic pH between 6.0 and 6.8 and at temperatures between 7 and 24°C (45–75°F). Temperatures below 7°C (45°F) will cause the plants to bolt. Kohlrabi has a high nitrogen requirement and due to the reduced activity of soil microbes in late fall and winter, organic matter should be added to the soil throughout the year to ensure an adequate supply of nutrients when sprouts are planted.

Plant kohlrabi in an area that receives at least six hours of full sunlight for optimum growth and development.

**Propagation** Kohlrabi can be direct seeded in the garden or started indoors to produce transplants. Seeds and transplants can be planted outdoors 1 to 2 weeks prior to the last frost date. For fall plantings, time seeding/transplanting so that plants mature no more than 2 to 3 weeks after the first frost date for the region. Seeds should be sown 0.6-1.9 in (0.25-0.75 in) deep. Direct seeded plants should be thinned when the plants have 3-4 true leaves. Transplants and thinned seedling should have a final spacing of 15 cm (6 in) between plants and 30.5 cm (12 in) between rows. **General care and maintenance** Kohlrabi has a shallow root system and should be watered regularly to keep the plants from drying out. Aim to apply 1 to 2 inches of water per week. Application of organic mulches will help to conserve water and keep the soil cool. Fertilizing kohlrabi plants with an appropriate nitrogen fertilizer helps to ensure rapid plant growth. Kohlrabi beds should be kept free from weeds, particularly when plants are young, by cultivating the soil around the plants. Care should be taken to avoid damage to the root system. **Harvesting** Kohlrabi is ready to harvest when the stems reach 5 to 7.6 cm (2-3 in) in diameter. Stems harvested later tend to be tough and woody. Young leaves can be harvested during the growing season and prepared in the same way as kale.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Alternaria leaf spot (Black spot, Gray spot)** *Alternaria brassicae*

##### **Symptoms**

Small dark spots on leaves which turn brown to gray; lesions may be round or angular and may possess a purple-black margin; lesions may form concentric rings, become brittle and crack in center; dark brown elongated lesions may develop on stems and petioles

##### **Cause**

Fungus

##### **Comments**

May become a problem during cool, wet periods

##### **Management**

Plant only pathogen-free seed; rotate crops; applications of appropriate fungicides control disease when present

## **Black rot** *Xanthomonas campestris*

### **Symptoms**

Seedlings develop wilted yellow to brown leaves and collapse; yellow, V-shaped lesions on mature leaf margins; dark rings can be found in the cross section of the stem

### **Cause**

Bacteria

### **Comments**

can be confused with Fusarium wilt; favors warm wet environments

### **Management**

Primary control methods based on good sanitation; plant disease-free seed; rotate crops every 2 years or less to non-brassica; avoid sprinkler irrigation

## **Clubroot** *Plasmoidiophora brassicae*

### **Symptoms**

Slow growing, stunted plants; yellowish leaves which wilt during day and rejuvenate in part at night; swollen, distorted roots; extensive gall formation

### **Cause**

Fungus

### **Comments**

Can be difficult to distinguish from nematode damage; fungus can survive in soil for periods in excess of 10 years; can be spread by movement of contaminated soil and irrigation water to uninfected areas

### **Management**

Once the pathogen is present in the soil it can survive for many years, elimination of the pathogen is economically unfeasible; rotating crops generally does not provide effective control; plant only certified seed and avoid field grown transplants unless produced in a fumigated bed; applying lime to the soil can reduce fungus sporulation

## **Damping-off (Wirestem)** *Rhizoctonia solani*

### **Symptoms**

Death of seedlings after germination; brown or black rot girdling stem; seedling may remain upright but stem is constricted and twisted (wirestem)

### **Cause**

Fungus

### **Comments**

Disease emergence in seedlings favored by cool temperatures

### **Management**

Plant pathogen-free seed or transplants that have been produced in sterilized soil; apply fungicide to seed to kill off any fungi; shallow plant seeds or delay planting until soil warms

## **Downy mildew** *Peronospora parasitica*

### **Symptoms**

Irregular yellow patches on leaves which turn light brown in color; fluffy gray growth on the undersides of the leaves

### **Cause**

Fungus

### **Comments**

Disease emergence favored by cool, moist conditions

### **Management**

Remove all crop debris after harvest; rotate with non-brassicas; application of appropriate fungicides may be required if symptoms of disease are present

## **Powdery mildew** *Erysiphe cruciferarum*

### **Symptoms**

Small white patches on upper and lower leaf surfaces which may also show purple blotching; patches coalesce to form a dense powdery layer which coats the leaves; leaves become chlorotic and drop from plant

### **Cause**

Fungus

### **Comments**

Disease emergence favored by dry season, moderate temperatures, low humidity and low levels of rainfall

### **Management**

Plant resistant varieties; rotate crops; remove all crop debris after harvest; remove weeds; avoid excessive application of nitrogen fertilizer which encourages powdery mildew growth; powdery mildew can be controlled by application of sulfur sprays, dusts or vapors

## **Pests**

### **Category : Insects**

#### **Beet armyworm** *Spodoptera exigua*

Young larvae

Beet armyworm eggs covered in  
white hairs

Beet armyworm larva

### **Symptoms**

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside

### **Cause**

Insect

### **Comments**

Insect can go through 3–5 generations a year

### **Management**

Organic methods of controlling the beet armyworm include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae

#### **Cabbage aphid** *Brevicoryne brassicae*

Cabbage aphid colony

### **Symptoms**

Large populations can cause stunted growth or even plant death; insects may be visible on the plant leaves and are small, grey-green in color and soft bodied and are covered with a white waxy coating; prefer to feed deep down in cabbage head and may be obscured by the leaves

### **Cause**

Insect

### Comments

Cabbage aphids feed only on cruciferous plants but may survive on related weed species

### Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

## **Cabbage looper** *Trichoplusia ni*

*Cabbage looper and damage*

### Symptoms

Large or small holes in leaves; damage often extensive; caterpillars are pale green with a white lines running down either side of their body; caterpillars are easily distinguished by the way they arch their body when moving; eggs are laid singly, usually on the lower leaf surface close to the leaf margin, and are white or pale green in color

### Cause

Insect

### Comments

Insects overwinter as pupae in crop debris in soil; adult insect is a dark colored moth; caterpillars have a wide host range

### Management

Looper populations are usually held in check by natural enemies; if they do become problematic larvae can be hand-picked from the plants; an organically acceptable control method is the application of *Bacillus thuringiensis* which effectively kills younger larvae; chemical sprays may damage populations of natural enemies and should be selected carefully

## **Cutworms** *Agrotis* spp.

*Peridroma saucia*

*Nephelodes minians*

and others

*Cutworm feeding on plant stem*

*Cutworms will curl up into a characteristic C shape when disturbed*

*Cutworm larva severing plant stem*

### Symptoms

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5â€“5.0 cm (1â€“2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed

### Cause

Insects

### Comments

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato

## **Management**

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically

## **Diamondback moth** *Plutella xylostella*

*Diamondback moth pupae*

*Larva feeding on cabbage leaf*

### **Symptoms**

Young larvae feed between upper and lower leaf surface and may be visible when they emerge from small holes on the underside of the leaf; older larvae leave large, irregularly shaped shotholes on leaf undersides, may leave the upper surface intact; larvae may drop from the plant on silk threads if the leaf is disturbed; larvae are small (1 cm/0.3 in) and tapered at both ends; larvae have to prolegs at the rear end that are arranged in a distinctive V-shape

### **Cause**

Insect

### **Comments**

Larvae take between 10 and 14 days to mature and spin a loose, gauze-like cocoon on leaves or stems to pupate

### **Management**

Larvae can be controlled organically by applications of *Bacillus thurengiensis* or Entrust; application of appropriate chemical insecticide is only necessary if larvae are damaging the growing tips of the plants

## **Flea beetles** *Phylotreta* spp.

*Crucifer flea beetle damage on broccoli leaf*

### **Symptoms**

Small holes or pits in leaves that give the foliage a characteristic “shothole” appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5–3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance

### **Cause**

Insects

### **Comments**

Younger plants are more susceptible to flea beetle damage than older ones; older plants can tolerate infestation; flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year

### **Management**

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application of diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a

week but will need reapplied

## **Large cabbage white (Cabbageworm) *Pieris rapae***

*Cabbageworm and frass*

### **Symptoms**

Large ragged holes in leaves or bored into head; green-brown frass (insect feces) on leaves; caterpillar is green in color and hairy, with a velvet-like appearance; may have faint yellow to orange stripes down back; slow-moving compared with other caterpillars

### **Cause**

Insect

### **Comments**

Larvae can be distinguished from other caterpillars by their sluggish movement; in large numbers larvae can cause extensive damage very quickly

### **Management**

Hand-pick caterpillars from plants and destroy; scrape eggs from leaves prior to hatching; apply appropriate insecticide if infestation is very heavy

## **Thrips (Western flower thrips, Onion thrips, etc.) *Frankliniella occidentalis***

*Thrips tabaci*

*Western flower thrips*

### **Symptoms**

If population is high leaves may be distorted; leaves are covered in coarse stippling and may appear silvery; leaves speckled with black feces; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color

### **Cause**

Insect

### **Comments**

Transmit viruses such as Tomato spotted wilt virus; once acquired, the insect retains the ability to transmit the virus for the remainder of its life

### **Management**

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic

## **Category : Nematodes**

### **Root knot nematode *Meloidogyne* spp.**

#### **Symptoms**

Galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; reduction in plant vigor; yellowing plants which wilt in hot weather

#### **Cause**

Nematode

#### **Comments**

Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or

garden with this type of soil is most likely

### **Management**

Plant resistant varieties if nematodes are known to be present in the soil ;check roots of plants mid-season or sooner if symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens

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# Lavender

## Description

Lavender is the name given to several species of herbaceous, perennial shrubs in the genus *Lavandula* which are grown as ornamental plants or for essential oil. Lavender plants are small, branching and spreading shrubs with grey-green leaves and long flowering shoots. The leaves can be simple or pinnate measuring 30–50 mm (1–2 in) in length. The plant produces flowers on shoots or spikes which can be 20–40 cm (8–16 in) long. The flowers are lilac or blue in color. Lavender can grow to 0.4 m (1.3 ft) in height and live for 20–30 years. Lavender may also be referred to as true lavender, medical lavender, smelling lavender, thin-leaved lavender or English lavender and is believed to originate from the Mediterranean, Middle East and India.

*Lavender*

*Lavender flowerheads*

*Lavender flowering*

## Uses

Lavender flowers can be used in cooking as a herb or used to produce lavender sugar. Fresh flowers can be used as a flavoring in desserts and sauces. Bees which collect lavender nectar produce a high quality honey. Lavender is also cultivated as an ornamental plant or for the extraction of essential oil. The flower spikes are popularly dried and used in flower arranging.

# Propagation

**Basic requirements** Lavender grows very well in a wide range of climates, and optimally at temperatures between 7 and 21°C (44.6–69.8°F). Lavender plants require bright sunlight for adequate growth and should be positioned accordingly. The plants will grow best in light to sandy, well-draining soils with a pH of 5.8–8.3. The plants are drought tolerant once established but require regular watering while they establish. **Propagation** Lavender is usually propagated vegetatively from cuttings or by dividing the mother plant. Cuttings are best taken directly after the plants bloom. The cuttings should be taken from stems with no flower buds and should be prepared for planting by removing the leaves at the bottom of the stem. The cuttings should then be planted in pots containing a high quality, sterile potting soil and watered regularly until they root. The cuttings should develop a root system of their own in approximately 3 weeks. **Planting** Lavender plants can be planted Spring through to Fall. If planting in the Fall, care should be taken to use larger plants with an established root system to allow the plants to establish in the soil quickly before winter sets in. Spring planted lavender can be smaller as it can establish over the summer. Rooted cuttings can be planted directly in the garden after they have been hardened. Plants should be spaced 0.5–1.0 m (2–3 ft) apart depending on the variety, allowing 1–2 m (3–6 ft) between rows. **General care and maintenance** Once established, lavender requires little care. It benefits from prompt harvest if the flowers are to be used for further processing. Faded blooms should be removed to promote further blossoming. Light pruning encourages the plant to branch. Care should be taken not to over water the plants by allowing the plants to dry out between waterings. **Harvesting** Flowerheads can be harvested from the plant at any time. Flowerheads to be used for the extraction of essential oil are best harvested when only 1/2 to 1/3 of the florets are open. Harvesting is usually done by hand but may be achieved mechanically in commercial production. After harvest, the flowers should be hung upside down in bunches to dry out.

*Commercially grown lavender*

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Root rot** *Phytophthora* spp.

*Pythium* spp.

*Rhizoctonia* spp.

#### **Symptoms**

Wilting leaves; yellow leaves; dying leaves; discolored root tissue

#### **Cause**

Oomycete

**Comments**

Disease favors cold wet soils

**Management**

Avoid over-watering plants; plant lavender in well-draining soils

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# Leek

## Description

Leek, *Allium ampeloprasum*, also known as *Allium porrum*, is a biennial vegetable in the family Liliaceae, grown for its edible bulb and leaves. The plant is a slightly developed bulb attached to a cylindrical stem formed by the overlapping thick, flat leaves. The plant can produce clusters of white, pink or purple flowers and blue-black seeds in the second year. The plant can reach 0.6–0.9 m (2–3 ft) and can be grown as an annual, harvested after one growing season or as a biennial with two growing seasons. Although modern leek does not grow wild, it was likely domesticated from wild ancestors in the Mediterranean region.

*Leek blossom*

*Harvested leeks*

*Leek scape (flower bud)*

*Growing leeks*

*Leek foliage*

*Leeks*

## Uses

Leeks are consumed as a vegetable after cooking and are incorporated into many dishes.

# Propagation

**Basic requirements** Leeks grow very well in cool climates and can be successfully grown in most soils as long as they are rich and well draining. Leek will grow optimally in a well-draining loam with a pH between 5.5 and 7.0. Leek will grow optimally at temperatures between 18-21°C (65-70°F) with 8 hours of bright sunlight. **Propagation** In areas with short growing seasons, leeks should be planted from transplants started indoors. Seeds should be planted at a depth of 0.6-1.3 cm (0.25-0.5 in) leaving 7.5-10 cm (3-4 in) between plants and allowing 20-40 cm (8-16 in) between rows. The soil should be moist to a depth of (18 in) and have reached a minimum temperature of 7°C (45°F) for successful germination. Transplants should be planted 5-8 cm (2-6 in) apart in rows spaced 30-90 cm (12-36 in) apart. In order to produce large stalks either plant the leek in a depression 7-10 cm (3-4 in) deep and gradually fill to the leaves. Alternatively, the leeks may be planted at ground level, with soil being added around the stalk throughout the season. **General care and maintenance** Leeks require regular watering for optimum development and should be provided with water once a week by soaking the soil to a depth of around 18 inches. Blanching leeks encourages the production of long white stalks. Blanching is achieved by gradually mounding the soil around the stalk to leaves. Blanching should not be carried out until the plants have reached an appropriate size - roughly that of a pencil. Leeks will benefit from the addition of nitrogen fertilizer throughout the growing season. Fertilizer should be applied as a side dressing. Keep leek beds weed free by carefully cultivating around the plants taking care not to damage the leek roots. **Harvesting** Leeks develop slowly and take about 100 and 120 days to reach maturity. Leeks are ready for harvest when the stalk has reached 3.5 cm (1 in) in diameter. Harvest by carefully loosening the plant with a garden fork and pulling from the soil.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Botrytis leaf blight** *Botrytis squamosa*

###### **Symptoms**

Small white lesions with light green halos which may expand slightly as they age; in prolonged periods of moisture fungus may develop rapidly and cause leaf blighting

###### **Cause**

Fungus

###### **Comments**

Disease emergence favors high humidity and warm temperatures; fungus survives on piles of crop debris or in soil; older leaves more susceptible to blighting than younger leaves

###### **Management**

Plant leeks in single rows allowing at least 30 cm between plants to promote good air circulation and quick drying of foliage after rain; time irrigation to allow plants time to dry out sufficiently; apply appropriate fungicide sprays when plants have at least five true leaves and early symptoms of disease

### **Damping-off** *Fusarium* spp.

#### **Symptoms**

Rotting seeds that are covered in mold; discolored root tips which may be pink, tan, yellow, red or black; slowly growing seedlings which wilt and die

#### **Cause**

Fungi

#### **Comments**

Fungus survives in soil and disease emergence is favored by moist to wet soil

#### **Management**

Plant only disease-free seed; treat seed with fungicide; rotate crops with cereals or grasses to reduce levels of pathogen in soil; steam treatment or fumigation of soil can help reduce levels of *Fusarium* in the soil

### **Downy mildew** *Peronospora parasitica*

#### **Symptoms**

Pale spots or elongated patches on leaves; gray-purple fuzzy growth on leaf surface; leaves turning pale then yellow; leaf tips collapsing

#### **Cause**

Fungi

#### **Comments**

Disease favors cool, humid weather

#### **Management**

Avoid planting infected sets; rotate crops to non-allium species for 3-4 years; plant in well-draining areas and do not overcrowd plants; destroy all infected crop debris; apply appropriate foliar fungicides taking care to apply thoroughly to waxy leaves

### **Pink root** *Phoma terrestris*

#### **Symptoms**

Light pink roots which darken and turn purple; roots become transparent and water soaked; plant may look like it has a nutrient deficiency; infected seedling may die; stunted plants with undersized, shriveled bulbs

#### **Cause**

Fungus

#### **Comments**

Fungus colonizes plant through root tips; fungus can survive in soil down to a depth of 45 cm (17.7 in)

#### **Management**

Disease is most severe when alliums are planted continuously or in a 1-year rotation, a rotation of 3-6 years is preferred; plant more resistant varieties; solarization and/or fumigation can help reduce the levels of pathogen in the soil

### **Purple blotch** *Alternaria porri*

#### **Symptoms**

Small water-soaked lesions on leaves or stalk with white centers; which enlarge to become zonate and brown to purple in color with red or purple margin surrounded by yellow zone; large lesions may coalesce and girdle leaf, killing any tissue between the lesions and the leaf tip; severely infected foliage may die

#### **Cause**

Fungi

#### **Comments**

Disease emergence favored by wet foliage, with sporulation occurring during the night during periods of high humidity

### **Management**

Cultural controls include long rotations with non-hosts and the reduction of leaf wetness by planting in well-draining soil and timing irrigation to allow plants to dry adequately during the day; some fungicides are effective at controlling the disease but should be rotated for optimal control

## **White rot *Sclerotinia cepivorum***

### **Symptoms**

Older leaves yellowing; stunted growth; death of all leaves; fluffy white growth on base of bulb which spreads up bulb to storage leaves

### **Cause**

Fungus

### **Comments**

Fungus can survive in soil for 20 years and is one of the most damaging diseases of Allium crops worldwide, causing major crop losses

### **Management**

Fungicide treatment may not be effective at controlling white rot under conditions which are favorable to the fungi's development and control may have to rely on cultural methods: avoid transferring soil or plant material between sites; treat seeds with hot water prior to planting; use a long term rotation with non-allium crops; apply appropriate fungicides if available

## **Pests**

### **Category : Insects**

#### **Leafminers *Lyriomyza* spp.**

### **Symptoms**

Thin, white, winding trails on leaves; heavy mining can result in white blotches on leaves and leaves dropping from the plant prematurely; early infestation can cause fruit yield to be reduced; adult leafminer is a small black and yellow fly which lays its eggs in the leaf; larvae hatch and feed on leaf interior

### **Cause**

Insects

### **Comments**

Mature larvae drop from leaves into soil to pupate; entire lifecycle can take as little as 2 weeks in warm weather; insect may go through 7 to 10 generations per year

### **Management**

Check transplants for signs of leafminer damage prior to planting; remove plants from soil immediately after harvest; only use insecticides when leafminer damage has been identified as unnecessary spraying will also reduce populations of their natural enemies

#### **Onion maggot *Delia antiqua***

### **Symptoms**

Stunted or wilting seedlings; plant will commonly break at soil line if an attempt is made to pull it up; if infestation occurs when plants are bulbing, bulbs will be deformed and susceptible to storage rots after harvest; adult insect is a greyish fly which lays white, elongate eggs around the base of the plant; the larvae that emerge from the eggs are tiny and white and bore into the onion plant; mature larvae are about 1 cm (0.4 in) long with feeding hooks

### **Cause**

Insect

## **Comments**

Females can lay several hundred eggs during their 2-4 week lifespan; insect overwinters as pupae in the soil

## **Management**

Management of onion maggots is heavily reliant on good sanitation; all bulbs should be removed at the end of the season as maggots will die without a food source; commercial onion growers must often rely on the application of appropriate granular insecticides and, in some cases, insecticide sprays are also required; home gardeners should try to remove any volunteer wild onion and chive plants as these can act as an infection source; floating row covers may provide protection by preventing females from laying eggs around the plants

## **Thrips *Thrips tabaci***

### **Symptoms**

Leaves turning silver to gray in color; leaves twisted and dying

### **Cause**

Insect

### **Comments**

Insect favors hot, arid conditions; builds up immunity to insecticides quickly

## **Thrips (Onion thrips, Western flower thrips) *Thrips tabaci***

*Frankliniella occidentalis*

### **Symptoms**

Discolored, distorted tissue; scarring of leaves; severely infected plants may have a silvery appearance

### **Cause**

Insect

### **Comments**

Thrips are most damaging when they feed at the early bulbing stage of development; both onion thrips and western flower thrips have an extensive host range and can be introduced from other plants

## **Management**

Natural enemies include some species of predatory mite, pirate bugs and lacewings; avoid planting onion in close proximity to grain fields as thrips populations build up on these plant in the spring; overhead irrigation of plants may help reduce thrips numbers; apply appropriate insecticides at first sign of thrips damage

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# Lemon grass

## Description

Lemongrass, *Cymbopogon citratus*, is a perennial grass in the family Poaceae grown for its fragrant leaves and stalks which are used as a flavoring. The grass grows in dense clumps and has several stiff stems and slender blade-like leaves which droop towards the tips. The leaves are blue-green in color, turning red in the Fall and emit a strong lemon fragrance when damaged. Lemongrass produces large compound flowers on spikes when grown in the tropics, but rarely flowers when grown in more Northern latitudes. Lemon grass can reach a height of 1.8 m (6 ft) and will grow for several years, typically its economical lifespan is 4 years. Lemongrass may also be referred to as ginger grass or citronella grass and likely originates from Sri Lanka or Malaysia although a wild form of the plant is not known.

*Lemon grass stems*

*Lemon grass leaves*

*Lemon grass*

## Uses

The stalks (leaf bases) of the plant are commonly used to flavor dishes in Southeast Asian cooking. The heart of young shoots may be cooked and consumed as a vegetable. The tougher leaves are used to flavor dishes but are typically removed before serving. Leaves may also be used to make lemon grass tea. The essential oil extracted from the leaves is commonly used in insect repellents, perfumes and soaps.

# Propagation

**Basic requirements** Lemongrass is a tropical plant and as such will grow best in warm, sunny and humid conditions of the tropics and subtropics. The plants can be grown at temperatures ranging from 10 to 33°C (50-91.4°F) but will grow optimally at temperatures between 25 and 30°C (77–86°F). The grass will grow in a wide range of soils but grows best in well-draining, fertile loam with a pH between 5.0 and 8.4. The grass can also be successfully grown in containers. Plants can be successfully grown in full sun or partial shade. **Propagation** As a clumping grass, lemongrass can be easily propagated by dividing stalks from the rhizome of a well established plant. The rhizome is best divided in the Spring in areas where the plant can be overwintered outdoors. In colder areas, the bulbous shoot base can be saved after harvest and stored for use the following Spring. The bulb can be divided prior to planting by slicing through the rhizome with a sharp spade or trowel. Ensure that each new plant has its own rootstock. **Planting** Commercially grown lemongrass is planted at a higher density than in the home garden with a within row spacing of 20 cm (8 in) and 40 cm (16 in). In the home garden, plants should be spaced between 90 and 150 cm (36-60 in) apart. Prepare the soil for planting by working in 2 to 4 inches of compost. **General care and maintenance** Lemongrass requires regular rainfall and if being grown in drier climates the plants should be watered and misted regularly. Plants have a heavy requirement for nitrogen during the growing season and should be fertilized with a balanced soluble fertilizer once a month. Container grown plants should be fed more frequently. Lemongrass can grow very large and will quickly out compete weeds. However, younger plants should be kept free by carefully cultivating or hand pulling any weeds from around the plants. **Harvesting** Lemongrass can be harvested at any time once the stalks have reached 1.3 cm (0.5 in) in diameter. Harvest stalks by cutting them at ground level with a sharp knife, or by bending the stalk and twisting.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### Rust *Puccinia nakanishikii*

*Rust symptoms on lemongrass*

*Rust pustules on lemongrass*

*Rusted lemongrass plant*

*Rust on lemongrass foliage*

*Rusted lemongrass*

## Symptoms

Light yellow spots on foliage; brown elongated streaks on leaves; dark brown pustules on underside of leaves; death of leaves and plant

**Cause**

Fungus

**Comments**

Spores can survive on lemon grass debris on ground; spread by wind, rain and watersplash

**Management**

Promote vigorous growth of plants by using mulches and fertilizer to stimulate growth; prune out diseased parts of plants to allow healthy regrowth; avoid overhead irrigation where possible

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# Lemon

## Description

Lemon, *Citrus limon*, is a small evergreen tree in the family Rutaceae grown for its edible fruit which, among other things, are used in a variety of foods and drinks. The tree has a spreading, upright growth habit, few large branches and stiff thorns. The tree possesses large, oblong or oval, light green leaves and produces purple-white flowers in clusters. The lemon fruit is an ellipsoid berry surrounded by a green rind, which ripens to yellow, protecting soft yellow segmented pulp. Lemon trees can reach 3–6 m (10–20 ft) in height and can live for many years, reaching full fruit bearing capacity in approximately 40 years. Lemon may also be referred to as bush lemon or Persian apple and likely originated from the eastern Himalaya of India.

*Seeds inside fruit*

*Fruit*

*Lemon tree*

*Fruit sliced open to reveal flesh*

*Cluster of lemon fruits*

*Lemon fruit ripening on tree*

## Uses

Due to their bitter taste, lemon fruit is not usually consumed fresh. It is used widely to make juices such as lemonade, as garnishes in cooking and as a flavoring in cooking and baking.

# Propagation

**Requirements** Lemon is a subtropical plant and the trees grow best in regions with a pronounced change in season. They will grow best at temperatures between 26–28°C (79–82°F) and are very sensitive to cold. Trees and fruit will be damaged or killed by freezing conditions without protection. The trees will tolerate drought conditions but perform poorly in water-logged soil. Trees will grow best when planted in a well-draining sandy loam with a pH between 6.0 and 7.5. Soil must be deep enough to permit adequate root development. Lemon trees will grow best when positioned in full sunlight.

**Budding** Budding should be carried out when seedling stems have reached roughly the diameter of a pencil (6–9 mm/0.25–0.36 in) and at a time when the bark of the rootstock tree is slipping (this is the term used to describe a period of active growth when the bark can be easily peeled from the plant). Twigs (budwood) should be collected from the previous growth flush or the current flush so long as the twig has begun to harden. The twigs should have well developed buds and should be as close as possible to the diameter of the rootstock onto which it will be joined. It is extremely important to only collect budwood from disease-free trees. The use of diseased budwood can cause the spread of many serious citrus diseases which can kill trees. The budwood to be used for propagation should be trimmed to create budsticks which are 20–25 cm (8–10 in) by removing any unwanted wood and leaves. These budsticks can be stored for 2–3 months under the correct conditions but it is best to use them as soon as possible after cutting. The simplest way to join the budwood to the rootstock is by T-budding. The area to be joined should be pruned to remove any thorns or twigs and the cut made approximately 15 cm (6 in) from the ground. Using a sharp knife, a 2.5–3.8 cm (1–1.5 in) vertical cut should be made in the stem of the rootstock, through the bark. A horizontal cut should be made at either the top or the bottom of the vertical cut to produce a ‘T-shape’. The horizontal cut should be made a slightly upward-pointing angle and should reach through the bark. Remove a bud from a budstick by slicing a thin, shield-shaped piece of bark and wood from the stem, beginning about 1.25 cm (0.5 in) above the bud. This piece should measure 1.9–2.5 cm (0.75–1.0 in) in length. Immediately insert the piece of bud into the cut on the rootstock by sliding it under the opened bark so that the cut surface lies flat against the wood of the rootstock plant. Finish the join by wrapping the bud with budding tape. After the union has formed and the tape is removed, the bud is forced to grow by cutting the rootstock stem 2.5–3.9 cm (1.0–1.5 in) above the join about 2/3 of the way through the stem on the same side as the join. The top of the seedling should then be pushed over towards the ground. This process, known as ‘elopping’ allows all of the nutrients to be diverted to the bud. Once the bud begins to grow and reaches several inches in length, the lop can be removed completely from the seedling.

**Planting seedlings** Lemon trees can be purchased as seedlings which have already been grafted and only require planting in the garden or orchard. The best time to plant citrus trees is in Spring after all danger of frost has passed in your area. Trees should be planted at or higher than the level of the nursery pot. Once the tree is positioned in the planting hole, backfill the soil by about half and water to allow the soil to settle around the lower roots before filling in the hole. The newly planted tree should be watered every few days.

**General care** Newly planted trees require proper irrigation to ensure they become established. During the first year, water should be applied at the base of the trunk so that the root ball is kept moist to allow the roots to establish in the soil. Newly planted trees should be provided with water every 3–7 days. The soil should be moist, but not wet. Trees planted in sandy soils will require water more frequently. Young trees will also require a light application of fertilizer every month in the first year. Lemon trees will need protection from cold temperatures to prevent damage. Soil can be mounded up around the trunk during the winter and removed in the Spring. Young trees can also be protected from frosts by covering them with tarps or blankets as required.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Anthracnose** *Colletotrichum gloeosporioides*

*Dark spores on spots*

*Anthracnose symptoms on lemon leaf*

#### Symptoms

Dieback of twigs; premature leaf drop; dark staining on fruit; leaves and twigs covered in dark spores.

#### Cause

Fungus

#### Comments

Disease common during wet Springs or long periods of wet weather late in season.

#### Management

If disease is damaging then appropriate fungicides should be applied to whole tree.

##### **Armillaria root rot (Mushroom root rot)** *Armillaria mellea*

*Mycelial mats on wood*

*Armillaria spp. often produce abundant quantities of white spores*

*Mushrooms of Armillaria*

#### Symptoms

Trees may wilt suddenly and collapse or decline slowly; leaves become chlorotic and drop from tree; if large parts of root are destroyed then whole canopy is affected; trunk may have area of rotting bark at the base; lesions on the trunk resemble *Phytophthora* gummosis; clusters of mushrooms may be present at the bottom of the tree and fan shaped mycelial mats are often present between the bark and the wood.

#### Cause

Fungus

#### Comments

Healthy trees are usually infected by infected pieces of wood or tree stumps which have been left in the ground after an orchard is cleared.

#### Management

Disease is difficult to control once it becomes established in an orchard; affected trees showing signs of decline should be removed along with as much of the roots system as possible; area where infected tree was should not be replanted with healthy citrus for a period of at least one year; fumigating soil can help to reduce soil inoculum but is not always completely effective.

##### **Black root rot** *Thielaviopsis basicola*

### **Symptoms**

Small brown-black lesions on roots which may coalesce and turn entire root black; root cortex may slough off to reveal the vascular tissue below; leaves of plant may be chlorotic.

### **Cause**

Fungus

### **Comments**

Serious disease of glasshouse grown citrus trees; pathogen usually drops to non-damaging levels after tree is transplanted to the field.

### **Management**

Keep glasshouses well lit and warm during winter to encourage vigorous root growth; use good quality potting soil which provides good aeration.

## **Mal secco *Phoma tracheiphila***

*Discolored wood on lemon tree infected with mal secco*

*Lemon tree infected with mal secco*

*Lemon tree infected with mal secco*

### **Symptoms**

Chlorosis of leaf veins; wilting leaves which drop from plant; the midrib of fallen leaves may have a red discoloration; infected bark may turn silver-grey in color.

### **Cause**

Fungus

### **Comments**

Disease a major problem in citrus growing areas in Mediterranean.

### **Management**

Spread of the disease into new areas can be prevented through the use of clean planting material; if trees become infected, diseased shoots and branches should be pruned out as soon as possible; avoid over head irrigation; trees can be protected from the disease by spraying with copper fungicides.

## **Category : Bacterial**

### **Bacterial canker (Blast) *Pseudomonas syringae***

#### **Symptoms**

Water-soaked or black lesions on leaf petioles; which rapidly expand along the leaf midrib; cankers on twigs and branches; twigs may be girdled and die; leaves turning black and dying; black lesions may be present on fruit.

#### **Cause**

Bacterium

#### **Comments**

Symptoms most severe on south facing side of tree exposed to winds.

#### **Management**

In areas where disease is severe, copper fungicides should be applied in Fall and Winter prior to the first rains.

## **Citrus canker *Xanthomonas axonopodis***

*Symptoms on fruit*

*Symptoms on leaves*

### **Symptoms**

Raised lesions on leaves, often at leaf margin or tip; lesions may also be present on twigs and fruits; young lesions are usually surrounded by yellow halo; depressed brown craters formed from collapse of lesions.

### Cause

Bacterium

### Comments

Bacteria survive in lesions; the main method of spread is via wind driven rain; bacteria may enter through pruning wounds.

### Management

If the disease is introduced to an area, all infected trees should be removed and destroyed; in areas where disease is endemic, windbreaks can help to reduce disease severity; cultural control of the disease should focus on controlling leaf miner populations, utilizing wind breaks and applications of copper sprays.

## Huanglongbing (Citrus greening, Yellow dragon disease) *Candidatus Liberibacter asiaticus*

*Candidatus Liberibacter africanus*

*Candidatus Liberibacter americanus*

citrus greening (*Candidatus Liberibacter asiaticus*) infected leaves

Symptoms of citrus greening (*Candidatus Liberibacter asiaticus*)

citrus greening (*Candidatus Liberibacter asiaticus*) symptoms

### Symptoms

Yellowing of one limb or one area of canopy; yellowing of leaf veins; blotchy mottling on leaf blades; twig and limb dieback; fruits dropping prematurely; small upwardly pointing leaves; small, misshapen fruit; fruit very bitter.

### Cause

Bacteria

### Comments

**History** Origins and spread Huanglongbing, or citrus greening, was first reported from Southern China in 1919 by American botanist Otto August Reinking who described a "yellow shoot" disease of citrus while evaluating diseases of economic plants in Southern China. A subsequent field survey conducted between 1941 and 1955 on citrus plants in the provinces of Guangdong, Fujian and Jiangxi by Chinese plant pathologist Lin Kongxiang (Kung Hsiang) determined that the disease likely originated in Chaozhou county in Guangdong as early as the 1870s. Lin adopted the name the local farmers had given to the disease of "huang long bing", which translates to "yellow dragon disease", a reference to the yellow coloration of new shoots on the infected trees. By 1936 Huanglongbing was considered a serious disease of citrus in China and it subsequently spread across Southeast Asia reaching Indonesia in 1948 and Taiwan in 1950 before spreading to the Philippines, Thailand and Malaysia in the 1950s, 60s and 70s respectively. The disease has been known by various names in different countries - "greening" in South Africa, "mottle leaf" in the Philippines, "dieback" in India and "vein phloem degeneration" in Indonesia - but in 1995 the disease was officially named Huanglongbing by the International Organization of Citrus Virologists (IOCV) and this name is now widely used to describe the disease in Africa, America and Asia. **Biology and ecology** The organism that causes Huanglongbing is a Gram-negative bacterium that is limited to the plant phloem - the plant system responsible for the delivery of sugars from the leaves to the growing parts of the plant. The bacteria involved have so far not been isolated and cultured but the disease is believed to be caused by bacteria belonging to the genus *Candidatus Liberibacter*. It is believed that there are at least two different forms of the disease, an African heat-sensitive form, *L. africanus* which survives in cool areas with temperatures below 30-32 C, and an Asian heat-tolerant form which occurs in areas where temperatures greatly exceed 30C. A third species, *L. asiaticus*, found in .A third species, *L. americanus* was detected in citrus trees in Sao Paulo, Brazil but there is presently little information on its climatic requirements. As this species is found in the same areas as *L. asiaticus* it seems likely that it has similar requirements. **Transmission** Huanglongbing can be transmitted by citrus psyllids or by grafting. The Asian citrus psyllid, *Diaphorina citri* is responsible for the spread of the disease in Asia and Oceania, Brazil and North America whereas the African citrus psyllid, *Trioza erytreae* is the main vector in Africa and Madagascar. Both psyllid species are present in the Indian Ocean islands of Reunion and

Mauritius, *Citrus psyllids* Citrus psyllids are tiny (3-4 mm) sap-sucking insects that excrete a sticky, sugary substance called honeydew. Both the Asian and African citrus psyllids are mottled brown in color but the Asian citrus psyllid possesses a brown head and the African species has a black head. Adult citrus psyllids will jump and/or fly for a short distance when they are disturbed. They are usually found on the undersides of leaves, often in high numbers. When a psyllid feeds on an infected plant, it acquires the disease after 15 to 30 minutes and feeding and is able to transmit the disease to new hosts after a period of 21 days. In order to transmit the disease successfully, the psyllids need only feed on a new host for a period of 15 minutes in order for successful transmission to occur. It is hypothesized that the bacterium multiplies within the body of the psyllid prior to transmission but this theory requires validation through experiments. *Grafting* Although the primary method of spread of the Huanglongbing bacterium is via the movement of citrus psyllids, the disease can also be transmitted through grafting practices. The ability of Huanglongbing to be transmitted by grafting was first demonstrated by Lin Kongxiang through experimental work which was published in 1956. The disease is not transmitted at high rates through grafting as not all buds on infected trees contain the bacterium.

### **Management**

**Control (i)** Cultural control Once a tree becomes infected with HLB, it cannot be cured. Control is therefore reliant on preventing the disease occurring in the first place and this is achieved through strict quarantining to prevent the introduction of citrus psyllids to areas which are currently free of the pest. Areas which are subject to quarantine have restrictions placed on the movement of citrus plants, fruit, equipment and items made from citrus. Infected trees should be removed as quickly as possible from plantations and destroyed. Identification of infected trees should be achieved through several surveys to ensure that infected trees which are not yet showing symptoms are identified. In Florida, the recommendation is to scout groves at least 4 times a year for disease symptoms. **(ii)** Control of citrus psyllids Citrus psyllid populations can be controlled through the application of chemical sprays. Insecticides have proved very effective at controlling *T. eryreae* in South Africa where systemic insecticides are applied to the tree at the base of the trunk. In areas of the USA, Citrus health management areas (CHMAs) have been created to encourage neighbouring growers to work together to prevent the disease. Control strategies which have been implemented by the program include scouting, mapping and large-scale spraying to control citrus psyllids.

## **Category : Viral**

### **Tristeza disease** Citrus tristeza virus (CTV)

#### **Symptoms**

Light green foliage; poor new growth; leaves may be dropping from tree; young trees blooming early; severely infected trees are stunted and bushy in appearance with chlorotic leaves and brittle twigs; some strains of the virus cause elongated pits in the trunk and branches which give the wood a rope-like appearance.

#### **Cause**

Virus

#### **Comments**

Disease spread from infected grafting material or by aphids.

#### **Management**

Quarantine procedures are used to control tristeza and prevent the pathogen from entering areas which are currently free of the disease.

## **Pests**

### **Category : Insects**

### **Aphids (Black citrus aphid, Brown citrus aphid)** *Toxoptera aurantii* *Toxoptera citricida*

*Brown citrus aphids on leaves*

*Brown citrus aphid (Toxoptera citricida)*

### Symptoms

Leaves curling; leaves and twigs covered in sticky substance which may be growing sooty mold; trees may show symptoms of tristeza (see entry); insects are small and soft bodied and are black in color.

### Cause

Insect

### Comments

Aphids transmit tristeza virus on citrus.

### Management

Aphid numbers tend to naturally decline as leaves harden off but can be a problem on young trees or varieties which continually produce flushes of new growth; pesticides are not generally recommended due to resistance and trees can withstand a high degree of leaf curling.

## **Citrus leaf miner** *Phyllocnistis citrella*

*Tunneling caused by leaf miner*

*Leaf curling distortion from citrus leafminer injury*

*Leafminer damage*

*Citrus leafminer (Phyllocnistis citrella) damaged leaves*

### Symptoms

Thin, winding trails on leaves; heavy infestation can result in curled and distorted leaves; adult leafminer is a tiny moth which lays its eggs in the leaf; larvae hatch and feed on leaf interior.

### Cause

Insect

### Comments

Leaf miners attack flushes of young growth and are unable to enter leaves once they harden.

### Management

Insecticide application are rarely warranted in mature orchards as yields are unaffected; young trees should be treated with appropriate insecticides to prevent retarded growth; cultural control methods include removal of water sprouts from trees and refraining from pruning live branches more than once a year to encourage uniform growth flushes which are short in duration.

## **Soft scales (Black scale, Brown soft scale , Citricolla scale)** *Saissetia oleae*

*Coccus hesperidum*

*Coccus pseudomagnoliarum*

*Citricolla scale (Coccus pseudomagnoliarum) on leaves*

*Black scale (Saissetia oleae)*

*Citricolla scale (Coccus pseudomagnoliarum)*

*Brown soft scale (Coccus hesperidum)*

*Brown soft scale (Coccus hesperidum) adults on citrus stem*

## **Symptoms**

Leaves covered in sticky substance and may have growth of sooty mold; reduced tree vigor; leaves and/or fruit dropping from plants; presence of black, brown or gray flattened scales on leaves, twigs and/or branches.

## **Cause**

Insects

## **Comments**

Insects can produce several overlapping generations per year.

## **Management**

Organically acceptable methods of control include the application of horticultural oils and preservation of natural enemies.

## **Thrips *Scirtothrips citri***

*South African citrus thrips*

*(Scirtothrips aurantiii) damaged lime*

*California citrus thrips (Scirtothrips citri)*

## **Symptoms**

Insect feeds under sepals of young fruit and causes a ring of scarred tissue as the rind expands; adult thrips are orange-yellow in color.

## **Cause**

Insect Citrus thrips

## **Comments**

Insects overwinter on trees as eggs and can undergo multiple generations per year.

## **Management**

Insecticide application is rarely required as healthy trees can withstand heavy feeding damage; insecticides can actually promote thrips populations by stimulating reproduction.

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# Lentil

## Description

Lentil, *Lens culinaris*, is a bushy, annual legume in the family Fabaceae grown for its edible seeds which are cooked and eaten. The lentil plant is slender and erect or sub-erect and has branching, hairy stems. The leaves of the plant are arranged alternately and are made up of 4–7 individual oval leaflets. The plant produces small blue, purple, white or pink flowers arranged on racemes with 1–4 flowers. The seeds, or lentils, are produced within rhomboidal pods and can range in size from 2–9 mm (0.1–0.3 in) in diameter depending on the variety and can be red-orange, yellow, green or black in color. There are generally 1–2 lentils per pod. Lentil plants can reach 15–75 cm (6–30 in) in height and as annuals, survive only one growing season. Lentil may also be referred to as red dhal or split pea and its origin is unknown although it is grown widely in Europe, Asia, and North Africa.

*Lentil plants growing in a field*

## Uses

The lentil seeds can be eaten raw or are cooked and eaten in soups and other dishes. They are commonly eaten as dahl (lentil seeds which have had the husk removed and then split). Lentil seeds can be used as a source of starch for the textile industry or can be ground into flour. The younger pods are sometimes eaten as vegetables.

## Propagation

**Basic requirements** Lentils are adapted to grow in cool climates and are tolerant of some light frost. Lentil plants can be grown on a wide variety of soils from sandy soils to clay loams but will grow optimally in a sandy, well-draining soil with a pH of 4.5 to 8.2. A soil pH of close to 7 is ideal. Lentils will be killed by waterlogged soil so good drainage is very important. Growing lentils on a South or East facing slope will help to warm the crop early in the growing season. The optimum temperature for their growth is approximately 24°C (75°F). Lentils require an average rainfall of 10 to 12 inches per year but are fairly tolerant of drought although yield will be reduced. Yield will also be reduced by high humidity which promotes vegetative growth. **Propagation** Lentils are propagated by seed and are either sown by broadcasting or by drilling in rows. Seed should be sown in soil which is firm and which has been prepared to a fine tilth. Seeds should be planted at a depth of 2.5–5.0 cm (1–2 in), leaving 20–30 cm (7.8–12 in) between individual plants and 15–18 cm (6–7 in) between rows. Due to the small size of the seeds, seedlings struggle to emerge if planted too deep in the soil. Commercial fields are planted at rates of between 30 and 80 kg of seed per acre, depending on the variety, when lentil is the sole crop being grown. The best yields are achieved when lentil is planted by drilling which ensures a uniform planting depth. In many countries where lentil is commercially produced, lentils are intercropped with crops such as rice or barley and seeding rates are reduced accordingly. **General care and maintenance** Lentil seeds are often inoculated with nitrogen-fixing bacteria prior to planting. These bacteria nodulate the plants, allowing them to fix atmospheric nitrogen found in the soil. Lentils should be inoculated with *Rhizobium leguminosarum* within 24 hours of planting if the planting field was not previously used to grow lentils or other legumes. If the nitrogen level in the soil is low at time of planting then an early nitrogen supplement should be applied at a rate of 30 to 40 lb per acre. This ensures that the seedlings have enough nitrogen while the root nodules develop. Lentils have high requirements for sulfur, potassium and phosphorus and a soil test should be used to establish the level of these nutrients in the soil and thus the rate at which they should be applied if the soil is found to be deficient. Optimum soil tests range 15 to 30 ppm (30 to 60 lb/acre) for P and 90 to 120 ppm (180 to 240 lb/acre) for K for most soils. Lentils do not compete well with weeds and the planting site should be cleared by hoeing prior to the seeds being planted. Lentils should be kept evenly moist and watering should be ceased when the pods have begun to dry out. **Harvesting** Lentils are ready to harvest when the plants turn yellow and the lower seed pods are yellow-brown in color. Plants should be watched carefully as this will happen over a period of a few days and the pods are easily shattered if left too long on the plants. Commercially grown lentil is harvested by swathing and the pods are threshed to collect the seeds. In the home garden, the pods can be picked from the plants or the whole plant can be gently pulled from the ground and set to dry on a rack for 1 to 2 weeks. The seeds can then be extracted from the dried pods by breaking them open and removing the seeds.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Anthracnose** *Colletotrichum truncatum*

##### **Symptoms**

Tan lesions with darker borders on leaves which often appear prior to flowering or shortly after bloom; diseased leaves may drop from the plant prematurely; tan to light brown lesions appear on lower stems and begin to spread upwards, appearing higher on the plant; lesions may contain numerous black dots; as plant matures, the lesions expand and may cover large areas of the stem; lesions may also be present on pods and are light to tan brown with a dark margin; diseased pods often produce discolored seeds; disease can cause severe losses in yield

##### **Cause**

Fungus

##### **Comments**

Disease emergence is favored by wet conditions; fungus is spread by splashing water; faba beans and field peas are alternate hosts for the fungus

##### **Management**

There are no varieties of lentil which are completely resistant to the disease but some are less susceptible than others and can be planted in areas where disease is prevalent; a well-timed application of an appropriate fungicide may be enough to control the disease but should be reapplied in the event of persistent wet weather

#### **Ascochyta blight** *Ascochyta pinodella*

*Ascochyta lesions on lentil leaf*

*Ascochyta symptoms on lentil plant*

##### **Symptoms**

Tan to light brown lesions with a dark border can appear on any aerial part of the plant (leaves, stems, pods, petioles, peduncles); during periods of high humidity, numerous black dots may be visible in the center of the lesions; diseased plants may abort flowers and/or fruits; seeds may be discolored

##### **Cause**

Fungus

##### **Comments**

Disease can be transmitted to seedlings from infected seeds; foliar transmission is favored by cool, moist soils

##### **Management**

Plant only disease-free seed or seed treated with a fungicide prior to planting; rotate crop away from lentil for a period of three years; remove and destroy all lentil crop residue after harvest to reduce the levels of inoculum the following growing season; a single application of an appropriate foliar fungicide is usually enough to control the disease but should be reapplied during persistent wet weather

#### **Powdery mildew** *Erysiphe pisi*

##### **Symptoms**

Yellow spots on upper surface of leaves; powdery gray-white areas which coalesce to cover entire plant; if plant is heavily infected it may appear light blue or gray in color

##### **Cause**

Fungus

##### **Comments**

Fungus overwinters on plant debris or alternate host; disease emergence is favored by warm, dry weather with cool nights that result in dew formation

### **Management**

Plant resistant varieties, particularly if sowing late; use overhead irrigation (washes fungus from leaves and reduces viability); plant crop as early as possible; frequent applications of sulfur may be required to control heavy infestations

## **Pests**

### **Category : Insects**

#### **Cutworms** *Agrotis* spp.

##### **Symptoms**

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5â€“5.0 cm (1â€“2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed

##### **Cause**

Insects

##### **Comments**

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato

##### **Management**

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically

### **Category : Others**

#### **Damping-off** *Pythium ultimum*

*Rhizoctonia solani*

##### **Symptoms**

Failure of seedling to emerge; light brown, seedlings with light brown to redwater-soaked roots and stems; collapse of plants; plant dry up and die; stunted plant growth; rotting taproot with few lateral roots

##### **Cause**

Fungi

##### **Comments**

Occurs more often in cold temperatures when growth of seedlings is slow and in moist soil

##### **Management**

Treat seeds with fungicide prior to planting

#### **Fusarium wilt** *Fusarium oxysporum*

##### **Symptoms**

Weak and wilting leaf stems, leaves and flowers; lower leaves drying out and dying; leaves turning brown or pale yellow; splitting the stem reveals discoloration of the inner tissue; leaves turn dull yellow in color and collapse; disease appears in fields in patches

**Cause**

Fungus

**Comments**

Disease emergence favors warm, moist soils; disease can be spread by water splash, movement of infected soil and plants and by infected seed

**Management**

The primary method of controlling the disease is to use resistant varieties; damage can be reduced by application of appropriate fungicides; crop debris should be removed or plowed deeply into the soil after harvest; if disease is present in the soil then a rotation to a non-host for a period of three years can reduce the levels of inoculum in the soil

**Gray mold** *Botrytis cinerea***Symptoms**

Plants turning yellow and wilting; diseased tissue covered with fuzzy gray fungal growth during periods of high humidity; lesions may girdle the stem and cause the upper canopy to die; if the disease does not girdle the stem, the upper leaves remain green and the lower canopy becomes necrotic

**Cause**

Fungus

**Comments**

Disease emergence is favored by cool, wet conditions and dense canopies which promote high humidity in the lower canopy; disease can be transmitted by infected seed or from infested crop debris from the previous year

**Management**

Plant only pathogen-free seed or seed treated with an appropriate fungicide prior to planting; avoid planting lentils in fields or areas adjacent to fields which had an outbreak of gray mold the previous year; remove and destroy lentil crop residue after harvest; applications of appropriate fungicides can be helpful for controlling the disease

**Mosaic** Alfalfa mosaic virus (AMV)

Bean yellow mosaic virus (BYMV)

Pea enation mosaic virus (PEMV)

**Symptoms**

Mottled dark and light green patterns on leaves; leaves may be distorted; yellow dots may be present on leaves; growth of plant may be reduced

**Cause**

Virus

**Comments**

Viruses are transmitted by aphids

**Management**

Plant virus-free seed; plant resistant varieties

**Sclerotinia rot** *Sclerotinia rolfsii***Symptoms**

Lesions girdle stem causing upper plant parts to become chlorotic and wilted; plants become necrotic after they die; disease often causes a patchwork of symptomatic plants throughout a field with plants initially becoming chlorotic and finally dying; fungus causes characteristic white lesions on stems which may be covered in a fluffy white growth during periods of wet weather

**Cause**

Fungus

**Comments**

Disease emergence is favored by cool, wet conditions and a dense canopy which promotes high humidity

**Management**

A long rotation to small grains can help to reduce the levels of inoculum in the soil; control of the disease using appropriate fungicides can be difficult to achieve as the disease is favored by dense plant canopies which can be hard to penetrate with chemicals

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# Lettuce

## Description

Lettuce, *Lactuca sativa*, is a leafy herbaceous annual or biennial plant in the family Asteraceae grown for its leaves which are used as a salad green. The lettuce plant can vary greatly in size, shape and leaf type but generally, the leaves of the plant form a dense head or loose rosette. The stem of the plant is short, with larger leaves arranged at the bottom and becoming progressively smaller further up the stem. Leaves can be smooth or curly and are usually green or red in color. The lettuce plant can grow to a height of 30–100 cm (12–40 in) in height and is typically grown as an annual, harvested after only one growing season. Lettuce may be referred to as garden lettuce and is believed to originate from Asia Minor and the Middle East.

*Close-up of lettuce leaves*

*Red leaf lettuce*

*Heads of lettuce*

*Iceberg lettuce*

*Red leaf lettuce*

*Head of lettuce*

## Uses

Lettuce is primarily eaten raw as a salad green. Some varieties can be cooked and eaten as a vegetable.

# Propagation

**Requirements** Lettuce is a cool season crop which will grow optimally at daytime temperatures of 15–20°C (59–68°F). The plant can be grown in a wide range of soils as long as it is fertile and moisture retaining due to the small root system of the plant. It is often grown in alkaline soil (pH greater than 7.0) but will not tolerate acid soil. Heat tolerant varieties can be grown over the summer months and care should be taken to protect the leaves from strong sun by shading or covering to prevent the plants from bolting. **Sowing seeds** Lettuce seeds can be sown directly in the garden or field as soon as the soil can be worked as the seeds will germinate at temperatures of 4.4°C (40°F) and above and seedlings will tolerate a light frost. Seeds should be sown 0.3–0.6 cm (1/8–1/4 in) deep and 2.5 cm (1 in) apart, leaving 50 cm (20 in) between rows. Cover the seeds lightly, tamp the soil and water the seeds. Seedlings should emerge in 2–15 days. When the plants have 2–3 true leaves then they should be thinned to a final spacing of 25–45 cm (10 to 18 in) depending on the variety. Plant new seeds every 2–3 weeks for a continuous harvest. **Transplants** Sow seeds in seedling trays in a sterile seed starting mix at a rate of approximately 3–4 seeds per inch (2.5 cm). Young plants can be potted up into larger pots or cell trays when they are about 2 weeks old. Plant transplants in the garden after hardening off, spacing plants 25–45 cm (10 to 18 in) (depending on variety) and allowing 50 cm (20 in) between rows. Plant new seeds every 2–3 weeks for a continuous harvest.

Lettuce seedlings

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Anthracnose (Shot-hole)** *Microdochium panattonianum*

##### **Symptoms**

Small water-soaked tan spots on outer leaves which may expand and turn straw colored; centers fall out of mature lesions giving plant a shot-hole appearance

##### **Cause**

Fungus

##### **Comments**

Fungus survives in crop debris in soil; disease spread by splashing water

## **Management**

Rotate crops; plow crop debris into soil; control wild lettuce populations around plantation; avoid overhead irrigation

## **Leaf drop (Sclerotinia drop) *Sclerotinia minor***

*Sclerotinia sclerotiorum*

*Plant infected with leaf drop surrounded by healthy plants*

*Lettuce head infected with leaf drop disease*

### **Symptoms**

Wilting of outside leaves which spreads inwards until whole plant is affected; soft watery lesions on leaves; leaves collapse and lie on soil surface; black fungal structures on infected leaf tissue and soil surface

### **Cause**

Fungi

### **Comments**

Fungi can survive in soil for 8-10 years

## **Management**

Disease significantly reduced by application of fungicides immediately after thinning plants; plow soil deeply; rotate crops with non-hosts

## **Powdery mildew *Erysiphe cichoracearum***

*Powdery mildew on lettuce*

*Powdery mildew on lettuce*

### **Symptoms**

White, powdery fungal growth on the top and underside of older leaves; leaves turning yellow or brown; small black fruiting bodies may be visible

### **Cause**

Fungus

### **Comments**

Disease emergence favors humid weather conditions; disease can be spread over long distance by wind movements

## **Management**

Disease can be controlled by application of sulfur at first sign of symptoms, as long as temperatures are high enough

## **Septoria leaf spot *Septoria lactucae***

### **Symptoms**

Small, irregularly shaped chlorotic spots on oldest plant leaves which enlarge and turn brown and dry out; lesions may fall out of leaves creating holes; leaf spots may have chlorotic halos; if plant is severely infected, lesions may coalesce forming large necrotic patches, wilting leaves and plant death

### **Cause**

Fungus

### **Comments**

Fungus survives in infected seed and in crop debris; disease spreads in humid or wet conditions; can be spread by splashing water; wild lettuce is an important overwintering site for the fungus

## **Management**

Plant pathogen free seed; plant in areas where Septoria is uncommon; ideal planting sites are in regions with low rainfall; hot water treatment of seeds prior to planting may help reduce levels of disease

## Category : Viral

### Big vein

*Close-up of lettuce leaf infected with MiLBVV*

*Lettuce infected with MiLBVV,  
enlarged veins clearly visible*

#### Symptoms

Veins enlarged and clear; puckered or ruffled leaves; upright outer leaves

#### Cause

Virus

#### Comments

Virus is soil-borne and is introduced to plants via the fungus *Olpidium brassicae*; disease more prevalent during cool weather

#### Management

Planting resistant varieties is the best method to control MiLBVV

## Category : Other

### Slugs & snails (Gray garden slug, Spotted garden slug, Brown garden snail, European garden snail , etc.)

*Decoratus reticulatum*

*Limax maximus*

*Helix aspersa*

*Cornu aspersum*

*European brown snail*

*Gray garden slug*

#### Symptoms

Irregularly shaped holes in leaves and stems; flowers and fruit may also be damaged if present; if infestation is severe, leaves may be shredded; slime trails present on rocks, walkways, soil and plant foliage; several slug and snail species are common garden pests; slugs are dark gray to black in color and can range in size from 2.5 to 10 cm (1-4 in); garden snails are generally smaller and possess a rounded or spiral shell

#### Cause

Mollusc

#### Comments

Slugs and snails prefer moist, shaded habitats and will shelter in weeds or organic trash; adults may deposit eggs in the soil throughout the season; damage to plants can be extensive

#### Management

Practice good garden sanitation by removing garden trash, weeds and plant debris to promote good air circulation and reduce moist habitat for slugs and snails; handpick slugs at night to decrease population; spread wood ashes or eggshells around plants; attract molluscs by leaving out organic matter such as lettuce or grapefruit skins, destroy any found feeding on lure; sink shallow dishes filled with beer into the soil to attract and drown the molluscs; chemical controls include ferrous phosphate for organic gardens and metaldehyde (e.g. Buggetta) and carbaryl (e.g Sevin bait) for non-organic growers

## Pests

## Category : Others

### Bottom rot *Rhizoctonia solani*

*Close-up of lesions on leaf midrib caused by bottom rot*

*Symptoms of bottom rot on iceberg lettuce clearly showing lesions associated with leaf midribs*

#### **Symptoms**

Small red to brown spots on lower leaves, usually on underside of midrib which may expand rapidly causing the leaves to rot; amber colored liquid may ooze from leaf lesions; as stems rot, head of lettuce becomes slimy and brown and collapse; a tan or brown mycelial growth may be visible in infected tissue

#### **Cause**

Fungus

#### **Comments**

Fungus survives on crop debris in soil; disease emergence favored by warm, wet weather

#### **Management**

Disease is most effectively managed by combining cultural control with fungicide application; plow soil before planting; rotate crops regularly; avoid irrigation close to harvest; plant varieties with an erect growth habit to reduce leaf contact with soil; apply appropriate foliar fungicides

### Downy mildew *Bremia lactucae*

*Downy mildew on lettuce leaves*

*Yellowing leaves caused by downy mildew*

#### **Symptoms**

Light green or chlorotic angular lesions on topside of leaves which turn yellow; fluffy white growth on underside of leaves

#### **Cause**

Fungus

#### **Comments**

Disease favors cool, moist conditions; can be spread via infected seed; fungus survives in plant debris and in wild lettuce plants

#### **Management**

Disease is controlled primarily by planting resistant varieties and/or by applying appropriate fungicides

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# Lime, sour

## Description

Lime, *Citrus aurantifolia*, is a small perennial evergreen tree in the family Rutaceae grown for its sour fruit. The lime tree is irregularly branched and possesses sharp spines. The leaves of the tree are elliptical with small rounded teeth around the edge. The leaves can grow 4–8 cm (1.6–3.2 in) in length. The tree produces small, cupped white flowers and yellowish-green fruit which is round or egg-like in shape. Lime trees can reach 5 m (16 ft) in height and can produce fruit for many years. Lime may also be referred to as sour lime, key lime, Mexican lime, acid lime or West Indian lime and originated in southeast Asia.

*Harvested limes*

*Lime fruit close-up*

*Lime blossom*

*Limes sliced open*

*Lime fruit growing on the tree*

*Lime fruits on the tree*

## Uses

Lime fruit is commonly used to make juices and cordials or for extraction of citric acid. It may be used as a flavoring in cooking. Lime oil can be extracted from the peel of the fruit.

# Propagation

**Requirements** Lime is a tropical plant and the trees grow best in regions with hot summers and warm winters where temperatures are typically between 25 and 30°C (77–86°F). Limes are more sensitive to cold than lemons and trees are killed by freezing conditions without protection. Lime trees are the most drought tolerant of all citrus trees and will grow best when planted in a well-draining sandy loam with a pH between 6.0 and 7.5. Soil must be deep enough to permit adequate root development. Lime trees will grow best when positioned in full sunlight. **Lime propagation** Unlike many other fruit bearing trees, limes are commonly propagated from seed as they will produce offspring that is true to the parent plant. In some cases, trees are propagated by removing offshoots from the main trunk (called suckers) and replanting although, if the tree is grafted, it should be noted that the suckers will be the same variety of the rootstock. **Planting seedlings** The best time to plant citrus trees is in Spring after all danger of frost has passed in your area. Trees should be planted at or higher than the level of the nursery pot. Once the tree is positioned in the planting hole, backfill the soil by about half and water to allow the soil to settle around the lower roots before filling in the hole. The newly planted tree should be watered every few days. **General care** Newly planted trees require proper irrigation to ensure they become established. During the first year, water should be applied at the base of the trunk so that the root ball is kept moist to allow the roots to establish in the soil. Newly planted trees should be provided with water every 3–7 days. The soil should be moist, but not wet. Trees planted in sandy soils will require water more frequently. Young trees will also require a light application of fertilizer every month in the first year. Lime trees will need protection from cold temperatures to prevent damage. Soil can be mounded up around the trunk during the winter and removed in the Spring. Trees can also be protected by stringing Christmas lights in the branches and covering the leaves with tarps. In areas with cold winters, lime trees are best grown in containers which allows them to be moved indoors during the winter months.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Anthracnose** *Colletotrichum gloeosporioides*

*Anthracnose (Colletotrichum acutatum) on Citrus latifolia.*

## **Symptoms**

Leaves dropping prematurely; leaves covered in dark fungal spores; red to green or black streaks on the mature fruits.

## **Cause**

Fungus

## **Comments**

Disease emergence favors warm temperatures.

## **Management**

If disease is damaging then appropriate fungicides should be applied to whole tree.

## **Armillaria root rot (Mushroom root rot) *Armillaria mellea***

*Armillaria root rot (Armillaria solidipes) fruiting bodies*

*Armillaria spp. often produce abundant quantities of white spores.*

*Armillaria mycelial mat*

## **Symptoms**

Trees may wilt suddenly and collapse or decline slowly; leaves become chlorotic and drop from tree; if large parts of root are destroyed then whole canopy is affected; trunk may have area of rotting bark at the base; lesions on the trunk resemble Phytophthora gummosis; clusters of mushrooms may be present at the bottom of the tree and fan shaped mycelial mats are often present between the bark and the wood.

## **Cause**

Fungus

## **Comments**

Healthy trees are usually infected by infected pieces of wood or tree stumps which have been left in the ground after an orchard is cleared.

## **Management**

Disease is difficult to control once it becomes established in an orchard; affected trees showing signs of decline should be removed along with as much of the roots system as possible; area where infected tree was should not be replanted with healthy citrus for a period of at least one year; fumigating soil can help to reduce soil inoculum but is not always completely effective.

## **Black root rot *Thielaviopsis basicola***

## **Symptoms**

Small brown-black lesions on roots which may coalesce and turn entire root black; root cortex may slough off to reveal the vascular tissue below; leaves of plant may be chlorotic.

## **Cause**

Fungus

## **Comments**

Serious disease of glasshouse grown citrus trees; pathogen usually drops to non-damaging levels after tree is transplanted to the field.

## **Management**

Keep glasshouses well lit and warm during winter to encourage vigorous root growth; use good quality potting soil which provides good aeration.

## **Blast *Pseudomonas syringae***

## **Symptoms**

Water-soaked or black lesions on leaf petioles; which rapidly expand along the leaf midrib; cankers on twigs and branches; twigs may be girdled and die; leaves turning black and dying; black lesions may be present on fruit.

## **Cause**

Bacterium

### Comments

Disease emergence favors wet, cool and windy weather.

### Management

In areas where disease is severe, copper fungicides should be applied in Fall and Winter prior to the first rains.

## Melanose *Diaporthe citri*

*Symptoms of Diaporthe citri on citrus twig. The pycnidial conidiomata are visible.*

*Melanose (Diaporthe citri) infected fruit*

### Symptoms

Small brown sunken spots which become raised and surrounded by a yellow halo; lesions eventually turn corky in texture; severe infections can cause newly emerging leaves to be crinkled and distorted; if infection of fruit occurs soon after petal fall, the pathogen causes large lesions on the fruit surface which may coalesce to produce large patches; late infection of fruit causes discrete pustules on the fruit.

### Cause

Fungus

### Comments

Disease is spread short distance through splashing water or over longer distances by wind.

### Management

If young trees become infected, it is possible to control the disease by pruning but this is not usually feasible for older trees; fungicides must be applied frequently in order to control the disease.

## Category : Bacterial

## Citrus canker *Xanthomonas axonopodis*

*Leaves symptom of citrus canker (Xanthomonas citri)*

*Twig symptoms of citrus canker (Xanthomonas citri)*

### Symptoms

Raised lesions on leaves, often at leaf margin or tip; lesions may also be present on twigs and fruits; young lesions are usually surrounded by yellow halo; depressed brown craters formed from collapse of lesions.

### Cause

Bacterium

### Comments

Can cause serious economic losses to grapefruit crop; bacteria survive in lesions; the main method of spread is via wind driven rain; bacteria may enter through pruning wounds.

### Management

If the disease is introduced to an area, all infected trees should be removed and destroyed; in areas where disease is endemic, windbreaks can help to reduce disease severity; cultural control of the disease should focus on controlling leaf miner populations, utilizing wind breaks and applications of copper sprays.

## Category : Other

## Huanglongbing (Citrus greening, Yellow dragon disease) *Candidatus Liberibacter asiaticus*

## *Candidatus Liberibacter africanus*

## *Candidatus Liberibacter americanus*

*Citrus greening (Candidatus Liberibacter asiaticus) infected leaves*

*Citrus greening (Candidatus Liberibacter asiaticus)*

*Symptoms of citrus greening (Candidatus Liberibacter asiaticus)*

*Citrus greening (Candidatus Liberibacter asiaticus) infected leaves*

### **Symptoms**

Yellowing of one limb or one area of canopy; yellowing of leaf veins; blotchy mottling on leaf blades; twig and limb dieback; fruits dropping prematurely; small upwardly pointing leaves; small, misshapen fruit; fruit very bitter

### **Cause**

Bacteria

### **Comments**

**History** *Origins and spread* Huanglongbing, or citrus greening, was first reported from Southern China in 1919 by American botanist Otto August Reinking who described a "yellow shoot" disease of citrus while evaluating diseases of economic plants in Southern China. A subsequent field survey conducted between 1941 and 1955 on citrus plants in the provinces of Guangdong, Fujian and Jiangxi by Chinese plant pathologist Lin Kongxiang (Kung Hsiang) determined that the disease likely originated in Chaozhou county in Guangdong as early as the 1870s. Lin adopted the name the local farmers had given to the disease of "huang long bing", which translates to "yellow dragon disease", a reference to the yellow coloration of new shoots on the infected trees. By 1936 Huanglongbing was considered a serious disease of citrus in China and it subsequently spread across Southeast Asia reaching Indonesia in 1948 and Taiwan in 1950 before spreading to the Philippines, Thailand and Malaysia in the 1950s, 60s and 70s respectively. The disease has been known by various names in different countries - "greening" in South Africa, "mottle leaf" in the Philippines, "dieback" in India and "vein phloem degeneration" in Indonesia - but in 1995 the disease was officially named Huanglongbing by the International Organization of Citrus Virologists (IOCV) and this name is now widely used to describe the disease in Africa, America and Asia. **Biology and ecology** The organism that causes Huanglongbing is a Gram-negative bacterium that is limited to the plant phloem - the plant system responsible for the delivery of sugars from the leaves to the growing parts of the plant. The bacteria involved have so far not been isolated and cultured but the disease is believed to be caused by bacteria belonging to the genus *Candidatus Liberibacter*. It is believed that there are at least two different forms of the disease, an African heat-sensitive form, *L. africanus* which survives in cool areas with temperatures below 30-32 C, and an Asian heat-tolerant form which occurs in areas where temperatures greatly exceed 30C. A third species, *L. asiaticus*, found in .A third species, *L. americanus* was detected in citrus trees in Sao Paulo, Brazil but there is presently little information on its climatic requirements. As this species is found in the same areas as *L. asiaticus* it seems likely that it has similar requirements. **Transmission** Huanglongbing can be transmitted by citrus psyllids or by grafting. The Asian citrus psyllid, *Diaphorina citri* is responsible for the spread of the disease in Asia and Oceania, Brazil and North America whereas the African citrus psyllid, *Trioza erytreae* is the main vector in Africa and Madagascar. Both psyllid species are present the Indian Ocean islands of Reunion and Mauritius, *Citrus psyllids* Citrus psyllids are tiny (3-4 mm) sap-sucking insects that excrete a sticky, sugary substance called honeydew. Both the Asian and African citrus psyllids are mottled brown in color but the Asian citrus psyllid possesses a brown head and the African species has a black head. Adult citrus psyllids will jump and/or fly for a short distance when they are disturbed. They are usually found on the undersides of leaves, often in high numbers. When a psyllid feeds on an infected plant, it acquires the disease after 15 to 30 minutes and feeding and is able to transmit the disease to new hosts after a period of 21 days. In order to transmit the disease successfully, the psyllids need only feed on a new host for a period of 15 minutes in order for successful transmission to occur. It is hypothesized that the bacterium multiplies within the body of the psyllid prior to transmission but this theory requires validation through experiments. **Grafting** Although the primary method of spread of the Huanglongbing bacterium is via the movement of citrus psyllids,

the disease can also be transmitted through grafting practices. The ability of Huanglongbing to be transmitted by grafting was first demonstrated by Lin Kongxiang through experimental work which was published in 1956. The disease is not transmitted at high rates through grafting as not all buds on infected trees contain the bacterium.

### Management

**Control (i)** Cultural control Once a tree becomes infected with HLB, it cannot be cured. Control is therefore reliant on preventing the disease occurring in the first place and this is achieved through strict quarantining to prevent the introduction of citrus psyllids to areas which are currently free of the pest. Areas which are subject to quarantine have restrictions placed on the movement of citrus plants, fruit, equipment and items made from citrus. Infected trees should be removed as quickly as possible from plantations and destroyed. Identification of infected trees should be achieved through several surveys to ensure that infected trees which are not yet showing symptoms are identified. In Florida, the recommendation is to scout groves at least 4 times a year for disease symptoms. **(ii)** Control of citrus psyllids Citrus psyllid populations can be controlled through the application of chemical sprays. Insecticides have proved very effective at controlling *T. eryreae* in South Africa where systemic insecticides are applied to the tree at the base of the trunk. In areas of the USA, Citrus health management areas (CHMAs) have been created to encourage neighbouring growers to work together to prevent the disease. Control strategies which have been implemented by the program include scouting, mapping and large-scale spraying to control citrus psyllids.

## Category : Viral

### Tristeza virus Citrus tristeza virus (CTV)

*Symptoms of tristeza virus on lime leaf*

*Pitting on lime stems caused by infection with tristeza virus*

#### Symptoms

Light green foliage; poor new growth; leaves may be dropping from tree; young trees blooming early; severely infected trees are stunted and bushy in appearance with chlorotic leaves and brittle twigs; some strains of the virus cause elongated pits in the trunk and branches which give the wood a rope-like appearance

#### Cause

Virus

#### Comments

Disease spread from infected grafting material or by aphids

#### Management

Quarantine procedures are used to control tristeza and prevent the pathogen from entering areas which are currently free of the disease

## Pests

### Category : Insects

### Aphids (Black citrus aphid and Brown citrus aphid) *Toxoptera aurantii*

*Toxoptera citricida*

*Brown citrus aphid (Toxoptera citricida) infestation*

*Brown citrus aphid (Toxoptera citricida)*

#### Symptoms

Leaves curling; leaves and twigs covered in sticky substance which may be growing sooty mold; trees may show symptoms of tristeza (see entry); insects are small and soft bodied and are black in color.

#### Cause

Insect

#### Comments

Aphids transmit tristeza virus on citrus.

#### Management

Aphid numbers tend to naturally decline as leaves harden off but can be a problem on young trees or varieties which continually produce flushes of new growth; pesticides are not generally recommended due to resistance and trees can withstand a high degree of leaf curling.

### **Citrus leaf miner** *Phyllocnistis citrella*

Adult citrus leafminer moth

Citrus leafminer larvae

Citrus leafminer infected leaves

Citrus leafminer damaged leaves

#### Symptoms

Thin, winding trails on leaves; heavy infestation can result in curled and distorted leaves; adult leafminer is a tiny moth which lays its eggs in the leaf; larvae hatch and feed on leaf interior.

#### Cause

Insect

#### Comments

Leaf miners attack flushes of young growth and are unable to enter leaves once they harden.

#### Management

Insecticide application are rarely warranted in mature orchards as yields are unaffected; young trees should be treated with appropriate insecticides to prevent retarded growth; cultural control methods include removal of water sprouts from trees and refraining from pruning live branches more than once a year to encourage uniform growth flushes which are short in duration.

### **Soft scales (Black scale, Brown soft scale , Citricolla scale)** *Saissetia oleae*

*Coccus hesperidum*

*Coccus pseudomagnoliarum*

Pyriform scale (*Protopulvinaria pyriformis*)

Soft scale (*Coccus capparidis*)

Citricola scale (*Coccus pseudomagnoliarum*) infestation

Florida red scale (*Chrysomphalus aonidum*)

Citricola scale (*Coccus pseudomagnoliarum*)

#### Symptoms

Leaves covered in sticky substance and may have growth of sooty mold; reduced tree vigor; leaves and/or fruit dropping from plants; presence of black, brown or gray flattened scales on leaves, twigs and/or branches.

#### Cause

Insects

#### Comments

Insects can produce several overlapping generations per year.

### Management

Organically acceptable methods of control include the application of horticultural oils and preservation of natural enemies.

## Thrips *Scirtothrips citri*

*South African citrus thrips  
(Scirtothrips aurantii) damage*

*California citrus thrips (Scirtothrips citri)*

### Symptoms

Insect feeds under sepals of young fruit and causes a ring of scarred tissue as the rind expands; adult thrips are orange-yellow in color.

### Cause

Insect Citrus thrips

### Comments

Insects overwinter on trees as eggs and can undergo multiple generations per year.

### Management

Insecticide application is rarely required as healthy trees can withstand heavy feeding damage; insecticides can actually promote thrips populations by stimulating reproduction.

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# Macadamia

## Description

Macadamia trees belong to the genus *Macadamia* which contains four species of tree or shrub in the family Proteaceae which are grown for their edible seeds (nuts). Cultivated macadamia is a derivative of the subtropical species' *Macadamia integrifolia* and *Macadamia tetraphylla* and their hybrids. Macadamia plants naturally have multiple stems but are trained to a central leader system (single stem) in plantations. The leaves of the trees are oval or oblong and are arranged in whorls of 3 or 4 depending on variety. The tree produces creamy white or pink-red flowers on racemes of 100â€“300 flowers and a rounded fleshy fruit up to 27 mm (1 in) in diameter. The flesh covers a single spherical or elliptical seed (nut) with a white or gray kernel depending on the variety of tree. Macadamia can reach a height of 20 m (65.6 ft) and have a commercial lifespan of 40â€“60 years. Macadamia may also be referred to as Queensland nut or Australian nut and originates from Australia.

*Macadamia tree and fruit*

*Macadamia leaf close-up*

*Macadamia blossoms*

*Macadamia fruits*

*Macadamia blossoms*

*Macadamia tree*

## Uses

The kernels of the macadamia nut are mainly consumed as a snack food. The kernels from *M. integrifolia* and *M. tetraphylla* can be eaten raw from the shell while the remaining Macadamia species contain toxins which must be removed prior to consumption. Macadamia may also be used in baked goods and confectionery.

## Propagation

**Basic requirements** Macadamia trees originate from the sub-tropical rainforests of Australia and therefore tend to grow best in areas of high humidity and high rainfall. They will grow optimally at average annual temperatures between 20 and 25°C (68–77°F) in a deep, well draining loam and sandy loam with a pH between 5.0 and 5.5. Trees should not be planted in heavy clays. It is recommended that macadamia only be planted in frost free areas, young trees will be killed by temperatures of -6°C (21°F) although older, established trees can tolerate some light frost. **Transplanting** When planting numerous macadamia trees in a plantation, consideration must be given to drainage, irrigation, row alignment and wind protection. Planting distances tend to be site specific and are dependent on factors such as the macadamia variety, soil and rainfall. In general, macadamia trees are planted 4 to 8 m (13-26 ft) apart within a row, allowing 7 to 11 m (23-36 ft) between rows. Young trees are planted in Spring and Fall by digging holes which are 45 cm deep and 60 cm in diameter. Once the tree is in position, the hole is backfilled with soil. It is recommended that some compost and rock phosphate be added to the backfill at time of planting. The soil around the tree should then be gently tamped and the tree watered. Staking will help to protect the young trees from wind damage. Grafted trees usually begin to produce fruit 3 years after planting. **General care and maintenance** During the first four years after planting, animal manure and a thick layer of organic mulch can be applied around the trees year round. After this period, the amount of manure added should be decreased to prevent the trees being provided with too much nitrogen and being deficient in potassium. In the first 4 years following planting, vegetative growth should be stimulated through pruning. Once the leading shoot has reached a height of approximately 80 cm (31.5 in) it should be clipped to stimulate branching. Established trees are usually pruned in the Spring when old, unproductive and diseased branches are removed from the canopy. Any nuts remaining on the tree should also be removed. Mulches are best applied after nut harvest to allow the material to decompose before the next crop. Avoid piling mulch up against the trunks to prevent disease. **Harvesting** Grafted trees will begin to produce a crop 3 years after planting but it is not until the 7th year that the crop will be of any economic significance. Trees will give maximum yields 15 to 20 years after planting. Nuts should be collected when they fall from the tree and this should be done every 1-2 weeks during the nut producing periods. In commercial plantations, nuts can be collected mechanically or by hand.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Anthracnose** *Colletotrichum gloeosporioides*

###### **Symptoms**

Black lesions on leaves and fruit; soft black lesions on husks of nuts followed by decay of nuts on the ground; senescent mature nuts may remain attached to the tree; shells of infected husks may turn brown-gray in color but the kernel inside remains unaffected

###### **Cause**

Fungus

###### **Comments**

Disease emergence favors high humidity; fungus survives on plant debris; spores are spread by splashing water

###### **Management**

Avoid stressing trees by providing them with adequate irrigation and fertilization; prune out dead or dying limbs from tree canopy to reduce levels of disease inoculum; control insect pests to prevent stress to trees

##### **Husk spot** *Pseudocercospora macadamiae*

###### **Symptoms**

Initial symptoms of the disease are chlorotic to yellow flecks on the husks which enlarge and develop tan brown centers; lesions coalesce and develop diffuse bright yellow halos; lesions may be covered in powdery gray spore masses during periods of wet weather; lesions mature into tough, woody spots; circular tan spots may develop inside the husk but shells and kernels remain unaffected

###### **Cause**

Fungus

###### **Comments**

Yield losses may result in susceptible varieties due to nuts dropping from tree prematurely; spores are spread by water splash from infected husks; diseased husks may produce spores for up to 2 years following infection

###### **Management**

If variety of macadamia being grown is susceptible to the disease then an appropriate protective fungicide should be applied to the fruits when they are approximately the size of a match head; remove and old and diseased husks from the tree to reduce inoculum levels

##### **Raceme blight** *Botrytis cinerea*

###### **Symptoms**

Small brown spots on flower petals which spread to racemes (flower stalks); infection may affect small flower buds,

florets and rachis; racemes turning black and dying; entire raceme may become blighted within a few days; necrotic flowers remain on tree and become covered in fuzzy gray fungal growth

#### Cause

Fungus

#### Comments

Disease emergence favors wet weather and cool temperatures

#### Management

Fungicide application is not usually warranted unless infection occurs during wet weather which can cause severe infections

### Slow and quick tree decline *Xylaria arbuscula*

*Phellinus gilvus*

*Acremonium recifei*

*Nectria rugulosa*

*Macadamia tree infected with quick decline with healthy trees*

#### Symptoms

Yellowing or browning of some leaves in the tree canopy; subtle change in color of tree canopy from dark to light green; entire tree turning brown; in final stages of disease, whole tree is brown and distinct from green trees around it; tree death may occur in a few months after initial symptoms have appeared

#### Cause

Fungi

#### Comments

#### Management

Remove any dead or diseased trees from the orchard; avoid wounding tree trunks

### Category : Oomycete

### Phytophthora trunk and stem canker *Phytophthora cinnamomi*

#### Symptoms

Nursery trees and young plantations trees are stunted and chlorotic and may be partially defoliated; if lesions girdle the stem then the tree will die; in mature trees, dark discoloration of wood is visible by removing the bark from the trunk of the tree; dark cankers may extend from trunk at soil line to the lower branches of the tree

#### Cause

Oomycete

#### Comments

Fungus survives in plant debris in soil; spread by water splash

#### Management

Plant only disease-free nursery stock; plant trees in well-draining soils on a slight mound to promote drainage and prevent water-logging; avoid wounds to the trunk of the tree which allow fungi to enter; incorporate organic matter into the soil around the tree; apply appropriate protective fungicides to tree trunks prior to wet season;

### Category : Other

#### Rats *Rattus rattus*

*Rattus norvegicus*

*Rattus fuscipes*

Brown rat, *Rattus norvegicus*

### Symptoms

Extensive loss and damage of developing nuts or nuts that have dropped from tree; nuts have holes approximately 1 cm in diameter gnawed through shell to gain access to kernels

### Cause

Rodents

### Comments

Encourage predatory birds such as owls by providing nesting boxes in the trees

### Management

All food sources for rats should be removed from the orchard, this includes old nuts, nut waste and wild tobacco; remove any rat nests from trees; keep grass around trees mown short and, if possible, maintain a clear mown area around the orchard to deter rats from entering and to aid predators such as owls in detecting and hunting rats

## Pests

### Category : Insects

#### Macadamia nut borer *Cryptophlebia ombrodelta*

### Symptoms

Entry holes in husks of nuts, usually close to the panicle; holes usually have insect frass protruding from them and husks may have shallow, dimple-like depressions; infested nuts drop from tree prematurely; insect eggs are scale-like and are laid on the surfaces of green husks; larvae are legless grubs which are pinkish in color when mature with dark green spots; adult insect is a red-brown moth

### Cause

Insect

### Comments

Larvae pupate in damaged nuts; entire lifecycle of the moth is completed in approximately 5 weeks

### Management

Control of macadamia nut borer can be difficult as insecticides are ineffective once the larvae have entered the nuts; appropriate insecticides should be applied if green fallen nuts exhibit damage or live, unparasitized eggs are present on the tree; old nuts should be removed from tree and the orchard ground at harvest

#### Tropical nut borer *Hypothenemus obscurus*

### Symptoms

Numerous round holes approximately 0.5 mm in diameter on husks; extensive tunnelling through husk and shell visible when nut is cut open; in late stage infestations the entire kernel may be consumed

### Cause

Insect

### Comments

Economic damage is usually incurred if the nuts remain on the ground for a period of three weeks or more before harvest

### Management

Control of the tropical nut borer relies on the use of resistant macadamia varieties and cultural control methods including harvesting nuts at three week intervals immediately removing husks, avoiding varieties prone to sticktight and removing damaged nuts from the orchard; applications of appropriate insecticides may be necessary

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# Mandarin oranges

## Description

Mandarin is the group name given to several classes of small oranges that includes mandarins, satsumas, clementines and tangerines which all belong to the species *Citrus reticulata* and the satsuma mandarin *Citrus unshiu*. Generally, mandarin trees are small and spiny with long, slender branches. They can have an erect or drooping growth habit depending on variety. The leaves of the trees are lanceolate and may be hairless or toothed with narrowly winged petioles. The trees produce flowers singly or in clusters and globose fruits with a bright orange to red-orange peel and segmented orange flesh. Mature mandarin trees can reach 7â€“8 m 23â€“26 ft in height and can be very long lived if they do not succumb to disease. Mandarins originate from Southeast Asia.

*Tangerines ripening on the branch*

## Uses

Mandarin oranges are commonly eaten fresh or may be processed for canned segments. They can be pressed or squeezed to produce juice which is used in many beverages. Mandarin essential oil is used as a flavoring in alcoholic drinks.

# Propagation

**Requirements** Mandarin oranges are subtropical plants and the trees grow best in regions with a pronounced change in season. They will grow best at temperatures between 12.8 and 37.8°C (55–100°F) during the growing season and 1.7 to 10°C (35–50°F) during dormancy. Mature mandarin orange trees can survive short periods of freezing, whereas young trees will be killed. Fruit will also be damaged by freezing conditions. The trees will tolerate drought conditions but perform poorly in water-logged soil. Trees will grow best when planted in a well-draining sandy loam with a pH between 6.0 and 7.5. Soil must be deep enough to permit adequate root development. Mandarin orange trees require full sun and should be protected from wind. **Mandarin oranges propagation** Mandarin orange seedlings are usually produced by grafting or budding to an appropriate rootstock as seeds will not produce fruit true to type. Grafting is the process by which a scion from plant is joined to the rootstock of another to produce a new tree. Budding is a special type of grafting where the scion that is joined to the rootstock consists of a single bud. Budding is commonly used in citrus propagation as it is the easier of the two processes and works very well. Common rootstocks for grafting and budding of citrus trees include sour orange and rough lemon. **Budding** Budding should be carried out when seedling stems have reached roughly the diameter of a pencil (6–9 mm/0.25–0.36 in) and at a time when the bark of the rootstock tree is slipping (this is the term used to describe a period of active growth when the bark can be easily peeled from the plant). Twigs (budwood) should be collected from the previous growth flush or the current flush so long as the twig has begun to harden. The twigs should have well developed buds and should be as close as possible to the diameter of the rootstock onto which it will be joined. It is extremely important to only collect budwood from disease-free trees. The use of diseased budwood can cause the spread of many serious citrus diseases which can kill trees. The budwood to be used for propagation should be trimmed to create budsticks which are 20–25 cm (8–10 in) by removing any unwanted wood and leaves. These budsticks can be stored for 2–3 months under the correct conditions but it is best to use them as soon as possible after cutting. The simplest way to join the budwood to the rootstock is by T-budding. The area to be joined should be pruned to remove any thorns or twigs and the cut made approximately 15 cm (6 in) from the ground. Using a sharp knife, a 2.5–3.8 cm (1–1.5 in) vertical cut should be made in the stem of the rootstock, through the bark. A horizontal cut should be made at either the top or the bottom of the vertical cut to produce a ‘T-shape’. The horizontal cut should be made a slightly upward-pointing angle and should reach through the bark. Remove a bud from a budstick by slicing a thin, shield-shaped piece of bark and wood from the stem, beginning about 1.25 cm (0.5 in) above the bud. This piece should measure 1.9–2.5 cm (0.75–1.0 in) in length. Immediately insert the piece of bud into the cut on the rootstock by sliding it under the opened bark so that the cut surface lies flat against the wood of the rootstock plant. Finish the join by wrapping the bud with budding tape. After the union has formed and the tape is removed, the bud is forced to grow by cutting the rootstock stem 2.5–3.9 cm (1.0–1.5 in) above the join about 2/3 of the way through the stem on the same side as the join. The top of the seedling should then be pushed over towards the ground. This process, known as ‘clopping’ allows all of the nutrients to be diverted to the bud. Once the bud begins to grow and reaches several inches in length, the lop can be removed completely from the seedling. **Planting seedlings** Mandarin orange trees can be purchased as seedlings which have already been grafted and only require planting in the garden or orchard. The best time to plant citrus trees is in Spring after all danger of frost has passed in your area. Standard sized trees should be spaced 3.7–7.6 m (12–25 ft) apart in an area that receives full sunlight, but is protected from strong winds which can damage the trees. Planting against a south facing wall will help protect the tree in cooler climates. **General care** Newly planted trees require proper irrigation to ensure they become established. During the first year, water should be applied at the base of the trunk so that the root ball is kept moist to allow the roots to establish in the soil. Newly planted trees should be provided with water every 3–7 days. The soil should be moist, but not wet. Trees planted in sandy soils will require water more frequently. Young trees will also require a light application of fertilizer every month in the first year.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Anthracnose** *Colletotrichum gloeosporioides*

###### **Symptoms**

Dieback of twigs; premature leaf drop; dark staining on fruit; leaves and twigs covered in dark spores

###### **Cause**

Fungus

###### **Comments**

Disease common during wet Springs or long periods of wet weather late in season

###### **Management**

If disease is damaging then appropriate fungicides should be applied to whole tree

##### **Armillaria root rot (Mushroom root rot)** *Armillaria mellea*

###### **Symptoms**

Trees may wilt suddenly and collapse or decline slowly; leaves become chlorotic and drop from tree; if large parts of root are destroyed then whole canopy is affected; trunk may have area of rotting bark at the base; lesions on the trunk resemble Phytophthora gummosis; clusters of mushrooms may be present at the bottom of the tree and fan shaped mycelial mats are often present between the bark and the wood

###### **Cause**

Fungus

###### **Comments**

Healthy trees are usually infected by infected pieces of wood or tree stumps which have been left in the ground after an orchard is cleared

###### **Management**

Disease is difficult to control once it becomes established in an orchard; affected trees showing signs of decline should be removed along with as much of the roots system as possible; area where infected tree was should not be replanted with healthy citrus for a period of at least one year; fumigating soil can help to reduce soil inoculum but is not always completely effective

##### **Black root rot** *Thielaviopsis basicola*

###### **Symptoms**

Small brown-black lesions on roots which may coalesce and turn entire root black; root cortex may slough off to reveal the vascular tissue below; leaves of plant may be chlorotic

###### **Cause**

Fungus

## **Comments**

Serious disease of glasshouse grown citrus trees; pathogen usually drops to non-damaging levels after tree is transplanted to the field

## **Management**

Keep glasshouses well lit and warm during winter to encourage vigorous root growth; use good quality potting soil which provides good aeration

## **Blast** *Pseudomonas syringae*

### **Symptoms**

Water-soaked or black lesions on leaf petioles; which rapidly expand along the leaf midrib; cankers on twigs and branches; twigs may be girdled and die; leaves turning black and dying; black lesions may be present on fruit

### **Cause**

Bacterium

### **Comments**

Symptoms most severe on south facing side of tree exposed to winds

## **Management**

In areas where disease is severe, copper fungicides should be applied in Fall and Winter prior to the first rains

## **Category : Bacterial**

## **Brown rot** *Phytophthora* spp.

### **Symptoms**

Water-soaked lesions on fruit close to maturation; leather tan to dark brown lesions on fruit; lesions with a pungent smell; leaves, twigs and flowers may be turning brown

### **Cause**

Oomycete

### **Comments**

Disease emergence favored by cool, wet conditions

## **Management**

Cultural control methods should focus on reducing leaf wetness e.g. mowing around trees to prevent grasses growing too long, proper irrigation management, pruning branches hanging low to the ground etc.; if fruit become infected, harvest should be delayed to allow all infected fruit to drop to the ground and minimizing contamination in the harvest; applications of copper fungicides to foliage can help protect the trees

## **Citrus canker** *Xanthomonas axonopodis*

*Citrus canker on mandarin fruit*

### **Symptoms**

Raised lesions on leaves, often at leaf margin or tip; lesions may also be present on twigs and fruits; young lesions are usually surrounded by yellow halo; depressed brown craters formed from collapse of lesions

### **Cause**

Bacterium

### **Comments**

Can cause serious economic losses to grapefruit crop; bacteria survive in lesions; the main method of spread is via wind driven rain; bacteria may enter through pruning wounds

## **Management**

If the disease is introduced to an area, all infected trees should be removed and destroyed; in areas where disease is

endemic, windbreaks can help to reduce disease severity; cultural control of the disease should focus on controlling leaf miner populations, utilizing wind breaks and applications of copper sprays

### **Huanglongbing (Citrus greening, Yellow dragon disease)** *Candidatus Liberibacter asiaticus*

*Candidatus Liberibacter africanus*

*Candidatus Liberibacter americanus*

#### **Symptoms**

Yellowing of one limb or one area of canopy; yellowing of leaf veins; blotchy mottling on leaf blades; twig and limb dieback; fruits dropping prematurely; small upwardly pointing leaves; small, misshapen fruit; fruit very bitter

#### **Cause**

Bacteria

#### **Comments**

Asiatic form of the bacteria found in Florida; transmitted by Asian citrus psyllid

#### **Management**

Regulating planting material is necessary for the control of the disease; in areas where disease is endemic, control strategies should focus on populations of the insect vectors, reducing inoculum and planting trees in conditions unfavourable to the spread of the pathogen; heat treatment of budwood can treat the disease

### **Stubborn disease** *Spiroplasma citri*

#### **Symptoms**

Stunted trees; leaves shorter and broader, cupped and upright; may be chlorotic or have a mottled appearance; stunted, malformed fruits and low yield

#### **Cause**

Bacterium

#### **Comments**

Transmitted by leafhoppers; can cause serious losses in hot, dry conditions

#### **Management**

Plant only material from disease-free budwood; if disease is endemic to the area then nursery trees should be grown in an enclosure to protect the trees from vectors; if a young orchard becomes infected, it should be removed and replanted with healthy material

### **Category : Oomycete**

### **Phytophthora gummosis** *Phytophthora* spp.

#### **Symptoms**

Sap oozing from cracks in bark; bark cracking, drying and falling off; lesions girdling trunk; severely infected trees have pale green leaves with yellow veins

#### **Cause**

Oomycete

#### **Comments**

Disease can develop rapidly in moist, cool conditions; spread by water splash

#### **Management**

Only plant disease-free nursery stock; plant trees in well-draining soil and avoid injuries to bark on trunk; trunk wraps can provide protection from freezing

### **Category : Viral**

### **Tristeza disease** Citrus tristeza virus (CTV)

#### **Symptoms**

Light green foliage; poor new growth; leaves may be dropping from tree; young trees blooming early; severely infected trees are stunted and bushy in appearance with chlorotic leaves and brittle twigs; some strains of the virus cause elongated pits in the trunk and branches which give the wood a rope-like appearance

#### Cause

Virus

#### Comments

Disease spread from infected grafting material or by aphids

#### Management

Quarantine procedures are used to control tristeza and prevent the pathogen from entering areas which are currently free of the disease

## Pests

### Category : Insects

#### Aphids (Black citrus aphid) *Toxoptera aurantii*

##### Symptoms

Leaves curling; leaves and twigs covered in sticky substance which may be growing sooty mold; trees may show symptoms of tristeza (see entry); insects are small and soft bodied and are black in color

##### Cause

Insect

##### Comments

Aphids transmit tristeza virus on citrus

##### Management

Aphid numbers tend to naturally decline as leaves harden off but can be a problem on young trees or varieties which continually produce flushes of new growth; pesticides are not generally recommended due to resistance and trees can withstand a high degree of leaf curling

#### Citrus leaf miner *Phyllocnistis citrella*

##### Symptoms

Thin, winding trails on leaves; heavy infestation can result in curled and distorted leaves; adult leafminer is a tiny moth which lays its eggs in the leaf; larvae hatch and feed on leaf interior

##### Cause

Insect

##### Comments

Leaf miners attack flushes of young growth and are unable to enter leaves once they harden

##### Management

Insecticide application are rarely warranted in mature orchards as yields are unaffected; young trees should be treated with appropriate insecticides to prevent retarded growth; cultural control methods include removal of water sprouts from trees and refraining from pruning live branches more than once a year to encourage uniform growth flushes which are short in duration

#### Soft scales (Black scale, Brown soft scale , Citricolla scale) *Saissetia oleae*

*Coccus hesperidum*

*Coccus pseudomagnoliarum*

##### Symptoms

Leaves covered in sticky substance and may have growth of sooty mold; reduced tree vigor; leaves and/or fruit dropping from plants; presence of black, brown or gray flattened scales on leaves, twigs and/or branches

**Cause**

Insects

**Comments**

Insects can produce several overlapping generations per year

**Management**

Organically acceptable methods of control include the application of horticultural oils and preservation of natural enemies

**Thrips *Scirtothrips citri*****Symptoms**

Insect feeds under sepals of young fruit and causes a ring of scarred tissue as the rind expands; adult thrips are orange-yellow in color

**Cause**

Insect - Citrus thrips

**Comments**

Insects overwinter on trees as eggs and can undergo multiple generations per year

**Management**

Insecticide application is rarely required as healthy trees can withstand heavy feeding damage; insecticides can actually promote thrips populations by stimulating reproduction

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# Mango

## Mango

### Crop Details

The following are the crop details for Mango

Scientific name: *Mangifera indica*

Order: Sapindales.

Family: Anacardiaceae.

Genus: Mangifera.

Species: M.indica.

Local names: Swahili (mwembe)

## Origin

Mango (*mangiferia indica*) is one of the most cultivated fruits that originated between northwest Myanmar, Bangladesh, and northwestern India. Numerous cultivars have been developed and spread all over the world including Kenya where it is cultivated in different parts of the country but primarily produced in Ukambani.

## General information about the crop

Mango is an evergreen tree in the *Anacardiaceae* family that is grown for its edible fruit.

It has a dark, glossy, elliptical, or lanceolate leaf with long petioles and a leathery texture. It produces dense clusters of flowers with cream-pink petals.

Mango fruit is roughly oval in shape, with uneven sides. The fruit is a drupe, with an outer flesh surrounding a stone. The flesh is soft and yellow-orange in color. The fruit's skin ranges from yellow-green to red. Mango trees can reach a height of 45 meters (148 feet) and live for more than a century. Mango is thought to have originated in India or Burma (Myanmar).

Mangoes are produced in most parts of Africa including Kenya, Ghana, Burkina Faso, Guinea, Gambia, Ghana, Mali, and Ivory Coast. In Kenya, it is produced in Garissa, Kitui, Murang'a, Elgeyo Marakwet, Lamu, Kilifi, Kwale, Garissa, Makueni, Taita Taveta, Tharaka Nithi, Embu but Ukambani leads in production.

The mango tree is always green and its fruits varied in size, some are round, and some are oval, slender, long, kidney-shaped, and heart-shaped. Some of the varieties of mangoes are either colored with a shade of red and others yellow while others are green.

Apple mango, Kent mango, Tommy mango, and Ngowe mango are Kenyan mango varieties.

Mango fruit is not only sweet but also has nutritional value as it helps improve immunity and plays an important role in digestion. Mango fruit is low in calories and is the best choice when reducing calorie intake. Mangoes have mostly consumed as a fruit known as mangoes which are highly rich in vitamins A, C, and D.

## Mango varieties

The first variety of mangoes was seen in India over 4000 years ago and then spread all over the world. Mango is now consumed all over the world more than any other fruit. Over 500 varieties of mangoes are known for different shapes, colors, lengths, and sizes. Green and yellow mangoes are the most common varieties in Kenya.

Polyembryonic cultivars are generated from seed obtained from a tree plant. It includes local cultivars such as "Dodo", "Ngowe", "Boribo", "Sabre", "Peach", and "Batawi".

Cultivar seeds can produce up to five nucellar embryos that are genetically identical to the parent tree.

Plants like "Tommy Atkins," "Kent," "Haden," and "Van Dyke" can only be propagated vegetatively. There are numerous advantages to vegetative propagation, such as early bearing, smaller trees, and so on. It should be encouraged as a result of this.

## Planting and propagation

Mango can be propagated either vegetatively or by seed. Its important for farmers to know that not all cultivars propagated by seed will produce seedlings that are same to their parent tree.

Plant propagation has got two distinct groups:

-Polyembroic cultivars.

## **-Husbandry.**

It is best to use fresh, healthy mango seeds from mature, well-grown trees. They need to be washed and dried in the shade for a few days before being planted. Sow them at a 15 x 30 cm spacing and 5 cm depth. Place them on their sides, with the most prominently curved edge facing up, to form a straight stem.

To hasten germination, the hard husk can be removed before sowing. Seedlings are best grown in a half-shade nursery.

Seeds germinate in 1 to 2 weeks and are transplanted into containers as soon as the first flush of growth hardens (about 4 weeks later and about 10 cm high) (about 18 x 24 cm).

When they reach pencil-thickness, which is approximately 20 cm above soil level, they are ready for grafting. Cleft graft with improved cultivar scion. Kenya Agricultural and Livestock Research Organization (KALRO) (Mtwapa, Thika, Embu), prison farms, or any farm with the desired cultivars are good sources of scions of improved cultivars. Water frequently and shade the grafted plants. At about 4 months after grafting, grafted seedlings will be ready for transplanting.

Choose the location of the orchard with care. It is recommended that the soil be deeply cultivated by ploughing. All trees, bushes, and weeds are to be removed from the field before transplanting. Transplanting is ideal during the start of the rainy season. The planting hole should be 60 x 60 cm in size and 100 cm in depth. The hole should be larger (about 90 mm) in dry condition.

Depending on the variety and growth habit of the mango variety chosen, the spacing between trees ranges from 9 x 9 to 14 x 14 m. Before returning the soil to the hole with the young plant, mix in at least two buckets of good compost and a handful of Mijingu rock phosphate before returning the soil to the hole with the young mango plant. Consolidate the soil around the plant. Mulch and water thoroughly. Irrigation should be limited to the first year of the young trees.

## **Climatic conditions, soils, and water**

For it to grow it requires a loamy, alluvial, well-drained, aerated, and deep soil which is well drained to hold its extensive roots. When the tree is growing irrigation is highly encouraged to widen its scope for intercropping. Irrigation is stopped when the tree is big to produce fruits. The correct temperature for growing mangoes is 24c-30c during the growing period with rainfall of 890-1,015 mm is considered ideal for mango growing.

## **Husbandry**

In the area directly beneath the tree canopy, weeds should be kept to a minimum. During the first five years, intercropping with annual crops is recommended to maximize income until an economical mango yield is achieved. In young plantations, mulching around the tree helps to suppress weeds and retain soil moisture.

Pruning is an essential practice for mango trees; it helps in shaping young trees. Apart from controlling pests, pruning mango trees promotes flowering.

Formative pruning is done on young trees during their first years to help them grow into the desired shape. In the first year, cap the seedling at 1 m in height to produce a spreading framework of branches. In the second year, prune to leave 4 to 5 well-spaced branches as future main branches.

## **Advantages of pruning:**

- It enables the tree to produce fruits on its tree's outer parts, which helps the fruit to mature on the trees.
- The open tree structure facilitates harvesting.
- It enables the tree to produce larger fruits.
- Allows other crops to be grown in the shade of trees.

The tree benefits from the natural conditions of sun and wind movement. This reduces relative humidity within the canopy while also creating a less conducive environment for disease development.

Following fruit harvest, structural pruning should be performed, with the canopy at least one meter above the ground.

Remove any dead or sucker branches that have grown from the main structural branches, and prune the canopy to allow sunlight to pass through the canopy and reach the ground beneath the tree.

## **Harvesting.**

Flowering usually begins after a dormant period caused by cool or dry weather. Smoke is commonly used by smallholder mango farmers to induce flowering.

A mango plantation will begin producing commercially marketable fruit from four to five years after planting and will be in good production after eight years, reaching full maturity at around 20 years of age.

A single tree should produce 200 to 500 fruits per year, with some varieties, such as "Dodo" and "Boribo," producing up to 1000 fruits per year. Most varieties produce biennially, and a poor harvest may follow a good one. Varieties with an annual bearing tendency should be selected.

Harvest mango fruit when it has reached the mature-green stage when it is hard and green. The "cheeks" of mature fruit are well-developed.

Fruit should be picked by hand. Clip them off with a long stalk of about 2 to 3 cm and pack the fruit in a single layer in the box or crate with the stalks facing downwards.

The latex that drips from the stalk must fall onto an absorbent material (for example tissue paper placed at the bottom of the container).

Although mature mangoes ripen quickly, they have a low tolerance for temperatures below 10°C, especially when picked fresh. Ripe fruits, on the other hand, can be stored at temperatures as low as 7 to 8°C without developing a chilling injury.

## **Products**

Apart from the Mango tree cultivated to produce fruits, it can also be as fodder where its leaves can be used to feed cattle in small quantities. Its wood can be used to generate charcoal and firewood and as a honey plant. A mango tree can also produce timber for construction and carpentry. Mangoes can also be poisonous to sensitive individuals and their sleeves and seeds can be used as medicine to treat coughs, colds, and styptic.

# Services

Mango trees provide various services to the soil, human beings, and animals. For example, it grows into an umbrella-shaped crown which provides shade and shelter for both animals and human beings. Also, when the leaves are used in mulching it improves soil fertility. A mango tree can also be intercropped with other plants and fruits to create a home garden.

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# Common Pests and Diseases

## Diseases

### Category : Other

#### Algal leaf spot *Cephaleuros virescens*

*Green algae (Cephaleuros spp.)*

*Algal leaf spot*

#### Symptoms

Orange rusty spots on both upper and lower leaf surfaces which may coalesce to form large irregularly shaped patches; scraping away the orange spots reveals a grayish discoloration of the leaf lamina underneath

#### Cause

Alga

#### Comments

Disease affects many fruit trees in the tropics; infection is unsightly but often harmless

#### Management

Ensure that trees are properly pruned and fertilized to promote vigor; remove all weeds from around tree bases; employ a wider tree spacing to increase air circulation around the trees; badly infested trees can be treated with copper containing fungicides

### Category : Fungal

## **Anthracnose** *Colletotrichum gleosporioides*

*Mango anthracnose leaf symptoms*  
(2)

*Anthracnose symptoms on mango*

*Anthracnose symptoms on mango fruit*

*Anthracnose symptoms on mango fruit*

*Anthracnose symptoms on mango fruit*

*Mango anthracnose leaf symptoms*

*Anthracnose symptoms on mango*

*Anthracnose symptoms on mango fruit*

*Anthracnose symptoms on mango fruit*

*Anthracnose symptoms on mango fruit*

*Anthracnose symptoms on mango*

*Anthracnose symptoms on mango fruit*

*Anthracnose symptoms on mango fruit*

*Anthracnose symptoms on mango fruit*

### **Symptoms**

Small, dark spots on flowers; spots coalesce to cover entire panicle; infected flowers dropping from tree; dark flecks or spots with yellow halo on young leaves; dark, irregular, sunken lesions on fruit; fruits dropping from tree before ripe

### **Cause**

Fungus

### **Comments**

Disease emergence favored by wet conditions; serious disease of mango wherever it is grown

### **Management**

Susceptible mango varieties should be protected with fungicide in commercial production and the timing of the applications are critical to successful control; appropriate fungicide should be applied during flowering and fruit development

## **Phoma blight** *Phoma glomerata*

### **Symptoms**

Angular or irregular brown lesions on old leaves; lesions may develop gray centers and dark margin; withering leaves; defoliation of tree

### **Cause**

Fungus

### **Comments**

## **Pink disease** *Erythricium salmonicolor*

### **Symptoms**

White, silk-like threads at forks of branches which coalesce to form a pink crust during wet conditions; twigs and branches above this site may be killed and foliage will begin to dry out and die; orange pustules may be present on infected bark

### **Cause**

Fungus

### **Comments**

Pink disease is a destructive disease of mango grown in the wet tropics

### **Management**

If pink disease is identified the recommended treatment is an application of an appropriate fungicide which can be applied by spraying or painting onto infected bark with a paintbrush

## **Powdery mildew** *Odium mangiferae*

*Powdery mildew symptoms on mango leaf (2)*

*Mango powdery mildew: leaf symptoms*

*Powdery mildew symptoms on mango leaf*

*Powdery mildew symptoms on mango panicle*

### **Symptoms**

Gray-white powdery growth on leaves, flowers and/or fruit; curled, distorted shoots; fruit aborted and dropping from tree

### **Cause**

Fungus

### **Comments**

Found in all mango growing regions; outbreaks sporadic but can be severe

### **Management**

Fungicides are very effective at controlling powdery mildew if applied at the first sign of the disease; chemical sprays only need be applied at flowering and fruit set

## **Sooty mold** Several species of fungus

*Premature aging and death of leaves*

*Sooty mold on leaves and twigs*

*Sooty mold on mango leaves*

### **Symptoms**

The leaves, twigs, inflorescence and fruits are covered with shiny black and sticky growth of fungal mycelium. The sooty mold won't cause any direct infection to plants, but it may effect the photosynthetic process which may cause premature aging and death of leaves. Also plants may show stunted growth.

### **Cause**

Fungus

### **Comments**

Sooty mold mainly develops on honey dew secreted by sap sucking insects like whiteflies, aphids, leaf hoppers, scale insects, mealybugs and psyllids. Also these insects are always associated with ants.

### **Management**

1. If plants are small wash mold with strong stream of water 2. Spraying starch also removes sooty mold 3. Control sap sucking insects 4. Also keep the trees free from ants by applying a sticky compound around the trunk.

## **Category : Bacterial**

### **Bacterial black spot (Bacterial canker)** *Xanthomonas campestris*

*Bacterial black spot of mango caused by X. citri pv. mangiferae indicae*

*Bacterial canker on mango*

*Bacterial canker on mango*

*Bacterial canker on mango*

### Symptoms

Angular, water-soaked spots on leaves which coalesce and turn black; black cankerous lesions on stems which crack and exude a gummy substance; irregular black lesions on fruits which extend into the flesh and exude gum; fruits dropping from plant

### Cause

Bacterium

### Comments

Bacterial black spot is found in most tropical and subtropical areas where mango is grown

### Management

Provide windbreaks for plants; prune out infected twigs; protective sprays of copper during wet weather help to protect plants from the disease

## Pests

### Category : Insects

#### Fruit fly *Ceratitis cosyra*

*Bactrocera obliqua*

*Bactrocera frauenfeldi*

*Anastrepha* spp.

*Predation of fruit fly larvae (third larval instar) by weaver ants*

*Fruit fly, Bactrocera jarvisi on mango fruit*

*Adult fruit fly (Bactrocera frauenfeldi)*

*Adult fruit fly (Bactrocera obliqua) on mango fruit*

*Fruit fly maggot (*Anastrepha* spp.) feeding on mango pulp*

### Symptoms

The adult female flies lay egg just under the skin of semi ripe fruits. The maggots develop and feed inside the fruit, causing the flesh to turn brown and soft which emits foul smell. This damage also act as entry site for fungal and bacterial pathogens.

### Cause

Insect

### Comments

The mature maggots fall out of the fruits and pupate in soil.

### Management

1. Collect the fallen fruits and destroy them. 2. Also harvest fruits early to reduce flies damage . 3. Use traps to monitor fruit flies. Traps can be purchased in the market or one can prepare themselves. Take plastic container with lids (one

quarts yogurt container is fine). Drill holes (10 to 16 holes) that are 3/16-inch in diameter around the upper side of the container. Add 1 to 2 inch of pure apple cider vinegar (not flavored one) and a drop of unscented liquid dishwashing soap into the container. Hang the container in shade near berry trees before fruits ripening and check the traps frequently for flies. Change the vinegar every week. 5. Spraying protein bait under leaf surface attract flies to single spot which make easier to kill them. 4. If infestation is severe spray suitable insecticide.

### **Mango hoppers** *Idioscopus clypealis*

*Idioscopus nitidulus*

*Amritodus atkinsoni*

*Mango leafhopper (Amritodus atkinsoni)*

*Leaf hopper on new mango leaf*

#### **Symptoms**

Reduced plant vigor; sticky substance coating leaves; may be a growth of sooty mold on sticky residues; curling and drying leaves

#### **Cause**

Insects

#### **Comments**

Insect emergence favored by shady and humid conditions

### **Mango mealybugs** *Drosicha mangiferae*

*Mealybugs on mango fruit*

*Mealybugs infestation on twigs and leaves*

*Mango infested with mealybug*

#### **Symptoms**

Both nymphs and female insects sucks sap from all parts mango tree (i.e., tender leaves, shoots and inflorescence). The infected inflorescences may dry up affecting the fruit set and may cause fruit drop. Severely infected plants may show wilting and thereby affect fruit setting.

#### **Cause**

Insect

#### **Comments**

a. Mealybugs lay eggs in soil near tree trunk. b. The mealybugs secrete the honey dew which causes sooty mold. c. It feeds on wide range of plant species.

#### **Management**

1. Collect and burn fallen leaves and twigs. 2. Flooding orchard with water during October kills egg present in soil. Also deep ploughing in November exposes egg to sunlight. 3. After hatching the nymphs start climbing tree and suck sap. To avoid this band the tree trunks with polythene sheet (400 gauge, 30 cm wide) at a height of about 30 cm from the ground level and apply grease at the lower edge of band. Or you can use Funnel Type Slippery Traps. 4. To control insects already on tree you can spray fish oil rosin soap or azadirachtin (neem products). 5. Also soil application of the spores of the fungus, Beauveria bassiana helps in reducing mealybug population. 6. If infestation is severe you can spray suitable insecticides

### **Mango tree borer** *Batocera rufomaculata*

*Adult mango tree borer (2)*

*Adult mango tree borer*

## Symptoms

Mango tree borer damage may first be noticed as circular holes in the bark. This damage indicates that the tree has been attacked by borers which have chewed exit holes in the wood. Mango tree borers feed on the bark of twigs and chew green growing tips; when feeding damage is severe, branches may be killed and the main stem of the tree may collapse; insect frass (feces) collects in cracks in the bark and around the base of the tree; holes become visible in the bark.

## Cause

Insect

## Comments

Mango tree borers are a pest of mango trees in many parts of Asia, Africa, Central America, the Caribbean and the Solomon Islands; female tree borers lay their eggs in an incision made in damaged mango bark; larvae bore through the wood as they feed and eventually pupate within the tree; adult insects emerge from an exit hole that they cut in the wood. Adult insects are 25–55 mm long with distinctive long antennae which extend the length of the body.

## Management

Application of appropriate insecticide to the trunk and branches of the tree when adult insects are present acts to kill any eggs and larvae that are present; insecticide applied to growing twigs and green shoots may deter adult feeding; probing injury sites with a knife or piece of wire can help to destroy larvae and eggs.

## White Mango Scale *Aulacaspis tubercularis*

*Mango scale*

*Scale infestation on mango leaves  
(also occurrence of sooty mold due  
to scale infestation)*

*Female and male scale insects*

## Symptoms

Scale insects suck the sap from leaves, branches and fruits which causes defoliation, drying up of young twigs, poor blossoming and also affect the quality of fruits by causing conspicuous pink blemishes. Infestation of young plants results in retarded growth. In case of severe infestation the fruits may fall prematurely, whereas the mature fruits are reduced in size. Another major problem with scale insect is the development of sooty mold due to honeydew secretion.

## Cause

Insect

## Comments

The insect has a wide host range and can be seen in all mango growing countries like Ghana, Kenya, Madagascar, Mozambique, South Africa, Tanzania, Uganda, Zimbabwe, Australia, China, India, Indonesia, Malaysia, Pakistan, Philippines, Sri Lanka, Taiwan, Thailand, Japan, Egypt, Iraq, Israel, Italy and in many South American countries.

## Management

Remove the infested plant parts and burn them. Spraying emulsive oil or suitable insecticides at recommended quantity will help in reducing scale population.

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# Marjoram

## Description

Marjoram is the name given to many species of perennial herb belonging to the genus *Origanum*, including the major species *Origanum majorana* which is grown for its leaves which are commonly used as a herb in cooking. Marjoram plants can be woody or herbaceous and possess multiple branching stems. The leaves are oval or round and are arranged alternately on the stems. The plants produce small pink, purple or white flowers and small oval, brown fruits and can reach up to 1 m (3.3 ft) in height. Marjoram is perennial and can be grown for 3–4 years but is commonly grown as an annual in northern climates. Marjoram may also be referred to as sweet marjoram and originated from the eastern part of the Mediterranean in Cyprus and southern Turkey.

*Marjoram plant*

*Marjoram flowers*

*Marjoram plant*

## Uses

The leaves of the marjoram plant are used fresh or dried as a herb in cooking. They may also be dried and used to extract essential oil which is used as a flavoring.

# Propagation

**Basic requirements** Marjoram is a temperate or subtropical plant and should be grown in full sunlight for best results. Marjoram will thrive in dry, rocky conditions which closely mimic their natural habitat. Plants will grow well in a rich, light loam with a pH range between 4.9–8.7. The optimum pH for marjoram is around 6.9. Marjoram is less hardy than its relative oregano and will grow best when the annual temperature does not fall below 15°C. **Propagation** Marjoram can be propagated from seed, cuttings, layering or by dividing the root. The optimum method of vegetative propagation depends on the size and growth habit of the mother plant. **Seeds** Seeds should be sown outdoors when the soil has warmed and all danger of frost has passed. Seeds can also be started indoors to produce transplants. Marjoram seeds should be sown indoors 6–8 weeks before planting outside. Sow seeds in a sterile seed starting mix in seed trays or pots 0.2–1.0 cm (0.08–0.4 in) deep and water gently. Ensure the temperature remains between 15.5 and 27°C (60–80°F). Seeds should germinate in about 5 days at 21°C (70°F). Due to the slow growing nature of the plant, many home growers choose to start with small plants which can be obtained from a nursery or garden center. **Layering** Sprawling marjoram varieties are easily layered by selecting a branch and covering with soil. A rock can be placed on top to hold the branch securely under the soil. The branch will develop its own root system and once established, can be cut from the mother plant and transplanted to a new site. **Cuttings** Larger, upright plants lend themselves to propagating from cuttings. Cuttings should be taken from approximately 20 cm (8 in) down the stem so that the basal portion of the cutting is hard and woody. The upper 5 cm (2 in) of the cutting can be nipped off to promote branching. Cuttings can be rooted in water, sand or a mixture of sand, peat and perlite. **Transplanting** Marjoram seedlings can be transplanted to the garden when they are between 6 and 8 weeks old, about 2 weeks after the last frost date. Plants should be spaced approximately 30 cm (12 in) apart, allowing 45 cm (18 in) between rows. Pinching back the growing tip of the plants after transplanting will encourage the growth of new shoots. Marjoram requires more moisture than oregano and soil moisture can be conserved by applying a layer of mulch around the plants. **General care and maintenance** Established marjoram plants are tolerant of drought but cannot tolerate water-logging. Established plants require additional irrigation only in very dry conditions. Marjoram planted outdoors requires minimum fertilization, particularly if planted in sandy or gravelly soils. In contrast, container grown plants require frequent addition of fertilizer. A half strength balanced fertilizer can be applied every two weeks if required. Marjoram plants should be pruned regularly to stimulate new growth. This pruning can simply be a method of harvesting from the plant but in the winter, any dead or damaged wood should be removed from the plant. **Harvesting** Marjoram leaves can begin to be harvested any time after the plants have reached a height of 15–20 cm (6–8 in). Harvest leaves by pinching the leaves from the tips of the stems to encourage more branching. Leaves should be pinched regularly to keep the plants productive and prevent them from going to seed. The best time to harvest marjoram leaves is just prior to flowering. Waiting for buds to form before harvesting will ensure the maximum essential oil content in the leaves.

# References

Savio, Y & Robinson C. (1998). Marjoram, sweet marjoram, knot marjoram. In: Speciality and Minor Crop Handbook. University of California Division of Agriculture and Natural Resources. Available at: [http://www.ctahr.hawaii.edu/sustainag/extn\\_pub/veggie%20pubs/Marjaram,%20Sweet%20Marjaram,%20Knot%20Marjoram.pdf](http://www.ctahr.hawaii.edu/sustainag/extn_pub/veggie%20pubs/Marjaram,%20Sweet%20Marjaram,%20Knot%20Marjoram.pdf). [Accessed 18 February 15]. Free to access . Meyers, M. (2005). Oregano and marjoram. The Herb Society of America. Available at: <http://www.herbsociety.org/factsheets/Oregano%20and%20Majoram.pdf>. [Accessed 18 February 15]. Free to access .

# Common Pests and Diseases

## Diseases

Category : Fungal

## **Mint rust** *Puccinia menthae*

### **Symptoms**

Small, dusty, bright orange, yellow or brown pustules on undersides of leaves; new shoots may be pale and distorted; large areas of leaf tissue die and leaves may drop from plant

### **Cause**

Fungus

### **Comments**

Disease also affects mint and can spread from nearby mint plants

### **Management**

Infected plants and rhizomes should be removed to prevent spread; heat treatment of roots may help to control the disease; roots should be immersed in hot water at 44°C (111°F) for 10 minutes, cooled using cool water and then planted as usual

## **Pests**

### **Category : Insects**

#### **Aphids (Peach aphid)** *Myzus persicae*

##### **Symptoms**

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants

##### **Cause**

Insects

##### **Comments**

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed

##### **Management**

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

#### **Cutworms** *Agrotis* spp.

##### **Symptoms**

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5–5.0 cm (1–2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed

##### **Cause**

Insect

##### **Comments**

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato

## **Management**

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically

## **Thrips (Western flower thrips) *Frankliniella occidentalis***

### **Symptoms**

If population is high leaves may be distorted; leaves are covered in coarse stippling and may appear silvery; leaves speckled with black feces; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color

### **Cause**

Insect

### **Comments**

Transmit viruses such as Tomato spotted wilt virus; once acquired, the insect retains the ability to transmit the virus for the remainder of its life

### **Management**

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic

## **Category : Mites**

## **Spider mites (Two-spotted spider mite) *Tetranychus urticae***

### **Symptoms**

Leaves stippled with yellow; leaves may appear bronzed; webbing covering leaves; mites may be visible as tiny moving dots on the webs or underside of leaves, best viewed using a hand lens; usually not spotted until there are visible symptoms on the plant; leaves turn yellow and may drop from plant

### **Cause**

Arachnid

### **Comments**

Spider mites thrive in dusty conditions; water-stressed plants are more susceptible to attack

### **Management**

In the home garden, spraying plants with a strong jet of water can help reduce buildup of spider mite populations; if mites become problematic apply insecticidal soap to plants; certain chemical insecticides may actually increase mite populations by killing off natural enemies and promoting mite reproduction

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# Mint

## Description

Mints belong to the genus *Mentha* and comprise approximately 20 species in the plant family Lamiaceae and are grown for their leaves which are widely used as a flavoring. Mint plants are mainly aromatic perennials and they possess erect, branching stems and oblong to ovate or lanceolate leaves arranged in opposing pairs on the stems. The leaves are often covered in tiny hairs and have a serrated margin. Mint plants produce a terminal flower spike and the flowers can be white or purple in color depending on variety. Mint plants are fast growing and can become very invasive. They can reach heights of 60–90 cm and will continue to grow for many years once established. Mint may also be referred to by species and these include, but are not limited to peppermint, spearmint, water mint and Japanese mint.

*Peppermint flowers*

*Chocolate mint*

*Mint plant*

## Uses

Mint leaves are used fresh or dried to make teas, jams and desserts. Essential oil can be extracted from the leaves and is used as a flavoring.

# Propagation

**Basic requirements** Mint is a rapidly growing plant which is very easy to grow. It is best grown in partial shade to full sun and is generally very hardy, tolerating temperatures down to -29°C (-20°F). Care should be taken with variegated varieties which may scorch in full sun. Mint is very fast growing which can lead to it invading gardens quickly unless controlled. The best soils for planting mint are rich and moist with a slightly acidic pH between 6.0 and 7.0. **Propagation** Mint is readily propagated from seeds, cuttings or by dividing an established plant. Seeds should be planted in the Spring or in the Fall in areas that are free from frost. Seeds should be sown to a depth of 6 mm (0.25 in). Seedling should be thinned after emergence such that the plants are spaced 46 to 61 cm (18 to 24 in) apart. Established mint can be easily divided for transplanting by taking some branches along with a portion of root. Many people choose to keep mint in containers or sink the containers into the ground when planting to prevent mint from spreading uncontrollably. **General care and maintenance** Mint is very vigorous and should be pruned regularly to keep the plants in check. Remove any unwanted runners and pinch the tips of the plants back regularly. Mint may be fertilized in the Spring with a slow release fertilizer to supply it with nutrients throughout the growing season. Pinch off any flowers that form to conserve the flavor of the leaves. Essential oil content is reduced during bloom. In areas with mild winters, mint can be moved to a sheltered area of the garden to overwinter, otherwise the plant can be cut to the ground in the Fall. Container grown mint plants can be brought indoors. **Harvest** Mint leaves can be harvested as soon as the plants have reached 8 to 10 cm (3-4 in) in height. Cut leaves and stems with a sharp knife or scissors. If harvesting whole stems, cut the stem at about 2.5 cm (1 in) from the soil line.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### Mint rust *Puccinia menthae*

##### Symptoms

Small, dusty, bright orange, yellow or brown pustules on undersides of leaves; new shoots may be pale and distorted; large areas of leaf tissue die and leaves may drop from plant

##### Cause

Fungus

##### Comments

Disease also affects mint and can spread from nearby mint plants

##### Management

Infected plants and rhizomes should be removed to prevent spread; heat treatment of roots may help to control the disease; roots should be immersed in hot water at 44°C (111°F) for 10 minutes, cooled using cool water and then planted as usual

# Pests

## Category : Insects

### Aphids (Peach aphid) *Myzus persicae*

#### Symptoms

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants

#### Cause

Insects

#### Comments

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed

#### Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

### Cutworms *Agrotis* spp.

#### Symptoms

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5â€“5.0 cm (1â€“2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed

#### Cause

Insect

#### Comments

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato

#### Management

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically

### Thrips (Western flower thrips) *Frankliniella occidentalis*

#### Symptoms

If population is high leaves may be distorted; leaves are covered in coarse stippling and may appear silvery; leaves speckled with black feces; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color

#### Cause

Insect

## **Comments**

Transmit viruses such as Tomato spotted wilt virus; once acquired, the insect retains the ability to transmit the virus for the remainder of its life

## **Management**

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic

## **Category : Mites**

### **Spider mites (Two-spotted spider mite) *Tetranychus urticae***

#### **Symptoms**

Leaves stippled with yellow; leaves may appear bronzed; webbing covering leaves; mites may be visible as tiny moving dots on the webs or underside of leaves, best viewed using a hand lens; usually not spotted until there are visible symptoms on the plant; leaves turn yellow and may drop from plant

#### **Cause**

Arachnid

#### **Comments**

Spider mites thrive in dusty conditions; water-stressed plants are more susceptible to attack

#### **Management**

In the home garden, spraying plants with a strong jet of water can help reduce buildup of spider mite populations; if mites become problematic apply insecticidal soap to plants; certain chemical insecticides may actually increase mite populations by killing off natural enemies and promoting mite reproduction

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# Molokhia (Mallow)

## Description

Molokhia, *Corchorus olitorius*, is an herbaceous annual plant in the family Malvaceae grown for its edible leaves which are consumed as a vegetable. The molokhia plant is tall and is either unbranched or possesses few lateral branches. The stems and leaves of the plant can be dark red or dark green or an intermediate color. The leaves are oval and tapering with serrated edges. The plant produces yellow flowers and pods that contain the seeds. Molokhia can grow to a height of 2–4 m (6.5–13 ft) and is an annual, harvested after one growing season. Molokhia may also be referred to as jute, nalta jute, red jute or mallow and likely originates from Africa.

*Molokhia*

*Molokhia seed pod*

*Molokhia flower*

*Molokhia seed pods*

*Molokhia plant in flower*

## Uses

The leaves of the plant are usually consumed after cooking as a vegetable. The stems and leaves exude a sticky gum-like substance (mucilage) when cooked, giving it a texture similar to okra. It is commonly incorporated into stews.

# Propagation

**General requirements** Molokhia typically requires warm, humid conditions to thrive and will grow best in deep, loose soils. It will grow well in sandy or clay loam with a pH between 5 and 8.6. It requires an average monthly rainfall of 75-100 mm. It is reported tolerate average annual temperatures of between 6.8 and 27.5°C (44.2-81.5°F). **Propagation** Molokhia is usually propagated from seed and should be planted 20 cm apart, allowing 50 cm between rows.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Anthracnose** *Glomerella cingulata*

##### **Symptoms**

Depressed yellow-brown, water-soaked lesions developing on stem; lesions become further depressed and turn black and necrotic; lesions may coalesce and girdle the stem, causing it to break

##### **Cause**

Fungus

##### **Comments**

Disease emergence is favored by wet weather conditions

##### **Management**

Reduce inoculum levels by removing crop debris from field after harvest

#### **Sclerotium rot** *Sclerotium rolfsii*

##### **Symptoms**

Water-soaked brown marks on stem of plant; stem peels back at lesion to reveal fibres underneath; fibre layer is discolored brown; plant begins to wilt; white mycelial growth may be present on affected areas of plant

##### **Cause**

Fungus

##### **Comments**

Fungus survives in crop debris in soil

##### **Management**

Remove infected plants; avoid overcrowding plants to promote air circulation; plow crop debris deep into soil; provide a barrier to infection by wrapping lower stems of plant with aluminum foil covering below ground portion of stem and 2-3 in above soil line

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# Mulberry

## Description

Mulberry is the name given to several species of deciduous shrub or tree in the genus *Morus* (family Moraceae) which are grown for their edible fruits. The genus includes white mulberry (*Morus alba*) and red mulberry (*Morus rubra*). Mulberries are small to medium sized shrubs or trees with a thick tan-gray ridged trunk and light green leaves which vary in shape depending on variety. Leaves are arranged alternately and are lobed or unlobed, cordate (heart-shaped), dentate (toothed) and acuminate (tapering). The trees produce small green-yellow flowers in dense spikes and an oval aggregate fruit made up of individual drupelets. The fruit can be white, pink or purple to purple-black in color and contains numerous brown seeds. Mulberry can reach a height of 15 m (49 ft) and are quite short lived, with an economic lifespan of around 15 years. Mulberry is believed to originate from China.

*Unripe fruits*

*Red mulberry*

*Ripening fruit*

*Unripe fruits*

*White mulberry tree*

*Female inflorescence*

*Red mulberry leaves*

*Male inflorescence*

*Mulberries*

## Uses

Mulberries can be eaten fresh or used as fillings for tarts and pies. The fruit may also be used to make jams and jellies. They have been traditionally planted as a food source for silk worms.

## Propagation

**Basic requirements** Mulberry trees should be grown in sunny locations, preferably in a deep soil. Mulberries are reasonably tolerant of drought, particularly white mulberry and can be grown successfully in poor soil. Mulberry will grow well in a variety of soils but optimum growth will be achieved when planted in a deep well draining loam with a slightly acidic pH of between 5.5 and 6.5. Fruit yields are increased when trees are positioned in full sun. Mulberry trees are cold hardy, although the specific temperature at which they will be damaged varies by variety. Some white mulberries can withstand temperatures of -32°C (-25°F). **Propagation** Mulberry trees can be propagated from seeds, cuttings or by grafting. Seeds should be collected from ripe fruits and removed by macerating the fruit in a water bath. Seeds which sink to the bottom of the bath are viable and can be planted immediately or dried and cold stored for planting later. Trees grown from seed can take 10 years or more to produce fruit. Cuttings can be taken during regular pruning of the tree. Branches should be 22 to 30 cm (8.6–11.8 in) in length and possess a minimum of three buds. Cuttings should be planted immediately. Grafted plants produce stronger root systems than trees produced by any other method of propagation. Grafting is usually achieved by budding in the Spring. **Planting** In the case of mulberry bushes, seedling are transplanted when they have reached 10–15 cm (4–6 in) in height. Seedlings for mulberry trees should be allowed to grow larger, usually at least 1 m (3.3 ft) in height and are trained prior to planting. Mulberry trees do not need to cross pollinate but if growing more than one tree they should be spaced 1.6 m (5.2 ft) apart. **General care and maintenance** Although established trees are relatively tolerant of drought, mulberries should be provided with additional irrigation during dry periods. The trees require little fertilization and a single annual application of a balanced fertilizer is usually sufficient to meet the growing requirement of the trees. Once trained, little pruning of the trees is required. Dead and damaged wood should be removed at the end of the growing season. **Harvesting** Mulberry fruit is usually ready for harvest in late Spring. The fruits are usually harvested by hand either by picking them from the tree directly, or by shaking the branches.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Armillaria root rot** *Armillaria mellea*

###### **Symptoms**

Small, discolored leaves which drop from tree prematurely; death of branches; death of entire tree; may be small mushrooms growing in clusters at base of tree

**Cause**

Fungi

**Comments**

Fungus survives in dead and decaying wood of infested tree stumps; disease spreads when mycelium colonizes roots of tree

**Management**

Control of Armillaria root rot once present is extremely difficult; great care should be taken to only plant disease-free planting material; trees should not be planted in recently cleared areas known to have been infested with Armillaria previously; diseased trees, including stumps, should be dug up and removed from orchards; avoid stressing trees by providing adequate irrigation, fertilization and insect control; applications of fungicides is not recommended on infected trees; trees may die within one to several years depending on the severity of the infection

**Category : Bacterial****Bacterial blight** *Pseudomonas syringae***Symptoms**

Small black, angular spots in leaves; large brown spots on leaves, flowers and/or fruits

**Cause**

Bacteria

**Comments**

Disease emergence favored by poor air circulation around branches and wet foliage

**Management**

Branches exhibiting dieback and severe blighting should be pruned out of the canopy; avoid overhead irrigation; if cankers appear on the trunk of the tree then it is likely it will die and it should be removed

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# Mushrooms

## Description

Mushrooms are the fleshy fruiting bodies of fungi and include edible species in the genus *Agaricus* (button mushrooms, portbellas and criminis), *Pleurotus* (oyster mushrooms), and *Volvariella*, (straw mushrooms). Mushrooms are highly variable in appearance depending on their stage of development and variety. *Agaricus* mushrooms have a cap and stem, the cap is a pale grey or brown in color and is rounder while immature, but flattens out as it reaches maturity and can reach a diameter of 5–10 cm (2–4 in). *Pleurotus* mushrooms may not have a stem and instead may be laterally attached to a growing substrate such as the bark of a tree. *Pleurotus* mushrooms are smooth and elongated and can reach 4–15 cm (1.5–6.0 in) in diameter. *Volvariella* mushrooms are small, with pink gills and a characteristic sac-like covering (volva) at the base of the stem. The cap can reach 5–15 cm (2–6 in) in diameter.

*Harvested Agaricus mushrooms*

*Wild growing oyster mushrooms*

*Oyster mushroom cultivation*

*Straw mushrooms*

*Agaricus mushrooms*

*Agaricus mushrooms*

## Uses

Mushrooms are widely used after cooking and are incorporated into many dishes worldwide.

## Propagation

**Basic requirements** Mushrooms grow from a filamentous mass ('mycelia' or 'spawn') that grows on dead or decaying plant material. *Agaricus* mushrooms can be cultivated in a dark, moist, cool space such as a basement. *Agaricus* mushrooms require a rich organic material in which to grow such as horse manure. Oyster mushrooms are cultivated on hardwood logs by introducing spawn into pre-drilled holes in the wood or by sawing a section through the log and covering the exposed wood in spawn before nailing the log back together. The logs are then stored in watertight bags containing sand and soaked with water. Oyster mushrooms can also be grown in straw or sawdust by inoculating the sterile substrate with spawn and sealing in plastic bags. Straw mushrooms can be grown on wheat straw, rice straw or sawdust inoculated with spawn and stored at temperatures between 28 and 36°C and relative humidity of 75–85%.

**Propagating *Agaricus* mushrooms** Substrate Substrates for growing *Agaricus* mushrooms are either agricultural by-products such as straw bedded horse manure or synthetic composts specially formulated for mushroom growing. Horse manure substrates should have a nitrogen content of 1.5–1.7%, while synthetic composts should contain between 1.7 and 1.9%. Additional nitrogen can be added to the substrate if required using nitrogen supplements or through the addition of poultry manure. Gypsum is commonly added to the mix to buffer the pH and to give the compost the desired structure for optimum mushroom growth. The growing substrate then must be composted to make it suitable for growing mushrooms. Horse manure is composted by turning every 4–5 days and watering after each turning to keep the substrate moist. The compost is ready to use when it turns a rich brown color, usually after 4 or 5 turnings. Other compost mixes should be turned after 5–6 days and kept moist by watering. The compost should be turned a second time and should be ready for use after another week. The compost is then set out in trays for planting the spawn. In commercial mushroom production, the compost is pasteurized to remove any fungal, bacterial or insect contaminants from the medium before the spawn is planted. Spawn Mushroom spawn can be purchased from many commercial seed companies or online suppliers. Spawn should be planted when the compost reaches 24°C (75°F) and should be planted in the trays at a depth of 5 cm (2 in) allowing 20–25 cm (8–10 in) between plantings. The temperature should be kept at 21°C (70°F) for the next 21 days before lowering to 15.6°C (60°F) and covering with a 2.5 cm (1 in) layer of good quality soil. The growing mushrooms should be kept moist throughout by watering with a gentle spray of water whenever the top of the soil begins to dry. Tiny white spots should begin to appear on the soil surface after approximately 3 weeks and will begin to be ready for harvest approximately 10 days later. **Harvesting** Harvest the mushrooms at soil level by carefully twisting them or by cutting them at soil level with sharp knife. Pulling can damage other surrounding mushrooms. Harvest flushes of mushrooms daily. The beds will continue to produce for up to 6 months.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Dactylium diseases** *Dactylium cladobotryum*

## **Symptoms**

Webbed, cottony mycelial growth on surface of casing and mushrooms; mycelium is usually white but may be gray or pink in color; infected mushrooms will develop a soft, watery rot

## **Cause**

Fungus

## **Comments**

Growth of the mold is restricted to the casing layer; disease can spread very quickly if left untreated

## **Management**

Control of the disease is achieved through good sanitation practices and cultural control methods; casing should be kept clean and sanitized; all tools and equipment should be cleaned and sanitized between use; keep beds free of any mushroom debris; pathogen is susceptible to low humidity and can be inhibited by lowering the humidity in the growing room

## **Green mold** *Trichoderma* spp.

*Penicillium cyclopium*

*Aspergillus* spp.

## **Symptoms**

A dense layer of mycelium is present on casing surface which is initially white in color but changes to green; developing mushrooms in or near the mycelium are brown and may be cracked or distorted

## **Cause**

Fungi

## **Comments**

One of the most common and destructive diseases of cultivated mushrooms

## **Management**

Prevention of disease is best achieved by following good sanitation practices; ensure compost is properly pasteurized prior to use and sterilize any supplements

## **Verticillium spot** *Verticillium fungicola*

## **Symptoms**

Small spotting on mushrooms; mushrooms deformed; surface of mushroom gray and fuzzy; localized dead areas on cap; pinched areas on cap; fruiting body may no longer be recognisable as a mushroom; severe infection can cause a deformation known as "dry bubble" which causes the sporocarp to appear as large puffball like masses; bubbles will become covered with a gray, fuzzy growth

## **Cause**

Fungus

## **Comments**

May be confused with bacterial infections; spread by flies and/or infected equipment

## **Management**

Bubbles should not be disturbed by touching and can be destroyed using salt; salt should be placed in a plastic cup and then placed over the bubbles to dry them out and provide a barrier to prevent spores spreading; fungicides are available for the treatment of Verticillium diseases of mushrooms but many have toxic effects on the mushrooms as they are themselves a fungus

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# Mustard

## Description

Mustards, (*Brassica* spp.) are herbaceous annual plants in the family Brassicaceae grown for their seeds which are used as a spice. Mustard plants are thin herbaceous herbs with yellow flowers. The leaves of the plant are toothed, lobed, and occasionally have the larger terminal lobes. Plants can reach 16 cm (6.3 in) in length. The yellow flowers grow in spike like clusters of 2–12 flowers and individual flowers are 8 mm (0.3 in) in diameter. The seeds are red to brown in color and produced from each flower. Mustard can grow 1.2–2 m (4–6.6 ft) in height and as an annual plant, survives only one growing season. Mustard may also be referred to as mustard, brown mustard, red mustard, yellow mustard or wedlock and is believed to have originated in the temperate regions of Europe.

*Mustard field*

*Mustard field*

*Mustard flowers*

## Uses

The leaves and shoots of the mustard plant are consumed as a vegetable in some countries. Mustard seed is incorporated into seasonings and dressings. Mustard may be grown as a cover crop in rotation with other vegetables.

# Propagation

**Basic requirements** Mustard grows very well in cool climates with short growing seasons, at temperatures as low as 4.4°C (40°F). Seedlings can tolerate some light frost but severe frost will kill the plants. The mustard plant can be grown in sandy, loamy or clay soils with a pH between 4.9 and 8.2 and prefers moist soil. The plant will tolerate partial shade. **Propagation** Mustards are propagated from seed and due to the small size of the seeds, should be planted in a well prepared seed bed which is firm and flat. Mustard seeds should be sown in Spring once soils have warmed to 4.4–7.2°C (40–45°F) and should be planted at a depth of 1.25–2.5 cm (0.5–1.0 in) at a density of 8–14 lbs of seeds per acre. The seed can be spread by broadcasting in the home garden or, in the case of commercial production, using a seed drill. Mustard generally matures in 80–85 days. **General care and maintenance** Weeds can cause huge losses in mustard cultivation as they quickly out compete seedlings and are difficult to eradicate once established. The best method of preventing weed growth in a mustard field is to plant seeds at the appropriate depth. Shallow planted seeds germinate rapidly, allowing the development of a uniform plant stand. Established plants are less susceptible to competition from weeds. Soil should be tested to determine nutrient requirements prior to planting. Mustard will benefit from the addition of supplemental nitrogen and this is generally applied at a rate of 100–120 lb per acre. **Harvesting** Mustard is generally ready to harvest 80 to 85 days after planting. The crop should be harvested promptly to reduce losses to shattering. In commercially grown fields the recommended method of harvest is swathing. The plants should be cut just below the height of the lowest seed pods. In the home garden, mustard can be harvested by hand by cutting the plants. The seeds can then be recovered from the pods and dried for storage.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Alternaria leaf spot (Black spot, Gray spot)** *Alternaria brassicae*

##### **Symptoms**

Small dark spots on leaves which turn brown to gray; lesions may be round or angular and may possess a purple-black margin; lesions may form concentric rings, become brittle and crack in center; dark brown elongated lesions may develop on stems and petioles

##### **Cause**

Fungi

##### **Comments**

May become a problem on cabbage during cool, wet periods

##### **Management**

Plant only pathogen-free seed; rotate crops; applications of appropriate fungicides control disease when present

### **Clubroot *Plasmodiophora brassicae***

#### **Symptoms**

Slow growing, stunted plants; yellowish leaves which wilt during day and rejuvenate in part at night; swollen, distorted roots; extensive gall formation

#### **Cause**

Fungus

#### **Comments**

Can be difficult to distinguish from nematode damage; fungus can survive in soil for periods in excess of 10 years; can be spread by movement of contaminated soil and irrigation water to uninfected areas

#### **Management**

Once the pathogen is present in the soil it can survive for many years, elimination of the pathogen is economically unfeasible; rotating crops generally does not provide effective control; plant only certified seed and avoid field grown transplants unless produced in a fumigated bed; applying lime to the soil can reduce fungus sporulation

### **Downy mildew *Peronospora parasitica***

#### **Symptoms**

Irregular yellow patches on leaves which turn light brown in color; fluffy gray growth on the undersides of the leaves

#### **Cause**

Fungus

#### **Comments**

Disease emergence favored by cool, moist conditions

#### **Management**

Remove all crop debris after harvest; rotate with non-brassicas; application of appropriate fungicides may be required if symptoms of disease are present

### **Powdery mildew *Erysiphe cruciferarum***

#### **Symptoms**

Small white patches on upper and lower leaf surfaces which may also show purple blotching; patches coalesce to form a dense powdery layer which coats the leaves; leaves become chlorotic and drop from plant

#### **Cause**

Fungus

#### **Comments**

Disease emergence favored by dry season, moderate temperatures, low humidity and low levels of rainfall

#### **Management**

Plant resistant varieties; rotate crops; remove all crop debris after harvest; remove weeds; avoid excessive application of nitrogen fertilizer which encourages powdery mildew growth; powdery mildew can be controlled by application of sulfur sprays, dusts or vapors

### **Sclerotinia stem rot (White mold) *Sclerotinia sclerotiorum***

#### **Symptoms**

Irregular, necrotic gray lesions on leaves; white-gray lesions on stems; reduced pod set; shattering seed pods

#### **Cause**

Fungus

#### **Comments**

Disease emergence favors moderate to cool temperatures and high humidity

#### **Management**

Rotate crop to non-hosts (e.g. cereals) for at least 3 years; control weeds; avoid dense growth by planting in adequately

spaced rows; apply appropriate foliar fungicides

### **White leaf spot** *Mycosphaerella capsellae*

#### **Symptoms**

Small, necrotic, brown spots on leaf tips or margins that matures to light gray or white with the original dark spot in center; margins of lesions may be darker; lesions may coalesce to form large chlorotic areas and cause defoliation

#### **Cause**

Fungus

#### **Comments**

Symptoms easily confused with downy mildew; disease emergence favored by wet leaves and cool temperatures

#### **Management**

No known plant resistance to white leaf spot so control relies on cultural practices such as rotating crops and removing weeds; application of appropriate fungicide may help control the disease

### **White rust** *Albugo candida*

*White rust symptoms on mustard*

*White rust symptoms on mustard*

*White rust symptoms on mustard foliage*

*White rust symptoms on mustard foliage*

#### **Symptoms**

White pustules on cotyledons, leaves, stems and/or flowers which coalesce to form large areas of infection; leaves may roll and thicken

#### **Cause**

Fungus

#### **Comments**

Fungus can survive for long periods of time in dry conditions; disease spread by wind

#### **Management**

Rotate crops; plant only disease-free seed; apply appropriate fungicide if disease becomes a problem

### **Category : Bacterial**

### **Bacterial black rot** *Xanthomonas campestris*

#### **Symptoms**

Irregularly shaped dull yellow areas along leaf margins which expand to leaf midrib and create a characteristic "V-shaped" lesion; lesions may coalesce along the leaf margin to give plant a scorched appearance

#### **Cause**

Bacterium

#### **Comments**

Pathogen is spread via infected seed or by splashing water and insect movement; disease emergence favored by warm and humid conditions

#### **Management**

Primary method of controlling black rot is through the use of good sanitation practices; rotate crops to non-cruciferous crops every 2 years; plant resistant varieties; control cruciferous weed species which may act as a reservoir for bacteria; plant pathogen-free seed

### **Category :**

## **Cabbage aphid** *Brevicoryne brassicae*

*Cabbage aphid colony*

### **Symptoms**

Large populations can cause stunted growth or even plant death; insects may be visible on the plant leaves and are small, grey-green in color and soft bodied and are covered with a white waxy coating

### **Cause**

Insect

### **Comments**

Cabbage aphids feed only on cruciferous plants but may survive on related weed species

### **Management**

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

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## **Category : Viral**

### **Mosaic** Turnip mosaic virus (TuMV)

#### **Symptoms**

Mottled pattern on leaves; vein clearing; downward rolling of leaves;

#### **Cause**

Virus

#### **Comments**

Virus transmitted by many species of aphid, including the peach aphid and cabbage aphid

### **Management**

Adjust planting date to avoid peak aphid activity; reflective mulches may deter aphids from crop; application of appropriate insecticides may help control secondary spread of virus but will not help plants already infected

## **Pests**

### **Category : Insects**

#### **Flea beetles** *Phyllotreta* spp.

##### **Symptoms**

Small holes or pits in leaves that give the foliage a characteristic "shot hole" appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5–3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance

##### **Cause**

Insect

##### **Comments**

Younger plants are more susceptible to flea beetle damage than older ones; older plants can tolerate infestation; flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year

##### **Management**

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application of diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied

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# Napier grass

## Description

Napier grass is one of the important perennial tropical forage crop belong to family Poaceae. It is also called Uganda grass or elephant grass. It is native to Africa but is now grown in many tropical countries. It is C4 plant and can grow well in marginal land. The grass grows tall and forms large clumps like bamboo.

*Napier grass stem*

*Napier grass inflorescence*

*Individual Napier grass clump*

*Napier grass row*

## Uses

Mainly used as fodder crop. Generally it is fed directly to cattle or made into silage or hay. It produces huge biomass and can be harvested multiple times in a year which making it a good raw materials for biofuel production. Napier grass is planted in marginal lands and slopes to increase soil fertility and to reduce soil erosion. It is also the main source for paper production in mnay regions. Napier grass is also used in integrated pest management strategy as pull crop mainly in maize and sorghum producing areas. Napier grass is grown along maize or sorghum (in rows or in borders) to reduce the stem borer population. It is also commonly grown in borders of many crops as windbreak and firebreak.

# Propagation

**Basic requirements** Napier grass is best grown in warm, tropical and subtropical regions. And grows well up to an altitude of 2000 m from sea level. Generally it performs very well at temperatures ranging from 25 to 40 degrees Celsius. Napier grass is very sensitive to frost and waterlogging conditions. **Planting** Napier grass usually produces few full form seeds. So the main mode of propagation is by stem cuttings. The cuttings with five internodes are planted by inserting into furrows at 75 cm apart, both along and between the rows.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### Head Smut Disease *Ustilago kamerunensis*

*Napier plant with smutted tillers  
(initial symptom)*

##### Symptoms

Infected plants show thinner, shorter stems and produce few small size leaves. The shoot becomes hard and flowers prematurely. Head turns into smut.

##### Cause

Fungus

##### Comments

The estimated yield loss due to smut disease ranges from 26 to 46%. Disease mainly spreads through wind and plant materials. Head smut was reported first in 1910 from Napier grass specimen collected from Cameroon. Later the disease was reported from other countries like Uganda (1930), Rwanda (1963), Tanzania (1975), Kenya (1980) and Congo. The disease needs more attention since there is risk of spreading to other African countries.

##### Management

Grow resistant varieties where available. Use disease-free planting materials. Keep the plants healthy by providing proper nutrients. Avoid using manure from livestock that have been previously fed with smut infected plants.

## Category : Viral

### Napier Grass Stunt Disease (NGSD) *Candidatus Phytoplasma oryzae (Ns-phytoplasma)*

*Napier grass stunt diseased growth from cut clumps*

*Stunt disease infected plant and the plant hopper that transmits the disease*

#### Symptoms

The infected plants typically have small yellow leaves and short internodes. It produce large number of tillers. Plant become stunted and eventually die.

#### Cause

Phytoplasma

#### Comments

The disease reduces forage yield by 40 to 90%. The disease is mainly transmitted by plant and leaf hoppers and stem cuttings.

#### Management

Use disease free healthy planting materials. Remove and destroy the infected plants. Follow crop rotation.

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# Nutmeg

## Description

Nutmeg, *Myristica fragrans*, is a tropical evergreen tree in the family Myristicaceae grown for its seeds which are used as spices. The nutmeg tree has natural conical shape with a grey-brown trunk and dark green glossy leaves. The branches of the tree spread in whorls and the leaves are oval or lanceolate in shape. Leaves are arranged alternately on the branches and are 5–15 cm (2–6 in) in length, smooth and lighter in color on the under side. The tree produces a clusters of numerous male flowers whereas the female flowers are produced solitary or in a maximum cluster of 3. The flowers are pale yellow and fragrant. The fruit of the nutmeg tree is a rounded fleshy berry which splits into two halves when it ripens. The seed inside is shiny dark brown and oval in shape. The seed coat is covered by lacy red aril which is attached at the base of the seed. Nutmeg trees can reach a height of 20 m (66 ft) and may live for upwards of 80 years. Nutmeg may also be referred to as mace and it is not known in a wild state. It likely originated from the Moluccan Islands, particularly the volcanic island of Banda.

*Nutmeg fruits on the tree*

*Nutmeg fruit*

## Uses

The seed of the nutmeg berry (nutmeg) and the aril (mace) are dried and used whole or ground as culinary spices.

# Propagation

**Basic requirements** Nutmeg is a tropical plant and requires dry periods to flower. It will grow best at temperatures between 20 and 30°C (68–86°F) and can tolerate a range of soils provided that they are well draining. Trees will grow optimally in a deep loamy sand rich in organic matter with a pH between 5.5 and 7.5. The trees love heat but should be protected from strong afternoon sun and also require some shelter from wind. **Propagation** Seeds Trees grown from seed do not flower until they are between 6 and 8 years old and sex cannot be determined until this time. For this reason, 2–3 seedlings are planted in one place in commercial production and excess male trees are removed or replanted when they can be identified as they will not produce fruit. Seeds should be planted immediately after harvest. They should not be allowed to dry out prior to planting. Seeds are commonly planted 6–6 m (20–20 ft) apart and thinned when required. A spacing of 10–10 m (33–33 ft) is desirable for fully grown trees. In the home garden a male and female tree are required for fruit production and they should be spaced at least 10 m (33 ft) apart. The tree will reach full size after about 20 years. **Marcotting** Nutmeg trees can also be grown from marcotted material. Vigorous branches are selected from female trees. The branches should be 1.2–1.5 cm in diameter. The branch is then split longitudinally in an area that is approximately 90 cm (35 in) from the end of the branch. Each split should be approximately 5 cm (2 in) in length. A bamboo splint is positioned along the area of the split to secure the branch and prevent it from breaking. A small piece of the split branch is then removed on the bottom side of the branch. This piece is approximately 6–12 mm (0.24–0.4 in) long. The remainder of the split is held open by placing a piece of hardwood to act as a wedge. Finally, the exposed piece of branch is dusted with rooting powder and wrapped in moistened peat moss, coconut coir or similar and sealed in polyethylene sheeting. Marcotted branches usually develop roots in 4–12 months. Once an adequate root system has developed, the branches are severed from the tree and potted. **Planting** Nutmeg trees should be planted in an area with adequate shade to protect the young trees while they establish. Shading is commonly achieved by intercropping with other crops such as cocoa or banana. Marcots are planted in holes which are approximately 60–60 cm (24–24 in). Composted manure is worked into the soil and the trees are set in the holes. Stakes are used to protect the newly planted trees. **Harvesting** Fruits are harvested when they are ripe by using a blade attached to the end of a long pole. A basket is also attached to the end of the pole such that when the fruit is cut from the tree with the blade, it drops into the basket. Seeds may also be collected from the ground after they have dropped from the tree but this encourages crop losses through disease.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Leaf spot (Shot hole)** *Colletotrichum gloeosporioides*

##### Symptoms

Sunken spots with yellow halo on foliage; center of spots dry out and drop from plant resulting in holes in the leaves (shot

hole)

#### **Cause**

Fungus

#### **Comments**

#### **Management**

Application of 1% Bordeaux mixture can help to control the disease

### **Thread blight** *Corticium* spp.

#### **Symptoms**

Fungus causes two different types of thread blight; the first type appears as fine white hyphae which aggregate to form threads arranged in a fan shape along the underside of leaves; the second type of blight is known as horsehair blight and appears as silk-like black threads which form an irregular network on stems and leaves

#### **Cause**

Fungi

#### **Comments**

Fungi survive on dried leaves; disease emergence is favored by heavy shading of plants

#### **Management**

If infection is severe it can be treated with 1% Bordeaux mixture; avoid shading plants and follow good sanitary practices to limit spread

## **Pests**

### **Category : Insects**

#### **Cocoa weevil** *Araecerus fasciculatus*

#### **Symptoms**

Circular bore holes on nut shells where adult has emerged; kernel destroyed by tunneling or completely hollowed out; adult is a small (3-5 mm) long beetle which is a mottled dark brown in color; larvae are small yellow-white grubs grubs

#### **Cause**

Insect

#### **Comments**

Cocoa weevils are potentially devastating post-harvest pests; larvae bore into the kernels to feed and pupate; adults bore an exit hole after pupation and emerge from the kernel

#### **Management**

The primary method of controlling the cocoa weevil is through the use of fumigants on the stored nuts

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# Oats

## Description

Oats are annual grasses belonging to the genus *Avena*, in the family Poaceae and are grown primarily for use as livestock feed. Several species of oats are grown commercially in different regions of the world, including *Avena sativa* (common oat), *Avena byzantina* (Algerian or red oat), *Avena nuda* (naked oat) and *Avena sterilis* (the sterile or animated oat). Like wheat, oats generally have been developed into different varieties that are adapted to planting at different times of the year. Spring oats are planted for a late summer harvest, whereas Winter oats are planted for harvesting in early to mid summer. Overwintering varieties are more commonly grown in regions with mild winters. Oats generally possess an upright stem and fibrous root system. The inflorescence consists of a number of branches, or racemes, and spikelets (20–150 per plant) which usually contain three florets or flowers (naked oats produce 3–7 flowers per spikelet). Generally, two seeds (kernels) are produced per spikelet, but sometimes only one develops. Ancestors of the common oat, *Avena sativa* and the closely related *Avena byzantina* originated from the Fertile Crescent of the Near East.

*Oats ready for harvest*

*Oat close-up*

*Oat*

*Field of oats*

*Oats*

*Ripening oats*

## Uses

Oats can be rolled or crushed to produce oatmeal or ground to produce oat flour. Oats may also be used in the production of several baked goods such as oat cakes or oat bread. The vast majority of commercially grown oats are used as livestock feed.

## Propagation

**Basic requirements** Oats grow best in cool, moist climates, with the optimum temperature for growth being between 20 and 21°C (68–70°F). The plants will thrive in well drained soils but are adapted to grow in many soil types, requiring a pH between 5.5 and 7.0. Oats are less tolerant of drought and heat than other cereals but, like other small grains, tolerate acidic soils well. **Propagation** Oats are propagated from seed which can be sown in Spring or in Fall depending on the variety, prevailing climate and the intended use. Commercially produced oats are drilled into a prepared seedbed. Seedbeds should be firm and free of any weeds or vegetation. If oats are being grown to harvest grain then the recommended seeding rate is 60–90 lb of seed per acre. This should be increased slightly if the seeds are being sown by broadcasting as is commonly the case in small-scale production or home gardens. Seeds should be sown at depths of 3–7 cm (1.2–2.8 in) allowing 15–17 cm (5.9–6.7 in) between rows. **General care and maintenance** Soil should be tested prior to planting oats in order to establish the rate of fertilizer and lime application required. Lime is often applied to raise the pH of the soil. If pH is too low, yields may be reduced. Nitrogen should be applied to oats after seedlings emerge at a rate of 20 lb per acre. Further applications are made throughout the growing season based on the specific soil and rotation schedule. In addition to nitrogen, oats require phosphorus and potassium for optimal growth. The rates of application of these nutrients should be based on the results of a soil test. **Harvesting** Oats are ready to harvest when the kernels are at the ‘hard dough’ stage when the grain moisture content drops below 14%. The plants will have lost their green color and appear yellow-brown. The kernels harden and cannot be dented with a fingernail. Commercially produced oats are harvested by combine. Small-scale productions can be harvested by hand cutting. After harvest, the grain must be dried before being stored.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Anthracnose** *Colletotrichum graminicola*

###### **Symptoms**

Red to brown oval lesions on the leaves; black fungal structures may visible on lesions; crowns become bleached and then turn brown; plants are more susceptible to lodging

###### **Cause**

Fungus

## **Comments**

Fungus survives as spores on seeds and crop debris; spores can be spread by wind or splashing water; nutrient deficient plants are more susceptible to the disease

## **Management**

Provide plants with adequate levels of fertilizer; rotate crops to improve soil quality; control weeds in field; turn crop debris into soil after harvest to limit release of spores; avoid planting oats in soils with a high pH`

## **Crown rust** *Puccinia coronata*

*Symptoms of crown rust on oat leaves*

*Symptoms of crown rust on oat leaves*

## **Symptoms**

Chlorotic flecks or brown necrotic spots on leaves or stems; yellow streaks or patches on foliage; brown necrotic streaks on foliage; raised orange pustules may be present on lesions

## **Cause**

Fungus

## **Comments**

One of the most destructive oat diseases

## **Management**

The most effective method of controlling rusts is to plant resistant varieties of oats; planting oats early allows them to mature before spores reach plants and escape most damage

## **Loose smut** *Ustilago avenae*

*Loose smut symptoms on oat*

*Loose smut symptoms on oat*

## **Symptoms**

Early emergence of heads; dark green or black masses in place of kernels

## **Cause**

Fungus

## **Comments**

Spores rupture out from protective membrane on heads; fungus can survive in infected seed

## **Management**

Use only certified smut-free seed; treat seeds with hot water prior to planting to kill fungi; treat seeds with systemic fungicide (fungi inside seed) fungicide; grow resistant varieties

## **Powdery mildew** *Erysiphe graminis*

## **Symptoms**

Patches of cottony, white-gray growth on upper surface of leaves which turn gray-brown; chlorotic patches develop on leaves opposite fungal growth; fungal fruiting bodies usually become visible as black dots on the mildew

## **Cause**

Fungus

## **Comments**

Disease emergence favors heavy nitrogen fertilization; high humidity and cool temperatures

## **Management**

Planting resistant varieties is one of the best ways to protect plants from powdery mildew; other control strategies

include: application of appropriate foliar fungicides, if available; removal of crop debris from field after harvest to reduce the level of overwintering fungus; removal of volunteer oat plants which can act as a reservoir for the disease

## Category : Viral

### Barley yellow dwarf Barley yellow dwarf virus (BYDV)

#### Symptoms

Stunted growth of plants; yellow green blotches at leaf tip, leaf margin or leaf blade; leaves turning bright yellow, red or purple

#### Cause

Virus

#### Comments

Transmitted by aphids; symptoms more apparent in colder temperatures

#### Management

Grow resistant or tolerant varieties; avoid planting crop very early or very late when aphid populations are high

## Category : Bacterial

### Scab *Fusarium* spp.

#### Symptoms

One or more spikelets on newly emerged head bleached; pink or orange fungal masses may be visible at the base of infected spikelet; infected spikelets do not produce seed or produce shriveled and/or discolored seed; severe infections can cause the kernels to have a chalky appearance and are frequently lost during harvest

#### Cause

Fungi

#### Comments

Fungus survives between seasons on host plant debris - other host include corn, wheat and barley; fungus can survive on host debris for several years; warm, moist conditions promote the spread of the disease when present

#### Management

Control of the disease can be difficult; crop rotation to a non-host is recommended for at least one year; applications of appropriate fungicides if available can help to control the disease in conjunction with the other measures detailed here

## Pests

### Category : Insects

### Aphids (Bird cherry-oat aphid, Russian wheat aphid, Corn leaf aphid, etc.)

*Rhopalosiphum padi*

*Diuraphis noxia*

*Sitobion avenae*

#### Symptoms

Yellow or white streaked leaves; flag leaves may be curled up; plants may be stunted and tillers may lie parallel to the ground; plants may turn a purple color in cold weather; insects are small and soft-bodied and may be yellow, green, black or pink in color depending on species; insects secrete a sugary substance called "honeydew" which promotes the growth of sooty mold on the plants

#### Cause

Insect

#### Comments

Fields should be checked for aphid populations periodically after emergence

### **Management**

Sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use; in commercial plantations aphid numbers are usually kept in check by predators and natural enemies; beneficial insect populations should be assessed before chemical control is considered; if no beneficial insect populations are present and aphids are damaging then apply appropriate insecticides

### **Armyworms** *Mythimna unipunctata*

*Spodoptera praefica*

#### **Symptoms**

Entire leaves consumed; notches eaten in leaves; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside

#### **Cause**

Insect

#### **Comments**

Insect can go through 3–5 generations a year

### **Management**

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae

### **Stinkbugs** *Euschistus* spp.

#### **Symptoms**

Damage to head during milk or soft dough stage; stink bugs often carry pathogens in their mouthparts which can cause secondary infections; adult insect is shield-shaped and brown or green in color; may have pink, red or yellow markings; eggs are drum shaped and laid in clusters on the leaves; larvae resemble the adults but are smaller

#### **Cause**

Insect

#### **Comments**

Adult insects overwinter under leaves, on legumes, blackberries or on certain weeds such as mustard or Russian thistle

### **Management**

Remove weeds around crop which may act as overwintering sites for stink bugs and practice good weed management throughout the year; organically accepted control methods include the use of insecticidal soaps, kaolin clay and preservation of natural enemies

### **Wireworms** *Aeolus* spp.

*Anchastus* spp.

*Melanotus* spp.

*Limonius* spp

#### **Symptoms**

Death of seedlings; reduced stand; girdled stems and white heads; wireworm larvae can be found in soil when dug round the stem; larvae are yellow-brown, thin worms with shiny skin

#### **Cause**

Insect

#### **Comments**

Larval stage can last between 1 and 5 years depending on species

## **Management**

Chemical control impossible in a standing crop, must be applied at preplanting or as a seed treatment; if wireworms are known to be present in soil fallow field during summer and till frequently to reduce numbers; rotate to non-host crop where possible; avoid planting susceptible crops after a wireworm infestation on cereals without either fallowing or applying appropriate pesticide

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# Oil palm

## Description

Oil palm, includes the palm species native to Africa, *Elaeis guineensis*, and the species native to South and Central America, *Elaeis oleifera*. Both species are perennial tropical trees in the family Arecaceae which are grown for their oil which is used in cooking and in industry. Oil palm trees are unbranched with a long stout single stem, or trunk, terminating in a crown of 7–100 leaves. The leaves are pinnate and can reach 3–5 m (9.8–16.4 ft) in length. The tree produces large, spherical red fruits in bunches. Up to 200 fruits can be produced per bunch and the oil is extracted from the pulp and kernel. Oil palm can reach heights of 20–30 m (65.6–98.4 ft) and has an economic lifespan of 25–30 years, at which point they become too tall to be managed efficiently and are cut down. Left alone, oil palm has been known to live for periods up to 200 years. Oil palm may also be referred to as African oil palm and originated from West Africa.

*Oil palm fruit*

*Oil palm plantation, Indonesia*

*Oil palm plantation*

*Harvested oil palm fruits*

*Oil palms*

*Oil palms*

## Uses

Palm oil is widely used as a cooking oil, as an ingredient in many processed foods and as a substitute for butter. Palm oil can be used to produce biodiesel. Palm oil is also used as a binding agent in cosmetics.

## Propagation

**Basic requirements** Oil palm is typically grown in tropical lowland regions over large areas. The tree requires deep soil and stable high temperatures ( $30\text{--}32^\circ\text{C}$ / $86\text{--}89.6^\circ\text{F}$  for at least 80 days) for optimum productivity. Temperatures below  $20^\circ\text{C}$  ( $68^\circ\text{F}$ ) will severely reduce the growth of both species, while the African oil palm will also suffer a reduction in growth at temperatures above  $40^\circ\text{C}$  ( $104^\circ\text{F}$ ). Palms will grow in a variety of deep tropical soils and will tolerate a pH between 4.0 and 8.0. Oil palms have a requirement for continuous moisture throughout the year. The trees can tolerate 2–3 months of dry conditions but it can affect yields. **Propagation** Trees are propagated from seed and are germinated prior to planting by moistening them and placing them in a small box within a polyethylene bag placed in a germinator. Once the seeds have germinated they are allowed to grow further in a pre-nursery (a prepared bed, tray or container with fertile soil). The seedlings are then planted on into a nursery where they will be allowed to grow for a further 6–12 months before they are planted in the field. Field seedlings are planted in the field allowing 9 m (29.5 ft) between trees and an additional 9 m (29.5 ft) between rows. Trees will begin to bear fruit after 3–4 years. **General care and maintenance** Oil palms are frequently planted along with a leguminous cover crop which helps provide nitrogen to the palms while also suppressing weeds. When bunches are harvested, it is usual for fronds to be pruned. The number of fronds per palm is maintained at between 35 and 40. Oil palm plantations are rarely, if ever, irrigated. Due to the moisture requirements of the palms, supplemental irrigation is recommended during dry spells. **Harvesting** Harvesting of oil palms generally begins 2.5 years after the trees are planted in the field. Harvesting takes place throughout the year, usually at 3-week intervals, as the bunches ripen. Bunches are harvested by cutting from the tree using a sharp knife or sickle.

*Oil palm nursery*

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## Common Pests and Diseases

### Diseases

**Category : Bacterial**

## **Bacterial bud rot** *Erwinia* spp.

### **Symptoms**

Parts of spear leaf petiole or rachi turning brown; discoloration may be associated with a wet rot; spear leaf may be wilted and/or chlorotic; leaves may be collapsing and hanging from the crown; infection of the bud results in buds becoming rotten and putrid, leading to death of the palm

### **Cause**

Bacteria

### **Comments**

Disease occurs in oil palm in Colombia, Costa Rica, Democratic republic of Congo, Ecuador, Nicarauga, Nigeria, Panama and Southeast Asia

### **Management**

Plant oil palm varieties with resistance to the bacteria; rotting tissue on spear leaves should be removed to prevent bacteria spreading to buds; palm buds can be protected using copper-based fungicides

## **Category : Fungal**

## **Ganoderma butt rot** *Ganoderma* spp.

### **Symptoms**

Reduced growth of palm, pale green foliage, older fronds turning chlorotic or necrotic; drooping fronds; on mature oil palms, spear leaves do not open, seedlings may exhibit a one-sided chlorosis or necrosis of the lower fronds; cross-sections of lower portion of trunk reveal a discoloration and softening of the central area and a distinct boundary is present between healthy and diseased tissue

### **Cause**

Fungi

### **Comments**

Serious disease in Far East

### **Management**

There are currently no fungicides recommended for protecting palms from Ganoderma butt rot; palms should be monitored closely for signs of disease, especially if a palm has died or been removed nearby as fungi can colonize old stumps and release spores; infected trees should be removed as once symptoms are present in foliage, a large portion of the trunk is already rotted and the palm is unstable; do not replant palm in soil where an infected palm has been removed

## **Oil palm wilt** *Fusarium oxysporum*

### **Symptoms**

Symptoms of the disease vary with age of host; disease can affect seedlings and mature trees; seedlings exhibit retarded growth, reduced leaf size, chlorosis of older leaves and tip necrosis; field palms may exhibit a bright yellow chlorosis of leaves in the mid-canopy which starts at the tip of the pinnae and moves towards petioles before affecting adjacent fronds and spreading to older leaves in the canopy; in older palms, lower leaves wilt and dry out and fronds break close to the base of the trunk; new fronds are chlorotic and stunted; the palm shows decline on one side and develops symptoms in the lower canopy; infection spreads rapidly upwards and infects the bud, killing the palm

### **Cause**

Fungus

### **Comments**

Fungus infests palms through the root system

### **Management**

International quarantine procedures have limited the spread of the disease between major palm oil producing countries; dead or dying trees should be felled and burned to prevent spread in plantations; if palms are replanted then new palm should be planted a distance of 3.9 m from infested stump; soil within a 3 m radius of infested stumps should be treated

with dazomet and covered for a period of 30 days

### **Pestalotiopsis leaf spot** *Pestalotiopsis* spp.

#### **Symptoms**

Tiny black spots on leaves which enlarge into 2 mm long elliptical, elongated lesions; lesions may expand and be surrounded by black tissue and chlorosis between lesions; lesions may be present on leaf petioles and rachis

#### **Cause**

Fungi

#### **Comments**

Disease has been reported worldwide

#### **Management**

If palm is severely diseased, it should be removed from plantation and destroyed; palms should be planted with adequate spacing to allow air to circulate between trees; remove weeds from around palms; applications appropriate broad spectrum foliar fungicides can help to protect the palms from disease

## **Pests**

### **Category : Insects**

#### **Mealybugs (Pineapple mealybug)** *Dysmicoccus brevipes*

##### **Symptoms**

Flattened oval to round disc-like insect covered in waxy substance on tree branches; insects attract ants which may also be present; insect colony may also be associated with growth of sooty mold due to fungal colonization of sugary honeydew excreted by the insect; symptoms of direct insect damage not well documented

##### **Cause**

Insect

##### **Comments**

Insects have a wide host range; often tended by ants which farm them for their sugary honeydew secretions; transmit Cocoa swollen shoot virus

##### **Management**

Mealybugs can potentially be controlled by natural enemies such as lady beetles but are commonly controlled using chemicals; chemical pesticides may also decrease populations of natural enemies leading to mealybug outbreaks

#### **Rhinoceros beetle** *Oryctes rhinoceros*

##### **Symptoms**

V-shaped cuts in palm fronds or holes in leaf midribs caused by beetles boring into crown to feed; adult insect is a large black beetle with a curved spine on its head; larvae are creamy white grubs with brown heads and 3 sets of prolegs at the anterior (head) end

##### **Cause**

Insect

##### **Comments**

Beetles are nocturnal and fly at night; also a damaging pest of oil palm

##### **Management**

Destroy any decaying logs in plantation by chopping and burning to kill any larvae that may be inside; remove any dead trees from plantation and destroy by burning; plant a cover crop to deter egg laying by females as they do not lay eggs in areas covered by vegetation; hooked wire can be used to extract larvae that are boring into young crowns

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# Okra

## Scientific Clarification

The following are the crop details for Okra:

Scientific name: *Abelmoschus esculentus*

Local names: Bamia, Binda (Swahili)

Order: Malvales

Family: Malvaceae

Genus: *Abelmoschus*

*Field of okra*

*Harvested okra pods*

*Okra pods*

*Okra flower and pods*

*Okra flower*

*Okra seed pod developing*

*Okra with pods*

*Okra plant with flower*

*Okra flower buds*

## General Information

Okra, also known as lady's fingers, is mainly grown for its young immature pods, which are consumed as a vegetable, raw, cooked, or fried. It is a common ingredient in soups and sauces. The pods can be conserved by drying or pickling. The leaves are sometimes used as spinach or cattle feed, the fibers from the stem for cord, the plant mucilage (thick gluey substance) for medical and industrial purposes, and the seeds as a substitute for coffee. Okra seeds contain a considerable amount of good-quality oil and protein.

Okra plants have small erect stems that can be bristly or hairless with heart-shaped leaves. The leaves are 10â€“20 cm (4â€“8 in) long with 5â€“7 lobes. The plant produces flowers with five white to yellow petals which are 4â€“8 cm (1.6â€“3.1 in) in diameter. The seed pod is a capsule up to 25 cm (10 in) long, containing numerous seeds. Okra can grow 1.2â€“1.8 m (4â€“6 ft) tall and as an annual plant, survives only one growing season.

It is believed to have originated in Ethiopia but is also particularly popular in India, West Africa, and Brazil.

## Okra Varieties in Kenya

Pusa sawani: High-yielding variety tolerant to vein mosaic. It grows 2 to 2.5 m tall and has long pods. (18 to 20 cm), dark green, smooth, and has 5 ridges. Mainly for export.

Clemson spineless: 1.2 to 1.5 m tall. Pods are about 15 cm long, green, and moderately ridged.

Green Emerald2: This variety is about 1.5 m tall. Pods are 18 to 20 cm long, slightly ridged (rounded), and green.

White velvet: A medium-tall variety of 1.5 to 1.8 m high. Pods are 15 to 18 cm long, slender, tapered, smooth, and creamy white.

Dwarf Green Long Pod: It grows up to 0.9 m high. It has several side branches. The pods are angular and green and about 18 to 20 cm long.

## Okra Varieties in India

Pusa Makhmali: Variety produces light green fruits.

Punjab no. 13: Suitable for cultivating in the spring-summer season. Fruits are light green, 5-ridged and of medium length.

Punjab Padmini: Fruits are quick growing, dark green, hairy, 5-ridged, and remain tender for a longer period. Matures within 55-60 days after sowing.

Parbhani Kranti: Fruits are medium-long with tender smooth surfaces at the marketable stage. Fruits have a good keeping quality. The average yield is 8.5-11.5 t/ha in 120 days.

Arka Anamika: Fruits are borne in two flushes. During the first flush, the fruits are borne on the main stem 45-50 days after sowing. During the second flush, the fruits are borne on short branches, which sprout from the middle portion of the

main stem. Fruits are spineless with 5-6 ridges, delicate aroma, and good keeping quality.

## Climatic Conditions, Soils, and Water Management

Okra is grown at elevations ranging from sea level to 1600 m. The optimum temperatures for the growth and production of high-quality pods range between 24 and 30°C. The crop is sensitive to frost and temperatures below 12°C.

Okra will grow on a wide range of soils, but it prefers soils high in organic matter. The seeds perform well on fertile, well-drained loamy soil. When the soil fertility level is low, organic manure, fertilizer, or compost can be applied to improve soil productivity. It must be frequently fertilized in sandy soils, as soluble nutrients readily leach from the root zone. Its optimum range of soil pH is between 5.8 and 6.5. A soil test will indicate if lime is required to adjust the pH and the amount to apply. If lime is recommended, dolomite should be used and applied 3 to 4 months before the crop is seeded. Okra is sensitive to salinity. Okra can grow in a wide range of rainfall regimes but needs 400 mm of water for the growing period of about 3 months.

## Uses

Okra is mainly consumed as a vegetable and it provides health benefits such as; strengthening bones, lowers blood pressure, prevents constipation and maintains healthy skin.

## Planting procedure

### Land preparation

Thorough soil preparation 2 to 3 months before planting is recommended to allow crop residues and organic matter in the soil to decompose before okra is planted. Early land preparation also permits weed seeds to germinate and allows early cultivation to destroy young weeds before planting.

### Soil management

The crop produces reasonably well on most soil types, although a fertile loam is preferable. Cultivars that are susceptible to root-knot eelworm (*Meloidogyne incognita*) do not produce a satisfactory crop on infected light or sandy soils. This species tolerates soils that are slightly acidic and will grow successfully in soils with a pH of 6.0-6.8.

### Sowing

Okra plants may be established by direct seeding in the field, by growing seedlings in nursery seedbeds, or by raising seedlings in plastic trays. Before planting, it is advisable to soak the okra seeds in water for 24 hours, to break seed dormancy and speed up the germination rate or reduce germination days. In Kenya, okra is sown directly in the field. About 8 to 10 kg of seed is required per hectare. The planting depth is about 1.5 cm.

Spacing varies from 45 x 45 cm, 50 x 30 cm, or 60 x 15 cm between the rows and within the rows, respectively. In some parts of Kenya, okra is planted 2 x 2 m in flood irrigation basins. Spacing of about 1 to 2 feet intra-row and 3 to 4 feet inter-row should be used. The main export season in Kenya is October to May; hence planting should start in July to target this export season. However, with irrigation okra can be grown all year round for the local and off-season export markets.

# Field Operations

## Fertilizer application

Before planting, manure or artificial fertilizer has to be mixed well into the top 10 cm of the soil. The uptake of minerals is rather high. When the crop yields 10 t of fresh fruits per hectare, the uptake is 100 kg N, 10 kg P, 60 kg K, 80 kg Ca, and 40 kg Mg. Fertilizer can be given in three split applications, at sowing, after 3 weeks, and again at 6 weeks after sowing.

The general recommendation in Kenya (issued by Horticultural Crops Development Authority) for conventional production (non-organic production) is as follows: well-composted manure should be applied at planting at the rate of 15 to 20 t/ha (17 to 20 gm/plant). It should be mixed thoroughly with the soil in the planting hole.

## Weeding

Okra is harvested over a long period and weed control is important throughout the cropping season. Smallholder growers in Kenya control weeds by hand hoeing.

## Rotation

Okra should be rotated with baby corn, maize, peas, onions, potatoes, fodder grass, or small grains. Being in the same family as cotton it shares the same complex of pests and diseases therefore okra should not be grown before or after cotton.

## Irrigation

Okra is a heavily foliated crop, so its water requirements are high. According to the Kenya Ministry of Agriculture, okra needs 400 mm of water during the growing season of three months. A general guideline for semi-arid areas, where okra is mostly grown in Kenya, is to provide about 35 mm of water per week (this equals 35 liters of water per square meter). Critical times for irrigating okra are at emergence and from flowering to pod production. Saline or chlorinated water should not be used for irrigation.

# Harvesting

Early-maturing cultivars give the first harvest 7 weeks after sowing. A developing fruit should be harvested 7-8 days after flowering. Earlier picking depresses yields because of suboptimal fruit weight. Delayed picking depresses marketable yields because over-aged fruits become fibrous. Therefore, okra fields are harvested at intervals of 2-3 days. For seed production, the whole crop can be harvested at once. As the plant continues to flower, fruits can be picked every 2 days. Picking fruits is usually done manually. Intensive contact with slightly hairy fruits and plants may lead to skin irritation.

Most varieties grown in Kenya are ready to pick 45 to 55 days after planting. Pods are ready for harvesting about 4 to 6 days after flowering. Pods are harvested when still tender and on attaining a length of 7 to 15 cm, depending on variety and market requirements.

Regular picking every 1 to 2 days is essential to ensure pods are within the size prescribed by the market. Okra should not be harvested when it is raining or excessively wet. Excess moisture can induce mold development on the pods and the cut petioles. Okra pods decay quickly; therefore they should be harvested within a day to market.

Harvesting is done by hand. The pods can be snapped off or cut off, leaving a small stalk not longer than one cm. The pods must be handled carefully otherwise they may be bruised and may discolor. It is best to pick pods into a waist bag to reduce skin damage and to avoid excessive bending of the pods. Wearing rubber gloves when harvesting and handling pods is recommended. This will protect the skin from irritating sap produced by the okra plant.

## Postharvest Treatment

After harvesting, the fruits can be stored for only 3-5 days at about 10°C; lower temperatures may cause damage to the fruits. Okra should not be washed until shortly before use as washing makes the fruit slimy.

Fresh okra can quite easily be transported in bulk and kept for several days without much loss of quality. Dried okra is an important product in West Africa. Some countries have a small canning and freezing industry.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Charcoal rot** *Macrophomina phaseolina*

###### **Symptoms**

Discoloration of stem at soil line; cankers on stem may spread upwards; leaves may wilt and drop from plant; numerous small black sclerotia (fungal fruiting bodies) develop in affected tissues and can be used to diagnose the disease

###### **Cause**

Fungus

###### **Comments**

Fungus had a wide host range and affects beans, tobacco, soybean, pigeon pea and many other crops; disease is primarily spread via microsclerotia in the soil

###### **Management**

Rotate crop to non-host to reduce build-up of inoculum in the soil; avoid water stress to plants by irrigating when required

##### **Fusarium wilt** *Fusarium oxysporum*

###### **Symptoms**

Wilting of cotyledons and seedling leaves; cotyledons become chlorotic at the edges and then necrotic; older plants exhibit symptoms of wilting and leaf chlorosis; wilting is usually gradual but may be pronounced after heavy summer rain; if infection is severe plants become stunted and may be killed; vascular system of infected plants becomes

discolored and can be seen by cutting the stem

#### **Cause**

Fungus

#### **Comments**

Disease emergence is favored by warm temperatures; fungus may be introduced to field through infected seed or by contaminated equipment and human movement

#### **Management**

Use on certified, disease-free seed; plant varieties with higher resistance to the disease in areas with a history of Fusarium diseases; fumigating the soil may reduce disease incidence

### **Powdery mildew** *Oidium asteris-punicei*

*Powdery mildew on okra*

#### **Symptoms**

Powdery white covering on leaves; patches may coalesce to cover entire plant; if plant is heavily infected leaves may roll upward and appear scorched

#### **Cause**

Fungus

#### **Comments**

Fungus overwinters on plant debris or alternate host; disease emergence is favored by warm, dry weather with cool nights that result in dew formation

#### **Management**

Use overhead irrigation (washes fungus from leaves and reduces viability); plant crop as early as possible; applications of appropriate fungicides may be necessary to control the disease

### **Southern blight** *Sclerotium rolfsii*

#### **Symptoms**

Sudden wilting of leaves; yellowing foliage; browning stem above and below soil; browning branches; stem may be covered with fan-like mycelial mat

#### **Cause**

Fungus

#### **Comments**

Fungus can survive in soil for long periods; disease emergence favored by high temperatures, high humidity and acidic soil; disease found mainly in tropical and subtropical regions, including the southern United States

#### **Management**

Remove infected plants; avoid overcrowding plants to promote air circulation; rotate crops with less susceptible plants; plow crop debris deep into soil; provide a barrier to infection by wrapping lower stems of plant with aluminum foil covering below ground portion of stem and 2-3 in above soil line

### **White mold** *Sclerotinia sclerotiorum*

#### **Symptoms**

Flowers covered in white, cottony fungal growth; small, circular, dark green, water-soaked lesions on pods leaves and branches which enlarge and become slimy; cottony white growth may be visible on lesions during periods of high humidity; death of branches and/or entire plant

#### **Cause**

Fungus

#### **Comments**

Fungus can survive in soil for in excess of 5 years; disease can be spread by wind, contaminated irrigation water and by infected seeds

### **Management**

Rotate crops with non-hosts like cereals and corn; plant rows parallel to direction of prevailing winds to prevent spread of disease from secondary hosts nearby; avoid excessive nitrogen fertilizer; use a wide row spacing

## **Category : Viral**

### **Enation leaf curl disease *Okra Enation Leaf Curl Virus (OELCV)***

*Enation on infected leaves*

*Twisting of stem and leaf petiole*

### **Symptoms**

On lower surface of leaves we will see a small pin head enations. This enation become warty and rough in structure at later stage. Reduce in leaf size. The stem, lateral branches and leaf petioles become twisted along enation. Leaves appear thick and leathery. In severely infected plants the emerging leaves shows bold enations and curling. And produce few deformed fruits.

### **Cause**

Virus

### **Comments**

The virus is transmitted by white fly.

### **Management**

1. Remove the infected plant and burn them to avoid further spread of disease
2. Use yellow sticky traps to monitor whiteflies population
3. If the whiteflies infestation is more spray suitable insecticides.

### **Yellow Vein Mosaic Disease *Bhendi Yellow Vein Virus (BYVMV)***

*Infected leaf*

*Yellow vein mosaic disease on mature plant*

*Yellow vein mosaic disease on young seedling*

### **Symptoms**

The infected leaves shows alternate patches of green and yellow. Veins become clear and chlorotic. With the progress of disease the veins become conspicuous and both vein and vein lets become thick. In advance stage the stems and leaf stalk become distorted. Fruits are yellowish green in color and small in size.

### **Cause**

Virus

### **Comments**

Transmitted by white fly *Bemisia tabaci*. It causes huge loss if disease occur at early stage of crop.

### **Management**

Use resistant cultivars. Sow disease free certified seeds. Roughing of infected plants. Follow crop rotation. Keep the field free from weeds. Control vector with suitable insecticides.

## **Pests**

### **Category : Insects**

## **Aphids (Green peach aphid, Potato aphid, etc.)** *Myzus persicae*

*Macrosiphum euphorbiae*

### **Symptoms**

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants

### **Cause**

Insects

### **Comments**

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed

### **Management**

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

## **Armyworms (Beet armyworm, Western striped armyworm)** *Spodoptera exigua*

*Spodoptera praefica*

### **Symptoms**

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside

### **Cause**

Insect

### **Comments**

Insect can go through 3–5 generations a year

### **Management**

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae

## **Corn earworm** *Helicoverpa zea*

### **Symptoms**

Larvae damage leaves, buds, flowers and pods; young caterpillars are cream-white in color with a black head and black hairs; older larvae may be yellow-green to almost black in color with fine white lines along their body and black spots at the base of hairs; eggs are laid singly on both upper and lower leaf surfaces and are initially creamy white but develop a brown-red ring after 24 hours and darken prior to hatching

### **Cause**

Insect

### **Comments**

Adult insect is a pale green to tan, medium sized moth; insect is also very damaging pests of corn; insect overwinters as pupae in the soil

### **Management**

Monitor plants for eggs and young larvae and also natural enemies that could be damaged by chemicals; *Bacillus thuringiensis* or Entrust SC may be applied to control insects on organically grown plants; appropriate chemical treatment may be required for control in commercial plantations

## **Cucumber beetles (Western striped cucumber beetle, Western spotted cucumber beetle, Banded cucumber beetle) *Acalymma vittata***

*Diabrotica undecimpunctata*

*Diabrotica balteata*

### **Symptoms**

Stunted seedling; damaged leaves, stems and/or petioles; reduced plant stand; plants may exhibit symptoms of bacterial wilt; scars on fruit caused by beetle feeding damage; adult beetles are brightly colored with either a green-yellow background and black spots or alternating black and yellow stripes

### **Cause**

Insect

### **Comments**

Beetles overwinter in soil and leaf litter and emerge from soil when temperatures begin to reach and exceed 12.7°C (55°F)

### **Management**

Monitor new planting regularly for signs of beetle; floating row covers can be used to protect the plants from damage but will need to be removed at bloom to allow bees to pollinate plants; applications of kaolin clay can be effective for management of small beetle populations; application of appropriate insecticides may be necessary

## **Loopers (Cabbage looper) *Trichoplusia ni***

### **Symptoms**

Large or small holes in leaves; damage often extensive; caterpillars are pale green with a white lines running down either side of their body; caterpillars are easily distinguished by the way they arch their body when moving; eggs are laid singly, usually on the lower leaf surface close to the leaf margin, and are white or pale green in color

### **Cause**

Insect

### **Comments**

Insects overwinter as pupae in crop debris in soil; adult insect is a dark colored moth; caterpillars have a wide host range

### **Management**

Looper populations are usually held in check by natural enemies; if they do become problematic larvae can be hand-picked from the plants; an organically acceptable control method is the application of *Bacillus thuringiensis* which effectively kills younger larvae; chemical sprays may damage populations of natural enemies and should be selected carefully

## **Thrips (Melon thrips) *Thrips palmi***

### **Symptoms**

If population is high leaves may be distorted; leaves are covered in coarse stippling and may appear silvery; leaves speckled with black feces; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color

### **Cause**

Insect

### **Comments**

Thrips can produce several generations of insect per year

### **Management**

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic

## **Category : Nematodes**

### **Root-knot nematode *Meloidogyne* spp.**

#### **Symptoms**

Galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; reduction in plant vigor; yellowing plants which wilt in hot weather

#### **Cause**

Nematode

#### **Comments**

Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or garden with this type of soil is most likely

#### **Management**

Plant resistant varieties if nematodes are known to be present in the soil ;check roots of plants mid-season or sooner if symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens

## **Category : Mites**

### **Spider mites (Two-spotted spider mite) *Tetranychus urticae***

#### **Symptoms**

Leaves stippled with yellow; leaves may appear bronzed; webbing covering leaves; mites may be visible as tiny moving dots on the webs or underside of leaves, best viewed using a hand lens; usually not spotted until there are visible symptoms on the plant; leaves turn yellow and may drop from plant

#### **Cause**

Arachnid

#### **Comments**

Spider mites thrive in dusty conditions; water-stressed plants are more susceptible to attack

#### **Management**

In the home garden, spraying plants with a strong jet of water can help reduce buildup of spider mite populations; if mites become problematic apply insecticidal soap to plants; certain chemical insecticides may actually increase mite populations by killing off natural enemies and promoting mite reproduction

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# Onion

## Description.

Crop details

The following are the crop details for onion.

Local Names: Kitunguu, (Swahili), Gitunguru (Kikuyu) Kitunguru (Maragoli).

Scientific Name: *Allium cepa*

Order: [Asparagales](#)

Family: [Amaryllidaceae](#)

Subfamily: [Allioideae](#)

Genus: [Allium](#)

Species: A. *cена*

Other names: bulb onion or common onion

*Onion foliage*

*Pink onion flowers*

*Onion bulb*

## General Information

Being a biennial vegetable onion is grown as an annual in temperate zones. The varieties that thrive in the tropics are effectively annuals because they can produce seed within the first year of growth.

The plant's stem is a flattened disc with tubular leaves that form a pseudo stem where their sheaths overlap. There are 3-8 leaves per plant that are either erect or oblique. The plant produces pink or white flowers cluster on its stalks. The bulbs are formed just above the flattened stem of the plant by overlapping leaves.

Onions may also be referred to as cultivars and these include red or purple onions, shallots, and spring onions or scallions. They are particularly suited to smallholder farming in most countries.

In the tropics onions can be grown year-round where irrigation is possible.

The bulb is made up of layers, each of which corresponds to a leaf. They are generally oval, but their shape can vary, and they appear in clusters of 3-18 per plant. It is shielded by a membrane that transforms into a paper coat. Onion plants can grow to a height of 50 cm (20 in) and are grown as annuals, harvested after one growing season; however, in the tropics, onions can be grown year-round if irrigation is available.

## Varieties

The history of ancestral onion species is not well documented. Ancient records of onion use span western and eastern Asia, so the geographic origin of the onion is uncertain. Yet, domestication likely took place in West or Central Asia. Onions have been variously described as having originated in Iran, western Pakistan and Central Asia.

### Onion Varieties in Kenya

**Red Creole:** This is a popular standard variety in high demand because of its good keeping quality. It produces mainly single onions from transplants, red, flat-round, and with a pungent taste.

**Red Tropicana :** Red bulbing type

**Red Tropicana F1 Hybrid :** Produces large, red, thick flat onions with firm pungent flesh. It is highly productive and therefore demands high levels of management. It keeps well in a dry aerated store.

**Bombay Red:** It is a variety of dry and warmer conditions. It is small to medium-sized, globe-shaped, purplish red, and pungent.

**Yellow Granex F1 Hybrid:** This is an early maturing high yielding attractive, thick flat onion with thin yellow scales. The flesh is medium firm, crisp, and mild in flavor. The shape and size are uniform leading to higher market prices, and the storage quality is good.

**Texas early Grano:** This is a fresh market, early maturing variety (100 - 120 days) with a rather short shelf life. It is yellowish, mild, and not very pungent. The bulbs are high-top shaped with dry yellow scales. It is a heavy yielder for high-altitude regions. Ideal for fish salads.

**White Creole:** This is a white variety normally used for dehydration.

**Green bunching:** non-bulbing spring onion. It has attractive tasty dark green leaves. It is an early and highly productive onion grown for stems rather than bulbs. It is tolerant to sun scorch and it is recommended for

salads and fresh markets.

### Onion Varieties in East Africa

In Tanzania, Red Bombay is the most popular onion variety. Its production is highest in March, May, and December and is predominantly sourced from Mangâ€™ola.

Other popular varieties grown in the East Africa region include Red Pinoy F1, Red Creole, Bombay Red, and Texas Early Grano.

*Onion sets are small, immature onion bulbs*

*Transplanting onions from cell trays*

*Transplants can be produced in cell trays*

## Climate Conditions, Soil, and Water Management

In temperate zones, onion is a cool-season biennial and is tolerant to frost. They produce bulbs with growing day lengths. Optimum temperatures for plant development are between 13 and 24Â°C, although the range for seedling growth is narrow, between 20 and 25Â°C. High temperatures favor bulbing and curing. In the tropics, only short-day or day-neutral onion varieties will form bulbs. These thrive in warm to hot climates of 15-30Â°C. If the temperature greatly exceeds that required for bulbing, maturity is hastened and bulbs do not grow to maximum size, consequently lowering the yields.

Onions can be grown on any fertile, well-drained, non-crusting soil. The optimum pH range is 6.0 to 6.8, although alkaline soils are also suitable. Onions do not grow well in soils below pH 6.0. On light sandy soils, irrigation is necessary. Irrigation could be either overhead or on a drip. Onions at the bulbing stage need a substantial amount of water, but excessive moisture must be avoided during the growing season. Avoid the application of fresh manure to the crop, as this will cause the plants to develop thick necks and too many leaves at the expense of bulb formation.

## Uses

The bulb is an edible vegetable and is the most commonly used part of the onion, usually consumed after cooking although it can be eaten fresh. The stems and leaves are also edible. In general, onions are used for salads (bunching onions or sliced full-grown bulbs), pickling (e.g. silver skin onions), cooking (such as in soups), and frying (for example, with meat). It also plays an important role in traditional medicine (e.g. as a diuretic).

## Planting Procedure

The planting procedure for onion is as follows:

A grower must consider several factors when planting onions, among them are onion varieties. Onions can be planted in three different ways: by sets transplants or direct seeding. Sets are grown from seeds, producing small bulbs before going dormant.

Planting sets and transplants can be advantageous because they are ready to harvest one to two months earlier than onions planted directly. Planting in sets and transplanting is much more expensive than direct seeding.

Harvests can be completed earlier in the year when using transplants or sets, which may result in higher profits if the market demand for the produce is higher. Planting sets or transplants necessitate the use of specialized planting equipment. It is necessary to consider the cost of acquiring the necessary equipment.

In some environments, using sets and transplants exposes the onion to environmental pressures for a shorter period of time, reducing the need for weed and pest control. A precision seed drill and other onion handling equipment are required for direct seeding. For direct seeding, the soil must be tilled, smoothed, and leveled prior to seeding.

The ideal soil site is well-drained and has a nearly neutral pH (6.6-6.8). (Growing Onions). Direct seeding requires that each seed be planted at the same depth below the soil surface in order for it to germinate and grow uniformly. Typically, seeds are planted 1 inch deep.

## Planting Systems

Nursery seeding and transplanting is the most common and practical option in the tropics. Transplants normally have 3 to 5 well-formed leaves at transplant time. Roots are pruned during planting, in order not to be bent upwards when transferred to the field. This facilitates early establishment of the plant.

Any germinated bulb of the above-mentioned varieties would produce 3-6 good size bulbs in about 3 months when planted with the rains. Choose only healthy bulbs for propagation.

Sets are used in some areas in the temperate zones to ensure large bulb size and uniform maturity. Sets are small dry bulbs, approximately 12 mm in diameter, which have been produced the previous season by seeding thickly or growing under conditions that favor rapid bulbing.

Direct seedling is possible and gives excellent results where herbicides can be used and the season is sufficiently long to provide early pre-bulbing growth. In the tropics this method is impractical due to enormous weeding costs in an organic system.

## Husbandry

Do not plant onions after the field has been planted with other Allium plants (e.g. garlic). Mulching onions with composted leaves and straw is highly recommended to maintain soil organic content, prevent soil-borne diseases, and suppress weeds. Planting onions in raised beds improve drainage and prevents damping-off diseases.

Weeding and harvesting are mostly done by hand, although chemical weed control is possible but not organic. Weed control is a critical part of onion production. Common weeds that affect onion and garlic include yellow nutsedge, field morning glory, cheeseweed, chickweed, henbit, lambs quarters, maretail, pigweed, purslane, shepherdspurse, annual bluegrass, barnyardgrass, and foxtail. Onion transplants and seedlings do not compete well with weeds, so hand cultivation or herbicides are necessary if weeds are a problem. Crop rotation is important to avoid the build-up of pests and diseases such as nematodes, Sclerotium and Fusarium.

# **Harvesting**

Harvesting takes place 90-150 days after sowing. Onions are ready for harvest when the leaves collapse. Alternatively, the leaves can be bent over and left to dry for 10-12 days. The crop is pulled out by hand and kept for some days in the field with the bulbs covered by the leaves (= windrowing). The leaves are then cut off and the mature bulbs are bagged or packed in crates if they are to be stored.

Freshly harvested onions are dormant and will not sprout for a variable period (this depends on the variety). Storage will extend the dormant period. Sprouting will increase in storage temperatures above 4.4°C. It will decrease again as temperatures exceed 25°C.

## **Postharvest Treatment**

### **Onion bulb curing**

Following harvest, bulbs are cured to heal wounds and for drying. Curing improves postharvest handling characteristics and limits the entry of organisms through the pseudostems or injured tissues. It also helps the formation of attractive, well-colored, intact outer skins. When weather permits, bulbs are cured in the field for several days, depending on environmental conditions, until the neck has sealed, the outer scales are papery and the wounds have healed.

For field or indoor curing at ambient temperature, bulbs are windrowed to air-dry or placed into well-ventilated boxes or bags, respectively. Onions can also be cured with forced circulation of warm (30°C), low-humidity air through bins or piles of onions placed on slatted floors for 12-24 h. During curing, onion can lose as much as 5% of its initial harvest weight.

### **Onion storage**

Green onions should be stored at 0°C and 95% RH with a storage life of up to 3 weeks. At 5°C, storage life may be limited to 1 week. Best storage occurs after bulbs have been cured to seal bulbs and heal damage as described above. Onion bulbs do not heal cuts and surface wounds as successfully as other crops such as Irish potato, so mechanical damage during harvest and handling should be minimized before storage.

Decay, sprouting, and rooting cause losses during storage. These losses can be minimized by storage at or near 0°C and 65-70% RH. Storage at high temperatures (25-35°C) may also be satisfactory.

Dry matter and moisture are lost during storage. Most bulbs shrink in size due to respiratory losses and carbohydrate translocation from the outer to inner scales or sprouting roots and shoots. This reallocation of resources causes the succulent outermost scales to gradually desiccate, becoming a dry protective layer, further reducing water loss from the inner scales.

Bulb diameter decreases because of the net loss of succulent scales over time. Onion respiration rates are temperature dependent, decreasing with refrigerated storage. Respiratory heat must be removed by ventilation or refrigeration. Relative humidity influences storage life by reducing shrinkage from water loss. Modified atmosphere storage with elevated CO<sub>2</sub> and reduced O<sub>2</sub> can extend onion storage life.

As a general rule, long-day types with high solids have longer storage potential than short-day types with low solids. Pungent cultivars generally have longer storage potential than sweet. A fully cured pungent bulb may be stored under optimal conditions for up to 1 year. In contrast, a sweet cultivar may only last 2-3 months under similar conditions.

### **Bulb rest and dormancy**

Onion bulb dormancy is complex with different phases. Onion bulbs first enter a state of rest at harvest maturity that lasts 6-8 weeks. After the rest period, a natural dormancy period begins and bulbs will not sprout or grow because inhibitors synthesized in green leaves earlier in development remain. The inhibitors

are gradually destroyed with time. Therefore, it is important to have normal senescence of onion leaves to ensure translocation of inhibitors to the bulb to improve storage life and reduce early sprouting. The change from rest to dormancy is gradual and highly dependent on the cultivar. Dormant bulbs will not sprout at optimal storage temperatures. Once dormancy has passed, root emergence occurs, followed by leaf shoots at favorable temperatures and moisture conditions.

### Bulb sprouting and sprout inhibition

Sprouting is optimum at 10-15°C. Sprouting is inhibited at both low and high temperatures as explained above. For long-term storage, a spray inhibitor such as maleic hydrazide (MH) is sometimes used, but it is banned in many countries. MH at a concentration of 2500 ppm is applied at 500 L water/ha. Spray inhibitors are generally applied in the field 1-2 weeks before harvest. If applied too soon, foliage injury occurs and when applied too late, foliar absorption is insufficient to be effective. To improve absorption, applications are made when most of the foliage is still green and when dew is not present. Onions treated with MH and held at a temperature between ~1°C and 0°C and 65-70% RH can be stored for as long as 6-7 months without sprouting. Bulb rooting and sprouting are inhibited by gamma irradiation and controlled-atmosphere storage at reduced O<sub>2</sub>, and continuous removal of newly formed roots tends to delay sprout emergence.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### Black mold *Aspergillus niger*

*Close up of black mold on onion scales*

*Symptoms of black mold on onion bulb*

*Symptoms of black mold on onion bulb*

#### Symptoms

Post-harvest black discoloration at neck; lesions on outer scales; black streaks under outer dry scales; entire surface of bulb turning black and shriveling

#### Cause

Fungus

## **Comments**

Wash hands thoroughly after coming into contact with fungus

## **Management**

Treat seeds with appropriate fungicide prior to planting to reduce rot in mature bulbs; avoid bruising bulbs during and after harvest; storing at temperatures below 15°C (59°F) prevents mold from spreading but it will resume once temperature increases

## **Botrytis leaf blight** *Botrytis squamosa*

*Lesions on onion leaves caused by Botrytis leaf blight*

*Lesions on onion leaves caused by Botrytis leaf blight*

*Lesions on onion leaves caused by Botrytis leaf blight*

## **Symptoms**

Small white lesions with light green halos which may expand slightly as they age; in prolonged periods of moisture fungus may develop rapidly and cause leaf blighting

## **Cause**

Fungus

## **Comments**

Disease emergence favors high humidity and warm temperatures; fungus survives on piles of crop debris or in soil; older leaves more susceptible to blighting than younger leaves

## **Management**

Plant onions in single rows allowing at least 30 cm between plants to promote good air circulation and quick drying of foliage after rain; time irrigation to allow plants time to dry out sufficiently; apply appropriate fungicide sprays when plants have at least five true leaves and early symptoms of disease

## **Downy mildew** *Peronospora destructor*

*Symptoms of downy mildew on onion leaves*

## **Symptoms**

Pale spots or elongated patches on leaves; gray-purple fuzzy growth on leaf surface; leaves turning pale then yellow; leaf tips collapsing

## **Cause**

Fungus

## **Comments**

Disease emergence favored by cool temperatures and leaf wetness

## **Management**

Avoid planting infected sets; rotate crops to non-allium species for 3-4 years; plant in well-draining areas and do not overcrowd plants; destroy all infected crop debris; apply appropriate foliar fungicides taking care to apply thoroughly to waxy leaves

## **Fusarium basal plate rot** *Fusarium oxysporum*

*cross section of onion bulb showing discoloration around basal plate*

### Symptoms

Curving, yellow or necrotic leaves; necrosis begins at leaf tips and moves downward; wilting plants; infected bulbs may be brown and watery with rot spreading from stem plate to basal leaves; stem plates may have brown discoloration

### Cause

Fungus

### Comments

Disease emergence favors moderate to high temperatures

### Management

Rotate with non-susceptible crops for at least 4 years, plant resistant onion varieties

## Fusarium damping-off *Fusarium oxysporum*

*Onion plant showing wilt associated with Fusarium damping-off*

### Symptoms

Rotting seeds that are covered in mold; discolored root tips which may be pink, tan, yellow, red or black; slowly growing seedlings which wilt and die

### Cause

Fungus

### Comments

Fungus survives in soil and disease emergence is favored by moist to wet soil

### Management

Plant only disease-free seed; treat seed with fungicide; rotate crops with cereals or grasses to reduce levels of pathogen in soil; steam treatment or fumigation of soil can help reduce levels of Fusarium in the soil

## Pink root *Phoma terrestris*

*Pink root symptoms*

*Pink root symptoms*

*Symptomatic onion roots*

### Symptoms

Light pink roots which darken and turn purple; roots become transparent and water soaked; plant may look like it has a nutrient deficiency; infected seedling may die; stunted plants with undersized, shriveled bulbs

### Cause

Fungus

### Comments

Fungus colonizes plant through root tips; fungus can survive in soil down to a depth of 45 cm (17.7 in)

### Management

Disease is most severe when onions are planted continuously or in a 1-year rotation, a rotation of 3-6 years is preferred; plant more resistant varieties; solarization and/or fumigation can help reduce the levels of pathogen in the soil

## Purple blotch *Alternaria porri*

<i>Advanced symptoms of purple blotch in onion field</i>	<i>Symptoms of purple blotch on onion leaves</i>	<i>Symptoms of purple blotch on onion leaves</i>
<i>Purple blotch symptoms on neck of onion</i>	<i>Symptoms of purple blotch on onion leaves</i>	

### **Symptoms**

Small water-soaked lesions on leaves or stalk with white centers; which enlarge to become zonate and brown to purple in color with red or purple margin surrounded by yellow zone; large lesions may coalesce and girdle leaf, killing any tissue between the lesions and the leaf tip; severely infected foliage may die

### **Cause**

Fungus

### **Comments**

Disease emergence favored by wet foliage, with sporulation occurring during the night during periods of high humidity

### **Management**

Cultural controls include long rotations with non-hosts and the reduction of leaf wetness by planting in well-draining soil and timing irrigation to allow plants to dry adequately during the day; some fungicides are effective at controlling the disease but should be rotated for optimal control

## **Rust *Puccinia porri***

*Close-up image of rust pustule on onion leaf*

*Rust symptoms on onion leaves*

*Orange rust pustules on onion leaves*

### **Symptoms**

Small white flecks on leaves and stems which develop into circular or elongated orange pustules; severe infestations can cause leaves to yellow and die

### **Cause**

Fungus

### **Comments**

Favors high humidity but low rainfall; spores can be transported over long distances by wind

### **Management**

No resistance known; use only disease-free seed and plant in well-draining soil; control weeds around crop; apply appropriate protective fungicide

## **Smut *Urocystis colchici***

*Stunted onion plants infected with smut*

*Onion plants showing symptoms of smut*

### **Symptoms**

Dark, thickened areas on cotyledons (seed leaves) which may become large and cause leaves to bend downwards; raised blisters may be present on the base of scales in older plants; lesion mature and become covered in black powdery fungal masses; plant growth stunted; death of plant occurs within 3-4 weeks

### **Cause**

Fungus

## **Comments**

Smut can persist in soil for many years and is mainly introduced through infected sets and transplants; spores can be spread by wind, on equipment or in irrigation water

## **Management**

No resistance to disease known in onion; plant onions during periods which promote rapid growth; plant only healthy sets and transplants - if smut is present in the soil they will not become infected

## **White rot *Sclerotium cepivorum***

### **Symptoms**

Older leaves yellowing; stunted growth; death of all leaves; fluffy white growth on base of bulb which spreads up bulb to storage leaves

### **Cause**

Fungus

### **Comments**

Fungus can survive in soil for 20 years and is one of the most damaging diseases of Allium crops worldwide, causing major crop losses

## **Management**

Fungicide treatment may not be effective at controlling white rot under conditions which are favorable to the fungi's development and control may have to rely on cultural methods: avoid transferring soil or plant material between sites; treat seeds with hot water prior to planting; use a long term rotation with non-allium crops; apply appropriate fungicides if available

## **Category : Bacterial**

### **Leaf streak and bulb rot *Pseudomonas viridiflava***

*Cross section of onion bulb infected with bacterial leaf streak and bulb rot*

*Onion plant infected with bacterial leaf streak and bulb rot*

*Lesion on onion leaf caused by bacterial leaf streak and bulb rot*

### **Symptoms**

Water-soaked, dark green oval lesions or streaks on leaves; tipburn of leaves; dark spots on wrapper scales of bulbs; reddish-brown discoloration of inner scales; rot developing in ring-like pattern

### **Cause**

Bacterium

### **Comments**

Little is known about the pathogen; greatest damage occurs during winter; rapid spread of disease on infected plants is promoted by rainfall

## **Management**

Avoid fertilizing plants during winter; apply appropriate bactericidal sprays

## **Category : Viral**

### **Onion yellow dwarf Onion yellow dwarf virus (OYDV)**

### **Symptoms**

Yellow streaks on bases of first leaves; all leaves which emerge after infection have yellow streak or are completely yellow; leaves may be flattened or crinkled; bulbs are undersized; flower stalks yellow and twisted; flower clusters small and seed is of poor quality

### **Cause**

Virus

#### Comments

Transmitted by several species of aphid, including the peach aphid; virus is not spread via seed or pollen

#### Management

Controlling aphids by applying insecticides is not effective due to the short amount of time aphid needs to transmit virus; other control methods include: planting sets or transplants which were produced in areas free of virus; growing plants from seed; removing any infected plants and planting more tolerant varieties

### Category : Oomycete

#### Pythium seed rot (Damping-off) *Pythium irregularare*

*Damping-off of onion seedlings caused by Pythium infestation*

#### Symptoms

Seeds water-soaked, mushy and decomposing; infected roots are gray and water-soaked; seedlings that have already emerged prior to infection collapse and die; older plants that become infected become severely stunted

#### Cause

Fungus

#### Comments

Disease emergence favors high soil moisture and cool temperatures

#### Management

Control of disease is dependent on minimizing soil moisture: break up compacted soil; plant in well-draining areas or raised beds; treat seeds with appropriate fungicides prior to planting

## Pests

### Category : Mites

#### Bulb mites *Rhizoglyphus* spp.

*Tyrophagus* spp.

#### Symptoms

Stunted plant growth; reduced stand; bulbs rotting in ground or in storage; pest is a cream-white, bulbous mite <1 mm in length, which resembles a pearl with legs

#### Cause

Arachnid

#### Comments

Damage to plants by bulb mites allows secondary invasion by other pathogens and can cause bulb rots

#### Management

Do not plant successive crops of onion or garlic in same location; allow field to fallow to ensure that any residual organic matter decomposes completely - crop residues can harbor mite populations; treating garlic seed cloves with hot water prior to planting may help reduce mite populations

### Category : Insects

#### Leafminers *Lyriomyza* spp.

*Leafminer damage to onion foliage*

*Leafminer trail on onion leaf*

### Symptoms

Thin, white, winding trails on leaves; heavy mining can result in white blotches on leaves and leaves dropping from the plant prematurely; early infestation can cause yield to be reduced; adult leafminer is a small black and yellow fly which lays its eggs in the leaf; larvae hatch and feed on leaf interior

### Cause

Insects

### Comments

Mature larvae drop from leaves into soil to pupate; entire lifecycle can take as little as 2 weeks in warm weather; insect may go through 7 to 10 generations per year

### Management

Check transplants for signs of leafminer damage prior to planting; remove plants from soil immediately after harvest; only use insecticides when leafminer damage has been identified as unnecessary spraying will also reduce populations of their natural enemies

## Onion maggot *Delia antiqua*

*Onion maggot and bulb damage*

### Symptoms

Stunted or wilting seedlings; plant will commonly break at soil line if an attempt is made to pull it up; if infestation occurs when plants are bulbing, bulbs will be deformed and susceptible to storage rots after harvest; adult insect is a greyish fly which lays white, elongated eggs around the base of the plant; the larvae that emerge from the eggs are tiny and white and bore into the onion plant; mature larvae are about 1 cm (0.4 in) long with feeding hooks

### Cause

Insect

### Comments

Females can lay several hundred eggs during their 2-4 week lifespan; insect overwinters as pupae in the soil

### Management

Management of onion maggots is heavily reliant on good sanitation; all onion bulbs should be removed at the end of the season as maggots will die without a food source; commercial onion growers must often rely on the application of appropriate granular insecticides and, in some cases, insecticide sprays are also required; home gardeners should try to remove any volunteer wild onion and chive plants as these can act as an infection source; floating row covers may provide protection by preventing females from laying eggs around the plants

## Thrips (Onion thrips, Western flower thrips) *Thrips tabaci*

*Frankliniella occidentalis*

*Onion thrips nymphs feeding on onion leaves*

### Symptoms

Discolored, distorted tissue; scarring of leaves; severely infected plants may have a silvery appearance

### Cause

Insect

## **Comments**

Thrips are most damaging when they feed on onions at the early bulbing stage of development; both onion thrips and western flower thrips have an extensive host range and can be introduced to onion from other plants

## **Management**

Natural enemies include some species of predatory mite, pirate bugs and lacewings; avoid planting onion in close proximity to grain fields as thrips populations build up on these plant in the spring; overhead irrigation of plants may help reduce thrips numbers; apply appropriate insecticides at first sign of thrips damage

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# Orange

## Description

Orange, *Citrus sinensis*, is an evergreen tree in the family Rutaceae grown for its edible fruit. The orange tree is branched with a rounded crown and possesses elliptical or oval leaves which are alternately arranged on the branches. The leaves have narrowly winged petioles, a feature that distinguishes it from bitter orange, which has broadly winged petioles. The tree produces white flowers singly or clustered on a raceme. The fruit is a spherical berry with a green-yellow to orange skin covered in indented glands and a segmented pulpy flesh and several seeds. Orange trees can grow to a height of 6–15 m (16–49 ft) and can live for periods in excess of 100 years. Most plantations have an economic lifespan of around 30 years. Orange may also be referred to as sweet orange or navel orange and is believed to have originated from a wild ancestor in the border between Vietnam and China.

*Close-up of orange skin*

*Orange slices*

*Orange blossoms*

*Tree branch heavy with oranges*

*Orange grove in California*

*Orange fruits and blossoms*

*Oranges ripening on the tree*

## Uses

Oranges can be consumed as a fresh fruit and are commonly pressed or squeezed to produce orange juice.

## Propagation

**Requirements** Orange is a subtropical plant and the trees grow best in regions with a pronounced change in season. They will grow best at temperatures between 12.8 and 37.8°C (55–100°F) during the growing season and 1.7 to 10°C (35–50°F) during dormancy. Mature orange trees can survive short periods of freezing, whereas young trees will be killed. Trees should be protected from frosts and freezing conditions to prevent damage. The trees will also tolerate drought conditions but perform poorly in water-logged soil. Trees will grow best when planted in a well-draining sandy loam with a pH between 6.0 and 7.5. Soil must be deep enough to permit adequate root development. Orange trees require full sun and should be protected from wind which can cause damage to the trees. **Orange propagation** Orange seedlings are usually produced by grafting or budding to an appropriate rootstock as seeds will not produce fruit true to type. Grafting is the process by which a scion from one plant is joined to the rootstock of another to produce a new tree. Budding is a special type of grafting where the scion that is joined to the rootstock consists of a single bud. Budding is commonly used in citrus propagation as it is the easier of the two processes and works very well. **Budding** Budding should be carried out when seedling stems have reached roughly the diameter of a pencil (6–9 mm/0.25–0.36 in) and at a time when the bark of the rootstock tree is slipping (this is the term used to describe a period of active growth when the bark can be easily peeled from the plant). Twigs (budwood) should be collected from the previous growth flush or the current flush so long as the twig has begun to harden. The twigs should have well developed buds and should be as close as possible to the diameter of the rootstock onto which it will be joined. It is extremely important to only collect budwood from disease-free trees. The use of diseased budwood can cause the spread of many serious citrus diseases which can kill trees. The budwood to be used for propagation should be trimmed to create budsticks which are 20–25 cm (8–10 in) by removing any unwanted wood and leaves. These budsticks can be stored for 2–3 months under the correct conditions but it is best to use them as soon as possible after cutting. The simplest way to join the budwood to the rootstock is by T-budding. The area to be joined should be pruned to remove any thorns or twigs and the cut made approximately 15 cm (6 in) from the ground. Using a sharp knife, a 2.5–3.8 cm (1–1.5 in) vertical cut should be made in the stem of the rootstock, through the bark. A horizontal cut should be made at either the top or the bottom of the vertical cut to produce a ‘T-shape’. The horizontal cut should be made a slightly upward-pointing angle and should reach through the bark. Remove a bud from a budstick by slicing a thin, shield-shaped piece of bark and wood from the stem, beginning about 1.25 cm (0.5 in) above the bud. This piece should measure 1.9–2.5 cm (0.75–1.0 in) in length. Immediately insert the piece of bud into the cut on the rootstock by sliding it under the opened bark so that the cut surface lies flat against the wood of the rootstock plant. Finish the join by wrapping the bud with budding tape. When the union is made and the tape is removed, the bud is forced to grow by cutting the rootstock stem above the join about 2/3 of the way through the stem. This cut should be made 2.5–3.9 cm (1.0–1.5 in) on the same side as the join. The top of the seedling should then be pushed over towards the ground. This process, known as ‘clopping’ allows all of the nutrients to be diverted to the bud. Once the bud begins to grow and reaches several inches in length, the lop can be removed completely from the seedling. **Planting seedlings** Orange trees can be purchased as seedlings which have already been grafted and only require planting in the garden or orchard. The best time to plant citrus trees is in Spring after all danger of frost has passed in your area. Standard sized trees should be spaced 3.7–7.6 m (12–25 ft) apart in an area that receives full sunlight, but is protected from strong winds which can damage the trees. Planting against a south facing wall will help protect the tree in cooler climates. **General care** Newly planted trees require proper irrigation to ensure they become established. During the first year, water should be applied at the base of the trunk so that the root ball is kept moist to allow the roots to establish in the soil. Newly planted trees should be provided with water every 3–7 days. The soil should be moist, but not wet. Trees planted in sandy soils will require water more frequently. Young trees will also require a light application of fertilizer every month in the first year.

*T-budding showing shield shaped piece of budwood inserted into stem of rootstock*

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Anthracnose** *Colletotrichum gloeosporioides*

###### **Symptoms**

Leaves dropping prematurely; leaves covered in dark fungal spores; red to green or black streaks on the mature fruits

###### **Cause**

Fungus

###### **Comments**

Disease common during wet Springs or long periods of wet weather late in season

###### **Management**

If disease is damaging then appropriate fungicides should be applied to whole tree

##### **Armillaria root rot (Mushroom root rot)** *Armillaria mellea*

###### **Symptoms**

Trees may wilt suddenly and collapse or decline slowly; leaves become chlorotic and drop from tree; if large parts of root are destroyed then whole canopy is affected; trunk may have area of rotting bark at the base; lesions on the trunk resemble Phytophthora gummosis; clusters of mushrooms may be present at the bottom of the tree and fan shaped mycelial mats are often present between the bark and the wood

###### **Cause**

Fungus

###### **Comments**

Healthy trees are usually infected by infected pieces of wood or tree stumps which have been left in the ground after an

orchard is cleared

### **Management**

Disease is difficult to control once it becomes established in an orchard; affected trees showing signs of decline should be removed along with as much of the roots system as possible; area where infected tree was should not be replanted with healthy citrus for a period of at least one year; fumigating soil can help to reduce soil inoculum but is not always completely effective

## **Black root rot *Thielaviopsis basicola***

### **Symptoms**

Small brown-black lesions on roots which may coalesce and turn entire root black; root cortex may slough off to reveal the vascular tissue below; leaves of plant may be chlorotic

### **Cause**

Fungus

### **Comments**

Serious disease of glasshouse grown citrus trees; pathogen usually drops to non-damaging levels after tree is transplanted to the field

### **Management**

Keep glasshouses well lit and warm during winter to encourage vigorous root growth; use good quality potting soil which provides good aeration

## **Blast *Pseudomonas syringae***

### **Symptoms**

Water-soaked or black lesions on leaf petioles; which rapidly expand along the leaf midrib; cankers on twigs and branches; twigs may be girdled and die; leaves turning black and dying; black lesions may be present on fruit

### **Cause**

Bacterium

### **Comments**

Symptoms most severe on south facing side of tree exposed to winds

### **Management**

In areas where disease is severe, copper fungicides should be applied in Fall and Winter prior to the first rains

## **Brown rot *Phytophthora* spp.**

### **Symptoms**

Water-soaked lesions on fruit close to maturation; leather tan to dark brown lesions on fruit; lesions with a pungent smell; leaves, twigs and flowers may be turning brown

### **Cause**

Oomycete

### **Comments**

Disease emergence favored by cool, wet conditions

### **Management**

Cultural control methods should focus on reducing leaf wetness e.g. mowing around trees to prevent grasses growing too long, proper irrigation management, pruning branches hanging low to the ground etc.; if fruit become infected, harvest should be delayed to allow all infected fruit to drop to the ground and minimizing contamination in the harvest; applications of copper fungicides to foliage can help protect the trees

## **Melanose *Diaporthe citri***

*Melanose symptoms on orange fruit*

*Melanose symptoms on orange fruit*

## **Symptoms**

Small brown sunken spots which become raised and surrounded by a yellow halo; lesions eventually turn corky in texture; severe infections can cause newly emerging leaves to be crinkled and distorted; if infection of fruit occurs soon after petal fall, the pathogen causes large lesions on the fruit surface which may coalesce to produce large patches; late infection of fruit causes discrete pustules on the fruit

## **Cause**

Fungus

## **Comments**

Disease is spread short distance through splashing water or over longer distances by wind

## **Management**

If young trees become infected, it is possible to control the disease by pruning but this is not usually feasible for older trees; fungicides must be applied frequently in order to control the disease

## **Category : Bacterial**

### **Citrus canker *Xanthomonas axonopodis***

*Symptoms of citrus canker on leaves and fruits*

## **Symptoms**

Raised lesions on leaves, often at leaf margin or tip; lesions may also be present on twigs and fruits; young lesions are usually surrounded by yellow halo; depressed brown craters formed from collapse of lesions

## **Cause**

Bacterium

## **Comments**

Bacteria survive in lesions; the main method of spread is via wind driven rain; bacteria may enter through pruning wounds

## **Management**

If the disease is introduced to an area, all infected trees should be removed and destroyed; in areas where disease is endemic, windbreaks can help to reduce disease severity; cultural control of the disease should focus on controlling leaf miner populations, utilizing wind breaks and applications of copper sprays

### **Huanglongbing (Citrus greening) *Candidatus Liberibacter asiaticus***

*Candidatus Liberibacter africanus*

*Candidatus Liberibacter americanus*

*Areas of quarantine for citrus greening and Asian psyllid in the USA*

*Symptoms of citrus greening on sweet orange*

*Symptoms of citrus greening on orange tree*

## **Symptoms**

Leaf symptoms of citrus greening include yellowing of one limb or one area of canopy, yellowing of leaf veins; blotchy mottling and/or green islands (spots) surrounded by completely yellow leaf tissue; twig and limbs begin to die back; fruits may drop prematurely and are often mishappen and lopsided; fruit has a bitter, salty taste

## **Cause**

Bacteria

## **Comments**

**History** Origins and spread Huanglongbing, or citrus greening, was first reported from Southern China in 1919 by

American botanist Otto August Reinking who described a "yellow shoot" disease of citrus while evaluating diseases of economic plants in Southern China. A subsequent field survey conducted between 1941 and 1955 on citrus plants in the provinces of Guangdong, Fujian and Jiangxi by Chinese plant pathologist Lin Kongxiang (Kung Hsiang) determined that the disease likely originated in Chaozhou county in Guangdong as early as the 1870s. Lin adopted the name the local farmers had given to the disease of "huang long bing", which translates to "yellow dragon disease", a reference to the yellow coloration of new shoots on the infected trees. By 1936 Huanglongbing was considered a serious disease of citrus in China and it subsequently spread across Southeast Asia reaching Indonesia in 1948 and Taiwan in 1950 before spreading to the Philippines, Thailand and Malaysia in the 1950s, 60s and 70s respectively. The disease has been known by various names in different countries - "greening" in South Africa, "mottle leaf" in the Philippines, "dieback" in India and "vein phloem degeneration" in Indonesia - but in 1995 the disease was officially named Huanglongbing by the International Organization of Citrus Virologists (IOCV) and this name is now widely used to describe the disease in Africa, America and Asia.

**Biology and ecology**

The organism that causes Huanglongbing is a Gram-negative bacterium that is limited to the plant phloem - the plant system responsible for the delivery of sugars from the leaves to the growing parts of the plant. The bacteria involved have so far not been isolated and cultured but the disease is believed to be caused by bacteria belonging to the genus *Candidatus Liberibacter*. It is believed that there are at least two different forms of the disease, an African heat-sensitive form, *L. africanus* which survives in cool areas with temperatures below 30-32°C, and an Asian heat-tolerant form which occurs in areas where temperatures greatly exceed 30°C. A third species, *L. asiaticus*, found in .A third species, *L. americanus* was detected in citrus trees in São Paulo, Brazil but there is presently little information on its climatic requirements. As this species is found in the same areas as *L. asiaticus* it seems likely that it has similar requirements.

**Transmission**

Huanglongbing can be transmitted by citrus psyllids or by grafting. The Asian citrus psyllid, *Diaphorina citri* is responsible for the spread of the disease in Asia and Oceania, Brazil and North America whereas the African citrus psyllid, *Trioza erytreae* is the main vector in Africa and Madagascar. Both psyllid species are present the Indian Ocean islands of Réunion and Mauritius, *Citrus psyllids* Citrus psyllids are tiny (3-4 mm) sap-sucking insects that excrete a sticky, sugary substance called honeydew. Both the Asian and African citrus psyllids are mottled brown in color but the Asian citrus psyllid possesses a brown head and the African species has a black head. Adult citrus psyllids will jump and/or fly for a short distance when they are disturbed. They are usually found on the undersides of leaves, often in high numbers. When a psyllid feeds on an infected plant, it acquires the disease after 15 to 30 minutes and feeding and is able to transmit the disease to new hosts after a period of 21 days. In order to transmit the disease successfully, the psyllids need only feed on a new host for a period of 15 minutes in order for successful transmission to occur. It is hypothesized that the bacterium multiplies within the body of the psyllid prior to transmission but this theory requires validation through experiments.

**Grafting**

Although the primary method of spread of the Huanglongbing bacterium is via the movement of citrus psyllids, the disease can also be transmitted through grafting practices. The ability of Huanglongbing to be transmitted by grafting was first demonstrated by Lin Kongxiang through experimental work which was published in 1956. The disease is not transmitted at high rates through grafting as not all buds on infected trees contain the bacterium.

## Management

**Control (i)** Cultural control Once a tree becomes infected with HLB, it cannot be cured. Control is therefore reliant on preventing the disease occurring in the first place and this is achieved through strict quarantining to prevent the introduction of citrus psyllids to areas which are currently free of the pest. Areas which are subject to quarantine have restrictions placed on the movement of citrus plants, fruit, equipment and items made from citrus. Infected trees should be removed as quickly as possible from plantations and destroyed. Identification of infected trees should be achieved through several surveys to ensure that infected trees which are not yet showing symptoms are identified. In Florida, the recommendation is to scout groves at least 4 times a year for disease symptoms.

**(ii)** Control of citrus psyllids Citrus psyllid populations can be controlled through the application of chemical sprays. Insecticides have proved very effective at controlling *T. erytreae* in South Africa where systemic insecticides are applied to the tree at the base of the trunk. In areas of the USA, Citrus health management areas (CHMAs) have been created to encourage neighbouring growers to work together to prevent the disease. Control strategies which have been implemented by the program include scouting, mapping and large-scale spraying to control citrus psyllids.

## Stubborn disease *Spiroplasma citri*

*Orange infected with stubborn disease*

*Orange tree infected with stubborn disease (left) beside a healthy tree (left)*

### Symptoms

Stunted trees; leaves shorter and broader, cupped and upright; may be chlorotic or have a mottled appearance; stunted, malformed fruits and low yield

### Cause

Bacterium

### Comments

Transmitted by leafhoppers; can cause serious losses in hot, dry conditions

### Management

Plant only material from disease-free budwood; if disease is endemic to the area then nursery trees should be grown in an enclosure to protect the trees from vectors; if a young orchard becomes infected, it should be removed and replanted with healthy material

## Category : Oomycete

### **Phytophthora gummosis** *Phytophthora* spp.

#### Symptoms

Sap oozing from cracks in bark; bark cracking, drying and falling off; lesions girdling trunk; severely infected trees have pale green leaves with yellow veins

#### Cause

Oomycete

#### Comments

Disease can develop rapidly in moist, cool conditions; spread by water splash

#### Management

Only plant disease-free nursery stock; plant trees in well-draining soil and avoid injuries to bark on trunk; trunk wraps can provide protection from freezing

## Category : Viral

### **Tristeza disease** *Citrus tristeza virus* (CTV)

*Orange tree infected with tristeza virus*

*Elongated pits under bud union caused by Tristeza virus infection*

*Orange tree infected with tristeza virus*

#### Symptoms

Light green foliage; poor new growth; leaves may be dropping from tree; young trees blooming early; severely infected trees are stunted and bushy in appearance with chlorotic leaves and brittle twigs; some strains of the virus cause elongated pits in the trunk and branches which give the wood a rope-like appearance

#### Cause

Virus

#### Comments

Disease spread from infected grafting material or by aphids

#### Management

Quarantine procedures are used to control tristeza and prevent the pathogen from entering areas which are currently free of the disease

## Pests

### Category : Insects

#### Aphids (Black citrus aphid) *Toxoptera aurantii*

##### Symptoms

Leaves curling; leaves and twigs covered in sticky substance which may be growing sooty mold; trees may show symptoms of tristeza (see entry); insects are small and soft bodied and are black in color

##### Cause

Insect

##### Comments

Aphids transmit tristeza virus on citrus

##### Management

Aphid numbers tend to naturally decline as leaves harden off but can be a problem on young trees or varieties which continually produce flushes of new growth; pesticides are not generally recommended due to resistance and trees can withstand a high degree of leaf curling

#### Asian citrus psyllid *Diaphorina citri*

*Asian citrus psyllid*

*Asian citrus psyllids on orange blossom*

##### Symptoms

Tips of leaves in new growth flushes are twisted and affected leaves do not expand properly; trees may show symptoms of citrus greening (see disease entry); the insect is tiny (4 mm in length) and has a mottled brown appearance; it feeds by inserting its mouthparts into the plant and sucking plant sap and as well as injecting toxins into the plant, it also transmits the deadly citrus greening disease; the insect feeds at an angle to the plant which makes it resemble thorns on the plant leaves

##### Cause

Insect

##### Comments

The Asian citrus psyllid attacks all varieties of citrus

##### Management

In the home garden, frequent applications of organic pesticides can be used to control the Asian citrus psyllid; applications must be frequent to be effective as these chemicals are usually very short lived in the environment; parasitic wasps have been released in California to control the psyllid in residential areas; in commercial orange production insecticides should be applied to control the insects as the spread of citrus greening has the potential to devastate commercial citrus production

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# Oregano

## Description

Oregano is the name given to many species of perennial herb belonging to the genus *Origanum*, including the major species *Origanum vulgare* which is grown for its leaves which are commonly used as a herb in cooking. Oregano plants can be woody or herbaceous and possess multiple branching stems. The leaves are oval or round and are arranged alternately on the stems. The plants produce small pink, purple or white flowers and small oval, brown fruits and can reach up to 1 m (3.3 ft) in height. Oregano is perennial and can be grown for 3–4 years but is commonly grown as an annual in northern climates. Oregano may also be referred to as European oregano or wild marjoram and originated from the Mediterranean.

*Oregano plant*

*Oregano flowers*

*Oregano foliage*

## Uses

The leaves of the oregano plant are used fresh or dried as a herb in cooking. They may also be dried and used to extract essential oil which is used in soaps or as flavorings in wines and liqueurs.

# Propagation

**Basic requirements** Oregano is a temperate or subtropical plant and will grow best in ample sunlight but can also be grown in partial shade. The plant grows best in light, well-draining soil with a pH of 4.5–8.7. Oregano will tolerate some cold but will grow best when the annual temperature does not fall below 15°C (59°F). **Propagation** Oregano can be grown from seeds, cuttings or by division or layering. Vegetative propagation is best for conserving desirable characteristics. **Seeds** Oregano seeds can be planted indoors to produce transplants or direct seeded. When direct seeding, seeds should be sown in rows spaced 50–60 cm (19–24 in) apart with seedlings thinned to allow 20 cm (8 in) between plants. Seeds will germinate in 4 days at a temperature of 21°C (70°F). **Cuttings** Root divisions and cuttings are best taken in late Spring when plant growth is at a maximum. Softwood cuttings taken from the new plant growth are quickest to root. Remove portions of stem 7.6–12.7 cm (3–5 in) in length using a sharp knife. Cut the stem at a 45° angle. Plant the cuttings in a light potting medium such as peat moss and vermiculite and keep moist until rooted. **General care and maintenance** Oregano grows very vigorously and requires little care. When the plant has reached approximately 15 cm (6 in) in height, pinching the growing tips will encourage the plant to branch. Oregano may be fertilized on a yearly basis with a balanced fertilizer. Once established, oregano requires little water. Supplemental irrigation may be applied during very dry spells. Divide established plants every few years to promote productivity and prevent the plant from becoming woody. **Harvesting** Oregano is best harvested just before flowering. The entire plant can be harvested by clipping the branches to leave only the lowest set of leaves. The leaves can be used fresh or they can be dried for longer storage. The clipped plant will begin to set out new growth within 2 weeks of harvest.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### Mint rust *Puccinia menthae*

##### Symptoms

Small, dusty, bright orange, yellow or brown pustules on undersides of leaves; new shoots may be pale and distorted; large areas of leaf tissue die and leaves may drop from plant

##### Cause

Fungus

##### Comments

Disease also affects mint and can spread from nearby mint plants

##### Management

Infected plants and rhizomes should be removed to prevent spread; heat treatment of roots may help to control the disease; roots should be immersed in hot water at 44°C (111°F) for 10 minutes, cooled using cool water and then

planted as usual

## Pests

### Category : Insects

#### Aphids (Peach aphid) *Myzus persicae*

##### Symptoms

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants

##### Cause

Insects

##### Comments

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed

##### Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

#### Cutworms *Agrotis* spp.

##### Symptoms

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5â€“5.0 cm (1â€“2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed

##### Cause

Insect

##### Comments

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato

##### Management

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically

#### Thrips (Western flower thrips) *Frankliniella occidentalis*

##### Symptoms

If population is high leaves may be distorted; leaves are covered in coarse stippling and may appear silvery; leaves speckled with black feces; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color

**Cause**

Insect

**Comments**

Transmit viruses such as Tomato spotted wilt virus; once acquired, the insect retains the ability to transmit the virus for the remainder of its life

**Management**

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic

**Category : Mites****Spider mites (Two-spotted spider mite) *Tetranychus urticae*****Symptoms**

Leaves stippled with yellow; leaves may appear bronzed; webbing covering leaves; mites may be visible as tiny moving dots on the webs or underside of leaves, best viewed using a hand lens; usually not spotted until there are visible symptoms on the plant; leaves turn yellow and may drop from plant

**Cause**

Arachnid

**Comments**

Spider mites thrive in dusty conditions; water-stressed plants are more susceptible to attack

**Management**

In the home garden, spraying plants with a strong jet of water can help reduce buildup of spider mite populations; if mites become problematic apply insecticidal soap to plants; certain chemical insecticides may actually increase mite populations by killing off natural enemies and promoting mite reproduction

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# Papaya (pawpaw)

## Crop Details

The following are the crop details for papaya.

Scientific name: *Carica papaya*

Local names: Pawpaw

Order: Violales.

Family: Caricaceae

Genus: Carica.

### General information

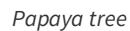
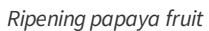
Pawpaw (*Carica papaya* L.) is a popular tropical American fruit. It is commonly cultivated for its small to large melon-like fruit.

The type of inflorescence produced by papaya trees reflects whether the tree is male, female, or hermaphrodite. Male trees have many flowers on long, pendulous panicles, whereas female trees have solitary flowers or clusters of a few yellow-green flowers.

The papaya fruit is a large fleshy berry with smooth green skin that turns yellow or orange when ripe. The fruit's flesh is thick and succulent, ranging in color from yellow to red or orange. Many black wrinkled seeds are present in the fruit.

Papaya trees can live for up to 25 years and grow to a height of 2-10 m (6.6-33 ft). To ensure maximum productivity, plantations are typically replaced every three years.

Papaya, also known as pawpaw, is thought to have originated in the Caribbean region of Central America.



## Pawpaw varieties

**The following are the most commonly grown pawpaw varieties in Kenya:**

Sunrise-Â producesÂ high-qualityÂ smoothÂ pear-shapedÂ fruitsÂ weighingÂ 400-650g.

TheÂ fleshÂ ofÂ theÂ fruitsÂ isÂ reddish-orange,Â andÂ theÂ varietyÂ isÂ prolific.

Mountain-Â producesÂ smallÂ fruitsÂ thatÂ areÂ onlyÂ suitableÂ forÂ jamÂ andÂ preserves.

Solo-Â growsÂ smallÂ roundÂ sweetÂ fruitsÂ thatÂ areÂ uniformÂ inÂ sizeÂ andÂ shape.

RedÂ royaleÂ F1-Â thisÂ isÂ anÂ improvedÂ breedÂ thatÂ producesÂ high-qualityÂ fruitsÂ weighingÂ 1.7-2.3kgs,Â withÂ aÂ redÂ attractiveÂ colorÂ andÂ aÂ sweetÂ flavor.

## Uses

The ripe fruits are high in vitamins C and A, which are frequently lacking in the diets of people living in the tropics. Immature fruits are stewed or boiled as a vegetable in some countries, such as the Philippines.

The unripe fruits of the *C. papaya* tree contain papain, a substance used commercially as a meat tenderizer. Crumpled leaves are used as a meat tenderizer in Southern Asia before wrapping meats.

Papain also has medicinal and industrial applications, such as tanning leather, preventing wool shrinkage, and keeping beer clear during the brewing process.

## Propagation

### Basic information

Papaya is a tropical plant that grows best in temperatures ranging from 21 - 33Â°C in frost-free areas. Papaya can be grown in a variety of soils as long as adequate drainage is provided, but it grows best in light, well-draining soils with a pH between 5.5 and 6.5.

A monthly rainfall of about 4 inches is required for papaya. Supplemental irrigation should be provided for trees in areas with

low rainfall.

Water-logged soils should be avoided because trees are extremely sensitive to flooding. Papaya trees are also susceptible to high winds, and tall trees can easily topple. Planting should be avoided in windy areas.

### **Seed propagation**

Pawpaw is almost entirely propagated from seeds in commercial cultivation. Seeds may be sown in trays filled with a suitable medium, peat pots, polyethylene bags, or directly in the field.

Germination occurs in 12-20 days. Seedlings are transplanted into 7.6 cm peat pots or 10 cm plastic bags at the two-leaf (cotyledonary leaves) stage, preferably at the onset of the rainy season.

Care should be taken during transplanting to avoid disturbing the roots. After planting out. Container-grown seedlings should be gradually hardened in sunlight before being field-transplanted 1.5-2 months after germination, at about 20 cm high and at the 8-to 12-leaf stage. Up to 15-20 seeds are sown in each hole during field planting.

Upon germination, seedlings are thinned out to leave five or six seedlings to grow to flower. At first flowering, a vigorous plant of the desired sex is kept and the others removed.

## **Cultivation**

### **Site preparation and planting**

Field preparation in many areas is poorly done due to lack of appropriate equipment or rough terrain. On heavy or compacted soils, subsoiling or ripping down to 50 cm or more is desirable to allow roots to penetrate deeply. Planting holes 30-45 cm in diameter are best dug with a tractor-mounted soil auger. If there is a chance of flooding, raised beds are used.

After about 6-8 weeks in the nursery, the seedlings should reach the 8- to 12-leaf stage and are most suitable for field planting. In rain-fed areas, field planting is done at the beginning of the rainy season. Seedlings grown in pots and bags are planted directly, with the removal of the pot or bags. Transplanted plants must be watered soon after planting to settle the soil around the root system.

Spacing between plants and between rows varies widely. Universally practiced is the single-row system, with plant spacing ranging from 1.8 to 3 m and between-row spacing varying from 1.8 m to as much as 3.6 m. The between-row spacing largely depends upon the degree of mechanization; a standard tractor requires approx. 3 m. The most frequently used spacing is 2.0-2.5 m within row — 2.5 m, giving a density of 1600-2000 plants/ha. The double-row system, with 2 m between a set of rows and 3.5 m between double rows, is used. Normally, two or three seedlings are planted in each hole, spaced about 30 cm apart.

## **Pawpaw general care and maintenance**

Weeds are a major source of competition for papaya seedlings, so keep the areas around the trees weed-free. Weeds can be effectively suppressed by a layer of mulch around the plants.

To meet the nutrient requirements for fruit production, papaya necessitates regular fertilizer applications. Fertilizer is typically applied 2-4 times per year in commercial plantations. In the home garden, 1/4 cup of a balanced fertilizer applied every 14 days is usually sufficient.

The amount of fertilizer should be increased as the trees mature. When the trees are 7 to 8 months old, 1-2 pounds of complete

fertilizer should be applied every 2 months.

Papaya trees should be watered regularly, particularly during hot, dry periods. Papaya trees do not require pruning but it is good practice to remove any dead leaves from the tree.

### **Harvesting**

Papaya fruits typically take 22-26 weeks to mature. The fruits can be picked when one-fifth of the fruit surface has turned from green to yellow, but leaving them on the tree longer increases the fruit's sugar content. Fruit can be twisted or snapped off the tree, or it can be cut usingÂ a sharp knife.

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## **Common Pests and Diseases**

### **Diseases**

#### **Category : Fungal**

**Anthracnose and charcoal spot** *Colletotrichum gleosporoides*

*Charcoal spot on papaya fruit*

*Charcoal spot*

*Anthracnose symptoms on papaya*

*Anthracnose symptoms on papaya*

*Anthracnose lesions on papaya fruit*

## Symptoms

Small water-soaked lesions of fruit during ripening; circular sunken lesions with light brown margins.

## Cause

Fungus

**Is caused by *Glomerellacingulata*, primarily infecting the fruit. The disease appears as small water-soaked circular spots that enlarge into brown-black sunken lesions as the fruit ripens. Fungicidal sprays can control this disease. A 20-minute hot-water dip (45°C) reduces post-harvest decay.**

## Comments

Fungi spread by wind and rain; disease emergence favored by high temperature and humidity; disease can have a serious impact on refrigerated fruit for export.

## Management

Appropriate protective fungicides should be applied; dipping fruits in hot water at 48°C for 20 minutes reduces the incidence of the disease.

## **Black rot** *Mycosphaerella caricae*

*Black rot symptoms*

## Symptoms

Black sunken rot on young fruits originating from stem end or contact with a leaf; young fruit withering and dropping from plant; small, brown sunken lesions with light brown margins on ripening fruit.

## Cause

Fungus

## Comments

Fungi enters fruit through wounds.

## Management

Appropriate protective fungicides should be applied; dipping fruits in hot water at 48°C for 20 minutes reduces the incidence of the disease.

## **Black spot** *Asperisporium caricae*

*Black spot of papaya* Infected fruit

*Black spot of papaya*

*Papaya (Carica papaya): Black spot, caused by Asperisporium caricae*

*Black spot symptoms*

*Black spot infected fruit*

*Symptoms*

*Black spot of papaya (Asperisporium caricae) infected fruit*

*Black spot symptoms*

*Close up of black spot of papaya*

*Symptoms of black spot on papaya fruit*

*Symptoms of black spot on papaya leaf*

*Symptoms of black spot on papaya leaf*

*Symptoms of black spot on papaya fruit*

## **Symptoms**

Circular water-soaked or brown lesions on older leaves; centers of lesions become bleached as they mature; leaves curling and turning brown; raised lesions on trunks; sunken circular lesions on fruit.

## **Cause**

Fungus

## **Comments**

Disease spread by wind and rain; disease emergence favored by cool weather interspersed with moisture from dew or rain.

## **Management**

Disease may require applications of appropriate fungicides for adequate control.

## **Cercospora black spot** *Cercospora papayae*

*Cercospora sp. on papaya*

*Symptoms of Cercospora black spot on papaya*

## **Symptoms**

Tiny black dots on fruit which enlarge to 3 mm across; spots are slightly raised and although indistinct on unripe green fruit, become visible on ripening to yellow; lesions on leaves are irregular in shape and gray-white in color; if infestation is severe, leaves may turn yellow and necrotic and drop from plant.

## **Cause**

Fungus

## **Comments**

Disease usually enters orchard from infected papaya leaves in adjacent orchards.

## **Management**

Applications of appropriate protective fungicides at intervals of 14 to 28 days provide satisfactory control of the disease.

## **Powdery mildew** *Oidium caricae-papayae*

Other fungi species

<i>Upper leaf surface</i>	<i>Mycelial growth on upper leaf surface</i>	<i>Symptoms</i>
<i>Lower leaf surface Infected fruits</i>	<i>Powdery mildew symptoms</i>	<i>Symptoms on lower leaf surface</i>
<i>Chlorotic lesions</i>	<i>Symptoms on upper leaf surface</i>	<i>Infected fruits</i>
<i>White mycelial growth on lower leaf surface</i>	<i>Chlorotic lesions due to powdery mildew infection</i>	<i>White mycelial growth on papaya fruit</i>
	<i>Symptoms on upper leaf surface due to powdery mildew infection</i>	<i>Powdery mildew of papaya caused by Oidium caricae</i>

### **Symptoms**

Infect all parts of tree. The infected leaves show white mycelial growth commonly on under surface , particularly near leaf veins. Some time white mycelial growth can also seen on upper leaf surface. The infected area becomes light green and chlorotic (lesions) with dark green margin.

### **Cause**

Fungus

### **Comments**

Powdery mildew pathogens are saprophytic need living host for survival and growth. The pathogen is favored by high humidity and low sunlight.

### **Management**

Remove the infected parts and dispose them properly. Avoid irrigating the trees by sprinkler. Provide proper nutrition to trees to withstand powdery mildew infection. If the disease is severe, apply suitable fungicides.

## **Category : Bacterial**

### **Bacterial canker and decline *Erwinia* spp.**

#### **Symptoms**

Angular water-soaked lesions on leaves; lesions coalesce and spread along leaf veins; witling leaves, particularly at top of canopy; water-soaked lesion and cankers on stem; cankers girdle stem and cause plant to collapse; small water-soaked lesions on green fruit.

#### **Cause**

Bacteria

#### **Comments**

Bacteria survive in lesions and cankers.

### **Internal yellowing *Enterobacter cloacae***

#### **Symptoms**

Flesh of ripe fruit discolored yellow; discolored areas soft with spreading margins; rotting odor.

#### **Cause**

Bacterium

#### **Comments**

Disease found in Hawaii.

## **Management**

Dipping fruits in hot water at 48°C for 20 minutes reduces the incidence of the disease and is currently the only method of control.

## **Category : Viral**

### **Bunchy top** Likely caused by *Rickettsia* bacteria

#### **Symptoms**

Chlorosis of young leaves; water-soaked spots on petioles and stems; petioles rigid, horizontal and shortened; thickened leaf blades that cup downward; internodes shorten and growth stops resulting in a bunchy appearance to the plants.

#### **Cause**

Bacteria

#### **Comments**

Transmitted by leaf hoppers.

#### **Management**

Use of tolerant varieties of papaya is currently the only method of control recommended.

### **Papaya ringspot** Papaya ringspot virus (PRV)

*Papaya Ringspot Virus symptoms*

*Papaya ringspot infected plant*

*Papaya Ringspot Virus (Potyvirus PRSV) infected leaves*

*Papaya ringspot symptoms on fruit*

*Foliar symptoms of papaya ringspot*

*Papaya ringspot symptoms on fruit*

*Foliar symptoms of papaya ringspot*

*Papaya ringspot symptoms on fruit*

*Foliar symptoms of papaya ringspot*

*Papaya ringspot symptoms on unripe fruit*

*Papaya ringspot symptoms on unripe fruit*

*Papaya ringspot symptoms on unripe fruit*

#### **Symptoms**

Dark green rings on fruit which may be slightly sunken and become less distinct as the fruit ripens; fruits may have uneven bumps; leaves often exhibit a bright yellow mosaic pattern and new leaves are small and plant growth is stunted.

#### **Cause**

Virus

#### **Comments**

Virus is transmitted by several aphid species.

#### **Management**

Infected plants should be removed and destroyed to prevent spread of the virus; new planting materials should be free of the virus; intercropping papaya with a non-host such as corn can help to reduce the incidence of the disease in papaya orchards by providing aphid vectors with an alternative feeding site.

## **Category : Oomycete**

### **Phytophthora fruit rot (Stem rot)** *Phytophthora palmivora*

*Fruit rot due to Phytophthora*

*Phytophthora stem rot affected papaya tree*

*Phytophthora fruit rot*

*Phytophthora infected tree*

*Phytophthora infected fruit*

*Stem rot symptom*

*Symptoms of Phytophthora infection on papaya fruit*

*Phytophthora on papaya fruit (after experimental inoculation with pathogen)*

*Symptoms of Phytophthora infection on papaya fruit*

*Symptoms of Phytophthora infection on papaya fruit*

*Symptoms of Phytophthora infection on papaya fruits*

## **Symptoms**

Water-soaked lesions on unripe fruit that oozes latex; withering fruit; water-soaked lesions on leaf scars of fruit bearing stem; mature fruit covered in white mycelium.

## **Cause**

Oomycete

## **Comments**

Fungi survive in soil and enter through wounds in stem; disease often emerges after hurricane damage.

## **Management**

Disease can be controlled through the use of appropriate protective fungicides such as mancozeb or copper sulfate; root rot in seedlings can be prevented by planting in holes filled with soil in which papaya has never been grown - by the time the roots extend out of the added soil the plant is no longer susceptible to the disease.

## **Pests**

### **Category : Insects**

**Papaya mealybug** *Paracoccus marginatus*

<i>Encyrtid wasp (Acerophagus papayae) used as biocontrol agent for papaya mealybug</i>	<i>Adult papaya mealybugs</i>	<i>Adults</i>
<i>Papaya mealybugs</i>	<i>Papaya mealybug (Paracoccus marginatus) adults</i>	<i>Papaya fruit infested by mealybugs</i>
<i>Mealybugs on papaya leaf</i>	<i>Papaya mealybug</i>	<i>Mealybugs of papaya fruit</i>
<i>Papaya mealybug infestation under the leaf</i>	<i>Papaya mealybug damaged tree</i>	<i>Damage to papaya tree due to mealybug infestation</i>
<i>Damage due to Papaya mealybug</i>	<i>Papaya mealybug (Paracoccus marginatus) infested fruit</i>	<i>Papaya mealybug (Paracoccus marginatus)</i>
<i>Mealybugs on papaya</i>		

## Symptoms

Flattened oval to round disc-like insect covered in cottony substance on tree; chlorosis, plant stunting, leaf deformation, early leaf and fruit drop insects attract ants which may also be present; insect colony may also be associated with growth of sooty mold due to fungal colonization of sugary honeydew excreted by the insect.

## Cause

Insect

## Comments

Insects have a wide host range; often tended by ants which farm them for their sugary honeydew secretions; transmit Cocoa swollen shoot virus.

## Management

Mealybugs can potentially be controlled by natural enemies such as lady beetles but are commonly controlled using chemicals; chemical pesticides may also decrease populations of natural enemies leading to mealybug outbreaks.

## Scale insects (White peach scale) *Pseudaulacaspis pentagona*

<i>White peach scale (Pseudaulacaspis pentagona) on papaya.</i>	<i>Scale insect infestation</i>	<i>Scale insects on papaya. Note - scale species unknown</i>
<i>Scale insects on papaya. Note - scale species unknown</i>	<i>Scale insects and damage on papaya fruit</i>	

## Symptoms

Scale insects cause damage by feeding on twigs, branches and fruit, injecting toxins into the plant as they do so; if the infestation is heavy, gumming may occur on the bark and twigs or entire branches can be killed; insects are flattened discs, or "scales" with no visible legs; scales produce a white waxy coating which eventually turns black (black cap stage).

## Cause

Insect

## **Comments**

Scale insects overwinter in the black cap stage; winged adult males mate with females which retain their eggs inside the body until they hatch.

## **Management**

Populations are often kept in check by natural enemies, including predacious beetles and some wasps - although broad-spectrum insecticides may result in outbreaks of scale by killing off populations of beneficial insects; trees can be sprayed with horticultural oils when dormant which effectively kill scales without damaging natural enemies.

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# Parsley

## Description

Parsley, *Petroselinum crispum* is an herbaceous biennial or perennial plant in the family Apiaceae grown for its leaves which are used as a herb. Parsley is an aromatic plant with an erect growth habit and possesses branched, hollow stems and dark green flat or curled leaves which are arranged alternately on the stems. The leaves form a rosette on younger plants. The plant produces small, yellow flowers on umbels. Parsley can reach 30–100 cm (12–39 in) in height depending on the variety being grown and is commonly grown as an annual, harvested after one growing season. Parsley may also be referred to as garden parsley and likely originates from the Mediterranean.

*Parsley flowers*

*Parsley seedling*

*Parsley leaf*

*Parsley flowers*

*Curly parsley*

*Flat leaf parsley*

## Uses

Parsley leaves are used fresh or dried as a culinary herb. Fresh leaves are also commonly used as a garnish. The taproot of some cultivars is edible and may be eaten as a vegetable. Essential oil can be extracted from the parsley flowers and is used as a flavoring.

## Propagation

**Basic requirements** Parsley plants will grow best when planted in bright sunlight or partial shade. Plants grow best at temperatures between 7 and 16°C (45–61°F) in a well-draining loam which is high in organic matter. It will grow optimally when the soil pH is between 4.9 and 8.2. **Propagation** Parsley can be propagated from seed, either by direct seeding or sowing indoors to produce transplants. Seeds should be sown in the spring when the soil has warmed. Soaking the seeds overnight prior to planting will aid germination. Seeds should be planted no more than 6 mm (0.25 in) deep using 10 to 15 seeds per inch of row space. Seeds should be kept moist and not allowed to dry out. After emergence, seedlings should be thinned to a final spacing of 10–15 cm (4–6 in) apart, leaving 30–60 cm (12–24 in) between rows.

Parsley should be left in the ground for a second year if the collection of seed is desired. **General care and maintenance**

Parsley is generally very easy to care for. Keep plants productive by clipping the branches to promote new growth. Remove any flower stalks as they form during the first year of growth to prevent the plant going to seed, retaining the flavor of the leaves. Weeds should be removed from around parsley plants by carefully cultivating the soil. A layer of mulch applied around the plants can help suppress weeds. Fertilizer may be applied to the soil before planting seeds and during the growing season, plants can be side dressed with nitrogen to keep plants productive. Parsley can be overwintered successfully by protecting the plants with a frame or layer of straw. Leaves can be continually harvested over the winter months. **Harvesting** Parsley is usually ready for harvest about 75 days after sowing, when the plants have reached approximately 20 cm (~8 in) in height. In the home garden, parsley leaves can be harvested as required or whole plants can be harvested and dried for longer storage. If the whole plant is cut, plant growth is usually sufficient to allow for 3 cuttings per year.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Alternaria leaf blight** *Alternaria petroselini*

###### **Symptoms**

Brown-black necrotic lesions on leaves which may have chlorotic margins; lesions expand and coalesce causing the death of leaves and petioles; dark necrosis on crown and upper region of taproot; damping-off of seedlings

###### **Cause**

Fungus

###### **Comments**

Disease spread primarily by planting infected seed

## **Management**

Plant only pathogen-free seed; apply appropriate foliar fungicide; rotate crops to non-umbelliferous varieties for a period of 2-4 years if soil-borne fungi

## **Cercospora leaf blight** *Cercosporidium punctum*

### **Symptoms**

Small, necrotic flecks on leaves which develop a chlorotic halo and expand into tan brown necrotic spots; lesions coalesce and cause leaves to wither, curl and die

### **Cause**

Fungus

### **Comments**

Disease can be introduced through infested seed and spread by wind or water splash; symptoms usually occur on younger foliage first

## **Management**

Plant only pathogen-free seed; rotate crops; plow crop debris into soil after harvest; apply appropriate fungicide sprays

## **Crater spot** *Rhizoctonia solani*

### **Symptoms**

Small, water-soaked lesions on crowns or petioles in contact with soil; collapse of petioles; petioles drying; lesions develop a sunken appearance and a dry, firm texture

### **Cause**

Fungus

### **Comments**

Disease emergence is favored by warm, moist conditions and practices which introduce soil contact with crowns and petioles

## **Management**

Destroy crop debris or plow deeply into soil; avoid planting seeds too deep to prevent petioles coming into contact with soil; apply appropriate protective fungicides at plant bases; rotate crops with non-hosts such as grains to prevent disease building up in the soil

## **Damping-off** *Pythium* spp.

*Rhizoctonia solani*

### **Symptoms**

Soft, rotting seeds which fail to germinate; rapid death of seedling prior to emergence from soil; collapse of seedlings after they have emerged from the soil caused by water-soaked reddish lesions girdling the stem at the soil line

### **Cause**

Fungi

### **Comments**

Damping-off diseases favor conditions which slow seed germination; fungi can be spread in water, contaminated soil or on equipment

## **Management**

Avoid planting parsley in poorly draining, cool, wet soil; planting in raised beds will help with soil drainage; plant high quality seed that germinates quickly; treat seeds with fungicide prior to planting to eliminate fungal pathogens

## **Powdery mildew** *Erysiphe heraclei*

### **Symptoms**

Powdery growth on leaves, petioles flowers stalks and bracts; leaves becoming chlorotic; severe infections can cause flowers to become distorted

### **Cause**

Fungus

## **Comments**

Fungus can spread long distances in air; disease emergence is favored by high humidity and moderate temperatures; infection is most severe in shaded areas

## **Management**

Plant tolerant varieties; avoid excess fertilization; protective fungicide applications provide adequate protection; sulfur application can be used in infection occurs early in season

## **Rust** *Puccinia* spp.

*Uromyces* spp.

*Nyssopsora* spp.

## **Symptoms**

Light green discolored lesions on leaves which become chlorotic; yellow-orange pustules on underside of leaves; stems bend and become swollen or distorted; plants may be stunted

## **Cause**

Fungi

## **Comments**

Some species infect only parsley while others have alternative hosts which may provide a reservoir for the disease; disease emergence is favored by high humidity

## **Management**

Plant in well-draining soils to reduce humidity around plants; apply appropriate systemic fungicide

## **Septoria leaf spot** *Septoria petroselini*

*Close-up of Septoria lesion on parsley*

*Symptoms of Septoria leaf spot on parsley leaf*

*Septoria lesions on parsley leaves*

## **Symptoms**

Small, angular, gray-brown spots with defined red-brown margins on leaves; black fungal fruiting bodies may be visible on surface of lesions; leaves becoming chlorotic and necrotic

## **Cause**

Fungus

## **Comments**

Disease spread via infected seed, by contaminated irrigation water and by equipment or people moving through wet plants

## **Management**

Control of disease is reliant on cultural control methods and good sanitation practices: use pathogen free seeds or treat seeds with fungicide prior to planting; rotate crops; plow plant debris into soil; if disease is present avoid working with infected plants when foliage is wet; apply appropriate protective fungicides

## **Category : Viral**

### **Carrot motley dwarf (CMD)** Carrot redleaf virus (CRLV)

+ Carrot mottle virus (CMoV)

## **Symptoms**

Yellow and red leaves; stunted plant growth

## **Cause**

Viruses

## **Comments**

Disease transmitted by aphids; both viruses must be present to cause carrot motley dwarf

## **Management**

Avoid planting coriander in close proximity to overwintered carrot fields

# **Pests**

## **Category : Insects**

### **Aphids (Willow-carrot aphid) *Cavariella aegopodii***

*Willow-carrot aphid colony*

#### **Symptoms**

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants

#### **Cause**

Insect

#### **Comments**

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed; willow-carrot aphid will also attack parsnip, carrot and celery

#### **Management**

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

### **Armyworm *Pseudaletia unipuncta***

*Armyworm*

#### **Symptoms**

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside

#### **Cause**

Insect

#### **Comments**

Insect can go through 3–5 generations a year

#### **Management**

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are

available for the home garden do not provide adequate control of the larvae

### **Cutworms** *Agrotis* spp.

*Peridroma saucia*

*Nephelodes minians*

and others

*Cutworm severing plant stem*

#### **Symptoms**

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5â€“5.0 cm (1â€“2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed

#### **Cause**

Insects

#### **Comments**

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato

#### **Management**

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically

### **Category : Nematodes**

#### **Root knot nematode** *Meloidogyne* spp.

#### **Symptoms**

Galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; reduction in plant vigor; yellowing plants which wilt in hot weather

#### **Cause**

Nematode

#### **Comments**

Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or garden with this type of soil is most likely

#### **Management**

Plant resistant varieties if nematodes are known to be present in the soil ;check roots of plants mid-season or sooner if symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens

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# Parsnip

## Description

Parsnip, *Pastinaca sativa*, is an herbaceous biennial plant in the family Apiaceae grown for its edible taproot resembling a pale carrot. The parsnip plant has an erect, branched stem with a rosette of leaves which are oblong or triangular in shape and 30–38 cm (12–15 in) in length. The leaves at the top of the plant are smaller and attached directly to the stem. The plant produces flowers on umbels which are yellow or orange in color with wide petals. The taproot of the plant is thick and fleshy and can grow between 10 and 23 cm (4–9 in) in length. The parsnip plant may grow to a height of 90–180 cm (35–70 in) in height and is usually grown as an annual for only one growing season. Parsnip may also be referred to as wild parsnip and originates from the Mediterranean.

*Harvested parsnips*

*Parsnip foliage*

## Uses

The parsnip root is primarily eaten as a root vegetable after cooking. May be sliced and turned into crisps. The leaves of the plant are also edible and may be cooked and eaten as a vegetable.

# Propagation

**Basic requirements** Parsnips are cool-season crops which can be planted in early Spring and left in the ground all summer for harvest in the Fall or in the spring of the following year. Parsnips grow best in a well-draining, loose, sandy soil which is free of large rocks and has a pH between 5.8 and 7.5. Parsnips require full sun for optimum development but will tolerate some very light shade. The optimum temperature for their growth is between 15.6 and 18.3°C (60–65°F) and they do not tolerate heat in the same way that carrots do. The plants also require plenty moisture and organic matter. parsnips do very well in raised beds and can also be grown in containers. **Sowing seeds** Parsnip is usually direct seeded and should be planted 3–5 weeks before the last frost date. Soil should be prepared prior to planting by removing rocks and breaking up any hard lumps down to a depth of at least 30 cm (12 in). It is also beneficial to work some compost into the soil prior to planting. Avoid using fresh manure as it can cause forking of the roots. Sow seeds 1.3–1.9 cm (0.5–0.75 in) deep, planting 2–3 seeds per inch of row allowing 46–61 between rows. When seedlings reach 2.5 cm (1 in) in height, thin them to a final spacing of 5–10 cm (2–4 in) between plants by snipping with scissors - this avoids damaging plant roots. **General care and maintenance** Parsnips benefit from a plentiful moisture supply and should be provided with 2.5 cm (1 in) of water each week. Mulching around the plants helps to conserve moisture and reduce weeds. Plants can also be protected over winter with a thick layer of mulch Any weeds growing around the plants should be carefully removed. The plants should be fertilized 5–6 weeks after the seeds are sown. **Harvesting** For best results, parsnips should not be harvested until after the first light frosts in Fall, when the tops of the plants have frozen. Frost stimulates the conversion of starch in the roots to sugars giving the roots a sweeter flavor. Care should be taken to harvest before the ground freezes or to cover the plants to prevent freezing. Parsnips are harvested by gently digging around the plant to expose the top of the root and gently, but firmly pulling the root from the soil by grasping the top of the parsnip just above the root. Parsnip tops should be twisted off and the roots washed prior to refrigeration in airtight bags. Parsnips may also be stored in moist sand to keep them fresh prior to use.

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# Common Pests and Diseases

## Diseases

### Category : Oomycete

#### Cavity spot *Pythium* spp.

##### Symptoms

Sunken, elliptical, gray lesions across the root; outer layer of root ruptures and develops dark, elongated lesions; small vertical cracks may form on the cavities

##### Cause

Fungi

##### Comments

Fungi can persist in soil for several years and disease outbreaks are associated with wet soils; flooded soil increases the number of cavities formed

## **Management**

Some cultural practices can control the disease: avoid planting in fields/areas known to previously had carrot spot; do not over-fertilize plants; application(s) of appropriate fungicide can provide adequate control

## **Category : Fungal**

### **Damping-off *Pythium* spp.**

*Rhizoctonia solani*

#### **Symptoms**

Soft, rotting seeds which fail to germinate; rapid death of seedling prior to emergence from soil; collapse of seedlings after they have emerged from the soil caused by water-soaked reddish lesions girdling the stem at the soil line

#### **Cause**

Fungi

#### **Comments**

Damping-off diseases favor conditions which slow seed germination; fungi can be spread in water, contaminated soil or on equipment

#### **Management**

Avoid planting parsnips in poorly draining, cool, wet soil; planting in raised beds will help with soil drainage; plant high quality seed that germinates quickly; treat seeds with fungicide prior to planting to eliminate fungal pathogens

### **Downy mildew *Peronospora umbellifarum***

#### **Symptoms**

Yellow spots on upper surface of leaves; white fluffy growth on underside of leaves; lesions become darker as the mature

#### **Cause**

Fungus

#### **Comments**

Disease affects young, tender leaves; disease emergence and spread is favored by prolonged leaf wetness

#### **Management**

Plant pathogen-free seed; do not overcrowd plants; rotate crops with non-umbelliferous varieties

### **Itersonilia canker *Itersonilia perplexans***

#### **Symptoms**

Small brown necrotic lesions on leaves with pale green halos; lesions may coalesce to form large necrotic patches; gray to black lesions on bases of petioles; red-brown cankers on root crown and shoulder with rough texture

#### **Cause**

Fungus

#### **Comments**

Disease typically emerges late in growing season and emergence is favored by cool, wet weather conditions

#### **Management**

The disease can be reduced by keeping the shoulder of parsnip roots covered with soil throughout the growing season; inoculum can be reduced by rotating crops, planting in well-draining soils, removing weeds and plowing crop debris into soil after harvest

### **Powdery mildew *Erysiphe heraclei***

#### **Symptoms**

Powdery growth on leaves, petioles flowers stalks and bracts; leaves becoming chlorotic; severe infections can cause flowers to become distorted

#### **Cause**

Fungus

## **Comments**

Fungus can spread long distances in air; disease emergence is favored by high humidity and moderate temperatures; infection is most severe in shaded areas

## **Management**

Plant tolerant varieties; avoid excess fertilization; protective fungicide applications provide adequate protection; sulfur application can be used in infection occurs early in season

# **Pests**

## **Category : Insects**

### **Aphids (Willow-carrot aphid) *Cavariella aegopodii***

*Willow-carrot aphid colony*

#### **Symptoms**

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants

#### **Cause**

Insect

#### **Comments**

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed; willow-carrot aphid will also attack parsnip, parsley and celery

## **Management**

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

### **Beet armyworm *Spodoptera exigua***

*Beet armyworm larva*

#### **Symptoms**

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside

#### **Cause**

Insect

#### **Comments**

Insect can go through 3–5 generations a year

### **Management**

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae

## **Carrot rust fly** *Psila rosae*

*Carrot rust fly*

### **Symptoms**

Surface scarring of taproot caused by tunnels; tunnels are filled with a rust colored mush; adult insect is a small, dark colored fly; larvae are white maggots approximately 1 cm (0.3 in) long

### **Cause**

Insect

### **Comments**

Carrot rust fly also attacks carrot, celery and other Umbelliferous crops which will also need to be protected if carrot rust fly is a problem

### **Management**

Use of row covers will help to protect plants from damage but they must be installed before adult fly lays eggs on plants; harvest parsnips in blocks; do not leave any parsnips in the ground over winter to reduce overwintering sites

## **Cutworms** *Agrotis* spp.

*Peridroma saucia*

*Nephelodes minians*

and others

*Cutworm feeding on plant stem*

### **Symptoms**

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5–5.0 cm (1–2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed

### **Cause**

Insects

### **Comments**

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato

### **Management**

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically

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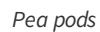
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# Pea

## Description

Pea, *Pisum sativum*, is an annual herbaceous legume in the family Fabaceae grown for its edible seeds and seedpods. The pea plant can be bushy or climbing, with slender stems which attach to a substrate using tendrils. Each leaf has 1–3 pairs of oval leaflets and can reach 1–6 cm in length. The plant produces white, red or purple flowers and swollen or compressed green seedpods which can be straight or curved. The pods can range in size from 4 to 15 cm long and 1.5–2.5 cm wide. Each pod contains between 2 and 10 seeds, or peas. The pea plant is an annual plant, surviving only one growing season and can reach 30–150 cm in height. Pea may also be referred to as garden pea, English pea or green pea and likely originates from Southwest Asia.



## Uses

Young green seeds and pods can be eaten fresh or cooked as a vegetable.

# Propagation

**Basic requirements** Peas are cool-season crops and should be grown in early Spring or late summer to avoid high summer temperatures. Peas grow best at temperatures between 15 and 24°C (60–75°F) and are tolerant of frost down to -6.5°C (20°F) although they are generally less sensitive to Spring frost. Pea plants will grow best in soils rich in organic matter with a pH between 5.5 and 7. They should be planted in a well draining soil or raised bed as they do not tolerate too much moisture. Peas perform best in full sunlight although they are also tolerant of partial shade. **Sowing seeds** Peas should be direct seeded in the garden in Spring as soon as soil is workable and its temperature is above 4.4°C (40°F), or in late summer 8–10 weeks before the first frost date. The optimum soil temperature for germination is 10–25°C (50–77°F), lower temperatures will slow germination. Seeds should be planted 2.5–5.0 cm (1–2 in) apart with shallow planting beneficial in soils which are cool and wet. Seeds should be sown 2.5–10.0 cm (1–4 in) apart allowing 45 cm (~18 in) between rows. Seedling should emerge in 9–13 days at a soil temperature of 15.5°C (60°F) and do not require thinning. **General care and maintenance** Tall, vining pea varieties require a trellis to support their growth. Trellises can be made easily out of chicken wire or lengths of string and the plants will begin to grow around them, using tendrils to grip around the support. If growing a variety that requires trellising then the row spacing should be adjusted accordingly. Cool season crops are often attacked by powdery mildew and where the disease is known to be problematic, resistant varieties should be planted.

Pea trellis

Peas growing on string supports

Pea supports

Peas growing on a home made trellis

Vining peas will use tendrils to grasp around supports

Pea seedlings should emerge in 9–13 days at optimal soil temperature

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# Common Pests and Diseases

# Diseases

## Category : Fungal

### Aphanomyces root rot (Common root rot) *Aphanomyces euteiches*

#### Symptoms

Leaves turning yellow starting from bottom of plant and moving upwards; pod production reduced; soft dark lesions on roots; plants may be severely stunted

#### Cause

Fungus

#### Comments

Disease emergence favors high soil moisture; currently a problem in the midwest and northeast US

#### Management

No fungicides effectively control this disease and no pea varieties with high resistance, control therefore relies on avoiding planting in infested fields; rotate crops to avoid build up of disease in soil

### Ascochyta disease *Mycosphaerella pinodes*

*Phoma medicaginis*

*Ascochyta pisi*

*Ascochyta lesions on pods and leaves*

#### Symptoms

Tan or purple lesions on leaves, stems and pods which may expand and produce a concentric ring pattern; blossoms or pods may drop or become distorted if lesions girdle sepals

#### Cause

Fungi

#### Comments

Disease emergence favors high moisture

#### Management

Grow peas in dry areas; use an appropriate fungicide to treat seeds prior to planting; discard any seed which is known to be heavily infected

### Brown spot *Pseudomonas syringae*

#### Symptoms

Water-soaked spots on leaves, stems and pods identical to those caused by bacterial blight; after several days lesions turn tan, lose their water-soaked appearance and resemble a scorch or burn; stem lesions are sunken and elongated and spread upwards; symptomatic leaves dry and drop from plant

#### Cause

Bacterium

#### Comments

Disease is spread by infected seed; bacterium survives in soil for several months; brown spot more common on plants injured by wind, frost and hail or by mechanical means

#### Management

Plant only disease-free seed; continuously rotate crops; avoid planting peas in fall when they are more likely to be injured by inclement weather

### Downy mildew *Peronospora viciae*

## **Symptoms**

Yellow-brown blotches on upper surface of leaves; angular patches of fluffy white-gray fungus on lower side of leaves; plant growth may be stunted or distorted and whole plant may die before flowering; plant may produce

## **Cause**

Fungus

## **Comments**

Fungus overwinters in soil and on crop debris; fungus can survive in soil for 10-15 years

## **Management**

Rotate crops for at least 5 years; till crop debris deeply; avoid sowing pea in late Autumn at greater soil depths as this can promote severe infections

## **Fusarium root rot** *Fusarium solani*

### **Symptoms**

Stunted plant growth; yellowing, necrotic basal leaves; brown-red or black streaks on roots that coalesce as they mature; lesions may spread above the soil line

## **Cause**

Fungus

## **Comments**

Damage caused by the emergence of the disease is worsened by warm, compacted soils, limited soil moisture and poor soil fertility

## **Management**

There are currently no pea varieties with resistance to Fusarium root rot so control relies on cultural practices e.g. do not plant peas in same area more than once in any 5 year span or treating seeds with an appropriate fungicide prior to planting

## **Gray mold (Botrytis mold)** *Botrytis cinerea*

### **Symptoms**

Fuzzy gray elongated lesions which girdle stem causing wilting of upper parts of plant; lower leaves may be covered in fuzzy gray growth which causes them to dry out and shrivel; small, oval, water-soaked lesions on pods which are tan in color; pod lesions spread irregularly and become gray and sunken; young pods may shrivel and become covered in fuzzy, gray mycelial growth

## **Cause**

Fungus

## **Comments**

Fungus survives in or on crop debris in soil; disease spreads by splashing water and on equipment under favorable conditions

## **Management**

There is no reported resistance to gray mold in pea; potassium deficiency may make plants more susceptible and should be supplemented in deficient soils; the fungus causing gray mold has developed resistance to many systemic fungicides and control relies on the application of an appropriate protective fungicides if flowering and pod set coincides with wet weather

## **Powdery mildew** *Erysiphe pisi*

*Powdery mildew on pea*

*Powdery mildew on pea*

### **Symptoms**

Yellow spots on upper surface of leaves; powdery gray-white areas which coalesce to cover entire plant; if plant is heavily infected it may appear light blue or gray in color

**Cause**

Fungus

**Comments**

Fungus overwinters on plant debris or alternate host; disease emergence is favored by warm, dry weather with cool nights that result in dew formation

**Management**

Plant resistant varieties, particularly if sowing late; use overhead irrigation (washes fungus from leaves and reduces viability); plant crop as early as possible; frequent applications of sulfur may be required to control heavy infestations

## Rhizoctonia seedling blight *Rhizoctonia solani*

**Symptoms**

Water-soaked sunken, red-brown lesions on hypocotyls (germinating shoot below seed leaves) and epicotyls (shoot above seed leaves); death of growing tip as it emerges from soil; new shoots may emerge from a node at seed but may also be killed

**Cause**

Fungus

**Comments**

Fungus can survive in soil for long periods; disease most damaging in warm conditions; fungus spreads by wind, contaminated water, equipment and movement of people and animals in plantation

**Management**

Crop rotation helps to reduce the build up of the fungus in the soil; reduce soil compaction; do not plant seeds too deep

## Septoria blotch *Septoria pisi*

*Septoria blotch symptoms on pea*

*Septoria blotch symptoms on pea*

*Septoria blotch symptoms on pea*

*Septoria lesions on pea pods*

*Septoria lesions on pea foliage*

**Symptoms**

Irregular yellow lesions on leaves and pods with no definitive margin that coalesce to form large yellow patches; large patches may dry out and become covered in black fungal fruiting bodies

**Cause**

Fungus

**Comments**

Disease emergence favors high humidity and moderate temperatures; disease is common but rarely causes economic damage as it occurs mainly on old leaves and pods

**Management**

Rotating crops regularly prevents disease build-up in soil

## Category : Bacterial

### Bacterial blight *Pseudomonas syringae*

**Symptoms**

Small, water-soaked spots on leaves steam and pods which coalesce and turn brown and necrotic; lesions on leaves are angular and develop translucent centers; lesions on stem may enlarge and girdle stem, killing plant parts above; lesions on pods may cause seeds to be covered in slime

**Cause**

Bacterium

### Comments

Disease is spread both in and on seed and can survive like this for 3 years; if infected seed is used, the whole pea crop can be lost if conditions are favorable to the bacterium

### Management

Plant resistant varieties; plant only disease-free seed; disinfect all tools and equipment regularly; avoid sprinkler irrigation

## **Streak** Pea streak virus (PSV)

### Symptoms

Purple or brown necrotic streaks on stems and petioles; small brown necrotic lesions on leaves; brown, sunken lesions on pods; pods fail to fill properly or do not fill at all; pods discolored; dieback of growing tips; chlorosis of leaves

### Cause

Virus

### Comments

Transmitted by pea aphids; alfalfa most important perennial virus reservoir

### Management

No resistance to virus; avoid planting peas close to established alfalfa; insecticide application of little benefit due to short time aphid requires to transmit virus but can help control secondary spread

## **Category : Viral**

## **Enation mosaic** Pea enation mosaic virus (PEMV)

### Symptoms

Blister-like outgrowths (enations) on underside of leaves and on pods; leaves with translucent areas; severely deformed plants

### Cause

Virus

### Comments

Virus is transmitted by several species of aphid

### Management

In areas where virus is a problem, early planting may allow plants to mature before virus becomes severely damaging; control of aphid populations and hosts plants which act as reservoirs can help control spread of virus

## **Mosaic** Red clover vein mosaic virus (RCVMV)

### Symptoms

Mottled patterns on leaves; yellow leaf veins; distorted leaves; stunted plants which often die

### Cause

Virus

### Comments

Virus transmitted by aphids; aphids acquire virus from perennial hosts such as clover and alfalfa and spread to peas

### Management

No known resistance to virus, control depends on control of aphid populations; apply appropriate insecticide if aphid populations are significant

## **Pests**

## **Category : Insects**

## **Aphids (Pea aphid, Bean aphid, Cowpea aphid, Melon aphid, Peach aphid, etc.)**

*Acyrthosiphon pisum*

*Aphis spp.*

*Myzus persicae*

*Close-up image of a pea aphid  
(Acyrthosiphon pisum)*

### **Symptoms**

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plant

### **Cause**

Insects

### **Comments**

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed

### **Management**

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

## **Leafminers *Lyriomyza spp.***

*Typical leafminer trail*

### **Symptoms**

Thin, white, winding trails on leaves; heavy mining can result in white blotches on leaves and leaves dropping from the plant prematurely; early infestation can cause yield to be reduced; adult leafminer is a small black and yellow fly which lays its eggs in the leaf; larvae hatch and feed on leaf interior

### **Cause**

Insects

### **Comments**

Mature larvae drop from leaves into soil to pupate; entire lifecycle can take as little as 2 weeks in warm weather; insect may go through 7 to 10 generations per year

### **Management**

Check transplants for signs of leafminer damage prior to planting; remove plants from soil immediately after harvest; only use insecticides when leafminer damage has been identified as unnecessary spraying will also reduce populations of their natural enemies

## **Mexican bean beetle *Epilachna varivestis***

*Mexican bean beetle larva*

*Egg cluster*

*Adult beetle*

### Symptoms

Irregular patches of feeding damage on underside of leaves which causes the top surface of the leaf to dry out, giving the leaves a lacy appearance; insect will also damage flowers and small pods; pods may be damaged so badly that they drop from the plant; adult insect is an orange-brown beetle with black spots; larvae are fat-bodied grubs which taper at the end and are in rows of conspicuous spines

### Cause

Insect

### Comments

Beetles can decimate bean crops; beetles overwinter as adults and undergo 2-3 generations per year

### Management

Some bean varieties may be less attractive hosts for the beetle, e.g. snapbeans are preferred hosts over lima beans; early varieties may escape damage form beetles beetle populations can be reduced by remove overwintering sites such as brush and leaves on the ground; handpick larvae and adults; brush eggs from leaves and destroy; apply insecticidal soap to leaf undersides if infestation is heavy

## Thrips (Western flower thrips, Onion thrips, etc.) *Frankliniella occidentalis*

*Thrips tabaci*

*Western flower thrips*

### Symptoms

If population is high leaves may be distorted; leaves are covered in coarse stippling and may appear silvery; leaves speckled with black feces; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color

### Cause

Insect

### Comments

Transmit viruses such as Tomato spotted wilt virus; once acquired, the insect retains the ability to transmit the virus for the remainder of its life

### Management

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic

## Category : Nematodes

### Root knot nematode *Meloidogyne* spp.

#### Symptoms

Galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; reduction in plant vigor; yellowing plants which wilt in hot weather

#### Cause

Nematode

#### Comments

Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or garden with this type of soil is most likely

## **Management**

Plant resistant varieties if nematodes are known to be present in the soil; check roots of plants mid-season or sooner if symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens

## **Category : Mites**

### **Spider mites (Two-spotted spider mite) *Tetranychus urticae***

#### **Symptoms**

Leaves stippled with yellow; leaves may appear bronzed; webbing covering leaves; mites may be visible as tiny moving dots on the webs or underside of leaves, best viewed using a hand lens; usually not spotted until there are visible symptoms on the plant; leaves turn yellow and may drop from plant

#### **Cause**

Arachnid

#### **Comments**

Spider mites thrive in dusty conditions; water-stressed plants are more susceptible to attack

#### **Management**

In the home garden, spraying plants with a strong jet of water can help reduce buildup of spider mite populations; if mites become problematic apply insecticidal soap to plants; certain chemical insecticides may actually increase mite populations by killing off natural enemies and promoting mite reproduction

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# Peach

## Description

Peach, *Prunus persica*, is a deciduous tree or shrub in the family Rosaceae grown for its edible fruit of the same name. The peach tree is relatively short with slender and supple branches. The leaves are alternately arranged, slender and pointed. The tree produces pink flowers which have five petals and emerge in January and February. The fruit is a velvety, soft, fleshy red to yellow-orange fruit which is oval in shape and 3-8 cm in diameter. Peach trees can grow up to 8 m (19 ft) in height and produce fruit for 10 to 20 years. Peach may also be referred to as nectarine, the two fruits belonging to the same species, although nectarines have smooth skin, and are believed to have originated in China.

*Peach skin*

*Harvest*

*Flower close-up*

*Peaches*

*Peach blossoms*

*Peach trees blossoming*

*Peach fruit and stone*

*Peach fruits on the tree*

*Peach*

## Uses

Peach trees are primarily grown for their fruit which is consumed fresh. Peach trees are also grown as ornamental plants.

## Propagation

**Basic requirements** Peaches grow best in areas with warm summers and require a summer temperature between 20 and 30°C (68-86°F) for the fruit to mature. The trees also have a chilling requirement to break dormancy but fruit buds can be damaged by prolonged periods below -15°C (5°F) and as such, the majority of production takes place in countries which are relatively close to the equator. In addition, peach trees bloom early and can be damaged by late frosts. Trees grow best in well-draining sandy loams in areas that receive full sun but can will grow in a variety of soils as long as water does not sit on the surface after heavy rainfall. It can be beneficial to plant the trees on elevated land to allow cold air to drain away. Trees will grow optimally in soils with a pH of 6.5. **Propagation** Peach trees are propagated vegetatively to maintain the desirable genetic characteristic of the parent. Commercial trees are usually propagated by T-budding in the summer. T-budding involves joining a bud from a desired variety onto an appropriate rootstock. Buds can also be collected late in the summer for budding during dormancy. The budwood should be collected from healthy shoots of current season growth, leaves removed and the budwood kept moist until the union with the rootstock is made. The budwood is joined to the rootstock by inserting the bud stick into a T-shaped cut on the bark of the rootstock and allowing it to grow. The rest of the tree is pruned to force the growth of the new bud which has the desired characteristics. **Planting** Peach trees should be planted in full sun. Plant bare root trees in a pre-dug hole which is slightly wider than the root ball. Backfill the hole so that the tree is planted to its original planting depth ensuring that the bud union is above the soil line. It is usually possible to identify this from changes in the color of the bark. If planting multiple trees, space them at least 7.6 m (25 ft) apart. **General care and maintenance** Peaches should be pruned annually, including the year of planting and are best trained to an open center. When the tree is bearing fruit, it is important to thin the fruits to prevent the tree from over-bearing. Aim to have 1 fruit every 8 inches. This allows fruits to become larger and prevents the tree from reducing production the following year. Trees should be watered regularly during the growing season to aid with fruit development. During dry periods, water trees every 10 to 14 days. Apply water deeply and widely, to at least the width of the canopy. Trees will also benefit from the application of a nitrogen fertilizer in Spring.

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## Common Pests and Diseases

### Diseases

Category : Bacterial

## Bacterial canker *Pseudomonas syringae*

Canker on peach trunk

Canker on peach trunk

Canker on peach trunk

Canker on peach trunk (bark peeled to show discoloration to tissue underneath)

Peach tree with dark cankers on bark

Canker exuding gum on infected peach tree

### Symptoms

Cankers on twigs at bases of flower and leaf buds, in pruning wounds or at the base of spurs which exude amber colored gum; cankers spread upwards and form sunken areas in winter; if pathogen enters dormant buds they may be killed or open normally in Spring before collapsing in early Summer; infected buds may be symptomless

### Cause

Bacterium

### Comments

Disease emergence favors high moisture and low temperatures in the spring; young trees particularly susceptible; trees grown in sandy soils that drain poorly are also susceptible

### Management

Ensure that a suitable peach variety and rootstock is chosen based on geographic location and environmental conditions to prevent stress to tree which predisposes tree to canker disease; apply protective copper spray to trees before flowering; prune trees in early summer to decrease likelihood of infection

## Bacterial spot *Xanthomonas campestris*

Symptoms of bacterial spot on peach leaf

Symptoms of bacterial spot on peach leaf

Symptoms of bacterial spot on peach leaves

Symptoms of bacterial spot on peach leaves

Peach tree infected with bacterial spot

Symptoms of bacterial spot on peach fruit

### Symptoms

Water soaked, angular gray lesions on the underside of the leaves which turn purple and necrotic in the center and cause a shot hole appearance if lesion center drops out; if lesions are present in high numbers on leaves they may become chlorotic and drop from tree; cankers develop on twigs either as raised blisters or as a dark area surrounding a bud that fails to open; in years of severe infection the entire fruit crop may be lost; lesions on fruit begin as small brown, water-soaked lesions which may exude gum

### Cause

Bacterium

### Comments

Periods of frequent rainfall during late bloom and early petal drop increase likelihood of fruit and leaf infection; infection is rare during hot, dry weather

### Management

Avoid planting susceptible peach varieties in areas where disease is known; once disease is visible it can be difficult to control, protective copper applications in the Fall prior to leaf drop and/or application in early growing season may help prevent the disease; care should be taken as peach trees are very sensitive to copper

## Crown gall *Agrobacterium* spp

*Galls on roots of peach tree*

*Crown gall symptoms*

*Large gall on trunk of peach tree*

*Symptoms of crown gall on trunk of peach tree*

*Gall on branch of peach tree*

*Symptoms of crown gall on trunk of peach tree*

*Galls on peach roots*

*Gall on peach tree*

### **Symptoms**

Galls on roots and/or crown of tree which can range in size from so small they are not visible to the naked eye up to 10 cm (4 in) in diameter; galls first become visible as white, fleshy swellings that grow rapidly and become tan to brown in color; galls typically develop at the site of a wound and new galls form adjacent to old ones the next year

### **Cause**

Bacterium

### **Comments**

Infection with crown gall begins at the site of plant wounds; disease emergence is favored by poorly-drained, alkaline soils and previous feeding damage by nematodes

### **Management**

Chemical control of the disease is generally ineffective; an effective bacterial biological control is available for commercial production; cultural control methods include: planting only certified, disease-free material, planting peach in well-draining soil, rotating infected fields with a non-host before peach is planted and also using good sanitation practices

## **Scab *Cladosporium carpophilum***

*Scab symptoms on peach fruit*

*Scab symptoms on peach fruit*

*Scab symptoms on peach twig*

*Scab symptoms on peach fruit*

*Scab symptoms on peach twigs*

*Scab on peach fruit*

### **Symptoms**

Small, green to olive circular spots on surface of fruit, usually close to stem end, which enlarge, darken and develop a green or yellow halo; lesions may coalesce and cause fruit surface to crack; lesions on infected green twigs are hardly visible to start off with but become brown with a raised border before turning purple or dark brown; infected leaves develop angular or circular lesions on the lower surface which are initially a similar color to the leaf but turn olive green as they mature; leaf lesions may coalesce to form chlorotic patches; defoliation may occur

### **Cause**

Fungus

### **Comments**

Fungus overwinters in in twig lesions or on bark surface

### **Management**

Control currently relies completely on the use of fungicides; pruning the tree canopy promotes good air circulation and allows light to penetrate which can help control scab

## **Category : Fungal**

## Brown rot *Monilinia fructicola*

*Blighted blossoms*

*Brown rot on fruit*

*Brown rot on fruit*

*Symptoms of brown rot on fruits*

*Symptoms of brown rot on peach twigs and blossoms*

*Symptoms of brown rot on peach blossom*

### Symptoms

Brown discoloration of fruit skin and inner tissue; fruit skin wrinkled; collapsed flowers exuding sap from their bases; tan cankers with dark edges on twigs; gray-brown spore masses may be present on cankers

### Cause

Fungus

### Comments

Fungus survives in mummified fruit on the tree, blighted blossoms, cankers and infected twigs; blossom and twig blights are promoted by periods of wet weather

### Management

The currently most effective method of controlling brown rot is through the application of appropriate protective fungicides timed so that they are applied when the susceptible flower parts are exposed or after a wet period; avoiding sprinkler irrigation protects the leaves and flowers from wetness that promotes the disease. Cultural control methods include: removing mummified fruit from tree, pruning infected twigs and reducing plant stress by providing adequate levels of water and fertilizer

## Rust *Tranzschelia discolor*

*Rust symptoms on peach leaves*

*Rust symptoms on peach leaves*

*Rust spots on peach leaves*

### Symptoms

Pale yellow-green spots on both upper and lower leaf surfaces which are angular in shape and turn bright yellow in color; spots on lower leaf surface develop orange-red spores

### Cause

Fungus

### Comments

Fungus overwinters in twigs or in leaves which remain attached to the tree

### Management

Rust can be prevented by spraying trees with protective fungicides; application is usually carried out one, two and three months before harvest in areas prone to early season outbreaks of the disease and after harvest in areas where disease is less problematic or emerges later in the season

## Shot hole disease *Wilsonomyces carpophilus*

*Shot hole symptoms on peach fruit*

*Shot hole lesions on peach fruit*

*Shot hole lesions on peach fruit*

*Shot hole lesions on peach fruit*

### Symptoms

Brown lesions with purple edge on fruit, twigs and buds; holes in leaves due to lesions which have dried and dropped out; brown lumps developing in the center of lesion (visible with hand lens); buds turning brown or black and exuding sap; tan lesions with brown margins which exude sap on twigs

#### Cause

Fungus

#### Comments

Disease emergence favors wet, windy conditions

#### Management

Application of Bordeaux mixture before rains in Fall are sufficient to protect dormant buds and twigs over winter

### Silver leaf disease *Chondrostereum pupureum*

#### Symptoms

Leaves have a silvery appearance; if infection is severe the leaves may curl upwards and become necrotic; death of individual limbs or entire tree may occur; fungal fruiting bodies appear on the surface of the dead bark

#### Cause

Fungus

#### Comments

Pathogen is spread via spores released after rainfall during periods of high humidity and can enter trees through pruning wounds; risk of infection is increased if tree is pruned during late winter or early spring; trees also susceptible when they are heavily pruned

#### Management

Control of silver leaf disease is difficult and infection can be widespread after rainfall in areas where the disease is present; strategies to reduce the incidence of the disease include: removing all plant debris e.g. pruning waste, stumps, and logs; pruning tree during dry periods and treating large pruning wounds with fungicidal dressing

## Category : Viral

### Leaf curl *Taphrina deformans*

Peach leaf curl symptoms

Peach leaf curl symptoms

Peach leaf curl symptoms on young peach tree

Peach leaf curl symptoms

Peach leaf curl symptoms on foliage

Peach leaf infected with leaf curl

Leaf curl on peach

#### Symptoms

Yellow to red patches on young leaves in Spring which thicken and pucker causing leaf to curl; puckered parts of leaf may develop white covering; infected leaves may drop from plant or remain attached and turn dark brown; infection of fruit is rare but causes irregular, raised and wrinkled red lesions

#### Cause

Fungus

#### Comments

Emergence of leaf curl is promoted by periods of cool, wet weather during the early stages of bud development

#### Management

The primary method of controlling peach leaf curl is the application of appropriate fungicides and/or planting resistant peach varieties; no peach varieties are completely resistant to leaf curl

## **Plum pox virus** Plum pox virus (PPV)

*Symptoms of plum pox on peach leaves*

*Symptoms of plum pox on peach fruit*

### **Symptoms**

First expanding leaves exhibit chlorotic vein clearing and veinbanding; lamina twisted and distorted; fruit show dark rings, lines and spots; symptoms on fruit may disappear on ripening; fruit may be deformed

### **Cause**

Virus

### **Comments**

Virus is transmitted by aphids but most common method of spread is diseased plant material

### **Management**

Plant certified healthy material; remove infected trees from orchard; chemical sprays to control aphids may prolong spread of virus

## **Category : Oomycete**

### **Phytophthora root and crown rot** *Phytophthora* spp.

*Peach tree showing symptoms of Phytophthora infection*

### **Symptoms**

Poor new growth; leaves chlorotic, small in size and sparse; fruit may be small, brightly colored and susceptible to sunburn; shoots may suffer from dieback and tree will often die within weeks or months of first signs of infection or decline gradually over several seasons; root crown may show signs of decay which develops into a canker; bark of infected crown tissue turns dark brown; cankers may occur on aerial parts of plant

### **Cause**

Oomycete

### **Comments**

Severity of disease is linked to soil moisture content; water-saturated soils promote development of fungus

### **Management**

Management of phytophthora is reliant on good management of water: peach trees should be planted in well-draining soil to minimize the frequency and duration of water saturated soil; trees should be propagated from resistant rootstock and application of appropriate systemic fungicides may provide some protection from the disease

## **Pests**

### **Category : Insects**

### **Fruittree leafroller** *Archips argyrospila*

*Fruittree leafroller*

## Symptoms

Leaves of plant rolled and tied together with silk webbing; feeding damage to rolled leaves; defoliation of plant; silk webbing may also be present on fruits and fruits may have substantial scarring from feeding damage; larvae wriggle vigorously when disturbed and may drop from plant on a silken thread

## Cause

Insect

## Comments

Only one generation of insect per year

## Management

Monitor plants regularly for signs of infestation; remove weeds from plant bases as they can act as hosts for leafrollers; avoid planting pepper in areas where sugarbeet or alfalfa are grown nearby; *Bacillus thuringiensis* or Entrust SC may be applied to control insects on organically grown plants; apply sprays carefully to ensure that treatment reaches inside rolled leaves

## Oriental fruit moth *Grapholitha molesta*

Oriental fruit moth larva inside peach

Flagging caused by oriental fruit moth strike

Oriental fruit moth larva and damage to shoot tip

## Symptoms

Wilting shoot tips ("flagging") caused by insect feeding; insect frass may be visible around entry holes burrows in fruit which cause the fruit to be soft, mushy and discolored; adult insect is a small gray moth; larvae are initially white with a black head but turn pink with a brown head as they mature

## Cause

Insect

## Comments

Oriental fruit moths overwinter as mature larvae inside protective cocoons in protected areas of trees or in leaf debris on the ground; insect may undergo six or more generations per year

## Management

Management of the oriental fruit moth usually involves the application of insecticides or the use of mating disruptants; commercial growers should monitor moth numbers using pheromone traps and apply insecticide if average number of moths exceeds 10 per trap; chemical sprays should not be applied within 14 days of harvest

## Scale insects (White peach scale, San Jose scale) *Pseudaulacaspis pentagona*

*Quadrapsidiotus perniciosus*

White peach scale infestation

Damage to fruit caused by San Jose scale

Damage to fruit caused by San Jose scale

White peach scale infestation

White peach scale on peach branch

## Symptoms

Scale insects cause damage by feeding on twigs, branches and fruit on peach trees, injecting toxins into the plant as they do so; if the infestation is heavy, gumming may occur on the bark and twigs or entire branches can be killed; insects are flattened discs, or "scales" with no visible legs; scales produce a white waxy coating which eventually turns black (black cap stage)

## Cause

Insect

### Comments

Scale insects overwinter in the black cap stage; winged adult males mate with females which retain their eggs inside the body until they hatch

### Management

Populations are often kept in check by natural enemies, including predacious beetles and some wasps - although broad-spectrum insecticides may result in outbreaks of scale by killing off populations of beneficial insects; peach trees can be sprayed with horticultural oils when dormant which effectively kill scales without damaging natural enemies

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# Peanut (groundnut)

## Scientific Clarification

The following are the crop details for Groundnuts

Scientific name: *Arachis hypogaea*

Local names: Njugu (Swahili)

Order: Fabales

Family: Fabaceae

Genus: *Arachis*

*Harvesting peanut*

*Peanut kernels*

*Peanut with flower*

*Peanut flower and bee*

*Harvesting peanut*

*Peanut field*

*Peanut seedlings*

*Peanut foliage*

*Peanut foliage*

## General Information

Groundnuts are small erect or trailing herbaceous legumes, about 15 to 60 cm high. The fruit is a pod with one to five seeds that develop underground within a needle-like structure called a peg.

The leaves are arranged in alternate pairs and have leaf-like attachments near the stalk. The groundnut plant produces yellow, orange, cream, or white flowers which produce 'pegs', characteristic floral structures which sink into the ground to grow the pod. The pods can reach up to 10 cm (4 in) in length and can contain between 1 and 5 seeds. The plant can reach 0.6 m (2 ft) in height depending on the variety and as an annual plant, survives only one growing season.

The seeds are rich in oil (38-50%), protein, calcium, potassium, phosphorus, magnesium, and vitamins.

Groundnuts also have considerable medicinal value. They are reported to be useful in the treatment of diseases such as hemophilia, stomatitis, and diarrhea.

In sub-Saharan Africa, groundnuts are a basic staple crop, cultivated mainly by small-scale farmers both as subsistence and as a cash crop. It is an important source of protein and other nutrients for poor rural communities. In Africa, groundnut yields are traditionally low, due to unreliable rains, little technology available to small-scale farmers, pest and disease occurrence, poor seed variety, and increased cultivation on marginal land (ICRISAT).

Groundnuts may also be referred to as peanut, monkeynut, or earth nut. Groundnuts originated in South America from southern Bolivia to north-western Argentina. The Portuguese took them from Brazil to West Africa and then to southwestern India in the 16th century. Africa is now regarded as a secondary center of diversity.

*Peanut Processing*

*Roasted, salted peanuts*

## Groundnut Varieties in Kenya

There are two main varieties of groundnuts in Kenya:

Runner type

Bunch type

The runner is a large variety and it's highly preferred because of high yields, it matures in 90-100 days. Bunch varieties are small, tastier, and highly marketable, it matures in 60- 75 days.

Other varieties include Red Valencia, Red Oriata, Manipinta, Makulu Red, Bukene, Homa Bay, Texas Peanut, and Atika.

Red Valencia: This variety is easy to grow and produces two to five kernels per long pod. It's slightly smaller in size and has a sweeter taste with papery red seed covers.

## Climate Conditions, Soil, and Water Management

Groundnuts are grown in most tropical, subtropical, and temperate countries between 40°N and 40°S latitude, especially in Africa, Asia, North, and South America. They are grown in the warm tropics and subtropics below 1500 m above sea level, and in temperate humid regions with sufficiently long warm summers. The optimum mean daily temperature to grow is 30°C and growth ceases at 15°C. Cool temperatures delay flowering. Groundnuts cannot stand frost. Between 500 and 600 mm of water reasonably well distributed through the growing season allows good

production.

Groundnuts are drought-tolerant species and can withstand severe lack of water, but the yield is generally reduced. If harvesting conditions are wet, aflatoxins (severe poison produced by some fungi such as *Aspergillus* spp) may develop on the nuts. Aflatoxin contamination is a major hazard to human and animal health. When groundnuts are poorly dried and stored, they pick mold and dirt, which attracts fungi, that release aflatoxin chemicals that are dangerous to human health, especially the liver.

Pods develop underground and must be recovered at harvest, therefore crumbly, well-drained soils are preferred, but plants grow and develop adequately on heavier clay soils. For optimum growth, soil pH should be in the range of 5.5 to 6.5, though Bunch types tolerate more acidic conditions (pH 4.5) and some cultivars grow well in alkaline soils up to pH 8.5.

## Uses

Most commercially grown peanuts are used for the extraction of their oil which is used in cooking. The by-product of oil extraction is a pressed cake which is used as animal feed and also in the production of peanut flour. Raw kernels are also commonly roasted and eaten as a snack food.

The vegetative residues from the crop are excellent forage.

## Planting Procedure

Peanut is usually propagated from seed. Seeds should be planted in a well-prepared seedbed in soil that is loose and crumbly with no large clumps. The seedbed should be free from weeds which will compete with the peanut seedlings. Weeds may be removed by hand cultivating or through the use of an appropriate herbicide. Peanut seeds should be planted by hand to a depth of 3–5 cm (1–2 in). It is best to ridge the soil or use flat beds as this will make harvesting the peanuts easier.

After ploughing and harrowing to a fairly good tilth, ridges that are 80 cm apart with flattish tops, should be made so that two rows of nuts can be planted on each ridge. Seeds for planting should be well selected: they should be clean, well-filled, and without any blemishes. Seeds should be kept in their pods and shelled a few days before planting. Planting depth is like maize about 5 to 8 cm. Seed rate is 40 to 50 kg/ha depending on the size of the seeds.

## Intercropping

They can be grown as a sole crop and also intercropped with maize, soybean, and cassava. It is also a good intercrop for upland rice, sorghum, okra, sugarcane, and sunflower.

In some areas, they are grown under perennial tree crops such as coconut, oil palm, or rubber. Groundnuts when used as intercrop for upland maize and planted along the contour reduce soil runoff. The plant also reduces the population of African bollworms because it serves as a hiding place for beneficial insects. There is an increase in the yield of groundnuts when intercropped with early-maturing pigeon peas.

## Husbandry

To achieve maximum economic yields, weeds must be eliminated. Groundnuts are poor competitors with weeds during the early stages of growth. Weeding should be done early while at the same time earthing up the ridges to encourage "pegging" i.e. young nuts penetration through the soil. Once pegging has started, only hand weeding should be undertaken to avoid disturbing the young nuts or damaging the flowers. Clean weeding should be done in up to 6 weeks after which hand weeding should take over.

The only peculiar nutrient requirement is for calcium (Ca) in the podding zone. Calcium is absorbed directly by the pods if soil moisture is adequate. A shortage of Ca in that zone will result in empty pods (especially in Runner cultivars). The crop's needs for nitrogen should be satisfied with symbiotic fixation by strains of Rhizobium of the cowpea group, so nitrogen fertilizers are not generally required.

In some areas of acid soils, lime is applied to raise the pH and supply Ca. Moisture stress during flowering or pod filling reduces yield therefore irrigation is important during those periods to minimize or eliminate the stress, and increase production and seed quality. Where yields are unsatisfactory (heavily eroded soils) an application of 200 kg/ha of rock phosphate is recommended.

## Harvesting

Bunch cultivars are harvested 85-100 days after sowing and Runner cultivars 110-130 days after sowing in the warm tropics. Dig a few plants up to see if the nuts are ready. The nuts should be brown on the outside, firm, and dry. Usually, at maturity the inside of the pods is grey and some rattling occurs when pods are shaken. Severe disease of foliage sometimes results in harvesting before seeds are fully mature.

Plants should be carefully dug out to avoid nuts breaking off and remaining in the ground. Dry for 2-3 days, then rip the pods from the bushes and place them on mats to dry for another 7-10 days to about 10% moisture.

Shelling should be done by hand. Broken, dirty, or damaged nuts should be discarded as these will lower the quality and hence the selling price. When the groundnuts are poorly dried and stored, they pick mold and dirt, which attracts fungi, that release aflatoxin chemicals that are dangerous to human health, especially the liver. Nuts to be used as seeds the following year should not be shelled.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Botrytis blight** *Botrytis cinerea*

##### **Symptoms**

Numerous spots on upper surface of leaflets; entire plant or discrete parts may wilt and die; pods and stems become covered in fungal sclerotia.

##### **Cause**

Fungus

##### **Comments**

Disease emergence favors high moisture and high temperature; plants damaged by frost or other pathogens are particularly vulnerable to attack.

##### **Management**

Avoiding frost damage by planting early peanut varieties can help protect the plant from fungal colonization; application of appropriate foliar fungicides (e.g. benomyl), where available, can help to control the disease.

#### **Charcoal rot** *Macrophomina phaseolina*

##### **Symptoms**

Water soaked lesions on stems of seedlings close to soil line; lesions girdle stem and kill seedlings; lesions in similar area may be present in older plants; lesions are initially water-soaked but turn brown; if lesions girdle the stem, plant wilts and branches die; infections beginning in the roots cause leaves to turn yellow and wilt and causes stems to be blighted.

##### **Cause**

Fungus

##### **Comments**

Fungus survives in crop debris in the soil; disease emergence is favored by high soil temperatures which cause plants to be water stressed and more susceptible to disease; fungus can survive for prolonged periods in dry soils but are killed in wet soil.

##### **Management**

Rotating crop with rice for a period of 3-4 years can reduce the level of ooculum in the soil; providing the plants with adequate irrigation and fertilization reduces susceptibility to the disease; there are currently no resistant varieties of peanut; frequent irrigation to wet soil reduces the incidence of the disease.

#### **Cylindrocladium black rot** *Cylindrocladium crotalariae*

*Blackened and shriveled roots due to black rot infection*

*Rotting caused by Cylindrocladium black rot on peanut*

*Plants yellowing and wilting*

*Clusters of fungal fruiting bodies on peanut stem*

##### **Symptoms**

Leaves on main stem turning chlorotic and wilting; entire plant wilts very rapidly when there is a period of water stress following high moisture; clusters of red-brown fungal bodies occur on stems, pegs and pods; roots destroyed; roots

blackened and shriveled.

#### Cause

Fungus

#### Comments

Crops planted early are more susceptible to the disease as they are often exposed to cooler temperatures and higher soil moisture; disease is seed transmitted and also can spread over long distances by wind.

#### Management

The most effective method to control the disease is to plant peanut varieties that have some resistance to the disease; rotation of crop with nonhost such as corn, cotton or tobacco may help to reduce inoculum in the soil; application of appropriate soil fumigants in heavily infested fields can help to control the disease.

### Early leaf spot *Cercospora arachidicola*

*Close-up image of an early leaf spot lesion on peanut*

*Symptoms of early leaf spot on peanut leaves*

#### Symptoms

Small chlorotic flecks on leaf petioles, stems and pegs which enlarge and turn dark in color; lesions on upper surface of leaves usually possess a yellow halo and are reddish brown on the underside of leaves.

#### Cause

Fungus

#### Comments

Disease emergence is favored by high humidity and warm temperatures; spread of the disease is promoted by prolonged leaf wetness.

#### Management

If disease is present, a rotation away from peanut for a period of 2-3 years is advised but is insufficient to control the disease completely; peanut crop debris should be plowed into soil after harvest and any volunteers removed from the nonhost crop; fungicides should be applied with caution as they can exacerbate other foliar diseases where they are present.

### Late leaf spot *Cercospora personatum*

*Severe defoliation in peanut field infected with Cercospora*

*Cercospora infected peanut leaves*

*Defoliation due to Cercospora infection*

*Peanut plant infected with Cercospora fungus*

*Peanut plant infected with Cercospora fungus*

*Peanut plant infected with Cercospora fungus*

*Cercospora lesions on peanut*

#### Symptoms

Small chlorotic flecks on leaf petioles, stems and pegs which enlarge and turn dark in color; symptoms may be very similar or identical to early leaf spot and can only be differentiated by examination of conidia under a microscope.

#### Cause

Fungus

#### Comments

Disease emergence is favored by high humidity and warm temperatures; spread of the disease is promoted by prolonged leaf wetness.

### Management

If disease is present, a rotation away from peanut for a period of 2-3 years is advised but is insufficient to control the disease completely; peanut crop debris should be plowed into soil after harvest and any volunteers removed from the nonhost crop; fungicides should be applied with caution as they can exacerbate other foliar diseases where they are present.

## **Phyllostica leaf spot** *Phyllostica arachidis-hypogaea*

*Circular lesions with red-brown margins and light brown or tan centers on leaves*

*Symptoms of Phyllostica leaf spot on peanut leaves*

### Symptoms

Circular lesions with red-brown margins and light brown or tan centers on leaves; centers of lesions may dry out and drop from leaf resulting in a "shot-hole" appearance.

### Cause

Fungus

### Comments

Phyllostica leaf spot is known to occur in the U.S., India, China, Argentina, Thailand, the Philippines, Pakistan, Zimbabwe, Niger and Burkino Faso.

### Management

Disease is held in check by fungicides applied to control early or late leaf spot.

## **Rust** *Puccinia arachidis*

*Rust symptoms on peanut*

*Rust symptoms on peanut*

*Rust symptoms on peanut*

*Symptoms of rust on peanut leaves*

*Rust symptoms on peanut*

*Symptoms of rust on peanut leaves*

*Rust symptoms on peanut*

*Symptoms of rust on peanut leaves*

*Symptoms of rust on peanut leaves*

*Symptoms of rust on peanut leaves*

### Symptoms

Characteristic orange pustules on undersides of leaves which become covered in masses of red-brown spores; pustules may form on pods.

### Cause

Fungus

### Comments

Peanut rust is highly specific to peanut; disease emergence and spread is favored by warm temperatures followed by leaf wetness.

### Management

Allow field to fallow for at least one month between successive peanut plantings; remove any volunteer peanut plants

during fallowing to reduce inoculum; sprays of appropriate fungicides such as Bordeaux mixture can effectively control the disease; such fungicides are often also effective at controlling leaf spot.

## **Sclerotinia blight** *Sclerotinia minor*

Severe Sclerotinia blight on peanut	Early infection of Sclerotinia minor on peanut	Hard black sclerotia on infected peanut stems
Sclerotia of Sclerotinia minor inside peanut pod	Stem shredding by Sclerotinia minor on peanut	Sclerotia, stem bleaching and shredding by Sclerotinia minor on peanut

### **Symptoms**

Tips of infected branches wilt or flag rapidly; early signs of infection include the presence of small water-soaked lesions at the base of the stems which turn yellow or bleached; leaves on infected branches turn chlorotic and then wither; fluffy white fungal growth may appear on infected tissues during periods of high humidity.

### **Cause**

Fungus

### **Comments**

Fungus can survive for prolonged periods in the soil, even in the absence of peanut; emergence of the disease in the peanut crop is favored by periods of cool weather, moist soil and high humidity.

### **Management**

Plant seeds which are coated with protectants; avoid injuring plants with tools and/or machinery; application of appropriate fungicides can reduce crop losses when disease is present; avoid excessive irrigation during cool weather.

## **Southern stem rot** *Sclerotium rolfsii*

Below-ground symptoms of southern stem rot.	Dense white mycelial growth and brown sclerotia of <i>Sclerotium rolfsii</i> , causing southern stem rot of peanut	White fungal mat developing on the stem close to the soil line
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### **Symptoms**

Lateral branches or main stem yellowing and wilting; white fungal mat developing on the stem close to the soil line; white to brown spore containing structures developing from the fungal mats.

### **Cause**

Fungus

### **Comments**

Pathogen has a large host range and attacks many crops including sugar beets; disease favors dry soils which crack deeply, allowing the penetration of oxygen.

### **Management**

Plow crop debris deeply into soil after harvest of crop; crop rotation of 3-4 years are very effective at reducing soil inoculum in the case of severe infestations; applications of appropriate fungicides can help suppress stem rot but care should be taken with selection as some pesticides (e.g. benomyl) are known to increase the severity of the the disease.

## **Verticillium wilt** *Verticillium* spp.

### **Symptoms**

Chlorosis of leaf margins; curling leaves; loss of leaf turgor; plants wilt and become stunted as the disease progresses; plants wilt rapidly during periods of water stress; vascular system becomes discolored.

**Cause**

Fungi

**Comments**

Fungus can survive in the soil for several years; disease is spread to uninfested fields by movement of infested soil or contaminated tools and machinery; there are no peanut varieties known to have resistance to the disease.

**Management**

Irrigate plants frequently to reduce wilting of infected plants and allow them to reach maturity; eliminate weeds in the plantation which may allow inoculum to build up in the soil; remove and destroy infected crop residue after harvest to reduce inoculum in the field.

**Web blotch (Phoma leaf spot) *Phoma arachidicola***

*Web blotch infected leaves*

**Symptoms**

Circular, brown-black lesions on the upper surfaces of the leave; web or net-like brown lesions on leaves may form on leaves during periods of high humidity; as disease progresses, lesions darken and develop a rough texture; lesions may cover entire leaf surface.

**Cause**

Fungus

**Comments**

Disease emergence is favored by cool, moist conditions and periods of prolonged leaf wetness.

**Management**

Remove and destroy infested crop debris to prevent build up of inoculum in soil; rotate crops away from peanut; foliar fungicide applications are largely ineffective if conditions are favorable for the disease.

**Category : Viral****Stunt** Peanut stunt virus (PSV)

*Peanut stunt virus infected leaf*

*Symptoms on leaves*

*Peanut stunt virus infected plants*

*Symptoms of peanut stunt virus on peanut leaves*

**Symptoms**

Leaves curled and pale yellow to green; leaf petioles shortened; plants growth severely stunted; plants may produce very few pods if they have been infected early in the growing season.

**Cause**

Virus

**Comments**

PSV is transmitted by aphids; legumes such as white clover are the primary source of inoculum.

**Management**

Avoid planting peanut in close proximity to legumes such as clover; remove any infected plants from plantation to reduce inoculum.

**Tomato spotted wilt virus & Peanut bud necrosis** Tomato spotted wilt virus (TSWV)

## Peanut bud necrosis virus (PBNV)

<i>Groundnut bud necrosis disease symptoms:mild chlorotic mottle or specks on young, quadrifoliate leaves, which develop into chlorotic and necrotic rings and streaks (left). Necrosis of the terminal bud (right)</i>	<i>Tomato spotted wilt virus symptoms</i>  <i>Twisted terminal with mottled leaflets due to tomato spotted wilt virus</i>	<i>Symptoms of tomato spotted wilt virus</i>  <i>Tomato spotted wilt virus infected plants</i>
<i>Stunted plant with small, darkened pods due to tomato spotted wilt virus</i>		

### Symptoms

Chlorotic spots or mottled patterns on leaves; drooping leaflets during hot weather; necrosis of terminal buds; stunted growth; new leaflets are reduced in size and may be puckered with mosaic mottling.

### Cause

Virus

### Comments

Both viruses have an extremely wide host range and are transmitted by thrips vectors.

### Management

Use high quality seed and use adequate plant spacings to avoid overcrowding; provide plants with adequate irrigation and fertilization to encourage the fast establishment of seedlings and growth of a close canopy which is unattractive to thrips vectors; intercropping peanut with sorghum or millet can reduce disease incidence.

## Pests

### Category : Insects

#### Armyworms *Spodoptera* spp.

<i>Death of armyworm (<i>Spodoptera frugiperda</i>) larva due to external parasitoid (biological control)</i>	<i>Beet armyworm (<i>Spodoptera exigua</i>) adult</i>	<i>Armyworm (<i>Spodoptera frugiperda</i>) adult</i>
<i>Southern armyworm (<i>Spodoptera eridania</i>) larva</i>	<i>Beet armyworm (<i>Spodoptera exigua</i>) larva</i>	<i>Yellowstriped armyworm (<i>Spodoptera ornithogalli</i>) larva feeding on leaves</i>
<i>Armyworm (<i>Spodoptera frugiperda</i>) eggs</i>	<i>Armyworm (<i>Spodoptera frugiperda</i>) larva feeding on leaves</i>	

### Symptoms

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside.

**Cause**

Insect

**Comments**

Insect can go through 3–5 generations a year.

**Management**

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae.

**Thrips (Tobacco thrips) *Frankliniella fusca***

*Frankliniella occidentalis*

*Thrips palmi*

*Thrips damage to young peanut plant*

*Thrips damage to peanut*

**Symptoms**

If population is high leaves may be distorted; leaves are covered in coarse stippling and may appear silvery; leaves speckled with black feces; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color.

**Cause**

Insect

**Comments**

Thrips transmit viruses to plants, including Tomato spotted wilt virus and Peanut bud necrosis virus.

**Management**

use adequate plant spacings to avoid overcrowding; provide plants with adequate irrigation and fertilization to encourage the fast establishment of seedlings and growth of a close canopy which is unattractive to thrips vectors.

**Velvetbean Caterpillar *Anticarsia gemmatalis***

*Velvetbean caterpillar Adult*

*Velvetbean caterpillar Adult on peanut plant*

*Dark form of velvetbean caterpillar feeding on peanut leaves.*

*Green form of a velvetbean caterpillar feeding on peanut leaves*

*Dark form of a velvetbean caterpillar, *Anticarsia gemmatalis**

**Symptoms**

The larva causes damage to plant by feeding on leaves. The larva after hatching from egg starts feeding on leaves. The first and second stage larva skeletonise the leaves by feeding only on soft parts. The later stage larvae consumes entire leaves. They will strip the field just in four to seven days. The larvae may also feed on tender stem, buds and pods.

**Cause**

Insect

**Comments**

Velvetbean caterpillars feeds on legume (like soybean, kudzu, velvetbean, horse beans, cowpea), cotton and several weeds. Generally moths lay eggs in mass under leaf surface.

**Management**

Encourage natural predators and parasites in the field; early or late planting of crops helps in escaping the insect attack;

grow available resistant varieties; spray biocontrol agents like nuclear polyhedrosis virus (NPV) and the bacterium *Bacillus thuringiensis* (Bt). If the incidence is severe spray suitable insecticide.

## Category : Nematodes

### Root knot nematode *Meloidogyne* spp

Galls on root due to Root-knot nematode, *Meloidogyne arenaria*.

Galls on peanut roots

Root-knot nematode, *Meloidogyne arenaria*, on peanut showing severe galling.

#### Symptoms

Galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; reduction in plant vigor; yellowing plants which wilt in hot weather.

#### Cause

Nematode

#### Comments

Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or garden with this type of soil is most likely.

#### Management

Plant resistant varieties if nematodes are known to be present in the soil ;check roots of plants mid-season or sooner if symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens.

## Category : Mites

### Two-spotted spider mite *Tetranychus urticae*

Spider mite damaged leaves

Spider mite damaged leaves

Spider mites infestation

#### Symptoms

Leaves stippled with yellow; leaves may appear bronzed; webbing covering leaves; mites may be visible as tiny moving dots on the webs or underside of leaves, best viewed using a hand lens; usually not spotted until there are visible symptoms on the plant; leaves turn yellow and may drop from plant.

#### Cause

Arachnid

#### Comments

Spider mites thrive in dusty conditions; water-stressed plants are more susceptible to attack.

#### Management

Spraying plants with a strong jet of water can help reduce buildup of spider mite populations; if mites become problematic apply insecticidal soap to plants; certain chemical insecticides may actually increase mite populations by killing off natural enemies and promoting mite reproduction.

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# Pear

## Description

The European pear, *Pyrus communis*, is a perennial deciduous tree in the family Rosaceae, grown for its fruit. The tree is a short deciduous tree with a tall and narrow crown and alternately arranged, simple leaves. The leaves are elliptical with finely serrated margins and defined tips and can reach 2–12 cm (0.7–4.7 in) in length. The tree produces white flowers which are 2.5 cm (1 in) in diameter and a fleshy green pyriform fruit. Pear trees can reach 9 m (30ft) and will produce fruit for about 20 years. The European pear may be referred to by name of its cultivars which include the Bartlett, d'Anjou, Kaiser Alexander and Comice pears. The European pear occurs only as cultivated trees and does not grow wild in nature. It is descendant of wild European and Asian pear trees.

*Young pears*

*Pear buds*

*Pear blossoms*

*Pear trees in blossom*

*Pear blossoms*

*Pear fruits*

## Uses

The pear fruit is eaten fresh or can be cooked in a range of sweet dishes. The fruit may also be pressed for juice. The leaves of the tree can be used to produce dyes and the wood can be used in carpentry and is very durable.

# Propagation

**Basic requirements** Pears grow very well in areas that have a late frost and a cool, dry summer and will grow at temperatures between -26 and 45°C (-14.8–133°F). Pear trees have a chilling requirement of between 1000 and 1500 hours between 0 and 7°C (32–44.6°F) to break dormancy depending on the particular variety being grown. Generally, trees must cross pollinate with a different variety in order to successfully set fruit. Pear trees require a deep, well draining soil with a pH of 6–7 and will grow in sandy, medium or heavy soil. Pear trees are the most tolerant of all fruit trees of wet soils but roots should not be waterlogged for more than a few days at a time. **Propagation** Pear trees are propagated by budding onto suitable rootstocks. Rootstocks are usually also pear but quince is also used in warmer growing regions. Pear trees are usually acquired from the nursery as bare-rooted seedlings. They are planted by digging a hole which is large enough to accommodate the outstretched roots of the tree without bending. The graft union should be at least 10–15 cm (4–6 in) above the soil line. Trees should be spaced 4.8 m (16 ft) apart, leaving 7.5 m (25 ft) between rows. The best time for planting is in early Spring or Fall while the trees are still dormant. Young trees are susceptible to wind damage and should be provided with a wind break. **Training and pruning** Pear trees are usually trained in the same way as apple trees and often they follow a central leader system. The central leader system encourages earlier fruiting and is recommended for European pear varieties. The system consists of one main trunk which gives rise to 12 to 16 primary scaffold branches. The tree becomes conical in shape, being wider at the bottom and narrower at the top. The shape is achieved through selective pruning of the branches in the years after planting. At time of planting, the tree is headed back by cutting the leader at a height of approximately 90 cm (36 in) from the ground. All branched lower than 76 cm (30 in) from the ground should also be removed at this time alongside and damaged or broken branches and those with narrow crotch angles. In the first winter following planting, the longest, most vigorous, vertical shoot should be selected as the leader and other vigorous shoots with narrow crotch angles removed. Branches with wide crotch angles (>40°) can be left on the tree and corrected with spacers (lengths of wire secured around the branch to correct the growth angle). Each year, while the tree is dormant, the central leader should be headed back by about 1/3 of its length and any vigorous, competing branches with narrow crotch angles removed. After the tree has fruited for two years, some branches will need removed to open up the canopy. **General care and maintenance** The amount of fertilizer that should be supplied to pear trees depends on the soil type and composition and should be checked with the aid of a soil test. Less nitrogen is supplied to pear trees than to apple as it promotes vigorous growth, increasing susceptibility to fire blight. In the first year of growth, phosphorous and potassium may be required but in subsequent years, only nitrogen is generally added to the soil. The area around the base of the pear tree should be kept free from weeds which compete for water and nutrients. In commercial plantations, appropriate herbicides may be used for weed control. In the home garden, weeds can be removed by hand. Pear trees may require fruit to be thinned to prevent over production which can lead to reduced yields in subsequent years or cause damage to the tree through excess weight. Fruits should be thinned early in the season to a final density of approximately 1 fruit every 15 cm (6 in). **Harvesting** Pear fruits are usually harvested when mature, but are ripened off of the tree. Pears allowed to ripen on the tree tend to ripen from the core outwards, resulting in fruit with mushy centers. It can be difficult to determine the correct time to harvest pears and so a variety of factors should be taken into consideration prior to picking. One of the most common indicators of maturity is the firmness of the fruit. Commercial plantations use devices called penetrometers to determine fruit firmness. Pears should be harvested when the reading is between 16 and 19 pounds.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Armillaria root rot (Oak root fungus) *Armillaria mellea***

###### **Symptoms**

Small, discolored leaves which drop early; death of branches; death of plant; clusters of honey-colored mushrooms may sprout at base of plant

###### **Cause**

Fungus

###### **Comments**

Fungus survives on dead roots in soil

###### **Management**

Armillaria root rot cannot be effectively controlled once it has become established in an orchard; diseased or dead plants should be uprooted and removed; planting resistant rootstocks is the most effective method of preventing the disease

##### **Blast *Pseudomonas syringae***

###### **Symptoms**

Water-soaked or black lesions on leaf petioles; which rapidly expand along the leaf midrib; cankers on twigs and branches; twigs may be girdled and die; leaves turning black and dying; black lesions may be present on fruit

###### **Cause**

Bacterium

###### **Comments**

Disease emergence favors cold, wet weather

###### **Management**

In areas where disease is severe, copper fungicides should be applied in Fall and Winter

#### Category : Fungal, Oomycete

##### **Crown and root rot *Phytophthora* spp.**

###### **Symptoms**

Leaves wilting but remain attached to the tree; reduced growth; early senescence; cankers at soil level, dark discoloration of bark which is slimy when wet

###### **Cause**

Oomycete

###### **Comments**

Disease emergence favors poorly drained soil and standing water

###### **Management**

Practice good water management to prevent emergence of disease; do not over-water trees or allow water to accumulate in soil; there is no treatment for Phytophthora infection once present; no apple varieties are resistant to all

strains of the pathogen

## Category : Bacterial

### Fire blight *Erwinia amylovora*

#### Symptoms

Shoots and blossoms turning black and shriveling; plant appears as if it has been scorched by fire; watery exudate may be present on infected areas

#### Cause

Bacterium

#### Comments

Disease emergence favors warm rainy days during bloom; care should be taken to time antibiotic application properly

#### Management

Cut out diseased wood; treat with Bordeaux mixture or approved fixed copper materials for organic production; streptomycin or copper application to blossoms may be necessary to prevent spread

### Scab *Venturia pirina*

#### Symptoms

Yellow or chlorotic spots on leaves; dark olive green spots on leaves and fruit; may be a velvety growth on spots on undersides of leaves; twisting of leaves; distorted leaves; severely infected leaves turn yellow and drop from tree

#### Cause

Fungus

#### Comments

Fungus overwinters on dead foliage on ground; spores dispersed by wind; high moisture encourages fungal growth

#### Management

Remove all leaves dropped from tree in the fall and compost to prevent any diseases surviving in debris; application of zinc and fertilizer grade urea in the Fall may be necessary to speed leaf drop, lime should then be added to fallen leaves; fungicide application may be necessary in areas where leaves remain wet for periods in excess of 9 hours; fungicides such as copper soaps and Bordeaux mixture should be applied if there is a chance of wet period as soon as leaf tips emerge

## Category : Other

### Pear decline Pear decline phytoplasma

#### Symptoms

Poor shoot growth; dieback of shoots; reddening and rolling of upper leaves in canopy; premature leaf drop; reduced leaf and fruit size

#### Cause

Phytoplasma

#### Comments

Transmitted by pear psylla

#### Management

Plant trees which have been grafted on tolerant rootstocks; control pear psylla on trees

## Pests

## Category : Insects

## **Codling moth** *Cydia pomonella*

### **Symptoms**

Holes and burrows in fruit; holes may be blocked with crumbly brown frass (insect excrement); wounds may be shallow or may be deep burrows extending to the fruit's core; adult insect is a dark brown moth; larvae are pink with a brown head and may be up to 1.3 cm (0.5 in) long

### **Cause**

Insect

### **Comments**

Insect usually undergoes 2-4 generations per year

### **Management**

Proper pruning methods help to open out tree canopy to ensure treatments penetrate interior of the tree and reach larvae; removal of any wild hosts or trees in abandoned orchards helps remove reservoirs of insect; organically acceptable control methods include application of Entrust and kaolin clay; small scale growers and home gardeners can remove infested fruit by hand before larvae leaves fruit to reduce insect population; successful reduction of insect population in large scale orchards is usually achieved by mating disruption by releasing pheromones over successive years

## **Leafrollers (Omnivorous leafroller, Redbanded leafroller, etc)** *Platynota stultana*

*Argyrotaenia velutinana*

### **Symptoms**

Leaves of plant rolled and tied together with silk webbing; feeding damage to rolled leaves; defoliation of plant; silk webbing may also be present on fruits and fruits may have substantial scarring from feeding damage; larvae wriggle vigorously when disturbed and may drop from plant on a silken thread

### **Cause**

Insect

### **Comments**

Adult insect is a moth which can fly over several miles to find suitable hosts

### **Management**

Monitor plants regularly for signs of infestation; remove weeds from plant bases as they can act as hosts for leafrollers; *Bacillus thuringiensis* or Entrust SC may be applied to control insects on organically grown plants; apply sprays carefully to ensure that treatment reaches inside rolled leaves

## **Pear psylla** *Psylla pyricola*

### **Symptoms**

Reduced tree vigor and death of trees caused by pear decline; insect is a dark red-brown insect resembling a tiny cicada

### **Cause**

Insect

### **Comments**

Pear psylla are a serious pest of pear and have a high capacity for developing resistance to insecticides used in their control

### **Management**

Control of pear psylla populations is best conducted when trees are dormant; organically acceptable control methods include the use of insecticidal oils and kaolin clay; appropriate insecticidal sprays can be applied during the dormant season to reduce the populations of overwintering insects

## **Spring pear cankerworm (Fall pear cankerworms)** *Paleacrita vernata*

*Alsophila pometaria*

### **Symptoms**

Leaves are skeletonized to nothing but the veins; young fruit have scarred depressions

**Cause**

Insect

**Comments**

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# Pearl Millet

## Description

Pearl millet, *Pennisetum glaucum*, is an annual grass in the family Poaceae which is grown widely in Africa and India for its grain which can be used to make flour and other foodstuffs. Pearl millet is a very robust grass which tillers widely and grows in tufts. It has slender stems which are divided into distinct nodes. The leaves of the plant are linear or lance-like, possess small teeth and can grow up to 1 m (3.3 ft) in length. The inflorescence of the plant is a spike-like panicle, made up of many smaller spikelets where the grain is produced. Pearl millet can reach 0.5 to 4 m (1.6â€“13.1 ft) in height depending on the cultivar and is an annual plant, harvested after one growing season. Pearl millet may also be referred to as bulrush millet, cat-tail millet or yellow bristle grass and originates from the Sahel zone of Africa. Synonyms are *P. americanum* (L.) Leeke, and *P. typhoides* (Burm.) Stapf. & Hubb.) And common names include bullrush millet, cat-tail-millet, mil-a-chandelle, bajra, kambu, duhkn.

*Pearl millet spike*

*Pearl millet spikes*

*Pearl millet field, India*

*Pearl millet spikes*

*Pearl millet spike*

*Pearl millet*

## Uses

Pearl millet grain can be ground into flour and used to produce porridge, or a type of flat bread. It can also be cooked and prepared in a manner similar to couscous or rice. The plant stems can be used for roof thatch and building construction. In countries other than Africa and India it is most widely grown as fodder.

## Propagation

**Basic requirements** Pearl millet is adapted for growth in dry conditions where there is low rainfall. It is a warm season crop which will produce tillers at temperatures of 21–24°C (69.8–75.2°F) and develop spikelets at the slightly higher temperature of 25°C (77°F). Pearl millet is tolerant of a variety of soils, including acidic and sandy soils and those which are nutrient poor but it will not tolerate waterlogging. The plants will grow optimally in a well-draining, fertile soils with a pH between 6.0 and 7.0. **Propagation** Pearl millet is propagated directly from seed. Pearl millet seed is usually sown directly on fields on hills or ridges with short lived cultivars being planted as soon as possible after the wet season in semi-tropical regions. A well-prepared seedbed is important to ensure rapid development of seedlings. Pearl millet seeds are best sown when the soil has warmed to at least 20°C (68°F). Seed can be sown in furrows if the soil is light or if the plant is being grown in drier areas, or by broadcasting. Seeding rates vary from 12–15 lb of seed per acre when using a seed drill, to 30–40 lb per acre when seed is broadcast. A distance of 45–60 cm (17.7–23.6 in) is usually allowed between rows. **General care and maintenance** Pearl millet is a fast growing crop that will quickly be able to outcompete weeds. It is, however, important to maintain a weed-free seed-bed as young seedlings are susceptible to competition. Traditional cultivation of pearl millet in Africa relies on rainfall to irrigate the plants and involves the application of little to no nitrogen fertilizers. The reason for this is often the application of nitrogen promoted vigorous early growth that can result in the plants using up water required at later stages of growth. In more temperate regions where pearl millet is grown as a forage crop, fertilizer application should be based on the results of a soil test.

**Harvesting** Pearl millet reaches maturity between 50 and 180 days after planting, depending on the variety. The crop is harvested by hand either by cutting the spikes from the plant or by cutting the whole plant.

## References

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of tropical food crops and has donated many of these together with critical descriptors to Cornell University's Department of Plant Pathology & Plant-Microbe Biology working there with Dr Kathie Hodge. The collection, titled Robert J Williams Photograph Collection, can be accessed via:

<http://www.plantpath.cornell.edu/CUPpages/CUPphotos.html#CUP-Williams> Dr Williams has retired to a smallholding in west Wales, growing fruit and veg, where he also writes content for PlantVillage, sharing his valuable knowledge.

## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Cercospora leaf spot** *Cercospora penniseti*

###### **Symptoms**

Small dark lesions on leaves which are usually oval in shape but may be oblong to rectangular; centers of lesions are gray to tan in color with visible black dots; lesions may be covered in spores during wet weather; lesions may also be present on the stems and are slightly longer than those on the leaves.

###### **Cause**

Fungus

###### **Comments**

Disease emergence occurs when high temperatures coincide with periods of high humidity.

###### **Management**

Avoid planting millet varieties that are highly susceptible to Cercospora fungi; control weeds in field; rotate crops and practice good sanitation; no chemical control is needed to treat the disease.

##### **Ergot** *Claviceps fusiformis*

*Ergot infected spike on left*

*Pearl millet Ergot*

###### **Symptoms**

Ergot is a disease of pearl millet grain-bearing heads (inflorescences). The first sign of ergot infection in pearl millet is the appearance of viscous creamy-pink exudations, called honeydew on the flowering heads. Subsequently hard brown spiky structures are formed, called sclerotia.

###### **Cause**

Fungus

###### **Comments**

Ergot reduces grain yields and constitutes a health hazard to humans and animals that consume pearl millet products contaminated with the alkaloid-containing sclerotia of the causal fungus. It is a particularly serious disease of pearl millet F1 hybrids. Biology and Epidemiology: Infection of the individual florets on a pearl millet inflorescence occurs via the stigmas, i.e. the white feathery structures through which the florets are fertilised following pollination. Initial infection is from spores (ascospores) produced from sclerotia in the soil or in crop debris. Secondary infection is from the spores (conidia) produced in the honeydew. Once the stigmas have been pollinated they rapidly wither and are no longer available as the infection route for the ergot fungus. Pearl millet plants are protogynous, with the stigmas emerging before the anthers. Pearl millet F1 hybrids demonstrate synchronous flowering, so that most of the inflorescences in a crop will be at the protogynous stage with little or no pollen available, which makes F1 hybrids particularly vulnerable to ergot infection. Heavy rain at flowering time washes down pollen, extending the period at which the stigmas are available for infection as well as providing ideal conditions for germination and sporulation of the ergot fungus.

## Management

Ergot can be managed in pearl millet, through the use of host plant resistance, pollen management, avoidance and sanitation. Host plant resistance to ergot can be developed using appropriate inoculation, hybridisation and selection techniques. Sources of host plant resistance are developed and made available by public- and private-sector seed companies. It has been shown in research station experiments that using pollen donor plants to coincide with the protogynous stage of crop flowering can significantly reduce infection in ergot susceptible pearl millet F1 hybrids. Avoidance of ergot is achieved through the selection of cultivars that flower during periods of fine dry weather, so that pollen wash and pathogen germination are minimised. Sanitation measures involve the removal and burning of infected inflorescences as soon ergot symptoms are seen. When this is done at the honeydew stage it will reduce secondary spread within the crop. When done at the sclerotial stage it will reduce the inoculum bank for infections in subsequent seasons and reduce the dangers of consumption of the the poisonous alkaloids getting into food and feed products.

## Pearl Millet Downy Mildew *Sclerospora graminicola*

Downy mildew infection process

Green Ear symptoms caused by  
Downy Mildew in Pearl Millet

Seed treatment plot

Underside of leaf of infected plant  
showing sporangiospores and  
sporangia

Downy mildew on Pearl Millet

Epidemiology of downy mildew in  
pearl millet

Indian Pearl Millet

Healthy Pearl Millet and downy  
mildew infected green ear with no  
usable grain

## Symptoms

The earliest symptoms are chlorosis at the base of a leaf, with subsequent leaves on the plant becoming more and more chlorotic, with the chlorosis always extending from the bases towards the tips of the leaves. The underside of chlorotic leaves develop white powdery or downy growth of sporangia and the spores that they bear. There is a distinct margin between diseased leaf tissue at base of leaf and healthy tissue towards tip. Inflorescences of infected tillers develop the characteristic green-ear symptoms where the grain is replaced by whip-like vegetative structures. Inflorescences can be partially or fully converted to green-ear, depending on the time in inflorescence development at which the infection occurred. Partial green-ear always begins at the base of the inflorescence. Plants infected at an early stage of development, before tillering begins can be killed.

## Cause

Oomycete

## Comments

Serious disease in Africa and India, occurs wherever millet is grown.

## Management

The disease is systemic with the pathogen infecting the growing point of each tiller as the leaf and panicle tissues are being formed. Primary infection is from oospores which are long-lived in the soil. Secondary infection is from the spores produced by the sporangia on the undersides of infected leaves. Oospores are formed in necrotic infected plant material, which then contribute to the inoculum bank in the soil. To reduce infection rogue infected plants when found in the field; treat seeds with an appropriate systemic fungicide prior to planting and continue to spray the crop at least once every 25 days after sowing. **Seed treatment** Pearl millet downy mildew can be effectively controlled through the use of metalaxyl-based fungicide seed treatments. Application rates as low as 2 g a.i. per kg seed, using specially formulated seed-treatment products, can provide complete control of downy mildew even with highly susceptible hybrids. There is no value of subsequent foliar fungicide sprays following effective seed treatment. **On-farm sanitation and selection** In situations where resistant cultivars and seed treatments are not available, farming communities can reduce the incidence of downy mildew in pearl millet by on-farm sanitation practices and the selection of seed from robust downy mildew-free plants. Secondary spread of downy mildew within a crop is caused by the spores produced on diseased

leaves, so removal of diseased plants or tillers at the first sign of disease should minimise secondary spread. Removal of diseased plants prior to inflorescence emergence, combined with selection of seed for the next season's sowing from robust, downy mildew-free plants, should also reduce the level of susceptibility in the local cultivar gene pool developing a population of locally DM-resistant cultivars. Sanitation and selection will be more effective if done on a community basis rather than by individual farmers acting alone. The basis for effective on-farm actions is for farmers to fully understand the cause and epidemiology of the disease. Host Plant Resistance Pearl millet downy mildew is best managed by the use of resistant cultivars. Much has been learnt and done in the last 30 years to identify and utilise host plant resistance to this disease, through research done by ICRISAT in collaboration with National Agricultural Research Services (NARS) in India and other countries. In India, the existence of a strong and effective national agricultural research system together with effective public- and private-sector seed companies, has enabled the development and dissemination of a succession of cultivars and hybrids that have a high degree of resistance to downy mildew. The pathogen, however, is variable in its pathogenicity, so that cultivars or hybrids resistant to downy mildew in one region may not be resistant elsewhere. The greatest range of pathogenicity occurs in the Sahel zone of Africa, where the host and pathogen have co-evolved over a long period. Pearl millet hybrids developed for resistance to downy mildew in India have been highly susceptible when grown in the Sahel. Through the ICRISAT-NARS cooperative International Pearl Millet Downy Mildew Nursery program, sources of resistance have been identified that are effective throughout India and right across the African Sahel.

### Rust *Puccinia substriata*

*Typical rust symptoms*

#### Symptoms

Small yellow or white raised spots on upper and lower leaf surfaces; spots tend to be more numerous on lower leaf surface; spots enlarge and develop into red-brown pustules which may be surrounded by a yellow halo.

#### Cause

Fungus

#### Comments

Spores can be spread via wind and survive in crop debris in the soil.

#### Management

Plant resistant varieties of millet if rust is a persistent problem; avoid the use of overhead irrigation; do not plant millet in close proximity to eggplant or other Solanaceous crops; there are no recommended chemical controls for rust.

### Smut *Tolyposporium penicillariae* Bref.

*Sori turning dark brown or black as they mature*

*Infected florets develop as plump green sacs or sori*

#### Symptoms

Smut is a disease of pearl millet grain-bearing heads (inflorescences) that can significantly reduce grain yields, wherever the crop is grown. Infected florets develop as plump sacs or sori, initially green in colour and then turning dark brown or black as the sori mature. The sori are filled with black spores of the causal fungus, hence the name smut.

#### Cause

Fungus

#### Comments

Biology and epidemiology: Individual florets are infected by air-borne spores of the causal fungus when the inflorescences are at the protogynous stage. i.e. when the stigmas have emerged before pollination has occurred.

Mature spores released from the sori when the crop is threshed are mixed with seed from non-infected florets, and these are the source of infection for the subsequent crop.

## **Management**

Smut is best managed by the use of resistant cultivars.

## **Category : Other**

### **Striga or Purple Witchweed [Orobanchaceae] *Striga hermonthica***

Purple Witchweed, *Striga hermonthica*

Pearl millet parasitized by  
witchweed in Niger

Severe infestation of witchweed in a  
pearl millet crop in Niger

## **Symptoms**

Purple Witchweed is the most serious parasitic weed on pearl millet in Africa, causing severe crop losses to this and other crops in the Sahel region. In India *Striga asiatica* is the most common witchweed species, though here it is not regarded as a serious problem in pearl millet.

## **Cause**

Weed

## **Comments**

Biology & Epidemiology: Seeds of this parasitic plant remain dormant in the soil until exudates from roots of pearl millet plants (and other host species) stimulate their germination. Germ-tubes then invade the pearl millet roots, establishing a pathway for the extraction of moisture and nutrients from the pearl millet plant to enable the witchweed plants to develop and produce a crop of purple flowers. The flowers produce seed which add to the seed bank in the soil for parasitism of future crops.

## **Management**

The most effective management would be achieved by the use of host-plant resistance. In situations where there are no witchweed-resistant cultivars available, farming communities can reduce the levels of damage to the crop by: a) hand-pulling the witchweed plants as soon as they are visible, thereby reducing the loss of nutrients and moisture by the crop plants and preventing the addition of more witchweed seeds to the seed bank in the soil; b) the use of 'trap' or 'decoy' crops such as cowpea or soybean, possibly as an intercrop, which can stimulate germination of the witchweed seeds but are not parasitised, thus reducing the seed bank available for the pearl millet crop. In addition there are reports of control of witchweed by treating crop seeds with chemicals that prevent the germinating witchweed seeds from parasitising the crop plants. Where such seed treatments have been shown to be effective, are approved for use and are within the economic capabilities of the cultivator, they could be used as part of an integrated management program. Farming communities can also attempt to develop locally-effective resistant varieties by selection of seed from plants that appear to have not been parasitised. A combination of effective locally-available management methods is recommended in an integrated management program.

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# Pecan

## Description

Pecan, *Carya illinoiensis*, is a large deciduous tree in the family Juglandaceae grown for its edible seeds (nuts). The pecan tree has a thick gray-brown trunk which can reach 2 m (6.6 ft) in diameter and a rounded canopy that spreads. The bark is ridged and has a scaly appearance. The twigs of the tree are red-brown in color and the foliage is dark green. The leaves are pinnately divided and composed of 9–17 oblong-lanceolate leaflets. Each leaflet has a serrated margin and a downward curving tip. The tree produces separate male and female catkins with the male producing pollen and the female developing into the fruit. The male catkin is slender and pendulous, measuring 22–50 cm (8.7–19.7 in) in length and the female catkins are much smaller and possess 3–6 flowers in a cluster. The fruit is an oval-oblong drupe containing a single seed surrounded by a thin shell. The outer husk (shuck) is green, turning brown-black when mature at which point it also splits open to release the nut. The edible kernel of the nut is light brown in color and ridged longitudinally. Pecan trees can reach a height of 40–50 m (131–164 ft) and can live for several hundred years in a wild state. Commercial trees usually have an economic lifespan of approximately 25 years. Pecan originates from the North America, specifically, the South.

Pecan

Pecan tree

Pecan inflorescence

Pecan husks

Pecan inflorescence

Pecan fruits on the tree

## Uses

Pecan nuts are consumed fresh or after roasting as a snack food or may be used as an ingredient in baked goods or confection

## Propagation

**Basic requirements** Pecan trees have a high water requirement and within their native range they are found growing in deep soils where their extensive roots can reach the water table or along river banks or streams. Pecan trees thrive in areas with long hot summers and cool winters. Trees can be grown in a range of soils but will grow optimally in a deep, well draining clay loam or sandy loam with a pH 6.0–7.5. Growing multiple pecan trees requires a great deal of space as the trees can reach a very large size. **Propagation** Pecan trees can be propagated from nuts or by budding or grafting. Nuts for propagation should be collected in the Fall from trees which gave good fill. The seeds require stratification prior to planting. Stratification is the name given to a cold treatment which breaks the dormancy of the seed, speeding the germination process. Nuts are stratified at 2–5°C (35.6–41°F) for a period of 3- to 90 days and then incubated at room temperature. Nuts should be soaked in water for 24 hours prior to the treatment and kept moist throughout by mixing the nuts on moist vermiculite. The nuts can be planted outdoors in late winter if they are planted in place. If growing the seedlings in containers it is best to wait to plant until all threat of frost has passed. Seedling or grafted trees should be planted in full sun to part shade although trees are sensitive to shading and care should be exercised to ensure that the trees are not too shaded. Trees should be spaced 9–10 m (30–35 ft) apart. **General care and maintenance** Newly planted trees must be supplied with adequate moisture to meet their growing requirements in the first few years following planting. Trees must be supplied with 10 to 15 gallons of water weekly. This water can come from rainfall, irrigation, or a combination of both. Fertilization rates should ideally be based on the results of a soil test prior to planting but generally, 4 lbs of a complete fertilizer should be applied in a circular area around the base of the tree measuring 25 square feet. Fertilizer should never be placed directly in the planting hole as it can cause damage to the tree roots. A subsequent similar application in the summer should be enough to meet the growth requirements of the tree. The following year, apply 4 lbs of complete fertilizer per inch of tree diameter. Fertilizer should not be placed within 30.5 cm (12 in) of the tree's trunk. **Harvesting** Pecans should be harvested as soon as the nuts have reached maturity, when the shuck has lost its green color and has started to split. In commercial plantations, hydraulic shakers may be used to dislodge the nuts from the tree.

## References

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Anthracnose** *Colletotrichum gloeosporioides*

##### **Symptoms**

Shiny, dark brown sunken lesions on green fruit which may coalesce to cover the whole fruit; may be pink colored fungal masses on lesions during wet weather; yield may be reduced

##### **Cause**

Fungus

##### **Comments**

Fungus overwinters on tree; disease emergence favors warm temperatures and high rainfall

##### **Management**

Disease can be controlled by regularly applying appropriate fungicides; mummified fruit and infected branches should be removed to reduce inoculum; avoid cover crops which are an alternative host for the fungus; plant anthracnose resistant varieties

#### **Downy spot** *Pseudocercosporella caryigena*

##### **Symptoms**

Circular, pale yellow spots on lower surface of leaves; spots may be covered with fuzzy white growth during wet; lesions develop through leaves and become visible on upper leaf surface; lesions on upper leaf surface yellow-brown; leaflets may drop from tree; nut yield may be reduced due to defoliation

##### **Cause**

Fungus

##### **Comments**

Fungus survives in infected leaves from previous season; disease occurs sporadically in Southeastern U.S. and is common in the U.S. state of Texas

##### **Management**

Downy spot is controlled by the fungicides that are applied to protect against scab

#### **Powdery mildew** *Phyllactinia guttata*

##### **Symptoms**

Small, powdery white spots on leaves and fruit; spots spread to cover entire leaf; small black fungal fruiting bodies may be visible in the white growth; young leaflets may crinkle as they mature

##### **Cause**

Fungus

##### **Comments**

Some pecan varieties are susceptible to powdery mildew and disease is not controlled by scab fungicides and plants should be scouted for the disease over the summer months

##### **Management**

Trees showing symptoms should be treated with appropriate sulfur-containing fungicides

#### **Vein spot** *Gnomonia nerviseda*

##### **Symptoms**

Dark brown to black lesions associated with vascular tissues e.g. along leaf veins or leaf midribs; leaves may fall from trees

##### **Cause**

Fungus

#### Comments

Fungus survives in plant debris on the ground

#### Management

Fungicide applications made to control scab should also be sufficient to control vein spot; there are some pecan varieties that are less susceptible to vein spot such as Melrose and Cherokee

### Zonate leaf spot *Grovesinia pyramidalis*

*Zonate leaf spot symptoms on pecan leaf*

*Close-up of zonate leaf spot lesions on pecan leaflet*

*Zonate leaf spot lesions on pecan leaflet*

#### Symptoms

Lesions with concentric rings on leaves which are tan to light brown on the leaf underside and gray-brown on the upper leaf surface; a crystalline substance may be present on the surface of the lesion; infected leaves dry out by late summer and drop from the tree prematurely; defoliation may be severe

#### Cause

Fungus

#### Comments

Disease can develop rapidly after wet periods in the summer months and symptoms are worse in low-lying orchards

#### Management

The disease can be controlled by application of appropriate fungicides

### Category : Bacterial

### Bacterial leaf scorch *Xylella fastidiosa*

*Bacterial leaf scorch symptoms on pecan*

#### Symptoms

Tan to brown necrotic lesions with distinct dark brown line separating the diseased tissue from healthy; lesions occur on leaf margin or apex; entire leaves becoming necrotic; leaflets may drop from tree; symptoms may be confined to one limb or scattered throughout canopy

#### Cause

Bacterium

#### Comments

Vector of pathogen unknown, likely spread by xylem feeding insects

#### Management

Control of the disease should focus on limiting stress to the trees by providing adequate irrigation, thinning trees and controlling damaging insects

### Crown gall *Agrobacterium tumefaciens*

#### Symptoms

Galls of various sizes on roots and root crown below the soil line; galls may occasionally grow on the trunk; galls are initially light colored bulges which grow larger and darken; galls may be soft and spongy or hard; if galling is severe and girdles the trunk then young trees are weakened due to constricted vascular tissue; trees may be stunted and rarely die

#### Cause

Bacterium

#### Comments

The bacterium enters host plants through wounds and causes plant cells to proliferate and cells to be undifferentiated, leading to the formation of a gall

#### Management

Only plant disease-free nursery stock; plant trees in well-draining soils; avoid wounding the plants as much as possible; fresh wounds can be treated with a biocontrol agent (*Agrobacterium tumefaciens* K84), if available, to prevent the bacterium colonizing

### **Scab** *Cladosporium caryigenum*

*Close-up image of scab lesions on pecan foliage*

*Scab symptoms on pecan shucks*

*Scab symptoms on pecan shucks*

*Scab symptoms on pecan shucks*

*Scab lesions on pecan foliage*

*Scab lesions on pecan foliage*

#### Symptoms

Small, rough or velvety olive green to black spots on leaves, green twigs or fruit; lesions may coalesce to form large dark areas with an irregular shape; leaflets may drop from plant if they are infected at the base of the petiole; lesions on young leaves may dry out and crack, resulting in a "shot hole" appearance as the leaves expand; lesions on shucks are virtually identical to those on the leaves ; severe infection of fruit can cause fruit to stop developing

#### Cause

Fungus

#### Comments

Fungus overwinters in tissues infected previous year

#### Management

Scab is usually controlled by a series of fungicide sprays between budbreak and shell hardening

### **Category : Oomycete**

### **Shuck and kernel rot** *Phytophthora cactorum*

#### Symptoms

Rotting fruit with rot starting at stem end of fruit; dark brown rot with light brown margin spreading to cover entire fruit; kernels have a dark seed coat and bitter taste

#### Cause

Oomycete

#### Comments

Disease outbreaks sporadic but can be very damaging

#### Management

Appropriate fungicides should be applied at first sign of infection to reduce the severity of the infection; cultural control methods include thinning the canopy to promote good air circulation around the foliage and planting pecan in well-draining soils

# Pests

## Category : Insects

### Black pecan aphid *Melanocallis caryaefoliae*

Adult winged black pecan aphid

Lesions on pecan leaflet caused by black pecan aphid

Black pecan aphids and damage on pecan leaflet

Feeding damage on pecan leaflet caused by black pecan aphid

#### Symptoms

Bright yellow angular spots on leaves between veins; the spots turn brown and, if there are a few present on the leaflet; the leaflet will drop from the tree; premature dropping of leaves causes reduced nut yields; insect is small and soft bodied and ranges in color from various shades of green to black; nymphs are usually lighter in color than the adults

#### Cause

Insect

#### Comments

The characteristic stickiness of plants which is usually present during aphid infestation cannot be used as an indicator of black pecan aphid attack as this aphid does not produce honeydew

#### Management

Trees should be inspected for aphids regularly due to their potential to cause severe damage; an appropriate insecticide which does not harm beneficial insects should be applied to reduce the aphid population

### Pecan nut casebearer *Acrobasis nuxvorella*

Damage to pecan nutlets by pecan nut casebearer

Damage to pecan nutlets by pecan nut casebearer

#### Symptoms

Holes in nutlets at base which usually is associated with black frass that protrudes from the hole; frass and damaged nutlets are held together by silken thread; adult insect is a small, light gray moth; larvae are initially white with a brown head and mature to olive or jade green

#### Cause

Insect

#### Comments

Larvae pupate to adult moths within the nut; insect overwinters as larva and may undergo several generations per year with the total number determined by location

#### Management

The primary method of controlling the pecan nut casebearer is through the application of an appropriate insecticide; insect growth regulators are preferable to organophosphates, carbamates or pyrethroids which disrupt populations of beneficial insects; *Bacillus thurengiensis* can also be an effective method of controlling the moth larvae but application must be timed well in order to be effective

### Pecan weevil *Curculio caryae*

#### Symptoms

Adult feeding on nuts prior to nut hardening causes nuts to drop from the tree; adult feeding causes a dark brown stain

where the insect's mouthparts puncture the nut shell; larvae feed inside the nuts and can completely destroy the kernels; there are often little outward symptoms of larval feeding; shucks may remain attached to the nut shell; adult insect is a light brown-gray beetle with long snout; larvae are creamy white grubs with brown heads

#### **Cause**

Insect

#### **Comments**

Trees should be monitored closely for signs of weevil infestation, particularly in dry years or if trees have a history of weevil infestation

#### **Management**

Pecan weevils can be controlled through the use of traps (there are several commercially available traps for pecan weevils) or by wrapping sticky bands around the tree trunk to prevent adult weevils climbing the trees,

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# Pepper, bell

## Description

Bell peppers, *Capsicum annuum* are a cultivar group of annual or perennial plants in the family Solanaceae grown for their edible fruits. Bell pepper plants are short bushes with woody stems that grow brightly colored fruits. The alternating leaves are elliptical, smooth edged, and come to a distinct point. The plant produces white or purple bell-shaped flowers which are 2.5 cm (1 in) in diameter. Red, yellow, purple, or brown fruit are produced each season about 3-6 weeks after flowering. Pepper plants can grow 1 m (3.3 ft) tall and are usually grown as annuals in temperate regions for only one growing season. Bell pepper may be referred to as red pepper, yellow pepper or green pepper and is believed to have originated in Central and South America.

Purple bell pepper

Pepper foliage and fruit

Bell pepper blossom

Bell pepper ripening from green to red

Bell pepper plant

Green bell peppers

## Uses

Bell peppers can be eaten fresh as a salad vegetable, or cooked in a variety of dishes.

## Propagation

**Basic requirements** Bell peppers are warm-season crops and grow best at temperatures between 18 and 30°C (65–86°F). They can be grown in many soil types although sandy soils warm faster in Spring and are good for early planting. The soil should have a pH between 6 and 7. Peppers will not tolerate water saturated soil and should be planted in a well draining soil or raised bed. Peppers should be planted in an area that receives full sun for most of the day.

**Sowing seeds** In most cases, pepper seeds should be started indoors 8–10 weeks before the last Spring frost. Pepper should only be direct seeded in areas with a long, warm growing season, otherwise seeds should be sown indoors in flats or cell trays using a sterile seedling mix. Plant seeds to a depth of 1.3 cm (1/2 in) and water lightly. Seeds should not be allowed to dry out as there will be a negative impact on germination rates. Trays should be positioned in a warm, bright, South facing window or under fluorescent lighting. The optimum soil temperature for germination is 21–29°C (70–85°F). A heat mat can be used to warm the flats if required. Seedlings will emerge within 8–25 days and after the seedlings have developed two sets of true leaves they can be moved to a larger (3-4 in) pot. Seedlings should be provided with ample light and adequate fertilizer. **Transplanting** Peppers are usually transplanted 2–3 weeks after the last frost when the soil temperature has reached a minimum of 15.5°C (60°F). Covering soil with dark plastic or mulch a week prior to planting outdoors can help bring the soil temperature up more quickly in colder regions, allowing earlier planting. Beginning approximately 7–10 days before transplanting, plants should be set outside to harden off (see <https://www.plantvillage.com/posts/264>). The hardening off process is very important as peppers are very susceptible to transplant shock. The planting site should be prepared by incorporating plenty of organic matter to encourage vegetative growth. When transplanting seedlings, allow 30–45 cm (12–18 in) between plants and 60–76 cm (24–30 in) between rows. Side dress plants with a nitrogen fertilizer at planting. Drip or soaker irrigation is preferred to overhead irrigation and plants should be watered evenly to keep them moist. Mulching around the plants can also help to conserve soil moisture. **General care and maintenance** Peppers will benefit from applications of fertilizer to keep them supplied with essential nutrients. A timed release fertilizer can be applied at bloom or the plants can be fed with a liquid fertilizer at planting and every two weeks thereafter. In addition, pepper plants can produce a heavy load of fruit and it can be helpful to provide the plants with some support using stakes or cages to prevent branches from breaking under the weight. Use a soft material to tie plants to stakes or cages.

Pepper plant in tomato cage

Pepper plants in cages in raised bed

Pepper seedlings potted into larger pots

Pepper seedlings in cell trays

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## Common Pests and Diseases

# Diseases

## Category : Fungal

### **Anthracnose** *Colletotrichum* spp.

*Anthracnose lesions on pepper fruit - note concentric patterning*

*Large anthracnose lesion on pepper fruit*

*Anthracnose lesion on pepper fruit*

*Anthracnose lesions on pepper fruit*

#### **Symptoms**

Circular lesions on fruit which contain tan to orange to black concentric rings in the center; lesions usually reach 3 cm (1.2 in) in diameter but may enlarge to cover most of the fruit surface; lesions may also occur on leaves and stems and appear as irregularly shaped gray spots with dark margins

#### **Cause**

Fungi

#### **Comments**

Anthracnose is found in all major vegetable growing areas worldwide and can cause large losses if left untreated

#### **Management**

Always plant disease-free seeds and transplants; seeds can be freed from infection by treating with hot water at 52°C (125.6°F) for 30 minutes; if disease is known to present, the field should be rotated with non-susceptible crops for a period of 3 years; plowing crop residue deeply into the soil or removing crop debris can help to reduce inoculum in the soil

### **Cercospora leaf spot (Frogeye leaf spot)** *Cercospora capsici*

*Cercospora lesions on pepper leaf*

#### **Symptoms**

Initial symptoms of infection are the formation of small, circular, water-soaked spots on leaves, stems, petioles and/or peduncles; the lesions mature to have white to brown centers surrounded by a brown to red or purple border; as the lesions expand, they may develop a water-soaked outer edge and dark outer ring which gives the lesions a concentric appearance; mature lesions are brittle and cracked in the center; lesions may be between 0.3 and 1.3 cm (0.1"0.5 in) in diameter;

#### **Cause**

Fungus

#### **Comments**

Cercospora leaf spot is mainly a disease of tropical and subtropical countries and occurs mainly in Africa, South America, Asia and the West Indies. In the U.S. it is found mainly in the southeastern states

#### **Management**

Cercospora infections are usually minor in pepper and require no treatment; crop debris should be removed and destroyed after harvest or buried in the soil; application of an appropriate fungicide can help to reduce damage if applied early on in the infection; practicing crop rotation reduces the incidence of the disease

### **Damping-off** *Pythium* spp.

*Rhizoctonia solani*

*Damping-off of pepper seedling*

*Damping-off of pepper seedling*

*Shriveled stem of infected pepper plant*

### Symptoms

Seeds did not germinate; seedlings collapsing and dying; dark stems which are shriveled near the soil line; water-soaked lesions on the stem; water-soaked discolored roots

### Cause

Fungi

### Comments

Disease can be spread in infected soil and irrigation water; disease emergence favored by overcrowded plants and excessive nitrogen fertilization

### Management

Avoid planting in poorly draining, cool, wet soil; planting in raised beds will help with soil drainage; plant high quality seed that germinates quickly; treat seeds with fungicide prior to planting to eliminate fungal pathogens

## **Fusarium wilt** *Fusarium oxysporum* most likely

### Symptoms

Yellowing of foliage and wilting upper leaves; wilting spread to all parts of plant; leaves remain attached to plant and are dark green in color; red-brown discoloration of vascular tissue; plant death

### Cause

Fungus

### Comments

Disease emergence favors high soil moisture content

### Management

Plant pepper in well draining soils and avoid waterlogging

## **Gray leaf spot** *Stemphylium* spp.

### Symptoms

Initial symptoms of disease appear as small, red-brown spots on leaves measuring 1–2 mm in diameter; as disease progresses, lesions expand and turn lighter in the center; lesions expand to 3–5 mm in diameter and mature lesions have white or gray centers and red-brown margins; high numbers of lesions may form on leaves causing them to turn yellow and drop from the plant

### Cause

Fungi

### Comments

Disease has worldwide distribution but is most common in peppers grown in the cool-season in tropical and subtropical climates; pathogen also attacks tomatoes

### Management

As pepper nursery beds seem to be more susceptible to gray leaf spot infection, control relies on good management of the beds; beds should be well ventilated and all crop debris should be promptly removed; beds should not be planted next to pepper or tomato fields; if disease is present and spreading then application of appropriate fumigant fungicides should be effective at eradicating the pathogen; lesions on plants in an established field usually do not warrant treatment

## **Powdery mildew** *Leveillula taurica*

*Powdery mildew symptoms on pepper leaf*

*Pepper leaf infected with powdery mildew*

*Pepper leaf infected with powdery mildew*

### Symptoms

Patches of white, powdery fungal growth on the underside of the leaves; yellow to brown discoloration of the upper leaf; edges of leaves may curl upwards exposing the underside of the leaf; leaves may begin dropping from plant

### Cause

Fungus

### Comments

Disease can occur in both humid and dry conditions; disease spreads most rapidly in humid conditions; disease commonly affects older leaves

### Management

Apply appropriate fungicide if disease is severe

## **Southern blight *Sclerotium rolfsii***

*As the disease progresses the plant will continue to wilt and leaves will eventually turn brown. Because the canopy is being destroyed fruit will become more susceptible to sunscald and secondary pathogens.*

*Discolored pepper stem*

*The fungus can often be seen growing as a white mycelial mat growing on the stem and the surrounding soil. The mycelia will develop sclerotia which are light tan to dark brown pathogen survives in the soil or in plant debris, volunteers and weeds.*

*Pepper plant infected with Southern blight*

*Southern blight grows best in warm, humid conditions. The first symptom is the wilting of the the plant to wilt. At the collar region of the stem you will notice a brown blighted section.*

*Stem lesions on pepper caused by Southern blight*

### Symptoms

Sudden wilting of leaves; yellowing foliage; browning stem above and below soil; browning branches; stem may be covered with fan-like mycelial mat

### Cause

Fungus

### Comments

Fungus can survive in soil for long periods; disease emergence favored by high temperatures, high humidity and acidic soil; disease found mainly in tropical and subtropical regions, including the southern United States

### Management

Remove infected plants; avoid overcrowding plants to promote air circulation; rotate crops with less susceptible plants; plow crop debris deep into soil; provide a barrier to infection by wrapping lower stems of plant with aluminum foil covering below ground portion of stem and 2-3 in above soil line

## **Verticillium wilt *Verticillium* spp.**

### Symptoms

Initial symptoms of the disease include plants becoming stunted and lower leaves turning yellow; as the infection progresses, more leaves turn yellow and begin dropping from the plant; plants wilt during the day and recover at night; wilting becomes permanent and plant death ensues.

### Cause

Fungi

## **Comments**

Disease is present in pepper grown in Europe, Canada and the U.S.; the severity of the disease when it emerges is dependent on many factors, including the strain of the pathogen, host susceptibility, soil type and prevailing climatic conditions

## **Management**

There are currently no effective control strategies for *Verticillium* wilt once it is present in the field; cultural control practices should be employed to lessen the chances of the disease emerging in the first place; management strategies include rotating the crop every 3–4 years away from pepper; soil fumigation and/or solarization can reduce the level of inoculant in the soil

## **Category : Bacterial**

### **Bacterial canker *Clavibacter michiganensis***

#### **Symptoms**

Small, raised, white lesions on leaves that grow larger, turn brown and necrotic and may have a yellow halo; raised white lesions on fruit which coalesce to form larger spots, often with white halo

#### **Cause**

Bacterium

#### **Comments**

Symptoms can be mistaken for bacterial spot; disease emergence favors high temperatures and high humidity; disease can be spread between peppers and tomatoes

#### **Management**

Use only certified seed and disease free transplants; treat seeds with hot water prior to planting to kill bacteria; sanitize all equipment regularly; rotate crops with non-solanaceous plants

### **Bacterial spot *Xanthomonas campestris***

*Xanthomonas euvesicatoria*

*Xanthomonas perforans* = [*Xanthomonas axonopodis* (syn. *campestris*) pv. *vesicatoria*]

*Xanthomonas vesicatoria*

*Xanthomonas gardneri*

A shot hole appearance on a leaf infected with bacterial spot.

Symptoms of bacterial spot on pepper foliage

Symptoms of bacterial spot on pepper leaf

Symptoms of bacterial spot on pepper fruit

#### **Symptoms**

Water-soaked lesions that dry out and turn brown forming on the underside of the leaves; raised brown cankers on stems; cracked brown lesions on fruit.

#### **Cause**

Bacterium

#### **Comments**

Disease emergence favored by warm, wet conditions; the pathogen can enter a field on seed and transplants and can be spread within a field by wind-driven rain, clipping plants and aerosols.

## **Management**

Use disease free planting material; remove and destroy all crop debris after harvest, or plow material deeply under soil.

## **Bacterial wilt *Ralstonia solanacearum***

*Bacterial ooze from infected pepper stem*

*Pepper plant killed by bacterial wilt*

*Bacterial wilt symptoms in pepper field*

### **Symptoms**

Upper leaves of plant wilt on hot days and recover in the evening and early morning; affected leaves remain green and attached to the plant; if conditions are favorable to the development of the disease then the entire plant may wilt; vascular tissue in lower stems is often discolored brown; severe infection may result in bacteria oozing from the stems; symptoms are often found associated with low lying areas of fields where water collects

### **Cause**

Bacteria

### **Comments**

Most major losses in pepper crop are incurred in tropical and subtropical growing regions; disease also affects tomato, potato, tobacco and eggplant crops; bacteria enter the plants through tiny wounds in roots

## **Management**

Bacterial wilt is very difficult to control once it is established in a field; cultural control methods include planting disease-free seedlings and ensuring irrigation water is free of the pathogen; plants should not be irrigated excessively to prevent build-up of water which favors the development of the disease; pepper should be rotated with non-susceptible crops to prevent the build up of the pathogen in the soil

## **Category : Other**

### **Blossom-end rot n/a**

*Anything that reduces the plants ability to uptake calcium can lead to the development of this disorder, with one of the main reasons being the availability of water. Symptoms begin as a small, water soaked light brown spot at the blossom end of the fruit.*

*As the fruit grows the spot will also enlarge and may eventually cover up to half of the fruit. Fungi and bacteria may attack the damaged tissue causing tissue discoloration.*

*Blossom-end rot on pepper fruit*

*Blossom-end rot on pepper fruit*

### **Symptoms**

Small water-soaked area on end of fruit where the blossom was occurring or on the side of unripe fruit; lesion enlarges and turns sunken, tan brown and leathery in appearance

### **Cause**

Low calcium concentration in fruit

### **Comments**

Physiological disorder; low calcium may result from competition from other ions in soil e.g. potassium; can also be caused by drought stress; fluctuations in soil moisture or application of excessive amounts of nitrogen fertilizer which promotes rapid vegetative growth

## **Management**

Maintain soil pH at 6.5; lime soil to increase the concentration of calcium in soil and decrease competition with other ions; use mulch to reduce drought stress; avoid ammonium fertilizers as they may increase competition with calcium by increasing ammonium ions in soil, use nitrate instead; avoid over fertilizing

## **Magnesium deficiency**

### **Symptoms**

Symptoms of magnesium deficiency appear on older leaves first; initial symptoms are interveinal chlorosis of the leaves and, occasionally, a purple tinge to the leaves; as the deficiency becomes more severe, leaves may appear white with green veins; severe deficiencies may lead to reduced fruit yield

### **Cause**

Nutritional disorder

### **Comments**

Magnesium deficiency is rare in field grown peppers but can arise in sandy soils when heavy rain causes leaching

### **Management**

Magnesium deficiency can be prevented by applying dolomite lime to the soil, if an increase in soil pH is required, or through applications of a fertilizer containing magnesium

## **Nitrogen deficiency**

### **Symptoms**

Plants exhibit reduced growth and leaves are smaller than normal; leaves exhibit a general yellowing; fruit are reduced in size and pale in color; older leaves of the plant show symptoms first and the yellowing progresses to younger leaves

### **Cause**

Nutritional disorder

### **Comments**

Nitrogen deficiency usually arises in commercial plantations through inadequate fertilizer application; heavy rain can leach nitrogen from sandy soils

### **Management**

If detected early, symptoms of nitrogen deficiency can be treated by applying appropriate amounts of nitrogen fertilizer

## **Category : Viral**

### **Mosaic** Cucumber mosaic virus (CMV)

Potato virus Y (PVY)

*Cucumber mosaic virus symptoms  
on pepper leaf*

*Cucumber mosaic virus symptoms  
on pepper foliage*

### **Symptoms**

Alternating light and green areas or mosaic patterns on the leaves; leaves distorted and curled; slow plant growth

### **Cause**

Virus

### **Comments**

Transmitted by aphids; weeds can act as a source of inoculum; insecticides are not effective due to the speed with which aphids can transmit the virus

### **Management**

Remove weeds around crop; use reflective mulches to deter aphids from plants

### **Tomato spotted wilt virus** Tomato spotted wilt virus (TSWV)

Symptoms on fruit are particularly evident as fruit matures. This picture is a stunted bell pepper fruit with severe TSWV infection

Leaves of infected plants may also develop chlorotic or necrotic ring spots

Necrosis of pepper fruit caused by TSWV

In addition to chlorosis leaves may also become twisted and distorted. The severity and appearance of symptoms will vary depending on the cultivar, the age of the plant at the time of infection, environmental conditions and the virus isolate.

TSWV is transmitted by thrips, which can only acquire the virus as larvae and transmits it as an adult. The initial symptom is chlorosis on leaves

Fruit may also be affected, developing chlorotic or necrotic spots, ring spots or mosaics.

Pepper plant infected with TSWV

Characteristic ring spots on pepper fruit

## Symptoms

Symptoms may vary widely depending on variety and environmental conditions; generally leaves become spotted and bronzed in appearance; plant may droop or wilt; fruit develop concentric rings which are light in color and become necrotic

## Cause

Virus

## Comments

Virus can infect a wide range of plants including crops, ornamentals and weeds; once acquired by the thrips vector, the insect is capable of transmitting the virus for the rest of its life

## Management

Management of the disease is aimed at control of the thrips vector (see Thrips)

## Category : Oomycete

### **Phytophthora blight *Phytophthora capsici***

The pathogen can easily spread through rain splash or running water and wind.

Field infestation of Phytophthora blight

Phytophthora blight symptoms on pepper fruit

Symptoms of the disease includes wilting of the plant. However, other diseases can also cause this symptom and the plants needs to be carefully analyzed for confirmation.

Pepper plants infected with Phytophthora blight

A characteristic symptom is the crown rot and black lesion at the crown region which is indicative of the disease. Such symptoms develop especially during high rainfall conditions or in areas with water logging or excessive moisture.

Pepper plant infected with Phytophthora blight

## Symptoms

Black lesions on stems; wilting plant; circular gray-brown lesions on leaves; dark lesions on fruit which may be covered in white sporangia

## Cause

Oomycete

## **Comments**

Disease highly water dependent and spores can be spread by water splash; disease can move root to root to infect a row of plants

## **Management**

Plant disease free transplants; manage water carefully as pathogen depends on water for survival; rotate crops; apply appropriate fungicide

# **Pests**

## **Category : Insects**

### **Aphids *Myzus persicae***

*Aphids (and ladybug larva) on pepper leaf*

#### **Symptoms**

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants

#### **Cause**

Insect

#### **Comments**

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed

## **Management**

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

### **Beet armyworm *Spodoptera exigua***

Young larvae

*Beet armyworm eggs covered in white hairs*

*Beet armyworm larva*

#### **Symptoms**

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside

#### **Cause**

Insect

## **Comments**

Insect can go through 3–5 generations a year

## **Management**

Organic methods of controlling the beet armyworm include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae

## **Colorado potato beetle** *Leptinotarsa decemlineata*

Larva

Adult potato beetle

## **Symptoms**

Feeding damage to foliage; if infestation is severe or if left untreated plants can be completely defoliated; adult insect is a black and yellow striped beetle; larvae are bright red with black heads when they first hatch and change color to pink; larvae have two rows of black spots

## **Cause**

Insect

## **Comments**

Adult beetles emerge in spring; female beetles lay eggs in batches of up to two dozen; eggs are orange-yellow and are laid on undersides of leaves; a female can lay 500 or more eggs over a four to five week period

## **Management**

Control of Colorado potato beetle can be challenging as they have developed high levels of insecticide resistance; in the home garden planting early maturing varieties of potato allows the plants to escape from most damage; adults and larvae should be hand picked from plants and destroyed in soapy water; applications of *Bacillus thuringiensis* can be effective at controlling larvae but should be applied frequently; some insecticides, including spinosad, are still effective against adult beetles

## **Flea beetles** Various

Flea beetles are often metallic in appearance

Flea beetle damage

## **Symptoms**

Small holes or pits in leaves that give the foliage a characteristic “shot hole” appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5–3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny and metallic in appearance

## **Cause**

Insects

## **Comments**

Flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year

## **Management**

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application of diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of

insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied

## **Leafminers** *Lyriomyza* spp.

*Leafminer trails on pepper leaves*

*Leafminer trails on pepper leaves*

### **Symptoms**

Thin, white, winding trails on leaves; heavy mining can result in white blotches on leaves and leaves dropping from the plant prematurely; early infestation can cause fruit yield to be reduced; adult leafminer is a small black and yellow fly which lays its eggs in the leaf; larvae hatch and feed on leaf interior

### **Cause**

Insects

### **Comments**

Mature larvae drop from leaves into soil to pupate; entire lifecycle can take as little as 2 weeks in warm weather; insect may go through 7 to 10 generations per year

### **Management**

Check transplants for signs of leafminer damage prior to planting; remove plants from soil immediately after harvest; only use insecticides when leafminer damage has been identified as unnecessary spraying will also reduce populations of their natural enemies

## **Leafroller (Omnivorous leafroller)** *Platynota stultana*

*Strawberry leaf uncurled to reveal leafroller and silk*

### **Symptoms**

Leaves of plant rolled and tied together with silk webbing; feeding damage to rolled leaves; defoliation of plant; silk webbing may also be present on fruits and fruits may have substantial scarring from feeding damage; larvae wriggle vigorously when disturbed and may drop from plant on a silken thread

### **Cause**

Insect

### **Comments**

Adult insect is a moth which can fly over several miles to find suitable hosts; alfalfa and sugar beet are good hosts

### **Management**

Monitor plants regularly for signs of infestation; remove weeds from plant bases as they can act as hosts for leafrollers; avoid planting pepper in areas where sugarbeet or alfalfa are grown nearby; *Bacillus thuringiensis* or Entrust SC may be applied to control insects on organically grown plants; apply sprays carefully to ensure that treatment reaches inside rolled leaves

## **Pepper weevil** *Anthonomus eugenii*

*Damage inside pepper fruit*

*Pepper weevil larvae inside a young fruit pod*

*Pepper weevil feeding on the bud of a pepper plant*

### **Symptoms**

Feeding damage to foliage, buds and tender young fruit pods; larvae feed within buds and fruit; older fruit misshapen and discolored; buds and fruit may drop from plant; adult weevil is a small black beetle; larvae are small cream-white

grubs with brown heads which can reach 0.6 cm (0.25 in) in length when mature

### Cause

Insect

### Comments

Weevil will go through multiple generations per year; pepper preferred host but weevil will feed on other plants in the nightshade family also

### Management

Remove any nightshade plants growing in close proximity to pepper; immediately remove any dropped fruit from soil surface; if pepper weevil becomes problematic, rotate crop the following year; organically acceptable control methods include sprays of pyrethrins; destroy pepper crop residue immediately after harvest

## Thrips (Western flower thrips, Onion thrips, etc.) *Frankliniella occidentalis*

*Thrips tabaci*

*Western flower thrip adult*

*Thrips infestation in a pepper blossom*

### Symptoms

If population is high leaves and buds may be distorted; leaves appear silvery and are speckled with black feces; insects will feed on and damage flowers; most damage occurs through the transmission of Tomato spotted wilt virus (TSWV); insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color

### Cause

Insect

### Comments

Insect transmits Tomato spotted wilt virus (see disease entry); once acquired, the insect retains the ability to transmit the virus for the remainder of its life

### Management

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic

## Tomato fruit worm (Corn earworm) *Helicoverpa zea*

*Mixture of larvae showing range of colors*

### Symptoms

Larvae burrowing into fruit near stem end and feeding on fruit interior causing decay; fruit turn red prematurely and fall from plant causing reduced yield; young caterpillars are cream-white in color with a black head and black hairs; older larvae may be yellow-green to almost black in color with fine white lines along their body and black spots at the base of hairs; eggs are laid singly on both upper and lower leaf surfaces and are initially creamy white but develop a brown-red ring after 24 hours and darken prior to hatching

### Cause

Insect

### Comments

Adult insect is a pale green to tan, medium sized moth; can be one of the most damaging pests of tomato; insect overwinters as pupae in the soil; the insect is also a damaging pest of corn and is also referred to as the corn earworm

### Management

Early treatment of tomato fruitworms is necessary as once they enter the fruit they are protected from sprays; monitor plants for eggs and young larvae and also natural enemies that could be damaged by chemicals; *Bacillus thuringiensis* or Entrust SC may be applied to control insects on organically grown plants; appropriate chemical treatment may be required for control in commercial plantations

## Category : Mites

### Spider mites (Two spotted spider mite) *Tetranychus urticae*

*Spider mite webs and damage*

*Stippled leaves of pepper plant*

*Spider mite webs and damage*

#### Symptoms

Leaves stippled with yellow; leaves may appear bronzed; webbing covering leaves; mites may be visible as tiny moving dots on the webs or underside of leaves, best viewed using a hand lens; usually not spotted until there are visible symptoms on the plant; leaves turn yellow and may drop from plant

#### Cause

Arachnid

#### Comments

Spider mites thrive in dusty conditions; water-stressed plants are more susceptible to attack

#### Management

In the home garden, spraying plants with a strong jet of water can help reduce buildup of spider mite populations; if mites become problematic apply insecticidal soap to plants; certain chemical insecticides may actually increase mite populations by killing off natural enemies and promoting mite reproduction

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# Pigeon pea

## Description

Pigeonpea, *Cajanus cajan*, is a perennial shrub in the family Fabaceae grown for its edible pods and seeds. Pigeonpea is a highly branched shrub with a woody base, slender stems and trifoliate leaves. The plant leaflets are oblong or elliptical in shape and the leaves are alternate and arranged spirally on the stems. The plant usually produces yellow flowers, but they can be yellow with streaks of purple or red. The flowers are produced on racemes of 5–10 flowers. The seed pods are flat and either straight or sickle shaped and measure 5–9 cm (2–3.5 in) in length. Each pod can contain between 2 and 9 seeds which can be white, cream, brown, yellow, purple or black or mottled with any combination of these colors. Pigeonpea can reach 0.5–4.0 m (1.6–13.1 ft) in height and is usually grown as an annual, harvested after one season. It may also be referred to as red gram or congo pea and originates from India.

Pigeon pea pod

Pigeon pea flower

Pigeon pea pods

Pigeon pea flower

Pigeon pea

Pigeon pea plant

## Uses

Pigeon pea is one of the most important legumes grown in semi-arid tropical regions and young seeds are consumed

fresh as a vegetable or can be allowed to mature before drying and eating as a pulse. The seed pods are also edible and are eaten as a vegetable. The leaves and seed husks of the plant can be used as an animal feed.

## Propagation

**Basic requirements** Pigeon pea grows best in hot humid climates where temperatures are between 18 and 38°C (64.4–100.4°F). The plants will grow in a wide range of soils, from sandy soil to clay and also in soils with low fertility. Pigeon pea will grow optimally in a well drained soil with a pH between 5.0 and 7.0. Once established, pigeon pea is relatively tolerant to drought conditions and can survive for long periods with little irrigation. **Propagation** Pigeon pea is propagated directly from seed which should be sown in a prepared seed bed. Seeds should be planted to a depth of 2.5–10 cm (1–4 in) leaving 30–50 cm (12–20) between plants and 150 cm (60 in) between rows. Higher seeding rates should be used if the plant is being grown for use as a green manure. Pigeon pea is commonly intercropped with millets, cotton, sorghum or groundnut. **General care and maintenance** All weeds should be eliminated from the seed bed to prevent competition with the initially slow growing seedlings. Generally, pigeon pea does not require irrigation or fertilization. An application of phosphate at a rate of 20–100 kg per hectare is recommended and irrigation may be necessary if the plants are intensively grown. **Harvesting** Pigeon pea is commonly harvested by hand. Machine harvesting by combine is possible if a variety is grown where pods ripen uniformly. The plant is cut at the ground when the majority of pods have reached maturity. The plants are air dried and then threshed to remove the seeds.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Alternaria blight** *Alternaria alternata*

###### **Symptoms**

Small irregular brown lesions on leaves which expand and turn gray-brown or dark brown with concentric zones; older areas of lesions may dry out and drop from leaves causing shot hole; lesions coalesce to form large necrotic patches

###### **Cause**

Fungus

###### **Comments**

Disease emergence favored by high humidity and warm temperatures; plants grown in nitrogen and potassium deficient soils are more susceptible

###### **Management**

Plant beans in fertile soil; foliar fungicide application may be required in order to control the disease

### **Anthracnose** *Colletotrichum* spp.

#### **Symptoms**

Small, dark brown to black lesions on cotyledons; oval or eye-shaped lesions on stems which turn sunken and brown with purple to red margins; stems may break if cankers weaken stem; pods drying and shrinking above areas of visible symptoms; reddish brown spots on pods which become circular and sunken with rust colored margin

#### **Cause**

Fungus

#### **Comments**

Disease transmitted through infected seed; fungus can survive in crop debris in soil and reinfect crop the following season

#### **Management**

Plant resistant varieties; use certified disease free seed; avoid sprinkler irrigation, water plants at base; plow bean crop debris into soil

### **Cercospora leaf spot** *Cercospora cajani*

#### **Symptoms**

Small light brown lesions on upper surfaces of leaves; angular brown spots on leaves; leaf death; lesions on stems and petioles

#### **Cause**

Fungus

#### **Comments**

### **White mold (Sclerotinia rot)** *Sclerotinia sclerotiorum*

#### **Symptoms**

Flowers covered in white, cottony fungal growth; small, circular, dark green, water-soaked lesions on pods, leaves and branches which enlarge and become slimy; cottony white growth may be visible on lesions during periods of high humidity; death of branches and/or entire plant

#### **Cause**

Fungus

#### **Comments**

Fungus can survive in soil for in excess of 5 years; disease can be spread by wind, contaminated irrigation water and by infected seeds

#### **Management**

Rotate crops with non-hosts like cereals and corn; plant rows parallel to direction of prevailing winds to prevent spread of disease from secondary hosts nearby; avoid excessive nitrogen fertilizer; use a wide row spacing

### **Category : Bacterial, Fungal**

### **Wilt** *Fusarium udum*

#### **Symptoms**

Sudden yellowing of leaves; death of leaves; plant death; blackened tissue at base of stem; symptoms may be present on only one side of plant

#### **Cause**

Fungus

#### **Comments**

Fungus can survive in soil for several years

#### **Management**

Practice long term crop rotation; avoid over or under watering plants

## Pests

### Category : Insects

#### Aphids (Cowpea aphid, Pea aphid, etc.) *Aphis craccivora*

*Acyrthosiphon pisum*

##### Symptoms

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants

##### Cause

Insect

##### Comments

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed

##### Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

#### Armyworms (Beet armyworm, Western striped armyworm) *Spodoptera exigua*

*Spodoptera praefica*

##### Symptoms

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside

##### Cause

Insect

##### Comments

Insect can go through 3–5 generations a year

##### Management

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae

#### Corn earworm *Helicoverpa zea*

##### Symptoms

Larvae damage leaves, buds, flowers, pods and beans; young caterpillars are cream-white in color with a black head and black hairs; older larvae may be yellow-green to almost black in color with fine white lines along their body and black spots at the base of hairs; eggs are laid singly on both upper and lower leaf surfaces and are initially creamy white but develop a brown-red ring after 24 hours and darken prior to hatching

**Cause**

Insect

**Comments**

Adult insect is a pale green to tan, medium sized moth; insect is also very damaging pests of corn; insect overwinters as pupae in the soil

**Management**

Monitor plants for eggs and young larvae and also natural enemies that could be damaged by chemicals; *Bacillus thuringiensis* or Entrust SC may be applied to control insects on organically grown plants; appropriate chemical treatment may be required for control in commercial plantations

**Cutworms** *Agrotis* spp.

*Peridroma saucia*

*Nephelodes minians*

and others

**Symptoms**

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5–5.0 cm (1–2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed

**Cause**

Insect

**Comments**

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato

**Management**

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically

**Leafminers** *Lyriomyza* spp**Symptoms**

Thin, white, winding trails on leaves; heavy mining can result in white blotches on leaves and leaves dropping from the plant prematurely; early infestation can cause fruit yield to be reduced; adult leafminer is a small black and yellow fly which lays its eggs in the leaf; larvae hatch and feed on leaf interior

**Cause**

Insects

**Comments**

Mature larvae drop from leaves into soil to pupate; entire lifecycle can take as little as 2 weeks in warm weather; insect may go through 7 to 10 generations per year

**Management**

Check transplants for signs of leafminer damage prior to planting; remove plants from soil immediately after harvest; only use insecticides when leafminer damage has been identified as unnecessary spraying will also reduce populations of their natural enemies

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# Pineapple

## Description

Pineapple, *Ananas comosus*, is an herbaceous biennial or perennial plant in the family Bromeliaceae grown for its edible fruit. The pineapple plant has a short stout stem and a rosette of sword-shaped leaves with needle-like tips. The leaves are waxy, have upturned spines on the margins and may be solid green or striped with red, white or cream. When the plant flowers, the stem begins to elongate and produces a flower head of small purple or red flowers, each with a pointed bract. The stem continues to elongate and sets down a tuft of short leaves called a 'crown'. Individual fruits develop from the flowers and fuse to form one large cylindrical fruit topped by the crown. This fruit, known as a pineapple, has a tough rind made up of hexagonal units and a fibrous, juicy flesh which may be yellow to white in color. Pineapple may reach 1.5–1.8 m (5–6 ft) in height and some varieties can grow for in excess of 20 years. Pineapple originates from the tropical regions of the Americas.

*Pineapple fruit*

*Pineapple rind*

*Pineapple flowering*

*Pineapple flowering*

*Pineapple foliage*

*Pineapple fruit ripening*

## Uses

Pineapple fruit is commonly eaten fresh or it may be cooked in a variety of dishes. Pineapple may also be canned or used to produce juice.

## Propagation

**Basic requirements** Pineapple is a tropical plant and grows best in temperatures between 23â€“32Â°C (73.4â€“89.6Â°F). The plant can tolerate colder temperatures for short periods but will be killed by frosts. Pineapple will grow optimally in well-draining sandy loam which is rich in organic matter. The optimum pH for pineapple growth is between 4.5â€“6.5. Established pineapple plants are tolerant of drought but will not tolerate waterlogged soil which quickly leads to root rot. **Propagation** Pineapple is propagated from crowns, slips or suckers, with slips or suckers being the preferred method for commercial growers. Pineapple suckers arise from leaf axils, while slips grow from the stalk below the fruit. These are cut from the parent plant and used to produce new plantings. The cuttings are usually cured for a day or two prior to planting by sitting them in the shade. Pineapple plantings are normally set out in double rows with the material staggered 25â€“30 cm (10â€“12 in) apart within the double row and allowing a further 60 cm (2 ft) between double rows. **General care and maintenance** Pineapples require supplemental irrigation during dry spells for optimum production. Mulching around the plants will help to conserve soil moisture. Ratooning may also be utilized as a means of encouraging growth. After the first crop of fruit, ratooning the plants will result in new fruit within 18 months. This process may be repeated a second or third time but then the crop will be rotated to prevent build up of disease. Removing suckers and slips from developing plants helps the plant to focus energy on growing the fruit and leads to larger fruit that develops quicker. Pineapples benefit from the application of additional nitrogen and potassium. Application rates depend largely on the type of soil the plants are growing in. Generally, little fertilizer is required during the first few months following planting but requirements increase rapidly in the period leading up to flower development. Fertilizers are usually applied as foliar sprays. **Harvesting** Pineapples are ready to harvest when at least one third of the fruit rind has turned from green to yellow. Fruits are harvested by hand by cutting the crown and peduncle from the plant. The fruit will continue to ripen off of the plant.

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## Common Pests and Diseases

### Diseases

#### Category : Bacterial

##### Bacterial heart rot and fruit collapse *Erwinia chrysanthemi*

###### Symptoms

Water-soaked lesions on the white basal sections of leaves in the central whorl which may spread to all leaves in the

central whorl; midportions of leaves become olive green in color with a bloated appearance; infected fruits exude juices and the shell becomes olive green; cavities form within the fruit

#### **Cause**

Bacterium

#### **Comments**

Disease is thought to be spread from the juices of infected fruits; bacteria in the juice can enter leaves through wounds; ants acts as vectors for the bacteria

#### **Management**

Remove and destroy infected fruits; avoid the use of infected crowns for seed material to prevent spread of the disease; planting to avoid flowering when adjacent field is fruiting can reduce disease development; use of miticides and control of ants can significantly reduce disease incidence

### **Category : Fungal**

#### **Butt rot, Black rot & White leaf spot *Chalara paradoxa***

#### **Symptoms**

Soft black rot which begins at the area where the seed piece detaches from the mother plant; entire seed piece may be rotted; black rot of fruit causes a soft, watery rot which darkens with time; small brown, wet spots develop on leaves; leaf spots enlarge and turn gray-brown with light brown margins

#### **Cause**

Fungus

#### **Comments**

Fungus survives in soil and pineapple residue; infects plants through fresh wounds

#### **Management**

Seed material should be stored on mother plants during dry weather and with good air circulation; freshly removed seed material should be dipped in an appropriate fungicide within 12 hours of removal from the mother plant; avoiding bruising and wounding of fruit during harvest helps to reduce black rot; harvested fruit should be dipped in an appropriate fungicide within 6-12 hours of harvest to prevent disease development during shipping

### **Category : Other**

#### **Marbling *Acetobacter* spp.**

*Erwinia herbicola*

#### **Symptoms**

Yellow to red or very dark brown discoloration of fruit flesh; infected tissues develop a granular texture with woody consistency and speckled color; single or multiple fruitlets may be affected; vascular system may appear speckled right down to core of fruit; symptoms develop during the last month of fruit maturation

#### **Cause**

Bacteria

#### **Comments**

Emergence of the disease is favored by warm, wet weather

#### **Management**

There are currently no methods of controlling the disease; the pineapple variety Smooth Cayenne appears to be moderately resistant to the disease

### **Category : Viral**

#### **Mealybug wilt Pineapple wilt virus (PWV)**

Pineapple plants infected with mealybug wilt

### Symptoms

Leaves turning red; tips of leaves become withered and turn brown; plants can be easily removed from the soil

### Cause

Virus

### Comments

Virus is transmitted by mealybugs; ants protect mealybug populations from predators and parasites and can allow mealybugs populations to reach very damaging levels if left uncontrolled

### Management

Ants should be controlled with an appropriate insecticide

## Category : Oomycete

### Phytophthora heart and root rot *Phytophthora* spp.

*Phytophthora* symptoms on pineapple

*Phytophthora* symptoms on pineapple fruit

Symptoms of *Phytophthora* root rot in pineapple field

Pineapple heart rot

Symptoms of *Phytophthora* root rot in pineapple field

### Symptoms

Young leaves failing to elongate and turning chlorotic; heart leaves wilting and turning brown; terminal whorl can be easily pulled from mother plant; water-soaked tissue at base of leaves; foul smell; leaves may be turning red and yellow with necrotic leaf margins and leaf tips; plants can easily be pulled out of the ground; fruits color prematurely

### Cause

Oomycete

### Comments

Fungi can survive in soil and plant debris for many years

### Management

Planting in raised beds helps to drain the soil and reduces incidence of the disease; mulch from pineapple debris should be avoided; pre-planting dips and foliar applications of Fosetyl Al are very effective at controlling the disease

## Pests

## Category : Insects

### Mealybugs (Pineapple mealybug) *Dysmicoccus brevipes*

#### Symptoms

Flattened oval to round disc-like insect covered in waxy substance on tree branches; insects attract ants which may also be present; insect colony may also be associated with growth of sooty mold due to fungal colonization of sugary honeydew excreted by the insect; plants may show symptoms of mealybug wilt (see entry)

#### Cause

Insect

### Comments

Insects have a wide host range; often tended by ants which farm them for their sugary honeydew secretions; transmit mealybug wilt in pineapple

### Management

Mealybugs can potentially be controlled by natural enemies such as lady beetles; ant populations which tend the mealybugs should be treated with an appropriate insecticide

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# Pistachio

## Description

Pistachio, *Pistacia vera*, is a deciduous tree in the family Anacardiaceae grown for its edible seeds (nuts). Pistachio is a small to medium sized tree with a branching main stem (trunk) and a spreading growth habit. The leaves of the pistachio are pinnate and composed of five individual oval leaflets. Male and female inflorescences are produced on different trees (dioecious). The flowers are small, brownish-green in color and lack petals. They are produced on panicles, each possessing several hundred flowers. The fruit of the tree is a drupe with an oblong kernel covered with a thin, bony shell. The shell splits along its long axes when mature. Pistachio trees can reach up to 20 ft (65.6 ft) in the wild but are generally smaller under cultivation. They reach maximum productivity in terms of fruit production after approximately 20 years and can live for several hundred years. Pistachio may also be referred to as green almond and originated from western Asia.

*Pistachio trees*

*Pistachio tree*

*Pistachio fruit*

*Pistachio buds*

*Pistachio buds*

*Pistachio tree*

## Uses

Pistachio nuts are eaten as a snack food, usually after salting and roasting.

## Propagation

**Basic requirements** Pistachio trees grow best in areas with a long hot summer and cold winter as the tree has a chilling requirement. The tree is tolerant of frost and can withstand winter temperatures as low as -20°C (-4°F). Trees are also drought resistant and can be grown on a wide range of soils, including rocky or stony soils, without irrigation but trees will grow optimally in well draining, deep sandy loams. Pistachio trees are wind pollinated and require the planting of both male and female trees for successful pollination and fruit set. **Propagation** Pistachio is usually propagated by budding on to a suitable pistachio rootstock. Rootstock varieties vary widely between growing areas. Budding is usually carried out in the Fall with the budded tree being planted the same year or the following year depending on the size of the seedling. Young trees are planted by digging a hole large enough to accommodate the root ball. The tree should be planted about an inch lower than it was grown in the container. Tree spacing varies depending on whether irrigation is used. In irrigated orchard, trees can be spaced in a 6–6 m (19.7–19.7 ft) grid pattern. In arid regions where supplemental irrigation is not used, trees may be spaced 8–10 m (26.2–32.8 ft) apart. Both male and female trees must be planted in order for the trees to bear fruit. Ratios of males to females vary from 1:8 to 1:11 males to females.

**General care and maintenance** Pistachios have a similar nitrogen requirement to other nut trees. Fertilizer should not be applied in the first year following planting but in the subsequent year, each tree should be supplied with 1 lb of ammonium sulfate split between two applications over the course of the growing season. In the years following, trees should be fertilized with actual nitrogen with application rates varying from 100 to 150 lb per acre. The nitrogen should be split evenly into two applications over the growing season. no nitrogen should be applied after June to prevent vigorous growth that may delay the tree entering dormancy, potentially leading to damage from early frosts.

**Harvesting** Newly budded pistachio trees will not begin to produce fruit for five years and will not reach maximum production until the twelfth year. Nuts are ready to harvest when the hull separates easily from the shell. This period extends for 7 to 10 days. If nuts are harvested before or after this critical period kernels may be underdeveloped and shells may become stained.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Alternaria late blight (Alternaria leaf spot)**

###### **Symptoms**

Black angular to circular lesions of leaves which enlarge and coalesce, forming tan patches; small black lesions on

immature nuts; lesions enlarge and coalesce; staining on hull; moldy kernels; severe infestation on leaves can cause premature defoliation

**Cause**

Fungus

**Comments**

Disease emergence favors high temperature and high humidity; fungus survives on plant debris

**Management**

The disease is difficult to control and all pistachio cultivars used commercially are susceptible; applications of appropriate fungicides may help to reduce the incidence of the disease; good irrigation practices should be followed; practices that reduce the wetness of the ground around plants is recommended

**Armillaria root rot (Oak root fungus) *Armillaria mellea***

**Symptoms**

Small, discolored leaves which drop early; death of branches; death of plant; clusters of honey-colored mushrooms may sprout at base of plant

**Cause**

Fungus

**Comments**

Fungus can survive on dead roots

**Management**

Armillaria root rot cannot be effectively controlled once it has become established in an orchard; diseased or dead plants should be uprooted and removed; planting resistant rootstocks is the most effective method of preventing the disease

**Panicle and shoot blight *Botryosphaeria dothidea***

**Symptoms**

Black circular spots on leaves, shoots and rachis; black lesions may be present at the base of shoots if bud has been infected; leaves on infected shoots begin to wither and results in blighted shoots which are visually distinct from surrounding green leaves; if lesions occur on petioles the leaflet will die; infection of rachis which move into shoots can result in sunken cankers on the trunk; cankers may exude a dark substance

**Cause**

Fungus

**Comments**

Fungus survives in dead infected material that remains on trees

**Management**

The disease is very difficult to control and treatment relies on a combination of pruning, fungicide application and good irrigation practices; multiple applications of an appropriate fungicide are required over the summer months; infected areas should be pruned by cutting 5 cm below symptomatic areas to reduce inoculum the following year; if sprinkler irrigation is used then water should be directed away from the tree canopy

**Powdery mildew *Phyllactinia guttata***

**Symptoms**

Small powdery white patches on leaves and fruit which can expand to cover the entire leaf or fruit surface; small black fungal fruiting bodies are often visible in the white patches

**Cause**

Fungus

**Comments**

Disease emergence favored by moderate temperature, poor air circulation around plant and shady conditions

**Management**

Disease does not cause severe damage to pistachio and control is not warranted

## **Rust** *Uromyces terebinthi*

### **Symptoms**

Round or irregularly shaped red-brown pustules on leaves, flowers, pedicels and/or fruit; leaves drop from tree prematurely and fruit become misshapen; leaves redden in late summer

### **Cause**

Fungus

### **Comments**

Disease occurs on pistachio trees in the Mediterranean, India and the Middle East; there have been several severe outbreaks of the disease in the Mediterranean

### **Management**

Disease is controlled by the application of appropriate fungicides

## **Septoria leaf spot** *Septoria* spp.

### **Symptoms**

Symptoms vary depending on the species of the fungus; clusters of small dark spots on leaves around secondary leaf veins; clusters enlarge and may cover large areas of the leaves; spots often coalesce to form large dark patches; later, patches turn chlorotic and then necrotic; disease may also present as angular brown spots on leaves which enlarge and coalesce to form large necrotic patches, or as numerous brown spots on both upper and lower leaf surfaces which possess black dots in the center

### **Cause**

Fungus

### **Comments**

Fungi overwinter in fallen leaves from previous season; disease is common in Mediterranean growing regions and in the Middle East

### **Management**

Control of the disease relies on preventative applications of appropriate fungicides which should be started when the first leaves expand and be repeated monthly thereafter

## **Category : Bacterial**

## **Crown gall** *Agrobacterium tumefaciens*

### **Symptoms**

Galls of various sizes on roots and root crown below the soil line; galls may occasionally grow on the trunk; galls are initially light colored bulges which grow larger and darken; galls may be soft and spongy or hard; if galling is severe and girdles the trunk then young trees are weakened due to constricted vascular tissue; trees may be stunted and rarely die

### **Cause**

Bacterium

### **Comments**

The bacterium enters host plants through wounds and causes plant cells to proliferate and cells to be undifferentiated, leading to the formation of a gall

### **Management**

Only plant disease-free nursery stock; plant trees in well-draining soils; avoid wounding the plants as much as possible; fresh wounds can be treated with a biocontrol agent (*Agrobacterium radiobacter* strain K84) which can reduce damage by the *Agrobacterium tumefaciens*)

## **Pistachio dieback** *Xanthomonas translucens*

### **Symptoms**

Dieback of twigs and branches; tree producing an excessive amount of resin; black, sooty lesions present on trunk and branches; dark staining of vascular tissues; the disease does not cause any lesions on leaves or fruit

**Cause**

Bacterium

**Comments**

Serious disease of pistachio in Australia; pathogen enters plant through wounds; can be spread by contaminated pruning shears

**Management**

Disinfect tools and equipment thoroughly between use

## Pests

### Category : Insects

#### **Pistachio psyllid** *Agonoscena targionii*

**Symptoms**

Leaves turning yellow and necrotic; curling leaves; leaves drying out; leaves dropping from plant prematurely; leaves may be covered with sticky honeydew and/or sooty mold; adult insect is generally yellow in color with brown spots or rings on the abdomen; adult insect is winged whereas nymphs lack wings

**Cause**

Insect

**Comments**

Insect excretes sticky honeydew which encourages growth of sooty mold

**Management**

Control typically relies on the application of appropriate insecticide but the insect has developed resistance to organophosphates in certain countries such as Syria

#### **Pistachio twig borer** *Kermania pistaciella*

**Symptoms**

Young flower clusters turning black and falling from trees; fruit dropping from tree; poor growth of twigs; adult insect is a small, dark colored moth which lays its eggs on flower clusters; larvae bore into the cluster and tunnel towards twigs excreting a dark colored frass (excrement)

**Cause**

Insect

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# Plantain

## Description

Plantain, *Musa paradisiaca* (syn. *Musa sapientum*) is an herbaceous perennial belonging to the family Musaceae. Plantains are distinguished from bananas by their fruit which, although morphologically very similar to bananas, are actually longer, firmer and possess a higher starch content and thicker skin than their sweeter relative. Like banana, the plant is tall and tree-like with a sturdy pseudostem and large broad leaves arranged spirally at the top. The leaves are large blades with a pronounced central midrib and obvious veins. They can reach up to 2.7 m (8.9 ft) in length and up to 0.6 m (2.0 ft) in width. Each pseudostem produces a group of flowers from which the fruits develop in an hanging cluster. In commercial plantations, the parent plant dies after harvest and is replaced with a daughter plant. However, a plantation can grow for 25 years or more if managed properly. The trees can reach heights between 2 and 9 m (6.6â€“29.5 ft). Plantains and the cultivated varieties are derived from ancestors which originated from the Malaysian peninsula, New Guinea and South-East Asia.

*Plantain tree*

## Uses

Plantains are eaten as a vegetable and are cooked prior to consumption. They are an important component of many dishes in Western Africa and Caribbean countries. In addition, the leaves of *Musa* species can be used as a source of fibre

for thread, cloth string, thread or can be used as thatch and roofing. The plants are also grown as an effective source of shade for other crops.

## Propagation

**Requirements** Plantains grow best in hot and humid climates, require a rainfall of at least 1000 mm (39.4 in) per year to survive and have a high light requirement. Plantains will grow optimally at 27°C (98.6°F) and require a deep soil, rich in organic matter which is well draining and well aerated. The plants will grow optimally in soil with a pH between 5.5 and 7.0. Young plantains are very susceptible to wind damage and it is recommended that they are planted in sufficient shelter or in a block so that the plants will protect one another. **Suckers** Plantains are vegetatively propagated, most often from suckers (shoots that grow from a bud at the base of the plant) or from corms (underground bulbs known as rhizomes). The use of whole corms is very laborious so it is more common to grow from small pieces of corm. There are three different types of banana suckers which are produced by the mother plant; maidenheads, sword suckers and water suckers. Maidenheads have a large pseudostem which does not produce fruit. Sword suckers have a narrow base, short pseudostem and narrow, blade-like leaves. They produce healthy, fruitful pseudostems when they mature. Water suckers have short pseudostems and broad leaves. Water suckers are not strongly attached to the rhizome and generally produce weaker plants and less fruit. Maidenheads and large sword suckers are preferred over water suckers. **Planting** The desired pieces of the plant are usually planted 30–60 cm (11.8–23.6 in) deep in the soil and should generally be planted at the end of the dry season or the beginning of the wet season. Plant spacing is dependent on the cultivar being planted. Frequent weeding is required until plants are tall enough to shade out competing plants and should be started about 6 weeks after planting. Plantains are fast growing and require the frequent addition of nutrients as well as additional irrigation in the dry season. Plantain is often grown alongside other crop plants with similar requirements, indeed, the young banana plants make excellent 'nurses' for other crops such as papaya or cocoa which can be grown very close to the young plantains.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Anthracnose** *Colletotrichum musae*

##### **Symptoms**

Brown spots on fruit peel; large brown to black areas; black lesions on green fruit

**Cause**

Fungus

**Comments**

Wet conditions promote growth and spread of disease; spread by rainfall through plant or banana bunch

**Management**

Commercially produced fruit should be washed and dipped in fungicide prior to shipping; protect fruit from injury; remove flower parts which can harbour fungus

**Black sigatoka** *Mycosphaerella fijiensis*

**Symptoms**

Red/brown flecks or spots on underside or topside of leaves; spots with dark or yellow border and grey centre; death of leaf surface; bunch not developing

**Cause**

Fungus

**Comments**

Currently the most important disease of banana; promoted by high moisture and spores spread by wind

**Management**

Export plantations may require regular fungicide applications; increase plant spacing to improve air circulation and reduce humidity; remove leaves with mature spots

**Panama disease (Fusarium wilt)** *Fusarium oxysporum*

**Symptoms**

Yellowing of older leaves; splitting of leaf sheaths; leaves wilting and buckling; death of entire canopy

**Cause**

Fungus

**Comments**

Lethal disease; spread in soil or running water

**Management**

Use disease free seed pieces; currently no effective treatment once plants are infected

**Rhizome rot** *Erwinia carotovora*

*Erwinia chrysanthemi*

**Symptoms**

Pseudostem breaks from rhizome; rhizome will not germinate; internal tissue yellow/brown and watery

**Cause**

Bacteria

**Comments**

Bacteria live in soil and enter plant through wounds; disease encouraged by wet, humid conditions

**Management**

Select only high quality, disease-free rhizomes for propagation; disinfect all tools used for propagation regularly; allow seed pieces to dry before planting

**Category : Viral**

**Bunchy top** Banana bunchy top virus (BBTV)

**Symptoms**

Dark green streaks in leaves; chlorotic and upturned leaf margins; leaves brittle and erect; plant has a "bunchy top"™; no bunches produced

**Cause**

Virus

**Comments**

Aphid transmitted; when infected symptoms appear after two more leaves are produced

**Management**

Plant less susceptible varieties; destroy infected plants to prevent spread of disease

## Category : Bacterial

### Moko disease *Ralstonia solanacearum*

**Symptoms**

Older leaves chlorotic, wilted and collapsing; spreads to entire canopy; collapse of pseudostem

**Cause**

Bacterium

**Comments**

Can be spread root to root or by insects or human activities such as machete pruning

**Management**

Plantations should be regularly monitored for presence of disease; if Moko is present, male buds should be removed and all tools thoroughly disinfected; infected plants may need to be destroyed along with any neighbouring plants

## Pests

### Category : Insects

#### Banana aphid *Pentalonia nigronervosa*

**Symptoms**

Deformed plants with curled, shriveled leaves; if infestation is severe, galls may form on leaves; colonies of aphids usually present in crown of plant at base of pseudostem or between the outer leaf sheaths; aphid is soft-bodied and red-brown to almost black in color

**Cause**

Insect

**Comments**

Colonies are often tended by ants; populations can build rapidly during warm weather

**Management**

Chemical control does not provide protection against transmission of Banana bunchy top and direct feeding damage is not usually severe enough to warrant spraying; insecticidal soaps can help control aphid populations; plants infected with bunch top should be removed and destroyed to prevent spread

#### Banana weevil *Cosmopolites sordidus*

**Symptoms**

Reduced plant growth; reduced fruit production; tunnels may be visible in corm as rounded holes up to 8 mm in diameter; plants wilting and toppling over; destruction of root system; plant death; adult insect is a hard-shelled beetle which is almost black in color; adult is commonly found between leaf sheaths; larvae are creamy-white, legless grubs with a red-brown head

**Cause**

Insect

**Comments**

Insects are nocturnal, feeding and mating only at night;

### **Management**

Plant only healthy plant material, do not plant if any tunnels are visible; hot water treatment of clean trimmed suckers can be used to kill off many eggs and grubs; applications of neem powder can reduce weevil numbers; appropriate insecticides applied at time of planting can help control weevil numbers

### **Coconut scale *Aspidiotus destructor***

#### **Symptoms**

Small, flat, whitish scales, usually on undersides of leaves but may also attach to petioles, peduncles and fruit; plant tissue discolored and yellowing

#### **Cause**

Insect

#### **Comments**

Coconut scale attacks a large number of hosts including coconut and other palm species, avocado, cassava, papaya, guava and sugar cane; most common in tropical regions

### **Management**

Biological control is the best way to manage scale, with lady beetles providing the most effective protection

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# Plum and prune

## Description

Plum, *Prunus domestica*, is a deciduous tree in the family Rosaceae grown for its edible fruits. The plum tree has an erect growing habit with a spreading canopy. It possesses large, thick, oval-shaped leaves which are darker in color on the upper surface than on the lower and which often have a serrated edge. The tree produces buds on terminal spurs on the branches with each bud generally producing 3–5 flowers. The fruit is a fleshy oval fruit with a single seed contained within a stone. The color of the fruit varies with variety and fruits can be purple, blue, green, red or yellow. Plum trees can attain a height of between 6 and 10 m (20–33 ft) and can live for periods in excess of 50 years if properly maintained. Plum may also be referred to as European plum and originates from Southwest Asia

*Plum tree*

*Plum fruits*

*Plum blossoms*

*Plum foliage*

*Plum leaf*

*Plum tree*

## Uses

Plum fruits are commonly consumed fresh or used to make jams or jellies. Plums may be dried to produce prunes.

# Propagation

**Basic requirements** Plums grow best in areas with warm summers and require a summer temperature between 20 and 30°C (68-86°F) for the fruit to mature. The trees also have a chilling requirement to break dormancy. Plum trees grow best in well-draining sandy loams in areas that receive full sun but can will grow in a variety of soils as long as water does not sit on the surface after heavy rainfall. It can be beneficial to plant the trees on elevated land to allow cold air to drain away. Trees will grow optimally in soils with a pH between 5.5 and 6.5 **Propagation** Plum trees are propagated vegetatively to maintain the desirable genetic characteristic of the parent. Plum rootstocks are commonly used but plum may also be grafted onto peach, Japanese apricot and almond rootstocks. Plum trees should be planted in full sun. Plant bare root trees in a pre-dug hole which is slightly wider than the root ball. Backfill the hole so that the tree is planted to its original planting depth ensuring that the bud union is above the soil line. It is usually possible to identify this from changes in the color of the bark. If planting multiple trees they should be spaced 2.0“2.5 m (6.6“8.2 ft) apart. Most plum varieties are self fruitful but cross pollination may be required for fruit set. Plums are pollinated by honeybees and it can be beneficial to maintain bee hives in orchards. **General care and maintenance** Plums should be pruned annually, including the year of planting and are best trained to an open center. When the tree is bearing fruit, it is important to thin the fruits to prevent the tree from over-bearing. Aim to have 1 fruit every 15“20 cm (6“7 in). This allows fruits to become larger and prevents the tree from reducing production the following year. Trees should be watered regularly during the growing season to aid with fruit development. During dry periods, water trees every 10 to 14 days. Apply water deeply and widely, to at least the width of the canopy. Trees will also benefit from the application of a nitrogen fertilizer in Spring. **Harvesting** Plum fruits should be allowed to mature on the tree. Fruits can be picked by hand when the skin has turned the color typical of the variety being grown.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Armillaria root rot** *Armillaria mellea*

##### Symptoms

If tree is infected after it has reached 5 years of age then typical symptoms include poor terminal growth and small leaves; around midsummer the whole tree suddenly collapses; in orchards trees usually die in a circular pattern; infected trees often have a fan-shaped white fungal mat growing between the bark and wood of the crown

##### Cause

Fungus

## **Comments**

Fungus survives in dead roots; symptoms similar to Phytophthora root rot; avoid planting plum in areas where oak has been planted recently

## **Management**

Once a tree is infected there is no treatment and it should be removed, fumigants do not control fungi in soil adequately; do not plant apricot in newly cleared forest or on the site of old orchards with a history of Armillaria

## **Black knot** *Apiosporina morbosa*

*Plum tree showing signs of infection*      *Black knot on plum tree with black knot disease*

## **Symptoms**

Elongated swellings (knots) on woody parts of tree which can reach up to 30 cm (12 in) long; knots are initially olive green in color with a corky texture but turn black in color and become hard and brittle; knots grow in length each year

## **Cause**

Fungus

## **Comments**

Infections occur on new shoots after rainfall and knots develop rapidly in second year

## **Management**

Prune knots on twigs and branches 8-10 cm (3-4 in) below the swelling and remove the pruned branches from the orchard; remove knots on older branches by removing the knot plus 2 cm (0.8 in) of surrounding tissue; removal of knots is most effective when done in midsummer; disease can be controlled by application of appropriate fungicides, if available, during shoot elongation

## **Brown rot** *Monolinia* spp.

*Symptoms of brown rot on plum fruit*

## **Symptoms**

Death of young blossoms and associated twigs and leaves; small tan cankers with dark margins on twigs; gummy exudate at base of flowers; brown spore masses on flowers in humid conditions; infected fruit usually exhibit a rapidly spreading brown rot but may also take the form of small necrotic spots; infected fruits usually remain attached to the tree

## **Cause**

Fungi

## **Comments**

Fungus survives in mummified fruit on the tree, blighted blossoms, cankers and infected twigs; blossom and twig blights are promoted by periods of wet weather

## **Management**

The currently most effective method of controlling brown rot is through the application of appropriate protective fungicides timed so that they are applied when the susceptible flower parts are exposed or after a wet period; avoiding sprinkler irrigation protects the leaves and flowers from wetness that promotes the disease. Cultural control methods include: removing mummified fruit from tree, pruning infected twigs and reducing plant stress by providing adequate levels of water and fertilizer

## **Powdery mildew** *Sphaerotheca pannosa*

*Podosphaera tridactyla*

## **Symptoms**

White powdery growth occurring in circular patches on fruit; scabby, dry patches on fruit; white powdery growth on leaves in Fall

## **Cause**

Fungi

## **Comments**

Disease emergence favored by cool, moist nights and warm days

## **Management**

Management of powdery mildew is reliant on the application of appropriate fungicides and cultural practices which promote good air circulation around tree canopies to lower humidity

## **Rust** *Tranzschelia discolor*

### **Symptoms**

Pale yellow-green spots on both upper and lower leaf surfaces which are angular in shape and turn bright yellow in color; spots on lower leaf surface develop orange-red spores

## **Cause**

Fungus

## **Comments**

Fungus overwinters in twigs or in leaves which remain attached to the tree

## **Management**

Rust can be prevented by spraying trees with protective fungicides; application is usually carried out one, two and three months before harvest in areas prone to early season outbreaks of the disease and after harvest in areas where disease is less problematic or emerges later in the season

## **Category : Bacterial**

### **Bacterial canker** *Pseudomonas syringae*

## **Symptoms**

Cankers on twigs at bases of flower and leaf buds, in pruning wounds or at the base of spurs which exude amber colored gum; cankers spread upwards and form sunken areas in winter; if pathogen enters dormant buds they may be killed or open normally in Spring before collapsing in early Summer; infected buds may be symptomless

## **Cause**

Bacterium

## **Comments**

Bacteria are spread by water splash; disease emergence favored by high humidity and low temperatures in spring

## **Management**

Ensure that a suitable plum variety and rootstock is chosen based on geographic location and environmental conditions to prevent stress to tree which predisposes tree to canker disease; apply protective copper spray to trees before flowering; prune trees in early summer to decrease likelihood of infection

### **Bacterial spot** *Xanthomonas campestris*

*Bacterial spot on plum leaf*

*Cankers on plum branches caused by bacterial spot*

*Symptoms of bacterial spot on plum fruit*

## **Symptoms**

Water soaked, angular gray lesions on the underside of the leaves which turn purple and necrotic in the center and cause a shot hole appearance if lesion center drops out; if lesions are present in high numbers on leaves they may become chlorotic and drop from tree; cankers develop on twigs either as raised blisters or as a dark area surrounding a bud that

fails to open; in years of severe infection the entire fruit crop may be lost; lesions on fruit begin as small brown, water-soaked lesions which may exude gum

#### **Cause**

Bacterium

#### **Comments**

Periods of frequent rainfall during late bloom and early petal drop increase likelihood of fruit and leaf infection; infection is rare during hot, dry weather

#### **Management**

Avoid planting susceptible varieties in areas where disease is known; once disease is visible it can be difficult to control, protective copper applications in the Fall prior to leaf drop and/or application in early growing season may help prevent the disease; care should be taken as peach trees are very sensitive to copper

### **Crown gall *Agrobacterium tumefaciens***

#### **Symptoms**

Galls on root and/or crown of tree which can range in size from so small they are not visible to the naked eye up to 10 cm (4 in) in diameter; galls first become visible as white, fleshy swellings that grow rapidly and become tan to brown in color; galls typically develop at the site of a wound and new galls form adjacent to old ones the next year

#### **Cause**

Bacterium

#### **Comments**

Infection with crown gall begins at the site of plant wounds; disease emergence is favored by poorly-drained, alkaline soils and previous feeding damage by nematodes

#### **Management**

Chemical control of the disease is generally ineffective; an effective bacterial biological control is available for commercial production; cultural control methods include: planting only certified, disease-free material, planting plum in well-draining soil, rotating infected fields with a non-host before plum is planted and also using good sanitation practices

### **Category : Oomycete**

### **Phytophthora root and crown rot *Phytophthora* spp.**

#### **Symptoms**

Poor new growth; leaves chlorotic, small in size and sparse; fruit may be small, brightly colored and susceptible to sunburn; shoots may suffer from dieback and tree will often die within weeks or months of first signs of infection or decline gradually over several seasons; root crown may show signs of decay which develops into a canker; bark of infected crown tissue turns dark brown; cankers may occur on aerial parts of plant

#### **Cause**

Oomycete

#### **Comments**

Severity of disease is linked to soil moisture content; water-saturated soils promote development of fungus

#### **Management**

Management of phytophthora is reliant on good management of water: plum trees should be planted in well-draining soil to minimize the frequency and duration of water saturated soil; trees should be propagated from resistant rootstock and application of appropriate systemic fungicides may provide some protection from the disease

### **Category : Viral**

### **Plum pox virus Plum pox virus (PPV)**

*Symptoms of plum pox virus on plum fruits*

**Symptoms**

Pale green chlorotic spots, rings and lines on leaves which appear in early summer; the spots may become necrotic; infected fruit have rings or spots on the surface and may have red rings or spots on the stone

**Cause**

Virus

**Comments**

Virus is transmitted by aphids but most common method of spread is diseased plant material

**Management**

Plant certified healthy material; remove infected trees from orchard; chemical sprays to control aphids may prolong spread of virus

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# Pomegranate

## Description

Pomegranate, *Punica granatum*, is a deciduous or evergreen tree or shrub in the family Punicaceae grown for its edible fruits. The pomegranate tree is branched and spiny with glossy, leathery, oval to oblong leaves that grow in whorls of five or more on the branches. The tree produces bright red flowers singly at the tips of the branches and a rounded hexagonal fruit with a thick pink-red skin. The fruit has a thick, leathery rind which protects the pulp[ and seeds inside. The inside of the fruit is separated into compartments by white spongy tissue. Each compartment contains seeds and pulp. Each pomegranate fruit may contain as many as 600 seeds. Pomegranate trees can reach a height of 10 m (33 ft) and can be very long lived, although their economic lifespan is usually between 12 and 15 years. Pomegranate may also be referred to as grenadine or Chinese apple and originated from Central Asia, likely in Iran.

*Fruits and foliage*

*Pomegranate flower*

*Pomegranate and seeds*

*Pomegranate tree in flower*

*Pomegranate flowers*

*Pomegranate fruit*

## Uses

Pomegranate is primarily eaten as a fresh fruit by splitting open the rind and consuming the seeds. The seeds may be

used in salads. The fruit may also be used to produce juice, either by removing and pressing the seeds or by pressing the whole fruit.

## Propagation

**Basic requirements** Pomegranates grow best in temperate or semi-arid climates with a cool winter and warm summer. They are less hardy than many other deciduous fruit trees but more hardy than citrus. Pomegranates will suffer severe damage when temperatures drop below -10°C (14°F). Pomegranate can be grown successfully on a range of soil types, including calcareous soils and acidic loam but will grow optimally in deep, well-draining loam. **Propagation** Commercial pomegranate trees are propagated from softwood and hardwood cuttings as seeds will not breed true to type. Hardwood cutting are generally preferred over softwood due to the ease with which they root. Hardwood cuttings are taken from shoots or suckers from the previous season and are rooted in nursery beds after treatment with a rooting hormone. Cuttings are grown in the nursery for one season before being planted out in the orchard. Rooted cuttings are best planted in winter or early spring and are usually spaced 3.5–5.5 m (11.5–18 ft) apart. The young trees are headed back to a height of 60–70 cm (23–28 in) after planting to promote branching. **General care and maintenance** Pomegranates have a similar water requirement to citrus trees and should be provided with additional irrigation during dry periods. Pomegranate orchards usually utilize drip, furrow or sprinkler irrigation systems to promote optimal yields. Pomegranates can be pruned to a single stemmed tree or allowed to grow as a multi-stemmed bush. Suckers should be removed from around the central trunks as they develop. Pomegranates will benefit from the addition of nitrogen. Nitrogen should be applied at a rate of 0.2–0.5 kg per tree each year. Pomegranate fruits are usually thinned to promote the production of larger fruits. **Harvesting** Pomegranate fruits are generally ready to harvest between 6 and 7 months after flowering, fruits should be allowed to mature fully on the branch prior to harvest as they will not continue to ripen off of the tree. Fully mature fruit turn bright red in color and make a metallic sound when tapped. Fruits should be harvested by cutting from the tree.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Cercospora fruit spot** *Cercospora punicae*

*Cercospora spot*

*Cercospora leaf spot*

*Cercospora spots on the leaves*

*Light brown spots on leaves*

*Symptoms on leaves*

## **Symptoms**

Light brown spots on leaves and fruit which enlarge and coalesce to form large black patches on fruit; black elliptical spots appear on twigs and become flattened and depressed with a raised margin; infected twigs dry out and die; infection may cause plant death.

## **Cause**

Fungus

## **Comments**

Disease emergence is favored by rainfall and water saturated soil.

## **Management**

Diseased fruits should be removed and destroyed; infected twigs and branches should be pruned out; applications of appropriate fungicides can help to control the disease.

## **Category : Other**

### **Heart rot (Black heart) *Alternaria* spp.**

## **Symptoms**

Interior of fruit rotting with no external symptoms; infected fruits are usually lighter in weight than healthy fruits and may be paler in color.

## **Cause**

Fungi

## **Comments**

May be linked to moisture levels at time of flowering.

## **Management**

No known method of control.

## **Pests**

## **Category : Insects**

### **Aphids (cotton aphids) *Aphis gossypii***

*Cotton aphid (Aphis gossypii) winged form*

*Cotton aphid infestation*

*Cotton aphid (Aphis gossypii) colony*

## **Symptoms**

Both adults and nymphs suck sap from growing shoots, flowers and young fruit. Heavy infestation leads to stunting or week tree. Sooty mold and soft rot may develop on the fruit.

## **Cause**

Insect

## **Comments**

Aphids are carried by ants from one plant to another.

## **Management**

Encourage natural enemies. Keep the field free from crop debris and weeds. Spraying strong jet of water to dislodge the aphid. If infestation is severe spray suitable insecticide.

### **Leaf-footed plant bugs *Leptoglossus clypealis***

*Leaf footed bug eggs*

*Adult insect*

*Adult western leaf footed bug*

*Leaf footed bugs adults and nymphs*

*Western leaf-footed bug adult*

*Western leaf-footed bug  
(*Leptoglossus clypealis*) adult*

## Symptoms

Both adult and nymphs feeds by penetrating their mouth parts to the thick skin of the pomegranate fruit to the arils resulting in withering of stung arils.

## Cause

Insect

## Comments

The insect have wide host range.

## Management

If the infestation is severe apply suitable insecticide.

## Mealy bug (Grape mealy bug, citrophilus mealybug, striped mealybug) *Pseudococcus maritimus*

*Pseudococcus calceolariae*

*Ferrisia virgata*

*Nymphs of citrophilus mealybug*

*citrophilus mealybug nymphs*

*citrophilus mealybug (*Pseudococcus calceolariae*) on pomegranate fruit*

*citrophilus mealybug sucking sap from fruit*

## Symptoms

The insect infect all parts of the plant. Both nymphs and adults suck the sap from the leaves, flowers and fruits, resulting in yellowing of leaves, curling and shedding of flowers and tender fruits. Also the market value of such fruits reduced. In dry season insect can invade roots and suck sap. Due to honey dew secretion sooty mold may develop on leaves and fruits.

## Cause

Insect

## Comments

Polyphagous insect. Female can lay 300 to 400 eggs in soil. Short life cycle (40 days).

## Management

Spraying soap solution reduces mealy bug population. Encourage natural enemies. If the infestation is severe apply suitable insecticide.

## Omnivorous leafroller *Platynota stultana*

*Larvae*

*Omnivorous leafroller larvae*

*Omnivorous leafroller (*Platynota stultana*) adult*

## Symptoms

Larvae enter the fruit by craving surface grooves, especially where the two fruits touched. It causes tunneling in fruit.

Due to the skin damage secondary pathogens may infect the fruits and resulting in rotting.

#### Cause

Insect

#### Comments

Insect lay eggs on weeds near the field in the off season.

#### Management

Keep the field free from weeds. Remove the infected fruits and burn them. Use pheromone trap to kill adult insects.

### Pomegranate fruit borer (Anar butterfly, common guava blue butterfly) *Virachola isocrates*

*Pomegranate fruit borer butterfly*

#### Symptoms

The female butterfly lay eggs on tender leaves. After hatching the larvae feeds on fruit by boring hole. The damaged fruit rots and emits a foul smell. One can see the excreta of larvae near the hole. The final stage larvae come out of the hole and pupate by spinning the web.

#### Cause

Insect

#### Comments

The life cycle of insect is completed in 1 to 2 months. Very common pests in Asia.

#### Management

Remove the damaged fruit and burn them. Grow available resisting varieties. If infestation is severe spray suitable insecticide.

### Category : Mites

### Citrus Flat mite *Brevipalpus lewisi*

*flat mite (Brevipalpus sp.) female  
live close-up*

*Brevipalpus sp. female*

*Flat mite (Brevipalpus sp.)*

#### Symptoms

Suck sap from fruit surface resulting in skin russetting, checking or leathery skin. This leads to reduce in market value of fruits. The citrus flat mite damage starts from the stem end of the fruit.

#### Cause

Mite

#### Comments

Mites are very small and difficult to trace them. If you use hand lens can see mites and their cast skins in the cracks of damaged fruits.

#### Management

Application of sulfur before and after flowering reduces the mite population.

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# Potato

## Description

### Crop details

The following are the crop details for potato:

Scientific name: Solanum tuberosum

Local names:

Viazi mbatata (Swahili)

Waru (Kikuyu)

English: Potato

Spanish: Papa

French: Pomme de terre

German: Kartoffel

Italian: Patata

Portuguese: Batata

Chinese: 薯仔 (shūzǐ)

Russian: Картофель (kartofel')

Arabic: بطاطس (batatas)

Hindi: आलू (aaloo)

Bengali: আলু (aloo)

Urdu: پتاتا (patata)

Greek: πατάτα (patata)

Order: Solanales

Family: Solanaceae

Genus: Solanum

## General Information

The potato (*Solanum tuberosum*) is a widely cultivated root vegetable in the Solanaceae family. They are native to the Andes Mountains in South America and have been grown for thousands of years. Potatoes are a staple food in many countries around the world and are used in a wide variety of dishes. They are high in carbohydrates, fiber, and vitamins C and B6.

Potatoes are typically planted in the spring and harvested in the late summer or early fall. They grow best in well-drained soils with a pH between 4.5 and 7.5. Potatoes require a lot of water, especially during the flowering and fruiting stages, and they are sensitive to frost.

The crop can be propagated from seed potatoes, which are small tubers that are planted in the soil. They can also be propagated from potato seed, which is a less common method. Once the seed potato or seed is planted, the plant will grow leaves and flowers, and then it will produce tubers underground.

The potato is a herbaceous perennial plant grown for its edible tubers. The plant has a branched stem and leaves consisting of leaflets that are both unequal in size and shape and can be oval to oblong in shape. The leaves can reach up to 10–30 cm in length. Tubers grow about 25 cm underground in the soil and can be yellow, red, or purple depending on the variety. The potato plant produces white or blue flowers and yellow-green berries. The plants can go up to 1m (3.3ft) in height.

Potatoes are grown in many countries across Africa, but the main potato-producing countries are Egypt, South Africa, Ethiopia, and Kenya. In these countries, potatoes are grown both for local consumption and for export.

Potatoes are a relatively new crop in Africa, having been introduced to the continent in the late 19th century. However, since then, potato production has increased significantly, with farmers in Africa recognizing the potential of the crop as a food security and income generation opportunity.

Potatoes grow well in the cool highland regions of Africa, where the temperature and rainfall are suitable for the crop. However, potato cultivation in Africa is often challenged by a lack of access to quality seed potatoes, a lack of irrigation systems, and the prevalence of pests and diseases.

FAOSTAT reports that production of potatoes in Africa has more than doubled, with eastern Africa producing the biggest yield. The crop is primarily produced by small-holder farmers, with Algeria leading in production with 4,928,028 tons per year, overtaking Egypt, which produces 4,800,000 tons per year.

The following is a summary of the physical attributes of potato crops:

**Leaves:** The leaves of the potato plant are simple and alternate. They are generally dark green and glossy in color and are smooth or slightly hairy. They are lobed or ovate in shape and can grow up to 15 cm long.

**Stems:** The stems of the potato plant are green, smooth, and slightly hairy. They grow to a height of 30–90 cm and are usually unbranched.

**Flowers:** The potato plant produces small, white or purple flowers that grow in clusters. These flowers are typically about 2 cm in diameter and have five petals.

**Tubers:** The tubers are the underground storage organs of the potato plant and are the part of the plant that is typically consumed as a vegetable. They are round or oblong in shape and can vary in size and color depending on the variety. They can be white, yellow, red, or purple.

**Root:** The potato plant has a deep taproot and fibrous root system that allow the plant to absorb water and nutrients from the soil.

**Fruits:** Potato plants produce small, green, and poisonous berries that are typically not consumed by humans.



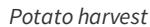
Potato flower



Potato field in flower



Potatoes being harvested in the garden



Potato harvest



Potato foliage

## Potato Varieties

Potatoes are grown in many countries across Africa, and different varieties are grown depending on the region and the local market. For example, in Egypt, the most common variety grown is Desiree, which is a red-skinned variety with a waxy texture that is good for boiling and mashing. In South Africa, farmers grow varieties such as "Bintje," "Sifra," and "Agria," which are known for their high yields and good storage capabilities. In Ethiopia, farmers grow varieties such as "Sarpo Mira," which is known for its resistance to pests and diseases, and "Shepody," which is known for its good taste and texture. In Kenya, farmers grow varieties such as "Kenya Mpya," "Shangi," and "Kenya Raha," which are known for their high yields and good taste.

It's worth noting that Africa has a rich diversity of local varieties of potatoes known as "landraces." These varieties have been developed and adapted to the local conditions and have the potential to provide food security and income for the farmers. However, the use of improved varieties and the adoption of good agricultural practices are necessary to achieve the full potential of potato production in Africa.

## Uses

Potato tubers are a staple food source in temperate regions and are eaten after cooking. They may be cut or sliced and made into potato chips or fries. Potatoes can also be processed into starch, alcohol or flour.

## Nutritional Information

Potatoes are a good source of carbohydrates, potassium, and vitamin C; they are also a source of fiber, vitamin B6, and folate. They are low in fat, calories, and sodium.

The values shown in the following table are approximate and may vary depending on the variety, growing conditions, and preparation method of the potatoes. Additionally, cooking and processing methods such as frying or mashing can change the nutritional value of potatoes and increase their calorie and fat content.

## Propagation

### Climatic conditions, soils and water

Potatoes are a cool-season crop that grows best in certain climatic, soil, and water conditions.

1. **Climatic conditions :** Potatoes prefer a cool climate with moderate temperatures and a long growing season. They

grow best at temperatures between 10°C–15°C (50°F–59°F) during the day and 5°C–10°C (41°F–50°F) during the night. Potatoes are sensitive to frost, and temperatures below 0°C (32°F) can damage the tubers. Potatoes also require a moderate-to-high amount of rainfall or irrigation.

**2. Soil conditions :** Potatoes grow best in well-drained soils that are rich in organic matter and have a pH between 4.5 and 7.5. They prefer soils that are high in nitrogen, phosphorus, and potassium and also require adequate levels of calcium, magnesium, and sulfur. Potatoes also grow well in sandy loam or clay soils.

**3. Water conditions :** Potatoes require a lot of water, especially during the flowering and fruiting stages. They need about 1-2 inches of water per week, and more in hot and dry weather. They prefer consistent moisture throughout the growing season but also require good drainage to prevent waterlogging and root rot. Potatoes are sensitive to drought and water stress, which can cause reduced yields and lower-quality tubers.

It's worth noting that while these are the ideal conditions for growing potatoes, the crop can be grown in a wide range of conditions, and some varieties are more tolerant to different conditions than others. Additionally, agronomic practices such as fertilization, irrigation, and crop rotation can help to improve the growth and yields of potatoes in challenging environments.

## Planting Procedure

The planting procedure for potatoes generally includes the following steps:

**1. Preparing the soil :** The soil should be well-drained and have a pH between 4.5-7.5. Prior to planting, the soil should be worked to a fine tilth, and any necessary amendments such as fertilizer or lime should be added.

**2. Choosing seed potatoes :** Seed potatoes should be disease-free and certified. They should be cut into pieces with at least one "eye" per piece, and should be left to dry for a few days before planting to allow the cuts to heal over.

**3. Determining the planting date :** The best time to plant potatoes will depend on your climate and the variety you are growing. Potatoes are typically planted in the spring, after the last frost date, and when the soil has warmed up to around 10-15°C (50-59°F).

**4. Planting the seed potatoes :** Seed potatoes should be planted at a depth of around 10-15 cm, with the "eyes" facing upward. They should be spaced around 30-40 cm apart, in rows that are 75-90 cm apart.

**5. Watering and mulching :** After planting, the soil should be watered well to settle the soil around the seed potatoes and to encourage germination. A layer of mulch, such as straw or grass clippings, can be applied to help retain moisture and suppress weeds.

**6. Care and maintenance :** As the plants grow, they will require regular watering, fertilization, and weeding. The plants should be hilled up (soil should be added to the base of the plant) as they grow to prevent the tubers from being exposed to sunlight, which can cause them to turn green and become inedible.

## Harvesting

Harvesting potatoes is the process of collecting the tubers, which are the edible part of the potato plant, from the soil. The timing of the harvest is crucial and will depend on the variety of potato being grown. Generally, potatoes are ready to be harvested when the foliage has died back and the skin of the tubers has hardened.

Before harvesting, farmers need to check the tubers for maturity. This can be done by gently digging up a few plants and checking the size and skin of the tubers. The tubers should be fully formed, and the skin should be tough enough that it can't be easily scraped off with your fingernail.

When it comes to the actual harvesting process, farmers should be careful not to damage the tubers. They should be carefully dug up using a spade or potato fork, taking care not to damage the tubers. It's better to harvest when the soil is dry and not wet. After harvesting, the tubers should be placed in a warm, dark, and well-ventilated place for a week or two to "cure" (harden the skin) before being stored.

After curing, the tubers should be cleaned of any dirt and debris, and any damaged or diseased tubers should be removed and discarded. Potatoes should be stored in a cool, dark, and well-ventilated place with a temperature between 4 and 8

Â°C (39 and 46 Â°F) and a relative humidity of 90 to 95 %.

It's important to harvest potatoes at the right time to ensure the best quality and storage potential. Overripe potatoes have a higher chance of spoilage and can't be stored as long as mature ones. Additionally, it's also important to properly cure, clean, and store the tubers to ensure they maintain their freshness and quality for as long as possible.

Potatoes should be planted in shallow trenches

Seed potatoes and seed pieces curing before planting

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## Common Pests and Diseases

### Diseases

#### Category : Bacterial

##### Bacterial ring rot *Clavibacter michiganensis*

Potato plant showing ring rot symptoms

Cross-section of infected potato tuber showing ring of discolored vascular tissue

#### Symptoms

Wilting stems and leaves; dying leaves; lower leaves wilting first; ring of creamy yellow to brown rot visible when tuber is cut crossways

#### Cause

Bacterium

#### Comments

Bacterium is tuber-borne; bacteria can enter tuber through cutting wounds; disease favored by wet, warm soils; bacteria overwinter in potato debris

#### Management

Plant only certified seed potatoes - certified seed potatoes are grown in seed beds with zero tolerance of ring rot; remove all crop debris from soil after harvest; sanitize tools and equipment regularly

## **Blackleg (Soft rot) *Erwinia carotovora***

*Soft rot symptoms on potato tubers*

### **Symptoms**

Small, water-soaked lesions on base of stems originating from seed piece; lesions may enlarge to form a large extended lesion stretching from base of stem to canopy; tissue becomes soft and water-soaked and can be light brown to inky black in color; wilted, curled leaves which have a soft and slimy texture when wet

### **Cause**

Bacterium

### **Comments**

Bacteria are carried on tubers and in wounds and can be spread to healthy tubers during handling and cutting of seed pieces; disease emergence favors high soil temperatures

### **Management**

Plant seed pieces which are the product of tissue culture; sanitize tools and equipment when cutting seed pieces to prevent bacterial contamination; avoid damaging tubers during harvest; reduce periods of leaf wetness by allowing enough time for leaves to dry throughout the day after watering

## **Common scab *Streptomyces* spp.**

*Tubers showing symptoms of common scab*

### **Symptoms**

Raised brown lesions on tubers with corky texture; deep, pitted brown or black lesions on tuber with straw-colored translucent tissue underneath

### **Cause**

Bacterium

### **Comments**

Disease is most severe during warm and dry conditions

### **Management**

Common scab can be very difficult to manage and prevention of the disease relies on combining several different methods. These include: avoiding planting infected tubers, using a 3-4 rotation away from potato; planting less susceptible potato varieties (none are immune); maintaining a high soil moisture content for 4-6 weeks after stolon tips begin to swell at the onset of tuber development; amending soil to lower pH and treating seed with appropriate fungicides when available

## **Category : Fungal**

## **Black dot *Colletotrichum coccodes***

### **Symptoms**

Small black dots (fungal fruiting bodies) on tubers, stolons and stems; roots may rot below ground; leaves may turn yellow and wilt; infection may cause defoliation

### **Cause**

Fungus

### **Comments**

Disease emergence favors poorly draining soil; poor aeration of soil and high temperatures; disease symptoms are most

severe in coarse soils that are low in nitrogen

### Management

Stressed plants are more susceptible to black dot; rotate crops away from potato; do not plant infested tubers or seed pieces; fertilize and water plants adequately; protective fungicides can be applied where available

## Black scurf & Rhizoctonia canker *Rhizoctonia solani*

Potato tuber covered with fungal fruiting bodies

Potato tuber covered with fungal fruiting bodies

Death of potato plant due to infection with Rhizoctonia

### Symptoms

Flat, irregularly shaped black or dark brown fungal fruiting bodies on tuber surface; tubers may be mishapen; red-brown to black sunken lesions on sprouts; lesions may girdle the main stem causing leaves to curl and turn yellow

### Cause

Fungus

### Comments

Fungus can be spread by infested soil or planting infected seed pieces and tubers; disease emergence favors cool, moist soil

### Management

No potato varieties are completely resistant to the disease; control relies on reducing the level of inoculum in both the soil and in tubers; methods include applying fungicide to seed pieces or soil; avoiding planting seeds too deeply in cold soils and rotating crop away from potato to reduce levels of soil inoculum

## Gray mold *Botrytis cinerea*

### Symptoms

Flowers covered in gray, fuzzy mold; wedge shaped tan lesions on leaves; a slimy brown rot may be present on stems, originating from the petiole; infected tubers have wrinkly skin and tissue underneath is soft and wet; tubers often develop a gray fuzzy growth

### Cause

Fungus

### Comments

Disease emergence favors excessive humidity, cool temperatures and shade

### Management

Cultural control is very important for managing the disease, provide plants with adequate fertilizer and water; application of appropriate protective fungicides where available can provide adequate control of disease but will not treat an established infection

## Pink rot *Phytophthora erythroseptica*

### Symptoms

Stunted plant growth; wilting leaves; dying leaves; marked tuber decay; dark brown eyes on tuber; cut tuber turns pink after 20-30 min air exposure, then turns brown and finally black

### Cause

Oomycete

### Comments

Disease emergence favors high soil water saturation late in the season

### Management

Plant potato in well-draining soils with no history of pink rot; avoid overwatering plants; avoid wounding during harvest

## Potato Early Blight *Alternaria solani*

*Close-up of leaf lesion caused by early blight*

*Destruction of potato plants by early blight*

*Symptoms of early blight on potato foliage*

### **Symptoms**

Dark lesions with yellow border which may form concentric rings of raised and sunken tissue on the leaves and stems; lesions initially circular but become angular; leaves become necrotic but remain attached to plant; dark, dry lesions on tubers with leathery or corky texture and watery yellow/green margins

### **Cause**

Fungus

### **Comments**

Disease emergence favors cycles of wet and dry conditions with periods of high humidity and leaf wetness

### **Management**

Application of appropriate protective fungicide can reduce severity of foliar symptoms; reduce stress to plants by fertilizing and watering adequately; plant late varieties which are less susceptible to disease; store tubers in cool environment

## **Powdery scab** *Spongospora subterranea*

*Powdery scab lesions on potato tuber*

*Close-up of powdery scab lesions*

### **Symptoms**

White to brown galls on the roots and stolon; raised pustules on tuber surrounded by potato skin; shallow depressions on tuber filled with brown spores

### **Cause**

Fungus

### **Comments**

Symptoms all occur below ground

### **Management**

Do not plant tubers showing symptoms of disease; avoid planting potato in poorly draining soils; if disease occurs rotate crop away from potato for a period of 3-10 years and avoid planting tomato

## **Verticillium wilt** *Verticillium dahliae*

*Verticillium albo-atrum*

*Yellowing potato foliage caused by Verticillium infection*

### **Symptoms**

Early death of plants; leaflets dying on only one side of the petiole or branching stem; cut through the stem reveals a discoloration of the tissue; discoloration of tubers at stem-end

### **Cause**

Fungi

### **Comments**

Disease emergence favors high temperature and moisture early in season followed by drought; disease can be spread to uninfected fields by wind or movement of infested soil particles

## **Management**

Planting resistant varieties of potato is the most common method of controlling the disease; cultural practices such as using furrow irrigation in place of sprinkler irrigation and avoiding overwatering plant can also reduce the severity of the disease should it occur

## **Category :**

### **Early Blight**

Symptoms

Cause

Comments

### **Early Blight Leaf**

Symptoms

Cause

Comments

## **Early Blight Symptoms**

Symptoms

**Cause**

**Comments**

## **Early Blight Symptoms**

**Symptoms**

**Cause**

**Comments**

## **Late Blight**

**Symptoms**

**Cause**

**Comments**

## **Late Blight Leaf**

Symptoms

Cause

Comments

## **Late Blight Leaf**

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## **Late Blight Leaf**

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**Cause**

**Comments**

## **Late Blight Leaf**

**Symptoms**

**Cause**

Comments

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Symptoms

Cause

Comments

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**Symptoms**

**Cause**

Comments

## **Late Blight Leaf**

Symptoms

Cause

Comments

## **Late Blight Symptoms**

Symptoms

**Cause**

**Comments**

## **Late Blight Symptoms**

**Symptoms**

**Cause**

**Comments**

## **Potato Healthy**

**Symptoms**

**Cause**

**Comments**

## **Potato Virus**

Symptoms

Cause

Comments

## **Potato Virus**

**Symptoms**

**Cause**

**Comments**

## **Category : Other**

**Leak** *Pythium* spp.

### **Symptoms**

Light tan, water soaked area around wound on tuber; internal rotting of tuber which results in internal tissue becomes spongy and possibly developing cavities; dark, watery fluid exudes from the tuber when squeezed

### **Cause**

Fungi

### **Comments**

Disease only affects tubers and fungus can only enter through wounds; all common potato cultivars are susceptible to leak; disease emergence is favored by relatively high temperatures

### **Management**

Rotating crops away from potato and destroying any infected tubers helps to control the disease; infection can be reduced by application of appropriate foliar fungicides; delaying harvest to allow the skin of the tuber to mature reduced the risk of injury to the tuber

## **Potato Viral Disease**

### **Symptoms**

### **Cause**

### **Comments**

### **Category : Oomycete**

## **Potato Late Blight *Phytophthora infestans***

*Infected leaf showing the distinctive white sporulating area*

*Late blight lesions on leaf*

*Potato plant destroyed by late blight*

*Diseased leaf on potato plant*

### **Symptoms**

Irregularly shaped spreading brown lesions on leaves with distinctive white fluffy sporulation at lesion margins on the underside of the leaf in wet conditions. In dry condition the lesions dry up and go dark brown with collapsed tissue; water-soaked dark green to brown lesions on stems also with characteristic white sporulation; later in infection leaves and petioles completely rotted; severely affected plants may have an slightly sweet distinctive odor; red-brown firm lesions on tubers extending several centimeters into tissue; lesions may be slightly sunken in appearance and often lead to secondary bacterial rots.

### **Cause**

Oomycete

### **Comments**

The pathogen can survive for several months to years in the soil; emergence of disease favored by moist, cool conditions; major cause of disease spread is infected tubers

### **Management**

Control depends on a multifaceted approach with importance of certain practices changing based on geographic location: destroy infected tubers; destroy any volunteer plants; application of appropriate fungicide to potato hills at emergence; time watering to reduce periods of leaf wetness e.g. water early to allow plant to dry off during the day; plant resistant varieties; apply appropriate protective fungicide if disease is forecast in area

### **Category : Viral**

## **Potato leaf roll Potato leafroll virus (PLRV)**

*PLRV-infected plant next to an uninfected potato plant*

*Plant infected with PLRV*

### **Symptoms**

Young leaves rolled and yellow or pink; lower leaves have leathery texture and roll upward; necrotic netting in vascular tissue of tuber may be present; plant exhibits an upright growth habit and growth may be stunted

### **Cause**

Virus

### **Comments**

Transmitted by several species of aphid; infected seed tubers and volunteer potato plants provide a source of inoculum for the virus

### **Management**

Grow plants produced clonally from PLRV-free stock; harvest potato crop early in temperate regions to avoid aphid migrations late in season; remove and destroy infected plants and tubers; application of appropriate insecticides where available may help reduce spread

## **Potato virus A** Potato virus A (PVA)

### **Symptoms**

Mild mosaic pattern or mottling on leaves; severely infected plants may have alternating patches of yellow and dark green tissue; leaves may have a shiny appearance; stems bending outwards slightly

### **Cause**

Virus

### **Comments**

Virus is transmitted by several species of aphid and can be transmitted to the next potato generation by planting infected tubers; tubers show no visible symptoms

### **Management**

Plant material which is free of PVA; plant tolerant potato varieties in areas where virus is common; application of appropriate systemic insecticides helps to control aphid populations

## **Potato virus X** Potato virus X (PVX)

### **Symptoms**

Mild mosaic pattern on leaves; severely infected plants may be dwarfed with smaller leaves; necrosis of plant tops and tubers may occur

### **Cause**

Virus

### **Comments**

PVX can be transmitted by infected leaves coming into contact with healthy ones

### **Management**

Planting seed free of PVX is the most important method of controlling the virus

## **Potato virus Y** Potato virus Y (PVY)

*Symptoms of PVY on potato leaf*

*Symptoms of PVY on potato tuber*

### **Symptoms**

Symptoms vary widely from mild mosaic of leaves to leaf necrosis and plant death depending on the variety of potato and the strain of the virus: leaves may turn yellow and drop from plant; symptoms may be present on only one shoot of

the plant; plants with severe leaf necrosis may produce tubers with light brown rings on the skin

#### Cause

Virus

#### Comments

Virus is transmitted by more than 25 different species of aphid; virus can be transmitted over long distances by aphids; can be transmitted mechanically by contact with infected leaves or tubers

#### Management

Plant only certified seed potatoes; application of appropriate systemic insecticides, where available, may control spread of virus within a single plantation but will not prevent spread caused by winged aphids; remove and destroy symptomatic plants; plant resistant varieties

## Pests

### Category : Insects

#### Aphids (Peach aphid, Potato aphid) *Myzus persicae*

*Macrosiphon euphorbiae*

*Adult potato aphid and offspring*

#### Symptoms

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants

#### Cause

Insects

#### Comments

Aphids are most damaging to potato through the transmission of viruses such as Potato leafroll virus; distinguishing aphid features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed

#### Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

#### Colorado potato beetle *Leptinotarsa decemlineata*

*Filed infestation of potato beetles*

*Larva*

*Adult Colorado potato beetle*

#### Symptoms

Feeding damage to foliage; if infestation is severe or if left untreated plants can be completely defoliated; adult insect is a black and yellow striped beetle; larvae are bright red with black heads when they first hatch and change color to pink;

larvae have two rows of black spots

### Cause

Insect

### Comments

Adult beetles emerge in spring; female beetles lay eggs in batches of up to two dozen; eggs are orange-yellow and are laid on undersides of leaves; a female can lay 500 or more eggs over a four to five week period

### Management

Control of Colorado potato beetle can be challenging as they have developed high levels of insecticide resistance; in the home garden planting early maturing varieties of potato allows the plants to escape from most damage; adults and larvae should be hand picked from plants and destroyed in soapy water; applications of *Bacillus thuringiensis* can be effective at controlling larvae but should be applied frequently; some insecticides, including spinosad, are still effective against adult beetles

### Cutworms *Agrotis* spp.

*Peridroma saucia*

*Nephelodes minians*

and others

*Cutworms will curl up into a characteristic C shape when disturbed*

*Cutworm feeding on plant stem*

*Cutworm larva severing plant stem*

### Symptoms

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5â€“5.0 cm (1â€“2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed

### Cause

Insects

### Comments

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato

### Management

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically

### Flea beetles *Epitrix* spp.

*Damage to potato foliage caused by flea beetles*

### Symptoms

Small holes or pits in leaves that give the foliage a characteristic â€œshot holeâ€ appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5â€“3.0 mm) dark colored beetle which jumps when disturbed; the beetles are

often shiny in appearance

#### **Cause**

Insects

#### **Comments**

Younger plants are more susceptible to flea beetle damage than older ones; older plants can tolerate infestation; flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year

#### **Management**

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application on diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied

### **Wireworms** *Aeolus* spp.

*Anchastus* spp.

*Melanotus* spp.

*Limonius* spp

Wireworms

#### **Symptoms**

Death of seedlings; reduced stand; girdled stems and white heads; wireworm larvae can be found in soil when dug round the stem; larvae are yellow-brown, thin worms with shiny skin

#### **Cause**

Insect

#### **Comments**

Larval stage can last between 1 and 5 years depending on species

#### **Management**

Chemical control impossible in a standing crop, must be applied at preplanting or as a seed treatment; if wireworms are known to be present in soil fallow field during summer and till frequently to reduce numbers; rotate to non-host crop where possible; avoid planting susceptible crops after a wireworm infestation on cereals without either fallowing or applying appropriate pesticide

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# Pumpkin

## Scientific Clarification

The following are the crop details for Cashew Nuts

Scientific name: Cucurbita spp. (Cucurbita maxima, Cucurbita moschata etc.)

Local names: Budho (Luo), Malenge (Kiawahili), Lisiebebe (Luhya), Marenge (Kikuyu), Risoa (Kisii), Ulenge (Kamba)

Order: Cucurbitales

Family: Cucurbitaceae

Genus: Cucurbita spp.

*Pumpkin fruit*

*Pumpkin*

*Flower*

*Pumpkin flowering*

*Pumpkin plant*

*Pumpkin leaves*

## General Information

Pumpkin is the name given to a group of plant species in the genus Cucurbita, including Cucurbita pepo, Cucurbita

*mixta*, *Cucurbita maxima*, and *Cucurbita moschata*. It is grown primarily as a vegetable or ornamental plant.

Pumpkins have long-running, bristled stems, large deeply-lobed leaves often containing white blotches, and yellow or orange flowers separated into male and female types on the same plant. The fruit is variable in shape and color but is often white, cream, or green, containing about 70% flesh and several large white seeds.

Pumpkin plants are short-lived annual or perennial vines with branching tendrils and broad lobed leaves. The plant produces large yellow or orange flowers and a pepo fruit (berry with a thick rind) known as a pumpkin. The fruit can range greatly in size, from miniature pumpkins weighing a few ounces to giant pumpkins which can reach over 75 lbs (34 kg). The skin of the pumpkin is usually ribbed and is usually orange in color although some varieties are green, grey, yellow, or red. Pumpkin plants are usually grown as annuals, surviving one growing season and the vines are capable of reaching 15 m (50 ft) in length if vines are allowed to root. Pumpkin may also be referred to as squash or marrow and is believed to have originated in Mexico and South America.

## Varieties of butternut available in Kenya

"Butternut 401". It has resistance to powdery mildew

"Bugle". It has resistance to powdery mildew.

"Early Butternut F1". It has resistance to powdery mildew.

"Ultra F1". It has resistance to Fusarium wilt and powdery mildew.

"Waltham". It has resistance to powdery mildew.

## Climate Conditions, Soil, and Water Management

Pumpkins and squashes (various *Cucurbita* spp.) are grown in the tropics from the lowlands up to 2500 m altitude. They are warm-season crops adapted to monthly mean temperatures of 18-27°C. *C. maxima* is the most tolerant of low temperatures, *C. moschata* and *C. argyrosperma* the least, with *C. pepo* intermediate. *C. maxima* and *C. pepo* have long been cultivated in temperate regions. Butternut appreciates part shade in very hot conditions, such as can be obtained when intercropped with other crops or grown under fruit trees.

Pumpkins and squashes respond very well to medium to heavy applications of compost or well-decomposed manure. They can be cultivated on almost any fertile, well-drained soil with a neutral or slight acid reaction (pH 5.5 to 7). They are drought-tolerant, require relatively little water, and are sensitive to waterlogging. Excessive humidity is harmful because of the development of leaf diseases, so none of the species do well in the humid tropics.

## Uses

Pumpkin flesh, leaves, and flowers can be cooked and eaten in a variety of dishes. The seeds are also edible and are commonly roasted and eaten as a snack.

Ornamental gourds are cultivars of *C. pepo* with small, bitter, and inedible fruits in many shapes, sizes, and colors.

The pumpkin has been used as a medicine in Central and North America. It is a gentle and safe remedy for several

complaints. The seeds are widely used as an anthelmintic. The complete seed, together with the husk, is used to remove tapeworms.

The fruit and seed decoctions have been reported to be used as diuretics and to reduce fevers, and are used for curing indigestion. The pulp is applied to burns and scalds, inflammation, abscesses, and boils. It is also used in the treatment of migraine and neuralgia.

## Planting Procedure

Pumpkins and squashes are grown from seed. Seeds may be sown in containers and transplanted to the field when they are 10 cm high. Direct seeding of 2 to 3 seeds per hill is commonly practiced. Trailing types are planted at distances of 2-3 m either way; the seed requirement is 2 to 3 kg/ha. The bushy types (mainly *C. pepo*) are planted closer, for example, plants spaced 60 to 120 cm in rows 1 to 1.5 m apart; the seed requirement is 3 kg/ha for pumpkin and 7 kg/ha for summer squash (*C. pepo*). Do not use seeds from plants where edible pumpkins and ornamental gourds are grown close together. Offspring will be bitter or even inedible.

## Husbandry

Sole cropping is sometimes used for commercial production. Pumpkins and squashes are also planted in home gardens or mixed with field crops such as maize. Cultural practices to improve growth and development include the removal of growing tips (in trailing varieties) to check growth, and the bagging of fruits in paper to protect against fruit flies and other pests. Fruit sets may be stimulated by manual pollination. The fruit may rot when in contact with moist soil, so often cut grass or leaves are placed beneath the fruit.

## Harvesting

Winter squashes and pumpkins are picked when mature in a once-over harvest or in several rounds, about 90 to 120 days after planting depending on the variety. Pumpkins are considered to be among the most efficient vegetable crops when evaluated on nutritional yield land area and labor needed. Indicative figures for the seed yield of *C. pepo* are 400 to 1500 kg/ha. A valuable source of oil and protein is thus neglected if the seeds are left unutilized. In seed production, isolation between fields of different *Cucurbita* species is recommended, not only for the reason of purity but also for obtaining maximum yields (pollen of other species may cause reduced fruit set).

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Alternaria leaf blight** *Alternaria cucumerina*

###### **Symptoms**

Small, yellow-brown spots with a yellow or green halo which first appear on the oldest leaves; as the disease progresses, lesions expand and become large necrotic patches, often with concentric patterning; lesions coalesce, leaves begin to curl and eventually die

###### **Cause**

Fungus

###### **Comments**

Disease is prevalent in growing areas where temperatures are high and rainfall is frequent

###### **Management**

Cucurbits should be rotated with another crop every 2 years to reduce levels of inoculum; crop debris should be removed from the field as quickly as possible after harvest or plowed deeply into the soil; applications of appropriate protective fungicides can help to slow the development of the disease; water plants from the base rather than from above to reduce periods of leaf wetness which are conducive to the development and spread of disease

##### **Alternaria leaf spot** *Alternaria alternata*

###### **Symptoms**

Initial symptoms appear as necrotic flecks on leaves with chlorotic halos; as the disease progresses, the flecks grow into spots which may join together into large, roughly circular lesions; if infestation is severe, leaves begin to turn yellow and die

###### **Cause**

Fungus

###### **Comments**

Pathogen survives between growing season on crop debris

###### **Management**

Crops debris should be removed from the field or plowed deeply into the soil after harvest; applications of appropriate protective fungicides can help reduce the incidence of the disease

##### **Cercospora leaf spot** *Cercospora citrullina*

###### **Symptoms**

Initial symptoms of disease occur on older leaves as small spots with light to tan brown centers; as the disease progresses, the lesions enlarge to cover large areas of the leaf surface; lesions may have a dark border and be surrounded by a chlorotic area; the centers of the lesions may become brittle and crack

###### **Cause**

Fungus

###### **Comments**

Fungus survives on plant debris; spread by wind and water splash; occurs mainly in tropical and subtropical growing regions

## **Management**

Any diseased plants should be removed and destroyed to prevent further spread; crop debris should be removed after harvest or plowed deeply into the soil to reduce inoculum

## **Downy mildew** *Pseudoperonospora cubensis*

*Downy mildew on pumpkin leaf*

*Downy mildew symptoms*

*Downy mildew symptoms*

### **Symptoms**

Dead or dying leaves; yellow to brown lesions on the upper side of leaves; purple growth developing on the underside of leaves

### **Cause**

Fungus

### **Comments**

Disease emergence favors cool nights and high moisture

### **Management**

Do not overcrowd plants; avoid overhead irrigation, water plants from base; apply appropriate fungicide

## **Fusarium crown and foot rot** *Fusarium solani*

### **Symptoms**

Wilting of leaves progresses to wilting of entire plant and plant dies within a few days; distinctive necrotic rot of crown and upper taproot when plant is uprooted; plant breaks easily below soil line

### **Cause**

Fungus

### **Comments**

Fungus can survive in soil for 2-3 years

### **Management**

Plant fungicide treated seed; rotate crops on 4 year rotation

## **Gummy stem blight** *Didymella bryoniae*

### **Symptoms**

Brown or tan spots of various sizes on leaves; leaves covered with lesions; stems splitting and forming cankers; wounds exude a brown, gummy substance; wilting vines; death of stems

### **Cause**

Fungus

### **Comments**

Disease may be seed-borne

### **Management**

Use disease free seed; treat seeds prior to planting; rotate crops every 2 years

## **Powdery mildew** *Erysiphe* spp.

*Sphaerotheca* spp.

*Powdery mildew on pumpkin leaves*

*Symptoms of powdery mildew on  
pumpkin vines*

*Powdery mildew on pumpkin leaf*

### **Symptoms**

White powdery mold on stems, leaves and petioles; stems may be weakened

**Cause**

Fungi

**Comments**

Disease emergence favors periods of dry weather

**Management**

Plant in sites with good air circulation and sun exposure; do not overcrowd plants; sanitize equipment regularly

**Septoria leaf spot** *Septoria cucurbitacearum***Symptoms**

Initial symptoms of disease are small dark water-soaked spots on the leaves which turn beige to white in dry conditions; lesions develop thin brown borders and the centers may become brittle and crack; small white spots may erupt on the surface of infected butternut and acorn squash and pumpkin fruit

**Cause**

Fungus

**Comments**

Pathogen can survive on crop debris for periods in excess of 1 year

**Management**

Scout plants during cool wet conditions for any sign of spots; early application of an appropriate protective fungicide can help limit the development of the disease if spots are found, cucurbits should be rotated with other crops every 2 years to prevent the build-up of inoculum; crop debris should be removed and destroyed after harvest

**Southern blight** *Sclerotium rolfsii*

*Southern blight symptoms on  
pumpkin fruit*

**Symptoms**

Sudden wilting of leaves; yellowing foliage; browning stem above and below soil; browning branches; stem may be covered with fan-like mycelial mat; rot on fruit that begins on side in contact with soil

**Cause**

Fungus

**Comments**

Fungus can survive in soil for long periods; disease emergence favored by high temperatures, high humidity and acidic soil; disease found mainly in tropical and subtropical regions, including the southern United States

**Management**

Remove infected plants; avoid overcrowding plants to promote air circulation; rotate crops with less susceptible plants; plow crop debris deep into soil; provided a barrier to infection by wrapping lower stems of plant with aluminum foil covering below ground portion of stem and 2-3 in above soil line

**Verticillium wilt** *Verticillium dahliae***Symptoms**

Symptoms generally appear after fruit set; chlorotic leaves which develop necrotic areas; leaves collapsing; symptoms only on one side of vine; discoloration of vascular tissue in roots

**Cause**

Fungus

## **Comments**

Fungus can survive in soil for many years; disease emergence favored by cool or mild weather in Spring

## **Management**

Do not plant in areas where other susceptible crops have been grown previously; delay planting until temperatures are warmer

## **Category : Bacterial**

### **Angular leaf spot *Pseudomonas syringae***

#### **Symptoms**

Small water-soaked lesions on leaves which expand between leaf veins and become angular in shape; in humid conditions, lesions exude a milky substance which dries to form a white crust on or beside lesions; as the disease progresses, lesions turn tan and may have yellow/green edges; the centers of the lesions dry and may drop out leaving a hole in the leaf

#### **Cause**

Bacterium

#### **Comments**

Spread through infected seed, splashing rain, insects and movement of people between plants; bacterium overwinters in crop debris and can survive for 2.5 years

#### **Management**

Use disease-free seed; do not grow plants in field where cucurbits have been grown in the previous 2 years; protective copper spray may help reduce incidence of disease in warm, humid climates; plant resistant varieties

### **Bacterial leaf spot *Xanthomonas campestris***

*Symptoms of bacterial spot on pumpkin fruit*

#### **Symptoms**

Dark, angular lesions on leaves; leaf lesions may coalesce and cause severely blighted foliage; water-soaked lesions which enlarge and develop into tan scabs, or blisters, on the fruit; blisters eventually flatten as they reach their full size

#### **Cause**

Bacterium

#### **Comments**

Jack-o-lantern varieties particularly susceptible; disease can spread rapidly in a field; disease can be introduced through contaminated seed

#### **Management**

Avoid overhead irrigation; rotate crops away from cucurbit species to prevent disease building up; use new seed each planting as saved seed is more likely to carry bacteria; apply appropriate protective fungicides; copper containing fungicides generally provide good control

### **Bacterial wilt *Erwinia tracheiphila***

*Symptoms of bacterial wilt (image of closely related summer squash)*

#### **Symptoms**

Wilting of individual runners or entire plant; leaves and stems of affected parts turn dark green; wilting is irreversible;

affected parts turn necrotic

#### **Cause**

Bacterium

#### **Comments**

Spread by striped or spotted cucumber beetles; disease can be confirmed by cutting the stem and slowly pulling the two ends apart - infected plants will ooze strings of bacterial exudate

#### **Management**

Control cucumber beetle populations on plants; hand pick adult beetles and destroy; soil and foliar application of appropriate insecticides may help to control populations

### **Category : Other**

#### **Aster yellows** Aster yellows phytoplasma

#### **Symptoms**

Foliage turning yellow; secondary shoots begin growing prolifically; stems take on a rigid, upright growth habit; leaves are often small in size and distorted, may appear thickened; flowers are often disfigured and possess conspicuous leafy bracts; fruits are small and pale in color

#### **Cause**

Phytoplasma

#### **Comments**

Disease is transmitted by leafhoppers and can cause huge losses in cucurbit crops

#### **Management**

Remove any infected plants from the field to reduce spread; control weeds in and around the field that may act as a reservoir for the phytoplasma; protect plants from leaf hopper vectors with row covers

### **Category : Viral**

#### **Cucumber mosaic** Cucumber mosaic virus (CMV)

#### **Symptoms**

Plants are severely stunted; foliage is covered in distinctive yellow mosaic; leaves of plant curl downwards and leaf size is smaller than normal; flowers on infected plants may be deformed with green petals; fruits become distorted and are small in size; fruit is often discolored

#### **Cause**

Virus

#### **Comments**

Transmitted by aphids; virus has an extensive host range; can be mechanically transmitted via tools etc.

#### **Management**

Control of the virus is largely dependant on the control of the aphid vectors; reflective mulches can deter aphid feeding; aphid outbreaks can be treated with mineral oils or insecticidal soap applications; some resistant varieties are available

#### **Squash mosaic** Squash mosaic virus (SqMV)

#### **Symptoms**

Symptoms vary with variety being grown but plants can show symptoms which include include green veinbanding, mottled leaves, blisters, ring spots or protruding veins at leaf margins; some squash varieties may develop leaf etiations; infected plants are often stunted and fruits may be malformed with mottled skin

#### **Cause**

Virus

#### **Comments**

Virus can be transmitted through infected seed and spread by striped cucumber beetles

## **Management**

Use only certified disease-free seed

## **Watermelon mosaic** Watermelon mosaic virus (WMV)

### **Symptoms**

Symptoms vary widely depending on species, cultivar, virus strain and environmental conditions; symptoms on leaves may include green mosaic patterning, green vein-banding, chlorotic rings and disfigured leaves

### **Cause**

Virus

### **Comments**

Virus is found in almost all Cucurbit growing regions in the world; virus is spread by over 20 aphid species

## **Management**

Treatments that control populations of aphid vectors can also reduce the incidence of the virus; spraying plants with mineral oils or insecticidal soaps can help to reduce aphid numbers

## **Zucchini yellow mosaic** Zucchini yellow mosaic virus (ZYMV)

### **Symptoms**

Infected plants are severely stunted and leaves can exhibit a variety of symptoms including yellow mosaic patterning, severe deformation, blistering, reduced size and necrosis; fruits are deformed

### **Cause**

Virus

### **Comments**

Disease can cause devastating epidemics when present

## **Management**

Use of resistant varieties, where available, is usually the most effective method of controlling the virus; control of aphid populations on the plants can be achieved through the use of mineral oils and insecticidal soaps but is rarely effective at controlling the virus

## **Category : Oomycete**

## **Phytophthora blight** *Phytophthora capsici*

*Symptoms of Phytophthora blight on  
pumpkin fruit*

*Symptoms of Phytophthora blight on  
pumpkin fruit*

### **Symptoms**

Sudden and permanent wilting of plant; leaves do not change color; plant death within a few days; roots and stem close to soil line discolored light to dark brown; plant easily removed from soil; fluffy mold growing on soft rotting fruit

### **Cause**

Oomycete

### **Comments**

Disease emergence favors warm, moist conditions

## **Management**

Efficient management of water to avoid saturated soil; avoid long periods of irrigation

## **Pests**

## **Category : Insects**

### **Aphids (Green peach aphid, Melon aphid) *Myzus persicae***

*Aphis gossypii*

#### **Symptoms**

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants

#### **Cause**

Insect

#### **Comments**

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed

#### **Management**

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

### **Armyworms (Beet armyworm, Western striped armyworm, etc.) *Spodoptera exigua***

*Spodoptera praefica*

*Beet armyworm larva*

#### **Symptoms**

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside

#### **Cause**

Insect

#### **Comments**

Insect can go through 3–5 generations a year

#### **Management**

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae

### **Cabbage looper *Trichoplusia ni***

*Cabbage looper*

#### **Symptoms**

Large or small holes in leaves; damage often extensive; caterpillars are pale green with a white lines running down either side of their body; caterpillars are easily distinguished by the way they arch their body when moving; eggs are laid singly, usually on the lower leaf surface close to the leaf margin, and are white or pale green in color

#### Cause

Insect

#### Comments

Insects overwinter as pupae in crop debris in soil; adult insect id a dark colored moth; caterpillars have a wide host range

#### Management

Looper populations are usually held in check by natural enemies; if they do become problematic larvae can be hand-picked from the plants; an organically acceptable control method is the application of *Bacillus thuringiensis* which effectively kills younger larvae; chemical sprays may damage populations of natural enemies and should be selected carefully

### **Cucumber beetles (Western striped cucumber beetle, Western spotted cucumber beetle, Banded cucumber beetle) *Acalymma vittata***

*Diabrotica undecimpunctata*

*Diabrotica balteata*

Pumpkin plant infested with cucumber beetles

Pumpkin plant infested with cucumber beetles

Banded cucumber beetle

Western spotted cucumber beetle

Western striped cucumber beetle

#### Symptoms

Stunted seedling; damaged leaves, stems and/or petioles; reduced plant stand; plants may exhibit symptoms of bacterial wilt; scars on fruit caused by beetle feeding damage; adult beetles are brightly colored with either a green-yellow background and black spots or alternating black and yellow stripes

#### Cause

Insect

#### Comments

Beetles overwinter in soil and leaf litter and emerge from soil when temperatures begin to reach and exceed 12.7°C (55°F)

#### Management

Monitor new planting regularly for signs of beetle; floating row covers can be used to protect the plants from damage but will need to be removed at bloom to allow bees to pollinate plants; applications of kaolin clay can be effective for management of small beetle populations; application of appropriate insecticides may be necessary

### **Cutworms Cutworms**

*Agrotis* spp.

*Peridroma saucia*

*Nephelodes minians*

and others

Cutworms will curl up into a characteristic C shape when disturbed

Cutworm larva severing plant stem

#### Symptoms

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5â€“5.0 cm (1â€“2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed

### Cause

Insects

### Comments

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato

### Management

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically

## Flea beetles *Epitrix* spp.

*Systema* spp

### Symptoms

Small holes or pits in leaves that give the foliage a characteristic â€œshot holeâ€ appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5â€“3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance

### Cause

Insects

### Comments

Younger plants are more susceptible to flea beetle damage than older ones; older plants can tolerate infestation; flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year

### Management

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application of diatomaceous earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied

## Squash bug *Anasa tristis*

*Squash bug nymphs*

*Close-up of squash bugs feeding on pumpkin fruit*

*Pumpkin leaves damaged by squash bugs*

*Pumpkin leaves damaged by squash bugs*

*Squash bug infestation on pumpkin*

*Squash bugs feeding on pumpkin leaves and fruit*

### Symptoms

Speckled leaves which turn yellow and brown; wilting plants; dieback of runners; blemished fruit; fruit death; adult

squash bugs are often misidentified as stink bugs; they are grey-black in color with orange and black stripes on the edges of their abdomen; nymphs are greenish gray in color and often covered in white powder; female squash bugs lay conspicuous copper colored eggs on the undersides of the leaves

#### **Cause**

Insect

#### **Comments**

Squash bugs overwinter in crop debris or under rocks and stones

#### **Management**

Destroy all crops residue as soon as possible after harvest or on plant death; apply row covers at planting to protect plants; organically acceptable control methods include applications of insecticidal soaps and oils

### **Squash vine borer *Melittia cucurbitae***

*Squash vine borer damaging vine*

#### **Symptoms**

Wilting plants; holes in vines or at base of petioles; green frass (insect excrement) visible around holes

#### **Cause**

Insect

#### **Comments**

Insect overwinters in soil as larvae or pupae and adults emerge in spring; adults lay eggs on leaves and larvae burrow into stems to feed

#### **Management**

Apply appropriate insecticide if eggs are found on leaves; plow plants into soil after harvest

### **Thrips (Western flower thrips) *Frankliniella occidentalis***

*Western flower thrips*

#### **Symptoms**

If population is high leaves may be distorted; leaves are covered in coarse stippling and may appear silvery; leaves speckled with black feces; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color

#### **Cause**

Insect

#### **Comments**

Transmit viruses such as Tomato spotted wilt virus; once acquired, the insect retains the ability to transmit the virus for the remainder of its life

#### **Management**

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic

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# Quince

## Description

Quince, *Cydonia oblonga*, is a bush-like deciduous tree in the family Rosaceae grown for its edible fruits. The tree has crowded, gnarled branches and a crooked growth habit. The leaves have a smooth upper surface and hairy lower surface. The tree produces single white-light pink colored flowers on tiny shoots and a large, fragrant, pome fruit. The fruit is initially covered in dense gray-white hairs but these disappear as the fruit ripens. The ripe fruit is a golden yellow color and resembles a pear or apple depending on variety. It has a soft, yellow pulp with a grainy texture protected by a thin skin. Quince trees can reach heights of 5–8 m (16–26 ft) and can live for periods in excess of 50 years and have an economic lifespan of approximately 25 years. Quince originates from Asia Minor.

*Quince fruit*

*Quince blossoms*

*Quince blossom*

*Quince fruit*

*Quince fruits*

*Quince fruits*

## Uses

Quince fruits are consumed fresh or may be used to make jams and jellies.

# Propagation

**Basic requirements** Quince trees grow well in a wide range of climates and soils but the plants shallow root system make it susceptible to drought or a low availability of water and additional irrigation may be required. Quince should be planted in full sun and will grow optimally at temperatures averaging 15°C (59°F). Quince trees are more tolerant of wet soils and drought than apple trees and, compared with other fruit trees, has good cold tolerance, being hardy to temperatures between -15 and -25°C (5 and -13°F respectively). Quince trees are easily damaged by strong winds and should be planted in a sheltered location which will also protect them from rapid temperature fluctuations which is also detrimental to their growth. **Propagation** Quince trees are usually propagated from hardwood cuttings or by budding onto a quince rootstock. Seeds can be grown but will not breed true to type and should not be used for commercial purposes where fruit quality is very important. Some varieties are not self compatible and require another variety for successful pollination and fruit production. Quince trees should be spaced 5–6 m apart (16–20 ft) apart, allowing 4–5 m (13–16 ft) between rows. **General care and maintenance** Quince trees are susceptible to fire blight and should not be fertilized excessively with nitrogen as this promotes vegetative growth which makes the trees more susceptible to the bacterium. Suckers should be removed by pruning from the tree in winter or early spring. Trees should be pruned in winter to thin out fruiting wood and stimulate new growth. If fruiting wood is pruned properly then fruits should not require thinning when the trees are bearing. Quince will benefit from regular deep watering during the summer months. **Harvesting** Quince fruits should be harvested when they are mature but not full ripe. Fruits will continue to ripen off of the tree and by harvesting in this manner, losses from fruit dropping from the tree are reduced. Fruit should be cut from the tree using a sharp knife as pulling them can cause damage to the skin.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### Brown rot *Monolinia* spp.

##### Symptoms

Death of young blossoms and associated twigs and leaves; small tan cankers with dark margins on twigs; gummy exudate at base of flowers; brown spore masses on flowers in humid conditions; infected fruit usually exhibit a rapidly spreading brown rot but may also take the form of small necrotic spots; infected fruits usually remain attached to the tree

##### Cause

Fungi

##### Comments

Fungus survives in mummified fruit on the tree, blighted blossoms, cankers and infected twigs; blossom and twig blights are promoted by periods of wet weather

## **Management**

The currently most effective method of controlling brown rot is through the application of appropriate protective fungicides timed so that they are applied when the susceptible flower parts are exposed or after a wet period; avoiding sprinkler irrigation protects the leaves and flowers from wetness that promotes the disease. Cultural control methods include: removing mummified fruit from tree, pruning infected twigs and reducing plant stress by providing adequate levels of water and fertilizer

## **Leaf blight (Leaf fleck) *Diplocarpon maculatum***

### **Symptoms**

Dark red spots on leaves; brown spots on leaves; leaves dropping from plant; small, raised purple spots with white centre on leaves; dark brown spots on leaves; no fruit produced; tree defoliation

### **Cause**

Fungus

### **Comments**

Fungus survives on plant debris

### **Management**

Remove all fallen leaves from orchard in Fall; avoid overhead irrigation; applications of appropriate fungicides may be required; orchards treated for scab are usually free of leaf blight

## **Category : Bacterial**

## **Fire blight *Erwinia amylovora***

### **Symptoms**

Blossoms wilting and dying; shoots shriveling and dying; cankers on branches; plant appears as if it has been scorched by fire; watery exudate may be present on infected areas

### **Cause**

Bacterium

### **Comments**

Bacterium overwinters in bark or cankers; spread by pollinating insects and by rain splash

### **Management**

Cut out diseased wood; treat with Bordeaux mixture or approved fixed copper materials for organic production; streptomycin or copper application to blossoms may be necessary to prevent spread

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# Radish

## Description

Radish, *Raphanus sativus*, is an herbaceous annual or biennial plant in the family Brassicaceae, grown for its edible taproot. The radish plant has a short hairy stem and a rosette (ground level horizontal and circular leaves) of oblong shaped leaves which measure 5â€“30 cm (2â€“12 in) in length. The top leaves of the plant are smaller and lance-like. The taproot of the plant is cylindrical or tapering and commonly red or white in color. The radish plant produces multiple purple or pink flowers on racemes which produce 2â€“12 seeds. The reddish brown seeds are oval, and slightly flattened. Radish is generally grown as an annual plant, surviving only one growing season and can reach 20â€“100 cm (8â€“39 in) in height depending on the variety. Radish may also be referred to by the name of the cultivar and names may include Chinese radish, Japanese radish or oriental radish. The origin of the radish plant has not been determined but they are found growing native from the Mediterranean to the Caspian Sea.

*Harvested radishes*

*Radish plants*

*Radish flowers*

*Radish flower*

*Radish seed pods*

*Radish*

## Uses

The radish root can be eaten fresh in salads or cooked with other ingredients such as meat. The leaves of the plant are also edible and can be used as a salad green.

## Propagation

**Basic requirements** Radishes are fast growing cool-season vegetables that grow very well in cool moist climates. The optimum temperature for the growth of radishes is between 10 and 18°C (50–65°F) and they grow best in a well-draining sandy loams which are rich in organic matter with a pH between 5.8 and 6.8.. Radish should be grown in full sun to part shade. **Propagation** Radish is propagated directly from seed into a prepared bed. Seeds should be planted in late winter to early spring for the first spring crop and plantings can be staggered to provide a continuous harvest. A small amount of nitrogen may be applied to the soil prior to planting (up to 60 kg per hectare). Seeds should be planted at a depth of 1 cm (0.5 in), allowing 2.5 cm (1 in) between individual plants and a further 30 cm (12 in) between rows.

Commercial producers may drill seeds using planting rates of 30–40 kg per hectare. **General care and maintenance** Radishes will benefit from the addition of small amounts of nitrogen fertilizer at regular intervals spaced over the growing season. Seedlings should be kept uniformly moist as they develop, but not wet. Weeds should be carefully removed from around the plants. **Harvesting** Radishes usually reach full maturity between 30 to 50 days after sowing. They should be harvested promptly as over-mature radishes become woody and develop a bitter taste. The plants may be topped by cutting back the leaves to a height of 7–10 cm (2.8–3.9 in) prior to harvesting, or whole plants can be pulled from the soil. Roots should be washed prior to storing to increase longevity.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Alternaria blight** *Alternaria* spp.

###### **Symptoms**

Yellow, dark brown or black circular spots on leaves with concentric rings on leaves, petioles, stems and/or flowers; center of lesions may dry and drop out, giving the leaf spots a shot-hole appearance; spots coalesce to form large necrotic patches; leaf drop may occur

###### **Cause**

Fungus

###### **Comments**

Disease emergence favors warm, wet weather

###### **Management**

Plant only certified, disease-free seed; treat seeds with hot water prior to planting; rotate crops to non-brassica species; irrigate plants in morning to allow sufficient time to dry out during the day; apply appropriate fungicide

### **Clubroot *Plasmodiophora brassicae***

#### **Symptoms**

Slow growing, stunted plants; yellowish leaves which wilt during day and rejuvenate in part at night; swollen, distorted roots; extensive gall formation

#### **Cause**

Fungus

#### **Comments**

Can be difficult to distinguish from nematode damage; fungus can survive in soil for periods in excess of 10 years; can be spread by movement of contaminated soil and irrigation water to uninfected areas

#### **Management**

Once the pathogen is present in the soil it can survive for many years, elimination of the pathogen is economically unfeasible; rotating crops generally does not provide effective control; plant only certified seed and avoid field grown transplants unless produced in a fumigated bed; applying lime to the soil can reduce fungus sporulation

### **Downy mildew *Peronospora parasitica***

#### **Symptoms**

Small angular lesions on upper surface of leaves which enlarge into orange or yellow necrotic patches; white fluffy growth on undersides of leaves

#### **Cause**

Fungus

#### **Comments**

Disease emergence favors cool damp weather

#### **Management**

Remove all crop debris after harvest; rotate with non-brassicas; it is possible to control downy mildew with the application of an appropriate fungicide

### **Fusarium wilt (Yellows) *Fusarium oxysporum***

#### **Symptoms**

Leaves turning yellow on one side of plant; leaves fall from plant leaving a defoliated stem

#### **Cause**

Fungus

#### **Comments**

Fungus can survive in soil for many years and can be spread to new areas via infected transplants, soil or on infested equipment. It may also be spread via infected water or by wind

#### **Management**

Disease can be effectively controlled by planting resistant radish varieties; once the pathogen has established, very little can be done to control it; spread can be prevented by sanitizing all equipment regularly; do not plant susceptible crops in previously infested soils

### **White rust *Albugo candida***

*White rust symptoms on radish*

#### **Symptoms**

White pustules on cotyledons, leaves, stems and/or flowers which coalesce to form large areas of infection; leaves may roll and thicken

**Cause**

Fungus

**Comments**

Fungus can survive for long periods of time in dry conditions; disease spread by wind

**Management**

Rotate crops; plant only disease-free seed; apply appropriate fungicide if disease becomes a problem

**Wirestem (Damping-off) *Rhizoctonia solani*****Symptoms**

Death of seedlings after germination; brown-red or black rot girdling stem; seedling may remain upright but stem is constricted and twisted (wirestem)

**Cause**

Fungus

**Comments**

Disease emergence favors cool, wet soils

**Management**

Plant pathogen-free seed or transplants that have been produced in sterilized soil; apply fungicide to seed to kill off any fungi; shallow plant seeds or delay planting until soil warms

**Category : Bacterial****Black root *Aphanomyces raphae*****Symptoms**

Small black-blue areas on roots which expand and girdle taproot; roots become constricted at site of lesions; black discoloration extends into root

**Cause**

Fungus

**Comments**

Fungus can survive in soil for prolonged periods

**Management**

Plant resistant radish varieties; rotate crops with non-brassica species

**Scab *Streptomyces scabies*****Symptoms**

Brown-yellow circular lesions on roots; sunken, cracked lesions which may be irregular in shape and coalesce

**Cause**

Bacteria

**Comments**

Disease also occurs in potato, turnip and rutabaga

**Management**

Management of scab can be very difficult; rotate crops to non-host for four years; maintain a high level of soil moisture; avoid increasing soil pH through soil amendments

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# Rapeseed (colza)

## Description

Rapeseed, *Brassica napus*, is an herbaceous annual or biennial member of the family Brassicaceae primarily grown for the oil which can be extracted from its seeds. The rapeseed plant has several erect, branched stems originating from a single base, the stems are purple in color towards the base. The leaves of the plant are bluish-green and mostly smooth. The basal leaves are stalked whereas the highest leaves grow straight off of the stem. The plant produces pale to bright yellow flowers which are 11â€“15 mm (0.4â€“0.6 in) in diameter, and after pollination the plant develops pods containing a single row of seeds. Each pod can contain 20â€“40 dark brown to black seeds. The rapeseed plant can reach 1.0â€“2.5 m (3.3â€“8.2 ft) and is grown as an annual, harvested after one growing season. Rapeseed may also be referred to as colza, oilseed rape, canola, swede rape or fodder rape and is believed to originate from the Mediterranean.

*Flowers*

*Seeds*

*Fruits of rapeseed*

*Flowers and fruit of rapeseed*

*Rapeseed fields*

*Rapeseed field*

*Flowers and seed pods*

*Rapeseed*

*Rapeseed flowers*

## Uses

The seeds of the plant are used to extract rapeseed oil which can be used as a cooking oil or in the production of margarine. Some recently developed cultivars have a high erucic acid content which is extracted for the production of industrial oil. Rapeseed is also grown as fodder for livestock.

## Propagation

**Basic requirements** Rapeseed is adapted to grow in cool, moist climates, requiring a temperature range of 2–10°C (35.6–56°F), although temperatures closer to 10°C (56°F) promote the most rapid growth. As a result, rapeseed is grown as a cool season crop in sub-tropical regions and a winter crop in more temperate areas. Rapeseed can be grown on a variety of soil types but medium textured, well-draining soils work best. Rapeseed should be grown in soil with a pH between 5.5 and 8.3. Rapeseed should not be grown in soil in which other brassicas have been grown within the past 3–4 years. **Propagation** Rapeseed is almost always propagated from seed which is sown in prepared fields by drilling in rows. Seeds are sown shallowly as the seeds are very small and seed should be sown at a depth of 2–3 cm (0.8–1.2 in). Spring crops of rapeseed should be drilled in rows 18–23 cm (7–9 in) apart, whereas winter crops require more space and should be drilled in rows approximately 40 cm (16 in) apart. **General care and maintenance** It is important to control weed growth in rapeseed fields as they can have a significant impact on the growth and productivity of the crop. Good preparation of the seedbed helps to limit weed growth. This is achieved by tilling the soil in the fall prior to planting, followed by shallow cultivation just prior to seeding. Rapeseed has a high nutrient requirement and a soil test should be carried out prior to planting in order to prevent nutrient deficiencies from occurring. Fertilizers are most successfully applied to the side of the seed furrows to prevent damage to the plants. Nitrogen fertilizer should be applied at a basic rate of 50–60 kg per hectare for spring planted rapeseed and 70 kg per hectare for winter crops. Fertilizer is commonly applied at time of sowing. In addition to nitrogen, rapeseed may also require the addition of phosphorus, potassium, sulfur and magnesium to the soil. The rate of application of these nutrients should be determined by a soil test. **Harvesting** Rapeseed is a fast-ripening plant and is ready for harvest when the seeds have turned from green to black in color. Rapeseed is mechanically harvested by combine or by swathing. In some countries, such as China, the crop is cut by hand.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Alternaria leaf spot** *Alternaria spp.*

##### **Symptoms**

Small dark spots on leaves which turn brown to gray; lesions may be round or angular and may possess a purple-black margin; lesions may form concentric rings, become brittle and crack in center; dark brown elongated lesions may develop on stems and petioles

##### **Cause**

Fungus

##### **Comments**

Disease emergence favors warm, wet conditions

##### **Management**

Plant only pathogen-free seed; rotate crops; applications of appropriate fungicides control disease when present

#### **Black rot** *Xanthomonas campestris*

##### **Symptoms**

Irregularly shaped dull yellow areas along leaf margins which expand to leaf midrib and create a characteristic "V-shaped" lesion; lesions may coalesce along the leaf margin to give plant a scorched appearance

##### **Cause**

Bacterium

##### **Comments**

Pathogen is spread via infected seed or by splashing water and insect movement; disease emergence favored by warm and humid conditions

##### **Management**

Primary method of controlling black rot is through the use of good sanitation practices; rotate crops to non-cruciferous crops every 2 years; plant resistant varieties; control cruciferous weed species which may act as a reservoir for bacteria; plant pathogen-free seed

#### **Downy mildew** *Peronospora parasitica*

##### **Symptoms**

Irregular yellow patches on leaves which turn light brown in color; fluffy gray growth on the undersides of the leaves

##### **Cause**

Fungus

##### **Comments**

Disease emergence favors cool temperatures; disease spreads quickly in wet conditions

##### **Management**

Remove all crop debris after harvest; rotate with non-brassicas; application of appropriate fungicides may be required if symptoms of disease are present

#### **Sclerotinia stem rot (White mold)** *Sclerotinia sclerotiorum*

##### **Symptoms**

Bleached stems; white fungal growth in or on the stems near the soil line; black fungal structures develop in the white fungal mass

##### **Cause**

Fungus

## **Comments**

Disease emergence favors moderate to cool temperatures and high humidity

## **Management**

Rotate crop to non-hosts (e.g. cereals) for at least 3 years; control weeds; avoid dense growth by planting in adequately spaced rows; apply appropriate foliar fungicides

## **White rust** *Albugo candida*

### **Symptoms**

White masses of fungal spores on the underside of leaves; green blisters on the leaves which turn white

### **Cause**

Fungus

### **Comments**

Fungus can survive for long periods of time in dry conditions; disease spread by wind

## **Management**

Rotate crops; plant only disease-free seed; apply appropriate fungicide if disease becomes a problem

## **Category : Bacterial**

## **Blackleg** *Leptosphaeria maculans*

### **Symptoms**

Circular gray lesions on the leaf surfaces with black specks forming in the center; cankers form on the stems later in the season and can cause plants to lodge and produce very little seed

### **Cause**

Fungus

### **Comments**

Disease emergence favors wet weather; disease stubble from previously infested crop is the main source of inoculum

## **Management**

Use of resistant varieties is very important in the control of the disease; pathogen varies in virulence throughout the world and rapeseed varieties therefore differ in susceptibility based on geographic location; rapeseed should be planted on a 3 year rotation to promote plant vigor and reduce disease susceptibility; crop stubble should be plowed into soil

## **Pests**

## **Category : Insects**

## **Cabbage aphid** *Brevicoryne brassicae*

*Cabbage aphid (Brevicoryne brassicae) on canola plant*

### **Symptoms**

Large populations can cause stunted growth or even plant death; insects may be visible on the plant leaves and are small, grey-green in color and soft bodied and are covered with a white waxy coating; prefer to feed deep down in cabbage head and may be obscured by the leaves.

### **Cause**

Insect

### **Comments**

Cabbage aphids feed only on cruciferous plants but may survive on related weed species.

### **Management**

Insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use.

## **Cutworms (Black cutworm) *Agrotis ipsilon***

### **Symptoms**

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5â€“5.0 cm (1â€“2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed

### **Cause**

Insect

### **Comments**

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato

### **Management**

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically

## **Flea beetles *Phyllotreta cruciferae***

### **Symptoms**

Small holes or pits in leaves that give the foliage a characteristic â€œshot holeâ€ appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5â€“3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance

### **Cause**

Insects

### **Comments**

Flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year

### **Management**

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application of diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied

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# Raspberry

## Description

Raspberry is the name given to two plant species in the genus *Rubus*, *Rubus idaeus* (red raspberry) and *Rubus occidentalis* (black raspberry) grown for their edible fruit. Raspberry plants have perennial root systems and biennial stems which are known as canes. The canes are woody, erect and shrub-like and generally undergo a period of growth one year and fruit production the next although primocane varieties exist that produce fruit in the first year. The canes may possess spines. Raspberry plants produce white or pink flowers with five petals which are surrounded by green sepals. After the plant has been pollinated, an aggregate berry is produced which consists of numerous druplets which are held together into the familiar raspberry fruit by tiny hairs. Raspberry canes can grow from 0.5 to in excess of 2 m (1.6â€“6.6 ft) in height and red raspberry will produce a commercial yield of fruit for 16â€“20 years, while black raspberry has a shorter lifespan and will produce for 4â€“8 years. Red raspberry may also be referred to as European raspberry, red garden raspberry or hindberry, while black raspberry may be referred to as blackcap raspberry and may have originated in the Ida mountains of Turkey.

*Raspberry foliage*

*Raspberry fruits ready to harvest*

*Raspberry blossoming*

*Raspberry cane with new shoot*

*Raspberry drupelets*

*Ripe raspberries*

## Uses

Raspberries are primarily consumed as a fresh fruit or may be processed into jams, jellies, juices and pulp.

## Propagation

**Requirements** Raspberry plants grow best in regions with cool summers and relatively mild winters. The plants are sensitive to high temperatures and grow best when daytime temperatures are around 25°C (77°F). Raspberries are best suited to well-draining sandy loams, rich in organic matter and have a pH between 5.5 and 6.5. Drainage is critical in raspberry propagation as the plants are susceptible to root rot. Plants require full sunlight and should not be planted in low lying areas where water may build up. Raspberries also require a post support system or trellis to support the weight of the fruit on the canes. Raspberry canes are biennial and produce fruit in the second year of growth. Canes in their first year of growth are called *primocanes* and those in the second year of growth are called fruiting canes or *floricanes*. The young canes are green in color, whereas the older floricanes are tougher and have a woody covering making them easy to tell apart. **Preparation** Soil may need prepared up to two years in advance of planting if major amendments are required. Acidic soil can be amended with lime to bring the pH up to a level suitable for raspberries. Organic content can be increased by planting a cover crop or by the addition of manure or compost. Avoid planting raspberries where peppers, eggplant, tomatoes or potatoes have been grown previously as these plants are host to *Verticillium* fungi which can cause root rot in raspberries. Choose a raspberry variety which is suited to your region. Red raspberries tend to be the most cold hardy, whereas black or yellow varieties are more sensitive. **Planting and trellising** Many raspberry varieties are very vigorous and using a support system such as a trellis will help to protect the canes from wind damage while also supporting the weight of the fruit crop. The trellis should be constructed before or at planting to avoid damaging the young plants after they are in the ground. The traditional method of supporting red raspberry canes is a post and wire system. This method involves running two wires about 60 cm (2 ft) apart vertically between wooden posts staked into the ground. The lower wire should be positioned 90 cm (3 ft) from the ground and the upper 1.5 m (5 ft) from the ground. The raspberry canes can then be tied to the wires. A second option is a T-trellis which is similar to the post and wire but the vertical wooden posts each have two cross bars to attach the wire. Two sets of wires run parallel to one another, one above the other. The vertical posts should be spaced 3.6–4.6 m (12–15 ft) apart with the lower wire positioned 90 cm (3 ft) from the ground and the upper 1.5 m (5 ft) from the ground. Raspberry plants in the home garden are usually grown from bare root plants or from tissue-cultured plants and should be planted in early Spring when the danger of any severe frosts has passed. The plants are usually planted in a row and the suckers will fill in the spaces to produce a hedge. Plant approximately 70 cm (27.5 in) apart, allowing 2.4–3 m (8–10 ft) between rows. **Pruning** Allow the raspberry plants to fill in the row to a width of about 30–38 cm (12–15 in) during the course of the growing season. Remove any suckers which are produced outwith this row. After harvest, cut the fruited canes of summer-fruited varieties to ground level. Select 6–8 of the strongest young canes on each plant and tie them to the supporting wires so that they are spaced 8–10 cm (3–4 in) apart. Cut all of the canes of Autumn fruiting varieties to ground level after harvest. Cut back canes as needed in the summer if required to prevent crowding.

T-trellis system

Raspberries are usually planted in a row and allowed to fill in to create a hedge

Post and wire trellis system

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### Cane blight *Leptosphaeria coniothyrium*

###### Symptoms

Purple black cankers form at wounds on young canes; cankers enlarge to encircle cane and cause wilting and death of lateral shoots; infected canes are often cracked and brittle, breaking easily; black specks (fungal fruiting bodies) may become visible in the cankers.

###### Cause

Fungus

###### Comments

Spread by rain splash from infected to healthy canes.

###### Management

Always plant raspberries in full sun and in an area with good drainage; plant only certified planting material; avoid over fertilizing plants; remove and destroy fruiting canes immediately after harvest; if pruning is necessary then make cuts during dry weather to allow wounds to heal before wet weather; control insect pests which may cause wounds to the canes such as crown borers and stem girdlers.

##### Gray mold *Botrytis cinerea*

*Rotting raspberry fruit covered with fungal growth of Botrytis cinerea (right) and Rhizopus sp. (left)*

###### Symptoms

Blasting symptoms (browning and drying) of one, or a cluster, of blossoms; soft, light brown areas on fruits which enlarge rapidly; berries become mummified and is covered in a gray powdery substance;

###### Cause

Fungus

###### Comments

Disease emergence favors high moisture and slow drying areas.

###### Management

Always plant raspberries in full sun and in an area with good drainage; plant only certified planting material; avoid over fertilizing plants; remove and destroy fruiting canes immediately after harvest; practice good weed management around the raspberry canes; harvest fruit frequently and during dry weather; remove and destroy diseased berries to reduce inoculum.

##### Raspberry leaf spot *Sphaerulina rubi*

*Symptoms*

*Severely damaged leaf*

*Infected leaves*

## Symptoms

The symptoms appear on young leaves as small dark green circular spots. As the disease progress the spots become light tan to gray color. Later the infected tissue may fall out. Severely infected leaves may fall off prematurely.

## Cause

Fungus

## Comments

Spores are spread by splashing water.

## Management

Remove infected crop debris and burn them. Provide proper air circulation around the plant. If the disease is severe, spray suitable fungicide.

## Spur blight *Didymella applanata*

Infected cane

Raspberry cane infected with spur blight

Spur blight (*Didymella*) on red raspberry.

## Symptoms

Purple-brown lesions on the stem just under the leaf or bud; lesions are usually on the lower portion of the stem; bark splitting on canes lengthways; brown triangular lesions may form on edges of leaves.

## Cause

Fungus

## Comments

Fungus is able to overwinter on diseased canes and disperse during rainfall and active wind.

## Management

Increase air circulation within the canopy by reducing the frequency of periods of leaf wetness (avoid overhead irrigation where possible) and thinning plants to reduce crowding; avoid excessive application of fertilizer, particularly nitrogen; practice good weed management; if disease is severe then an application of appropriate fungicide may be merited.

## Yellow rust *Phragmidium rubi-ideai*

Pustules of yellow rust (*Phragmidium rubi-ideai*) on the underside of raspberry leaves

## Symptoms

Yellow-orange pustules on underside of leaves; premature death of leaves, increased cold weather injury.

## Cause

Fungus

## Comments

Pathogen is not systemic and will not spread within the plant; spores are transmitted by wind.

## Management

Improve air circulation around the plants by pruning; removal of entire floricane and the first flush of growth on the primocane can greatly reduce the amount of inoculum but is not always economically feasible; growing raspberries in tunnels can greatly reduce incidence of disease if plants are protected before conditions are favorable to the rust pathogen.

## Category : Bacterial

## **Fire blight** *Erwinia amylovora*

<i>Damaged fruit cluster</i>	<i>Drying of cane to fire blight</i>	<i>cane tip become blackened, bend over and die which resembles the "shepherd's crook" appearance.</i>
<i>Infected berries</i>	<i>drying of berries</i>	

### **Symptoms**

The infected cane tip become blackened, bend over and die which resembles the "shepherd's crook" appearance. The affected cane may ooze cream colored bacteria under high humid conditions. If the infection continues down the cane, the leaf veins and surrounding tissue of the midvein turn black. Later whole leaf may wither and die. The infected berries do not mature, become brown, dry up, become very hard and remain on pedicel. Generally the infection is restricted to young growth of the plant.

### **Cause**

Bacterium

### **Comments**

The pathogen is transmitted by wind, rain splash and insects.

### **Management**

Use healthy and disease free seed materials. Remove and burn the infected parts.

## **Category : Viral**

### **Leaf curl** Raspberry leaf curl virus (RLCV)

*Chronic symptoms of raspberry leaf curl virus on raspberry cv. Lloyd George.*

### **Symptoms**

Leaflets small and rounded with margins curving downward and inward; new shoots yellowish, stiff, brittle, and shorter than previous year.

### **Cause**

Virus

### **Comments**

Transmitted by aphids.

### **Raspberry bushy dwarf** Raspberry bushy dwarf virus (RBDV)

### **Symptoms**

Yellowing leaves; reduction in cane height; crumbly fruit; reduced plant vigor.

### **Cause**

Virus

### **Comments**

Symptoms are not consistent from year to year; virus is transmitted through pollen.

### **Raspberry mosaic disease** Black raspberry necrosis virus (BRNV)

Raspberry leaf mottle virus (RLMV)

Rubus yellow net virus (RYNV)

Raspberry aphids (*Amphorophora agathonica*) feeding on black raspberry plants. This pest is a major culprit in spreading the black raspberry necrosis virus and raspberry mottle virus in North America.

### Symptoms

Short, fragile canes; mottled, puckered, upwardly arching leaves; green blister on leaves; downward curling leaves; yellow mottling.

### Cause

Virus complex

### Comments

Transmitted by aphids.

## Raspberry ringspot: TomRSV

Infected plant

Tobacco Ringspot Virus (*Nepovirus TRSV*) symptoms on raspberry

Tobacco Ringspot Virus (*Nepovirus TRSV*) infected plant

Symptoms of Tobacco Ringspot Virus (*Nepovirus TRSV*)

Raspberry ringspot nepovirus infection in raspberry cv. Malling Jewel, showing chlorotic blotches.

### Symptoms

Yellow rings on leaves; yellow leaf veins; delayed leaf development; yellowing of canes; poorly formed fruit.

### Cause

Virus

### Comments

Spread by several species of nematodes.

## Category : Oomycete

## Phytophthora root rot *Phytophthora fragariae*

Damaged root

The brownish area sharply demarcated from healthy tissue and the reddish discoloration on some roots.

Healthy raspberry roots (right) and roots infected by *Phytophthora fragariae* var. *rubi* (left). On infected plants, the secondary root system is completely destroyed, and wilting is then irreversible.

Wilting of a raspberry cane of two-years old due to phytophthora root rot

*Phytophthora fragariae* var. *rubi* infected root

Sudden wilt of suckers

### Symptoms

Canes show a lack of vigor and reduced stand; symptoms often more apparent in low lying areas of field or in 'dips' within rows; leaves on affected canes may take on a yellow, reddish or orange tinge and have scorched leaf edges; canes

which appear healthy may suddenly decline and collapse; infection can be confirmed by inspection of roots - infected plants will exhibit a characteristic brick red discoloration on scraping away the outer root surface.

#### **Cause**

Oomycete

#### **Comments**

Soilborne disease; emergence favors wet soil conditions.

#### **Management**

Once the disease has been introduced to a field then there is no method of treatment; good sanitation practices are important for preventing the introduction of the fungus into the plantation; always plant raspberries in well-draining soils or raised beds; one of the most effective methods of preventing the disease is to plant raspberry varieties which are resistant to the disease.

## **Pests**

### **Category : Insects**

#### **Weevils (Black vine weevil, Strawberry weevil, Clay-colored weevil) *Otiorhynchus* spp.**

*Full-grown larva; actual size about 6 mm or 1/4 inch*

*Black vine weevil (*Otiorhynchus sulcatus*) adult*

*Black vine weevil pupae*

#### **Symptoms**

Large notches chewed in leaves; reduced plant vigor and development; feeding damage to roots .

#### **Cause**

Insect

#### **Comments**

Adult stage coincides with harvest; hides in fruit; larvae feed on roots.

#### **Management**

Hand pick weevils from plants; adult beetles are nocturnal and hide in plant foliage during the day; chemical control can be difficult and involves spraying foliage or drenching soil with appropriate insecticides.

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# Rhubarb

## Description

Rhubarb is the name given to several species of herbaceous perennial plants in the genus *Rheum*, including *R. rharbarum* and *R. rhabonticum* (wild rhubarb), *R. rhabonticum* (garden rhubarb) and cultivated hybrid varieties designated as *R. hybridum* or *Rheum — hybrium* which are grown for their edible leaf stalks, or petioles. Rhubarb is a robust, clump forming plant. The large leaves are arranged in a rosette and have fleshy petioles which are often red in color and can reach 1.5 m (3.3–4.9 ft) in length. The leaves are large and palmate with an irregular undulating edge. The plant produces small, green-white flowers on the end of an erect stem. Rhubarb plants can reach 1.5 m (4.9 ft) in height and 2 m (6.6 ft) in diameter and petioles can be harvested for many years. Rhubarb is sometimes also referred to as pieplant and likely originated from Northern China and Siberia.

*Field of rhubarb*

*Rhubarb stalks*

*Rhubarb seeds*

*Rhubarb plant*

*Rhubarb leaf*

*Rhubarb (Brandy Carr Scarlet)*

*Rhubarb plant*

*Rhubarb foliage*

*Rhubarb crowns*

## Uses

The rhubarb petioles can be eaten fresh or cooked, usually with sugar to balance the sharp flavor of the plant. Rhubarb is a popular ingredient in pies and desserts.

## Propagation

**Basic requirements** Rhubarb grows best in temperate climates with cool summers and winters which result in the ground freezing. The plant requires winter temperatures below 4.4°C (40°F) to break dormancy. Rhubarb will grow optimally at temperatures of 15–20°C (59–68°F) and is adapted to high rainfall as long as there is adequate drainage. Plants will grow best in a fertile, well-draining soils rich in organic matter with a pH between 6.0 and 7.0.

**Propagation** Rhubarb can be propagated from seed but it is more common to grow from whole crowns or cut pieces of the crown (divisions). Each division of the crown should possess at least one healthy bud. Crowns should be planted as soon as possible after purchasing/dividing to prevent them drying out. This is best performed in early Spring to allow the new plants to establish in the soil. Choose a site that receives full sun. An area that receives afternoon shade may be beneficial in warmer areas. Prepare the site for planting by loosening the soil with a fork to a depth of approximately 25 cm (10 in). Incorporate organic matter such as a good quality compost or well-aged manure into the soil prior to planting and a small amount of fertilizer. Rhubarb crowns and divisions Planting should be planted at a depth of 5 cm (2 in) leaving 1 m (3.3 ft) between plants and 1.5–1.8 m (5–6 ft) between rows. Once in the ground, tamp the soil firmly around the crowns and water deeply. **General care and maintenance** Rhubarb requires regular watering during dry weather. A layer of organic mulch such as straw applied over newly planted crowns will help to conserve soil moisture while suppressing weeds. The soil should be kept moist but not wet. Rhubarb should be fertilized with nitrogen to promote vigorous and healthy growth. Nitrogen can be supplied at planting through the addition of well composted manure or a good quality compost. Nitrogen side-dressings should be made at regular intervals throughout the growing season. Rates should be adjusted based on the results of a soil test. **Harvesting** Rhubarb should not be harvested in the first year after planting if the plant is to be maintained as a perennial. In the second year, stalks may be harvested as they mature. Leaves should be fully mature prior to harvest. Stalks should be harvested by hand cutting. Always ensure that foliage remains on the plant. Do not overharvest.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### Gray mold *Botrytis cinerea*

##### Symptoms

Gray to brown discoloration of leaves; water-soaked areas which develop white-gray fuzzy growth under humid conditions; red-brown water-soaked areas developing on stalks

**Cause**

Fungus

**Comments**

Favors cool, damp, poorly ventilated conditions

**Management**

Allow plants adequate space when planting to promote good air circulation around the plants; application of appropriate fungicides can help to control the disease

**Category : Oomycete**

**Phytophthora root and crown rot** *Phytophthora* spp.

**Symptoms**

Depressed, brown lesions at base of stalks; leaves wilting; entire stalks collapse; crown and roots turn black and disintegrate

**Cause**

Oomycete

**Comments**

Disease emergence favors cool, rainy weather

**Management**

Plant rhubarb in well draining soils; avoid planting in soils where rhubarb has been grown in the past 4-5 years; mounding the soil can help to promote drainage around the plant

**Category : Other**

**Slugs** Various

**Symptoms**

Irregularly shaped holes in leaves and stems; flowers and fruit may also be damaged if present; if infestation is severe, leaves may be shredded; slime trails present on rocks, walkways, soil and plant foliage; several slug and snail species are common garden pests; slugs are dark gray to black in color and can range in size from 2.5 to 10 cm (1-4 in)

**Cause**

Mollusc

**Comments**

Slugs prefer moist, shaded habitats and will shelter in weeds or organic trash; adults may deposit eggs in the soil throughout the season; damage to plants can be extensive

**Management**

Practice good garden sanitation by removing garden trash, weeds and plant debris to promote good air circulation and reduce moist habitat for slugs and snails; handpick slugs at night to decrease population; spread wood ashes or eggshells around plants; attract molluscs by leaving out organic matter such as lettuce or grapefruit skins, destroy any found feeding on lure; sink shallow dishes filled with beer into the soil to attract and drown the molluscs; chemical controls include ferrous phosphate for organic gardens and metaldehyde (e.g. Buggetta) and carbaryl (e.g Sevin bait) for non-organic growers

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# Rice

## Scientific Clarification

The following are the crop details for Rice:

Scientific name: *Oryza sativa*  
Local names: Mchele(husked rice), Mpunga (upland rice)- Swahili  
Order: Cyperales  
Family: Poaceae  
Genus: *Oryza*

*Rice growing terraces in the Philippines*

*Mature Asian rice panicles*

*Rice terraces in Vietnam*

*Asian rice field*

*Asian rice with panicles*

*Asian "basmati" rice`*

## General Information

There are two species of cultivated rice in the world, *Oryza sativa* (Asian rice) and *Oryza glaberrima* (African rice). Both species are annual grasses (except in the tropics, where the plant can be perennial) that are cultivated for their grain which is considered a staple food in most parts of the world.

Asian and African rice plants are morphologically very similar and can be difficult to tell apart. They have rounded stems (called culms) which are divided into nodes and internodes. The plant leaves are borne on the nodes of the stem and are long and slender with a pronounced midrib.

The plant produces three flowers, two of which are reduced, on a spikelet on the terminal (last) internode of the stem. The rice grain is formed by the ripened ovary of the flower and is between 5 and 12 mm in length. Rice is an annual plant, harvested after one growing season, and can reach a height of between 1 and 1.8 m (3.3â€“ 5.9 ft) depending on the variety.

Rice is grown in four ecosystems, which are broadly defined based on water regimes. The ecosystems are irrigated rain-fed lowland and upland, and flood-prone.

Generally, African rice tends to form smaller, pear-shaped grains with red bran and olive to black seed coat and has several disadvantages compared with its Asian counterpart e.g. seed is easily scattered, the grain is difficult to mill and the crop gives a lower yield. The growing of Asian rice has therefore begun to supersede that of African rice in West Africa. Asian rice originates from China and African rice is believed to have been domesticated in areas around the Niger River in Africa.

## Rice Varieties in Kenya

"Sindano", highly susceptible to Rice Yellow Mottle Virus (RYMV), and "Basmati 217", highly susceptible to blast, have been grown since the 1960s.

Basmati 217: Grain yield 4.6 t/ha; very good cooking quality; resistant to RYMW and susceptible to blast.

Basmati 370: Grain yield of 5.3 t/ha; very good cooking quality; resistant to RYMW and susceptible to blast.

IR 2035-25-2: Grain yield of 5.5 t/ha; good cooking quality; moderately susceptible to RYMW and moderately resistant to blast.

IR 2793-80-1: Grain yield of 6.4 t/ha; good cooking quality; susceptible to RYMW.

BW 96: Grain yield of 9.0 t/ha; fair cooking quality; susceptible to RYMW and moderately resistant to blast.

UP 254: Grain yield of 6.4 t/ha; good cooking quality; moderately susceptible to RYMW and moderately resistant to blast.

AD 9246: Grain yield of 5.1 t/ha; good cooking quality; moderately resistant to RYMW and moderately susceptible to blast.

IR 19090: Grain yield of 5.8 t/ha; good cooking quality; moderately susceptible to RYMW and moderately resistant to blast.

The upland "NERICA" rice varieties were developed at the Africa Rice Center (AfricaRice) ex-WARDA. They are resistant to blast, RYMV stem borers, and leafminers and are high yielding and doing well from West Africa to Uganda.

In Kenya, they have great potential for medium altitudes with high rainfall or the possibility for irrigation. "NERICA" can be planted as other small grains, but does need irrigation, especially during flowering, and fertilization.

### Varieties in Tanzania

Supa: Optimal production altitude: 0-400 m; grain yield: 1.5-3.5 t/ha; moderately resistant to RYMV and sheath rot.

IR 54: Optimal production altitude: 400-600 m; grain yield: 4.0-7.0 t/ha; moderately resistant to bacterial blight and sheath rot.

IR 22: Optimal production altitude: 400-1000 m; grain yield: 6.6-8.0 t/ha; days to maturity: 120-135; resistant to bacterial blight.

Katrin: Optimal production altitude: 400-1000 m; grain yield: 6.6-8.0 t/ha; very low panicle shattering.

Dakawa: Optimal production altitude: 400-1000 m; grain yield: 3.5-5.2 t/ha; none-photoperiod sensitive; resistant to lodging except under high N levels; easy to thresh.

TXD 85: Optimal production altitude: 0-400 m; grain yield: 4.8-7.0 t/ha; moderately resistant to sheath rot, blast, and RYMV.

TXD 88: Optimal production altitude: 0-400 m; grain yield: 2.8-6.5 t/ha; moderately resistant to sheath rot, blast, and RYMV.

SARO 5: Optimal production altitude: 0-600 m; grain yield: 4.0-6.5 t/ha; susceptible to RYMV and sheath rot. Adapted to rain-fed lowlands and irrigated ecosystems.

Kalalu: Grain yield: 2-3 t/ha; resistant to RYMV and blast.

Mwangaza: Grain yield: 2-3 t/ha; resistant to RYMV and blast.

## Climate Conditions, Soil, and Water Management

Rice thrives on land that is water saturated or even submerged during part or all of its growth. Optimal temperatures for rice growing are 20 to 37.7°C, and no growth occurs below 10°C. The optimal pH is between 5 and 7, though rice has been grown in fields with a PH between 3 and 10. Rice will grow in altitudes ranging from 0 to 2500 m above sea level but worldwide is mostly grown on the humid coastal lowlands and deltas. Aquatic rice may require a dependable supply of fresh, slowly moving water, at a temperature of 21 to 29°C. Rain-fed rice requires an average of 800 to 2000 mm of rainfall well distributed over the growing season. If rainfall is less than 1250 mm annually, irrigation is used to make up the deficit. The crop is salt tolerant at some stages of growth; during germination but not seedling stages and has even been grown to reclaim salty soils. Terrain should be level enough to permit flooding, yet sloped enough to drain readily. The soils on which rice can grow are as varied as the climatic regime it tolerates, but ideally, it prefers a friable loam overlying heavy clay, as in many coastal and delta areas.

Zinc deficiency (2)

Zinc deficiency (1)

Nitrogen deficiency (2)

Plants showing Phosphorous deficiency

Symptoms of potassium deficiency (3)

Nitrogen deficiency

Symptoms of potassium deficiency (2)

Symptoms of potassium deficiency

Severe calcium deficit leaves

## Planting Procedure

Rice is always propagated by seed, which may be either broadcast or drilled directly in the field, or the seedlings may be grown in nurseries and transplanted. Direct seeding is done in dry or puddled soil. In puddled soil, the (pre-germinated) seeds are broadcast. The water level is kept at 0-5 cm under tropical conditions, but higher in temperate areas.

In dry soil, the seeds are sown after land preparation and covered lightly with soil by a tooth harrow. Germination occurs after heavy continuous rains. In upland rice cultivation the land is prepared in the dry weather and the rice is broadcast or dibbled in with the advent of the rains. Floating rice is cultivated in areas subject to deep flooding and the seed is sown

either dry or wet.

## Seedling production

The following are steps for producing healthy seedlings:

Seed selection: Select plump and healthy seeds.

Seed pre-treatment: This is practiced to secure better germination of seeds and better growth of seedlings. It involves:

Seed disinfection: Hot water treatment is effective in destroying the nematode *Aphelenchooides besseyi*, which causes white tip disease.

Seed soaking: To supply the required moisture for germination, shorten the germination period and reduce seed rotting. During the soaking period change water to remove poisonous substances and allow entry of fresh air.

Pre-sprouting: The seeds are drained and covered with grass for 24 to 48 hours. This ensures uniform seed germination, avoids sprouting, and allows air circulation for germination.

Sowing: Sowing 80 to 100 g/m<sup>2</sup> is normal practice. Broadcast seed uniformly. Do not submerge the nursery bed after sowing. Use a seed rate of about 20 kg/acre (50 kg/ha).

Seedbed preparation (nursery): Plough at least 2 weeks before sowing and flooding. Puddle 1 week before sowing and prepare a raised nursery bed. Drain the nursery bed the day before sowing to stabilize the surface of the soil. If the soil covering the nursery bed is too soft, sown grains are buried in the soil resulting in a poor establishment. For 1 ha of transplanted rice, a nursery of about 350 m<sup>2</sup> is required. Irrigate a few days after sowing so that the surface is kept moist, and as the seedlings emerge keep submerged conditions with water controlled at 1 to 3 cm according to the growth of the seedling. Raise the water level to 10 cm one day before uprooting to ease the washing off of soil that sticks to roots. This will make transplanting easy.

## Land Preparation

Preparation of land varies, even within the lowland rainfed-rice areas. Land can be prepared in the following ways:

Wetland tillage: This method is common in most tropical Asian countries. It consists of land soaking, in which water is absorbed until the soil is saturated. Ploughing, which is the initial breaking and turning over of the soil to a depth of 10-20 cm, is done using a wooden or light iron plough drawn by 1-2 buffaloes or oxen, preferably when there is 7.5-10 cm of water on the land and harrowing during which big clods of soil are broken and puddled with water. Puddling is important because it reduces moisture loss by percolation, better weed control, and ease of transplanting. The low redox potential of submerged puddled soil helps to conserve water-soluble nutrients, favors the accumulation of ammonium, increases biological nitrogen fixation, and increases the availability of phosphorus, silicon, iron, and manganese.

Dryland tillage: The land is prepared in the dry weather and the rice is sown just before the rains begin. This method makes it possible to have initial crop growth from early monsoon rains. Labor requirements for seed-bed preparation, land preparation, and transplanting are reduced and soil structure is better for stand establishment of the following non-rice crop. This method has its disadvantages: weed control is a major problem; percolation losses are high, making the chances of drought stress higher; and fertilizer requirements are often higher. To hold the water on the land and maintain it at the required depth, bunding and leveling are essential. The land is divided by contour bunds into fields, the size and shape of which vary with the topography. The bunds are usually made of clay, mud, and weeds, with controlled openings for the ingress and egress of water.

# Common Pests and Diseases

## Diseases

### Category : Bacterial

#### Bacterial leaf streak *Xanthomonas oryzae*

Advanced leaf streak symptoms in rice field

Bacterial leaf streak

Severely infected rice leaf

Initial symptoms of bacterial leaf streak on rice

#### Symptoms

Small, water-soaked streaks between leaf veins which are initially dark green and then turn translucent; streaks grow larger, coalesce and turn light brown in color; tiny beads of yellow colored bacterial exudate are common on the surface of the streaks; leaves turn brown and then gray-white in color before they die

#### Cause

Bacterium

#### Comments

Bacteria survive on infected seed and straw; bacteria may enter the plant through wounds; bacterial exudate can be spread in irrigation water; emergence of the disease is favored by high humidity and high temperatures; bacterial leaf streak is widespread in tropical Asia and West Africa

#### Management

Control of bacterial leaf streak is dependent on the use of resistant rice varieties and on planting of treated seed

#### Leaf scald *Microdochium oryzae*

#### Symptoms

As name suggest we will see scalded appearance on leaves. The lesion is marked with different zone from alternating light tan and dark brown from leaf tips or edges. As the leaves mature the lesion is with light brown halos. Margins and leaf tips are translucent.

#### Cause

Fungus

#### Comments

The symptoms may vary depends on cultivar, growth stage and plant density. The disease is severe in Latin America and West Africa.

#### Management

Grow resistant varieties. Treat the seeds with suitable fungicide. Apply only recommended quantity of nitrogen fertilizer in split dose.

#### Rice Bacterial blight *Xanthomonas oryzae* pv. *oryzae*

*Bacterial blight infected leaf*

*Bacterial leaf blight infected field  
and leaf*

*Bacterial blight infected leaves*

*Bacterial blight infected field*

### **Symptoms**

Water-soaked stripes on leaf blades; yellow or white stripes on leaf blades; leaves appear grayish in color; plants wilting and rolling up; leaves turning yellow; stunted plants; plant death; youngest leaf on plant turning yellow

### **Cause**

Bacterium

### **Comments**

One of the most important diseases of rice; disease found in tropical and temperate regions; greatest economic impact in Asia

### **Management**

Bacterial blight can be effectively controlled by planting resistant rice varieties; avoid excessive nitrogen fertilization; plow stubble and straw into soil after harvest

## **Category : Fungal**

**Bakanae** *Fusarium moniliforme*

*Bakanae infected plant in rice field*

### **Symptoms**

Seedlings are elongated, slender and pale; seedlings are stunted and chlorotic; death of seedlings; abnormal elongation of older plants which often makes them visible as they grow taller than uninfected plants in the field; sterile plants which do not produce panicles or produce empty panicles

### **Cause**

Fungus

### **Comments**

Disease transmitted through infected seed; disease emergence favored by high temperatures

### **Management**

Treating seeds with appropriate fungicides prior to planting can be very effective at controlling the disease; less susceptible rice varieties should be grown in areas where fungicide-treated seed is not available

**Brown spot** *Cochliobolus miyabeanus*

### **Symptoms**

Circular, brown lesions on seedling; distorted primary and/or secondary leaves on seedlings; black discoloration of roots; death of seedlings; circular or oval lesions with gray center and reddish-brown margin on older plants; death of large areas of leaves; brown or black spots on grain; reduced number of grains; reduced kernel weight

### **Cause**

Fungus

### **Comments**

Occurs wherever rice is grown; fungus overwinters on plant debris; disease emergence favored by water on surfaces of plant

### **Management**

Ensure plants are provided with correct nutrients and avoid water stress; chemical seed treatments are effective at reducing the incidence of the disease

### **False smut** *Ustilaginoidea virens*

*Individual grain transformed into smut*

*Cross-section of individual smut grain*

*False Smut*

#### **Symptoms**

The pathogen infect the rice plant during flowering stage and causes chalkiness of grain. The individual grains were covered with orange fungal mass in the beginning, later turns into greenish velvet color during sporulation stage and finally into charcoal black during spore maturation stage. It infect only few grains in spikelet. Recorded disease loss up to 75% in severe incidence. It also reduces market value of rice.

#### **Cause**

Fungus

#### **Comments**

It is seed born disease and may also affect seed germination.

#### **Management**

Treat seeds with hot water (52 C) for 10 min. Roughing the infected plants from field and from harvested grains. Keep the rice field and surrounding clean. Use resistant varieties. Maintain humidity in field by alternate wetting and drying.

### **Narrow leaf spot (Cercospora leaf spot)** *Cercospora oryzae*

*Narrow brown leaf spot infected leaves*

#### **Symptoms**

Short, elliptical or linear brown lesions on leaves; necrosis of leaves; blotchy pattern on leaves; premature ripening of kernels

#### **Cause**

Fungus

#### **Comments**

Disease occurs in major rice growing regions in tropical and sub-tropical Asia, Africa, Australia, North America, South America and Central America

#### **Management**

There are no chemical controls currently recommended for the treatment of the disease; treating seeds with hot water or appropriate fungicides prior to planting can reduce the incidence of the disease

### **Rice blast** *Magnaporthe grisea*

*Rice blast*

*Blast symptoms*

*Blast symptoms*

#### **Symptoms**

Lesions on all parts of shoot; white to green or gray diamond-shaped lesions with dark green borders; death of leaf blades; black necrotic patches on culm; rotting panicles

#### **Cause**

Fungus

## **Comments**

Most important disease of rice worldwide; causes most damage in areas of intense cultivation; disease emergence favors high soil nitrogen content

## **Management**

If disease is not endemic to the region, blast can be controlled by planting resistant rice varieties; avoid over-fertilizing crop with nitrogen as this increases the plant's susceptibility to the disease; utilize good water management to ensure plants do not suffer from drought stress; disease can be effectively controlled by the application of appropriate systemic fungicides, where available

## **Sheath blight *Rhizoctonia solani***

*Sheath blight symptoms*

*Water-soaked initial sheath blight lesion*

*Lesion on rice leaf sheath*

## **Symptoms**

Circular, oblong or elliptical, green to gray water-soaked spots on leaf sheaths; lesions with pale green or white center and purple-brown margin; lesions covering leaf sheaths and stems; poorly filled grains

## **Cause**

Fungus

## **Comments**

Occurs in all areas where rice is grown; second only importance to rice blast; most damaging in intensive rice production; spreads rapidly via irrigation

## **Management**

Avoid overfertilizing plants as excessive nitrogen application has been shown to increase susceptibility to the disease; applications of foliar fungicides may be required; two applications are recommended and should be timed so that the first application is made between the early internode elongation and the second application made on emerging panicles 10-14 days later

## **Stem rot *Magnaporthe salvinii***

*Stem rot infected plants*

## **Symptoms**

Symptoms generally begin to appear after the mid tillering stage; black lesions appear on outer leaf sheath at the water-line; lesions expand and begin to infect inner leaf sheaths and culm begins to rot; infections which reach the culm can lead to lodging of plants, unfilled panicles and death of tillers

## **Cause**

Fungus

## **Comments**

Fungus survives in crop debris in soil after harvest; fruiting bodies are carried to the surface when fields are flooded where they then infect leaf sheaths at the water line

## **Management**

Bury crop residue deeply in the soil after harvest; avoid excessive nitrogen fertilization; plant less susceptible rice varieties

## **Category : Viral**

## **Grassy stunt** Rice grassy stunt virus (RGSV)

### Symptoms

Stunted plants; short, narrow pale green or yellow leaves; mottled or striped pattern on newly unfolded leaves; irregular dark brown spots on leaves; few or no panicles produced;

### Cause

Virus

### Comments

Transmitted by leaf hoppers; disease widespread in rice growing regions of South and Southeast Asia, southern China, southern Japan and Taiwan

### Management

Several varieties of rice resistant to the leaf hopper vectors have been developed but the insects have overcome the resistance in several countries; applications of appropriate insecticides can help to reduce populations of vectors in temperate regions

## Tungro Rice tungro bacilliform virus (RTBV)

*Tungro virus infected field*

*Tungro virus infected leaves*

*Tungro virus infected plant*

### Symptoms

Plants are stunted with a yellow-orange discoloration; plants may have a reduced number of tillers and rust colored spots on leaves; leaves may be mottled, striped or exhibit interveinal necrosis

### Cause

Virus

### Comments

Disease is the most severely damaging virus of rice in South and Southeast Asia; virus is transmitted by leafhoppers

### Management

Rice varieties resistant to tungro virus have been developed and control the disease successfully; intense cultivation has led to the breakdown of the resistance by some virulent leafhopper strains; in Indonesia, the disease is successfully controlled by scheduling planting to obtain synchronous development and practicing crop rotation with resistant varieties

## Pests

### Category : Insects

#### Leafhoppers & planthoppers *Nephrotettix* spp.

*Recilia dorsalis*

*Nilaparvata lugens*

*Laodelphax striatellus*

*Sogatella furcifera*

Green Leafhoppers 1. *Nephrotettix virescens* 2. *Nephrotettix nigropictus*  
3. *Nephrotettix malayanus* Ishihara

a) *Nilaparvata lugens* male, b)  
*Nilaparvata lugens* female, c)  
*Sogatella furcifera* male, d) *S.  
furcifera* female, e) *Tagosodes  
orizicolus* male, f) *T. orizicolus*  
female, g) *T. cubanus*, h) *Nephrotettix  
virescens*, i) *Recilia dorsalis*.

## **Symptoms**

Plants may show no symptoms of leafhopper or planthopper damage; feeding punctures can leave the plants susceptible to bacterial or fungal infections; insects transmit many rice viruses; if infestations are severe, insects may cause plant to completely dry out; adults are pale green or brown winged insects with piercing-sucking mouthparts

## **Cause**

Insect

## **Comments**

Leaf and planthoppers transmit many rice viruses, including grassy stunt and tungro virus

## **Management**

Rotating crop for a period of one year is an effective and economical method of controlling hopper numbers; natural enemies and predators are often very successful at controlling hoppers and should be conserved by avoiding inappropriate use of insecticides which can damage their populations; planting resistant varieties is a very effective control method; chemical control with an appropriate insecticide may be necessary but should only be applied if the insects have reached an economic threshold

## **Mole cricket** *Gryllotalpa orientalis*

*Mole cricket*

## **Symptoms**

The insect is very destructive because it feeds on seeds, tillers of mature plants and roots. It mainly cuts the tillers at ground level and causes gaps in rice field. Usually the symptoms appear in patches.

## **Cause**

Insect

## **Comments**

We can see burrows of insect at sides of rice field and usually burrows will have heap of soil at entrance.

## **Management**

Use resistant varieties. Level the field properly and irrigate every 3-4 days after planting. Collect and kill the insects during land preparation. Avoid nurseries with raised bed to reduce cricket infestation during seedling stage. Improve biocontrol agents in field. If damage is large use food bait (commonly rice bran) mixed with insecticide and place along borders.

## **Rice bug** *Leptocoris oratorius F.* and *Leptocoris acuta Thunberg*

*Rice bug infested grains*

*Rice bug attacking spikelet*

## **Symptoms**

The insect attacks during spikelet stage of rice crop. Both nymphs and adults suck the content out of grains from pre-flowering spikelets to soft dough stage. This leads to unfilled, empty and discolored grains.

## **Cause**

Insect

## **Comments**

If the infestation is severe it may cause yield loss up to 30%.

## **Management**

Keep the field and surrounding area free from weeds which serve as alternative host for insect during non cropping season. Equal distribution of fertilizers and water in rice field to encourage even crop growth. Collect and kill insects

manually by using net during early morning and late after noon. Encourage biological control agents.

### **Rice case worm** *Paraponyx stagnalis Stagnalis* (Lepidoptera : Pyralidae)

*Nymphula depunctalis* (Guenee)

*Rice caseworm Nymphula depunctalis* (Guenee)

#### **Symptoms**

Case worm larvae scraps chlorophyll from leaves. Another important symptom is the larvae cuts off leaf tips and make cylindrical tubes around them. In infected field you can see cylindrical tubes attached to plants or floating on water surface.

#### **Cause**

Insect

#### **Comments**

The damaged leaf tissue looks like ladder.

#### **Management**

Drain water to remove floating larvae from field. Follow proper cultivation practices like nitrogen application and spacing. Encourage biological control agents like snails, spiders, lady bird beetles, dragon flies in rice field.

### **Rice gall midge** *Orseolia oryzae*

*Asian rice gall midge adult and eggs*

#### **Symptoms**

Gall midge maggot bore into bud or stalk of rice plant and feeds on internal content which leads to formation of tubular gall at the base of the tillers. This leads to elongation of leaf sheath which is commonly called as silver shoot or onion shoot. The leaves will be wilted, deformed and curled up.

#### **Cause**

Insect

#### **Comments**

It is common during tillering stage of rice crop.

#### **Management**

Grow available gall midge resistant cultivars. Follow proper cultural practices like crop rotation, ploughing the ratoon crop and other alternative hosts, planting early etc. Use light traps to attract adult flies and kill them. Conserve biocontrol agents in rice field.

### **Rice mealy bugs** *Brevennia rehi*

*Rice mealy bugs*

#### **Symptoms**

Both adult and nymphs feed on rice plant by sucking sap. The main symptoms are stunting and wilting of plants, yellowing and curling of leaves.

#### **Cause**

Insect

#### **Comments**

We can see white wax covered eggs, nymphs and adults on infected plants. The insects are common in field with well drained soil.

### Management

Augment biocontrol agents (like lady bird beetles, chloropid flies, spiders, small encyrtid wasps) in rice fields.

**Stem borers (Yellow stem borer, Striped stem borer, White stem borer, etc.)** *Scirpophaga incertulas*

*Chilo suppressalis*

*Scirpophaga innotata*

Stem borers symptom: 'deadheart' in seedling stage (12) and 'whitehead' after flowering (13)

Damage caused by stem borers: b) whitehead.

Rice stem borer

Adult rice stem borers

Yellow stemborer: *Scirpophaga incertulas*

### Symptoms

Longitudinal white patches on leaf sheaths; central leaf whorl drying out and turning brown; tillers drying out without producing panicles; panicles may dry out or may produce no grain; adult insects are nocturnal moths which lay their eggs on the leaves or leaf sheaths of the rice plants; larvae are legless grubs which feed on leaf sheaths before entering the stem of the plant

### Cause

Insect

### Comments

Stem borers are generally considered to be the most damaging insect pest of rice

### Management

Stem borers are difficult to control with insecticides as once they bore inside the stem they are protected from chemical sprays; in order for chemical control to be successful, repeated applications of appropriate insecticide must be made to the foliage; granular formulations give better control than sprays; clipping seedling prior to transplanting can successfully reduce moth numbers as eggs are laid at leaf tips; harvesting plants at ground level can remove the majority of larvae from the field; plowing or flooding the remaining stubble will kill off most of the remainder of the larvae in the field

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# Rosemary

## Description

Rosemary, *Rosmarinus officinalis*, is an erect, bushy evergreen shrub in the family Lamiaceae grown for its leaves which are used as a herb. The rosemary plant is usually erect in growth habit and possess branched woody stems with tufts of leaves. The leaves are opposite and usually bladelike and glossy green. The plant produces clusters of 5–10 blue, purple or pink flowers on short lateral branches and small oval fruit. Rosemary plants can reach 2 m (6.6 ft) in height and can be productive for many years (up to 30 if conditions are favorable for its growth). Rosemary originates from the Mediterranean.

*Rosemary*

*Rosemary flowers close-up*

*Rosemary flowers*

*Rosemary flowering*

*Rosemary foliage*

*Rosemary*

## Uses

Rosemary leaves can be used fresh or dried as a herb in cooking or in salads. The leaves and flowers can be used to extract rosemary oil which is used as a seasoning or as a scent in soaps and household products.

# Propagation

**Basic requirements** Rosemary is suited to both temperate and subtropical areas with most varieties growing optimally at temperatures between 6 and 24°C (39–75°F) in a well-draining loamy soil with a pH between 6.0 and 7.0. Rosemary plants require at least 6 hours of sun every day, direct sunlight being best. Rosemary can survive mild winters but will not tolerate temperatures that are regularly below -3°C (26.6°F). Established rosemary is very drought resistant. **Propagation** Rosemary can be propagated from seed, cuttings, or by air layering. Seeds germinate slowly, emerging after 3–4 weeks, and have a low germination rate so vegetative propagation is preferred. Cuttings should be taken from healthy, vigorous plants by taking a clipping about 7.6 cm (3 in) in length from the end of a branch. The leaves should be removed from the lower half of the cutting before planting in light textured potting media to root. The cutting should be watered regularly and kept moist, but not wet while they root. The new plants will be ready for transplanting after approximately 8 weeks. After hardening, transplants should be planted 45 cm (18 in) apart allowing 1.2 m (4 ft) between rows. **General care and maintenance** Rosemary is very prone to root rot and should therefore be planted in a well-draining soil and watered sparingly. Allow the soil to dry before watering, generally watering once every 1–2 weeks is sufficient but watering should be adjusted to suit climatic conditions. Plants will benefit from the regular addition of a balanced fertilizer. A layer of mulch will protect the plants over winter. **Harvesting** Rosemary can be harvested as soon as the plant is established in the ground and has reached a suitable size. Branches are harvested by cutting the terminal growth (25–30 cm/9.8–11.8 in) before they become woody. Rosemary can be harvested several times in one season but it is important to allow the plant to recover and replace growth before the next harvest.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Cottony soft rot** *Sclerotinia sclerotiorum*

###### **Symptoms**

Plants rapidly wilting and dying, often without turning yellow; as plants dry out they may turn straw yellow in color; small black fungal bodies (sclerotia) may be present on the surface of the root just below the soil line together with white fluffy mycelium; water soaked lesions may be present on the stem in Spring; infected tissues dry out and may become covered in white mycelium

###### **Cause**

Fungus

###### **Comments**

Disease emergence favors warm, humid conditions

###### **Management**

Plant only disease free material; if disease is known to be present rotate crops with non-hosts such as cereals which are a non-host

### **Downy mildew** *Peronospora lamii*

#### **Symptoms**

Leaves yellowing; white-gray fuzzy or downy growth developing on leaves

#### **Cause**

Fungus

#### **Comments**

Disease emergence favors cool, humid weather; disease spread favored by prolonged periods of wetness on leaves

#### **Management**

Promote good air circulation around plants by using adequate spacing; avoid wetting the foliage by watering the plant at the base

## **Category : Bacterial**

### **Crown gall** *Agrobacterium tumefaciens*

#### **Symptoms**

Galls of various sizes on roots and root crown below the soil line; galls may occasionally grow on the stems; galls are initially light colored bulges which grow larger and darken; galls may be soft and spongy or hard; if galling is severe and girdles the stem then plants may dry out and die

#### **Cause**

Bacterium

#### **Comments**

Disease enters through wounds on plant

#### **Management**

Only plant disease-free material; plant rosemary in well-draining soils; avoid wounding the plants as much as possible

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# Rutabaga

## Description

Rutabaga, *Brassica napus*, is an herbaceous biennial in the family Brassicaceae grown primarily for its edible root. The plant is believed to be a hybrid of turnip and wild cabbage. The leaves grow from a stout swollen stem (neck) close to the ground forming the crown of the plant. Rutabaga leaves are thick, smooth, and waxy. They are lobed and have a bluish hue. The plant produces light yellow flowers which are clustered at the top of a raceme. Unlike turnip, the flowers do not extend above the terminal buds. The taproot of the plant is a bulbous tuber, almost perfectly round, which can be purple, white, or yellow with yellow flesh. Rutabaga plants can reach a height of 30–46 cm (12–18 in) and although biennial, they are commonly grown as an annual, harvested after one growing season. Rutabaga may also be referred to as swede or yellow turnip and originates from Europe.

*Uprooted rutabaga plants*

## Uses

Rutabaga roots are usually consumed as a vegetable after cooking. The leaves are also edible and can be eaten fresh in salads or after cooking.

# Propagation

**Basic requirements** Rutabagas are cold hardy vegetables which can be grown early in the spring for a summer harvest or in the summer for harvesting in late fall. They prefer a fertile, well draining soil which has a pH between 6.0 and 7.0. The soil should have a loose texture for optimum root development. Rutabagas will grow best in full sun but will tolerate partial shade. The average daily temperature should fall between 10–18°C (50–65°F) for adequate growth.

**Planting** Rutabagas are usually direct seeded and can be sown as soon as the soil is workable in the Spring. For a Fall harvest, sow seeds about 2 months before the first frost in your area. Prepare the soil for planting by loosening it with a fork to a depth of about 30–38 cm (12–15 in). Remove any large rocks if present. Incorporate 2–4 inches of compost into the soil prior to planting. Sow seeds by broadcasting and raking 13 mm (0.5 in) into the soil. Thin seedlings to a final spacing of 7.5–10 cm (3–4 in). Alternatively, seeds can be sown in rows spaced 30–45 cm (12–18 in) apart. **General care and maintenance** Water rutabagas evenly and keep the soil moist for optimum growth. Mulching the plants will help to conserve moisture in the soil. Pull any weeds as they appear, the soil can be cultivated down to 2.5–5.0 cm (2–3 in) when the plants are small but this should be reduced as the plants grow larger to prevent damage to delicate feeder roots. **Harvesting** Rutabaga greens can be harvested from the plant when the leaves are about 10 cm (10 in) tall. If growing for both greens and roots then only remove 2–3 leaves from each plant. Roots are ready to harvest when they reach 2.5–7.5 cm (1–3 in) in diameter. Small rutabagas can often be harvested by gently pulling from the soil by hand but larger roots in heavier soil may need gently dug up with a garden fork. Store unwashed roots in a root cellar or basement.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Alternaria leaf spot** *Alternaria* spp.

###### **Symptoms**

Small dark spots on leaves which turn brown to gray; lesions may be round or angular and may possess a purple-black margin; lesions may form concentric rings, become brittle and crack in center; dark brown elongated lesions may develop on stems and petioles

###### **Cause**

Fungus

###### **Comments**

Disease emergence favors warm, wet conditions

###### **Management**

Plant only pathogen-free seed; rotate crops; applications of appropriate fungicides control disease when present

### **Anthracnose** *Colletotrichum higginianum*

#### **Symptoms**

Small circular or irregularly shaped dry spots which are gray to straw in color on leaves; a high number of spots may cause the leaf to die; lesions may coalesce to form large necrotic patches causing leaves to turn yellow and wilt; lesions may split or crack in dry centers

#### **Cause**

Fungus

#### **Comments**

Fungus overwinters on leaf debris and on related weeds; disease emergence is favored by moist, warm conditions

#### **Management**

Control of disease depends on sanitary practices; treat seeds with hot water prior to planting; rotate crops; plant in an area with good soil drainage; remove all cruciferous weeds which may act as a reservoir for the fungus

### **Black rot** *Xanthomonas campestris*

#### **Symptoms**

Irregularly shaped dull yellow areas along leaf margins which expand to leaf midrib and create a characteristic "V-shaped" lesion; lesions may coalesce along the leaf margin to give plant a scorched appearance

#### **Cause**

Bacterium

#### **Comments**

Pathogen is spread via infected seed or by splashing water and insect movement; disease emergence favored by warm and humid conditions

#### **Management**

Primary method of controlling black rot is through the use of good sanitation practices; rotate crops to non-cruciferous crops every 2 years; plant resistant varieties; control cruciferous weed species which may act as a reservoir for bacteria; plant pathogen-free seed

### **Cercospora leaf spot (Frogeye leaf spot)** *Cercospora brassicicola*

#### **Symptoms**

Angular or circular green to gray spots with brown borders on leaves; plant defoliation may occur in the case of a severe infestation

#### **Cause**

Fungus

#### **Comments**

Disease emergence favors cool temperatures and wet weather

#### **Management**

Plant only certified disease-free seed; avoid overhead irrigation; rotate crops to non-brassica species for 2-3 years; apply appropriate fungicide if disease emerges

### **Downy mildew** *Peronospora parasitica*

#### **Symptoms**

Irregular yellow patches on leaves which turn light brown in color; fluffy gray growth on the undersides of the leaves

#### **Cause**

Fungus

#### **Comments**

Disease emergence favors cool temperatures; disease spreads quickly in wet conditions

#### **Management**

Remove all crop debris after harvest; rotate with non-brassicas; application of appropriate fungicides may be required if symptoms of disease are present

## Pests

### Category : Insects

#### Cabbage aphid *Brevicoryne brassicaea*

*Cabbage aphid colony*

##### Symptoms

Large populations can cause stunted growth or even plant death; insects may be visible on the plant leaves and are small, grey-green in color and soft bodied and are covered with a white waxy coating; prefer to feed deep down in cabbage head and may be obscured by the leaves

##### Cause

Insect

##### Comments

Cabbage aphids feed only on cruciferous plants but may survive on related weed species

##### Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

#### Flea beetles *Phyllotreta* spp.

*Crucifer flea beetle*

##### Symptoms

Small holes or pits in leaves that give the foliage a characteristic "shot hole" appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5–3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance

##### Cause

Insects

##### Comments

Younger plants are more susceptible to flea beetle damage than older ones; older plants can tolerate infestation; flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year

##### Management

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous

plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application on diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied

## **Root maggots** *Delia* spp.

*Root maggots in soil*

### **Symptoms**

Scars and feeding tunnels on surface of turnip; root damage may be extensive; larvae are white or white-yellow in color, reach approx. 1 cm (0.3 in) in length and taper towards the head; adult insect is a small fly which resembles a housefly

### **Cause**

Insect

### **Comments**

Root maggots will attack all varieties of cruciferous plants; insect overwinters as pupae in the soil

### **Management**

If root maggots were problematic, avoid planting root crops in same area the following year; if crops are too badly damaged to harvest remove and destroy all crop debris; use of floating row covers can dramatically reduce damage to crops by preventing female flies from laying eggs - note, row covers only effective where root maggots are not already present; there are currently no pesticides registered for use on root maggots in the home garden in the USA

## **Wireworms** *Aeolus* spp.

*Anchastus* spp.

*Melanotus* spp.

*Limonius* spp

*Wireworms*

### **Symptoms**

Death of seedlings; reduced stand; girdled stems and white heads; wireworm larvae can be found in soil when dug round the stem; larvae are yellow-brown, thin worms with shiny skin

### **Cause**

Insect

### **Comments**

Larval stage can last between 1 and 5 years depending on species

### **Management**

Chemical control impossible in a standing crop, must be applied at preplanting or as a seed treatment; if wireworms are known to be present in soil fallow field during summer and till frequently to reduce numbers; rotate to non-host crop where possible; avoid planting susceptible crops after a wireworm infestation on cereals without either fallowing or applying appropriate pesticide

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# Rye

## Description

Rye, *Secale cereale*, is an herbaceous annual or biennial in the family Poaceae that is grown primarily for its grain. Rye has an erect slender stem topped with a curved spike which is 7â€“15 cm (3â€“6 in) length. The head is made up of individual spikelets each with two florets which produce 1â€“2 kernels. The spikelets are arranged alternately along the length of the head. The leaves of the plant grow from nodes on the stem and are lance-like blades, blue-green in color. Rye can reach 1â€“3 m (3.3â€“10 ft) in height and is either grown as an annual (spring rye) or biennial (winter rye). Modern rye does not occur naturally but is likely derived from wild ancestors found in Afghanistan, Iran and the Middle East.

*Rye ripening*

*Rye*

*Rye*

## Uses

Rye grain can be used to make alcoholic drinks such as whiskey, gin and beer or used as a livestock feed. Rye flour can be used to make bread. Rye is extensively grown as a winter cover crop to prevent soil erosion and the mature stems are commonly used as animal bedding.

# Propagation

**Basic requirements** Rye is a cool season annual grass which can be grown in a wide range of soils and climates. Rye grows best when planted in well draining sandy or light loams but can also be grown in clay soils. The optimum pH for rye growth is between 5.6 and 6.5. Rye will germinate when soil temperatures are between 4 and 5°C (39–41°F). Daily temperatures should not exceed an average of 20°C in order for the plant to grow adequately. Winter rye should be planted in fall to mid-winter depending on the variety and be overwintered for a summer harvest, while spring rye is planted in the spring for summer harvest. **Propagation** Rye is propagated directly from seed and can be sown by broadcasting or by drilling. Seeds should be sown to a depth of 2.5–5.0 cm (1–2 in) allowing 15–18 cm (6–7 in) between rows where seeds are drilled. Seeding If seeds are broadcast, they must be covered to ensure adequate germination. Seeding rates are generally between 100 to 150 kg of seed per hectare for winter rye and 150 to 200 kg per hectare for spring rye to produce a plant stand of 200-300 plants per square meter. **General care and maintenance** Rye fields should be kept free from weeds through the use of herbicides or by harrowing. Herbicides may be applied while the plants are at the tillering stage of growth. Rye will benefit from the addition of nitrogen which is often the biggest yield limiting factor in rye cultivation. Fertilizer should be applied when the crop begins to grow and the application may be split over two applications. **Harvesting** Rye is ready to harvest when the leaves are dead and the stems have turned yellow-brown in color. Rye is commonly harvested by combine but can also be harvested by hand.

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## Common Pests and Diseases

### Diseases

#### Category : Bacterial

##### **Bacterial blight (Bacterial leaf blight, Black chaff) *Xanthomonas translucens***

###### **Symptoms**

Water soaked spots on foliage; shriveling dead leaves; glossy yellow or brown streaks; plant appears stunted, slow plant growth

###### **Cause**

Bacteria

###### **Comments**

Disease spread through infected seed and splashing water

###### **Management**

Use only certified, disease-free seed; treat seeds with a fungicide prior to planting to prevent diseases which allow bacteria to enter easily; practice crop rotation to reduce disease build-up in soil

#### Category : Viral

## **Barley yellow dwarf** Barley yellow dwarf virus (BYDV)

### **Symptoms**

Stunted growth of plants; yellow green blotches at leaf tip, leaf margin or leaf blade; leaves turning bright yellow, red or purple

### **Cause**

Virus

### **Comments**

Transmitted by a few species of aphid; spread of disease is completely dependent on the movement of aphid vectors

### **Management**

Control of aphid population can provide some control of disease but is dependent on knowing which aphids are active in the field; planting to avoid periods of peak aphid activity can provide a measure of control

## **Category : Fungal**

### **Loose smut** *Ustilago tritici*

#### **Symptoms**

Early emergence of heads; dark green or black masses in place of kernels

#### **Cause**

Fungus

#### **Comments**

Spores rupture out from protective membrane on heads; fungus can survive in infected seed

#### **Management**

Use only certified smut-free seed; treat seeds with hot water prior to planting to kill fungi; treat seeds with systemic fungicide (fungi inside seed) fungicide; grow resistant varieties

### **Net blotch** *Drechslera teres*

#### **Symptoms**

Dark green water soaked spots; narrow brown blotches with netted appearance, surrounding tissue yellow; stripes running the length of leaf

#### **Cause**

Fungus

#### **Comments**

High humidity promotes spread of the disease

#### **Management**

Rotate rye with resistant crops; grow resistant varieties; remove and crop residue from soil surface; destroy volunteer rye plants

### **Powdery mildew** *Erysiphe graminis*

#### **Symptoms**

Patches of cottony, white-gray growth on upper surface of leaves which turn gray-brown; chlorotic patches develop on leaves opposite fungal growth; fungal fruiting bodies usually become visible as black dots on the mildew

#### **Cause**

Fungus

#### **Comments**

Disease emergence favors heavy nitrogen fertilization; high humidity and cool temperatures

#### **Management**

Planting resistant varieties is one of the best ways to protect plants from powdery mildew; other control strategies include: application of appropriate foliar fungicides, if available; removal of crop debris from field after harvest to reduce

the level of overwintering fungus; removal of volunteer wheat plants which can act as a reservoir for the disease

### Rust *Puccinia reconita*

#### Symptoms

Chlorotic flecks or brown necrotic spots on leaves or stems; yellow streaks or patches on foliage; brown necrotic streaks on foliage; raised orange pustules may be present on lesions

#### Cause

Fungus

#### Comments

Disease emergence favors moist weather and moderate temperatures

#### Management

The most effective method of controlling rusts is to plant resistant varieties of wheat; other methods of control include: destroying alternate hosts; applications of appropriate protective fungicides; growing wheat varieties that mature early

## Pests

### Category : Insects

#### Aphids (Bird cherry-oat aphid, Russian wheat aphid, Corn leaf aphid, etc.)

*Rhopalosiphum padi*

*Diuraphis noxia*

*Sitobion avenae*

#### Symptoms

Yellow or white streaked leaves; flag leaves may be curled up; plants may be stunted and tillers may lie parallel to the ground; plants may turn a purple color in cold weather; insects are small and soft-bodied and may be yellow, green, black or pink in color depending on species; insects secrete a sugary substance called "honeydew" which promotes the growth of sooty mold on the plants

#### Cause

Insect

#### Comments

Fields should be checked for aphid populations periodically after emergence

#### Management

Sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use; in commercial plantations aphid numbers are usually kept in check by predators and natural enemies; beneficial insect populations should be assessed before chemical control is considered; if no beneficial insect populations are present and aphids are damaging then apply appropriate insecticides

#### Armyworms (Armyworm, Western striped armyworm) *Mythimna unipunctata*

*Spodoptera praefica*

#### Symptoms

Entire leaves consumed; notches eaten in leaves; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside

#### Cause

Insect

## **Comments**

Insect can go through 3–5 generations a year

## **Management**

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae

## **Wireworms** *Aeolus* spp.

*Anchastus* spp.

*Melanotus* spp.

*Limonius* spp

## **Symptoms**

Death of seedlings; reduced stand; girdled stems and white heads; wireworm larvae can be found in soil when dug round the stem; larvae are yellow-brown, thin worms with shiny skin

## **Cause**

Insect

## **Comments**

Larval stage can last between 1 and 5 years depending on species

## **Management**

Chemical control impossible in a standing crop, must be applied at preplanting or as a seed treatment; if wireworms are known to be present in soil fallow field during summer and till frequently to reduce numbers; rotate to non-host crop where possible; avoid planting susceptible crops after a wireworm infestation on cereals without either fallowing or applying appropriate pesticide

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# Sage

## Description

Sage, *Salvia officinalis*, is a perennial shrub in the family Lamiaceae grown for its aromatic leaves which are used as a herb. Sage can be erect or grow along the ground and possesses a dense arrangement of woody stems with broad, elliptical, silvery-green leaves which are arranged alternately on the stems. The plant produces blue, pink or white flowers on a stalk. Sage plants generally grow to 40–70 cm (16–28 in) in height and can live to be 15–20 years old although they are usually replaced after 4–5 years in the garden when they become woody. Sage may also be referred to as common sage and originates from the Balkan peninsula.

Purple leaf sage

Sage flowers

Bumble bee visiting a sage flower

Sage flowering

Sage

Golden sage

## Uses

Sage leaves are used fresh or dry as a culinary herb. Oil can be extracted from the leaves and flowers of the plant and is used as a flavoring in alcoholic drinks and as a scent in perfume.

# Propagation

**Basic requirements** Sage grows best in a well draining, rich, clay loams with a pH between 6.5 and 7.0. It should be planted in full sun, although some afternoon shade is tolerated. Sage plants require warm temperatures and ample sunlight in order to produce a high essential oil content in the leaves. **Propagation** Sage is usually propagated from seed, although both cuttings, divisions and air layering is also successfully practised. The planting site should be warm, dry and protected from wind. Seeds should be sown after all danger of frost has passed leaving 23 cm (9 in) between seeds. Fertilizer may be added to the soil prior to planting to aid development. Plants should be thinned to a final spacing of 45 cm (18 in). **General care and maintenance** Sage plants should be pruned in early Spring to promote new growth, or after flowering in the summer. In addition to an application at planting, sage will benefit from a side dressing of fertilizer 6 to 8 weeks after planting. Sage will become very woody within 3-4 years of planting and should be replaced with new plants. **Harvesting** Sage is best harvested just before flowering when the essential oil content of the leaves is highest. Sage should be harvested by cutting the top 20 cm (8 in) of tender growth with a sharp knife. Commercial fields may be harvested by mowing but the highest quality product is achieved by harvesting only the leaves.

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# Common Pests and Diseases

## Diseases

### Category : Bacterial

#### Crown gall *Agrobacterium tumefaciens*

##### Symptoms

Galls of various sizes on roots and root crown below the soil line; galls may occasionally grow on the stems; galls are initially light colored bulges which grow larger and darken; galls may be soft and spongy or hard; if galling is severe and girdles the stem then plants may dry out and die

##### Cause

Bacterium

##### Comments

Disease enters through wounds on plant

##### Management

Only plant disease-free material; plant sage in well-draining soils; avoid wounding the plants as much as possible

### Category : Fungal

#### Mint rust *Puccinia menthae*

##### Symptoms

Small, dusty, bright orange, yellow or brown pustules on undersides of leaves; new shoots may be pale and distorted;

large areas of leaf tissue die and leaves may drop from plant

**Cause**

Fungus

**Comments**

May spread to or from nearby mint plants; remove infected plants

**Management**

Infected plants and rhizomes should be removed to prevent spread; heat treatment of roots may help to control the disease; roots should be immersed in hot water at 44°C (111°F) for 10 minutes, cooled using cool water and then planted as usual

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# Sorghum

## Description

### Crop Details

The following are the crop details for sorghum:

Scientific name: Sorghum bicolor

Order: Poales

Family: Poaceae (formerly known as Gramineae)

Genus: Sorghum

Local names: Swahili: mtama; Spanish: sorgo; French: sorgho; German: sorghum; Italian: sorgo; Portuguese: sorgo; Chinese (Mandarin): 索高 (Sōgāo); Japanese: 索高 (soroku); Hindi: ज्वार (jwar); Arabic: سُرْجُون (surqun)

### General Information

Sorghum is a type of cereal grain that belongs to the grass family Poaceae (formerly known as Gramineae). It is one of the top five cereal crops in the world, and is widely grown in Africa, Asia, and the Americas.

Sorghum is a tall, erect, annual grass that typically grows to a height of 1-2 meters. It has long, narrow leaves and produces large, compact clusters of grain on top of its stems. The grains are typically small and round, with a hard outer

layer that is difficult to remove. Sorghum plants come in many different colors, including red, brown, white, and yellow, and some varieties have a sweet taste.

The crop is hardy, can tolerate heat and drought, and is adapted to a wide range of soil types. It is a relatively low-maintenance crop, requiring less water and fertilizer than many other grains, which makes it an important crop for farmers in many parts of the world.

Sorghum spikelet

Sorghum

Sorghum plants

## Sorghum Varieties

Sorghum is a versatile crop that comes in many different varieties, each with its own unique characteristics and uses.

**Grain sorghum**, also known as milo, is the most widely grown type and is used for food, animal feed, and biofuel production. On the other hand, **sweet sorghum** has a high sugar content and is used for the production of sorghum syrup, molasses, and other sweeteners. **Forage sorghum**, which is primarily used for animal feed, is harvested for its leaves and stalks rather than its grain. There is also **broomcorn sorghum** grown for the production of brooms and brushes, which are made from the plant's long, stiff fibers. **Dual-purpose sorghum**, as the name suggests, is grown for both grain and forage and is used to feed both humans and animals. **High-tannin sorghum**, on the other hand, is grown for its high tannin content, which makes it resistant to bird and insect damage.

There are many specialty varieties of sorghum that are grown for specific uses, such as ornamental purposes, traditional medicine, and cultural practices.

## Climatic, soil, and water conditions

Sorghum is a highly adaptable crop that can grow in a variety of climatic, soil, and water conditions. However, there are certain optimal conditions for growing the crop that can maximize its yield and quality.

**Climate** : Sorghum is a warm-season crop that requires a long growing season with high temperatures and plenty of sunshine. It can tolerate drought, but excessive rainfall or humidity can increase the risk of diseases and reduce yield. Generally, sorghum grows well in areas with an average annual rainfall of 400–600 mm, although it can also be grown in areas with lower rainfall if there is access to irrigation.

**Soil** : Sorghum can grow in a wide range of soil types, from sandy to clayey, but it prefers well-drained soils with a pH between 5.5 and 7.5. It is important to have good soil fertility and adequate levels of nitrogen, phosphorus, and potassium for optimal growth and yield. The soil should also be free of weeds and other pests that can compete with sorghum for nutrients and water.

**Water** : Sorghum requires adequate moisture throughout its growing season, but it is also drought-tolerant and can survive in areas with limited water availability. It is important to have a reliable water source, either through rainfall or irrigation, to ensure that sorghum has enough water to grow and develop. However, overwatering can also be detrimental to sorghum, as it can lead to waterlogging and reduced yields.

Sorghum is a highly adaptable crop that can grow in a variety of climatic, soil, and water conditions. However, there are certain optimal conditions for growing sorghum that can maximize its yield and quality.

## Planting Procedure

The planting procedure for sorghum can vary depending on factors such as climate, soil conditions, and the specific sorghum variety being grown. However, there are some general guidelines that can help ensure the successful planting and growth of sorghum.

**Seed selection :** Choose high-quality sorghum seeds that are adapted to your climate and soil conditions. It is important to select seeds that are disease-free and have high germination rates.

**Land preparation :** Prepare the land by removing any weeds, rocks, or other debris that may interfere with planting. Till the soil to a depth of 15-20 cm to loosen the soil and improve drainage.

**Planting time :** Sorghum should be planted during the warmer months when the soil temperature has reached at least 15°C. The specific planting time will depend on the location and climate, but generally, sorghum is planted in the spring or early summer.

**Planting method :** Sorghum can be planted using various methods, such as direct seeding or transplanting. Direct seeding involves planting seeds directly into the soil, while transplanting involves starting the seeds in a nursery and then transplanting the seedlings into the field.

**Seed spacing :** Space the seeds according to the recommended spacing for your sorghum variety. Typically, sorghum seeds are planted in rows with a spacing of 60–75 cm between rows and 10–20 cm between seeds.

**Fertilization :** Apply fertilizers such as nitrogen, phosphorus, and potassium as recommended based on soil test results and the specific sorghum variety being grown.

**Irrigation :** Provide adequate water for the seeds to germinate and establish. The amount of water required will depend on the soil moisture level and the climate.

## Harvesting

The harvesting procedure for sorghum can vary depending on the specific variety, climate, and soil conditions. However, there are some general steps that can help ensure a successful and efficient harvest:

**Determine maturity:** Sorghum should be harvested when it reaches physiological maturity, which is when the seed head turns from green to yellow, brown, or red and the seeds become hard and difficult to dent.

**Timing :** The timing of the harvest will depend on the climate and variety, but generally, sorghum is harvested during the dry season, when the seeds have matured and dried out.

**Equipment :** Use appropriate equipment, such as a combine harvester or sickle, to harvest the sorghum.

**Cutting :** Use a sickle or combine harvester to cut the stalks near the base of the plant. The stalks can be cut at a height of 10-15 cm above the ground to leave some stubble for erosion control and soil conservation.

**Drying :** Allow the sorghum to dry in the field for a few days to a week to reduce moisture content and improve storage quality.

**Threshing :** Use a thresher or other equipment to remove the seeds from the seed head. Alternatively, the seed heads can be beaten with a stick to release the seeds.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Anthracnose** *Colletotrichum graminicola*

###### **Symptoms**

Small, circular red lesions with a distinct margin develop on leaves and stems; lesions may enlarge during humid weather conditions; plant becomes defoliated; tan spots with red margins may appear on upper parts of stems; plants may die before reaching maturity

###### **Cause**

Fungus

###### **Comments**

Disease emergence favors warm temperatures

###### **Management**

Plant resistant varieties; remove other susceptible plants e.g. Johnson grass; rotate crops; plow crop debris into soil after harvest

##### **Charcoal rot** *Macrophomina phaseolina*

###### **Symptoms**

Lower stalk appears shredded and dark gray; small, black fungal structures on internal parts of the stalk giving tissues a dark gray color; pith decomposes leaving only the outer stem tissue; infected plants will usually lodge

###### **Cause**

Fungus

###### **Comments**

Damage from the disease is usually greatest in fields which are subject to drought stress

###### **Management**

Plant varieties with strong stems; plant sorghum in fertile soil and avoid overcrowding unless using irrigation; use irrigation during flowering and grain-filling to reduce drought stress; rotate crop with cotton to reduce disease severity

## **Gray leaf spot** *Cercospora sorghi*

### **Symptoms**

Small red spots on leaves which enlarge to form rectangular lesions between leaf veins; lesions may coalesce to form stripes or irregular blotches

### **Cause**

Fungus

### **Comments**

Disease emergence is favored by periods of warm and wet weather during the growing season

### **Management**

Disease can be controlled by planting sorghum varieties that are tolerant or resistant to the disease

## **Rough spot** *Ascochyta sorghi*

### **Symptoms**

Small, oval or elongated red spots on leaves; lesions coalesce and develop hard black fungal fruiting bodies, giving the leaves a sandpaper-like texture; rough areas may become large enough to kill entire leaf

### **Cause**

Fungus

### **Comments**

Fungus survives between growing seasons on crop debris

### **Management**

Sorghum varieties with a high level of resistance should be planted in areas where the disease is problematic but the disease generally causes only minor losses when present

## **Smut (Covered Kernel)** *Sporisorium sorghi*

*Sporisorium* spp.

### **Symptoms**

Head replaced by brown, powdery mass of fungal spores covered by gray to brown membrane; entire head may be affected or fungus may be localized at the top, bottom or sides of the head; plants are usually of normal height

### **Cause**

Fungi

### **Comments**

Disease emergence favors cool dry soils

### **Management**

Disease can be controlled by growing resistant varieties and through the application of appropriate fungicides

## **Zonate leaf spot** *Gloeocercospora sorghi*

### **Symptoms**

Concentric or zoned patches of red and purple bands separated by straw colored or tan bands on leaves; spots often occur in a semi-circular pattern along leaf margins; salmon colored spore masses may develop on lesions during periods of wet weather

### **Cause**

Fungus

### **Comments**

Fungus may be able to spread via infested seed; common disease of sorghum during wet weather; fungus also attacks millet species

### **Management**

Losses can be reduced by rotating crop and practice of good sanitation by removing crop debris and susceptible weed species from the field

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# Soybean

## Description

Soybean, *Glycine max*, is an herbaceous annual plant in the family Fabaceae grown for its edible seeds. The soybean plant is usually an erect bush with woody stems and alternately arranged leaves. The leaves possess three individual leaflets which are oval or lance-like in shape, growing to a length of 3–10 cm (1.2–4.0 in). The soybean plant produces small white or purple flowers and curved seed pods which are 3–15 cm (1.2–6 in) in length and can contain between 1 and 5 seeds. The seeds can be a variety of colors including yellow, green, brown, black or a mottled combination. Soybean is an annual plant, surviving only one growing season and can reach heights of 0.2–1.5 m (0.7–1.4 ft). Soybean may also be referred to as soyabean or soya and originates from Northeast China.

*Soybean ready for harvest*

*Soybean ready for harvest*

*Healthy soybean field*

*Soybean pods*

*Hairs on soybean pod*

*Soybean flowering*

*Soybean flowering*

*Young cultivated soybean*

*Soybean*

## Uses

Soybean seeds can be used to make flour and dairy substitutes such as milk, margarine and yogurt and meat substitutes such as veggie burgers. Oil can be extracted from both the seeds and pods and the by product of the extraction is used as an animal feed. The oil from the plant is used in products such as paint, linoleum and soap. Soybean is also grown as a cover crop and used as animal fodder or hay.

## Propagation

**Basic requirements** Soybean is a short-day plant, requiring hot weather for optimum production. It can be grown year round in most parts of the tropics. Plants can be grown at ambient temperatures between 15 and 27°C (60–80°F) although temperature below 21°C (69.8°F) and above 32 (89.6°F) may reduce flowering. Temperatures exceeding 40°C (104°F) are detrimental to seed production. Soybeans are adapted to grow in a wide range of soils and climates but require adequate soil moisture for germination and seedling establishment. Plants are sensitive to waterlogging but are tolerant of drought conditions once established. Soybean grows best on a light, loose, well draining loam with a pH of 6.5. **Propagation** Soybean is propagated directly from seed. If seeds are to be planted in a field where soybean has not been grown in the 3–5 years previous, they should first be inoculated with nitrogen fixing bacteria. The seedbed should be prepared prior to planting by removing any crop residue, weeds and large stones. Tilling the soil helps to break up large clods of earth. Seeds may be sown mechanically or by hand. In tilled soils, seeds are usually planted at a depth 3.2–4.5 cm (1.25 to 1.75 in) in rows spaced 30 cm (11.8 in) apart. Alternatively, no-till planting may be used to plant seeds in the stubble of a previous crop without first cultivating the soil. With this method, seeds are drilled into the soil in rows spaced 17.8 cm (7 in) apart. No-till practices reduce soil erosion and reduces the loss of moisture in the soil. **General care and maintenance** Weeds are often a problem in soybean fields and can be reduced through good preparation of the seedbed and maintaining a weed-free seedbed for several weeks prior to planting. Weeds may be controlled with appropriate herbicides, where available, or through mechanical cultivation where necessary. Soybeans should be provided with irrigation at flowering and again at seed-set for maximum seed fill and optimal yield. Irrigation should be increased in sandy soils that do not retain as much moisture. Soybeans fix approximately half of the nitrogen they require for growth and the other half must be supplied from the soil or through fertilizer application. Soybean also requires an adequate supply of phosphorus and potassium and application rates should be based on the results of a soil test. **Harvesting** Soybeans are ready to harvest between 70 and 160 days after planting, depending on variety. Plants are ready for harvest when the leaves and stems have turned yellow and the seed pods brown to black. Soybeans for fresh use are cut while still green. Plants may be pulled by hand or cut with the use of a combine. Once cut, the seeds are removed from the pods by threshing.

*Soybean seedlings*

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# Common Pests and Diseases

## Diseases

### Category : Bacterial

#### Bacterial blight *Pseudomonas syringae*

Soybean infected with bacterial blight

Soybean infected with bacterial blight

##### Symptoms

Water-soaked spots on leaves which enlarge and become necrotic; spots may be surrounded by a zone of yellow discoloration; lesions coalesce and give plant a burned appearance; leaves that die remain attached to plant; circular, sunken, red-brown lesion may be present on pods; pod lesions may ooze during humid conditions

##### Cause

Bacterium

##### Comments

Disease can be introduced by contaminated seed; bacteria overwinters in crop debris; disease emergence favored by warm temperatures; spread is greatest during humid, wet weather conditions

##### Management

Plant only certified seed; plant resistant varieties; treat seeds with an appropriate antibiotic prior to planting to kill off bacteria; spray plants with an appropriate protective copper based fungicide before appearance of symptoms

#### Bacterial pustule *Xanthomonas campestris*

Bacterial pustule symptoms on soybean

Bacterial pustule symptoms on soybean

Bacterial pustule symptoms on soybean

##### Symptoms

Tiny pale green spots with raised centers on both upper and lower leaf surfaces which develop raised pustules in lesion center; pustules usually form in lesions on lower leaf surface; mottled brown areas may develop on leaves if lesions coalesce; small red-brown spots may develop on pods of some varieties

##### Cause

Bacteria

##### Comments

Disease is prevalent in soybean growing regions which experience warm temperatures and frequent rainfall during the growing season

##### Management

Plant varieties of soybean that are resistant to bacterial pustule; spray plants with an appropriate protective copper based fungicide before appearance of symptoms

### Category : Fungal

#### Rhizoctonia stem rot *Rhizoctonia solani*

##### Symptoms

Damping-off (pre- or post-emergence death) of seedlings caused by red-brown lesions which girdle the stem; lesions or cankers may be present on the stem of older plants and cause the death of the plant mid-season

**Cause**

Fungus

**Comments**

Disease emergence favors warm, dry soil and subsequent rainfall

**Management**

Treat seeds with an appropriate fungicide prior to planting; plant less susceptible varieties of soybean; plant only in well-draining soils

**Rust** *Phakopsora pachyrhizi*

*Rust symptoms on soybean*

*Rust symptoms on soybean*

**Symptoms**

Gray or red-brown water-soaked spots on leaves which turn tan to dark reddish brown in color lesions may also be present on stems, petioles and pods; volcano-shaped uredinia (spore producing structures) are present within the lesions; plants drop leaves and mature prematurely

**Cause**

Fungus

**Comments**

Rust development is favored by warm temperatures and periods of high humidity

**Management**

Plant soybean varieties that are resistant to rust; applications of appropriate foliar fungicides can help to control the disease

**Sclerotinia stem rot** *Sclerotinia sclerotiorum***Symptoms**

Upper leaves of plant become wilted and die; leaves turn a gray-green color and dry out; water-soaked lesions on stem nodes which change color from tan to white; lesions may girdle the stem and infection may spread to both side branches and pods; cottony white mycelial growth occurs on all infected plant parts

**Cause**

Fungus

**Comments**

Disease emergence favors cool, wet weather; pathogen is resistant to many fungicides

**Management**

Do not plant soybeans in fields where common bean, sunflowers or other susceptible crops have been grown the previous season; space plants in narrow rows; avoid excessive irrigation after plants are no longer flowering; plant soybean varieties that are less susceptible to the disease

**Septoria Leaf Blight** *Septoria glycines***Symptoms****Cause****Comments****Pests****Category : Insects**

## **Armyworms (Beet armyworm, Western striped armyworm) *Spodoptera exigua***

*Spodoptera praefica*

*Beet armyworm larvae feeding on soybean leaves*

### **Symptoms**

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside

### **Cause**

Insect

### **Comments**

Insect can go through 3–5 generations a year

### **Management**

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae

## **Cucumber beetles (Western striped cucumber beetle, Western spotted cucumber beetle) *Acalymma vittata***

*Diabrotica undecimpunctata*

*Spotted cucumber beetle on soybean*

### **Symptoms**

Stunted seedling; damaged leaves, stems and/or petioles; reduced plant stand; plants may exhibit symptoms of bacterial wilt; scars on fruit caused by beetle feeding damage; adult beetles are brightly colored with either a green-yellow background and black spots or alternating black and yellow stripe

### **Cause**

Insect

### **Comments**

Beetles overwinter in soil and leaf litter and emerge from soil when temperatures begin to reach and exceed 12.7°C (55°F)

### **Management**

Monitor new planting regularly for signs of beetle; floating row covers can be used to protect the plants from damage but will need to be removed at bloom to allow bees to pollinate plants; applications of kaolin clay can be effective for management of small beetle populations; application of appropriate insecticides may be necessary

## **Mexican bean beetle *Epilachna varivestis***

*Mexican bean beetle and damage to soybean foliage*

### **Symptoms**

Irregular patches of feeding damage on underside of leaves which causes the top surface of the leaf to dry out, giving the leaves a lacy appearance; insect will also damage flowers and small pods; pods may be damaged so badly that they drop from the plant; adult insect is an orange-brown beetle with black spots; larvae are fat-bodied grubs which taper at the end and are in rows of conspicuous spines

### **Cause**

Insect

### **Comments**

Beetles can decimate bean crops; beetles overwinter as adults and undergo 2-3 generations per year

### **Management**

Some bean varieties may be less attractive hosts for the beetle, e.g. snapbeans are preferred hosts over lima beans; early varieties may escape damage from beetles beetle populations can be reduced by removing overwintering sites such as brush and leaves on the ground; handpick larvae and adults; brush eggs from leaves and destroy; apply insecticidal soap to leaf undersides if infestation is heavy

## **Category : Others**

### **Brown spot** *Septoria glycines*

#### **Symptoms**

Upper leaves have light purple discoloration and a leathery appearance and bronzing of leaves may occur; red-purple angular or irregularly shaped lesions develop on both the upper and lower leaf surfaces and may coalesce to form large necrotic patches; multiple infections can cause chlorosis and defoliation of the plants; on petioles and stems, sunken red-purple lesions may develop and upper leaves appear blighted.

#### **Cause**

Fungus

#### **Comments**

Disease emergence favors warm, wet weather which promotes sporulation of the fungus; dry weather prevent the spread of the disease

#### **Management**

Plow crop residue into soil after harvest; plant soybean varieties that are less susceptible to the disease; rotate crops to a non-susceptible crop for at least one year; apply an appropriate foliar fungicide to protect plants from bloom to pod fill

### **Cercospora leaf blight** *Cercospora kikuchii*

#### **Symptoms**

Upper leaves turning yellow; purple-red lesions are present on leaves and coalesce to give the leaves a bronzed appearance; leaves develop a leathery texture; severe infections give leaves a blighted appearance and cause them to drop from the plant

#### **Cause**

Fungus

#### **Comments**

Disease development is favored by warm temperatures and high humidity

#### **Management**

No soybean varieties are immune to the disease but some have more resistance than others and can give some degree of control; crop debris should be plowed into soil following harvest to reduce build up of inoculum

### **Charcoal rot** *Macrophomina phaseolina*

#### **Symptoms**

Discoloration of stem at soil line; cankers on stem may spread upwards; leaves may wilt and drop from plant; numerous small black sclerotia (fungal fruiting bodies) develop in affected tissues and can be used to diagnose the disease

**Cause**

Fungus

**Comments**

Fungus had a wide host range and affects beans, tobacco, cowpea, pigeon pea and many other crops; disease is primarily spread via microsclerotia in the soil

**Management**

Organic soil amendments such as the addition of manure or neemcake can be used to reduce levels of inoculum in the soil

**Downy mildew** *Peronospora manshurica*

*Downy mildew symptoms on soybean leaf*

*Downy mildew symptoms on soybean leaf*

**Symptoms**

Yellow or pale green spots on upper surfaces of leaves which enlarge and coalesce to form yellow patches; lesions may turn gray-brown to dark brown with a yellow margin; fuzzy tufts of gray-purple mold develop on lesions on underside of leaves; infection of pods can cause seeds to be covered in masses of white mycelia with pods showing no external symptoms

**Cause**

Fungus

**Comments**

Disease emergence favors warm temperatures and periods of high humidity

**Management**

Treat seeds with an appropriate fungicide prior to planting; plow soybean residue into soil after harvest; grow soybean varieties which are resistant to the disease where possible; rotate crop away from soybean for a one year period

**Frogeye leaf spot** *Cercospora sojina*

*Frogeye leafspot lesions on soybean foliage*

*Frogeye leafspot lesions on soybean foliage*

**Symptoms**

Angular gray spots with purple to red-brown edges on leaves; brown to black fungal structures developing in the center of the spot; circular or elongated lesions where inner membrane of pod contacts the seeds;

**Cause**

Fungus

**Comments**

Disease emergence favors warm and humid conditions

**Management**

Plant high quality seed and use resistant varieties; rotate crop away from soybean for a period of 2 years; treat seeds with appropriate fungicide prior to planting; apply appropriate foliar fungicide

**Phytophthora rot** *Phytophthora megasperma***Symptoms**

Susceptible varieties of soybean may have water-soaked stems and yellowing leaves; yellowing occurs between leaf veins and along leaf margins; upper leaves of plant become chlorotic and wilted; tolerant soybean varieties may show stunted growth and slight yellowing

**Cause**

Oomycete

**Comments**

Disease emergence favors heavy, water saturated soil; flooded soil within 1 week of planting is most conducive to disease development

**Management**

Plant soybean varieties that are resistant to the disease - ensure variety is resistant to all races of fungus present in the field; treat seeds with an appropriate fungicide prior to planting; plant soybean in soil with good drainage

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# Spinach

## Description

Spinach, *Spinacia oleracea*, is a leafy herbaceous annual plant in the family Amaranthaceae grown for its leaves which are used as a vegetable. The spinach plant has simple leaves which stem from the center of the plant and measure about 2–30 cm (0.8–12.0 in) long and 1 to 15 cm (0.4–6.0 in) across. The leaves grow in a rosette and can appear crinkled or flat. The plant produces small yellow-green flowers which are 3–4 mm (0.1 in) in diameter. The flowers produce small fruit clusters which contain seeds. Spinach is an annual and survives only one growing season and can reach 30 cm (12 in) in height. Spinach originates from ancient Persia (now Iran).

*Red spinach leaf close-up*

*Red spinach leaves*

*Spinach flowers*

*Spinach leaves*

*Spinach*

*Young spinach plants*

## Uses

Spinach is eaten cooked as a vegetable and contains both large amounts iron, calcium, and other essential vitamins and minerals.

# Propagation

**Basic requirements** Spinach grows well in cool areas and can survive the first frost of temperate climates. It will germinate and grow optimally at temperatures between 4 and 16°C (40–60°F) but can withstand temperatures as low as -7°C (20°F). Spinach grows best in a well-draining loamy soil with a pH between 6.4 and 6.8. It is sensitive to acidic soil and if the pH is too high, adding lime is recommended. The soil temperature should not exceed 21°C (70°F).

**Propagation** Spinach is propagated from seed with round-seeded spinach usually being sown in early spring for a summer harvest and the prickly-seeded type which is usually sown in fall for harvest in winter and spring. Seeds should be planted at a depth of 1–2 cm (0.5–1 in) leaving 33–38 cm (13–15 in) between rows. When seedlings reach about 5 cm (2 in) in height they should be thinned out to a spacing of 8–10 cm (3–4 in) between plants.

**General care and maintenance** Spinach requires high levels of moisture, and if rainfall is inadequate, 2.5 cm (1 in) of water should be applied every 7–10 days. Spinach also has high requirements for nitrogen and potassium which should be provided by applying fertilizer based on the results of a soil test. Potassium poses little environmental risk and may be applied based on the results of a soil test. Timing of nitrogen applications vary by location as there is a risk of leaching during heavy rainfall. In the home garden, fertilizer is often not required as long as spinach is planted in a fertile soil. **Harvesting** Spinach leaves can be harvested as soon as they are large enough to use and may be harvested by hand or machine. Individual leaves may be harvested as required in the home garden or the whole plant can be cut. In commercial production, bunched fresh spinach is usually cut by hand. Spinach for processing may be cut by machine.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Anthracnose** *Colletotrichum* spp.

##### **Symptoms**

Small water-soaked spots on leaves which enlarge and turn tan or brown in color with a papery texture; if infection is severe, lesions may coalesce and cause severe blighting

##### **Cause**

Fungi

##### **Comments**

Disease emergence is favored by very wet weather; spores are spread by splashing water

##### **Management**

Only plant seed from disease-free plants; avoid sprinkler or overhead irrigation where possible, watering plants from the base to reduce leaf wetness; copper fungicides are sometimes used in the case of an epidemic but are largely ineffective at controlling the disease

## **Damping-off & Root rot** *Fusarium oxysporum*

*Rhizoctonia solani*

*Pythium* spp.

### **Symptoms**

Poor germination rate of seeds; death of newly emerged seedlings; stunted, yellow plants, particularly lower leaves; poor growth, wilting and collapse of older plants; roots may be water-soaked and discolored brown or black; necrotic lesions may girdle tap roots

### **Cause**

Fungus

### **Comments**

Symptomatic plants are often found in low-lying areas of the field or garden where water accumulates; disease symptoms are similar to symptoms caused by overwatering plants

### **Management**

Plant spinach in well draining soils; carefully manage irrigation to avoid saturating soil; use seed that has been treated with fungicide; avoid planting spinach successively in the same location

## **Downy mildew (Blue mold)** *Peronospora farinosa*

### **Symptoms**

Initial symptoms of the disease are yellow spots on cotyledons and leaves which enlarge over time and become tan in color with a dry texture; purple fungal growth is present on the underside of leaves; severe infestations can result in curled and distorted leaves

### **Cause**

Fungus

### **Comments**

Disease emergence favored by moist soil and cool temperatures

### **Management**

Plant varieties of spinach which are resistant to the disease; application of appropriate fungicides can help to protect the plant if applied before infection begins

## **Fusarium wilt** *Fusarium oxysporum*

### **Symptoms**

Yellowing of older leaves; plants reaching maturity early; premature death of plants; reduced seed production or death of plant before seed production takes place; vascular system of older plants may have a dark discoloration; seedlings may develop symptoms similar to damping off where cotyledons wilt and seedling dies; black lesions may be present on roots

### **Cause**

Fungus

### **Comments**

Fungus can survive on seed and can be spread to previously uninfested fields; disease emergence is favored by warm, acidic soil

### **Management**

Avoid planting spinach in soils known to be infested with Fusarium or where spinach has been planted the previous year; planting early can help protect the seedlings from the disease due to lower soil temperatures which are less favorable to the pathogen; avoid water stress to plants during flowering and seed set

## **White rust** *Albugo occidentalis*

### **Symptoms**

Yellow spots on upper side of leaves; clusters of white, blister-like pustules on underside of leaves which may spread to upper leaf surfaces in advanced stages of infection; infected plants show a loss of vigor and collapse if conditions are

favorable to rapid disease development

#### **Cause**

Fungus

#### **Comments**

Disease emergence favored by cool, humid nights and mild days

#### **Management**

Some spinach varieties are more tolerant of the disease than others; where protective fungicide applications are used, appropriate cultural control methods should also be utilized to reduce the risk of the pathogen developing tolerance to fungicide

## **Category : Viral**

### **Mosaic and other viruses** Cucumber mosaic virus (CMV)

Beet curly top virus (BCTV)

Tobacco rattle virus (TRV)

Tomato spotted wilt virus (TSWV)

etc.

#### **Symptoms**

Chlorotic leaves which may have necrotic spots, mosaic patterns or ringspots; leaves may be puckered and overall growth of plant is poor and stunted

#### **Cause**

Viruses

#### **Comments**

Transmitted by various insects such as aphids and thrips; Tobacco rattle virus is transmitted by nematodes in the soil and is not a common disease of spinach

#### **Management**

Practice good weed management around plants; insecticide applications are generally not effective at preventing the disease but can prevent secondary spread to neighboring fields

## **Pests**

### **Category : Insects**

#### **(Aphids, Peach aphid, Potato aphid) *Myzus persicae***

*Macrosiphon euphorbiae*

#### **Symptoms**

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distort, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants

#### **Cause**

Insects

#### **Comments**

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed

#### **Management**

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored

plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

## **Armyworms (Beet armyworm, Western striped armyworm) *Spodoptera exigua***

*Spodoptera praefica*

### **Symptoms**

ingular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside

### **Cause**

Insect

### **Comments**

Insect can go through 3–5 generations a year

### **Management**

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae

## **Cabbage looper *Trichoplusia ni***

### **Symptoms**

Large or small holes in leaves; damage often extensive; caterpillars are pale green with a white lines running down either side of their body; caterpillars are easily distinguished by the way they arch their body when moving; eggs are laid singly, usually on the lower leaf surface close to the leaf margin, and are white or pale green in color

### **Cause**

Insect

### **Comments**

Insects overwinter as pupae in crop debris in soil; adult insect is a dark colored moth; caterpillars have a wide host range

### **Management**

Looper populations are usually held in check by natural enemies; if they do become problematic larvae can be hand-picked from the plants; an organically acceptable control method is the application of *Bacillus thuringiensis* which effectively kills younger larvae; chemical sprays may damage populations of natural enemies and should be selected carefully

## **Wireworms *Aeolus* spp.**

*Anchastus* spp.

*Melanotus* spp.

*Limonius* spp

### **Symptoms**

Death of seedlings; reduced stand; girdled stems and white heads; wireworm larvae can be found in soil when dug round the stem; larvae are yellow-brown, thin worms with shiny skin

### **Cause**

Insect

### **Comments**

Larval stage can last between 1 and 5 years depending on species

### **Management**

If wireworms are known to be present in soil fallow field during summer and till frequently to reduce numbers; rotate to

non-host crop where possible; avoid planting susceptible crops after a wireworm infestation on cereals without either fallowing or applying appropriate pesticide

## Category : Mites

### Spinach crown mite *Rhizoglyphus* spp.

#### Symptoms

Leaves deformed; small holes in newly expanding leaves; mites are tiny and transparent, living deep in the crown of the spinach plant; damage can be done to newly emerged seedlings or to older plants

#### Cause

Arachnid

#### Comments

Mite infestation is favored by soils with a high organic content and by cool, wet weather conditions

#### Management

Destroy crop debris immediately after harvest; application of appropriate acaricide may be required if mites are damaging and weather conditions are cool and wet

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# Squash

## Description

Squash is the collective name given to several species of plant in the genus *Cucurbita*, including *C. maxima*, *C. mixta*, *C. moschata* and *C. pepo*, which are widely grown for their edible fruit. Squash plants are herbaceous annual plants which are either trailing vines or bush-like in morphology. Vines generally have large, lobed leaves and long vines which can climb by attaching to surfaces with their tendrils. Bushes generally take up less space than the sprawling vine types and may have prickly leaves. Squash plants produce yellow or orange flowers and green, white or yellow fruit in a variety of shapes and sizes with smooth or ridged skin. Vining squash varieties can reach several meters in length and, as annuals, survive only one growing season. Squash originate from North and Central America and are referred to by their cultivar name e.g. acorn squash, butternut squash, spaghetti squash, zucchini, banana squash, hubbard squash and buttercup squash.

Butternut squash

Zucchini flower

Galeux D'eysines squash and flower

Zucchini fruit

Zucchini foliage

Squash blossom

## Uses

Squash fruit can be cooked and eaten as a vegetable. Some varieties are grown as ornamentals.

## Propagation

**Basic requirements** Squash is a warm-season crop, requiring lots of sun and good drainage to develop optimally and growing best at temperatures between 18 and 25°C (65–75°F). Squash will yield best if grown in a fertile, well-draining soil, rich in organic matter and with a pH between 6.5 and 7.5. Squash should be planted in full sun and provided with ample soil moisture due to their shallow root system. Vining varieties can grow to very large sizes and require a good deal of space. Smaller bush varieties are available for more modest spaces. **Propagation** Squash is propagated from seed and can be direct seeded or sown indoors and transplanted. If direct seeding, seeds should be sown after the last frosts and when the soil has warmed to at least 15.6°C (60°F). Sow 1–2 seeds 1.3–2.5 cm (0.5–1.0 in) deep, at least 90 cm (~3 ft) apart if growing bush varieties and 120–150 cm (4–5 ft) apart if growing vining varieties. Allow a further 1–3 m (6–10 ft) between rows depending on the variety. If transplanting, seeds should be sown 3–4 weeks before the last frost date in your area and transplanted before the plants develop their second set of true leaves. Seeds sown both indoors and out require lightly moist soil for germination, care should be taken to avoid overwatering. Seeds should germinate in 5–10 days depending on the soil temperature. **General care and maintenance** Squash vines are sprawling and require plenty space to grow. Vines can be trained to grow on a trellis or fence. Squash also require a continuous supply of water and where drip irrigation is not being used, plants should be watered deeply once per week, providing at least an inch of water. Shallow watering or watering less frequently encourages a shallow root system. Mulches can be used to conserve soil moisture and black polyethylene mulch has the advantage of warming the soil. All squash varieties produce both male and female flowers (monoecious) and are pollinated by insects such as bees.

**Harvesting** Squash is ready to harvest when the rind is hard and cannot be punctured with a fingernail. The skin of mature fruits is dull and dry in appearance, especially when compared with the shiny skin of an immature fruit.

Squash seedling transplanted to garden

Squash seedlings in peat pots

Squash plant supported by a trellis

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Alternaria leaf blight** *Alternaria cucumerina*

##### **Symptoms**

Small, yellow-brown spots with a yellow or green halo which first appear on the oldest leaves; as the disease progresses, lesions expand and become large necrotic patches, often with concentric patterning; lesions coalesce, leaves begin to curl and eventually die.

##### **Cause**

Fungus

##### **Comments**

Disease is prevalent in growing areas where temperatures are high and rainfall is frequent.

##### **Management**

Cucurbits should be rotated with another crop every 2 years to reduce levels of inoculum; crop debris should be removed from the field as quickly as possible after harvest or plowed deeply into the soil; applications of appropriate protective fungicides can help to slow the development of the disease; water plants from the base rather than from above to reduce periods of leaf wetness which are conducive to the development and spread of disease.

#### **Alternaria leaf spot (Brown spot)** *Alternaria alternata*

*Alternaria leaf spot symptoms*

##### **Symptoms**

Initial symptoms appear as necrotic flecks on leaves with chlorotic halos; as the disease progresses, the flecks grow into spots which may join together into large, roughly circular lesions; if infestation is severe, leaves begin to turn yellow and die.

##### **Cause**

Fungus

##### **Comments**

Pathogen survives between growing season on crop debris.

##### **Management**

Crops debris should be removed from the field or plowed deeply into the soil after harvest; applications of appropriate protective fungicides can help reduce the incidence of the disease.

#### **Cercospora leaf spot** *Cercospora citrullina*

##### **Symptoms**

Initial symptoms of disease occur on older leaves as small spots with light to tan brown centers; as the disease progresses, the lesions enlarge to cover large areas of the leaf surface; lesions may have a dark border and be surrounded by a chlorotic area; the centers of the lesions may become brittle and crack.

##### **Cause**

Fungus

##### **Comments**

Fungus survives on plant debris; spread by wind and water splash; occurs mainly in tropical and subtropical growing regions.

## **Management**

Any diseased plants should be removed and destroyed to prevent further spread; crop debris should be removed after harvest or plowed deeply into the soil to reduce inoculum

## **Downy mildew** *Pseudoperonospora cubensis*

Diseased leaf

Lower surface

Downy mildew infected leaf

Symptoms on upper leaf surface

Symptoms on lower side of leaf

Infected leaf

Symptoms on lower surface of leaf

Downy mildew (*Pseudoperonospora cubensis*) squash leaf

Downy mildew symptoms on squash

Symptoms of downy mildew on underside of squash leaf

Close-up of downy mildew symptoms on squash

Downy mildew on squash foliage

### **Symptoms**

Small yellow areas on the upper leaf surface; brown lesions with irregular margins; gray mold on lower leaf surface.

### **Cause**

Fungus

### **Comments**

Disease emergence favored by moist conditions.

### **Management**

Do not overcrowd plants; avoid overhead irrigation, water plants from base; apply appropriate fungicide.

## **Fusarium crown and foot rot** *Fusarium solani*

### **Symptoms**

Wilting of leaves progresses to wilting of entire plant and plant dies within a few days; distinctive necrotic rot of crown and upper taproot when plant is uprooted; plant breaks easily below soil line

### **Cause**

Fungus

### **Comments**

Fungus can survive in soil for 2-3 years

### **Management**

Plant fungicide treated seed; rotate crops on 4 year rotation

## **Gummy stem blight** *Didymella bryoniae*

### **Symptoms**

Brown or tan spots of various sizes on leaves; leaves covered with lesions; stems splitting and forming cankers; wounds exude a brown, gummy substance; wilting vines; death of stems

### **Cause**

Fungus

### **Comments**

Disease may be seed-borne

### **Management**

Use disease free seed; treat seeds prior to planting; rotate crops every 2 years

## **Powdery mildew** *Erysiphe cichoracearum*

*Sphaerotheca fuliginea*

*Podosphaera xanthii*

*Powdery mildew symptoms on squash*

*Powdery mildew symptoms on squash*

*Powdery mildew symptoms on squash*

*Powdery mildew symptoms on squash foliage*

*Powdery mildew on squash leaf*

### **Symptoms**

White powdery growth on the upper surfaces of leaves and stems; infected areas stunted and distorted.

### **Cause**

Fungi

### **Comments**

Disease emergence favored by dry weather and high relative humidity.

### **Management**

Plant in sites with good air circulation and sun exposure; do not overcrowd plants; sanitize equipment regularly.

## **Septoria leaf spot** *Septoria cucurbitacearum*

### **Symptoms**

Initial symptoms of disease are small dark water-soaked spots on the leaves which turn beige to white in dry conditions; lesions develop thin brown borders and the centers may become brittle and crack; small white spots may erupt on the surface of infected butternut and acorn squash and pumpkin fruit

### **Cause**

Fungus

### **Comments**

Pathogen can survive on crop debris for periods in excess of 1 year

### **Management**

Scout plants during cool wet conditions for any sign of spots; early application of an appropriate protective fungicide can help limit the development of the disease if spots are found, cucurbits should be rotated with other crops every 2 years to prevent the build-up of inoculum; crop debris should be removed and destroyed after harvest

## **Verticillium wilt** *Verticillium dahliae*

### **Symptoms**

Symptoms generally appear after fruit set; chlorotic leaves which develop necrotic areas; leaves collapsing; symptoms only on one side of vine; discoloration of vascular tissue in roots

### **Cause**

Fungus

### **Comments**

Fungus can survive in soil for many years; disease emergence favored by cool or mild weather in Spring

## **Management**

Do not plant in areas where other susceptible crops have been grown previously; delay planting until temperatures are warmer

## **Category : Bacterial**

### **Angular leaf spot *Pseudomonas syringae***

#### **Symptoms**

Small water-soaked lesions on leaves which expand between leaf veins and become angular in shape; in humid conditions, lesions exude a milky substance which dries to form a white crust on or beside lesions; as the disease progresses, lesions turn tan and may have yellow/green edges; the centers of the lesions dry and may drop out leaving a hole in the leaf

#### **Cause**

Bacterium

#### **Comments**

Spread through infected seed, splashing rain, insects and movement of people between plants; bacterium overwinters in crop debris and can survive for 2.5 years

#### **Management**

Use disease-free seed; do not grow plants in field where cucurbits have been grown in the previous 2 years; protective copper spray may help reduce incidence of disease in warm, humid climates; plant resistant varieties

### **Bacterial leaf spot *Xanthomonas campestris***

#### **Symptoms**

Dark, angular lesions on leaves; leaf lesions may coalesce and cause severely blighted foliage; water-soaked lesions which enlarge and develop into tan scabs, or blisters, on the fruit; blisters eventually flatten as they reach their full size

#### **Cause**

Bacterium

#### **Comments**

Disease can spread rapidly in a field; disease can be introduced through contaminated seed

#### **Management**

Avoid overhead irrigation; rotate crops away from cucurbit species to prevent disease building up; use new seed each planting as saved seed is more likely to carry bacteria; apply appropriate protective fungicides; copper containing fungicides generally provide good control

### **Bacterial wilt *Erwinia tracheiphila***

*Squash plant infected with bacterial wilt*

*Squash plant infected with bacterial wilt*

*Strings of bacterial exudate between cut stem*

*Symptoms of bacterial wilt on squash stem*

*Squash plant infected with bacterial wilt*

#### **Symptoms**

Severely wilted vines; leaves appear dark green; dark discoloration on leaves and stems; rapid plant death

#### **Cause**

Bacterium

#### **Comments**

Spread by striped or spotted cucumber beetles; disease can be confirmed by cutting the stem and slowly pulling the two

ends apart - infected plants will ooze strings of bacterial exudate

### **Management**

Control cucumber beetle populations on plants; hand pick adult beetles and destroy; soil and foliar application of appropriate insecticides may help to control populations

## **Category : Other**

### **Aster yellows** Aster yellows phytoplasma

#### **Symptoms**

Foliage turning yellow; secondary shoots begin growing prolifically; stems take on a rigid, upright growth habit; leaves are often small in size and distorted, may appear thickened; flowers are often disfigured and possess conspicuous leafy bracts; fruits are small and pale in color

#### **Cause**

Phytoplasma

#### **Comments**

Disease is transmitted by leafhoppers and can cause huge losses in cucurbit crops

### **Management**

Remove any infected plants from the field to reduce spread; control weeds in and around the field that may act as a reservoir for the phytoplasma; protect plants from leaf hopper vectors with row covers

## **Blossom-end rot**

#### **Symptoms**

Symptoms first appear on immature fruits as small light brown spots close to the blossom end of the fruit; as fruit grow, the spots enlarge, resulting in dark leathery lesions sunken into the fruit

#### **Cause**

Nutritional disorder

#### **Comments**

### **Management**

Blossom-end rot is caused by a lack of calcium in the developing fruit and it occurs when the uptake of nutrients to the plant is disrupted; factors which disrupt nutrient uptake include drought, root damage or high soil salinity; application of excess nitrogen fertilizer may also contribute to the development of blossom-end rot as it promotes vigorous growth of vegetative tissues and depletion of calcium in the soil; watering plants evenly and regularly reduces the incidence of blossom-end rot

## **Category : Viral**

### **Cucumber mosaic** Cucumber mosaic virus (CMV)

#### **Symptoms**

Plants are severely stunted; foliage is covered in distinctive yellow mosaic; leaves of plant curl downwards and leaf size is smaller than normal; flowers on infected plants may be deformed with green petals; fruits become distorted and are small in size; fruit is often discolored.

#### **Cause**

Virus

#### **Comments**

Transmitted by aphids; virus has an extensive host range; can be mechanically transmitted via tools etc.

### **Management**

Control of the virus is largely dependant on the control of the aphid vectors; reflective mulches can deter aphid feeding; aphid outbreaks can be treated with mineral oils or insecticidal soap applications; some resistant varieties are available.

## **Cucurbit yellow stunting disorder virus** *Cucurbit yellow stunting disorder virus (CYSDV)*

Genus: Crinivirus

Group: "Positive sense ssRNA viruses"

### **Symptoms**

The symptoms generally appear on the older leaves first. Initially the symptom appears as chlorotic spotting which leads to interveinal chlorosis and followed by severe yellowing. The infected leaves may roll upward and become brittle. Also the infected plant may appear stunted.

### **Cause**

Virus

### **Comments**

The virus is mainly transmitted by whitefly *Bemisia tabaci*. The host range is restricted to the Cucurbitaceae (watermelon, melon, cucumber, squash, courgette etc.,).

### **Management**

Grow virus free and whiteflies free seed materials. During the growing season use yellow sticky traps to monitor and control whiteflies. Remove the infected plants and burn them. Keep the field free from weeds. In case severe infestation of whiteflies, use suitable insecticides. After a growing season remove the crop debris, volunteer plants and destroy them.

## **Squash mosaic** Squash mosaic virus (SqMV)

*Symptoms of squash mosaic on fruit*

*Symptoms of squash mosaic virus on leaves*

### **Symptoms**

Symptoms vary with variety being grown but plants can show symptoms which include green veinbanding, mottled leaves, blisters, ring spots or protruding veins at leaf margins; some squash varieties may develop leaf enations; infected plants are often stunted and fruits may be malformed with mottled skin

### **Cause**

Virus

### **Comments**

Virus can be transmitted through infected seed and spread by striped cucumber beetles

### **Management**

Use only certified disease-free seed

## **Watermelon mosaic** Watermelon mosaic virus (WMV)

### **Symptoms**

Symptoms vary widely depending on species, cultivar, virus strain and environmental conditions; symptoms on leaves may include green mosaic patterning, green vein-banding, chlorotic rings and disfigured leaves; infected fruits may develop green spots - particularly if fruit is yellow

### **Cause**

Virus

### **Comments**

Virus is found in almost all Cucurbit growing regions in the world; virus is spread by over 20 aphid species

### **Management**

Use of resistant varieties can greatly reduce virus incidence; treatments that control populations of aphid vectors can also reduce the incidence of the virus; spraying plants with mineral oils or insecticidal soaps can help to reduce aphid numbers

## **Zucchini yellow mosaic** Zucchini yellow mosaic virus (ZYMV)

### Symptoms

Infected plants are severely stunted and leaves can exhibit a variety of symptoms including yellow mosaic patternation, severe deformation, blistering, reduced size and necrosis; fruits are deformed

### Cause

Virus

### Comments

Disease can cause devastating epidemics when present

### Management

Use of resistant varieties, where available, is usually the most effective method of controlling the virus; control of aphid populations on the plants can be achieved through the use of mineral oils and insecticidal soaps but is rarely effective at controlling the virus

## Category : Oomycete

### Phytophthora crown and root rot *Phytophthora capsici*

*Rotting crown of yellow summer squash infected with Phytophthora*

*Phytophthora symptoms on pattapan squash*

*Wilting foliage of squash caused by Phytophthora infection*

*Dark discoloration of stem*

*Squash plant showing symptoms of wilt caused by Phytophthora root and crown rot*

### Symptoms

Sudden and permanent wilting of plant; leaves do not change color; plant death within a few days; roots and stem close to soil line discolored light to dark brown; plant easily removed from soil

### Cause

Oomycete

### Comments

Fungus can be spread through air; disease emergence favors high temperatures and water saturated soil

### Management

Efficient management of water to avoid saturated soil; avoid long periods of irrigation

## Pests

### Category : Insects

### Aphids (Peach aphid, Melon aphid) *Myzus persicae*

*Aphis gossypii*

*Aphid colony on underside of gourd leaf*

### Symptoms

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow

and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants

### Cause

Insects

### Comments

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed

### Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

## Armyworms (Beet armyworm, Western striped armyworm) *Spodoptera exigua*

*Spodoptera praefica*

*Beet armyworm larva*

### Symptoms

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside

### Cause

Insect

### Comments

Insect can go through 3–5 generations a year

### Management

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae

## Cabbage looper *Trichoplusia ni*

*Cabbage looper*

### Symptoms

Large or small holes in leaves; damage often extensive; caterpillars are pale green with a white lines running down either side of their body; caterpillars are easily distinguished by the way they arch their body when moving; eggs are laid singly, usually on the lower leaf surface close to the leaf margin, and are white or pale green in color

### Cause

Insect

### Comments

Insects overwinter as pupae in crop debris in soil; adult insect is a dark colored moth; caterpillars have a wide host range

## **Management**

Looper populations are usually held in check by natural enemies; if they do become problematic larvae can be hand-picked from the plants; an organically acceptable control method is the application of *Bacillus thuringiensis* which effectively kills younger larvae; chemical sprays may damage populations of natural enemies and should be selected carefully

## **Cucumber beetles (Western striped cucumber beetle, Western spotted cucumber beetle, Banded cucumber beetle) *Acalymma vittata***

*Diabrotica undecimpunctata*

*Diabrotica balteata*

*Striped cucumber beetle (Acalymma vittatum)* adults mass on squash leaf

*Banded cucumber beetle (Diabrotica balteata)* adult

*striped cucumber beetle (Acalymma vittatum)* adults and damaged leaf

*Striped cucumber beetle larval tunneling of base of winter squash*

*Striped cucumber beetle (Acalymma vittatum)* larval tunneling of base of squash plant

*Spotted cucumber beetle*

## **Symptoms**

Stunted seedling; damaged leaves, stems and/or petioles; reduced plant stand; plants may exhibit symptoms of bacterial wilt; scars on fruit caused by beetle feeding damage; adult beetles are brightly colored with either a green-yellow background and black spots or alternating black and yellow stripes.

## **Cause**

Insect

## **Comments**

Beetles overwinter in soil and leaf litter and emerge from soil when temperatures begin to reach and exceed 12.7°C (55°F).

## **Management**

Monitor new planting regularly for signs of beetle; floating row covers can be used to protect the plants from damage but will need to be removed at bloom to allow bees to pollinate plants; applications of kaolin clay can be effective for management of small beetle populations; application of appropriate insecticides may be necessary.

## **Cutworms *Agrotis* spp.**

*Peridroma saucia*

*Nephelodes minians*

and others

*Cutworm feeding on plant stem*

*Cutworm larva severing plant stem*

*Cutworms will curl up into a characteristic C shape when disturbed*

## **Symptoms**

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5–5.0 cm (1–2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed.

## **Cause**

Insects

## **Comments**

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato.

### **Management**

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically.

## **Flea beetles** *Epitrix* spp.

### **Symptoms**

Small holes or pits in leaves that give the foliage a characteristic “shot hole” appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5–3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance.

### **Cause**

Insects

### **Comments**

Younger plants are more susceptible to flea beetle damage than older ones; older plants can tolerate infestation; flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year.

### **Management**

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application of diatomaceous earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied.

## **Leaf miners** *Lyriomyza* spp.

*Leafminer damage on squash leaf*

### **Symptoms**

Thin, white, winding trails on leaves; heavy mining can result in white blotches on leaves and leaves dropping from the plant prematurely; early infestation can cause fruit yield to be reduced; adult leafminer is a small black and yellow fly which lays its eggs in the leaf; larvae hatch and feed on leaf interior

### **Cause**

Insect

### **Comments**

Mature larvae drop from leaves into soil to pupate; entire lifecycle can take as little as 2 weeks in warm weather; insect may go through 7 to 10 generations per year

### **Management**

Check transplants for signs of leafminer damage prior to planting; remove plants from soil immediately after harvest; only use insecticides when leafminer damage has been identified as unnecessary spraying will also reduce populations of their natural enemies

## Squash bug *Anasa tristis*

*Squash bug damage*

*Squash bug nymphs*

*Adult squash bug*

*Squash bugs on plant causing wilting leaves*

*Squash bug eggs on underside of squash leaf*

### Symptoms

Speckled leaves which turn yellow and brown; wilting plants; dieback of runners; blemished fruit; fruit death; adult squash bugs are often misidentified as stink bugs; they are grey-black in color with orange and black stripes on the edges of their abdomen; nymphs are greenish gray in color and often covered in white powder; female squash bugs lay conspicuous copper colored eggs on the undersides of the leaves

### Cause

Insect

### Comments

Squash bugs overwinter in crop debris or under rocks and stones

### Management

Destroy all crops residue as soon as possible after harvest or on plant death; apply row covers at planting; apply insecticidal soap or appropriate insecticide

## Squash vine borer *Melittia cucurbitae*

*Squash vine borer damage at base of squash plant; larva visible*

*Damage to squash vine by squash vine borer*

### Symptoms

Wilting plants; holes in vines or at base of petioles; green frass (insect excrement) visible around holes

### Cause

Insect

### Comments

Insect overwinters in soil as larvae or pupae and adults emerge in spring; adults lay eggs on leaves and larvae burrow into stems to feed

### Management

Apply appropriate insecticide if eggs are found on leaves; plow plants into soil after harvest

## Stinkbugs (Various) Various

*Brown stink bug*

### Symptoms

Dark colored pinpricks on fruit surrounded by a lighter area that turns yellow or remains light green; stink bugs often carry pathogens in their mouthparts which can cause secondary infections and decay of fruit; adult insect is shield-shaped and brown or green in color; may have pink, red or yellow markings; eggs are drum shaped and laid in clusters on the leaves; larvae resemble the adults but are smaller

### Cause

Insect

## **Comments**

Adult insects overwinter under leaves, on legumes, blackberries or on certain weeds such as mustard or Russian thistle

## **Management**

Remove weeds around crop which may act as overwintering sites for stink bugs and practice good weed management throughout the year; organically accepted control methods include the use of insecticidal soaps, kaolin clay and preservation of natural enemies; chemical treatments are not recommended for tomatoes that are to be processed for paste or canning unless secondary infections with other pathogens are a concern

## **Thrips (Western flower thrips, etc.)** *Frankliniella occidentalis*

*Western flower thrips*

### **Symptoms**

If population is high leaves may be distorted; leaves are covered in coarse stippling and may appear silvery; leaves speckled with black feces; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color

### **Cause**

Insect

### **Comments**

Transmit viruses such as Tomato spotted wilt virus; once acquired, the insect retains the ability to transmit the virus for the remainder of its life

## **Management**

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic

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# Starfruit (Carambola)

## Description

The Carambola tree, *Averrhoa carambola*, is a woody plant in the family Oxalidaceae grown for its fruit known as starfruit. Carambola trees are small, bushy evergreens with drooping branches. The tree possesses soft compound leaves composed of 2–5 leaflets which are green in color and arranged in a spiral around the branches. Each leaf is 15–20 cm (5.9–7.9 in) long and each leaflet 3.8–9 cm (1.5–3.5 in) long. The leaflets are oval or ovate in shape. The tree produces small lilac or purple flowers and The waxy fruit is orange-yellow in color, 7.5–12.5 cm (3.0–4.9 in) in length, oval and deeply ribbed. The Carambola tree has a lifespan of 40 years and reaches a height of 7–10 m (22–33 ft), spreading 6–7.6 m (20–25 ft) in diameter. Carambola may also be referred to as averrhoa, starfruit, five corner or coromandel gooseberry and originates from Southeast Asia.

*Fruit on branches*

*Carambola tree*

*Carambola flowers and fruits*

*Carambola flowers*

*Flowers and developing fruits*

*Carambola flowers*

*Carambola fruit*

*Carambola foliage*

*Carambola trunk*

## Uses

Carambola fruit can be eaten fresh or cooked and the juice can be used in iced beverages. The fruit is also used in relishes or as a seasoning.

## Propagation

**Basic requirements** Carambola is a tropical to subtropical tree which grows best in warm to hot temperatures between 20 and 35°C (68–95°F). Trees will generally cease to grow at temperatures below 18.3°C (65°F) although established trees can withstand short periods at -2.8°C (27°F). Carambola can be grown successfully in many soil types, from heavy clay to sandy soils but will perform optimally in a rich, well-draining loam with a pH between 4.5 to 7.0. Trees will not tolerate waterlogging but do require a moist soil for optimum production. **Propagation** Carambola is commonly grown from seed although veneer grafting onto suitable rootstock yields the best results for commercial production. Seeds only remain viable for a few days and should be plump and fully developed for propagation. Seeds should be planted in a well-draining potting media such as peat moss and will germinate in approximately 7 days depending on temperature. Once seeds have germinated, they should be transplanted into individual containers containing sandy loam soil. The seedlings should be kept in these containers until they are transplanted. Carambola trees should be planted in full sun and spaced 9 m (30 ft) apart. **General care and maintenance** Carambola trees require moist soil for optimum production. Young trees should be irrigated regularly after planting to promote establishment in the soil. Older trees should be watered regularly from flowering to fruit set. A layer of mulch around the trees will help to conserve moisture in the soil but should not be mounded up against the trunks. Young carambola will benefit from applications of fertilizer containing nitrogen, phosphorous, potassium and magnesium every 30 to 60 days. Established, mature trees should be fertilized 4 to 6 times per year. Young trees should be pruned in the first 1–2 years after planting by cutting the tips off of branches which are greater than 60–90 cm (2–3 ft) in length to encourage branching. Older trees should be pruned to maintain a manageable height. **Harvesting** Carambola fruit does not ripen off the tree and should be harvested when fully mature. Fruits are ready to harvest when they have turned from green to yellow in color, with the tips of the ribs remaining green. Fully ripe fruit naturally fall from the tree but can be picked earlier if desired.

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## Common Pests and Diseases

### Diseases

#### Category : Other

##### **Algal disease** *Cephaleuros virescens*

##### **Symptoms**

Orange, rusty pustules on leaves, stems, twigs and fruit; swelling tissue; leaves on infected twigs wilting and turning

yellow; dieback of shoots

#### Cause

Alga

#### Comments

Not usually a major problem but can be damaging when it emerges in unmanaged plantations; spread by water splash; disease emergence favors wet, humid conditions and poor air circulation

#### Management

Maintain proper irrigation, pruning and fertilization regimes in carambola plantations; appropriate copper based fungicides may be required to control the disease in severely infected plantations

### Category : Fungal

#### Alternaria black spot (Brown spot) *Alternaria alternata*

##### Symptoms

Small, circular light brown or black spots on skin of fruits; lesions develop sunken centres and olive-brown spores

##### Cause

Fungus

##### Comments

Fungi spread via wind and rain and enter plant via wounds

##### Management

Avoid wounding fruits during harvest

#### Anthracnose *Colletotrichum gleosporoides*

##### Symptoms

Tiny, slightly depressed light to dark brown spots which expand and make fruit soft; spots coalesce to form large irregular lesions; orange spore masses may develop; dark brown, oval shaped lesionunguss may develop on leaves

##### Cause

Fungus

##### Comments

Fungus is spread by wind, rain splash and insects

##### Management

Avoid wounding fruits during harvest

#### Cercospora leaf spot *Cercospora averrhoae*

##### Symptoms

Tiny necrotic or chlorotic spots on leaflets; spots grow larger and develop gray-white centers, reddish-brown margins and chlorotic halos; spots coalesce to form large lesions; leaves turn yellow and drop from palm

##### Cause

Fungus

##### Comments

Spores transmitted by rainsplash, wind, insects and irrigation water

##### Management

Plant carambola varieties that are more tolerant of the disease in areas where disease is present; disease can be controlled with regular applications of appropriate foliar fungicides

#### Flyspeck *Zygodiala jamaicensis*

##### Symptoms

Small black dots in roughly circular pattern on surface of fruit which can be rubbed off

**Cause**

Fungus

**Comments**

Symptoms resemble fly feeding damage; disease emerges in warm, wet conditions

**Management**

No specific treatments are currently recommended

**Category : Oomycete****Pythium root rot** *Pythium splendens*

*Pythium ultimum*

**Symptoms**

Canopy has sparse appearance; wilting during periods of water stress; foliage may show symptoms of nutrient deficiencies

**Cause**

Fungi

**Comments**

Disease most damaging during cool weather which is not optimum for the tree

**Management**

Plant only disease-free nursery stock; plant in areas with no history of the disease; avoid planting trees in low lying areas

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# Strawberry

## Description

Strawberry is the name given to several plant species in the genus *Fragaria*, including *Fragaria vesca* (wild strawberry), *Fragaria grandiflora*, *Fragaria magna*, *Fragaria chiloensis* and *Fragaria ananassa* (or *Fragaria x ananassa*) which are grown for their edible fruit. Strawberry is an herbaceous perennial in the family Rosaceae. The plant has a short stem and trifoliate leaves which form a crown close to the ground. The leaves display a variety of characteristics depending on the species, some are evergreen whereas some have leaves that will die and fall off in winter. The plant produces flower stalks from the crown and the flowers are white in color. The fruit of the plant is red and fleshy with small seeds on the outside. Strawberry can grow 20–25 cm (8–10 in) in height and has an economic life of 2–4 years before the plants are replaced. Strawberry may also be referred to as garden strawberry and the plant is grown in most northern temperate regions of the world. The first domestic hybrids were created in Europe.

Strawberry flower

Close-up of strawberry leaf

Close up of seeds of surface of fruit

Strawberry plants

Strawberry field

A ripe strawberry ready for harvest

## Uses

Strawberries are consumed as a fresh fruit or can be used to produce jams, jellies or preserves.

## Propagation

**Basic requirements** Strawberries grow very well in cool temperate climates, at temperatures below 30°C (86°F) and require at least 8 hours of sunlight per day. They can be grown successfully in a wide variety of soils from sandy soils to silty clay but will grow best in a deep, well draining loam rich in organic matter. The optimum pH for their growth is between 5.5 and 6.5. If drainage is poor then it is recommended to plant strawberry on beds raised by a minimum of 15–20 cm (6–8 in).

**Strawberry varieties** Strawberries generally fall into 3 categories: **June-bearing Evergreen Day-neutral** June-bearing plants commonly produce large fruits, and, as their name suggests, will produce a crop of fruit over a 2–3 week period around June. Evergreen strawberry varieties produce two (and sometimes 3) crops of fruit per year in spring and late summer or early fall. Day-neutral strawberry varieties will give you fruit in the first year, generally produce smaller fruits but will produce whenever the temperature is between 1.6–29°C (35–85°F).

**Propagation Seeds** It is generally considered to be more difficult to start strawberry plants from seed than it is to work with young plants. Depending on the variety of strawberry you have chosen, it may be necessary to cold treat your seeds before germination. This can be achieved by simply placing them in the freezer for 2–4 weeks before sowing.

Strawberry seeds should be sown in trays containing a good quality, sterile seed starting mix. Sow the seeds to a depth of 6 mm (0.25 in) and keep the soil moist (but not wet) while the seeds germinate. Seeds should germinate in 2–3 weeks. When the seedlings reach 2.5–5.0 cm (1-2 in) in height, thin the seedlings if they are too close together and repot or transplant to the garden when they have 3 leaves. If planting outside be sure to harden the seedlings off before you put them in the ground. **Runners** Strawberries produce offspring on a sideshoot known as a 'runner'. Runners can be removed from the mother plant and relocated. Simply plant the runners to the desired final spacing in a bed prepared similarly to planting seeds. **Planting** Begin preparing the strawberry bed as early as possible in the Spring when the soil becomes workable. Prepare the soil for planting by adding organic matter such as compost or well-rotted manure. Plant the strawberry transplants 38–60 cm (15–24 in) apart depending on variety and allow 90–120 cm (36–48 in) between rows. Be careful to plant so that the crown of the plant (the point from which the leaves emerge) is at the soil surface. If planted too deep, the plants may rot and if planted too shallow the plants may not take root. After planting, water the plants thoroughly. **General care and maintenance** In the first growing season after planting, the plants should not be allowed to produce fruit in order for the plants to concentrate their energy of vegetative growth. Pinch off any flowers as they are produced. Fruit can be harvested in the year after planting. When the desired density of plants is reached cut off any runners or cultivate with a hoe. Weeds should also be removed from the strawberry bed regularly. Strawberry plants also require adequate moisture and should receive 2.5–3.8 cm (1–1.5 in) of water per week either from rainfall or irrigation if needed. Strawberries will benefit from the addition of mulch which helps to conserve soil moisture and protects the plants from late frosts in Spring. If frost is forecast after planting the plants should be protected with row covers or other suitable material. Plants can also be protected with sprinkler irrigation. Row covers can also be used to protect the fruit from birds when fruiting. **Harvesting** Fruit should be harvested regularly (every other day) when it is being produced by picking the berry along with the cap and 0.5 in of stem. remove the berries by pinching the stem. Harvest only fully ripe strawberries as they will not ripen further after harvest.

Strawberry schematic showing runner

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## Common Pests and Diseases

### Diseases

#### Category : Bacterial

##### Angular leaf spot *Xanthomonas fragariae*

*Close up of diseased leaf*

*angular leaf spot of strawberry*

*Diseases leaf*

*Infected calyx*

*angular leaf spot lesions lower side*

*Angular leaf spot of strawberry  
(*Xanthomonas fragariae*)*

*Lower side of infected leaf*

*Strawberry leaf severely affected by  
*Xanthomonas fragariae*. Note its  
ragged appearance and the  
coalescence of the spots along the  
main veins.*

*Infected strawberry leaves*

*Angular leaf spot*

*Infected leaf*

*Lower surface of a strawberry  
leaflet affected by *Xanthomonas  
fragariae*. Angular, water-soaked  
and reddish-brown spots are evident*

*angular leaf spot of strawberry*

*Close up of angular leaf spot lesions  
on strawberry leaf*

*Symptoms of angular leaf spot on  
strawberry plant*

#### Symptoms

Very small water-soaked lesions on lower surfaces of leaves which enlarge to form dark green or translucent angular spots which ooze bacteria; lesions may coalesce to form reddish spots with a chlorotic halo.

#### Cause

Bacterium

#### Comments

Bacterium survives in crop debris and overwintering plants; can survive for long periods on plant debris but can not live free in soil; bacteria can be spread by splashing water.

#### Management

Use only certified planting stock; rotate crops and avoid overhead irrigation; chemical controls generally ineffective.

##### Leaf scorch *Diplocarpon earlianum*

*Overall view of strawberry plants with the fungal disease Leaf scorch caused by *Diplocarpon earlianum*.*

*Symptoms of leaf scorch on strawberry leaves*

*Close-up of leaf scorch lesion of strawberry leaf*

*Close-up of leaf scorch lesion on strawberry*

*Symptoms of leaf scorch on strawberry leaves*

*Leaf scorch lesions on strawberry*

### **Symptoms**

Irregular dark purple or brown blotches on upper leaf surface which may coalesce to produce large purplish brown patches; tissue between blotches may turn purple or red; lesions may also develop on flowers and fruits; affected petals may wither and drop from plant; lesions may girdle peduncles causing death of fruit.

### **Cause**

Fungus

### **Comments**

Disease emergence favored by wet foliage for extended periods of time.

### **Management**

Plant resistant varieties; regular renewal of plants; plant in an area with good air circulation and drainage in full sun; remove all foliage from plants at harvest; application of appropriate foliar fungicide may be required to provide control.

## **Category : Fungal**

### **Anthracnose *Colletotrichum fragariae***

*Colletotrichum gloeosporioides*

*Colletotrichum acutatum*

*Infected fruit*

*Infected leaves*

*Infected stem*

*anthracnose (*Colletotrichum acutatum*) infected stem*

*Fruit with symptoms of Anthracnose fruit rot. Note: Single, yellowed fruit on far left is not infected with Anthracnose fruit rot.*

*Salmon-colored anthracnose fruiting bodies (acervuli) on a strawberry fruit*

*Discoloration of stem*

*Anthracnose fruit rot*

*Gelatinous matrix of orange *C. acutatum* conidia produced within a sunken lesion on an infected strawberry.*

*Anthracnose fruit rot*

*Anthracnose fruit rot*

*Flowers and fruit symptomatic of anthracnose infection*

*Anthracnose fruit rot*

*Anthracnose lesion on strawberry runner*

*Cut through strawberry crown revealing discoloration caused by anthracnose infection*

### **Symptoms**

*Leaf spot* Round black or light gray lesions on leaves; numerous spots may develop but leaves do not die. *Runners and petioles* Dark brown or black sunken, circular lesions on stems, petioles and runners; plants may be stunted and yellow;

plants may wilt and collapse; internal tissues discolored red. *Crown rot* Youngest plant leaves wilt during water stress in early afternoon and recover in the evening; wilting progresses to entire plant; plant death; reddish-brown rot or streak visible when crown is cut lengthways. *Bud rot* Damp, firm dark brown to black rot on buds; plants with single buds may die; plants with multiple crown may wilt as disease progresses. *Flower blight* Dark lesion extending down pedicel which girdles the stem and kills the flower; flowers dry out and die; infection after pollination may result in small, hard, deformed fruit. *Fruit rot* Light brown water-soaked spots on ripening fruit which develop into firm dark brown or black round lesions.

### Cause

Fungi

### Comments

Plants that are planted in infected soil become infected by splashing water and soil; fungus survives in soil for up to 9 months.

### Management

Fumigating soil may help reduce soil inoculum; solarizing soil may destroy soil inoculum; rotate to non-host crops if fungigation or solarization is not possible; wash all soil from plant crowns prior to planting; weed around plants regularly; plant only disease free transplants; do not use excessive amounts of nitrogen fertilizer;

## Gray mold (*Botrytis* fruit rot, *Blossom blight*) *Botrytis cinerea*

Symptoms

*Botrytis* rot on Strawberry

*Botrytis* rot on Strawberry

*Botrytis cinerea* sporulation on a ripe strawberry.

Gray mold on strawberry fruit.

Early symptoms of gray mold on strawberry fruit.

Gray mold on strawberry fruit.

Gray mold symptoms on strawberry

### Symptoms

Blossoms turning brown and dying; misshapen fruit; patches of rot on fruit which enlarge and often affects entire fruit; masses of gray mycelium on surface of rotting tissue; no leakage of fluid from fruit; fruit becomes dried and mummified.

### Cause

Fungus

### Comments

Disease emergence favored by extended periods of high humidity or leaf wetness during flowering and moderate temperatures.

### Management

Remove and destroy all dead or infected material; remove decaying fruit; grow fruit under plastic; use plastic mulch to reduce fruit contact with soil; apply appropriate fungicides; plant in areas where wind will rapidly dry wet plants and fruit; plow crop debris into soil after harvest.

## Leaf spot (*Mycosphaerella* leaf spot) *Mycosphaerella fragariae*

<i>Infected foliage Symptoms</i>	<i>Strawberry leaf spot</i>	<i>Infected leaves</i>
<i>Symptoms of leaf spot on foliage</i>	<i>Advanced stages of leaf spot.</i>	<i>Leaf spot infected leaves</i>
<i>Mycosphaerella fragariae; Strawberry leafspot</i>	<i>Strawberry leaf spot early stages</i>	<i>Leafspot on strawberry</i>
	<i>Leaf spot symptoms on strawberry foliage</i>	<i>Leaf spot symptoms on strawberry foliage</i>

### **Symptoms**

Small round or irregular deep purple lesions on upper surfaces of leaves which enlarge and develop a gray-white center; lesions can grow large in susceptible varieties and the center of the lesion remains brown; lesions may also develop on fruit, petioles and stolons.

### **Cause**

Fungus

### **Comments**

Disease spread by splashing water.

### **Management**

Plant disease free stock; apply protective foliar fungicide.

## **Phomopsis leaf blight *Phomopsis obscurans***

<i>Brown, blighted areas of a strawberry leaf</i>	<i>Close-up of brown, blighted area with small, round, darker brown spore-producing bodies ("pycnidia")</i>	<i>Close-up of brown, blighted area with small, round, darker brown spore-producing bodies ("pycnidia")</i>
<i>Brown, blighted areas of strawberry leaves</i>	<i>Phomopsis leaf blight on strawberry leaf</i>	<i>Zonal lesion caused Phomopsis leaf blight</i>
<i>Phomopsis leaf blight on strawberry leaf</i>		

### **Symptoms**

One to five circular, red-purple spots on leaflet; distinct zonal patterns on leaves with dark brown center surrounded by lighter brown and then purple, red or yellow; dark elongated and sunken lesions on petioles, stolons and fruit trusses.

### **Cause**

Fungus

### **Comments**

Disease occurs worldwide and can cause severe defoliation.

### **Management**

Specific control measures not developed; remove older leaves after harvest; application of foliar fungicides after harvest may help control disease.

## **Powdery mildew *Spaerotheca macularis***

*powdery mildew symptoms on lower surface of strawberry leaf*

### Symptoms

Patches of fuzzy white fungal growth on lower leaf surface which enlarge and coalesce; leaf edges curling upwards; purple-red blotches on lower leaf surface; deformed fruit may be produced if flowers become infected, severe infections may cause the plant to produce no fruit

### Cause

Fungus

### Comments

Fungus overwinters on leaves; spores spread by wind

### Management

Apply protective fungicide e.g. sulfur at first signs of disease; plant resistant varieties; avoid overhead irrigation; remove dead leaves at harvest to decrease overwintering mycelium

## Category : Oomycete

### Red stele (Red core) *Phytophthora fragariae*

*Longitudinal section of roots of strawberry plants showing typical red-core symptoms caused by Phytophthora fragariae.*

*Strawberry roots infected with red stele*

*Strawberry roots infected with red stele*

*Healthy control strawberry plants (not affected by Phytophthora fragariae).*

*Strawberry roots infected with red stele*

*Healthy root system of young strawberry runner, not affected by Phytophthora fragariae, showing normal lateral root development.*

*Stunted strawberry plants infected with red stele*

### Symptoms

Stunted plant growth; old leaves withered and may have red yellow or orange tinge; new leaves small; little or no fruit produced and few runners; reddish discoloration of root core which may extend into the crown.

### Cause

Oomycete

### Comments

Can survive in cuttings and spread to new plants; disease emergence favored by wet or moist soils and cool, wet weather conditions; younger plants generally show more damage to roots.

### Management

Plant only certified stock; avoid transferring soil and water contaminates sites; avoid planting in areas with a history of red stele; plant in raised beds to improve drainage; if disease is present apply appropriate fungicide.

## Category : Other

### Slugs *Arion hortensis*

*Deroceras reticulatum*

etc.

Dusky slug (*Arion subfuscus*)

Banded wood snail (*Cepaea nemoralis*)

A common garden slug

### Symptoms

Irregularly shaped holes in leaves and stems; rough holes in ripe fruit; if infestation is severe, leaves may be shredded; slime trails present on rocks, walkways, soil and plant foliage; several slug and snail species are common garden pests; slugs are dark gray to black in color and can range in size from 2.5 to 10 cm (1-4 in).

### Cause

Mollusc

### Comments

Slugs prefer moist, shaded habitats and will shelter in weeds or organic trash; adults may deposit eggs in the soil throughout the season; damage to plants can be extensive.

### Management

Practice good garden sanitation by removing garden trash, weeds and plant debris to promote good air circulation and reduce moist habitat for slugs; handpick slugs at night to decrease population; spread wood ashes or eggshells around plants; attract molluscs by leaving out organic matter such as lettuce or grapefruit skins, destroy any found feeding on lure; sink shallow dishes filled with beer into the soil to attract and drown the molluscs; chemical controls include ferrous phosphate for organic gardens and metaldehyde (e.g. Buggetta) and carbaryl (e.g Sevin bait) for non-organic growers.

## Pests

### Category : Insects

#### Aphids (Peach aphid, Potato aphid, Melon aphid, Strawberry aphid) *Myzus persicae*

*Macrosiphon euphorbiae*

*Aphis gossypii*

*Chaetosiphon fragaefolii*

Adult and nymphs of cotton aphid  
(*Aphis gossypii*)

Winged green peach aphid (*Myzus persicae*) adult

Adult potato aphid (*Macrosiphum euphorbiae*) with young nymphs, in the act of giving birth to another nymph.

Strawberry aphid

### Symptoms

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants.

### Cause

Insects

### Comments

Aphids transmit several viruses which can be very damaging to strawberry, the insects rarely reach a high enough population to cause severe damage directly but the spread of viruses is a major concern in strawberry production.

### Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control;

check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use.

## **Armyworm (Beet army worm, southern armyworm) *Spodoptera exigua***

*Spodoptera eridania*

*Adult southern armyworm  
(*Spodoptera eridania*)*

*Southern armyworm damaged  
strawberry leaves*

*Larvae of southern armyworm  
(*Spodoptera eridania*)*

*Southern armyworm (*Spodoptera eridania*) larvae feeding on strawberry leaf*

*Adult beet armyworm -Gray forewings with a white or pinkish spot, whit hind wings, and small size distinguish this species.*

*Beet armyworm (*Spodoptera exigua*) larvae*

*Beet armyworm larva*

### **Symptoms**

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside.

### **Cause**

Insect

### **Comments**

Insect can go through 3–5 generations a year.

### **Management**

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae.

## **Japanese beetle *Popillia japonica***

*Japanese beetles*

*Japanese beetles*

*Japanese beetles and damage on strawberry plants*

### **Symptoms**

Leaves skeletonized (only veins remaining); flowers and buds damaged; plant damage may be extensive; adult insect is a metallic green-bronze beetle with tufts of white hair protruding from under wing covers on each side of the body; adult beetles are approximately 13 mm in length; larvae are cream-white grubs which develop in the soil.

### **Cause**

Insect

### **Comments**

One beetle generation every 1-2 years; pheromone traps may actually attract more beetles to home gardens and should generally be avoided; beetle overwinters as larvae in soil; beetle has an extensive range of over 300 host plants.

## **Management**

If beetles were a problem in the previous year, use floating row covers to protect plants or spray kaolin clay; adult beetles can be hand picked from plants and destroyed by placing in soapy water; parasitic nematodes can be applied to soil to reduce the number of overwintering grubs; insecticidal soaps or neem oil can help reduce beetle populations.

## **Loopers (Cabbage looper) *Trichoplusia ni***

*Cabbage looper (Trichoplusia ni)*  
adult moth

*Cabbage looper (Trichoplusia ni)* egg

*Cabbage loopers early instar larvae*

*Cabbage looper (Trichoplusia ni)*  
larvae

*Early instar larvae of cabbage*  
*looper*

*Cocoon and pupa of the cabbage*  
*looper (Trichoplusia ni) from which*  
*the moth has emerged.*

*Cabbage looper*

## **Symptoms**

Large or small holes in leaves; damage often extensive; caterpillars are pale green with a white lines running down either side of their body; caterpillars are easily distinguished by the way they arch their body when moving; eggs are laid singly, usually on the lower leaf surface close to the leaf margin, and are white or pale green in color.

## **Cause**

Insect

## **Comments**

Insects overwinter as pupae in crop debris in soil; adult insect is a dark colored moth; caterpillars have a wide host range.

## **Management**

Loopers populations are usually held in check by natural enemies; if they do become problematic larvae can be hand-picked from the plants; an organically acceptable control method is the application of *Bacillus thuringiensis* which effectively kills younger larvae; chemical sprays may damage populations of natural enemies and should be selected carefully.

## **Thrips (Western flower thrips) *Frankliniella occidentalis***

*Adults of Frankliniella occidentalis:*  
one male (smaller) and two females.

*Larvae of western flower thrips*  
(*Frankliniella occidentalis*)

*Adult western flower thrips*  
(*Frankliniella occidentalis*).

*Western flower thrips (Frankliniella*  
*occidentalis) damage*

*Western flower thrips (Frankliniella*  
*occidentalis) adult*

*Western flower thrips*

## **Symptoms**

Damage to strawberry flowers, including browning of anthers and stigmas; insects may be numerous on fruit and may cause bronzing around the cap; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color.

## **Cause**

Insect

## **Comments**

Thrips population builds up in spring on weeds and a number of crops and migrate to strawberries when crops are harvested or when weeds dry up.

## **Management**

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic.

## **Weevils (Strawberry root weevil, Rough strawberry root weevil, Black vine weevil)**

*Otiorhynchus* spp.

*Strawberry root weevil*  
(*Otiorhynchus ovatus*) adults are snout-nosed beetles and, depending on species, about 5-15mm long, black to brown in color.

*rough strawberry root weevil*  
(*Otiorhynchus rugosostriatus*) adult

*strawberry root weevil*  
(*Otiorhynchus ovatus*) adult

*Rough strawberry weevil*

## **Symptoms**

Notches in leaves of plants; plants stunted and dark in color with closely bunched leaves; adult insect is a snout-nosed beetle which can vary in color from dark to light brown depending on species; larvae are cream-white colored grubs which feed on roots below ground.

## **Cause**

Insect

## **Comments**

Damage within a field usually affects a circle of plants; weevil attack is sporadic and can be very damaging.

## **Management**

Keep strawberry beds free of weeds and grass; avoid planting close to woodland or blackberry or elderberry which may harbor weevil populations; pesticide sprays or dusts which contain pyrethroids are effective at controlling strawberry weevils.

## **Category : Mites**

### **Spider mites (Strawberry spider mite) *Tetranychus turkestanii***

Spider mites are almost microscopic. Most are about the size of a period made by a typewriter.

spider mites (*Tetranychus* spp.) adults

Spider mites (*Tetranychus* spp.)

Strawberry spider mite (*Tetranychus turkestanii*) infected field

Strawberry spider mite (*Tetranychus turkestanii*) infested leaf

Spider mite damage to strawberry leaf

## **Symptoms**

Leaves stippled with yellow; leaves may appear bronzed; webbing covering leaves; mites may be visible as tiny moving dots on the webs or underside of leaves, best viewed using a hand lens; usually not spotted until there are visible symptoms on the plant; leaves turn yellow and may drop from plant.

## **Cause**

Arachnid

## **Comments**

Spider mites thrive in dusty conditions; water-stressed plants are more susceptible to attack.

## **Management**

In the home garden, spraying plants with a strong jet of water can help reduce buildup of spider mite populations; if mites become problematic apply insecticidal soap to plants; certain chemical insecticides may actually increase mite populations by killing off natural enemies and promoting mite reproduction.

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# Sugarcane

## Description

Sugarcane, *Saccharum officinarum*, is a perennial grass in the family Poaceae grown for its stem (cane) which is primarily used to produce sucrose. Sugarcane has a thick, tillering stem which is clearly divided into nodes and internodes. The leaves of the plant grow from the nodes of the stem, arranged in two rows on either side of the stem. The leaves are tubular and blade-like, thicker in the centres than at the margins and encircle the stem. The inflorescence of sugarcane is a terminal panicle which possesses two spikelets and seeds protected by husks (glumes) covered in silky hair. Two flowers are produced on the inflorescence, one sterile and the other bisexual. Sugarcane can reach a height of up to 6 m (3.3 ft) and once harvested, the stalk will regrow allowing the plant to live for between 8 and 12 years. Sugarcane may also be referred to as noble cane and originates from New Guinea.

*Harvested sugarcane*

*Sugarcane*

*Sugarcane flowering*

## Uses

Sugarcane is primarily used for the production of cane sugar (sucrose). One of the biproducts of sugarcane production is bioethanol which can be used as a fuel in place of gasoline. The dried fibre which is left over after the extraction of the sugarcane juice is called bagasse and is used in paper and textile production, as a fuel or as an organic mulch.

# Propagation

**Basic requirements** Sugarcane grows best in tropical and subtropical regions as the plants require a warm, sunny and moist environment for growth. Plants will grow optimally at temperatures between 26 and 33°C (78.8–91.4°F) where there are no frosts which will damage the plants. Sugarcane can be grown successfully in a variety of soils but will perform optimally in deep, well-draining soils, rich in organic matter with a pH between 5.0 and 8.0. Sugarcane requires an average annual rainfall of between 1800 and 2500 mm per year for adequate growth. If rainfall is too low, plants should be grown with irrigation to maximize yield. **Propagation** Sugarcane is vegetatively propagated by planting part of a mature cane called ‘setts’. Setts should be cut from carefully selected mature canes. A few days before the cuttings are taken, the end of the canes are removed to break the apical dominance of the cane and promote the breaking of buds. The best cuttings are taken from the upper portions of the cane and should be approximately 40 cm (16 in) in length with 2–3 buds. Sugarcane setts should be planted horizontally or at a 45° angle in furrows 15–30 cm (6–12 in) deep. Once in the ground, the setts should be covered with a thin layer of soil. Setts can be grown in a nursery bed and transplanted to the field or planted directly at the final growing site. The average planting density for sugarcane is 15,000–24,000 cuttings per hectare of land. Normally furrow method of planting is followed. A new method called pit method of planting promises two to three times more yield and more ratoon (up to 10) compared to furrow method.

**General care and maintenance** Plantations should be kept free from weeds with weeding being carried out every 3–4 weeks. Weeds can be removed by hand or through the use of machinery or appropriate chemicals. If rainfall is not sufficient to meet the growth requirements of the plants then irrigation must be supplied every 2–4 weeks through furrow or sprinkler irrigation. Soil should be mounded up around the base of the canes 1–2 times during the growing season to promote good root development, aid drainage in heavy soil or prevent lodging in light soils. **Harvesting** Sugarcane is most commonly harvested by hand cutting. Stalks should be cut close to the ground with a sharp knife when the canes are fully mature.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Eye spot** *Helminthosporium sacchari*

##### **Symptoms**

Small water-soaked spots on leaves; elongated water-soaked spots in shape of an eye; straw colored lesions with reddish brown center develop from water-soaked lesions.

##### **Cause**

Fungus

### **Comments**

Disease emergence favored by cloudy weather, high humidity and low night temperatures or wet leaves from precipitation or irrigation.

### **Management**

Disease can be controlled through the application of appropriate foliar fungicides.

## **Pineapple disease** *Ceratocystis paradoxa*

### **Symptoms**

Setts not rooting; central soft portion of set has red discoloration which turns brown-black; cavities in infected internodes; In older canes leaves may be yellowing and plant appears withered; cut stem has a strong smell of pineapple

### **Cause**

Fungus

### **Comments**

Primarily a disease of setts; fungus enters cut ends of stem or through other wounds

### **Management**

The most effective method of managing the disease is through the use of resistant sugarcane varieties; if planting varieties that are susceptible to the disease then plant them in dry, well-draining soils

## **Red rot** *Colletotrichum falcatum*

### **Symptoms**

Yellowing, drying leaves; elongated red lesions on leaf midribs which may develop a straw yellow center; splitting open the stalk lengthwise reveals reddish patches of tissue interrupted by white areas; vascular tissue may also be red

### **Cause**

Fungus

### **Comments**

Disease has eliminated several varieties of sugarcane

### **Management**

Planting resistant varieties of sugar cane is the most effective method of controlling the disease; remove crop debris from the plantation to reduce inoculum levels; rogue diseased plants; harvest crop promptly if growing a susceptible variety; treating seed pieces with hot water prior to planting can reduce the incidence of the disease but foliar fungicide application has proved to be an ineffective method of control

## **Sugarcane smut disease** *Ustilago scitaminea*

### **Symptoms**

Stunted growth of sugarcane stools; profuse production of tillers; shortened internodes; stems thin with narrow, erect leaves; black whip-like structure emerging from terminal bud

### **Cause**

Fungus

### **Comments**

Disease transmitted through infected setts and by wind

### **Management**

The disease can be successfully controlled by planting varieties of sugarcane which are resistant to the disease; disease can usually be eliminated from seed pieces by hot water treatment prior to planting; infected plants should be removed

## **Category : Bacterial**

## **Leaf scald** *Xanthomonas albilineans*

### **Symptoms**

White "pencil line" extending the entire length of leaf lamina; etiolated leaves; leaf tips drying out resulting in a scalded

appearance

**Cause**

Bacterium

**Comments**

Disease emergence favored by water stressed plants

**Management**

The most effective method of preventing the disease is to plant resistant sugarcane varieties; treatment of seed cane with hot water to clean the material prior to planting can help to prevent the disease

**Category : Viral**

**Mosaic** Sugarcane mosaic virus (SCMV)

Sorghum mosaic virus (SrMV)

Maize dwarf mosaic (MDMV)

Johnsongrass mosaic virus (JGMV)

**Symptoms**

Distinct patterns on contrasting greens on leaves i.e. dark green patches surrounded by paler green; reddening of leaves; leaf necrosis

**Cause**

Viruses

**Comments**

Symptoms may be caused by 4 different viruses

**Management**

Plant varieties of sugarcane which are tolerant of viruses

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# Sunflower

## Description

Sunflower, *Helianthus annuus*, is an herbaceous annual plant in the family Asteraceae, grown for its seeds. The plant has a thick, hairy, erect stem which gives rise to a large flower head. The plant has large, broad lower leaves which are oval and arranged alternately on the stem and smaller, narrower upper leaves which are attached individually to the stem. The flower head is a large disc reaching 10â€“30 cm (4â€“12 in) in diameter which is made up of 16â€“30 individual florets which are yellow-gold in color. The outer florets are sterile and produce the outer petals of the flower head, while the inner florets will mature into the seeds in the central disc. Sunflowers are annual plants, harvested after one growing season and can reach 1â€“3.5 m (3.3â€“11.5 ft) in height. Sunflower may also be referred to as girasole and originates from North America.

*Sunflower foliage*

*Back of flower*

*Field of sunflowers*

*Sunflower head close-up*

*Sunflower seeds*

*Developing flower head*

*Sunflowers*

*Sunflower close-up*

*A field of sunflowers*

## Uses

Sunflower seeds can be eaten either fresh or cooked or used to extract oil which is widely used in cooking. The seeds are commonly harvested for bird seeds. Sunflowers are often grown as ornamental plants due to their large, attractive flower head.

## Propagation

**Requirements** Sunflowers are generally very easy to grow and thrive in areas with long hot summers which promote flowering. They grow best at temperatures between 21 and 25.5°C (70–78°F). Sunflowers can be very large and require plenty of space although there are some varieties which have been specially bred to be compact for growing in smaller spaces or for growing in containers. Sunflowers will grow in a variety of soils as long as they are not waterlogged and can be grown successfully at a pH ranging from 6.0 to 7.5. A pH above 6.0 is not recommended. They should be grown in an area that receives full sunlight and it is preferable to provide them with some shelter from wind which can damage the stems e.g. along a fence or wall. Sunflowers originate from the dry prairie regions of North America and are drought resistant once established. Their easy to grow nature makes them ideal plants for growing with children. **Planting**

Sunflowers are most easily grown by direct seeding outdoors. In areas with a long growing season, they should be planted in late Spring after all danger of frost and when the soil has warmed through. However, in areas with short growing seasons, the seeds can be planted a week or two before the last frost date as the plants are tolerant to cold. Prepare the soil for planting by digging to loosen the soil and break up any large clumps. Plant seeds 2.5–5.0 cm (1–2 in) deep and space them 10–15 cm (3–4 in) apart. If planting in rows, allow 0.75 m (~30 in) between each one. An application of a balanced fertilizer at planting promotes the development of a strong root system. The seeds should sprout in 7–10 days. When the seedlings are about 15 cm (6 in) tall with two pairs of true leaves, thin the plants to a final within row spacing of 60 cm (2 ft). Sow more seeds every 2–3 weeks for a continuous bloom over the summer.

**General care** Although sunflowers are drought resistant, frequent, deep watering promotes the development of a strong root system. The plants do not require fertilizing, indeed, addition of nitrogen promotes vegetative growth and will delay flowering. The stems of the plants can easily reach in excess of 1.8 m (6 ft) in height and will benefit from some support. Bamboo stakes work well. **Harvesting** Sunflowers are ready to harvest when the back of the flowers begin to turn yellow and the flower head droops. Cut the stem about 5 cm (2 in) below the head and hang up to dry in a warm, well ventilated place for several weeks. When the heads are thoroughly dried, remove the seeds with a brush or by hand. Allow the seeds to dry out for a further few days before storing.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Alternaria leaf blight** *Alternaria helianthi*

*Alternaria* lesions on sunflower leaves

##### **Symptoms**

Dark brown lesions on leaves surrounded by a yellow halo; lesions coalesce and become irregularly shaped and cause leaves to become blighted; plant becomes defoliated and dies

##### **Cause**

Fungus

##### **Comments**

Disease emergence favors hot weather and frequent rainfall; fungus may survive in crop debris or on suitable weed hosts; disease can be transmitted through infested seed

##### **Management**

Prune out infected leaves; use adequate plant spacing to reduce humidity around plants and promote good air circulation; disease can be controlled by application of appropriate foliar fungicide

#### **Downy mildew** *Plasmopara halstedi*

Downy mildew on sunflower leaf

Symptoms of downy mildew on sunflower foliage

##### **Symptoms**

Death of seedlings leading to reduced stand in field; if seedlings survive they may be chlorotic with thickened leaves; white cottony growth is present on leaf undersides; systemic infection causes stunted plant growth and reduced seed production

##### **Cause**

Fungus

##### **Comments**

Disease emergence favors high humidity; fungus can survive in soil for up to 10 years

##### **Management**

Plant sunflower varieties that are resistant to downy mildew; treat seeds with an appropriate fungicide prior to planting; foliar fungicides are ineffective at controlling systemic infections and are not recommended

#### **Phoma blight** *Phoma macdonaldii*

Symptoms of Phoma blight of sunflower

Symptoms of Phoma blight of sunflower

##### **Symptoms**

Symptoms of the disease develop after flowering; large black lesions appear on stem and coalesce to form large

blackened areas; dark colored irregularly shaped lesions appear on leaves and flowers; early infections can cause flowers to die; infected plants die prematurely and produce little seed; disease often affects plants in a circular pattern in the field

#### Cause

Fungus

#### Comments

Fungus survives in seeds or sunflower debris in the field; disease emergence favors periods of wet weather during flowering

#### Management

Rotate crop to a non-host (e.g. small grains) a period of 4 years; plant hybrids which are more tolerant of the disease; control stem weevil populations in sunflower fields

### **Powdery mildew** *Erysiphe cichoracearum*

#### Symptoms

Powdery white patches which appear initially on lower leaves but which may spread to all above-ground parts of plants; white patches turn gray in color and black fungal fruiting bodies are visible; severely infected leaves may turn yellow and dry up

#### Cause

Fungus

#### Comments

Conditions which favor the development of the disease match those that are favorable for the host plant; disease emergence is favored by periods of high humidity where leaves remain dry

#### Management

Allow adequate spacing between plants to promote good air circulation around foliage; plant sunflowers in an area that receives full sun for most of the day; remove and destroy all sunflower crop debris after harvest; applications of appropriate foliar fungicides can help control the disease but care should be taken as some labels do not allow seeds from treated plants to be used as food or feed

### **Septoria leaf spot** *Septoria helianthi*

#### Symptoms

Water-soaked circular or angular spots on leaves with a greasy, greenish appearance on lower leaves; lesions are usually gray with a darker margin; some lesions may have a narrow yellow border; tiny black fungal fruiting bodies may be present in the lesions

#### Cause

Fungus

#### Comments

Little is known about the survival and spread of the pathogen which causes the disease; spores are believed to be spread by splashing water; disease will develop rapidly during periods of moderate to warm weather with high rainfall

#### Management

Plant high quality seed which is free of diseases; rotate crop away from sunflower for a period of 3 years, especially if overhead irrigation is used; fungicides are rarely required for the treatment of Septoria leaf spot

### **Verticillium wilt** *Verticillium dahliae*

*Verticillium* wilt symptoms on sunflower

Sunflowers infected with *Verticillium* wilt

Sunflowers infected with *Verticillium* wilt

#### Symptoms

Lower leaves developing mottled appearance; leaf tissue between veins turns yellow and then brown; infected leaves

wilt, dry out and eventually die; stems of plants may become blackened close to the soil line; a cross section of the stem reveals blackened vascular system

#### **Cause**

Fungus

#### **Comments**

Fungus is soil-borne and enters plants through the roots, invading the vascular system; pathogen can be spread to uninfested fields through contaminated irrigation water or movement of infested soils

#### **Management**

Plant high quality, disease-free seed; avoid planting sunflowers in fields known to have been infested with *Verticillium* previously; plant resistant sunflower hybrids in areas where disease is known to be problematic

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# Sweet potato

## Description

### Crop Details

The following are the crop details for sweet potato.

**Scientific Name:** *Ipomoea batatas*

**Kingdom:** Plantae

**Order:** Solanales

**Family:** Convolvulaceae

**Species:** *I. batatas*

Local Names: Viazi vitamu (Swahili); Makwasi (Kikamba, Kenya); Mapwoni (Luhya, Kenya)

*Close-up of flower*

*Sweet potato harvest*

*Sweet potato vine*

## General information.

Sweet potato, a herbaceous perennial vine belonging to the Convolvulaceae family, is cherished for its versatile, edible storage roots or tubers. Native to Central America, this plant has now established itself across the globe. These robust vines, known for their heart-shaped lobed leaves and charming white or lavender flowers, can stretch up to 4m (13 ft) in a single growing season. Tubers come in a fascinating array of shapes and colors, from red, yellow, brown, and white to even purple.

Cultivated mainly in small-scale subsistence farming in East Africa, sweet potatoes are gradually gaining recognition among other indigenous foods. Its tubers are usually white, red, or purple, and increasingly, yellow-fleshed types are garnering popularity due to their high sugar, vitamin A, and lower dry matter content. Consumed either boiled or roasted, often accompanying milk, porridge, soups, or meat, they contribute significantly to diet diversity. Moreover, their young leaves, high in protein and essential vitamins like B1, B2, and folic acid, serve as a nutritious green vegetable. The vines also double as a fodder crop, providing a nutritious feed, especially during the dry season. This remarkable plant, thus, goes beyond being a mere staple, offering considerable nutritional and agronomic advantages.

## Uses

Sweet potato tubers are consumed raw as a vegetable or processed into flour or starch. The leaves can be eaten raw or cooked.

## Varieties

Sweet potato varieties offer diverse benefits, ranging from yield and performance to culinary value and pest tolerance, with each possessing unique characteristics that reduce the risk of agricultural failure. The different varieties cater to various regional needs and are primarily grown in East Africa for subsistence farming, contributing not only to food diversity but also as a vital fodder crop during dry seasons.

Red-skinned varieties with cream flesh are popular across most regions of Kenya for their high yield. Additionally, the wide range of cultivars extends from the standard white, red, and purple types to the increasingly popular yellow-fleshed ones. The latter are particularly celebrated for their high sugar and vitamin A content, and lower dry matter composition, making them a powerful tool in fighting vitamin A deficiency in children.

Beyond their tubers, sweet potato plants provide young leafy shoots high in protein, approximately 20% of dry weight, and rich in b-carotene, thiamine (vitamin B1), riboflavin (B2), folic acid, and ascorbic acid. These nutrient-rich leaves are often consumed as vegetables, thereby enhancing the plant's versatility and nutritional contribution. With each variety catering to different needs, sweet potatoes continue to gain popularity and form a critical part of the food and agricultural landscape.

## Climate conditions, soil, and water management

Sweet potato thrives in sunny conditions but can manage with 30-50% less sunlight. For optimal growth, it prefers an annual rainfall of 600-1600 mm, evenly distributed throughout the growing season. However, dry periods can encourage the growth of storage roots. Despite its drought tolerance, extended dry spells, particularly during planting or root development, can significantly reduce yields.

Soil management, especially maintaining organic matter, is crucial for water retention in rain-fed crops. Organic matter and plant mulches help soil retain moisture, reduce surface evaporation, and prevent soil crusting. They also enhance rainwater absorption. Weeds, competing for water, should be regularly removed and can be used as additional mulch.

Where irrigation is feasible, the aim should be to maintain consistent soil moisture. Watering should sufficiently wet the root zone without causing deep drainage or runoff. Overwatering can lead to nutrient leaching and contamination of water sources. Light-textured soils require more frequent, lesser amounts of irrigation to avoid runoff losses.

Post cultivation, the land is usually fashioned into ridges, or mounds for those working manually. However, in well-drained soils, flat fields are also possible. Ridges on sloping land should align with contours to reduce erosion and increase rainwater absorption. They should be higher in wet areas for better soil drainage.

## Propagation and planting

Sweet potatoes can be planted at any time if there is no critical dry season. Planting early in the rainy season is best in regions with a critical dry season. If the rainy season is long and wet, it is usually planted near the end.

Sweet potato planting material is obtained from either vine cuttings, which is the most common source, or storage roots.

Plant cuttings should be planted at approximately 15 x 20 cm spacing if planting material is to be kept in a multiplication plot before planting the next crop. After 45 days, new growth may be ready for cutting.

## Planting

Use of stem cuttings:

Farmers obtain mature crop cuttings before or shortly after harvesting storage roots.

The cuttings are either used to establish a maintenance field or planted directly into the next sweet potato crop.

The following factors influence yield when using stem cuttings:

Choosing 'clean' planting material is critical.

This includes removing any insects, soil, or signs of virus or fungal disease from the cuttings.

In general, the apical (tip) portion of the vine is superior to the middle or basal portions.

This portion has been shown to establish faster than other portions and is less likely to be infested with sweet potato weevils and fungal pathogens.

For cultivars with long vines, the second or third cut is sufficient.

If vine growth has been so rapid that the stem has not matured in the apical portion, the second cutting may be superior to the tip portion.

The number of nodes is more important than the length of the cut.

The average size is 20-40 cm, with 5-8 nodes.

Field conditions may influence the relationship between cutting length and crop development.

Farmers should experiment to see what length works best for their specific situation.

Usually, one-third to two-thirds of the cutting is buried.

A minimum of 2-3 nodes, but up to approximately 8 nodes, are placed beneath the soil.

The time between cutting and planting may affect yield depending on the storage conditions for the cuttings.

Storing cuttings in humid conditions for one to two days may encourage node rooting.

Longer storage may be detrimental to the establishment due to the depletion of the cuttings' energy reserves.

To reduce losses, remove the leaves from the lower portion of the cutting and store bundles

of cuttings in a cool, shady, wind-free location wrapped in a wet cloth or sack.

If roots form during storage, they must be carefully planted to avoid root damage.

Use of storage roots: Storage roots are used while there are inadequate stem

cuttings available

or when pest and disease infestation is so severe that only a few healthy vines remain.

Since the sprouts can be harvested mechanically from the seedbed, they can also be used in highly mechanized production.

Healthy storage roots should be selected from high-yielding plants.

The roots are densely planted in a seedbed far from different candy potato crops.

To help retain moisture, the roots are covered with about 3 cm of soil, and the bed is covered with straw.



When the sprouts have grown effectively, they are cut near their base and planted in the field.



To increase the number of cuttings, remove the sprout tips when they are about 20 cm long to promote branching.

Rapid seed multiplication: Rapid multiplication can be used when a large number of cuttings are required.

Although sweet potato growers have not fully acknowledged the value of this practice, it may be the simplest way to produce a large number of planting materials.

The following steps are involved in this method:

30 cm cuttings are taken from established plants or sprouted storage roots.

These are then cut into single-node cuttings with the attached leaf. The vine's tip is discarded.

A seedbed is produced by mixing loose, humus-rich soil with ash.

Plant the single-node cuttings densely, with the stem section buried and the leaf upright.

The seedbed is watered on a regular basis and kept moist, especially during the first week of the establishment.

When the seedlings have developed enough roots, they should be transplanted into the field after about 2 weeks.

To avoid damaging the roots, they should be carefully removed from the seedbed.

To avoid excessive evaporation and wilting, transplanting should be done in the late afternoon.

### Degeneration of planting material

When the sweet potato is vegetatively propagated for several generations, yield decline is common.

This is usually due to a virus buildup, many of which have no obvious symptoms.

This frequently gives the impression that a new variety (carrying few viruses) yields significantly higher than traditional varieties,

when in fact it may not be any better after a year or two of virus accumulation.

Heat treatment and meristem culture (from research institutions) can be used to remove viruses.

Depending on the severity of the original virus infestation, this process typically results in a yield increase of 20 to 200% for both vines and roots.

The higher yield may be maintained in the field for several years before the virus load has built up.

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## Planting method

After forming ridges or mounds, sweet potato cuttings are planted by burying the lower portion in the top of the ridge or mound. A hole can be dug with a stick or by hand, and soil should be gently pressed around the inserted cutting. The stem is typically positioned at an angle.

According to some workers, cuttings oriented across the ridge yield more than those oriented along the ridge. Ridge spacing in ridge planting systems is typically 90-120 cm, while row spacing is 20-30 cm (3-5 plants per meter). Higher plant density generally results in a lower yield per plant but a higher yield per hectare. With short growing seasons, close spacing is used, and wider spacing may be preferred where the market prefers larger storage roots.

The size and spacing of mounds are determined by soil conditions. They can be planted 75-200 cm apart and with several cuttings per mound. Although some farmers plant two cuttings at each mound, there is little evidence that this is beneficial. Single cuttings are said to produce a higher proportion of large storage roots.

### **Husbandry**

Weed infestation is a problem in the first two months of growth and requires adequate control to ensure high yield. Following that, the vines' vigorous growth effectively covers the ground and smothers weeds. Manual weeding is commonly used in the tropics. Sweet potato responds well to fertilization, especially if the land has been cropped continuously. However, fertilizer is rarely used in the tropics.

To improve soil fertility, manure or good compost should be added. This is a common practice among smallholders and traditional farmers. Around the world, sweet potato is used in a wide range of cropping systems. Rotating sweet potato with other crops such as rice, legumes, and maize is beneficial for disease, pest, and weed control.

### **Harvesting**

The harvesting season for sweet potato storage roots is not well defined; it varies depending on the cultivar, cultural practices, and climate. In tropical countries where sweet potatoes are grown for domestic consumption, 'progressive harvesting' (piece-meal harvesting) is common practice. To avoid weevil damage, it is generally recommended to harvest within 4 months. Manual harvesting with implements such as a stick, spade, or hoe is common in the tropics.

## **Common Pests and Diseases**

### **Diseases**

#### **Category : Fungal**

##### **Alternaria leaf spot & Leaf and stem blight *Alternaria* spp.**

*Random scatter of dark brown lesions with concentric rings and yellow halo*

#### **Symptoms**

Brown lesions on leaves with concentric rings resembling a target; lesions are usually restricted to the older leaves and may be surrounded by a yellow halo; small gray-black oval lesions with lighter centers may occur on stems and leaf petioles and occasionally on leaves; stem and petiole lesions enlarge and often coalesce resulting in girdling of the stem; defoliation may occur

#### **Cause**

Fungus

#### **Comments**

Stem and leaf petiole blight is much more destructive than leaf spots caused by *Alternaria*; stem and petiole blight is a severe disease of sweet potato in East Africa and has also been reported from Asia, South America and Cuba

#### **Management**

Destroy all sweet potato crop residue immediately following harvest; plant resistant or tolerant sweet potato varieties where available; plant only disease-free seed material

##### **Black rot *Ceratocystis fimbriata***

*Ceratocystis* black rot of sweetpotato

### Symptoms

Stunted plants; wilting plants; yellowing plants; dropping leaves; plant death; circular brown-black patches of rot on tubers

### Cause

Fungus

### Comments

Rot continues to develop in stored tubers

### Management

Only disease-free seed material should be planted; sweet potato should not be planted in sites where sweet potato has been grown during the previous 3-4 years; transplant material should be collected from plant by making cuts above-ground; seed material should be treated with an appropriate fungicide prior to planting

## Fusarium root and stem rot *Fusarium solani*

### Symptoms

Swollen and distorted base of stems; deep, dark rot extending deep into tuber and forming elliptical cavities; growth of white mold

### Cause

Fungus

### Comments

Disease can be spread by infected transplants

### Management

Disease is generally not a problem if good sanitation is implemented; select only disease-free roots for seed; use cut transplants rather than slips; practice crop rotation; treat seed roots with an appropriate fungicide prior to planting

## Category : Bacterial

### Bacterial soft rot *Erwinia chrysanthemi*

#### Symptoms

Brown to black water-soaked lesions on stems and petioles which expand rapidly and cause large areas of soft rot on the stem; stem may collapse causing several vines to wilt; entire plant may die; storage roots may develop areas of soft rot which is initially colorless, but eventually turns brown with a black margin

#### Cause

Bacterium

#### Comments

Symptoms develop after hot weather; can effect stored tubers

#### Management

Avoid wounding storage roots at all stages of growth; plant only disease-free seed material; discard any stored roots which become infected with the disease; vines for transplanting should be cut above the soil surface; plant sweet potato varieties which are resistant to the disease

### Bacterial wilt *Ralstonia solanacearum*

#### Symptoms

New sprouts wilting and have water-soaked bases which turn yellow-brown to dark brown in color; vascular system of the sprouts is discolored brown; infection of healthy transplants causes the lower portions of the stems to become water-soaked and turn a similar color to infected sprouts; yellow-brown streaks may develop inside storage roots and, if

infection is severe, gray-brown water-soaked lesions may be present on the root surface

#### **Cause**

Bacterium

#### **Comments**

The bacteria causing the disease is an important pathogen of other crops but in sweet potato it is only severe in certain regions of China where it can cause 70-80% reductions in yield

#### **Management**

Quarantine procedures have been put in place in regions of China where the disease is severe; only disease-free storage roots should be used for planting and planting should only be done in sites free of the disease; rotating sweet potato with a flood crop such as paddy rice or a non-host such as corn or wheat can be beneficial; growing sweet potato during cooler periods of the year allows some avoidance of the disease

### **Leaf and stem scab *Sphaceloma batatas***

#### **Symptoms**

Small brown lesions on leaf veins which become corky in texture and cause veins to shrink which in turn causes leaves to curl; lesions on stem are slightly raised and have purple to brown centers with light brown margins; scabby lesions form on stems when lesions coalesce

#### **Cause**

Fungus

#### **Comments**

Leaf and stem scab is one of the most severe diseases of sweet potato; disease is most severe in regions where there is frequent fog, rain or dew accumulation and is common in Asia and Australia

#### **Management**

Avoid the use of overhead irrigation; rotate sweet potato with other crops; use only disease-free planting material; destroy sweet potato crop residue immediately after harvest; application of appropriate fungicides can help to control the disease, good control of the disease can be achieved with benomyl and chlorothalonil where licensed for use

### **Category : Viral**

#### **Pox *Streptomyces ipomoea***

#### **Symptoms**

Poor growth of plants; reduced yield; circular dark brown, corky lesions on tubers which are V-shaped in cross section; cracked and distorted tubers which resemble dumbbells; rotting feeder roots

#### **Cause**

Bacterium

#### **Comments**

Disease emergence favors light, sandy soils

#### **Management**

The most effective method of controlling the disease is through the use of resistant varieties of sweet potato; if resistant varieties are not being used then the soil should be maintained at a low pH which is unfavorable to the pathogen; sweet potato should be rotated with other crops which are non-hosts to prevent build up of the pathogen in the soil; fumigation of the soil prior to planting can be an effective method of reducing the severity of the disease

### **Sweet potato virus disease (SPVD) *Sweet potato feathery mottle virus (SPFMV)* and *Sweet potato chlorotic stunt virus (SPCSV)***

#### **Symptoms**

Sweet potato virus disease is a disease complex caused by two viruses; sweet potato chlorotic stunt virus (SPCSV) and sweet potato feathery mottle virus (SPFMV). The symptoms are severe stunting of infected plants, stunting, distorted and chlorotic mottle or vein clearing of the leaves. It is confirmed that SPCSV enhances the accumulation of SPFMV. The symptoms caused by SPCSV alone is negligible. Whereas symptoms caused by SPFMV is localized, mild and often

asymptomatic and won't cause significant damage to the plant. Common symptom include appearance of feathery, purple patterns on the leaves.

#### **Cause**

Virus

#### **Comments**

It is estimated that SPVD causes yield loss up to 80 - 90%. The disease was first reported in 1939 from eastern Belgian Congo (present Democratic Republic of Congo). SPCSV is crinivirus of Closterviridae and SPFMV is potyvirus belong to Potyviridae. SPFMV is transmitted by a wide range of aphid species. SPCSV is transmitted by white flies (*Bemisia tabaci*).

#### **Management**

Use healthy cuttings for planting. Remove the infected plants and burn them. Follow crop rotation. Spray suitable insecticides to control aphids and white flies.

### **Category : Other**

#### **Sweet Potato Early Blight**

##### **Symptoms**

##### **Cause**

##### **Comments**

#### **Sweet Potato Healthy**

##### **Symptoms**

##### **Cause**

##### **Comments**

#### **Sweet Potato Late Blight**

##### **Symptoms**

##### **Cause**

##### **Comments**

#### **Sweet Potato Viral Disease**

##### **Symptoms**

##### **Cause**

##### **Comments**

#### **Category :**

#### **Virus**

##### **Symptoms**

##### **Cause**

##### **Comments**

### **Pests**

#### **Category : Insects**

#### **Sweet Potato stem borer** *Omphisa anastomosalis*

##### **Symptoms**

Larvae bores into the stem leading to the storage roots. Feeding in the crown region leads to wilting, yellowing and dying

of plant. The borers can be easily identified by the presence of fecal matter on the soil surface and holes on the stem.

#### **Cause**

Insect

#### **Comments**

Larva is light-purple and/or yellowish-white in color.

#### **Management**

Keep the field free from weeds especially *Ipomoea* spp. Fallow the land for few season if infestation is more. Use insect free planting material. Use pheromone traps to monitor and control the insect.

### **White grub *Phyllophaga ephilida***

*White grub larvae*

#### **Symptoms**

Grub feeds on underground parts including main stem and roots. They also feed on tubers by making tunnels. The infected plant become wilted and die eventually.

#### **Cause**

Insect

#### **Comments**

White grub are the larvae of scarab beetles commonly called as May and June beetles. The grubs are white in color and appear C shape. They generally feed on soil, organic matter and plant materials.

#### **Management**

Cultural practice: Deep summer ploughing to expose grub and pupa present in soil. Provide proper drainage to soil to avoid excess moisture. Follow crop rotation with soybean to reduce grub population. Application of biocontrol agents like *Bacillus popilliae* and *B. lentimorbus* bacteria kill the grubs.

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# Tarragon

## Description

Tarragon, *Artemisia dracunculus*, is an herbaceous perennial in the family Asteraceae grown for its leaves which are used a culinary herb. The tarragon plant is erect with slender, often branching stems and simple needle-like leaves which are glossy green and very aromatic. The plant produces a drooping head at the end of the stem which contains up to 40 yellow-green florets. Tarragon can reach a height of 1.5 m (5 ft) and can live for many years, dying back in the Winter and regrowing in Spring. Tarragon may be referred to by their cultivar group and these include French tarragon and Russian Tarragon. The origin of the plant is unknown but it has a wide distribution which covers Europe, parts of Asia and North America.

*Tarragon plant*

*Tarragon seedheads*

*Tarragon*

## Uses

Tarragon leaves are used either fresh or dried as a culinary herb. Essential oil can be extracted from the leaves and flowers.

# Propagation

**Basic requirements** Tarragon grows best in temperate climates and can survive some light frost. Tarragon will perform optimally when planted in a dry location in full sun. Soil should be light in texture and well-draining, with a pH between 6.3 and 7.5. Plants tend to perform better in slightly acidic soils. Tarragon will not tolerate wet soil and requires only 300 to 1300 mm of rainfall annually. **Propagation** Tarragon is usually vegetatively propagated from stem or rhizome cuttings. Stem cuttings should be 15 cm (6 in) in length and taken from the shoot tip. Use of a rooting hormone will aid tarragon rooting. Root cuttings should be 5 cm (2 in) in length and should be taken together with a new shoot. Beds should be prepared for planting by incorporating organic matter and an all purpose fertilizer, if desired, into the soil. This should be worked into the top 15–20 cm (6–10 in) of the soil to provide nutrients and improve soil aeration. Tarragon should be planted in Spring after all danger of frost and newly rooted plants should be planted 25 cm (10 in) apart allowing 25–40 cm (10–16 in) between rows. **General care and maintenance** In commercial tarragon production, it is common to mulch fresh plantings with straw to conserve moisture in the soil, suppress weeds and lower the soil temperature. Tarragon roots are tender and this helps them to establish in the soil. Tarragon should be watered regularly but soil should be allowed to dry out between irrigations. Plants do not require the addition of any fertilizer as the flavor is improved by growing in nutrient poor soil. Tarragon should be pruned regularly to promote branching. **Harvesting** In the home garden, sprigs of tarragon can be harvested as required by pinching 1/3 of the length of the stem. Commercially produced tarragon is first harvested about 2 months after transplanting when the plants are well established. Plants are harvested 2–3 times over the growing season by cutting the tender tops.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### Tarragon rust *Puccinia dracunculina*

##### Symptoms

Yellow or white spots on underside of leaves; bright orange or yellow pustules on underside of leaves; leaves may turn yellow; growth is stunted and plant may become stunted

##### Cause

Fungus

##### Comments

Spread of disease favored by poor air circulation around plants; spores are transmitted by wind

##### Management

Remove all crop debris and infected leaves; avoid the use of overhead irrigation or water in the morning to allow plant foliage to dry during the day; ensure plants are well spaced to promote good air circulation around plants

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# Tea

## Description

Tea, *Camellia sinensis*, is a tree or small shrub in the family Theaceae grown for its leaves which are used to make beverages. The tea plant is branching with alternate elliptical leaves. The leaves are leathery in texture, matte green in color and have serrated edges. The tea plant can take the form of a tree with a bowl-shaped canopy but is usually pruned under cultivation to be smaller and shrub-like. The plant produces fragrant white flower singly or in small clusters. Tea tree can reach up to 15 m (49 ft) in height and can live anywhere between 30 and 50 years. The plant originates from China.

*Flowers and fruits*

*Tea plantation*

*Tea plantation*

*Flower*

*Flowers*

*Leaves*

*Flower bud*

*Leaves*

*Tea leaves*

## Uses

Tea leaves are usually infused with boiling water to produce an infused drink. In China, most tea leaves are processed for green tea (little or no fermentation of the leaves) whereas most Assam tea is processed for black tea which is manufactured by fermenting and crushing the leaves.

## Propagation

**Basic requirements** Tea grows best in warm and humid climates. It will tolerate temperatures between 14 and 27°C (57.2–80.6°F) with 18–20°C (64.4–68°F) being optimum. Tea plants will not tolerate frost and mean temperatures should not fall below 13°C (55.4°F) or exceed 29°C (84.2°F). Tea grows optimally in deep, well-draining, tropical red soils with an acidic pH between 4.5 and 6.0. Tea requires an average annual rainfall of 1600 mm per year distributed evenly throughout the growing season. In growing regions that experience a long dry season, tea plants require shading to increase the humidity around the plants. **Propagation** Tea is propagated from seed or rooted leaf cuttings. Good quality seeds are selected by immersing in water for 30 minutes and selecting the seeds which sink. Seeds are commonly germinated by placing them between wet cloths. Seeds which successfully germinate are transferred to a nursery bed to grow for 2–3 years. Before transplanting to the field, the plants are cut back to a height of 15 cm (6.0 in). Leaf cuttings are also used to establish new tea plantations. Single node cuttings are taken from the desired variety and rooted in polyethylene bags containing soil by firmly pressing the stem into the soil. The bags are then placed in a shaded area and watered regularly. New tea plants produced from rooted cuttings are usually planted out in the field after 6–9 months. Tea can be planted as single rows, double rows or as a hedge. Plantations established on slopes are planted on contour rows. Seedlings or cuttings are usually planted 60 cm (24 in) apart, allowing 1.5 m (5 ft) between rows. The tea plants are often interplanted with legumes or grasses to conserve soil moisture and prevent soil erosion. Shade trees are utilized in tea plantations grown at lower altitudes. **General care and maintenance** Newly planted tea plantations must be kept free from weeds while the tea plants establish. Weeding should be done by hand until the canopy closes and shades out weeds. Tea plants should be pruned to encourage the production of lateral branches. Bushes are shaped by tipping and thinning of branches to create the desired shape. Pruning should be maintained throughout the life of the plantation to keep the plants a manageable size and maintain productivity. pruning is best carried out when the plants are dormant where possible. If trees do not have a dormant period then they should be pruned in winter or after the dry period depending on geographic location. The tree clippings can be left in the centers of the rows to act as an organic mulch. Tea plantations are usually fertilized 2–3 times per year. The amount of each nutrient added to the soil will depend on the soil's own deficiencies and should ideally be based on the results of soil testing or by testing the leaves for nutrient deficiencies. **Harvesting** Tea is harvested by plucking which involves the removal of the youngest leaves at the shoot terminals. The terminal bud is removed along with the two leaves directly below (fine plucking) or the bud and three leaves (coarse plucking). The younger leaves have the best flavor and removing three leaves increases production but diminishes the overall quality by including an older leaf. Tea plants are plucked by hand by grasping the plant between thumb and forefinger and is usually carried out every 7–14 days depending on altitude.

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# Common Pests and Diseases

## Diseases

### Category : Other

#### Algal leaf spot *Cephaleuros virescens*

##### Symptoms

Gray, green or tan raised spots or blotches with green margins on leaves

##### Cause

Algae

##### Comments

Disease emergence favored by high temperature and humidity

##### Management

Avoid overhead irrigation which can spread the disease; provide adequate space between plants to maximize air circulation around foliage; avoid wounding plants; prune out diseased parts of plants by cutting 6 inches below any visible symptoms; application of appropriate protective fungicides should be made in Spring when old leaves drop from plants

### Category : Fungal

#### Blister blight *Exobasidium vexans*

##### Symptoms

Small, pinhole-size spots on young leaves; spots become transparent, larger, and light brown; blisters on underside of leaves; dark green, water-soaked zones surrounding blisters; blisters may be white and velvety or brown; young stems bent and distorted, may break off or die

##### Cause

Fungus

##### Comments

Endemic to all major tea growing regions

##### Management

Plant tea varieties which are less susceptible to the disease; apply appropriate foliar or systemic fungicides to protect the plants

#### Camellia dieback and canker *Glomerella cingulata*

##### Symptoms

Leaves suddenly turning yellow and wilting; branch tips dying; gray blotches on bark and stem which develop into sunken areas (cankers); cankers girdling the stem; parts of plant above cankers losing vigor, wilting and dying; symptoms more pronounced during hot, dry weather

##### Cause

Fungus

##### Comments

Fungus can enter plant through wounds

##### Management

Plant in well draining, acidic soils; remove diseased twigs by cutting several inches below cankered areas and disinfecting tools between cuts; apply appropriate protective fungicides during periods of wet weather or natural leaf drop to protect leaf scars from infection

#### Camellia flower blight *Ciborinia camelliae*

**Symptoms**

Small, brown, irregular-shaped spots on the flower petals; whole flower turning brown; flowers dropping from plant

**Cause**

Fungus

**Comments**

Disease emerges early in Spring during periods of high moisture

**Management**

Remove all infected flowers from plants; remove all crop debris from around plants; soil drenches with appropriate fungicides can help to reduce the intensity of the disease

**Horse hair blight** *Marasmius crinis-equi***Symptoms**

Black threadlike structures resembling horse hair attached to upper branches of plant by small brown discs; leaves drop rapidly from plant

**Cause**

Fungus

**Comments**

Fungus spreads to healthy parts of plants by extending hair-like threads

**Management**

Remove and destroy all crop debris from around plants; prune out infected or dead branches from the plant canopy

**Poria root disease (Red root disease)** *Poria hypoleteritia***Symptoms**

Yellowing foliage; wilting and/or sudden death of part of plant; withered leaves remain attached to the plant for several days; uprooting the bush reveals whitish mycelium and red discoloration of the roots

**Cause**

Fungus

**Comments**

Spread by mycelial strands in the soil

**Management**

Remove any visibly infected bushes and any adjacent plants which are showing signs of yellowing; remove any stumps or trees within infested area; all living and dead roots which are about pencil thickness or more should be removed from the site by digging using a fork; all material collected should be destroyed by burning; bushes surrounding the infested area should be treated with an appropriate fungicide applied as a soil drench; cleared site should be planted with grass for a period of two years before tea is replanted

**Root rot** *Phytophthora cinnamomi***Symptoms**

Leaves turning yellow; poor plant growth; entire plant wilting; roots discolored; rapid death of plant

**Cause**

Oomycete

**Comments**

Disease emergence favors poorly drained, warm soils

**Management**

Disease is difficult to manage once plants become infected so control methods should focus on protecting plants; always plant tea in well-draining soils which are not as favorable for the survival of the pathogen; application of appropriate fungicides can help to protect plants from infection

# Pests

## Category : Insects

### Aphids (Tea aphid) *Toxoptera aurantii*

#### Symptoms

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants

#### Cause

Insects

#### Comments

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed

#### Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

### Tea scale *Fiorinia theae*

#### Symptoms

Pale yellow spots on leaves; entire leaves yellowing; leaves turning brown and dropping prematurely; reduced flower size; adult insect is an oblong shape with a ridge down the center parallel to the sides; the scale is initially bright yellow in color but darkens to a dark brown; insect is mainly found on the undersides of leaves

#### Cause

Insect

#### Comments

#### Management

Light infestations can be scraped off the plant and destroyed or infested leaves can be hand picked; heavier infestations can be treated with a horticultural oil after bloom; appropriate insecticides can be applied but are only effective against scales that are actively crawling

## Category : Mites

### Spider mites (Two-spotted spider mite) *Tetranychus urticae*

#### Symptoms

Leaves stippled with yellow; leaves may appear bronzed; webbing covering leaves; mites may be visible as tiny moving dots on the webs or underside of leaves, best viewed using a hand lens; usually not spotted until there are visible symptoms on the plant; leaves turn yellow and may drop from plant

#### Cause

Arachnid

#### Comments

Spider mites thrive in dusty conditions; water-stressed plants are more susceptible to attack

#### Management

In the home garden, spraying plants with a strong jet of water can help reduce buildup of spider mite populations; if

mites become problematic apply insecticidal soap to plants; certain chemical insecticides may actually increase mite populations by killing off natural enemies and promoting mite reproduction

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# Teff

## Description

Teff, *Eragrostis tef*, is a warm season annual grass in the family Poaceae grown for its grain which can be ground into flour. The teff plant characteristically possesses a large crown and many tillers (lateral offshoots originating from the base of the stem). The plant is fine stemmed and grows in tufts. It produces a panicle (a branched flower cluster) with spikelets that hold the grain. The panicle can possess 190 to 1410 spikelets and can be either compact or loose in form. The teff grain ranges in colour from white to brown or reddish purple and is very small in size (1.0-1.7 mm in length). The plant produces 2-12 white or dark brown flowers on the spikelets. Teff is an annual plant, harvested after one growing season and it can grow 25-135 cm in height depending on the cultivar. Teff may also be referred to as Tef, Xaafii, lovegrass, annual bunch grass or warm season annual bunch grass and it originates from Ethiopia.

Teff field in Ethiopia

Teff

Teff

## Uses

Teff is grown predominantly as a cereal crop in Ethiopia. The grain can be used to make flour or porridge or can be fermented and made into type of flatbread called *injera*, which is eaten widely in Ethiopia. Grain can also be used to brew alcoholic beverages or grown as a forage for livestock or for use in building construction. As the grain lacks gluten, it can be used to produce gluten-free specialty products for people with allergies to gluten.

## Propagation

**Basic requirements** Teff is a warm season annual and can be grown in a wide range of climates and soil as it will tolerate both drought conditions and waterlogging. If the soil is waterlogged it is generally preferred to grow the crop on a raised seed bed to help drainage. The crop can be grown at temperatures ranging from 10°C to 27°C in areas with an average annual rainfall of 450–550 mm, requiring 450–550 mm during the growing season. Teff plants are sensitive to daylength and optimal flowering is reached with a daylength of 12 hours. **Propagation** Teff is grown directly from seed in a prepared seed bed. The field is prepared for planting by plowing several times and, in areas where drainage is poor, furrows or raised beds are created to aid drainage. In moisture-stressed fields, the seedbeds are tightly packed prior to sowing seed to help prevent the soil surface drying too quickly and minimize the effect of low moisture on germination. Teff seeds are usually sown on the soil surface and left uncovered or are covered lightly with tree branches. Seeding rates vary by region but generally, 15–55 kg of seeds are sown per hectare of land. If seeds are sown mechanically with a broadcaster or seed drill, lower seeding rates can be used. Higher seeding rates are required when hand sowing teff seed due to the small size of the seeds making it difficult to broadcast evenly. **General care and maintenance** Teff should be grown in a weed-free field for best results. Preparing the bed by plowing prior to planting the seeds will help to destroy existing weeds. If weeds begin to grow during the growing season the field may be hand weeded 25–30 days after teff emergence, when the plants reach the early tillering stage. If weeds continue to be a problem then a second hand weeding can be carried out when teff reaches the stem elongation stage. Weeding after heading is not recommended. Teff can be fertilized to promote good production. Fertilizer can be safely applied at the same time as seed is sown without adversely affecting germination. Addition of nitrogen to the soil promotes vegetative growth of teff, while phosphorus applications will promote grain production. Potassium has been found to be of little importance for the growth of teff. **Harvesting** Teff is ready for harvest between 60 and 120 days after planting when the leaves of the plants turn from green to yellow in color. Prompt harvest before the plants dry out completely helps to prevent the seedheads from shattering, reducing losses. At harvest, care must be taken to ensure that the grain does not get mixed with soil as the small grain size makes it impossible to separate back out. The seed is separated from the chaff by trampling or threshing.

Teff harvest

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## Common Pests and Diseases

# Diseases

## Category : Fungal

### Teff rust *Uromyces eragrostidis*

#### Symptoms

Brownish-red pustules on leaves

#### Cause

Fungus

#### Comments

Disease occurs in Africa

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# Thyme

## Description

Thyme, *Thymus vulgaris*, is a small, perennial, evergreen shrub in the family Lamiaceae grown primarily for its leaves which are used as a herb. The thyme plant has an erect or ascending growth habit and possesses many woody, branching stems. The leaves of the thyme plant are linear or elliptical and are arranged alternately on the stems. The leaves are densely covered in minute hairs and have numerous red-brown oil glands on the surface which take the appearance of small dots. The leaves can be green or variegated. The plant produces whorls of tiny pink, lilac or pale purple flowers on a terminal spike and tiny brown fruits, each with one seed. Thyme can reach a height of up to 50 cm (20 in) and can be grown as an annual or a perennial. Thyme may also be referred to as common or garden thyme and originates from the Mediterranean.

*Thyme*

*Thyme*

*Thyme flowering*

## Uses

Thyme leaves and flowers can be used fresh or dried as a herb in cooking. Bees which collect nectar from thyme flowers produce a high quality honey. Essential oil can be extracted from the leaves and is commonly used in the manufacture of perfume or as flavoring in toothpastes.

# Propagation

**Basic requirements** Thyme grows best in warm, sunny climates at temperatures between 4 and 28°C (39.2–82.4°F) but will grow best at 16°C (60.8°F). Established plants can survive temperatures down to -16°C (3.2°F). Thyme is tolerant of drought conditions but water-logged soil is detrimental to its survival and production. Thyme will grow best in well-draining, fertile sandy loam or sand. Thyme should be planted in alkaline soils and require full sunlight for optimum productivity. **Propagation** Thyme is propagated from seed and can be direct seeded or sown in a nursery to produce transplants. Thyme can also be propagated from cuttings, air layering or by division of the roots. When planting seeds, they should be covered with a thin layer of soil to prevent them from drying out while they germinate. Seedlings should be thinned to a final spacing of 10–15 cm (4–6 in) allowing 20–25 cm (8–10 in) between rows. Transplants can be planted in the field after hardening when they are 5–8 cm (2–3 in) tall. Cuttings should be taken from healthy, vigorous plants by taking a clipping about 7.6 cm (3 in) in length from the end of a branch. The leaves should be removed from the lower half of the cutting before planting in light textured potting media to root. The cutting should be watered regularly and kept moist, but not wet while they root. The new plants will be ready for transplanting after approximately 8 weeks. After hardening and are planted in the same way as seed-grown transplants.

**General care and maintenance** It is common practice to mulch thyme plants with a layer of limestone gravel to suppress weeds, conserve soil moisture, improve drainage around the plant crown and reflect light back to the foliage. Once planted, thyme will grow adequately without fertilization, but will benefit from the occasional application of well aged manure or a balanced fertilizer. Similarly, thyme can withstand drought but will benefit from supplemental irrigation during dry periods. The soil should be allowed to dry out between waterings. Thyme plants should be pruned regularly by pinching off the tips of the shoots to promote branching. **Harvesting** Thyme is best harvested just prior to flowering when the essential oil content of the leaves is at its highest. Plants can also be harvested during flowering but the flowers are very attractive to bees and this may make harvesting more problematic at this time. Thyme is harvested by cutting the branches 8–10 cm (3–4 in) above the ground. Cutting can be done by hand or, in the case of commercial production, by machine.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Alternaria blight** *Alternaria brassicicola*

##### **Symptoms**

Small, round, yellow, brown or black spots with concentric rings which appear first on lower shaded leaves; holes in leaves caused by lesions drying and dropping out; leaves dropping; death of plant

##### **Cause**

Fungus

**Comments**

Spread by infected seed; use wide plant spacing to promote air circulation

**Management**

Remove and destroy infected leaves; use wide plant spacing to promote air circulation around foliage

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# Tobacco

## Description

Tobacco, *Nicotiana tabacum*, is an herbaceous annual or perennial plant in the family Solanaceae grown for its leaves. The tobacco plant has a thick, hairy stem and large, simple leaves which are oval in shape. The tobacco plant produces white, cream, pink or red flowers which grow in large clusters, are tubular in appearance and can reach 3.5-5.5 cm (1.25-2 in) in length. Tobacco may reach 1.2-1.8 m (4-6 ft) in height and as is usually grown as an annual, surviving only one growing season. Tobacco may also be referred to as Virginia tobacco or cultivated tobacco and originates from South America.

*Tobacco harvest*

*Tobacco flowering*

*Tobacco flowers*

*Tobacco plants*

*Tobacco field*

*Tobacco plants*

## Uses

Tobacco is a stimulant and the dried leaves of the tobacco plant can be cured and used to produce tobacco cigarettes, cigars and snuff or for pesticide production.

# Propagation

**Basic requirements** Tobacco grows very well in a wide range of climates and will grow optimally at temperatures between 20 and 30°C (68–86°F) in areas where there is a dry period to facilitate harvest of the leaves. The type of soil depends on the variety of tobacco being grown but the best yields are usually obtained in loam to sandy loam soils. The soil should have a pH between 5.0 and 6.6. Tobacco plants are easily damaged by waterlogged soils and quality can be affected by high salinity. Plants should therefore be grown in a well draining and well aerated soil. **Propagation** Tobacco is propagated from seed on protected (covered) seed beds or in the glasshouse and transplanted to the final growing site. Seeds grown outdoors are protected for the first few weeks to prevent weather damage to the emerging young plants. seedlings are transplanted after 30–60 days when they are approximately 15 cm (6 in) in height. The young plants should be spaced 46–61 cm (18–24 in) apart. **General care and maintenance** The best quality tobacco leaves are produced when the flowerheads of the plants are removed, a process known as topping. Topping plants promotes the development of suckers which should also be removed. Suckers are removed through the use of chemicals in commercial tobacco production with some hand removal also necessary. Fertilizer and irrigation requirements of tobacco vary with the variety being grown but generally, tobacco has a requirement of 40–80 kg per hectare of nitrogen, 80–90 kg per hectare of phosphorous and 50–110 kg per hectare of potassium. **Harvesting** Tobacco is harvested by hand in most parts of the world by picking 2–3 leaves from each plant per harvest. In the USA and Canada, tobacco plants are mechanically harvested by cutting the stalks of the plants. Only fully mature leaves should be harvested when hand picking is practiced and harvests should be carried out at weekly intervals. After harvest, leaves are usually tied in pairs to cure.

# References

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Alternaria leaf spot (Brown spot)** *Alternaria alternata*

*Closeup of brown spot*

*Alternaria; Brown spot on lower leaf*

*Symptoms of brown spot*

*Brown spot on tobacco*

### Symptoms

Small, circular, target-like spots on lower leaves; lesions are usually surrounded by a bright yellow halo; lesions enlarge and coalesce; centers of lesions dry out and drop from leaf giving foliage a ragged appearance; if variety of tobacco being grown is susceptible to the disease then spots may also appear on stalks and suckers; if spots girdle stems then the

plant may be killed.

### Cause

Fungus

### Comments

Disease emergence favors warm, wet weather; excessive fertilization can cause greater crop losses.

### Management

Rotating crop away from tobacco can help to reduce the levels of inoculum in a field; stalks and roots left after harvest should be removed and destroyed; control nematodes in the soil; ensure plants have adequate potassium available to promote vigorous growth.

## Blue mold *Peronospora tabacina*

*Blue-gray fungal growth is produced on the underside of the spots when the fungus is active*

*Blue mold symptoms on tobacco*

*Blue mold symptoms on tobacco seedling*

*Tobacco seedlings infected with blue mold*

*Blue mold symptoms on tobacco*

### Symptoms

Circular patch of seedlings developing yellow leaves; seedlings in center may have leaves that have curled into a cup shape; fluffy blue spores developing on underside of leaves; distorted leaves; yellow lesions on leaves which may have blue mold growing on them.

### Cause

Fungus

### Comments

Disease emergence favors cool, wet conditions.

### Management

Avoid over fertilizing tobacco crop and the use of overhead irrigation which created favorable conditions for the development of the fungus; applications of appropriate protective fungicides is usually necessary to control the disease in temperate and subtropical areas.

## Frogeye leaf spot *Cercospora nicotianae*

*Disease symptom on infected leaves*

*Leaf spot symptoms*

*Frogeye leaf spot on tobacco*

### Symptoms

The pathogen infects all stages of crop (even after the leaves are harvested). Initially the lower leaves exhibit brown, round lesions which resembles frog-eye shape (generally of 2 -15 mm in diameter) with grayish center. The disease spreads upwards. Under favorable condition lesions may coalesce to become bigger lesions resulting in drying of leaves. Also we can see black dots (spores) in the centre of this lesions.

### Cause

Fungus

### Comments

The disease is favored by wet weather conditions. The pathogen is more prevalent in Taiwan, Nigeria, Pakistan, Central America and India.

### Management

Remove and burn the infected leaves. Follow crop rotation. Keep the field free from weeds. Follow proper crop density. If

the disease is severe apply suitable fungicides.

## Category : Oomycete

### Black shank *Phytophthora parasitica*

<i>Black shank symptom</i>	<i>Black shank infected plant</i>	<i>Leaves with symptoms of the disease "Black shank" in this case called "Foliar Black shank" on dark tobacco.</i>
<i>The split open stalk showing dark pith in discrete discs</i>	<i>Stalks generally develop black lesions which may extend several inches above the ground</i>	

#### Symptoms

Rapid yellowing and wilting of the plant proceeds plant death; dark brown to black sunken lesion is usually present on the stalk of the plant close to the soil line; lesion may extent up the stalk turning it black; splitting open stalks reveals darkened pith in discrete discs.

#### Cause

Oomycete

#### Comments

Disease emergence favors poorly drained soil and warm weather.

#### Management

Rotating the crop away from tobacco for at least one year will help to reduce levels of inoculum; plant tobacco varieties that have some degree of resistance to the disease; apply appropriate fungicides to the soil; plant tobacco in well draining soils; destroy stalks and roots immediately after harvest to reduce overwintering sites for the pathogen; control nematodes in the soil.

## Category : Other

### Broomrape *Orobanche cernua*

*Orobanche ramosa*

<i>Seeds of Nodding broomrape (<i>Orobanche cernua</i>)</i>	<i>Broomrape in tobacco field</i>	<i>Branched broomrape (<i>Orobanche ramosa</i>) attached to the tobacco roots</i>
<i>Nodding broomrape (<i>Orobanche cernua</i>) in tomato field</i>	<i>Nodding broomrape (<i>Orobanche cernua</i>) seeds</i>	

#### Symptoms

Broomrape is a complete root parasite which lacks chlorophyll and conspicuous leaves. Generally the weed shoots emerge near the tobacco plants in cluster and there roots were attached to tobacco roots to extract nutrients and water. The infested plants become weak, stunted with pale leaves. Eventually the whole plant may wilt.

#### Cause

Weed

#### Comments

It will cause 30 to 70% yield loss depends on severity of infestation. Broomrape also attacks on tomato, okra, eggplant etc.

#### Management

Deep summer ploughing helps in exposing weed seeds to sunlight and reduce weed population. Remove the emerged weeds before flowering and burn them (hand weeding). Rotating the crop with sorghum, black gram etc., to reduce weed population.

## Category : Fungal, Oomycete

### **Collar rot** *Sclerotinia sclerotiorum*

*Plants can be rotted in half by complete rotting of a portion of the lower stem.*

*Collar rot infected plants*

*Lower stem of an infected plants which severely rotted.*

#### **Symptoms**

Water-soaked, soft, green, lesion at base of stem; white mycelium present on lesion; black fungal structures developing out of the white fungal growth.

#### **Cause**

Fungus

#### **Comments**

Serious disease of glasshouse grown tobacco plants.

#### **Management**

Reduce build-up of moisture in glasshouses by increasing ventilation and air circulation; increase frequency of leaf clipping and reduce the amount of leaves removed at each clipping; avoid injury to seedlings.

## Category : Bacterial

### **Granville wilt** *Ralstonia solanacearum*

*Infected stem*

*Infected plant*

*Symptoms on infected stem*

*Bacterial wilt infected plant*

#### **Symptoms**

Wilting on one side of the plant; entire plant begins to wilt and plant usually dies; if plant does not die then growth is usually stunted with twisted and distorted leaves; the stalk of the plant turns black, especially at the soil line.

#### **Cause**

Bacterium

#### **Comments**

The disease is most damaging in fields where tobacco has been grown the previous year and in wet areas of fields; bacterium can also colonize other Solanaceous crops such as tomato, pepper and eggplant as well as several weed species.

#### **Management**

One of the most important management strategies for Granville wilt is crop rotation as the bacteria that cause the disease do not survive well in the absence of the tobacco host plant; a rotation away from tobacco for as little as one year is highly beneficial; some tobacco varieties are more susceptible to the disease than others, although none are completely immune, and should be grown when the disease is of concern; all tobacco crop debris should be removed and destroyed following harvest to reduce inoculum levels.

## Category : Viral

### Tobacco Leaf Curl disease

Tobacco Leaf Curl Virus (TLCV)

Begomovirus

*TLCV infected field*

*Tobacco Leaf Curl Virus (TLCV)  
infected plant*

#### Symptoms

The infected plants are stunted with twisted stem ; leaves become small, curled, twisted and puckered. The veins of infected leaves may become thickening or show enations.

#### Cause

Virus

#### Comments

The virus is transmitted by whiteflies *Bemisia tabaci* .

#### Management

Use available resistant varieties. Controlling the whiteflies will reduce the virus spread- use yellow sticky traps or cover the tobacco seedling /nursery with nylon nets or growing barrier crops (like sunflower etc.,) around the nursery may reduce the white fly population.

### Tobacco mosaic

Tobacco mosaic virus (TMV)

*Infected leaf*

*Tobacco plant showing symptoms of  
infection with Tobacco Mosaic Virus.*

*Tobacco plant infected with TMV*

#### Symptoms

Alternating light and dark green patches on the leaves; leaves turning brown and drying out.

#### Cause

Virus

#### Comments

Can be spread by farming equipment and on hand that have come into contact with cigarettes or other tobacco product; wash hands after tobacco use before touching plants.

#### Management

Plant resistant tobacco varieties; remove and destroy any infected plants; disinfect tools thoroughly; wash hands thoroughly after use of tobacco products before handling plants; avoid having tobacco products on person when working with tobacco plants.

### Tomato spotted wilt virus on Tobacco

Tomato Spotted Wilt Virus (TSWV)

Tospovirus

*TSWV infected plant*

*The mature leaves showing  
concentric ring spots*

*Infected plant in the field showing  
symptoms*

#### Symptoms

It infects all stage of tobacco plant. The infected young leaves may turn yellow then reddish brown; buds may become distorted and deformed. The mature leaves may develop concentric ring spots which later coalesce to form large areas of dead tissue . Some leaves shows yellowing and death of plant tissue along leaf veins. Stem may also show dark oblong

concentric spots and lesions.

#### Cause

Virus

#### Comments

The virus attack wide variety of crops and is mainly transmitted by thrips.

#### Management

Remove the infected plant and burn them. Keep the field free from weeds. Spraying suitable insecticide to control thrips.

## Pests

### Category : Insects

#### Aphids *Myzus persicae*

*Development of sooty mold on tobacco leaves due to aphids infestation*

*Aphid infestation*

*Aphid infestation on tobacco leaf*

#### Symptoms

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants.

#### Cause

Insect

#### Comments

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed.

#### Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use.

#### Horworms (Tobacco hornworm, Tomato hornworm) *Manduca quinquemaculata*

*Manduca sexta*

*Hornworm larvae feeding on tobacco leaves*

*Tobacco hornworm*

*Tobacco leaf damaged by hornworms*

#### Symptoms

Feeding damage to leaves or leaves stripped from plant; heavy infestation may result in damage to fruit appearing as large open scars; large green caterpillars may be spotted on plant; caterpillars may reach in excess of 7.5 cm (3 in) in length and possess a spike at the end of their body; most common species have 7 diagonal stripes on sides or 8 v-shaped markings on each side; single eggs may be present on leaves and measure approx 1.3 mm in diameter; eggs are in

initially light green in color and turn white prior to hatching.

#### Cause

Insect

#### Comments

Insect overwinters as pupa in soil; typically undergoes 2 generations per year; heavy infestations are more common in warm areas.

#### Management

Hand pick larvae from plants leaving any parasitized larvae behind to promote populations of natural enemies (these larvae can be distinguished by the presence of white, oblong-shaped cocoons on their backs); sprays of *Bacillus thuringiensis* are organically acceptable and highly effective.

### **Loopers (Cabbage looper, Alfalfa looper) *Trichoplusia ni***

*Autographa californica*

*Cabbage looper and damage on tobacco*

#### Symptoms

Large or small holes in leaves; damage often extensive; caterpillars are pale green with a white lines running down either side of their body; caterpillars are easily distinguished by the way they arch their body when moving; eggs are laid singly, usually on the lower leaf surface close to the leaf margin, and are white or pale green in color.

#### Cause

Insect

#### Comments

Insects overwinter as pupae in crop debris in soil; adult insect is a dark colored moth; caterpillars have a wide host range.

#### Management

Looper populations are usually held in check by natural enemies; if they do become problematic larvae can be hand-picked from the plants; an organically acceptable control method is the application of *Bacillus thuringiensis* which effectively kills younger larvae; chemical sprays may damage populations of natural enemies and should be selected carefully.

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# Tomato

## TOMATO

### Description

### Crop Details

The following are the crop details for tomato

Scientific name: *Lycopersicon esculentum*

Order: Solanales

Family: Solanaceae

Genus: Solanum

Species: S. lycopersicum

### Local Names

Nyanya (Swahili) Inyanya (Iuhya)

### General information.

Tomato is an herbaceous annual in the family Solanaceae grown for its edible fruit. The plant can be erect with short stems or vine-like with long, spreading stems.

The stems are covered in coarse hairs and the leaves are arranged spirally. The tomato plant produces yellow flowers, which can develop into a cyme of 3–12, and usually, a round fruit (berry) that is fleshy, smoothed skin, and can be red, pink, purple,

brown, orange, or yellow in color.

The tomato plant can grow 0.7â€“2 m (2.3â€“6.6 ft) in height and as an annual, is harvested after only one growing season. Tomato may also be referred to as the love apple and originates from South America.

Tomatoes are native to South and Central America, but they are now grown all over the world.

Tomatoes are one of Africa's most widely grown vegetable crops. They are grown for home consumption in almost every homestead's backyard across Sub-Saharan Africa.

They are a good source of vitamins as well as a cash crop for smallholders and medium-scale commercial farmers. Tomatoes used as flavor enhancers in food are always in high demand, both fresh and processed.

*Tomatoes ripening on the vine*

*Ripening fruits*

*Flowers*

*Immature tomato*

*Tomato leaf close-up*

*Tomato stems and foliage*

*Tomato flower*

*Unripe tomato fruits*

*Ripe tomato fruit*

## Varieties

Tomatoes are classified into two types based on plant habit: determinate and indeterminate. Determinate (and semi-determinate) varieties have flower clusters at the end of their stems. The determinate is shorter and bushier, whereas the semi-determinate is taller. Indeterminate varieties produce new leaves and flowers all the time and can grow very tall. Indeterminate varieties bear fruit for a longer period of time. Indeterminate varieties must be staked and pruned and require more labor.

### a). Roma tomato variety

They are also referred to as a paste tomato. Paste tomatoes, like roma tomatoes, have a thicker fruit wall, fewer seeds, and a denser but grainier flesh.

Roma tomatoes are oblong in shape and large for their size. They are also firmer than non-roma or paste tomatoes.

They are determinate in the sense that they ripen all of sudden in place of at some stage in the season. While they can be consumed raw, they are at their best when cooked.

### b). Anna F1 tomato variety

These varieties produce very high yields, require less labor, and are relatively resistant to tomato diseases. It's a fresh market tomato variety that grows best in a greenhouse. It's an oval-shaped, deep-red fruits.

It is one of Kenya's tomato varieties resistant to Alternaria stem canker, nematodes, and Fusarium wilt.

This variety matures quickly, relatively seventy-five days after transplanting. Its maturity period is determined by the weather.

The first harvest of Anna F1 yields less than later harvests, as with most tomato varieties in Kenya. Anna F1 produces an average of 74 tons of tomatoes per acre and 35 kg per tomato plant.

### c). Bingo

Bingo is a large-fruited Heirloom Tomato Seed is widely adapted to a wide range of growing conditions and consistently produces large, smooth fruit. To protect the fruit from sunburn, the plant grows a dense canopy of leaves.

#### **d). Plum**

A plum tomato, also known as a processing tomato or paste tomato, is a tomato variety bred for sauce and packing.

They are typically oval or cylindrical in shape, with fewer locules than standard round tomatoes and a higher solid content, making them more suitable for processing.

#### **e). Cherry tomato**

The cherry tomato is a small round tomato that comes in red, yellow, green, and black colors. Since they're naturally sweet, they are typically eaten raw in salads.

## **Uses**

Tomato fruit can be eaten raw or cooked and is used in many dishes. The fruit may also be processed into juice, soup, ketchup, puree, paste or powder.

## **Planting and propagation**

Tomatoes can be direct-seeded or transplanted in the field, but this method is costly because large amounts of seed are required (about 500 to 1000 g of seeds/ha) and four weeks of weeding labor is added to the growing costs.

Growing young transplants in a special nursery, on the other hand, allows growers to achieve high seedling uniformity while using less seed and saving money on weeding.

#### **Nursery bed preparation:**

Build raised seedbeds with a maximum width of one meter in an area where no potatoes, tomatoes, eggplants, or peppers have been grown in the last three years.

Add about 5 kg of good compost per m<sup>2</sup> to seedbeds that are finely cultivated on top.

Use a pointed stick to drill shallow seeding furrows. One hectare of tomatoes necessitates 150 to 200 g of germinating seed.

Sow seeds in the furrows and lightly cover with soil.

Firmly pat with the flat side of a rake or similar tool, then mulch and water generously.

Fresh manure should never be used on a seed bed because it will burn young seedlings.

After seedlings emerge, remove the mulch from the rows to allow sunlight to reach the young seedlings.

Growing individual plants in banana leaf pots or plastic seedling trays improves eventual plant establishment by reducing transplant shock and root damage during transplanting. To maintain good, healthy growth, the young seedlings require adequate water. Reduce watering a week before transplanting to harden the seedlings. Seedlings that are three to four weeks old (15 to 25 cm tall with 3 to 5 true leaves) are ready for transplanting.

To avoid root damage, seedlings must be thoroughly watered 12 to 14 hours before being lifted from the seedbed. To reduce transplant shock, plant seedlings in the afternoon or on a still, cloudy day, and water them immediately.

Plant establishment can be greatly accelerated by applying as little as a cup of water per plant immediately after planting.

Plant spacing and distance between rows are determined by the cultivar's growth habit and whether the plants are to be staked or allowed to grow on the ground.

Indeterminate varieties are typically staked, whereas determinate varieties can be grown without staking in the field. Plants are typically spaced 30 to 60 cm apart in single or double rows on 1.0 to 1.4 m wide beds.

## **Husbandry**

Tomatoes respond well to liberal applications of well-rotted compost or manure. A spoonful (or three teaspoons) of rock

phosphate should also be added to each planting hole. If the soil is deficient in organic matter, it is best to grow a crop of high-quality green manure like cowpeas, mucuna, soybeans, or crotalaria before transplanting tomato seedlings.

Avoid commercial nitrogen fertilizers because too much nitrogen causes fruit puffiness and blossom-end rot, as well as excessive vegetative growth. Excess free nitrogen in the soil softens the leaves and makes the plants more appealing to pests and diseases. Weed competition can be fierce, especially in the hot and humid tropics.

Slash emerging weeds as close to the ground as possible between rows of tomatoes to control weeds on open land crops. Leave slashed weeds as mulch on the soil to help prevent erosion, lower soil temperature, and conserve soil moisture. This should be supplemented by manual weeding in rows and straw mulching of the beds.

### **Staking**

For tall growing indeterminate varieties, firmly plant a 2 m stake in the ground for each tomato plant and loosely tie the stems as the plant grows. Alternatively, place a sturdy pole in the ground every four meters and run two wires - one at 2 meters and another at 0.15 meters above the ground. Connect the two wires behind each tomato plant with a fairly strong string. As the plants grow, they can be carefully twisted around the strings.

### **Pruning**

For indeterminate tomato varieties, pruning is required. On a weekly basis, one or two main stems should be allowed to grow and the side branches (laterals) should be pinched off as the crop grows. When 6 to 8 flower clusters form, the growing top should be pinched off to promote the development of large marketable fruit.

Remove any leaves that are close to the ground to help prevent blight infection. On determinate cultivars, there is no pruning and no regulation of fruit number and clusters. Semi-determinate cultivars can be grown as both a determinate and an indeterminate crop.

To avoid spreading tobacco mosaic virus disease, smokers should thoroughly wash their hands with soap before handling tomato plants.

Tomatoes require adequate irrigation during the early stages of plant growth, fruit set, and fruit enlargement.

The consistency of water supply to the plants is critical in achieving uniform maturity. It also reduces the occurrence of blossom-end rot, a physiological disorder caused by a lack of calcium during fruit enlargement. Watering is required at least twice a week in dry weather. Because it does not cause water splashes on the plants, drip irrigation is the most efficient and risk-free method of irrigation.

Although indeterminate, cherry tomatoes can produce quite well even when not staked in the field, but they must be given adequate space because they spread quite widely (one m<sup>2</sup> per plant is recommended). Higher output and easier field management are advantages of the costly staking procedure.

### **Harvesting and post handling practices.**

Before being marketed, fresh-market tomatoes are frequently harvested at the mature-green stage and ripened in transit or storage. Ethylene is sometimes used to quickly and uniformly ripen mature-green tomatoes before shipping them to market, but this has a negative impact on quality. In Kenya, this is not a common practice. Pre-ripe tomatoes are generally of lower quality (lower soluble solids, ascorbic acid, and reducing sugars) than plant-ripened tomatoes.

Fresh-market tomato cultivars' growth and ripening patterns necessitate frequent pickings for either mature-green or plant-ripe fruits. Processing tomatoes, as opposed to fresh market or table tomatoes, are picked fully ripe. Harvesting is often done by machine in developed countries. Tomatoes used in pureed products such as soup, juice, and sauces are grown until more than 85% of the fruits are ripe. Those for whole tomatoes are picked while still firm, but only about 65% of the crop may be ready at once.

To prepare tomatoes for market, store them in a shady location, either in the field or at home, after picking. The marketable fruits are then packaged in appropriate containers, which are typically 20-kg wooden boxes, bamboo baskets, plastic boxes, or other locally available packaging materials.

Proper packaging protects the fruits and reduces water loss. Tomato storage life is determined by the maturity stage at which they are harvested as well as the desired fruit quality. Quality is highest when fully ripe, whether artificially or

naturally. To ripen properly, mature-green tomatoes should be stored for 7 to 10 days at 13 to 18°C and 85 to 90% RH.

The single most important visual parameter of tomato quality is color. Lycopene development is generally poor at temperatures above 30°C. This is the primary reason that tomatoes grown in the hot tropics have a pale red or yellowish color and are bland in flavor.

Cherry tomato harvesting and packaging are determined by market demand. Fruit clusters can be cut for distant markets when the fruits turn red or pink, depending on the cultivar. For the domestic market, firm red ripe fruits are required. However, cherry tomatoes for the export market are graded and packaged into pre-packs before being shipped directly to supermarkets in the export destinations.

A marketable yield of 20 tons/ha or higher is considered a good yield. Under experimental conditions at KALRO, Thika Horticultural Research Station, yields of up to 60 tons/ha have been obtained.

## Climate conditions, soil and water management

For high yield and premium quality, tomatoes prefer a relatively cool, dry climate. It is, however, adaptable to a wide range of climatic conditions. Tomatoes have been grown as far north (under protection) as the Arctic Circle and as far south as the hot and humid equator. Temperatures between 21 and 24°C are ideal for growth and development. Prolonged exposure to temperatures below 12°C can result in chilling. Temperatures above 27°C have a negative impact on growth and fruit set.

Pollen and egg cells are destroyed when the maximum daytime temperature is 38°C or higher for 5 to 10 days. Fruit set is also generally poor when night temperatures exceed 21°C just before and after flower formation. Flower abortion can also be caused by hot, dry winds.

Tomatoes are not affected by day length and can produce fruit in photoperiods ranging from 7 to 19 hours. Tomatoes can be grown in a variety of soil types, from sandy loam to clay-loam soils rich in organic matter. The ideal pH range for soil is 6 to 6.5; higher or lower pH can result in mineral deficiencies or toxicities. Flooding for extended periods is harmful to tomato growth and development.

### Small-holder farmer tomato seed production

It is not recommended to use hybrid varieties for seed production. The label "F1" denotes these varieties. If a hybrid variety is preferred, it can only be used for one generation (one crop cycle).

#### Conditions to be followed when producing seed:

- â€¢ The tomato seed should only be multiplied once.
- â€¢ The tomato seed plot should be 25 meters away from any other tomato crop.
- â€¢ The plot should not have recently had tomatoes planted.
- â€¢ The tomato crop should be scouted for pests and diseases on a regular basis.
- â€¢ Fruits should not be included in the first step for seed extraction.
- â€¢ After planting the seed, the off types should be uprooted as soon as possible.
- â€¢ The plot should be properly weeded.
- â€¢ Proper crop management is required, such as fertilizer application, pruning, staking irrigation, and so on.

### Seed extraction process

- â€¢ Pick ripe fruit from only robust, disease-free plants (plants free of bacterial canker, bacterial speck, bacterial spot, anthracnose fruit rot, early blight, late blight, and tomato mosaic virus).

• Wash the fruit, preferably with a potassium-based soap, to reduce the risk of disease infection.

• Cut the fruit in half and scoop out the seeds with a spoon. Alternatively, squeeze the pieces into a clean bucket, plastic, glass, or ceramic bowl until only the seed-jelly and fruit sap remain.

• Cover the bowl with a cloth or paper to keep dirt and other contaminants out, but don't make it airtight.

Allow the seeds to sit for 1 to 5 days (usually 2 to 3 days in warm areas).

If seeds cannot be sown right away, they should be stored in a waterproof container (transparent plastic bag / clear glass bottle). Transparent materials allow sunlight in, reducing mould growth. Put some ashes in the bottom of the container to absorb moisture and keep the seeds from moulding. When storing seeds in pots or bottles, the tops should be covered with plastic film to prevent water seepage and mite infestation.

• Keep the seed container in a cool, dry location.

• Check the seeds for mould development on a regular (at least weekly) basis. If mould is found, the seeds should be dried again.

Seeds can be stored for up to two years if properly dried.

One kg of tomatoes will produce between 1 and 4 grams of seeds.

*Square tomato cage*

*Tomatoes with trellis*

*Tomatoes growing with a stake support system*

*Tomato trellis*

*Creative tomato trellis*

*Young tomato plant positioned within a cage*

*Staked tomatoes growing in a raised bed*

*Tomato cages give the plant support and keep fruit off of the ground*

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Anthracnose** *Colletotrichum coccodes*

*Large lesion on tomato fruit*

*Sunken, and circular lesions on the fruit is a characteristic symptom.*

*Anthracnose symptoms on tomato leaf*

*Anthracnose symptoms on tomato leaf*

*Anthracnose symptoms on tomato leaf*

*Anthracnose on tomato fruit*

*Anthracnose on tomato fruit*

*Anthracnose on tomato fruit*

*Anthracnose on tomato fruit*

#### **Symptoms**

Fruit symptoms are the most common although stem, leaves and roots can also be infected; disease causes characteristic sunken circular lesions on the fruit; the indentations on may have visible concentric brown and yellow rings; lesion centers turn tan in color as they mature and become dotted with small black fungal fruiting bodies (microsclerotia); lesions can grow very large

#### **Cause**

Fungus

#### **Comments**

Disease emergence favors warm weather; appears early in the spring

#### **Management**

Avoid sprinkler irrigation when fruit is ripening; rotate crops with other non-solanaceous plants

#### **Black mold** *Alternaria alternata*

*Black mold infected tomato leaves*

*Canker at the base of plant, blackish growth of Alternaria conidia*

*Alternaria black molds / stem cankers (Alternaria spp.) canker at the base of plant*

*Alternaria black molds / stem cankers (Alternaria spp.) leaf symptoms: dark brown to black areas of tissue*

*Black mold symptom*

#### **Symptoms**

Disease causes the appearance of black or brown lesions on the surface of ripe fruit; lesions may be tiny flecks or may be large patches of decaying tissue; during periods of humid weather, the lesions may become covered in black, velvety spore masses.

#### **Cause**

Fungus

#### **Comments**

Disease is found wherever tomatoes are grown; ripe fruit become increasingly susceptible to the fungus the longer they stay on the vine after ripening.

## Management

Cultural control methods such as avoiding wetting the foliage when watering and harvesting fruits as soon as they are ripe can help to reduce the incidence of the disease; in areas where disease is a persistent problem, chemical control may be necessary with an appropriate fungicide; fungicide is usually applied 4-6 weeks prior to the first anticipated fruit harvest.

## Early blight *Alternaria solani*

Sporulation from an infected fruit lesion. The fungus survives on infected tomato debris

A dark lesion at the shoulder of the fruit

Severely blighted leaves

Concentric leaf lesions can be seen on infected leaves

Close up of early blight leaf lesion

Early blight symptoms on tomato stem

A fruit in the field with severe infection

Fruit symptoms include small black v-shaped lesions at the shoulders of the fruit

The canker may enlarge to girdle the whole stem

Oval shaped lesions with a yellow chlorotic region

Blighted tomato plants

Early blight symptoms on tomato fruit

A chain of *Alternaria* spores

*Alternaria* stem canker symptoms

The leaves completely collapse in severe infection.

Early blight symptoms on tomato foliage

Early blight symptoms on tomato foliage

Early blight symptoms on tomato foliage

## Symptoms

Early blight symptoms start as oval shaped lesions with a yellow chlorotic region across the lesion; concentric leaf lesions may be seen on infected leaves; leaf tissue between veins is destroyed; severe infections can cause leaves to completely collapse; as the disease progresses leaves become severely blighted leading to reduced yield; tomato stems may become infected with the fungus leading to *Alternaria* stem canker; initial symptoms of stem canker are the development of dark brown regions on the stem; stem cankers may enlarge to girdle the whole stem resulting in the death of the whole plant; brown streaks can be found in the vascular tissue above and below the canker region; fruit symptoms include small black v-shaped lesions at the shoulders of the fruit (the disease is also known black shoulder); lesions may also appear on the fruit as dark flecks with concentric ring pattern; fruit lesions can be seen in the field or may develop during fruit transit to the market; the lesions may have a velvety appearance caused by sporulation of the fungus

## Cause

Fungus

## Comments

Disease can spread rapidly after plants have set fruit; movement of air-borne spores and contact with infested soil are causes for the spread of the disease

## Management

Apply appropriate fungicide at first sign of disease; destroy any volunteer solanaceous plants (tomato, potato, nightshade etc); practice crop rotation

## Fusarium wilt *Fusarium oxysporum*

<i>Seedling showing browning of the vascular system</i>	<i>Yellowing of the leaves on one side of the plant</i>	<i>Yellowing, wilting, and necrosis of older leaves on one side of the plant</i>
<i>Whole plant dying</i>	<i>Fusarium wilt symptoms may appear on one half of an infected plant indicating the blockage in the vascular system on that side</i>	<i>Plants infected with Fusarium wilt</i>
<i>Wilting tomato plants</i>		<i>Vascular discoloration caused by Fusarium wilt infection</i>
<i>Wilting tomato plants with characteristic yellow discoloration at top of plant</i>	<i>Fusarium wilt in tomato field</i>	<i>Symptoms of fusarium wilt on tomato foliage</i>
<i>Symptoms of fusarium wilt on tomato foliage</i>	<i>Collapse of tomato plant infected with Fusarium wilt</i>	<i>Discolored tomato stem tissue caused by fusarium wilt</i>

## Symptoms

Symptoms of Fusarium wilt may first appear as yellowing and wilting of leaves on one side of the leaf midrib or plant; one-sided symptoms are caused by a blockage in the vascular system supplying the symptomatic side of the plant; as the disease progresses, older leaves become necrotic and the plant begins to wilt; fruit on infected plants is smaller and yield is reduced; damage to leaves makes fruit susceptible to sunscald; stem symptoms may be mistaken for bacterial wilt but a bacterial ooze test will be negative; stem tissue becomes discolored brown

## Cause

Fungus

## Comments

Disease emergence favors warm, moist soil Fusarium wilt is not a major issue in tomato production, however, the disease can still cause minor losses

## Management

Plant resistant varieties; sanitize all equipment regularly; control root knot nematodes; rotate crops away from tomato for several years

## Gray mold (Botrytis blight) *Botrytis cinerea*

<i>Infected fruit</i>	<i>Infected foliage</i>	<i>Sporulation on infected stem</i>	<i>Infected stem</i>
<i>Infected stem</i>		<i>Symptoms on stem</i>	<i>Gray molds infected stem</i>
<i>Gray mold symptoms on tomato fruit</i>	<i>Gray mold symptoms on tomato stem</i>		<i>Gray mold symptoms on tomato stem</i>

## Symptoms

Disease appears on tomato seedlings at or just below the soil line as a fuzzy gray-brown lesion which often girdles the stem, if stem is girdled all parts of the plant above the lesion begin to wilt; infected flowers and calyxes become covered in gray spores; unripe fruit turns light brown or gray in color and rots; green fruit infected by airborne spores develop

circular white rings called "ghost spots".

### Cause

Fungus

### Comments

Gray mold is usually associated with wounds on plants; can develop in relatively cool conditions.

### Management

Liming soil to increase calcium content can help to reduce plant susceptibility to gray mold; application of appropriate fungicide prior to formation of dense canopy.

## Leaf Mold *Passalora fulva*

<i>Leaf mold symptoms</i>	<i>Yellow spots Infected leaf, upper side</i>	<i>Brown, felt-like patches of conidia on lower leaf surface</i>
<i>Yellow spots due leaf mold</i>	<i>Spots look diffuse on lower leaf surface.</i>	<i>Spots look diffuse with fuzzy growth on lower leaf surface.</i>
<i>Yellow areas on upper leaf surface</i>	<i>Leaf spots and sporulation on underside of leaf</i>	<i>Spots on upper leaf surface due to leaf mold fungus</i>
<i>Close-up of moldy growth on underside of leaf spot.</i>	<i>Symptoms on lower surface</i>	<i>Symptoms on leaf mold infected fruits</i>
<i>Brown leaf spots on upper leaf surface</i>		<i>Leaf mold symptoms on lower leaf surface</i>

### Symptoms

The older leaves exhibit pale greenish to yellow spots (without distinguishable margins) on upper surface. Whereas the lower portion of this spots exhibit green to brown velvety fungal growth. As the disease progress the spots may coalesce and appear brown. The infected leaves become wither and die but stay attached to the plant. The fungus also infects flowers and fruits. The affected flowers become black and drop off. The affected fruit intially shows smooth black irregular area on the stem end but later it becomes sunken, leathery and dry.

### Cause

Fungus

### Comments

The disease is favored by high relative humidity. Also a common disease in green house tomato crop.

### Management

Grow available resistant varieties. Avoid leaf wetting and overhead application of water. Follow proper spacing to provide good air circulation around the plants. Remove the infected plant debris and burn them. If the disease is severe scarry suitable fungicide.

## Septoria leaf spot *Septoria lycopersici*

*Septoria leaf spot symptoms on tomato foliage*

*Septoria leaf spot symptoms on tomato foliage*

*Close-up of a Septoria lesion on tomato*

*Close-up of leaf lesion showing gray-white center with fungal fruiting bodies*

*Symptoms of Septoria leaf spot on tomato foliage*

*Septoria leaf spot symptoms on tomato leaf*

*Septoria leaf spot lesion on tomato leaf*

## **Symptoms**

Symptoms may occur at any stage of tomato development and begin as small, water-soaked spots or circular grayish-white spots on the underside of older leaves; spots have a grayish center and a dark margin and they may colase; fungal fruiting bodies are visible as tiny black specks in the center of spot; spots may also appear on stems, fruit calyxes, and flowers.

## **Cause**

Fungus

## **Comments**

Spread by water splash; fungus overwinters in plant debris.

## **Management**

Ensure all tomato crop debris is removed and destroyed in Fall or plowed deep into soil; plant only disease-free material; avoid overhead irrigation; stake plants to increase air circulation through the foliage; apply appropriate fungicide if necessary.

## **Target Spot** *Corynespora cassiicola*

*Black lesions with conidia*

## **Symptoms**

The fungus infects all parts of plant. Infected leaves shows small, pinpoint, water soaked spots initially. As the disease progress the spots enlarge to become necrotic lesions with conspicuous concentric circles, dark margins and light brown centers. Whereas the fruits exhibit brown, slightly sunken flecks in the beginning but later the lesions become large pitted appearance.

## **Cause**

Fungus

## **Comments**

The pathogen infects cucumber, pawpaw , ornamental plants, some weed species etc. The damaged fruits are susceptible for this disease.

## **Management**

Remove the plant debris and burn them. Avoid over application of nitrogen fertilizer. If the disease is severe spray suitable fungicides.

## **Verticillium wilt** *Verticillium albo-atrum*

*Verticillium dahliae*

*Close up of distinctive, one-sided chlorotic leaf*

*Single leaf showing v-shaped necrosis*

*Close up of distinctive, one-sided chlorotic leaf*

*Single leaf showing necrosis and chlorosis.*

*Single leaf showing v-shaped necrosis and chlorosis.*

*Verticillium wilt symptoms on tomato foliage*

*Verticillium wilt symptoms on tomato leaf*

*Verticillium wilt of tomato*

*Verticillium wilt symptoms on tomato leaf*

## **Symptoms**

Symptoms appear first on lower leaves and spread upwards; initial symptoms of the disease may be visible as yellow blotches on the lower leaves of the plant; a rapid yellowing of leaves follows as the disease progresses; leaf veins turn brown and brown dead spots appear on the leaves; leaves may wilt then die and drop from the plant; the disease progresses upwards through the stem causing the plant to be stunted; leaves at the top of the plant remain green; fruits develop yellow shoulders and yield is reduced; loss of leaves results in fruit being susceptible to sun scald.

## **Cause**

Fungi

## **Comments**

Fungi survive in crop debris in soil; disease emergence favors cool weather.

## **Management**

Plant resistant varieties; sanitize all equipment on a regular basis; rotate with non-susceptible crops.

## **Category : Bacterial**

### **Bacterial canker *Clavibacter michiganensis***

<i>A disease in rapid progress killing large sections of plants in a greenhouse</i>	<i>Lesions on the fruit has a bird's eye appearance</i>	<i>Ripe fruits with netted appearance</i>
<i>Netted appearance of fruits on symptomatic plants</i>	<i>A cut portion of the stem indicating discoloration</i>	<i>Severe leaf blighting under extremely high disease incidence</i>
<i>Infected stem can be noticed when cut open</i>	<i>Leaf blighting spreading across a row in greenhouse production</i>	<i>Canker on the infected stem</i>
<i>Vascular discoloration of the stem of infected plants</i>	<i>Progression of the symptoms on the entire plant in a greenhouse facility</i>	<i>The first symptom is the unilateral wilting of plants and formation of light colored streaks up on leaf midribs, petioles and stems</i>
<i>Raised spots on unripe fruit</i>	<i>Foliar symptoms of bacterial canker and wilt</i>	<i>Foliar symptoms of bacterial canker and wilt</i>
<i>Raised spots on unripe fruit</i>	<i>Symptoms of bacterial canker and wilt on tomato stems</i>	<i>Symptoms of bacterial canker and wilt on tomato fruit</i>
<i>Bacterial canker and wilt of tomato</i>		

## Symptoms

Bacterial canker can affect tomato plants of any age, seedlings may be killed quickly once they become infected; initial symptoms of bacterial canker is the unilateral wilting of plants and formation of light colored streaks up and down the outside of the leaf midrib, petiole and stem; streaks on stems may break open to form cankers; mature leaves develop small necrotic spots on the upper leaf surfaces or small raised white spots on the leaves; white spots develop on fruit, usually while they are still green; spots on fruit develop a raised dark center and are known as "bird's eye spots"

## Cause

Bacterium

## Comments

Can cause serious crop losses

## Management

Plant only certified seed and transplants; hot water treatment of seed to remove bacteria; rotate crops with non-host plants; turn crops into soil after harvest to promote decomposition

## Bacterial speck *Pseudomonas syringae*

<i>Spots on tomato fruit caused by bacterial speck</i>	<i>Bacterial speck on tomato leaf</i>	<i>Bacterial speck on tomato leaf</i>
<i>Bacterial speck on tomato leaf</i>	<i>Bacterial speck on tomato leaf</i>	

## Symptoms

Dark specks appear on the leaves, often associated with a yellow halo; foliar symptoms of bacterial speck are very difficult to distinguish from bacterial spot but can be differentiated by symptoms on the fruit; lesions on fruit are much

smaller than those caused by bacterial spot; lesions on fruit are raised and scaly.

## Cause

Bacterium

## Comments

Disease emergence favors cool, moist weather.

## Management

Do not plant in same area in successive years; use only high quality, disease-free seed and transplants; protective sprays of copper can help to reduce incidence of the disease.

## Bacterial spot *Xanthomonas campestris* pv. *vesicatoria*

*Xanthomonas euvesicatoria*

*Xanthomonas perforans* = [*Xanthomonas axonopodis* (syn. *campestris*) pv. *vesicatoria*], *Xanthomonas vesicatoria*

*Xanthomonas gardneri*

Leaves will ooze from the cut end only in case of bacterial spot

Fruit spots can also be slightly raised and scabby looking

Lesions on the fruit can also be raised around the margins and sunken in the middle

Lesions on the fruit can also be raised around the margins and sunken in the middle

Fruit infections start as a slightly raised blister

Severe defoliation of infected plants can occur leading to a blighted look in large tomato fields

Lesions may coalesce forming necrotic areas on the leaf giving it a blighted appearance

Mature spots, with or without yellowing have a greasy appearance and can be transparent

Petioles with spot lesions are turning yellow followed by complete necrosis

Severe infections causes the leaves to look blighted

Bacterial spot lesions starts out as small water-soaked spots.

Symptoms of bacterial spot on tomato foliage

bacterial spot causes significant crop losses during rainy conditions

Symptoms of bacterial spot on tomato fruit

Symptoms of bacterial spot on tomato foliage

Symptoms of bacterial spot on tomato foliage

Symptoms of bacterial spot on tomato fruit

Symptoms of bacterial spot on tomato fruit

Symptoms of bacterial spot on tomato foliage

Symptoms of bacterial spot on tomato foliage

Bacterial spot symptoms on tomato fruit

Bacterial spot symptoms on tomato foliage

## Symptoms

Bacterial spot lesions starts out as small water-soaked spots; lesions become more numerous and coalesce to form necrotic areas on the leaves giving them a blighted appearance; if leaves drop from the plant severe defoliation can occur leaving the fruit susceptible to sunscald; mature spots have a greasy appearance and may appear transparent when held up to light; centers of lesions dry up and fall out of the leaf; blighted leaves often remain attached to the plant and give it a blighted appearance; fruit infections start as a slightly raised blister; lesions may have a faint halo which

eventually disappears; lesions on fruit may have a raised margin and sunken center which gives the fruit a scabby appearance.

### Cause

Bacterium

### Comments

Bacteria survive on crop debris; disease emergence favored by warm temperatures and wet weather; symptoms are very similar to other tomato diseases but only bacterial spot will cause a cut leaf to ooze bacterial exudate; the disease is spread by infected seed, wind-driven rain, diseased transplants, or infested soil; bacteria enter the plant through any natural openings on the leaves or any openings caused by injury to the leaves.

### Management

Use only certified seed and healthy transplants; remove all crop debris from planting area; do not use sprinkler irrigation, instead water from base of plant; rotate crops.

## **Bacterial wilt *Ralstonia solanacearum***

*A field of tomato with high bacterial wilt incidence (80-90%)*

*Secondary spread through water movement to adjacent plants on both sides from an infected plant*

*Darkening of the vascular system*

*Large section of severely infected plants*

*Bacterial ooze from a freshly cut stem*

*Severe symptoms of bacterial wilt*

*Severely wilted tomato plants*

*Surface of the stem is darkening and collapsing*

*Tomato plants infected with bacterial wilt*

### Symptoms

Initial symptoms of the disease is the wilting of a few of the youngest leaves; the disease progresses rapidly in hot weather and the entire plant wilts suddenly and dies; in cooler conditions, wilting is less rapid and plant may produce roots on the stems; vascular tissue shows a brown discoloration and decaying roots; stems cut under water will ooze bacterial exudate and will confirm the symptoms are not caused by Fusarium wilt.

### Cause

Bacterium

### Comments

Bacterial wilt can cause complete destruction of the crop under conditions suitable for the spread of the soil-borne bacterium; disease causes serious losses in tomatoes grown in tropical and subtropical regions.

### Management

Cultural practices may help to reduce incidence of the disease, rotate tomato with other, non-susceptible crops; avoid over-watering plants.

## **Category : Other**

### **Blossom-end rot**

*Internal symptoms of BER*

*Blossom-end rot on tomato fruit*

*Blossom-end rot on tomato fruit*

*BER on the side of the fruit*

*Blossom-end rot on tomato fruit*

*The problem often occurs at the blossom end of the fruit*

*Light tan, water-soaked areas on tomato fruit*

*Blossom-end rot on tomato fruit*

## Symptoms

Blossom end-rot is caused by a low concentration of calcium in the tomato fruit; symptoms initially appear as light tan, water-soaked areas which can then enlarge and turn black and leathery in appearance; symptoms are most often seen at the blossom end of the fruit, but may also occur on the side of the fruit; blossom-end rot may also occur internally with no visible symptoms on outside of fruit.

## Cause

Physiological disorder.

## Comments

Low calcium may result from competition from other ions in soil e.g. potassium; can also be caused by drought stress; fluctuations in soil moisture or application of excessive amounts of nitrogen fertilizer which promotes rapid vegetative growth; calcium cannot be translocated from the leaves to the fruit; foliar applications of Ca materials have not proven to reduce BER, since very little Ca is taken up by the fruit; in greenhouse production not cycling the irrigation system at night can increase BER, since night is an important period of Ca uptake.

## Management

Maintain soil pH at 6.5; lime soil to increase the concentration of calcium in soil and decrease competition with other ions; use mulch to reduce drought stress; avoid ammonium fertilizers as they may increase competition with calcium by increasing ammonium ions in soil, use nitrate instead; avoid over fertilizing.

## Catface

*Catfacing Catface symptoms*

*Catface symptoms*

*Catface symptoms*

*Catface symptoms*

## Symptoms

Catface usually occurs on the blossom end, tomato fruits are usually misshapen with large holes or corky brown scars close to the blossom end of the fruit; fruits are often flattened and may be kidney shaped; holes on the fruit extend deep inside the fruit.

## Cause

Physiological disorder

## Comments

The catface deformity is possibly caused by internal or external changes that occurs during the formation of the flower resulting in the abnormal development of the fruit; the exact cause is unknown, there may be several factors in fruit deformation; cold weather is known to be a factor along with extreme fluctuations in temperatures between day and night; hormone based herbicides may also cause catfacing; varieties that produce large tomatoes are more prone to

catfacing.

### **Management**

Avoid pruning tomato plants excessively; avoid excessive fertilization with nitrogen which promotes rapid vegetative growth; if growing tomatoes in a glasshouse, provide the plants with heat to prevent temperatures dropping to damaging levels, particularly at night.

## **Edema (Oedema)**

*Close-up of edema blister*

*Close-up of edema blister*

*Edema*

*Symptoms of edema on tomato leaves*

*Edema symptoms*

*Symptoms of edema on tomato leaves*

### **Symptoms**

Swellings and/or blisters or calluses on leaves caused by rupturing epidermal and inner leaf cells ; deformed foliage which curls; leaf tissue may also tear as the leaf matures; symptoms are often mistaken for disease or insect damage

### **Cause**

Physiological disorder

### **Comments**

Edema occurs when water is absorbed from the soil faster than it can be transpired through the leaves and is caused by soil being warmer than the surrounding air

### **Management**

Tomato plants should always be planted in well draining soil or potting media; avoid overwatering tomato plants, particularly during periods of low light and cool temperatures; if growing tomatoes in a glasshouse then anything that can be done to increase drainage and air circulation will be helpful in preventing edema; reduce humidity in the glasshouse in the morning by venting the house (heat may need to be turned up during this period depending on outdoor temperatures)

## **Fertilizer burn**

### **Symptoms**

Symptoms may first appear as slowed growth and wilting; leaf tips and margins turn brown; plants have a scorched appearance.

### **Cause**

Excess nitrogen salts

### **Comments**

Fertilizer burn is usually caused by an excess of nitrogen salts in the soil which causes an osmotic stress on the plant tissues. The tissues dry out and die resulting in the characteristic scorched appearance of the leaves.

### **Management**

Apply appropriate dose of fertilizer for the particular soil in which the plants are growing - nutrient requirements can be ascertained with a soil test; if liquid fertilizer was used, symptoms may be reversed by watering the plants heavily to leach some of the salts from the soil.

## **Little leaf**

*Little leaf symptoms*

*Little leaf symptoms*

*Little leaf symptoms*

*Interveinal chlorosis and leaf distortion caused by Little leaf*

*Little leaf symptoms*

*Interveinal chlorosis*

## **Symptoms**

Little leaf symptoms include interveinal chlorosis of young leaves, distortion and failure of leaves along the midrib to expand, radial cracks of fruits extending from the calyx to the blossom scar and failure of blooms to set; symptoms progress to increased leaflet distortion and more pronounced interveinal chlorosis.

## **Cause**

Nutritional disorder

## **Comments**

Three conditions appear to pre-dispose plants to little leaf. 1) high soil temperatures 2) high soil moisture and 3) presence of predisposing population of bacterial/fungal microorganisms in the soil.

## **Management**

Little leaf is usually associated with water-logged areas of fields, subsequent drying out of affected areas usually resolves the problem and subsequent plant growth is normal; controlling the soil pH may also help the problem.

## **Magnesium deficiency**

*Magnesium deficiency*

## **Symptoms**

Symptoms of magnesium deficiency appear on older leaves first; initial symptoms are interveinal chlorosis of the leaves and, occasionally, a purple tinge to the leaves; as the deficiency becomes more severe, leaves may appear white with green veins; severe deficiencies may lead to reduced fruit yield.

## **Cause**

Nutritional disorder

## **Comments**

Magnesium deficiency is rare in field grown tomatoes but occurs more frequently in soilless tomato culture.

## **Management**

Magnesium deficiency can be prevented in tomato by applying dolomite lime to the soil, if an increase in soil pH is required, or through applications of a fertilizer containing magnesium.

## **Multiple nutrients deficiency**

### **Symptoms**

#### **Cause**

Nutritional disorder

#### **Comments**

## **Nitrogen deficiency**

### **Symptoms**

Affected plants are smaller in size and grow less vigorously than healthy plants; symptoms appear on older leaves first; tomato leaves exhibit a general yellowing occasionally accompanied by purple leaf veins; plants possess thinner stems and fruit is smaller than healthy plants; fruits may be misshapen with a lighter red color than healthy plants.

#### **Cause**

Nutritional disorder

### Comments

Nitrogen deficiency usually arises in tomato plantations through inadequate fertilizer application; heavy rain can leach nitrogen from sandy soils.

### Management

If detected early, symptoms of nitrogen deficiency can be treated by applying appropriate amounts of nitrogen fertilizer.

## Phosphorous deficiency

### Symptoms

Growth of tomato seedlings is reduced compared with healthy plants; leaves appear darker green and may have a purple tinge; in older tomato plants, leaves grow upright and appear light green on the upper surface and purple on the lower surface; symptoms appear on older leaves first.

### Cause

Nutritional disorder

### Comments

Phosphorous deficiency is rare in soils that are already used for agricultural purposes; in field grown tomatoes phosphorous deficiency more commonly appears in newly cleared land which has never been used to grow crops; phosphorus deficiency may occur on soilless tomato cultures if applications of the nutrient are inadequate.

### Management

Soil levels of phosphorous should be measured prior to planting to determine the appropriate application for the particular site; phosphorous should be applied to the soil prior to planting if required as applications made after the onset of tomato growth are not usually successful in preventing symptoms.

## Potassium deficiency

### Symptoms

Affected plants are smaller than healthy plants with smaller fruits and reduced yields; tomato leaves exhibit "bronzing", older plant leaves turn tan and then brown at the margins; if deficiency is prolonged, leaves become necrotic at the margins and turn yellow between leaf veins.

### Cause

Nutritional disorder

### Comments

Potassium deficiency is usually caused by an inadequate fertilization, it is more common in sandy soils where the nutrient is easily leached from the soil by heavy rainfall.

### Management

Potassium deficiency can be corrected through applications of the nutrient as a side dressing and/or through an irrigation system.

## Sunscald

*sunscald affected fruit*

*Sunscald*

*Sunscald on tomato*

*Sunscald on tomato*

### Symptoms

Symptoms of sunscald are most common on green fruit; white or yellow necrotic patches develop on the sides of the fruit that are facing the sun; blisters may be white with a yellow halo; damaged areas may become flattened in appearance and papery in texture; damaged areas are often invaded by secondary pathogens and turn black.

### Cause

Physiological disorder

### Comments

Sunscald is common on plants which have been moved suddenly from a shaded location to full sun.

### Management

Healthy plants with full foliage are less susceptible to sunscald as the leaves provide fruits with shading, ensure plants are watered regularly and fertilized adequately; use shade cloth to protect the fruits from the sun; control diseases that develop to prevent defoliation which can lead to sunscald.

## Water stress

*Moisture stress rings (from fluctuations in water, most likely because of heavy rains)*

*Water stress cracks on tomato fruits*

### Symptoms

Leaves are green but wilting; leaves roll downwards and eventually drop from the plant; fruits may develop symptoms of **Blossom-end rot** (See entry).

### Cause

Physiological stress

### Comments

It is important to distinguish between plants that are temporarily wilted on hot days and those that are stressed due to lack of moisture in the soil; on very hot days tomato plants will wilt as the rate of transpiration exceeds the rate at which water can be taken up from the soil by the roots and the plants will usually recover in the evening when temperatures are cooler.

### Management

Tomato plants should be watered deeply and evenly to avoid water stress; aim to keep the soil moist but not wet; allow the top of the soil to dry before watering again.

## Zippering

*Zippering*

*Zippering of tomato*

### Symptoms

Thin brown scars extending longitudinally from the petiole to the blossom-end of the fruit; each scar has smaller scars crossing it tranversely rendering it zipper-like in appearance; holes may open on along the scarred area.

### Cause

Physiological disorder

### Comments

Zipper scars on tomato fruit are most prevalent in cool weather.

### Management

The most effective method of preventing zippering is to grow tolerant varieties; when growing tomatoes in the glasshouse, appropriate temperatures should be maintained.

## Category : Oomycete

**Buckeye rot (Phytophthora root rot)** *Phytophthora* spp.

*Buck eye symptoms on green fruit*

*Buck eye symptoms on green fruit*

*Completely wilted plants due to Phytophthora root rot*

*Root rot infection on young plants*

*Tomato fruits infected with buckeye rot*

*Tomato fruits infected with buckeye rot*

*Symptoms of buckeye rot on tomato fruit*

*Symptoms of buckeye rot on tomato fruit*

*Symptoms of buckeye rot on tomato fruit*

## **Symptoms**

Buck eye rot of tomato initially appears as a brown spot on the fruit which enlarges over the fruit surface and forms concentric rings; the lesions may eventually cover up to half of the fruit and the flesh develops a soft rot underneath the skin; green or red fruits can be affected and disease often develops where fruit is in contact with the soil; white cottony growth may be visible in the centers of affected regions; spots enlarge and form large concentric ring shaped symptoms which are usually brown in color with sunken edges; the *Phytophthora* pathogen also causes root rot; young plants may exhibit a white cottony growth at crown of the plant and begin to wilt as the damage to the roots progresses; *Phytophthora* root rot can cause severe destruction of plant roots and cause the plants to wilt completely.

## **Cause**

Fungi

## **Comments**

Prolonged period of warm wet conditions favor disease occurrence; heavy soil saturation also favors disease development in soils where pathogen is present; disease can be spread by splashing water.

## **Management**

Cultural control methods such as mulching around the plants and practicing rotation away from tomato can help to reduce losses from the disease; fungicides applied for the control of late blight also help to control the development of buckeye rot; solarizing or fumigating soil can help to reduce levels of inoculum.

## **Late blight** *Phytophthora infestans*

<i>The entire fruit can become infected, and the white mycelium may appear during wet weather</i>	<i>Fruit lesions changes to greasy spots</i>	<i>Foliage becomes shriveled and brown</i>
<i>Fruit lesions start as water soaked regions</i>	<i>White moldy growth on the underside of the leaves</i>	<i>Leaf lesions appear as water-soaked regions that rapidly change to brown lesions</i>
<i>Late blight symptoms on tomato stem</i>	<i>Late blight symptoms on tomato leaves</i>	<i>Late blight symptoms on tomato</i>
<i>Late blight symptoms on tomato leaves</i>	<i>Late blight symptoms on tomato stem</i>	<i>Late blight symptoms on tomato stems</i>
<i>Late blight stem lesion</i>	<i>Late blight symptoms on tomato stem</i>	<i>Late blight symptoms on tomato foliage</i>
<i>Late blight symptoms on tomato</i>	<i>Late blight symptoms on tomato</i>	<i>Late blight symptoms on tomato</i>
<i>Late blight symptoms on tomato</i>	<i>Late blight symptoms on tomato fruit</i>	<i>Late blight symptoms on tomato</i>
<i>Tomato plantation with late blight infestation</i>	<i>Late blight lesion on tomato leaf</i>	<i>Tomato plants damaged by late blight</i>
<i>Late blight symptoms on tomato foliage</i>	<i>Late blight symptoms on tomato fruit</i>	<i>Late blight symptoms on tomato fruit</i>
<i>Late blight symptoms on tomato foliage</i>	<i>Late blight symptoms on tomato fruit</i>	<i>Late blight symptoms on tomato foliage</i>

## Symptoms

Late blight affects all aerial parts of the tomato plant; initial symptoms of the disease appear as water-soaked green to black areas on leaves which rapidly change to brown lesions; fluffy white fungal growth may appear on infected areas and leaf undersides during wet weather; as the disease progresses, foliage becomes becomes shriveled and brown and the entire plant may die; fruit lesions start as irregularly shaped water soaked regions and change to greasy spots; entire fruit may become infected and a white fuzzy growth may appear during wet weather.

## Cause

Oomycete

## Comments

Can devastate tomato plantings.

## Management

Plant resistant varieties; if signs of disease are present or if rainy conditions are likely or if using overhead irrigation appropriate fungicides should be applied.

## Category : Viral

## **Tomato mosaic virus** Tomato mosaic virus (ToMV)

<i>Symptoms on leaves</i>	<i>Tomato Mosaic Virus symptom on tomato plant</i>	<i>ToMV infected tomato leaf</i>
<i>Tomato Mosaic Virus (Tobamovirus ToMV) infected tomato plant</i>		

### **Symptoms**

Symptoms can occur at any growth stage and any part of the plant can be affected; infected leaves generally exhibit a dark green mottling or mosaic; some strains of the virus can cause yellow mottling on the leaves; young leaves may be stunted or distorted; severely infected leaves may have raised green areas; fruit yields are reduced in infected plants; green fruit may have yellow blotches or necrotic spots; dark necrotic streaks may appear on the stems, petioles leaves and fruit.

### **Cause**

Virus

### **Comments**

ToMV is a closely related strain of Tobacco mosaic virus (TMV), it enters fields via infected weeds, peppers or potato plants; the virus may also be transmitted to tomato fields by grasshoppers, small mammals and birds.

### **Management**

Plant varieties that are resistant to the virus; heat treating seeds at 70°C (158°F) for 4 days or at 82–85°C (179.6–185°F) for 24 hours will help to eliminate any virus particles on the surface of the seeds; soaking seed for 15 min in 100 g/l of tri-sodium phosphate solution (TSP) can also eliminate virus particles - seeds should be rinsed thoroughly and laid out to dry after this treatment; if the virus is confirmed in the field, infected plants should be removed and destroyed to limit further spread; plant tomato on a 2-year rotation, avoiding susceptible crops such as peppers, eggplant, cucurbits and tobacco; disinfect all equipment when moving from infected areas of the field.

## **Tomato spotted wilt** Tomato spotted wilt virus (TSWV)

Severe stunting of the plants can also be seen in case of TSWV infection

Leaf purpling can vary in its form for different varieties

Numerous small ring spots on a fruit infected with TSWV.

Severe leaf spot symptoms can be seen

Leaf spots may resemble bacterial spot

Symptoms of TSWV on tomato foliage

Symptoms of TSWV on tomato fruit

TSWV symptoms on tomato fruit

Fruit necrosis and splitting

Zonate ring spots on a fruit infected with TSWV.

Large ring spot symptoms

Large necrotic areas may form on the leaves

Symptoms of TSWV

Symptoms of TSWV on tomato foliage

Tomato plants infected with TSWV

TSWV symptoms on tomato fruit

Leaf purpling is another symptom of plants infected with TSWV.

Complex ring spots on fruit infected with TSWV

Fruit symptoms on a mature green fruit

Leaf symptoms

Symptoms of TSWV vary among different varieties of tomato

Necrotic spots on tomato leaf caused by TSWV

TSWV symptoms on tomato leaf

## Symptoms

Infected plants exhibit bronzing or purpling of the upper sides of young leaves and develop necrotic spots; leaf spots may resemble those caused by bacterial spot, but a bacterial ooze test will be negative; leaves may cup downwards, shoot tips may begin to die back; symptoms on ripe fruit appear as chlorotic spots and blotches, often with concentric rings; ring spot symptoms vary with different tomato cultivars; irregular ripening caused by TSWV can also show up when fruit are treated with ethylene gas; green fruit may exhibit slightly raised areas with faint concentric zonation.

## Cause

Virus

## Comments

TSWV infects numerous ornamentals, vegetables, field crops and weeds; virus is vectored by at least eight species of thrips; thrips, acquires the virus during the larval stages, and transmit the virus when they are adults.

## Management

Control populations of western flower thrips and onion thrips

**Tomato Yellow Leaf Curl disease** Tomato Yellow Leaf Curl Virus (TYLCV)

family Geminiviridae, genus Begomovirus

<i>Early infection of tomato by tomato yellow leaf curl virus often leads to severe stunting of the plant. Infected plant in the foreground with an uninfected one in the back.</i>	<i>Tomato Leaf Curl Virus symptoms TYLCV infected plant</i>	<i>Tomato plant affected by Tomato Leaf Curl Virus. TYLCV infected field</i>
<i>Symptoms on infected tomato plant</i>	<i>Symptoms on leaves</i>	<i>TYLCV infected leaves</i>
<i>Infection at later stages of the plant often leads to stunting and malformation of terminals, yellowing of leaf margins and the characteristics upward cupping of leaves ("leaf curl")</i>	<i>Yellowing and shortening of internodes of greenhouse-grown tomatoes due to TYLCV.</i>	<i>Tomato Yellow Leaf Curl Virus (Begomovirus TYLCV) infected plant</i>
<i>Symptoms of TYLCV on greenhouse-grown tomatoes.</i>		

## Symptoms

The infected leaves become reduced in size, curl upward, appear crumpled and show yellowing of veins and leaf margins. The internodes become shorter and whole plant appear stunted and bushy. The whole plant stand erect with only upright growth. The flowers may not develop and drop off.

## Cause

Virus

## Comments

The virus is transmitted by white flies and may cause 100 % yield loss if the plants infect at early stage of crop. The virus also infect other hosts like common bean, ornamental plants and several weed species.

## Management

Grow available resistant varieties. Transplant only disease and whiteflies free seedlings. Remove the infected plants and burn them. Keep the field free from weeds. Use yellow sticky traps to monitor and control whiteflies. If the insect infestation is severe spray suitable insecticides.

## Pests

### Category : Insects

#### Aphids (Peach aphid, Potato aphid) *Myzus persicae*

*Macrosiphon euphorbiae*

*Potato aphids feeding on tomato leaf*

*Potato aphid on tomato leaf*

*Potato aphids adult*

*Green peach aphid adult*

*Potato aphid (*Macrosiphum euphorbiae*) on tomato leaves*

*Green peach aphid (*Myzus persicae*) adults*

*Green peach aphid (*Myzus persicae*) nymphs*

*Aphids feeding on tomato (note presence of 'mummies' - parasitized aphids)*

## Symptoms

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or be distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants.

## Cause

Insect

## Comments

Distinguishing features of aphids include the presence of cornicles (tubular structures) which project backwards from the insect's body; aphids will generally not move very quickly when disturbed; aphids may also transmit plant viruses to the plant when they feed.

## Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use.

## Beet armyworm *Spodoptera exigua*

*Beet armyworm eggs covered in white hairs*

*Young larvae*

*Beet armyworm larva*

## Symptoms

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside.

## Cause

Insect

## Comments

Insect can go through 3-5 generations a year.

## Management

Organic methods of controlling the beet armyworm include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that

are available for the home garden do not provide adequate control of the larvae.

## **Colorado potato beetle** *Leptinotarsa decemlineata*

Adult beetles on Jimsonweed Larva

Colorado potato beetle larvae on tomato leaf

Adult beetle

### **Symptoms**

Feeding damage to foliage; if infestation is severe or if left untreated plants can be completely defoliated; adult insect is a black and yellow striped beetle; larvae are bright red with black heads when they first hatch and change color to pink; larvae have two rows of black spots.

### **Cause**

Insect

### **Comments**

Adult beetles emerge in spring; female beetles lay eggs in batches of up to two dozen; eggs are orange-yellow and are laid on undersides of leaves; a female can lay 500 or more eggs over a four to five week period.

### **Management**

Control of Colorado potato beetle can be challenging as they have developed high levels of insecticide resistance; adults and larvae should be hand picked from plants and destroyed in soapy water; applications of *Bacillus thuringiensis* can be effective at controlling larvae but should be applied frequently; some insecticides, including spinosad, are still effective against adult beetles.

## **Cutworms** Various species including:

*Agrotis* spp.

*Peridroma saucia*

*Nephelodes minians*

etc.

Cutworm feeding on plant stem

Cutworms will curl up into a characteristic C shape when disturbed

Cutworms larva severing plant stem

### **Symptoms**

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5–5.0 cm (1–2 in) in length; larvae may exhibit a variety of patterns and coloration but are usually dirty gray or brown to black with dark spots or lines and will curl up into a characteristic C-shape when disturbed

### **Cause**

Insect

### **Comments**

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato

### **Management**

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested

areas of garden or field if not growing organically

## Flea beetles *Epitrix* spp.

Potato flea beetle injury on potato leaf

Typical shothole feeding wounds of potato flea beetles on tomato leaf

Feeding damage to tomato fruit

Flea beetle damage to tomato leaves and fruit

Flea beetles causing damage to a young tomato seedling

### Symptoms

Small holes or pits in leaves that give the foliage a characteristic “shothole” appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; feeding damage may also occur on the fruit; the pest responsible for the damage is a small (1.5–3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance.

### Cause

Insects

### Comments

Flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year.

### Management

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application on diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied.

## Hornworms (Tomato hornworm, Tobacco hornworm) *Manduca quinquemaculata*

*Manduca sexta*

Tomato hornworm frass

Tomato hornworm (*Manduca quinquemaculata*) on tomato

Tobacco hornworm (*Manduca sexta*) on tomato vine

Tobacco hornworm

Tomato hornworm (note black spike on posterior)

Parasitized tobacco hornworm with wasp cocoons on its back

### Symptoms

Feeding damage to leaves or leaves stripped from plant; heavy infestation may result in damage to fruit appearing as large open scars; large green caterpillars may be spotted on plant; caterpillars may reach in excess of 7.5 cm (3 in) in length and possess a spike at the end of their body; most common species have 7 diagonal stripes on sides or 8 v-shaped markings on each side; single eggs may be present on leaves and measure approx 1.3 mm in diameter; eggs are initially light green in color and turn white prior to hatching.

### Cause

Insect

### Comments

Insect overwinters as pupa in soil; typically undergoes 2 generations per year; heavy infestations are more common in

warm areas.

### Management

Hand pick larvae from plants leaving any parasitized larvae behind to promote populations of natural enemies (these larvae can be distinguished by the presence of white, oblong-shaped cocoons on their backs); sprays of *Bacillus thuringiensis* are organically acceptable and highly effective.

### Leafminers *Tuta absoluta*

*Lyriomyza* spp.

Water synthetic sex pheromones trap for *Tuta absoluta*

Leafminer injury to tomato leaves

Leaf miner injured tomato leaves

*Tuta absoluta* adult insect

Tomato leafminer damage

Leafminer damaged leaves

Leafminer damage on tomato plant

Leafminer damage on tomato leaf

### Symptoms

Thin, white, winding trails on leaves; heavy mining can result in white blotches on leaves and leaves dropping from the plant prematurely; early infestation can cause fruit yield to be reduced; adult leafminer is a small black and yellow moth which lays its eggs in the leaf; larvae hatch and feed on leaf interior. THIS IS A TEST

### Cause

Insect

### Comments

Origin and distribution of *Tuta absoluta*: This species is originated in South American countries. Later the insect spread to Spain (2006), France, Italy, Greece, Malta, Morocco, Algeria, Libya and Turkey in following years. Further the insect has been identified in Syria, Lebanon, Jordan, Iraq, Iran, Saudi Arabia, Yemen, Oman and the rest of the Gulf states. In Africa it spreads from Egypt to Sudan, South Sudan, Ethiopia, Uganda, Kenya and Tanzania (in East) and to Senegal and Nigeria through the west. (It spread through infested fruits and packaging materials) Life cycle: Mature larvae drop from leaves into soil to pupate; entire lifecycle can take as little as 2 weeks in warm weather; insect may go through 7 to 12 generations per year. Yield loss: If unchecked, insect will cause 100% yield loss. The larvae feeds on apical buds, tender new leaflets, flowers, and green fruits which make it a serious pest in tomato. Host Range: This insect also attacks other solanaceous crops like potato, eggplant, pepino and tobacco. It is also reported on many solanaceous weeds.

### Management

Leafminer natural enemies normally keep populations under control; check transplants for signs of leafminer damage prior to planting; remove plants from soil immediately after harvest if making new plantings in same place or close by; keep the field free from weeds especially *Solanum*, *Datura*, *Nicotiana*; use pheromone traps and white sticky traps to monitor and control insect; only use insecticides when leafminer damage has been identified as unnecessary spraying will also reduce populations of their natural enemies.

### Loopers (Cabbage looper , Alfalfa looper) *Trichoplusia ni*

*Autographa californica*

*Early instar cabbage looper larvae*      *cabbage looper (*Trichoplusia ni*) larvae*      *Cabbage looper (*Trichoplusia ni*) adult*

*Cabbage looper (*Trichoplusia ni*)*      *Cabbage looper (*Trichoplusia ni*) eggs on tomato leaves*      *Cabbage looper and damage*

### Symptoms

Large or small holes in leaves; damage often extensive; caterpillars are pale green with a white lines running down either side of their body; caterpillars are easily distinguished by the way they arch their body when moving; eggs are laid singly, usually on the lower leaf surface close to the leaf margin, and are white or pale green in color.

### Cause

Insect

### Comments

Insects overwinter as pupae in crop debris in soil; adult insect is a dark colored moth; caterpillars have a wide host range.

### Management

Looper populations are usually held in check by natural enemies; if they do become problematic larvae can be hand picked from the plants; an organically acceptable control method is the application of *Bacillus thuringiensis* which effectively kills younger larvae; chemical sprays may also damage populations of natural enemies and should only be considered if sunburn of fruit is likely.

## Stinkbugs (Various) Various

*Stink bug feeding on a fruit*      *White to yellow spots occurring under the epidermis are a characteristic symptom of cloudy spot caused by stink bug feeding.*      *A ripe fruit with a yellow irregular spots*

*Red shouldered stink bug*      *The symptom is developed due to the release of an enzyme that affects the coloring of a ripening fruit.*      *Brown marmorated stink bug*

*Brown stink bug feeding on tomato fruit*      *Newly hatched brown marmorated stink bug eggs and young larvae*

### Symptoms

Dark colored pinpricks on fruit surrounded by a lighter area that turns yellow or remains light green; stink bugs often carry pathogens in their mouthparts which can cause secondary infections and decay of fruit; adult insect is shield-shaped and brown or green in color; may have pink, red or yellow markings; eggs are drum shaped and laid in clusters on the leaves; larvae resemble the adults but are smaller.

### Cause

Insect

### Comments

Several types of stink bug can cause damage to tomatoes; adult insects overwinter under leaves, on legumes, blackberries or on certain weeds such as mustard or Russian thistle.

### Management

Remove weeds around crop which may act as overwintering sites for stink bugs and practice good weed management throughout the year; organically accepted control methods include the use of insecticidal soaps, kaolin clay and

preservation of natural enemies; chemical treatments are not recommended for tomatoes that are to be processed for paste or canning unless secondary infections with other pathogens are a concern.

## **Thrips (Western flower thrips, Onion thrips, etc.)** *Frankliniella occidentalis*

### *Thrips tabaci*

Smaller, tan thrips on left is the onion thrips (*Thrips tabaci*). Larger yellowish thrips on the right is the western flower thrips (*Frankliniella occidentalis*).

Western flower thrips (*Frankliniella occidentalis*) damage

onion thrips (*Thrips tabaci*) damage on tomato

Western flower thrips

Green tomato showing damage caused by flower thrips (*Frankliniella tritici*).

### Symptoms

If population is high leaves and buds may be distorted; leaves appear silvery and are speckled with black feces; most damage occurs through the transmission of Tomato spotted wilt virus (TSWV); insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color.

### Cause

Insect

### Comments

Transmit Tomato spotted wilt virus (see disease entry); once acquired, the insect retains the ability to transmit the virus for the remainder of its life.

### Management

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic.

## **Tomato fruit worm (Corn earworm)** *Helicoverpa zea*

Corn earworm adult

Larva damaging fruit

Late instar larva on tomato foliage

Corn earworm larva feeding on tomato fruit

Early instar larva on tomato leaf

Tomato fruitworm feeding on fruit

### Symptoms

Holes in tomato fruit, including entry holes near stem end; feeding turns inside of tomato into a watery cavity filled with cast skins and frass (insect feces); damaged fruit ripens prematurely; young caterpillars are cream-white in color with a black head and black hairs; older larvae may be yellow-green to almost black in color with fine white lines along their body and black spots at the base of hairs; eggs are laid singly on both upper and lower leaf surfaces and are initially creamy white but develop a brown-red ring after 24 hours and darken prior to hatching.

### Cause

Insect

### Comments

Adult insect is a pale green to tan, medium sized moth; can be one of the most damaging pests of tomato; insect overwinters as pupae in the soil; the insect is also a damaging pest of corn and is also referred to as the corn earworm.

### Management

Early treatment of tomato fruitworms is necessary as once they enter the fruit they are protected from sprays; monitor plants for eggs and young larvae and also natural enemies that could be damaged by chemicals; *Bacillus thuringiensis* or Entrust SC may be applied to control insects on organically grown plants; appropriate chemical treatment may be required for control in commercial plantations.

## Category : Others

### Curly top Beet curly top virus (BCTV)

*BCTV symptoms on tomato*

*Curly top symptoms on tomato*

#### Symptoms

Young plants are usually killed by the virus; older plants are stunted and turn yellow to bronze in color with purple-tinged leaves; leave become thickened and roll upwards; leaf petioles roll downwards; green fruit turns red regardless of its age and becomes dull in color and wrinkled; plants do not recover from the disease and will not flower or produce fruit after infection.

#### Cause

Virus

#### Comments

Virus is transmitted by beet leafhoppers; insects transmit the disease between over 300 species of plant, including beets, tomato, squash, swiss chard, cucumber and melon.

#### Management

There is no resistance to Beet curly top virus in tomato so control relies on the management of the leafhopper vector; dense stands of tomato may discourage leafhoppers from visiting the plants; chemical spraying programs to protect against beet leafhoppers have been implemented in some areas of the US state of California ; in areas where the virus is a chronic problem, in areas where curly top is chronic, dense plant spacing, shading, row covers, and intercropping have been reported to reduce levels of infection.

## Category : Nematodes

### Root knot nematode *Meloidogyne* spp.

*The characteristic symptom is the galling of the roots*

*A close-up of a washed root from the field with large galls.*

*Healthy tomato plant (left) next to one infested with root knot nematodes (right)*

*Tomato plant dug up to reveal galling on roots*

*Extensive galling of tomato roots*

#### Symptoms

The characteristic symptom of root knot nematodes is the presence of galls on roots which can be up to 3.3 cm (1 in) in diameter but are usually smaller; galls cause a reduction in plant vigor; if the galls on the roots are extensive then plants may yellow and wilt, particularly in hot weather.

#### Cause

Nematode

#### Comments

Galls can appear as quickly as a month prior to planting; nematodes prefer sandy soils and damage in areas of field or garden with this type of soil is most likely; disease can be a major problem if soils are infected with *Meloidogyne* sp. and

resistant varieties are not used for production.

### Management

Plant resistant varieties if nematodes are known to be present in the soil; check roots of plants mid-season or sooner if symptoms indicate nematodes; solarizing soil can reduce nematode populations in the soil and levels of inoculum of many other pathogens.

## Category : Mites

### Spider mites (Two-spotted spider mite) *Tetranychus urticae*

Spider mite adult

Close-up view of two-spotted spider mites (*Tetranychus urticae*)

Spider mite

Twospotted spider mite  
(*Tetranychus urticae*) adults

Spider mites on tomato

### Symptoms

Leaves stippled with yellow; leaves may appear bronzed; webbing covering leaves; mites may be visible as tiny moving dots on the webs or underside of leaves, best viewed using a hand lens; usually not spotted until there are visible symptoms on the plant; leaves turn yellow and may drop from plant.

### Cause

Arachnid

### Comments

Spider mites thrive in dusty conditions; water-stressed plants are more susceptible to attack.

### Management

In the home garden, spraying plants with a strong jet of water can help reduce buildup of spider mite populations; if mites become problematic apply insecticidal soap to plants; certain chemical insecticides may actually increase mite populations by killing off natural enemies and promoting mite reproduction.

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# Turnip

## Description

Turnip, *Brassica rapa*, is an herbaceous annual or biennial plant in the family Brassicaceae grown for its edible roots and leaves. The plant possesses erect stems and 8–12 leaves forming a crown. The leaves are light green in color, hairy and thin. The plant produces light yellow flowers which are clustered at the top of a raceme and are often extended above the terminal buds. The leaves can reach 30.5–35.5 cm (12–14 in) in length, while the branching flower stems can reach 30.5–91.5 cm (12–36 in). The taproot of the plant is a bulbous tuber, almost perfectly round, which is usually a mixture of purple, white and yellow. Turnip is usually grown as an annual and harvested after one growing season. Turnip may also be referred to as annual turnip and originates from Europe.

*Turnips and greens*

*White turnips*

*Turnip harvest*

*Turnip*

*Field of turnip*

*Turnips*

## Uses

Turnips are eaten as a vegetable after cooking. The shoots and leaves can be eaten fresh in salads or the entire plant can be used as a forage for livestock.

## Propagation

**Requirements** Turnips are cold hardy vegetables which can be grown early in the spring for a summer harvest or in the summer for harvesting in late fall. They prefer a fertile, well draining soil which has a pH between 6.0 and 7.0. The soil should have a loose texture for optimum root development. Turnips will grow best in full sun but will tolerate partial shade. The average daily temperature should fall between 10°–18°C (50°–65°F) for adequate growth.

**Planting** Turnips are usually direct seeded and can be sown as soon as the soil is workable in the Spring. For a Fall harvest, sow seeds about 2 months before the first frost in your area. Prepare the soil for planting by loosening it with a fork to a depth of about 30–38 cm (12–15 in). Remove any large rocks if present. Incorporate 2–4 inches of compost into the soil prior to planting. Sow seeds by broadcasting and raking 13 mm (0.5 in) into the soil. Thin seedlings to a final spacing of 7.5–10 cm (3–4 in). Alternatively, seeds can be sown in rows spaced 30–45 cm (12–18 in) apart.

**General care** Water turnip plants evenly and keep the soil moist for optimum growth. Mulching the plants will help to conserve moisture in the soil. Pull any weeds as they appear, the soil can be cultivated down to 2.5–5.0 cm (2–3 in) when the plants are small but this should be reduced as the plants grow larger to prevent damage to delicate feeder roots.

**Harvest** Turnip greens can be harvested from the plant when the leaves are about 10 cm (10 in) tall. If growing turnips for both greens and roots then only remove 2–3 leaves from each plant. Roots are ready to harvest when they reach 2.5–7.5 cm (1–3 in) in diameter. Small turnips can often be harvested by gently pulling from the soil by hand but larger roots in heavier soil may need gently dug up with a garden fork. Store unwashed roots in a root cellar or basement.

## References

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Alternaria leaf spot (Black spot, Gray spot)** *Alternaria spp.*

*Alternaria lesions on turnip leaf*

#### Symptoms

Small dark spots on leaves which turn brown to gray; lesions may be round or angular and may possess a purple-black margin; lesions may form concentric rings, become brittle and crack in center; dark brown elongated lesions may develop on stems and petioles

#### Cause

Fungus

**Comments**

May become a problem during cool, wet periods

**Management**

Plant only pathogen-free seed; rotate crops; applications of appropriate fungicides control disease when present

**Anthracnose** *Colletotrichum higginisianum*

*Anthracnose symptoms on turnip leaf*

**Symptoms**

Small circular or irregularly shaped dry spots which are gray to straw in color on leaves; a high number of spots may cause the leaf to die; lesions may coalesce to form large necrotic patches causing leaves to turn yellow and wilt; lesions may split or crack in dry centers; dry sunken spots on roots which enlarge and turn gray or brown

**Cause**

Fungus

**Comments**

Fungus overwinters on leaf debris and on related weeds; disease emergence is favored by moist, warm conditions

**Management**

Control of disease depends on sanitary practices; treat seeds with hot water prior to planting; rotate crops; plant in an area with good soil drainage; remove all cruciferous weeds which may act as a reservoir for the fungus

**Black root** *Aphanomyces raphari***Symptoms**

Small black-blue areas on roots which expand and girdle taproot; roots become constricted at site of lesions; black discoloration extends into root

**Cause**

Fungus

**Comments**

Fungus can survive in soil for prolonged periods

**Management**

Control depends on crop rotation with non-brassica species

**Black rot** *Xanthomonas campestris***Symptoms**

Seedlings develop wilted yellow to brown leaves and collapse; yellow, V-shaped lesions on mature leaf margins; dark rings can be found in the cross section of the stem

**Cause**

Bacterium

**Comments**

Disease emergence favors warm, wet conditions

**Management**

Primary control methods based on good sanitation; plant disease-free seed; rotate crops every 2 years or less to non-brassica; avoid sprinkler irrigation

**Cercospora leaf spot (Frogeye leaf spot)** *Cercospora brassicicola*

*Cercospora* lesions on turnip leaf

### Symptoms

Angular or circular green to gray spots with brown borders on leaves; plant defoliation may occur in the case of a severe infestation

### Cause

Fungus

### Comments

Disease emergence favors cool temperatures and wet weather

### Management

Plant only certified disease-free seed; avoid overhead irrigation; rotate crops to non-brassica species for 2-3 years; apply appropriate fungicide if disease emerges

## Clubroot *Plasmodiophora brassicae*

*Deformed turnip roots caused by club root infection*

### Symptoms

Slow growing, stunted plants; yellowish leaves which wilt during day and rejuvenate in part at night; swollen, distorted roots; extensive gall formation

### Cause

Fungus

### Comments

Can be difficult to distinguish from nematode damage; fungus can survive in soil for periods in excess of 10 years; can be spread by movement of contaminated soil and irrigation water to uninfected areas

### Management

Once the pathogen is present in the soil it can survive for many years, elimination of the pathogen is economically unfeasible; rotating crops generally does not provide effective control; plant only certified seed and avoid field grown transplants unless produced in a fumigated bed; applying lime to the soil can reduce fungus sporulation

## Downy mildew *Peronospora parasitica*

### Symptoms

Irregular yellow patches on leaves which turn light brown in color; fluffy gray growth on the undersides of the leaves

### Cause

Fungus

### Comments

Disease emergence favors cool temperatures; disease spreads quickly in wet conditions

### Management

Remove all crop debris after harvest; rotate with non-brassicas; application of appropriate fungicides may be required if symptoms of disease are present

## Sclerotinia rot (White mold) *Sclerotinia sclerotiorum*

Infections usually begin at the base of the plant and will cause tan water soaked lesions on leaves.

Eventually cottony white mycelia will develop and cover infected tissues. From this mycelia black seed like bodies (sclerotia) will be produced

White lesions on turnip stems caused by Sclerotinia rot

### Symptoms

Irregular, necrotic gray lesions on leaves; white-gray leions on stems; reduced pod set; shattering seed pods

### Cause

Fungus

### Comments

Disease emergence favors moderate to cool temperatures and high humidity

### Management

Rotate crop to non-hosts (e.g. cereals) for at least 3 years; control weeds; avoid dense growth by planting in adequately spaced rows; apply appropriate foliar fungicides

## White spot *Pseudocercospora capsellae*

### Symptoms

Small, necrotic, brown spots on leaf tips or margins that matures to light gray or white with the original dark spot in center; margins of lesions may be darker; lesions may coalesce to form large chlorotic areas and cause defoliation

### Cause

Fungus

### Comments

Disease emergence favors cool and wet conditions

### Management

No known plant resistance to white leaf spot so control relies on cultural practices such as rotating crops and removing weeds; application of appropriate fungicide may help control the disease

## Wirestem (Damping-off) *Rhizoctonia solani*

### Symptoms

Death of seedlings after germination; brown-red or black rot girdling stem; seedling may remain upright but stem is constricted and twisted (wirestem)

### Cause

Fungus

### Comments

Disease emergence favors cool, wet soils

### Management

Plant pathogen-free seed or transplants that have been produced in sterilized soil; apply fungicide to seed to kill off any fungi; shallow plant seeds or delay planting until soil warms

## Category : Viral

## Turnip mosaic Turnip mosaic virus (TuMV)

*TuMV symptoms on turnip*

*Turnip infected with TuMV*

*TuMV symptoms on turnip*

*TuMV infected turnip plants*

*TuMV symptoms on turnip*

*Aphid vectors of turnip mosaic feeding on turnip*

*Turnip mosaic virus symptoms on turnip*

## Symptoms

Yellow and green mosaic patterns on leaves; necrotic areas on leaves; vein clearing and chlorosis may occur in older leaves; black spots and brown necrotic streaks on stems; stunted plant growth and reduced yield

## Cause

Virus

## Comments

Transmitted by many species of aphid, including cabbage aphids and peach aphids

## Management

Use of reflective mulches may help to deter aphid feeding; applications of appropriate insecticides may reduce secondary spread of virus

# Pests

## Category : Insects

### Cabbage aphid *Brevicoryne brassicae*

*Cabbage aphid colony*

## Symptoms

Large populations can cause stunted growth or even plant death; insects may be visible on the plant leaves and are small, grey-green in color and soft bodied and are covered with a white waxy coating; prefer to feed deep down in cabbage head and may be obscured by the leaves

## Cause

Insect

## Comments

Cabbage aphids feed only on cruciferous plants but may survive on related weed species

## Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

### Flea beetles *Phyllotreta* spp.

## *Crucifer flea beetle*

### **Symptoms**

Small holes or pits in leaves that give the foliage a characteristic “shot hole” appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5–3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance

### **Cause**

Insects

### **Comments**

Younger plants are more susceptible to flea beetle damage than older ones; older plants can tolerate infestation; flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year

### **Management**

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application on diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied

## **Root maggots *Delia* spp.**

### *Root maggots in soil*

### **Symptoms**

Scars and feeding tunnels on surface of turnip; root damage may be extensive; larvae are white or white-yellow in color, reach approx. 1 cm (0.3 in) in length and taper towards the head; adult insect is a small fly which resembles a housefly

### **Cause**

Insect

### **Comments**

Root maggots will attack all varieties of cruciferous plants; insect overwinters as pupae in the soil

### **Management**

If root maggots were problematic, avoid planting root crops in same area the following year; if crops are too badly damaged to harvest remove and destroy all crop debris; use of floating row covers can dramatically reduce damage to crops by preventing female flies from laying eggs - note, row covers only effective where root maggots are not already present; there are currently no pesticides registered for use on root maggots in the home garden in the USA

## **Wireworms *Aeolus* spp.**

*Anchastus* spp.

*Melanotus* spp.

*Limonius* spp

### *Wireworms*

**Symptoms**

Death of seedlings; reduced stand; girdled stems and white heads; wireworm larvae can be found in soil when dug round the stem; larvae are yellow-brown, thin worms with shiny skin

**Cause**

Insect

**Comments**

Larval stage can last between 1 and 5 years depending on species

**Management**

Chemical control impossible in a standing crop, must be applied at preplanting or as a seed treatment; if wireworms are known to be present in soil fallow field during summer and till frequently to reduce numbers; rotate to non-host crop where possible; avoid planting susceptible crops after a wireworm infestation on cereals without either fallowing or applying appropriate pesticide

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# Vanilla

## Description

Vanilla, *Vanilla planifolia*, is a fleshy perennial vine in the family Orchidaceae grown for its pods and seeds which are used as a flavoring. The vanilla plant has a long succulent stem and grows by wrapping around trees. The vine has alternate, fleshy oblong or lanceolate leaves which are rounded at the base. The plant produces flowers on short racemes, each possessing 6–15 flowers, and fruits which take the form of narrow, cylindrical pods (or beans), each possessing many small black seeds. The vanilla plant can reach a height of 10–15 m (33–49 ft) in height and has an economic lifespan of approximately 10 years. The plant is native to Central America.

*Vanilla plant*

*Variegated vanilla foliage*

*Vanilla pods*

*Vanilla pods*

*Vanilla flower*

*Vanilla plant with seed pods*

## Uses

Vanilla bean extract is used a flavoring in confectionery and baking. Essential oils extracted from the plant are also used in the perfume industry.

# Propagation

**Basic requirements** Vanilla is a tropical plant and will grow best in warm, humid climates at temperatures between 21 and 32°C (33.8–89.6°F). Vanilla requires a soil rich in calcium and potassium and will grow best in a soil which is light and well-draining, with a pH between 6.0 and 7.0. Vanilla is a climbing plant and should always be provided with a support to grow on. It is usually planted alongside a companion tree, known as a tutor tree which has the added benefit of providing it with shade. Vanilla grows naturally in forests, often in clearings and alongside rivers and lakes where the forest canopy is thinner. **Propagation** Vanilla is usually propagated vegetatively from stem cuttings from a mother plant which has not been allowed to flower. Cuttings are best taken during the dry season when growth of the vines is slower. A cutting of 1.5 m (5 ft) should be taken and planted at the base of the support tree after removing the lower leaves. Cuttings should be planted at least 2 m (6.6 ft) apart. If a support tree is being used, it is preferable to use a type with a high number of lower branches. Vanilla may also be grown on a trellis or support post. **General care and maintenance** Vanilla should be managed to keep the vines at a manageable height as left unchecked they will continue to grow to the crowns of the supporting trees. When the plants reach a height of 1.6–1.8 m they should be bent back over the nearest suitable branch and the end of the shoot planted back into the ground and covered with soil. Planting the end of the shoot encourages the growth of roots and the continual production of newly rooted shoots helps to maintain a healthy plantation. Shoots may also be cut at the desired height and planted next to the same tutor tree once the wound has dried to create a new rooted plant. Vanilla should be mulched with organic mulch such as grass clippings to help suppress weeds and conserve soil moisture. Vanilla will benefit from the addition of fertilizer but applications are unnecessary and are rarely made in commercial production. Vanilla is naturally pollinated by small mexican bees and, although pollination is possible if the bees are present, plants are usually hand pollinated to ensure production.

**Harvesting** Vanilla is ready for harvest between 6 and 9 months after flowering when the pods are still dark green and the tip is beginning to turn yellow.

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Anthracnose** *Colletotrichum* spp.

##### **Symptoms**

Small, sunken, dark brown spots on leaves, fruits, stems and/or flowers; infected fruits dropping from plants before they reach maturity; damage to fruit is more pronounced during warm and humid periods of the growing season; symptoms generally develop first on apical parts of plant and spread to leaves and stems

##### **Cause**

Fungus

##### **Comments**

Disease emergence is favored by excessive shading of plants and overcrowding

### **Management**

Provide plants with adequate fertilization; application of an appropriate fungicide, e.g. Bordeaux mixture, can help to protect the plant from the disease

### **Black rot *Phytophthora* spp.**

#### **Symptoms**

Water-soaked green to black rot of stems, leaves and/or pods; thin white mycelium may be visible in infected tissues; disease usually begins at the apical part of the plant and spreads to leaves, stems and all other parts of the plant

#### **Cause**

Oomycete

#### **Comments**

Disease emergence favored by prolonged wet weather, poorly draining soil, excessive shading of plants, overcrowded plants and lack of weed control in the plantation

### **Management**

Plant vanilla using recommended spacing; control weeds around plants; remove infected parts of plants and destroy by burning; application of appropriate fungicide can help to protect the plants from disease

### **Rust *Uromyces joffrini***

#### **Symptoms**

Yellow to orange pustules on undersides of leaves which enlarge and coalesce causing the entire leaf to dry out; plant development slows and if disease is left untreated then plant becomes unproductive, defoliates and dies

#### **Cause**

Fungus

#### **Comments**

Rust is most common in traditional vanilla plantations where there is overcrowding, excessive shading of plants and excessive moisture

### **Management**

Removal of some leaves from the plants allows better penetration of sunlight; disease can be controlled through the application of appropriate fungicides

### **Category : Oomycete**

### **Root and stem rot *Fusarium batatas***

#### **Symptoms**

Fungus causes brown lesions on roots which turn brown and dry out; plants begin to rot at the apical tip and stop growing; plant begins to produce new roots from apical tissue; if there is not enough moisture, stems dry out and crack longitudinally; cracks will eventually cover the whole stem and the plant will die

#### **Cause**

Fungus

#### **Comments**

Emergence of the disease is favored by excessive soil moisture, too much shading of plants, inadequate fertilization, over-crowding and drought stress

### **Management**

Plant vanilla in well-draining soils and avoid overcrowding the plants; prune out infected plant parts; plant vanilla varieties that are tolerant or resistant to the disease

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# Walnut

## Description

Walnut, *Juglans regia*, is a deciduous tree in the Family Juglandaceae grown for its edible seeds. Walnut trees are large and vigorous with a wide-spreading canopy. The trunk of the tree can reach 2 m (6.6 ft) in diameter and mature trees possess smooth, silver-gray bark. Walnut leaves are composed of an odd number of smaller, oval shaped leaflets which are bright green in color. The tree produces male flowers on catkins and female flowers on terminal clusters where the fruit develops. The fruit of the walnut tree is a fleshy green drupe in which the nut is encased. The kernel of the nut is protected by a corrugated woody shell. Walnut trees can reach 25–35 m (82–115 ft) in height and can live for periods in excess of 200 years. Walnut may also be referred to as Persian walnut, English walnut, common walnut or European walnut and originates from central Asia.

Nut

Mature tree

Female flowers

Walnut catkins

Walnut foliage

Walnut fruit on the branch

## Uses

Walnut kernels can be eaten fresh or processed for use in baked goods and confectionery. The timber of the tree is a

highly valued as a wood for furniture making in Europe. Kernels may also be used as an animal feed or used to extract oil which was once a popular thinner for oil based paints.

## Propagation

**Basic requirements** Walnut can be grown successfully in a wide variety of climates but blossoms can be damaged by frost or high humidity. Must walnut varieties have a winter chilling requirement of 800–1000 hours below 7°C (45°F) to break dormancy and require a growing season of at least 200 frost-free days. Walnut trees should be planted in areas where there is good air circulation and drainage and will grow optimally when planted in a deep, fertile, well-draining loam soil with a pH between 5.5 and 6.5. Walnut roots systems can be extensive and it is not unusual for walnut roots to grow to depths of 4.5 m (15 ft). Water-logged soils will limit root growth and should be avoided. Walnuts will usually begin to produce in the fourth or fifth year following planting. **Propagation** Walnut trees are usually propagated vegetatively by budding or grafting, while saplings for rootstock are grown from seed. The planting site should be prepared by levelling the ground and eliminating weeds. Trees are planted by digging a hole that is twice as wide as the existing root ball. Aged manure or compost may be added to the soil at time of planting by incorporating it into the backfill soil. Trees should be spaced 10–15 m (33–50 ft) apart. In commercial plantations, trees may be spaced closer together. Grafted trees will begin to bear fruit in 5 years, while non-grafted plants may take 7-8 years. Newly planted young trees require staking as the new wood is soft and the tree can be damaged by winds. **General care and maintenance** Walnut trees should be trained to a central leader or modified leader system. Trees should be pruned in the Fall to prevent sap bleeding. Once the desired shape has been achieved, annual pruning should focus on thinning the tops of the trees to allow better air and light penetration to the canopy. In commercial orchards, lower limbs may be removed to facilitate the movement of machinery through the orchard. Newly planted walnut trees should be provided with supplemental irrigation for the first two years following planting. Trees should be watered deeply and the soil allowed to dry out between waterings. Irrigation is also required in the period after bloom in order to maximize nut production. In addition to an initial application of manure at planting, trees should be provided with 100–400 g of nitrogen per tree until the fifth year. In the sixth year, trees may be provided with up to 100 kg of nitrogen per hectare. **Harvesting** Walnuts in the home garden can simply be collected when they drop from the tree. In commercial orchards, walnuts are commonly harvested with the use of a mechanical shaker. Once the nuts are collected, they must be immediately hulled (the process of removing the nut from the green flesh) and dried.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

## **Anthracnose** *Gnomonia leptostyla*

*Anthracnose lesions on black walnut leaves*

### **Symptoms**

Brown to black lesions on leaves, petioles, shoots and/or husks which fade toward the center and may be surrounded by a chlorotic halo; spots may coalesce to form large necrotic patches, usually located close to leaf margins; lesions on shoots, petioles and leaf midribs become elongated and sunken

### **Cause**

Fungus

### **Comments**

Disease affects English walnut and is widespread in Europe; disease is also known to occur in the Pacific Northwest of the United States

### **Management**

Control of anthracnose in pistachio relies on the application of appropriate fungicide sprays; cultural practices can help to reduce the severity of the disease and include: removing leaf debris from around plants, avoiding wetting foliage when irrigating, spacing trees adequately to increase air circulation and applications of nitrogen fertilizer in Spring to delay leaf maturity and reduce the development of lesions

## **Armillaria root rot (Oak root fungus)** *Armillaria mellea*

### **Symptoms**

Small, discolored leaves which drop early; death of branches; death of plant; clusters of honey-colored mushrooms may sprout at base of plant

### **Cause**

Fungus

### **Comments**

Fungus survives on dead roots in soil

### **Management**

Armillaria root rot cannot be effectively controlled once it has become established in an orchard; diseased or dead plants should be uprooted and removed; planting resistant rootstocks is the most effective method of preventing the disease

## **Powdery mildew** *Phyllactinia guttata*

### **Symptoms**

Small, powdery white spots on leaves and fruit; spots spread to cover entire leaf; small black fungal fruiting bodies may be visible in the white growth; young leaflets may crinkle as they mature

### **Cause**

Fungus

### **Comments**

Disease emergence favored by moderate temperature, poor air circulation around plant and shady conditions

### **Management**

Disease is not severe enough on walnut to warrant control

## **Category : Viral**

## **Blackline disease** Cherry leaf roll virus (CLRV-W)

### **Symptoms**

Gradual reduction in tree vigor; leaves are yellow and drooping; defoliation occurs prematurely and is followed by

dieback of terminal shoots; small holes or cracks may be present at the graft union and underlying tissue may be discolored

#### Cause

Virus

#### Comments

Virus may be introduced from infected graft wood or infected pollen

#### Management

Introduction of the disease to uninfested areas can be prevented by using virus-free graft and budwood from English walnut; in areas where the disease is uncommon, immediate removal of trees identified as being infected can prevent spread

### Category : Bacterial

#### Crown gall *Agrobacterium tumefaciens*

##### Symptoms

Galls of various sizes on roots and root crown below the soil line; galls may occasionally grow on the trunk; galls are initially light colored bulges which grow larger and darken; galls may be soft and spongy or hard; if galling is severe and girdles the trunk then young trees are weakened due to constricted vascular tissue; trees may be stunted and rarely die

##### Cause

Bacterium

##### Comments

The bacterium enters host plants through wounds and causes plant cells to proliferate and cells to be undifferentiated, leading to the formation of a gall

##### Management

Only plant disease-free nursery stock; plant trees in well-draining soils; avoid wounding the plants as much as possible; fresh wounds can be treated with a biocontrol agent (*Agrobacterium tumefaciens* K84), if available, to prevent the bacterium colonizing

#### Walnut blight *Xanthomonas campestris*

##### Symptoms

Small, water-soaked spots on immature fruit which darken and rapidly enlarge; bacterial exudate may be present during wet weather; if infection occurs prior to shell hardening then the kernels shrivel; infections which occur later may cause kernel discoloration but the fungus does not usually invade the kernel; catkins which become infected are dark and shrivelled; new shoots may also be attacked and lesions may girdle the stem, killing the shoot above; lesions may form on tree bark and may also extend into the pith causing cankers to form; lesions on leaves are brown with a green-yellow perimeter; leaf lesions may coalesce to form large necrotic areas

##### Cause

Bacterium

##### Comments

Bacteria overwinter in dormant buds; following bud break the following year, bacteria infect surrounding leaves and young fruit; emergence of walnut blight is favored by periods of wet weather

##### Management

The primary method of controlling walnut blight is the application of copper containing bactericides such as Bordeaux mixture; bactericides should be applied weekly to protect new growth during periods of wet weather

### Category : Oomycete

#### Phytophthora root and crown rot *Phytophthora* spp.

##### Symptoms

Slow growing trees with reduced vigor; leaves of tree turning yellow and wilting; shoots and branches dying back; if tree is girdled at the trunk or root crown then death occurs, usually within one growing season; infected tree roots are necrotic and discolored black or brown; most roots eventually die; trees with crown rot may exhibit cankers of the root crown which extend above the soil line; cankers are visible as discolored bark and possess a zonate appearance when the bark is removed

#### **Cause**

Oomycete

#### **Comments**

Disease emergence favored by water saturated soils; disease is usually introduced to orchards through contaminated soil, water and plants

#### **Management**

Control should focus on minimizing soil wetness and saturation by planting trees in well-draining soils; drainage can be improved by levelling soil or installing drainage systems; avoid wetting tree trunks when irrigating; ensure graft union is several centimeters above the soil line when planting trees

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# Watermelon

## Description

Watermelon, *Citrullus lanatus*, is a vining annual plant in the family Cucurbitaceae grown for its fleshy fruit. Watermelon vines are thin, grooved and covered in tiny hairs. Vines are branching and possess deeply lobed pinnate leaves. The plant produces solitary yellow flowers and a large spherical to oblong fruit. The fruit is a 'pepo' - a fleshy fruit protected by a thick leathery rind. The fruit is smooth, light to dark green in color and can be striped, marbled or solid green. The flesh of the fruit is usually red in color but some cultivars produce green, orange or white flesh and contains numerous seeds which are usually black or dark brown in color. Watermelon vines can reach a length of 3 m (10 ft) and as an annual, survives only one growing season. Watermelon originates from Africa.

*Watermelon cut open to show flesh and seeds*

*Young watermelon fruit developing on the vine*

*Watermelon on vine*

*Watermelon on vine*

*Watermelon blossom*

*Watermelon blossom*

## Uses

Watermelon is usually consumed as a fresh fruit. In Africa it is sometimes cooked before eating and may also be used as

an animal feed.

## Propagation

**Requirements** Watermelon is a warm-season crop, requiring lots of sun and good drainage to develop optimally and growing best at temperatures between 18 and 28°C (65–82°F). Watermelon will yield best if grown in a light, well-draining soil, rich in organic matter and with a pH between 6.0 and 7.0. Watermelon should be planted in full sun and heavy feeders. They need to be provided with even soil moisture and fertilized regularly. Vining varieties can grow to very large sizes and require a good deal of space. **Sowing seeds** Watermelon can be direct seeded in areas with a long, warm growing season but in more Northern climates it should be sown indoors and transplanted. If direct seeding, seeds should be sown after the last frosts and when the soil has warmed to at least 18.4°C (65°F). Allow 90–120 cm (~3–4 ft) between seeds in a row and 150–180 cm (~5–6 ft) between rows. If transplanting, seeds should be sown approximately 3–4 weeks before the last frost date in your area and transplanted after the plants develop their first set of true leaves. Sow seeds in 3–4 in pots using a sterile seed starting mix and planting to a depth of 1–2 cm (~0.5 in). Thin seedlings once they are established. Seeds sown both indoors and out require lightly moist soil for germination, care should be taken to avoid overwatering as seeds are prone to rotting. Seeds should germinate in 3–10 days depending on the soil temperature. **Transplanting** Watermelon seedlings should be transplanted when all danger of frost has passed and the soil has warmed to at least 18.4°C (65°F). Covering soil with dark plastic or mulch a week prior to planting outdoors can help bring the soil temperature up more quickly in colder regions, allowing earlier planting. Beginning approximately 7–10 days before transplanting, plants should be set outside to harden off (see <https://www.plantvillage.com/posts/264>). The planting site should be prepared by incorporating plenty of organic matter to encourage vegetative growth. When transplanting seedlings, allow 90–120 cm (~3–4 ft) between plants and 150–180 cm (~5–6 ft) between rows. Drip or soaker irrigation is preferred to overhead irrigation and plants should be watered evenly to keep them moist. **General care** Watermelon vines are sprawling and require plenty space to grow. Vines can be trained to grow on a trellis or fence to save space. Watermelon plants have a very deep root system which allows them to access soil moisture efficiently. However, if conditions are very dry for prolonged periods then additional water should be provided.. Plastic mulches are highly recommended in areas where conditions are not ideal for growth as they conserve soil moisture and black polyethylene has the advantage of warming the soil. Floating row covers can be beneficial while the plants establish to protect against insect pests. **Harvesting** Watermelons are ready to be harvested when the tendrils closest to the fruit are beginning to dry out and turn brown. The underside of the melon should be beginning to turn yellow

Watermelon seedling

Germinating watermelon

## References

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# Common Pests and Diseases

## Diseases

### Category : Fungal

#### **Alternaria leaf blight** *Alternaria cucumerina*

##### **Symptoms**

Small, yellow-brown spots with a yellow or green halo which first appear on the oldest leaves; as the disease progresses, lesions expand and become large necrotic patches, often with concentric patterning; lesions coalesce, leaves begin to curl and eventually die

##### **Cause**

Fungus

##### **Comments**

Disease is prevalent in growing areas where temperatures are high and rainfall is frequent

##### **Management**

Cucurbits should be rotated with another crop every 2 years to reduce levels of inoculum; crop debris should be removed from the field as quickly as possible after harvest or plowed deeply into the soil; applications of appropriate protective fungicides can help to slow the development of the disease; water plants from the base rather than from above to reduce periods of leaf wetness which are conducive to the development and spread of disease

#### **Alternaria leaf spot (Brown spot)** *Alternaria spp.*

*Alternaria lesions on melon foliage*

*Alternaria lesions on melon foliage*

*Alternaria lesions on watermelon leaf*

##### **Symptoms**

Irregularly shaped or circular dark brown lesions on leaves; lesions may occur in concentric circles

##### **Cause**

Fungus

##### **Comments**

Spores survive on plant debris; transmitted via wind and rain

##### **Management**

Rotate crop with non-cucurbit for at least 2 years; plow crop debris deeply into soil after harvest; avoid overhead irrigation, water plants at base; apply appropriate protective fungicides

#### **Anthracnose** *Colletotrichum orbiculare*

*Anthracnose lesions on watermelon fruit*

*Close-up image of anthracnose lesion on watermelon rind*

*Anthracnose lesions on watermelon fruit*

*Anthracnose lesions on watermelon foliage*

*Anthracnose lesions on watermelon stem*

*Anthracnose lesions on watermelon foliage*

##### **Symptoms**

Angular dark brown or black lesions on leaves with yellow border; elongated lesions with sunken centers on stems and fruit

**Cause**

Fungus

**Comments**

Spread by wind and rain

**Management**

Rotate crops with non-cucurbits every 1-2 years to prevent disease build-up; plant only disease free, treated seed

**Cercospora leaf spot** *Cercospora citrullina***Symptoms**

Initial symptoms of disease occur on older leaves as small spots with light to tan brown centers; as the disease progresses, the lesions enlarge to cover large areas of the leaf surface; lesions may have a dark border and be surrounded by a chlorotic area; the centers of the lesions may become brittle and crack

**Cause**

Fungus

**Comments**

Fungus survives on plant debris; spread by wind and water splash; occurs mainly in tropical and subtropical growing regions

**Management**

Any diseased plants should be removed and destroyed to prevent further spread; crop debris should be removed after harvest or plowed deeply into the soil to reduce inoculum

**Downy mildew** *Pseudoperonospora cubensis*

*Necrotic leaves curling upwards due to downy mildew infection*

*Leaves severely infected with downy mildew*

*Downy mildew symptoms on watermelon foliage*

*Downy mildew symptoms on watermelon foliage*

*Symptoms of downy mildew on watermelon leaf*

**Symptoms**

Yellow mottling on leaves; dark brown lesions on leaves; leaves curling inwards;

**Cause**

Fungus

**Comments**

Spread by airborne spores and water splash

**Management**

Do not overcrowd plants; avoid overhead irrigation, water plants from base; apply appropriate fungicide

**Fusarium wilt** *Fusarium oxysporum*

*Discolored stem tissue caused by Fusarium infection*

*Symptoms of fusarium wilt in a watermelon field*

*Symptoms of fusarium wilt in a watermelon field*

**Symptoms**

Wilting plants; wilting confined to one or more vines; foliage has a dull gray-green appearance and turns yellow as the disease progresses; vascular tissue has a red discoloration

**Cause**

Fungus

### Comments

Disease can be spread through infected seed or via contaminated water and/or equipment

### Management

Plant in well draining soils and avoid waterlogging; plant fungicide treated seed; rotate crops on 4 year rotation

## Gummy stem blight *Didymella bryoniae*

*Gummy stem blight lesions on watermelon foliage*

*Gummy stem blight lesions on watermelon foliage*

*Gummy stem blight symptoms on watermelon*

*Gummy stem blight symptoms on watermelon*

*Gummy stem blight lesions on watermelon stem*

*Close-up of gummy stem blight lesion on watermelon leaf margin*

*Gummy stem blight lesions on watermelon foliage*

*Symptoms of gummy stem blight on watermelon stems and leaves*

### Symptoms

Round or irregular brown lesions with faint concentric rings on cotyledons; brown or white lesions on crown and stems; soft, circular brown lesions on fruit; lesions on stems and fruit may be oozing an amber colored sticky substance

### Cause

Fungus

### Comments

Fungus can be spread by infected seed, air currents or water splash; survives on plant debris in soil; disease emergence is favored by warm, wet conditions

### Management

Use disease free seed; treat seeds prior to planting; rotate crops every 2-3 years to a non-cucurbit to reduce disease build up in soil; reduce crop residue in soil by plowing plant debris into soil after harvest; application of preventative fungicides are usually required to control the disease successfully

## Powdery mildew *Podosphaera xanthii*

*Podosphaera fuliginea*

*Symptoms of powdery mildew on watermelon leaves*

*Symptoms of powdery mildew on watermelon leaves*

*Symptoms of powdery mildew on watermelon leaves*

### Symptoms

Reddish or bronze appearance of older leaves; obvious patches of white powdery growth on leaves

### Cause

Fungi

### Comments

Disease emergence favored by dry weather and high relative humidity

### Management

Plant in sites with good air circulation and sun exposure; do not overcrowd plants; sanitize equipment regularly

## Verticillium wilt *Verticillium dahliae*

### Symptoms

Symptoms generally appear after fruit set; chlorotic leaves which develop necrotic areas; leaves collapsing; symptoms only on one side of vine; discoloration of vascular tissue in roots

#### Cause

Fungus

#### Comments

Fungus can survive in soil for many years; disease emergence favored by cool or mild weather in Spring

#### Management

Do not plant in areas where other susceptible crops have been grown previously; delay planting until temperatures are warmer

### Category : Bacterial

#### Angular leaf spot *Pseudomonas syringae*

##### Symptoms

Small water-soaked lesions on leaves which expand between leaf veins and become angular in shape; in humid conditions, lesions exude a milky substance which dries to form a white crust on or beside lesions; as the disease progresses, lesions turn tan and may have yellow/green edges; the centers of the lesions dry and may drop out leaving a hole in the leaf

##### Cause

Bacterium

##### Comments

Spread through infected seed, splashing rain, insects and movement of people between plants; bacterium overwinters in crop debris and can survive for 2.5 years

##### Management

Use disease-free seed; do not grow plants in field where cucurbits have been grown in the previous 2 years; protective copper spray may help reduce incidence of disease in warm, humid climates; plant resistant varieties

#### Bacterial fruit blotch *Acidovorax avenae*

*Symptoms of bacterial fruit blotch on watermelon fruit*

*Symptoms of bacterial fruit blotch on watermelon fruit*

*Symptoms of bacterial fruit blotch on watermelon fruit*

*Symptoms of bacterial fruit blotch on watermelon foliage*

*Symptoms of bacterial fruit blotch on watermelon foliage*

##### Symptoms

Small water-soaked lesions on top or sides of fruit which enlarge over surface; lesions on fruit may turn reddish or brown and crack

##### Cause

Bacterium

##### Comments

Spread through infected seed or water splash; disease emergence favors wet conditions

##### Management

Use pathogen-free seed and transplants; rotate crops; avoid the use of overhead irrigation

### Category : Other

#### Aster yellows Aster yellows phytoplasma

### **Symptoms**

Foliage turning yellow; secondary shoots begin growing prolifically; stems take on a rigid, upright growth habit; leaves are often small in size and distorted, may appear thickened; flowers are often disfigured and possess conspicuous leafy bracts; fruits are small and pale in color

### **Cause**

Phytoplasma

### **Comments**

Disease is transmitted by leafhoppers and can cause huge losses in cucurbit crops

### **Management**

Remove any infected plants from the field to reduce spread; control weeds in and around the field that may act as a reservoir for the phytoplasma; protect plants from leaf hopper vectors with row covers

## **Blossom-end rot**

### **Symptoms**

Symptoms first appear on immature fruits as small light brown spots close to the blossom end of the fruit; as fruit grow, the spots enlarge, resulting in dark leathery lesions sunken into the fruit

### **Cause**

Nutritional disorder

### **Comments**

Watermelon varieties that produce long fruit are more susceptible to blossom-end rot

### **Management**

Blossom-end rot is caused by a lack of calcium in the developing fruit and it occurs when the uptake of nutrients to the plant is disrupted; factors which disrupt nutrient uptake include drought, root damage or high soil salinity; application of excess nitrogen fertilizer may also contribute to the development of blossom-end rot as it promotes vigorous growth of vegetative tissues and depletion of calcium in the soil; watering plants evenly and regularly reduces the incidence of blossom-end rot

## **Category : Viral**

### **Cucumber green mottle mosaic** Cucumber green mottle mosaic virus (CGMMV)

### **Symptoms**

Early symptoms on young plants include vein-clearing and the development of crumpled leaves; older plants develop bleached and/or chlorotic leaves. As the infection progresses, leaves develop mottling and become blistered and distorted. Leaf symptoms are very difficult to distinguish from other mosaic viruses of Cucurbits/ Severity of symptoms varies depending on the strain of the virus.

### **Cause**

Virus

### **Comments**

All Cucurbit species are susceptible to the virus, some cucumber varieties have been developed which have some resistance to the disease and are available in Canada and Europe.

### **Management**

As the virus is spread primarily by infected seed, only disease-free seed from a reputable supplier should be planted. Seedlings and plants infected with the virus should be removed and destroyed to prevent spread. All seedlings/plants within a 3-5 ft radius of the infected plant should also be destroyed. The virus can be spread mechanically via tools and on hands, good sanitation should be practiced at all times to prevent virus transmission - disinfect all tools and equipment between uses by dipping in a solution of bleach or using a commercially available disinfectant such as Virkon.

### **Cucumber mosaic** Cucumber mosaic virus (CMV)

### **Symptoms**

Plants may be severely stunted; foliage is covered in distinctive yellow mosaic; leaves of plant curl downwards and leaf

size is smaller than normal; flowers on infected plants may be deformed with green petals; fruits become distorted and are small in size; fruit is often discolored

#### Cause

Viruses

#### Comments

Transmitted by aphids; virus has an extensive host range; can be mechanically transmitted via tools etc.

#### Management

Control of the virus is largely dependant on the control of the aphid vectors; reflective mulches can deter aphid feeding; aphid outbreaks can be treated with mineral oils or insecticidal soap applications; some resistant varieties are available

### **Watermelon mosaic** Watermelon mosaic virus (WMV)

#### Symptoms

Symptoms vary widely depending on species, cultivar, virus strain and environmental conditions; symptoms on leaves may include green mosaic patterning, green vein-banding, chlorotic rings and disfigured leaves

#### Cause

Virus

#### Comments

Virus is found in almost all Cucurbit growing regions in the world; virus is spread by over 20 aphid species

#### Management

Treatments that control populations of aphid vectors can also reduce the incidence of the virus; spraying plants with mineral oils or insecticidal soaps can help to reduce aphid numbers

### **Zucchini yellow mosaic** Zucchini yellow mosaic virus (ZYMV)

#### Symptoms

Infected plants are severely stunted and leaves can exhibit a variety of symptoms including yellow mosaic patterning, severe deformation, blistering, reduced size and necrosis; fruits are deformed

#### Cause

Virus

#### Comments

Disease can cause devastating epidemics when present

#### Management

Use of resistant varieties, where available, is usually the most effective method of controlling the virus; control of aphid populations on the plants can be achieved through the use of mineral oils and insecticidal soaps but is rarely effective at controlling the virus

## Pests

### Category : Insects

#### **Aphids (Peach aphid, Melon aphid)** *Myzus persicae*

*Aphis gossypii*

*Peach aphid colony*

#### Symptoms

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow

and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants

### **Cause**

Insects

### **Comments**

Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; will generally not move very quickly when disturbed

### **Management**

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

## **Cabbage looper *Trichoplusia ni***

R.J. Reynolds Tobacco Company  
Slide Set, R.J. Reynolds Tobacco  
Company, Bugwood.org

### **Symptoms**

Large or small holes in leaves; damage often extensive; caterpillars are pale green with a white lines running down either side of their body; caterpillars are easily distinguished by the way they arch their body when moving; eggs are laid singly, usually on the lower leaf surface close to the leaf margin, and are white or pale green in color

### **Cause**

Insect

### **Comments**

Insects overwinter as pupae in crop debris in soil; adult insect is a dark colored moth; caterpillars have a wide host range

### **Management**

Looper populations are usually held in check by natural enemies; if they do become problematic larvae can be hand-picked from the plants; an organically acceptable control method is the application of *Bacillus thuringiensis* which effectively kills younger larvae; chemical sprays may damage populations of natural enemies and should be selected carefully

## **Cutworms *Agrotis* spp.**

*Peridroma saucia*

*Nephelodes minians*

and others

*Cutworm severing plant stem*

### **Symptoms**

Stems of young transplants or seedlings may be severed at soil line; if infection occurs later, irregular holes are eaten into the surface of fruits; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant; larvae are 2.5â€“5.0 cm (1â€“2 in) in length; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed

### **Cause**

## Insects

### Comments

Cutworms have a wide host range and attack vegetables including asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato and tomato

### Management

Remove all plant residue from soil after harvest or at least two weeks before planting, this is especially important if the previous crop was another host such as alfalfa, beans or a leguminous cover crop; plastic or foil collars fitted around plant stems to cover the bottom 3 inches above the soil line and extending a couple of inches into the soil can prevent larvae severing plants; hand-pick larvae after dark; spread diatomaceous earth around the base of the plants (this creates a sharp barrier that will cut the insects if they try and crawl over it); apply appropriate insecticides to infested areas of garden or field if not growing organically

## Flea beetles *Epitrix* spp.

### Symptoms

Small holes or pits in leaves that give the foliage a characteristic "shot hole" appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed; the pest responsible for the damage is a small (1.5–3.0 mm) dark colored beetle which jumps when disturbed; the beetles are often shiny in appearance

### Cause

Insects

### Comments

Younger plants are more susceptible to flea beetle damage than older ones; older plants can tolerate infestation; flea beetles may overwinter on nearby weed species, in plant debris or in the soil; insects may go through a second or third generation in one year

### Management

In areas where flea beetles are a problem, floating row covers may have to be used prior to the emergence of the beetles to provide a physical barrier to protect young plants; plant seeds early to allow establishment before the beetles become a problem - mature plants are less susceptible to damage; trap crops may provide a measure of control - cruciferous plants are best; application of a thick layer of mulch may help prevent beetles reaching surface; application of diamotocoeus earth or oils such as neem oil are effective control methods for organic growers; application of insecticides containing carbaryl, spinosad, bifenthrin and permethrin can provide adequate control of beetles for up to a week but will need reapplied

## Thrips (Western flower thrips, Onion thrips, etc.) *Frankliniella occidentalis*

*Thrips tabaci*

### Symptoms

If population is high leaves may be distorted; leaves are covered in coarse stippling and may appear silvery; leaves speckled with black feces; insect is small (1.5 mm) and slender and best viewed using a hand lens; adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color

### Cause

Insect

### Comments

Transmit viruses such as Tomato spotted wilt virus; once acquired, the insect retains the ability to transmit the virus for the remainder of its life

### Management

Avoid planting next to onions, garlic or cereals where very large numbers of thrips can build up; use reflective mulches early in growing season to deter thrips; apply appropriate insecticide if thrips become problematic

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# Wheat

## Description

Wheat, is the name given to several plants in the genus *Triticum* including *Triticum aestivum*, *Triticum compactum*, *Triticum spelta* and *Triticum durum*, which are annual or biennial grasses grown primarily for their grain. Wheat species possess an erect smooth stem with linear leaves that grow in two rows on either side of the stem with larger 'flag' leaves at the top of the stem. The stem terminates in a spike that is made up on individual spikelets, each possessing 3–9 florets. The wheat fruit develops within the spikelets, maturing to a seed (kernel). Wheat can reach 1.2 m (4 ft) in height and like other cereals, has been developed into different varieties that are adapted to planting at different times of the year. Spring wheat is planted for a late summer harvest, whereas Winter wheat is planted for harvesting in early to mid summer. Overwintering varieties are more commonly grown in regions with mild winters. Wheat may be referred to by variety and these include durum or macaroni wheat (*Triticum durum*), club wheat (*Triticum compactum*), spelt wheat (*Triticum spelta*) and bread wheat (*Triticum aestivum*). Wheat originated in the Fertile Crescent of the Middle East.

*Wheat harvest*

*Wheat spikes*

*Ripe wheat close-up*

*Close-up of ripe wheat spike*

*Immature wheat*

*Combine harvesting wheat*

*Wheat seedlings*

*Wheat seed head (spike)*

*Wheat field*

## Uses

Wheat is one of the most important food plants in the world. It is used primarily to produce flour for bread. It is used widely in the production of many other baked goods. Wheat grain is also used in the manufacture of alcoholic beverages and alcohol. Wheat straw is used as an animal feed and in the manufacture of carpets, baskets, packing, bedding, and paper.

## Propagation

**Wheat varieties** One of the first things to consider before planting is which type of wheat you want to grow. There are several different varieties to choose from depending on the time of year and how you want to utilize your harvest. Wheat is broadly categorized into Winter wheat and Spring wheat. Winter wheat is high yielding and is planted in the Fall and harvested in the Spring or Summer of the following year (depending on location). Spring wheat is not as high yielding but tolerates drier conditions. It is planted in the Spring and harvested in the Fall. Both Spring and Winter wheat is then further categorized as soft wheat, hard wheat, spelt or durum.

**General requirements** Wheat can be grown in a wide variety of climates but grows best in cool regions where the temperature is between 10 and 24°C (50–75°F). Wheat will not grow at temperatures above 35°C (95°F). Wheat will grow optimally in a deep, fertile, well draining and well aerated soil at a pH between 5.5 and 7.5.

**Planting** Winter wheat varieties should be planted in the Fall approximately 6 to 8 weeks before the first frost date. Spring wheat varieties should be planted as soon as the soil can be worked in the Spring. Commercially grown wheat is usually mechanically drilled using a machine that creates a furrow and drops the seed in before covering it back up. Wheat seeds can be sown by hand broadcasting in smaller areas, or using a hand-cranked seeder. Seeds are usually sown to depths ranging from 2 to 12 cm (0.8–4.7 in) depending on soil conditions (seed must be sown deeper in drier soil). Once the seeds have been scattered, the soil should be raked lightly to set the seeds at the desired depth.

**Harvesting** Wheat is ready to harvest when the stalks and heads have turned from green to yellow and the seed heads are drooping towards the ground. Check the seeds for ripeness before harvest. They should be firm and crunchy and not doughy in texture. Commercially produced wheat is usually harvested using a combine. Smaller plots can be harvested by hand using a scythe or sickle. Small plots can be harvested by snipping off the heads with a pair of scissors.

*Commercially produced wheat is usually harvested by combine*

*Winter wheat seedlings*

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## Common Pests and Diseases

### Diseases

#### Category : Bacterial

##### Bacterial leaf streak and black chaff *Xanthomonas campestris*

Symptoms of bacterial streak on wheat leaves

Foliar symptoms on field plants

Symptoms of black chaff on head

Symptoms of bacterial streak on wheat leaves

#### Symptoms

Sudden appearance of water-soaked, light brown, elongated lesions on upper leaves; lesions quickly dry out and turn into necrotic streaks on the leaves; black stripes occur on glumes and purple black lesions appear on rachis and peduncle if infection is in the head

#### Cause

Bacterium

#### Comments

Disease spread through infected seed and splashing water

#### Management

Avoid planting seed from infected fields; avoid overhead irrigation; plant less susceptible cultivars

##### Basal glume rot *Pseudomonas syringae*

Basal glume rot symptoms on wheat

#### Symptoms

Dull brown to black discoloration of glumes which is more pronounced on the inner side; seeds may be shriveled; if infection is severe, entire glume may be discolored; small water-soaked lesions may form on leaves

#### Cause

Bacterium

#### Comments

Disease spreads primarily through infected seed

#### Management

Avoid planting seed from plants grown in fields where the disease is known to be present

#### Category : Viral

##### Barley yellow dwarf Barley yellow dwarf virus (BYDV)

*Yellow leaves on wheat infected with BYDV*

*Purple leaves on wheat infected with BYDV*

*BYDV infection in winter wheat*

*Common wheat infected with BYDV*

### Symptoms

Yellowing leaves, particularly the flag leaves; stunted plants due to shortened internodes; leaves may be red, purple, orange, green or brown; leaves may be distorted

### Cause

Virus

### Comments

Transmitted by a few species of aphid; spread of disease is completely dependent on the movement of aphid vectors

### Management

Control of aphid population can provide some control of disease but is dependent on knowing which aphids are active in the field; planting to avoid periods of peak aphid activity can provide a measure of control

## Category : Fungal

### Common bunt (Stinking smut) *Tilletia tritici*

*Bunt balls caused by common bunt in wheat*

*Wheat spike showing symptoms of common bunt, right.*

*Wheat spike showing symptoms of common bunt, also known as stinking smut.*

### Symptoms

Slender heads which take longer to turn color than healthy heads; glumes spread apart to reveal spori or "bunt balls" (balls containing fungal spores) which are a similar size to normal kernel but are gray-brown in color; bunt balls break open on harvest and give off a fishy odor

### Cause

Fungus

### Comments

Disease is most commonly introduced through infected seed although spores are spread by wind

### Management

Disease can be controlled by planting resistant wheat varieties, planting disease-free seed and using a seed treatment prior to planting; disease may also be avoided by planting wheat early in the Fall and by shallow seeding

### Ergot disease *Claviceps purpurea*

*Ergot on wheat spike*

*Wheat spikes infected with ergot*

### Symptoms

Main symptoms of ergot is the grains in the head are replaced by dark purple to black sclerotia. These ergot bodies were made up of vegetative strands of fungus. The sclerotic interior is white or tennis white in color. The size of grain kernel and ergot are similar in size. The initial symptom before sclerotia bodies is honey dew symptom occur during flowering stage. The fungus produce yellowish, sugary excretions and can see as droplets on flower parts.

## Cause

Fungal

## Comments

Ergot is toxic to animals including birds.

## Management

Follow crop rotation with non host crops for one year. Deep summer ploughing kills sclerotia bodies present in soil. Keep the field free from grasses and other weeds. Use disease free seeds.

## Eyespot *Oculimacula* spp.

*Wheat stems showing lesions caused by eyespot (*Oculimacula yallundae*).*

*Eyespot lesion on wheat stem*

*Eyespot lesions girdling wheat stems*

## Symptoms

Elliptical lesions that first appear on leaf sheath and gradually spread to stem; lesions are yellow-brown to tan in color and occur length-ways down the stem; lesions can occur individually or groups of lesions can coalesce to form large areas of discoloration; lesions may eventually girdle the stem; a gray, thread-like fungal growth may occur on the stem beneath the lesion; mature stems may have a charred appearance; infected tillers mature early and develop white heads and poorly filled seed; tillers may fall if stems are severely infected

## Cause

Fungus

## Comments

Primary route of infection is by splashing water; emergence of disease favored by high soil moisture content and a dense crop canopy

## Management

Rotation of crop away from cereals for a period of 2-3 years will reduce levels of inoculum in the field; fungicides are commonly applied close to stem elongation to control the disease; plant resistant wheat varieties if available in your area

## Fusarium head blight (Scab) *Fusarium* spp.

*Fusarium head blight symptoms on wheat*

*Fusarium head blight symptoms on wheat*

*Partially bleached heads in field of wheat*

## Symptoms

One or more spikelets on newly emerged head bleached; pink or orange fungal masses may be visible at the base of infected spikelet; infected spikelets do not produce seed or produce shriveled and/or discolored seed; severe infections can cause the kernels to have a chalky appearance and are frequently lost during harvest

## Cause

Fungus

## Comments

Fungus survives between seasons on host plant debris - other host include corn and barley; fungus can survive on host debris for several years; warm, moist conditions promote the spread of the disease when present

## Management

Control of the disease can be difficult; durum wheat appears to be more susceptible to the disease than common wheat; crop rotation to a non-host is recommended for at least one year; applications of appropriate fungicides if available can help to control the disease in conjunction with the other measures detailed here

## **Phythium root rot** *Phythium sp.*

*Wheat seedlings showing "damping off", which can be caused pre- or post-emergence by early infection with fungi causing common root rot, foot rot, and crown rot, which may be numerous *Helminthosporium*, *Fusarium*, or *Pythium* species.*

### **Symptoms**

The infected plants become chlorotic and/ stunted. Often the symptom is confused with nitrogen deficiency. And the plants may produce shriveled grain. Even a mild infection reduce tillers, plant population and maturity. Since symptom appear through out the field make if difficult to diagnose the disease.

### **Cause**

Fungal

### **Comments**

Fungus live for years in soil and on old root debris.

### **Management**

Use good quality seeds. Provide supplemental phosphorous. Sowing when soil temperature is about 50 F increase germination and establishment. Seed treatment with suitable fungicides.

## **Powdery mildew** *Erysiphe graminis*

*Wheat leaf showing powdery mildew*

*Powdery mildew symptoms on wheat*

*Powdery mildew on wheat*

*Powdery mildew colonies on wheat leaf*

*Wheat leaf showing fungal growths due to powdery mildew*

### **Symptoms**

Patches of cottony, white-gray growth on upper surface of leaves which turn gray-brown; chlorotic patches develop on leaves opposite fungal growth; fungal fruiting bodies usually become visible as black dots on the mildew

### **Cause**

Fungus

### **Comments**

Disease emergence favors heavy nitrogen fertilization; high humidity and cool temperatures

### **Management**

Planting resistant wheat varieties is one of the best ways to protect plants from powdery mildew; other control strategies include: application of appropriate foliar fungicides, if available; removal of crop debris from field after harvest to reduce the level of overwintering fungus; removal of volunteer wheat plants which can act as a reservoir for the disease

## **Rusts** Stem rust (*Puccinia graminis*)

Leaf rust (*P. tritici*)

Stripe rust (*P. striiformis*)

*Wheat stem rust symptoms*

*Stripe rust on wheat spike*

*Wheat stem rust Stripe rust*

*Leaf rust symptoms on wheat*

*Wheat stripe rust*

*Leaf rust*

### **Symptoms**

Chlorotic flecks or brown necrotic spots on leaves or stems; yellow streaks or patches on foliage; brown necrotic streaks on foliage; raised orange pustules may be present on lesions

### **Cause**

Fungus

### **Comments**

Disease emergence favors cool, wet conditions

### **Management**

The most effective method of controlling rusts is to plant resistant varieties of wheat; other methods of control include: destroying alternate hosts; applications of appropriate protective fungicides; growing wheat varieties that mature early

## **Tan spot *Pyrenophora tritici-repentis***

*Wheat leaf showing symptoms of tan spot*

*Tan spot lesion on wheat leaf*

### **Symptoms**

Oval or diamond shaped necrotic lesions with brown centers and yellow halos on leaves

### **Cause**

Fungus

### **Comments**

Disease infection requires a wet period of between 6 and 48 days

### **Management**

Disease can be significantly reduced by rotating crops with non-hosts and tilling crop debris into soil after harvest

## **Pests**

### **Category : Insects**

## **Aphids (Bird cherry-oat aphid, Russian wheat aphid, Corn leaf aphid, etc.)**

*Rhopalosiphum padi*

*Diuraphis noxia*

*Sitobion avenae*

*Black mold on wheat*

*Russian wheat aphid*

*Aphids on wheat*

*Aphids on wheat foliage*

### Symptoms

Yellow or white streaked leaves; flag leaves may be curled up; plants may be stunted and tillers may lie parallel to the ground; plants may turn a purple color in cold weather; insects are small and soft-bodied and may be yellow, green, black or pink in color depending on species; insects secrete a sugary substance called "honeydew" which promotes the growth of sooty mold on the plants

### Cause

Insect

### Comments

Fields should be checked for aphid populations periodically after emergence

### Management

Sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use; in commercial plantations aphid numbers are usually kept in check by predators and natural enemies; beneficial insect populations should be assessed before chemical control is considered; if no beneficial insect populations are present and aphids are damaging then apply appropriate insecticides

## Armyworms (Armyworm, Western striped armyworm) *Mythimna unipunctata*

*Spodoptera praefica*

*Armyworm*

### Symptoms

Entire leaves consumed; notches eaten in leaves; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside

### Cause

Insect

### Comments

Insect can go through 3–5 generations a year

### Management

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae

## Stinkbugs *Euschistus* spp.

*Green stink bug on wheat*

*Stink bug feeding on developing wheat kernels*

## **Symptoms**

Damage to head during milk or soft dough stage; stink bugs often carry pathogens in their mouthparts which can cause secondary infections; adult insect is shield-shaped and brown or green in color; may have pink, red or yellow markings; eggs are drum shaped and laid in clusters on the leaves; larvae resemble the adults but are smaller

## **Cause**

Insect

## **Comments**

Adult insects overwinter under leaves, on legumes, blackberries or on certain weeds such as mustard or Russian thistle

## **Management**

Remove weeds around crop which may act as overwintering sites for stink bugs and practice good weed management throughout the year; organically accepted control methods include the use of insecticidal soaps, kaolin clay and preservation of natural enemies

## **Wireworms** *Aeolus* spp.

*Anchastus* spp.

*Melanotus* spp.

*Limonius* spp

*Wireworm larvae*

## **Symptoms**

Death of seedlings; reduced stand; girdled stems and white heads; wireworm larvae can be found in soil when dug round the stem; larvae are yellow-brown, thin worms with shiny skin

## **Cause**

Insect

## **Comments**

Larval stage can last between 1 and 5 years depending on species

## **Management**

Chemical control impossible in a standing crop, must be applied at preplanting or as a seed treatment; if wireworms are known to be present in soil fallow field during summer and till frequently to reduce numbers; rotate to non-host crop where possible; avoid planting susceptible crops after a wireworm infestation on cereals without either fallowing or applying appropriate pesticide

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# Yams

## Description

Yam is the name given to several plant species in the genus *Dioscorea* including *Dioscorea alata* (white yam), *Dioscorea bulbifera* (potato yam), *Dioscorea cayenensis* (yellow yam), *Dioscorea esculenta* (Asiatic yam) and *Dioscorea batatas* (Chinese yam) that are grown for their edible tubers. These species are not to be confused with the sweet potato, *Ipomoea batatas*, which is often referred to as a yam in the US. Yam plants are herbaceous annual or perennials with climbing or trailing vines. The vines can be smooth or prickly, reaching 10 m (32.8 ft) or more in length depending on the variety. The leaves of the plant are simple and usually oval to heart-shaped with petioles which are the same length, or slightly longer, than the leaf blade itself. Some varieties possess spikes at the bases of the leaves. The plant can produce one singular tuber or several tubers which extend from stolons from a central corm (up to 20) depending on the species. The tubers can be cylindrical, curved or lobed, with brown, grey, black or pink skin and white, orange or purplish flesh. Most yams are annual plants, harvested after one season, but some are perennial with tubers increasing in size each year with the vines dying back at the end of the growing season and regrowing on the return of favorable conditions. The origin of yams is uncertain and genetic information suggests that there may be more than one point of origin.

*Dioscorea bulbifera*

## Uses

Yams are used differently in different parts of the world. They are consumed after cooking by frying, boiling or roasting. The green parts of some plants can be cooked and consumed as a vegetable. Yams may also be used to produce flour or starch.

*Yam tubers at market*

## Propagation

**Basic requirements** Yams are mainly grown in tropical and subtropical climates and they do not grow well at temperatures below 22°C (71.6°F) and are killed by frost.. The optimum temperature for the growth of yams is between 25 and 30°C (77–86°F). They grow optimally in well-draining fertile soils with a pH between 5.5 and 6.5 in full sun or part shade. Very wet soils should be avoided as this promotes tuber rot. **Propagation** Yams are propagated vegetatively from small tubers. Land should be prepared for planting by plowing and harrowing. Tubers should be planted in trenches to a depth of 15 cm (6 in) allowing at least 30 cm (12 in) between individual plants and 1.5 m (5 ft) between rows. The soil is often mounded around plants or ridged to aid drainage. It is common practice to stake plants with a 2×4 m (6.6×13.2 ft) support to allow them to climb and ensure that all parts of the plant receive adequate sunlight. **General care and maintenance** Yams require 100 cm of water distributed evenly throughout the growing season. Yam plants should be mulched after planting to prevent plants from drying out. Failure to mulch the plants will result in drastic decreases in yield. **Harvesting** Yams can be harvested at any time after the leaves have started to yellow. The soil should be carefully dug around the tuber and the the tuber cut from the vine. Harvesting is best carried out on sunny, dry days to prevent tuber rot.

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## Common Pests and Diseases

### Diseases

#### Category : Fungal

##### **Anthracnose (Scorch)** *Colletotrichum gleosporoides*

*Anthracnose symptoms on yam foliage*

*Anthracnose symptoms on yam foliage*

#### Symptoms

Small, dark brown spots or black lesions on leaves which may be surrounded by a chlorotic halo; leaf necrosis; dieback of stem; withered leaves and scorched appearance

#### Cause

Fungus

## **Comments**

Disease overwinters in plant debris; occurs worldwide

## **Management**

The most effective method of controlling the disease is to plant yam varieties that are resistant to anthracnose such as TDA 291 or TDA 297

## **Category : Viral**

### **Yam mosaic disease *Yam mosaic potyvirus***

*Yam mosaic virus infected plant (2)*

*Yam mosaic virus infected leaves (2)*

*Yam mosaic virus infected leaf (3)*

*Yam mosaic virus infected leaves*

*Yam mosaic virus infected plant*

*Yam mosaic virus infected leaf (2)*

*Yam mosaic virus infected leaf*

## **Symptoms**

The common symptoms are infected leaves show yellow and green patterns (called mosaics) between the veins or may show a narrow green strips bordering the veins (called vein banding). If the disease is severe the leaves become long, thin and strap shape (called shoe-string symptom) and whole plant become stunted. Plant may produce few small tubers with less starch content. Some plants may recover from the virus infection soon after first symptom but virus may survive in plant and reduce the vigour.

## **Cause**

Virus

## **Comments**

The virus is transmitted by aphids and tubers/setts. It may cause up to 40% loss in yield. Yam mosaic virus is always associated with yam mild mosaic virus, yam badnaviruses and cucumber mosaic virus in Africa making this disease more complex. Disease is reported in West Africa , South America and Caribbean.

## **Management**

Use healthy and disease free tubers or setts for planting. Select healthy and large tubers for planting instead of small tubers. Keep fields free from weeds. Collect crop debris and destroy them.

## **Pests**

## **Category : Nematodes**

### **Dry rot disease (caused by yam nematode) *Scutellonema bradys***

*Yam tubers infested by nematode and white scale insect*

*Yam tuber infested by dry rot nematode*

## **Symptoms**

The infected tubers show dry rot of 1 to 2 cm. Initially this dry rot is of cream and light yellow lesions appear just below the outer skin without any external symptom. With progress in disease lesion spreads deeper (maximum up to 2 cm). At later stage the rot become light and dark brown to black in color and tubers may show external cracks. Entry of fungus

through this wounds causes further decay of tubers in storage. There is no above ground symptom with yam nematode infestation.

#### **Cause**

Nematode

#### **Comments**

Some time the infected tubers may not show external cracking which make it difficult to diagnose. In that case scrap out the external layer of tuber to check the disease incidence.

#### **Management**

Use disease free tubers/setts for planting. Treating tubers with hot water for 40 min at 50-55 C before sowing and after harvest to reduce disease both in field and storage. In Africa smearing tubers with wood ash or cow dung shows reduced nematode infection in field. Follow crop rotation with non host or antagonist crops like ground nut, sorghum, maize, chili pepper etc.

### **Root Knot Nematode *Meloidogyne incognita*(Kofoid & White)**

*Galled tubers with crazy roots*

#### **Symptoms**

The infected plants are stunted with poor growth. The leaves turn yellow in color. Tubers and feeder roots are galled. Tubers are deformed and develop abnormal rootlets. Reduction in edible portion of tubers.

#### **Cause**

Nematode

#### **Comments**

It reduces market value and quality of tubers (up to 32 - 59 % in Nigeria). The actual yield loss is estimated up to 27 to 55 %.

#### **Management**

Deep summer ploughing to expose and kill nematode. Follow crop rotation with non host crops like groundnut and maize.

### **Category : Insects**

### **Mealybugs *Rastrococcus* spp.**

#### **Symptoms**

Flattened oval to round disc-like insect covered in waxy substance on tree branches; insects attract ants which may also be present; insect colony may also be associated with growth of sooty mold due to fungal colonization of sugary honeydew excreted by the insect

#### **Cause**

Insect

#### **Comments**

Insects have a wide host range; often tended by ants which farm them for their sugary honeydew secretions

#### **Management**

Prune out heavily infested branches; mealybugs can potentially be controlled by natural enemies; chemical pesticides may decrease populations of natural enemies leading to mealybug outbreaks; horticultural oils or soapy solutions can be used to treat heavy infestations

### **White Scale insects *Aspidiella hartii***

*Yam tuber infested by white scale insect (2)*

*White scale insects infested yam tubers*

*Yam tuber infested by white scale insect*

### Symptoms

The leaves and tubers are covered with small white scales from field to storage. Even though it won't effect yield sometimes foliage cause poor growth and tubers may show delay in germination or even stopped. Severe infestation may leads to tuber shrivel.

### Cause

Insect

### Comments

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