Complete Process of Apple Cultivation in India

1. Climate Requirements

- **Temperature**: Ideal temperature ranges between **21°C to 24°C** during the growing season.
- **Chilling Hours**: Apple trees require **1,000–1,500 chilling hours** below 7°C during dormancy for proper flowering and fruiting.
- **Altitude**: Best grown at altitudes between **1,500–2,700 meters above sea level**.
- **Rainfall**: Requires **100–125 cm of annual rainfall**, but excessive rain during flowering can affect fruit set.

2. Soil Requirements

- **Type**: Well-drained **loamy soils** rich in organic matter.
- **pH Level**: Ideally between **5.5 and 6.5**.
- **Drainage**: Good drainage is essential to prevent root rot. Avoid heavy clay or waterlogged soils.

3. Selection of Planting Material

- **Varieties**:
  - **Traditional Varieties**: Red Delicious, Golden Delicious, Royal Delicious, American Trel, Granny Smith
  - **Hybrid and Improved Varieties**: HRMN-99, Super Chief, Oregon Spur, Starkrimson
- **Rootstocks**: MM111, MM106 (Semi-dwarf), M9 (Dwarf)
- **Quality**: Disease-free, certified plants from nurseries.

4. Nursery Establishment and Grafting

- Apple plants are propagated through **budding or grafting** on rootstocks.
- **Steps for Nursery Preparation**:
  - Prepare raised nursery beds.
  - Sow seeds for rootstock and allow them to grow for a year.
  - Perform **T-budding** or **whip grafting** with desired varieties.
  - Maintain proper spacing and irrigation in the nursery.

5. Land Preparation

- **Plowing and Leveling**: Land should be **deep-plowed and leveled**.
- **Organic Matter**: Add **well-decomposed FYM (Farmyard Manure) at 10-15 tons/ha**.
- **Pit Digging**:
  - Pits of **1m x 1m x 1m** are dug before planting.
  - Fill pits with **FYM, topsoil, and biofertilizers** for better root growth.

6. Spacing and Plant Population

- **Traditional Orchard**: **6m × 6m spacing**, about **250 trees per hectare**.
- **High-Density Plantation**: **3m × 3m spacing**, up to **1,000 trees per hectare**.
- **Ultra-High Density Plantation**: **1.5m × 1.5m spacing**, over **3,000 trees per hectare** using dwarf rootstocks like M9.

7. Root Dip Treatment Before Planting

- Before transplanting, roots should be dipped in a **Bavistin (fungicide) solution** (0.2%) to prevent fungal infections.
- **Hormone Treatment**: Dipping roots in **IAA (Indole Acetic Acid) solution** enhances root development.

8. Transplanting Process

- **Best Season**: Late winter to early spring (**January–March**) for temperate regions.
- **Procedure**:
  - Plant saplings in prepared pits.
  - Fill with **topsoil mixed with FYM**.
  - Water immediately after planting.
  - Support plants with **stakes** in high-wind areas.

9. Nutrient Management and Fertilization

Growth Stage	Fertilizer Requirement (Per Tree Per Year)
First Year	10 kg FYM, 100 g NPK (12:12:12)
Second Year	20 kg FYM, 250 g NPK
Fruiting Stage	40 kg FYM, 500 g NPK, 100 g Boron

- **Micronutrient Management**: Zinc and Boron sprays help in flower and fruit development.

10. Irrigation and Water Management

- **Frequency**:
  - **Young trees**: Water every **7-10 days** in summer.
  - **Bearing trees**: Water every **15-20 days**.
- **Methods**:
  - **Drip irrigation** (preferred for high-density planting).
  - **Basin irrigation** for traditional planting.
- **Water Stress Effects**: Lack of water can lead to **poor fruit set and low yield**.

11. Pest and Disease Management

Major Pest/ Disease	Control Measure

Codling Moth	Spray Chlorpyrifos (0.05%)
Aphids	Neem oil or Dimethoate (0.03%)
Apple Scab	Spray Mancozeb (0.25%)
Powdery Mildew	Sulfur dusting or Wettable Sulfur (0.2%)

12. Pruning and Training

- **Pruning Time**: Late winter (January–February).
- **Types of Training Systems**:
  - **Modified Central Leader** (for normal orchards).
  - **Spindle Bush** (for high-density planting).

13. Flowering and Pollination

- Apples require **cross-pollination**, so **bee hives** (5–7 hives per hectare) are introduced.
- Pollinizer varieties like Golden Delicious should be **planted at a ratio of 1:8**.

14. Harvesting and Yield

- **Harvesting Time**: August–October (varies by variety and region).
- **Yield (Per Hectare)**:
  - **Traditional Orchard**: **10–15 tons**.
  - **High-Density Orchard**: **40–50 tons**.
  - **Ultra-High Density Orchard**: **60–80 tons**.

Financial Analysis of Apple Cultivation (Per Hectare)

1. Expected Cost of Cultivation

Input	Cost (Rs)
Land Preparation	20,000
Saplings (1000 plants)	3,00,000
Fertilizers & FYM	50,000
Agrochemicals	40,000
Irrigation Setup	70,000
Labour	60,000
Miscellaneous	30,000
Total Cost	**5,70,000**

2. Expected Income (Per Hectare)

Item	Details	Income (Rs)
Yield	50,000 kg	-
Market Rate	Rs 80/kg	-
Total Income	**50,000 × 80**	**40,00,000**

3. Profit Estimation

| Total Revenue | 40,00,000 |
| Total Cost | 5,70,000 |
| Net Profit | 34,30,000 |

Conclusion

Apple farming in India is highly profitable, especially with high-density plantations. While the **initial investment is high**, the **returns are substantial** if proper management practices are followed. The key to success lies in **choosing the right variety, maintaining proper orchard management, and ensuring effective pest control**.

Horticulture : Crop Cultivation Guidence

The Coconut

1. Introduction: The coconut (cocos nucifera L.) is a Tropical fruit plant grown on a large scale in a number of countries in tropical and sub-tropical areas. The place of origin though contradictory, is believed to be somewhere in South Asia –Malaysia. In India, coconut palms are grown on the entire coastal belt. Major share goes to Kerala, Karnataka and Tamil Nadu followed by Goa, Maharashtra, Andhra Pradesh, and Orissa.
2. Importance: Every part of the coconut palm is useful to mankind. It supplies food, fuel, drink, oil and shelter to us. The wet kernel, desicated copra, coconut water, cream flour, oil, cake, toddy, husk, fibre, shell, coir, wood and leaves are used for one purpose or the other.
3. Climate: The coconut palm grows well in a equatorial climate. The long spells of hot and dry weather, severe winters and extremes of temperatures are not favourable for coconut growing. However, it thrives well upto 1000 m above the sea level. The well distributed rainfall ranging from 100 to 300 cm is favourable.
4. Soil: The coconut palm can grow in a wide range of soil conditions ranging from laterite, alluvial, red, sandy loam having pH range from 5.5 to 8.0. Soil should be fertile and good drainage without any hard substratum within one of the surface.
5. Varieties : There are number of varieties grown in different parts, which are classified as under:-

a. Tall varieties :-

   i. West Coast Tall
   ii. Lakshadweep
   iii. Andaman
   iv. Kappadam
   v. Laguna
   vi. San Raman

a. Dwarf varieties:

   i. Chowghat – Dwarf green,
   ii. Dwarf orange
   iii. Malayon Dwarf
   iv. Mangipod

a. Hybrid varieties

   i. T X D
   ii. D X T

a. Selections- Pratap, Banoli, etc.

1. Propagation: The coconut palm is commonly propagated by seeds. Since the productivity of the palm depends on the quality of the seedlings, utmost importance should be given to select the best nuts. The mother palms should be regular bearers giving annual yield of more than 100 nuts with the copra content of 150 g per nut. The mother palm should be within the age group of 20 to 40 years. These palms producing barren nuts and shedding immature nuts in large number should be discarded for the nursery purpose.
2. Planting and Season: The planting distance depends on the type of plant or variety, soil type and weather monoculture or associated culture or mixed culture is adopted, distance should be in such a way that the fronds (leaves) of planting adjacent palms to do not overlap when fully grown. The spacing maybe 7 to 8 m both ways for tall varieties. Well developed and well grown seedlings about 1 to 2 years old should be selected for planting. The planting should be done on onset of monsoon for which the pits of 0.75 x 0.75 x 0.75 m should be opened and filled with a mixture of compost, bone meal, super phosphate, well before the monsoon.
3. Interculturing: Weeding and stirring the soil around the plant should be done frequently. The interspace may be kept clean or utilised for taking other crops, seasonals or perennials.
4. Care of young plants: The young palms need proper care during the early stages of growth from transplanting upto 5^{th} year. The seedlings should be protected from stray cattle. During summer months, shade and frequent watering must be provided to the young palms to avoid casualties. The care should be taken to see that the collar and leaf axils of the seedlings are not covered by mud, water or soil.
5. Special horticulture practices: The dwarf varieties are considered on self-pollinating while tall varieties are considered cross pollinating inter planting of mix planting be done to increase the fruit set. Honey bees are considered to be very useful for pollination and be rared in the viscinity of palm cultures.
6. Irrigation: The coconut palm requires large quantities of water for its normal growth and timely production. In normal conditions and in absence of rains every palm needs about 16-18 litre water daily. Regular irrigation helps to increase the fruit set, improve size and copra content. However, stagnation of water and ill drained conditions should be strictly avoided.
7. Nutrition: To get a good yield, palms should be fertilized regularly and with a quick frequency, Bimonthly applications are more beneficial. Every well grown palm should be applied with 25 kg. Of FYM 1 kg of 5:10:5. Micronutrients/Ormichem @ 2 kg/palm once in a year should be applied to avoid any micro-nutrient disorders.
8. Plant protection: Important pests, Rhinocerous beetle, Red palm weevil, leaf eating caterpillar and cockchafer beetle are the major insect pests. Occassionally mealy bug, rat and slug also become trouble some. Bud rot and leaf rot and root wilt can cause severe damage to palms. One should be very alert to notice the symptoms of any post and take the suitable control measures. Close planting should be avoided plantation should be kept weed free and clean. The palms should be cleared off at least once in a year. Providing a good drainage and feeding the palms with balanced nutrition is useful to keep palms healthy.
9. Harvesting and yield: The well developed nuts should be harvested one month earlier to full maturity. Harvesting of nuts is a skilled and risky job. 2 to 6 harvestings can be done yearly. Average 80 to 100 nuts are harvested per tree/year.

Post harvest handling and sale: The nuts are hardy and can be kept for a long time. Nuts harvested at less than 9 months age will be dried spoiled or without or very thin layer of copra. Copra is removed and then processed for different purposes or dried and stored and sold as dry copra.

Agriculture Farming

Coconut Production – A Month Wise Practices

Coconut Production Guide:

Introduction to Coconut Production:

Coconut is one of the best plants that can produce fruits for years. There are many improved/hybrid/commercial varieties grown across India. Coastal areas are very famous for coconut production. By following some tips and proper management practices, on can obtain decent profits with coconut production. In the following article let us discuss month wise tips and cultural practices to follow throughout the year (month wise) when you plan for coconut production.

Quality Seedlings in Coconut Nursery.

Coconut Production Practices – the top Coconut Production States in India:

The following are the top 10 coconut production states in India.

1. Tamil Nadu
2. Karnataka
3. Kerala
4. Andhra Pradesh
5. Odisha
6. West Bengal
7. Gujarat
8. Maharashtra
9. Assam
0. Bihar

Coconut Health Benefits:

The following are some of the health benefits of the coconut fruit.

Health Benefits of Coconut.

- Good for the immune system and it can work as anti-viral, antibacterial, anti-fungal, and anti-parasite.
- Coconut provides a natural source of energy & enhances physical and athletic performance.
- Coconut is good for digestion and absorption of nutrients, vitamins, and minerals.
- Consumption of coconut improves the insulin secretion and symptoms of diabetes.
- Coconut may protect from a certain type of cancers.
- Coconut may reduce the risk of heart attack. It can also improve HDL (good cholesterol).
- Coconut may restore and support the thyroid function.
- Coconut can help in protecting against kidney disease.
- Coconut is good for weight loss.
- Coconut is good for hair and skin health.
- Coconut has good anti-aging properties.
- A coconut is an excellent option for protecting from sun stroke.

Coconut in Indian Languages:

Coconut (English), Nariyal (Hindi), Thengai (Tamil), Nalikeram / Thenga (Malayalam),Kobbari Kaaya(Telugu), Thenginakai (Kannada Narcole (Bengali), Naliyer / Nariyal(Gujarati),Naarlu (Konkani), Naral (Marathi), Nadia (Oriya), Gola / Nariyal (Punjabi),Narjeel(Kashmi

Coconut Production Practices – In the month of April:

- You must make sure that the soil is suitable for coconut growing by digging of a profile pit of 3 feet X 3 feet X 3 feet.
- If there is any calcareous nodules or sheetrock presence, those soils are not suitable and must be avoided plantations.
- You must ensure that the soil is well-drained and keep in mind that the coconut trees are sensitive to waterlogging conditions.
- In case of going for the soil test, a soil sample should be collected for every one feet depth of soil from the profile pits.
- If the soil pH value ranges from 7.0 to 8.0, then you can consider the soil for growing coconut trees.

Coconut Production Practices – In the month of May:

- Ploughing should be carried out in summer with MB plough twice and levelling of land should be done.
- Alignment and peg marking for pit digging at 8 meter X 8 meter or 7.5 meters x 7.5 meters spacing between the rows and sho be given. If the spacing is 8 meters x 8 meters, it will accommodate 60 coconut plants/acre whereas 7.5 meters x 7.5 meters car accommodate 70 coconut plants/acre.
- Pit digging – Care should be taken while pit digging. Make sure to place the dugout topsoil (1 ½ foot) to the right side of the pit The dugout bottom soil (1 ½ foot) should be placed to the left side of the pit.
- The dugout pits should be allowed to expose to the sun at least for 2 to 3 weeks before filling the pits to control soilborne disea
- The ideal pit size should be about 90 cm X 90 cm X 90 cm.
- Quality planting material is very important as these trees are going to serve for years to come. Quality and disease-free plantinç material should be procured from certified nurseries.

Read: Cocunut Cultivation Project Report.

Coconut Production Practices – In the month of June:

- Each Pit filling should be carried out with topsoil mixed with 20 to 25 kg's of well-decomposed farmyard manure (FMY) and 1 kg single super phosphate and 1 kg of Neem Cake and 100 and 100 grams of 10 % Follidol dust.
- You must ensure to fill the pits with the soil at least 6 inches above the ground level so that when the soil settles down, it will be the ground level at the time of planting.
- Securing the field is one of the priority tasks needs to be completed by arranging the fencing around the field to prevent any trespassing by animals.
- Generally, drip irrigation is recommended in a coconut orchard, so this requires marking for trench cutting. One should comple the trench cutting for installing the drip irrigation.
- Farmers can make additional income by growing intercrops during initial years. You can sow any green manure crops or inter-crops with the receipt of monsoon showers.

Bangalore bondam grown for tender coconut water purpose.

Coconut Production Practices – In the month of July:

- Selecting the quality of coconut seedlings is another important task before any planting is done.
- Selection should be made on coconut plants which have sprouted early in the nursery bed and vigorous growing.
  1. Select the plants which are free from diseases.
  2. Select the seedlings which are at least 1 year old with more number of healthy leaves and stout stem at the plant base.
  3. Selected planting material should be transported to main field from the nursery.
- After getting required plants, keep them in a trench near the water source, and they should be watered regularly till the seedli are planted in the field.
- If there is any indication of monsoon delay, you must ensure that the pits dug for plantation should be soaked by providing reg irrigation.
- Make sure the coconut saplings (seedlings) planted at the centre of the pit.
- Watering should be done immediately after planting in the pit.
- Irrigation should be given at every 5 to 6 days interval during the first month and later at 8 to 9 days interval provided there are rains during the initial 2 years. There is no need of any watering in rainy season and make sure the soil has well-drainage in case water logging conditions.

Coconut Production Practices – In the month of August:

Weed free plantation ensures good yield and less consumption of fertilizers / nutrients / manures. Weeding should be carried out least once in a month during rainy season (monsoon season) to control weeds. Clean and make the plant basins to retain the wat working around the plant base.

Coconut Production Practices – In the month of September:

- Apply 10 grams of Carbofuron – 3g granules in the leaf whorls to save the coconut plants from the beetles, black headed caterpillars and red palm – weevil attacks.
- If slug caterpillars are observed well before defoliating the coconut leaves, you can control them by spraying any contact poiso like Monocrotophos.

Coconut Production Practices – In the month of October:

- Gap filling should be carried out in case of any plant death. These dead plants should be replaced by new plants.
- In case of high rain fall zones, planting of coconut can be carried out in the months of October and November.
- Farmers can go for any inter crops for rabi season during this month, if they did not cultivate any intercrops during the months June and July.

Coconut Production Practices – In the month of November:

- Mulching can be done in this month to prevent the soil moisture loss and control the weeds apart from preventing from soil erosion. Mulch materials like dry leaves and coconut husk can be used.
- Make sure to water the plants regularly at 7-9 days intervals.
- It is advised to provide first trop dressing in the plant basin with 125 grams of urea plus 250 grams of Super phosphate plus 425 grams of MOP and water immediately after the application.

Coconut Production Practices – In the month of December:

- It is essential to keep the coconut plant basins weed free by hoeing and mulching the soil.
- To control any termites at the base of the trunk, spray Chloropyrephos @ 5 ml / litre of water.
- Monitor each and every plant for any appearance of small circular holes on the stem with brownish viscores fluid oozing out, th indicates the red palm weevil pest/disease attack and this can be controlled by root feeding with Monocrotophos 10 ml / litre of water and immediate removal of the dead and dying plant.

Coconut Production Practices – In the month of January:

- In this month, make sure to provide frequent and regular irrigation at 7 to 9 days interval.
- Mulching should be done at the plant basins with coconut husk or any other dry hay which can later serve as good organic compost.

Coconut Production Practices – In the month of February:

- In this month, make sure to water the plants 6 to 9 days regularly and avoid any water stress.

Coconut Production Practices – In the month of March:

- Apply the fertilizers at least six inches from the plant and irrigate the pits immediately after application of fertilizers.
- Apply 1 full basket of mulch material to prevent the moisture evaporation and weed growth in the plant basins.

Coconut Production Practices – April Month:

- As it is the summer time in India, coconut plants should be irrigated regularly either through **drip irrigation** or at least once in 5 days interval through basins irrigation. However, drip irrigation is most recommended watering method as it saves water, controls weed growth and properly ensures fertilizer application at the root (if fertilizers are provided through drip system).

Coconut Production Practices – May Month:

- As it is a hot summer month, avoid any water stress and provide regular and sufficient irrigation.

Complete Coconut Farming Read: Here.

Growing Black Pepper: Read Here.

Author: **Jagdish**

Coconut

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

Pestalotiopsis leaf spot (Pestalotiopsis palm arum) sign
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

Damage due to lethal yellowing

Lethal yellowing infected coconut trees

Infected coconut trees

Lethal yellowing infected palm

Symptoms of lethal yellowing on coconut palm

Lethal yellowing damaged tree

Cocos nucifera spear leaf is dying just as the last leaves are discoloring due to lethal yellow phtyoplasma

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
Damged and/or aborted flowersd; 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) adult

Lure and trap for Coconut Rhinoceros Beetle

coconut rhinoceros beetle injury to young coconut tree

coconut rhinoceros beetle (Oryctes rhinoceros) pupae

Damage due to coconut rhinoceros beetle

Rhinoceros beetle damage

Coconut rhinoceros beetle larvae

coconut rhinoceros beetle (Oryctes rhinoceros) injured trees

Damage due to rhinoceros beetle

Coconut Rhinoceros Beetle (CRB)

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)

Scale on coconut foliage

Coconut scale (Aspidiotus destructor) adults

Coconut scale infestation

Coconut scale damage

coconut scale (Aspidiotus destructor) adults and early instars

coconut scale (Pinnaspis buxi)

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) tended by ants

Coconut mealybug damage

Coconut mealybugs (Nipaecoccus nipae)

Coconut mealybug (Nipaecoccus nipae) adult

Colony of coconut mealybugs (Nipaecoccus nipae)

Adults of coconut mealybug (Nipaecoccus nipae)
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

Coconut mite damage coconut fruits

Coconut mite feeding injury

Mite damage
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

Pestalotiopsis leaf spot (Pestalotiopsis palm arum) sign
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

Damage due to lethal yellowing

Lethal yellowing infected coconut trees

Infected coconut trees

Lethal yellowing infected palm

Symptoms of lethal yellowing on coconut palm

Lethal yellowing damaged tree

Cocos nucifera spear leaf is dying just as the last leaves are discoloring due to lethal yellow phtyoplasma

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
Damged and/or aborted flowersd; 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) adult

Lure and trap for Coconut Rhinoceros Beetle

coconut rhinoceros beetle injury to young coconut tree

coconut rhinoceros beetle (Oryctes rhinoceros) pupae

Damage due to coconut rhinoceros beetle

Rhinoceros beetle damage

Coconut rhinoceros beetle larvae

coconut rhinoceros beetle (Oryctes rhinoceros) injured trees

Damage due to rhinoceros beetle

Coconut Rhinoceros Beetle (CRB)

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)

Scale on coconut foliage

Coconut scale (Aspidiotus destructor) adults

Coconut scale infestation

Coconut scale damage

coconut scale (Aspidiotus destructor) adults and early instars

coconut scale (Pinnaspis buxi)

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) tended by ants

Coconut mealybug damage

Coconut mealybugs (Nipaecoccus nipae)

Coconut mealybug (Nipaecoccus nipae) adult

Colony of coconut mealybugs (Nipaecoccus nipae)

Adults of coconut mealybug (Nipaecoccus nipae)
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

Coconut mite damage coconut fruits

Coconut mite feeding injury

Mite damage

Scarring of coconut fruits due to coconut mites

Eriophyid mites feeding injury to coconut

Mite feeding injury

Symptoms due to coconut mite infestation

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.

Scarring of coconut fruits due to coconut mites

Eriophyid mites feeding injury to coconut

Mite feeding injury

Symptoms due to coconut mite infestation

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.

Coconut

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

Pestalotiopsis leaf spot (Pestalotiopsis palm arum) sign
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

Damage due to lethal yellowing

Lethal yellowing infected coconut trees

Infected coconut trees

Lethal yellowing infected palm

Symptoms of lethal yellowing on coconut palm

Lethal yellowing damaged tree

Cocos nucifera spear leaf is dying just as the last leaves are discoloring due to lethal yellow phtyoplasma

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
Damged and/or aborted flowersd; 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) adult

Lure and trap for Coconut Rhinoceros Beetle

coconut rhinoceros beetle injury to young coconut tree

coconut rhinoceros beetle (Oryctes rhinoceros) pupae

Damage due to coconut rhinoceros beetle

Rhinoceros beetle damage

Coconut rhinoceros beetle larvae

coconut rhinoceros beetle (Oryctes rhinoceros) injured trees

Damage due to rhinoceros beetle

Coconut Rhinoceros Beetle (CRB)

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)

Scale on coconut foliage

Coconut scale (Aspidiotus destructor) adults

Coconut scale infestation

Coconut scale damage

coconut scale (Aspidiotus destructor) adults and early instars

coconut scale (Pinnaspis buxi)

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) tended by ants

Coconut mealybug damage

Coconut mealybugs (Nipaecoccus nipae)

Coconut mealybug (Nipaecoccus nipae) adult

Colony of coconut mealybugs (Nipaecoccus nipae)

Adults of coconut mealybug (Nipaecoccus nipae)
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

Coconut mite damage coconut fruits

Coconut mite feeding injury

Mite damage
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

Pestalotiopsis leaf spot (Pestalotiopsis palm arum) sign
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

Damage due to lethal yellowing

Lethal yellowing infected coconut trees

Infected coconut trees

Lethal yellowing infected palm

Symptoms of lethal yellowing on coconut palm

Lethal yellowing damaged tree

Cocos nucifera spear leaf is dying just as the last leaves are discoloring due to lethal yellow phtyoplasma

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
Damged and/or aborted flowersd; 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) adult

Lure and trap for Coconut Rhinoceros Beetle

coconut rhinoceros beetle injury to young coconut tree

coconut rhinoceros beetle (Oryctes rhinoceros) pupae

Damage due to coconut rhinoceros beetle

Rhinoceros beetle damage

Coconut rhinoceros beetle larvae

coconut rhinoceros beetle (Oryctes rhinoceros) injured trees

Damage due to rhinoceros beetle

Coconut Rhinoceros Beetle (CRB)

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)

Scale on coconut foliage

Coconut scale (Aspidiotus destructor) adults

Coconut scale infestation

Coconut scale damage

coconut scale (Aspidiotus destructor) adults and early instars

coconut scale (Pinnaspis buxi)

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) tended by ants

Coconut mealybug damage

Coconut mealybugs (Nipaecoccus nipae)

Coconut mealybug (Nipaecoccus nipae) adult

Colony of coconut mealybugs (Nipaecoccus nipae)

Adults of coconut mealybug (Nipaecoccus nipae)
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

Coconut mite damage coconut fruits

Coconut mite feeding injury

Mite damage

Scarring of coconut fruits due to coconut mites

Eriophyid mites feeding injury to coconut

Mite feeding injury

Symptoms due to coconut mite infestation

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.

Scarring of coconut fruits due to coconut mites

Eriophyid mites feeding injury to coconut

Mite feeding injury

Symptoms due to coconut mite infestation

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Comments
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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.

Disease management **I. Basal stem rot -** ***Ganoderma lucidum*** **Cultural Method** • Apply *Bacillus subtilis* (Pf1) @ 200 g/ palm + *Trichoderma viride* @ 200 g/palm/ year • Apply 200g phosphobacteria and 200 g Azotobactor mixed with 50 Kg of FYM/palm • Green manure crops must be raised and ploughed *in situ* • Neem cake 5 kg/tree must be applied along with fertilizers **Chemical** • Aureofungin-sol 2 g + 1 g Copper sulphate in 100 ml water or 2 ml of Tridemorph in 100 ml water applied as root feeding. (The active absorbing root of pencil thickness must be selected and a slanting cut is made. The solution to be taken in a polythene bag or bottle and the cut end of the		

root should be dipped in the solution).
Forty litres of 1% Bordeaux mixture should be applied as soil drench around the trunk in a radius of 1.5 metre.

II. Bud rot - *Phytophthora palmivora*

The infective tissues from the crown region should be removed and protected with Bordeaux paste. Spray Bordeaux mixture at 1% or Copper oxy chloride 0.25 % on crown region as pre-monsoon spray. Spray Copper oxy chloride 0.25 % after the onset of monsoon.

III. Stem bleeding disease

The bark of the trunk should be removed in the bleeding area and Bordeaux paste should be applied in this area.

IV. Pencil point disease

Because of micronutrient deficiency, the stem will taper towards its tip with lesser number of leaves. The leaf size will be greatly reduced and the leaves will be pale and yellow in colour. Along with the

recommended fertilizer dose, 225 g each of Borax, Zinc sulphate, Manganese sulphate, Ferrous sulphate, Copper sulphate and 10 g of Ammonium molybdate may be dissolved in 10 1 of water and poured in the basin of 1.5 m radius.

a. Preparation of 1% Bordeaux mixture

A quantity of 400 g of copper sulphate should be dissolved in 20 litres of water and 400 g of lime in another 20 litres of water separately. The copper sulphate solution should be added to the lime solution constantly stirring the mixture. Earthen or wooden vessels alone should be used and metallic containers should not be used. To find out whether the mixture is in correct proportion, a polished knife should be dipped in the mixture for one minute and taken out. If there is reddish brown deposit of copper, additional quantity of lime should be added till there is no deposit in the knife.

b. Preparation of

Bordeaux paste

Take 200 g of Copper sulphate and dissolve it in one litre of water and 200 g of lime in one litre of water separately. Both are mixed simultaneously in a third vessel and the resultant mixture can be used as a paste.

Harvest and post harvest technology

Harvest 11-12 months old fully matured nuts at an interval of 30-45 days depending on the yield level of the garden. For household use keep the nuts in vertical direction. Dry copra either by sun drying or by using copra dryers. Store the copra at 5-6 % moisture content. Store the copra in polythene tar coated gunny bags.

The diseases of the coconut palm are

Bud Rot - *Phytophthora palmivora*

Leaf Rot - *Bipolaris halodes*

Stem Bleeding - *Ceratocystis paradoxa* and *Chalara paradoxa*

Root (Wilt) Disease - Unknown Etiology

Thanjavur Wilt -

Ganoderma lucidum Mahali - *Phytophthora palmivora* Crown Chocking Leaf Blight or Grey Leaf Spot - *Pestalosia palmivora* Lethal leaf blight - *Lasiodiplodia theobromae* Tatipaka Disease - Phytoplasma Botryodiplodia Nut Fall - *Botryodiplodia theobromae* Inflorescence Blight and Nut Fall - *Colletotrichum gloeosporioides*, *Gloeosporium spp* Mid Whorl Yellowing / Quick Yellow Declining - *Phytoplasma*		
Last Update :Jan 2023		

Bud Rot - *Phytophthora palmivora*
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Root (Wilt) Disease - Unknown Etiology
Thanjavur Wilt - *Ganoderma lucidum*
Mahali - *Phytophthora palmivora*
Crown Chocking
Leaf Blight or Grey Leaf Spot - *Pestalosia palmivora*
Lethal leaf blight - *Lasiodiplodia theobromae*
Tatipaka Disease - Phytoplasma
Botryodiplodia Nut Fall - *Botryodiplodia theobromae*

Inflorescence Blight and Nut Fall - *Colletotrichum gloeosporioides*, *Gloeosporium spp*
Mid Whorl Yellowing / Quick Yellow Declining - *Phytoplasma*

Horticulture

From Seed to Shelf: The Complete Guide to Coconut Farming

Cocos nucifera (L.) is a vital member of the palm family. Coconut farming is the cultivation of the versatile and beneficial Coconut palm. It involves growing these tall, graceful trees for their various products, such as Coconuts, Coconut water, oil, and husks. This agricultural practice plays a crucial role in many tropical regions worldwide.

Understanding Coconut Botany

The Coconut palm, scientifically known as Cocos nucifera (L.), belongs to the Arecaceae family. It is a versatile plant with various pa used for different purposes – from the fruit for consumption to the leaves for roofing material. The Coconut tree has a tall, slender trunk topped with long, pinnate leaves that can grow up to 20 meters in height. Its flowers are small and white, and it produces la spherical fruits known as Coconuts.

Each part of the Coconut palm serves a unique function in sustaining its growth and reproduction. Coconut palms thrive in tropic climates due to their high tolerance for salty soil conditions and coastal environments. They require adequate sunlight, warm temperatures, and consistent rainfall throughout the year to flourish.

Optimal Climatic Conditions for Coconut

Coconut thrives in tropical climates with consistent warmth and humidity. The optimal climatic conditions for Coconut cultivatior include temperatures from 20 to 30°C throughout the year. These palms require ample sunlight for proper growth, making regio near the equator ideal for their cultivation.

Rainfall is crucial; a well-distributed annual rainfall of around 2000 to 2500 mm ensures sufficient moisture for healthy Coconut tr Coconuts are vulnerable to strong winds and storms, so planting them in areas shielded from such harsh weather conditions is essential. Coastal areas provide the perfect combination of sandy soil and saline water necessary for robust Coconut growth.

Soil Types and Preparation for Coconut Cultivation

Coconuts thrive in well-drained sandy or loamy soils with good water-holding capacity. Before planting, ensure the soil is rich in organic matter and pH level of 5.0 and 8.0. Properly preparing the soil involves clearing weeds or debris, tilling the land to loosen compacted soil, and incorporating organic fertilizers like compost or manure.

In case you missed it: **Coconut Production – A Month Wise Practices**

This helps improve soil fertility, providing a healthy environment for Coconut trees to grow. Coconut cultivation also benefits from adding micronutrients like boron, zinc, and magnesium based on soil test results. Additionally, maintaining optimal moisture leve the soil through irrigation practices is essential for healthy Coconut tree growth.

Coconut Varieties/Types

Various Coconut varieties are cultivated worldwide, each with unique characteristics and uses. Some popular varieties include the Malayan Dwarf, King Coconut, and Jamaica Tall. The Malayan Dwarf is known for its high-yielding capacity and resistance to disea

The King Coconut is famous for its sweet water content and bright orange husk color, making it a favorite in tropical regions. On t other hand, the Jamaica Tall variety is preferred for its strong resilience against harsh weather conditions. Other notable types inc the West Coast Tall, Chowghat Orange Dwarf, and Vanimo Green.

Propagation Techniques for Coconut Trees

One common method is through seed germination, where mature Coconuts are collected for planting purposes. The seeds shou be soaked in water for a few days before sowing to promote sprouting. Another technique is to use seedlings or nursery-raised pla These young Coconut plants are carefully nurtured in controlled environments until they are ready to be transplanted into the fie This method ensures quicker establishment and uniform growth across the plantation.

In some cases, vegetative propagation techniques like stem cutting or tissue culture may also be employed for specific purposes, such as maintaining desirable traits or rapid multiplication of elite varieties. Each propagation technique has its own set of requirements and benefits, allowing farmers to choose the most suitable method based on their goals and available resources.

Planting Methods and Spacing

Planting can be done using either seedlings or direct seeds, with seedlings being the preferred choice for better quality control. Proper spacing between Coconut trees is essential to allow each tree enough space to grow without competing for sunlight, nutrients, and water. The recommended spacing between Coconut trees varies depending on the variety and soil fertility but generally ranges from 7-9 meters apart.

This ensures adequate airflow and sunlight penetration while also facilitating ease of maintenance activities such as pruning and harvesting. Before planting, it is important to prepare the soil by loosening it up to promote root development and incorporating organic matter for improved nutrient uptake. Proper planting depth is key to preventing root suffocation while allowing for the st anchorage of the tree.

Irrigation Management in Coconut Farming

Irrigation management plays a crucial role in Coconut farming, ensuring the trees receive adequate water for optimal growth anc productivity. Coconut trees require consistent moisture levels, especially during dry periods, to thrive. Proper irrigation helps in maintaining soil moisture balance and prevents water stress. Drip irrigation is commonly used in Coconut plantations as it deliver water directly to the roots, promoting efficient water usage and reducing wastage.

In case you missed it: **Innovative Strategies for Boosting Coconut Pollination and Yield**

Monitoring soil moisture levels is important to adjust irrigation schedules accordingly and prevent both overwatering and underwatering. Rainfall patterns should also be considered when planning irrigation schedules to supplement natural precipitati effectively. Proper drainage systems are necessary to prevent waterlogging, which can lead to root suffocation and nutrient deficiencies. By implementing effective irrigation management practices, Coconut farmers can ensure healthy tree growth and maximize yield potential.

Nutrient Requirements and Fertilization Practices

Coconuts require a balanced supply of nutrients to thrive and produce high-quality yields. Key nutrients for Coconut trees include nitrogen, phosphorus, potassium, magnesium, calcium, and sulfur. Fertilizers can help replenish the soil with these essential nutrients that may be lacking naturally. Organic fertilizers are beneficial for long-term soil health and sustainability. Inorganic fertilizers can provide a nutrient boost when needed.

Conduct soil tests regularly to determine the specific nutrient needs of your Coconut plantation. You can tailor your fertilizer application to meet those requirements accurately. Over-fertilization of Coconut can lead to nutrient imbalances and environmer issues like water pollution. Therefore, it's essential to follow recommended dosage guidelines and fertilize responsibly for optimal growth and productivity in your Coconut farm.

Integrated Pest and Disease Management

Pests and diseases can wreak havoc on Coconut farms, affecting both the quality and quantity of the harvest. Some common pes include Coconut mites, rhinoceros beetles, and red palm weevils. These insects can cause significant damage to Coconut trees if r properly managed. Coconut trees are susceptible to fungal infections like root wilt disease and leaf blight. Proper monitoring and timely treatment are essential in preventing these diseases from spreading throughout the plantation.

Integrated pest and disease management is crucial in maintaining a healthy crop without relying solely on chemical intervention combining biological, cultural, and chemical pest control methods, farmers can effectively manage pests while minimizing environmental impact. Additionally, practicing good sanitation by removing diseased plant material can help prevent the spread infections. Crop rotation with non-host plants can also disrupt pest life cycles.

Inter-cropping and Crop Rotation Strategies

By planting compatible crops between Coconut trees, farmers can maximize land use efficiently. These inter-crops can provide additional income while the Coconut trees mature. Crop rotation involves rotating different crops on the same land to enhance so fertility and reduce pests and disease buildup. It helps maintain soil health by preventing nutrient depletion.

In case you missed it: **Best Fertilizer for Coconut Trees: Organic, NPK, Compost Manure, Dose, and Schedule**

Some popular inter-crops for Coconut farming include legumes like beans and peas, root vegetables such as sweet potatoes, or e fruits like papaya and banana. These plants not only complement each other but also benefit from the shade provided by the talle Coconut trees.

Pruning and Maintenance of Coconut Trees

Pruning and maintenance of Coconut trees are essential tasks to ensure healthy growth and optimal yield. Regular pruning helps removing dead or diseased fronds, allowing for better air circulation and sunlight penetration. It also promotes the growth of new fronds and facilitates easier harvesting. When it comes to maintenance, keeping the area around the Coconut tree free from weed crucial.

Weeds compete with the Coconut tree for nutrients and water, potentially hindering its growth. Regular weeding is necessary to prevent weed infestation. Monitoring for Coconut pests and diseases is another important aspect of maintenance. Early detection help prevent widespread damage to the Coconut plantation. Implementing integrated pest management techniques can effecti control pests without harming the environment.

Harvesting and Yield Optimization

The ideal time to harvest Coconut fruits is when they are about 10-12 months old. At this stage, the Coconut will have maximum w content and a soft kernel inside. Harvesting Coconut too early or too late can affect the quality of the Coconut. To optimize yield, u sharp tools for harvesting to avoid damaging the tree or fruits. It's also important to handle the Coconuts with care during harvest as bruises or cuts can lead to spoilage.

After harvesting, it's crucial to store the Coconuts properly in a cool and dry place to maintain their freshness and prevent mold

growth. Proper storage conditions also play a significant role in optimizing yield and extending shelf life.

Average Yield of Coconuts

Coconuts are known for their high-yield potential. Each tree can produce an average of 50 to 80 Coconuts per year. However, the y can change based on various factors, such as the age and health of the tree, environmental conditions, and proper management practices. Young Coconut trees may take several years to reach full production capacity, but once matured, they can sustain consistent yields for decades.

In case you missed it: **Growing Dwarf Coconut Trees – A Complete Guide**

Regular pruning and fertilization play a crucial role in maintaining optimal production levels. In some regions with favorable grow conditions, Coconut plantations have been reported to achieve even higher yields, exceeding 100 Coconuts per tree annually. This demonstrates the resilience and productivity of this tropical crop when well cared for.

Tips to Boost Coconut Yield

Firstly, consider investing in high-quality seeds or seedlings from reputable sources. Starting with healthy and disease-resistant pl can set the foundation for a successful harvest. Proper irrigation is crucial for Coconut trees. Ensure they receive sufficient water, especially during dry periods, but be cautious of overwatering, which can lead to root rot. Monitor soil nutrient levels regularly and provide appropriate fertilization based on soil tests. Balanced nutrition is key to promoting growth and increasing yields.

Implement effective pest and disease management practices to protect your Coconut trees from common threats. Regular scout and prompt action are essential. Pruning old or diseased fronds helps improve air circulation around the tree canopy, allowing for better sunlight penetration, which promotes fruit development. Maintain good hygiene practices in your orchard by removing fal

leaves and debris regularly to prevent the spread of diseases.

Post-Harvest Handling and Processing

After harvesting the Coconuts, they need to be handled carefully to maintain quality. The first step is to remove the husk and shel access the white flesh inside. Harvesting can be done manually or using machinery, depending on the scale of production. Once extracted, the Coconut flesh can be processed into various products like desiccated Coconut, Coconut milk, oil, and water.

Each product requires specific processing methods to ensure quality and taste. Desiccated Coconut involves drying the grated fle while making Coconut oil involves pressing it for extraction. Proper storage is essential for post-processing to prevent spoilage. Products are stored in a dry place away from direct sunlight. Packaging also plays a major role in maintaining freshness and extending shelf life.

Marketing Strategies for Coconut Products

Utilize social media platforms to showcase the versatility of Coconuts – from skincare products to culinary delights. Consider packaging design that reflects the natural and eco-friendly qualities of Coconuts. Participate in trade shows and farmer's markets connect directly with consumers and educate them about the benefits of Coconut products.

In case you missed it: **High Density Coconut Plantation – Spacing, Yield**

Offer sample sizes or trial packs to encourage first-time buyers to experience the goodness of Coconuts. Partner with local stores specialty shops for distribution, making it easier for customers to access your Coconut offerings. Stay updated on consumer preferences to tailor your marketing strategies accordingly, ensuring sustained interest in Coconut products.

Sustainability in Coconut Farming

Sustainability in Coconut farming is crucial for the long-term health of both the environment and the industry. Farmers are increasingly adopting sustainable practices to ensure a balance between productivity and environmental stewardship. Implemen organic farming methods, such as using natural fertilizers and pesticides, helps reduce chemical runoff into water sources. Additionally, practicing crop rotation can help maintain soil fertility and prevent diseases.

Investing in renewable energy sources can decrease reliance on fossil fuels, reducing greenhouse gas emissions. Water managen techniques like drip irrigation also play a significant role in conserving water resources. Coconut farming presents numerous opportunities for small-scale and large-scale growers alike. However, successful Coconut farming requires careful attention to det at every stage, from selecting quality seeds to implementing effective cultivation practices and post-harvest management.

Natural Solutions for Peony Leaf and Flower Problems: 100% Effective Remedies

Maximizing Profits with Avocado Contract Farming in India: A Comprehensive Guide

Natural Solutions for Hydrangea Problems: 100% Effective Remedies for Leaf and Flowe

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Revolutionizing Citrus Preservation: Toward Healthier, Greener Future

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Protecting Crops with AI: Smart Pest Contro for Better Yields

Author: **Jagdish**

DISEASES OF COCONUT

Dr. A. Snehalatha Rani
Scientist (Plant Pathology)
Horticultural Research Station
Ambajipeta, East Godavari District
Andhra Pradesh

PLANTATION CROPS

- India is a major producer of plantation crops with an area of 36.41 lakh ha,
  production of 169.8 lakh MT
  productivity of 4.7 MT/ha.

- Coconut
- Cocoa
- Cashew
- Oil palm

DISEASES OF COCONUT

Mean percent disease incidence of coconut from 2008 – 2013

S. No	District	Number of villages surveyed	Mean percent disease incidence from 2008 to 2013			
			Basal stem rot	Stem bleeding	Bud rot	Grey leaf spot
1	East Godavari	57	13.82	3.49	1.93	Traces
2	West Godavari	15	11.42	4.94	2.12	Traces
3	Srikakulam	21	13.7	4.48	1.56	Traces
4	Vijayanagaram	4	7.2	11.2	1.12	Traces
5	Visakhapatnam	5	10.02	0.5	4.06	Traces
Mean		102	11.23	4.92	2.15	Traces

Various symptoms of Basal stem rot : *Ganoderma spp*

Ganoderma applanatum
Ganoderma lucidum

Various symptoms of Basal stem rot : *Ganoderma spp*

Various symptoms of Basal stem rot : *Ganoderma spp*

Intensity of Basal stem rot disease in Narsapur mandal of West Godavari District:

Village: Sitarampuram
Mandal: Narsapur
District: W. G. Dt

Soil type: Sandy soil
Cropping system: Sole coconut

Intensity of Basal stem rot disease at Dagguluru village in West Godavari District:

Village: Dagguluru
Mandal: Palakollu
District: W. G. Dt

Soil type: Black soil
Cropping system: coconut on rice bunds

MANAGEMENT STRATEGIES

- Application of recommended dose of fertilizers
- Drip or basin method of irrigation
- Frequent watering or irrigation especially during summer months.
- While irrigation, care should be taken to avoid flow of water from diseases trees to other healthy trees.
- Injury or damage to roots and pruning and cutting of the roots
- Raising and ploughing in situ of green manure crops like sunhemp and sesbania

MANAGEMENT STRATEGIES

- The disease was found to be more in lighter soils than in heavy black soils.
- During the recent years, the disease is also found in heavy soils such as black cottony soils and also on paddy field bunds.
- Sowing of indicator plants, Red gram and Bengal gram
- Red gram plants shows bark splitting symptom as the identification mark for basal stem rot disease.
- Bengal gram plants shows withering, yellowing and drying of lower set of leaves followed by upper leaves as the identification mark of basal stem rot disease or *Ganoderma* wilt disease of coconut.

MANAGEMENT STRATEGIES

- Frequent observation and detection of the disease symptom
- Uprooting and destruction of diseased and dead palms along with the roots.
- Isolation of diseased trees from healthy palms by digging isolation trenches of 1m depth and 0.5m depth.
- Application of 50g of *Trichoderma viride* in combination of 5kg of neem cake to the diseased plant as the curative measure once in every year.
- Application of the above said mixture at the rate of 1kg to all the healthy palms in the diseased garden as a prophylactic measure.
- Clean cultivation and cultural practices needs to be followed.

Application of *Trichoderma viride* and neem cake mixture to the diseased palms

INDICATOR PLANTS

Red gram

Bengal gram

MASS MULTIPLICATION AND DEMONSTRATION OF BIO CONTROL BASED INTEGRATED DISEASE MANAGEMENT PACKAGE AGAINST BASAL STEM ROT (*GANODERMA WILT*) DISEASE IN COCONUT

- Large scale demonstration of developed prophylactic and curative packages against basal stem rot disease in coconut in farmer's gardens

- 10 acre coconut gardens at two locations, Antarvedi and Kesanapalli villages of East Godavari district
- Horizontal Spread of basal stem rot disease after one year of treatment imposition at five demonstrated gardens

S.No	Name of the village	Number of diseased palms		Percent Disease Incidence	
		Aug 2012	Aug 2013	Aug 2012	Aug 2013
1	Antarvedi	244	102	38.85	14.64
2	Kesanapalli	112	70	18.66	11.66

Effect of bio control based integrated disease management package against basal stem rot disease at Antarvedi and Kesanapalli Demonstration sites

S.No	Stage of the disease development	Percentage of palms	
		At Antarvedi	At Kesanapalli
1	Palms showing completely dried symptom on the stem	62.3	37.5
2	Palms showing reduced disease spread on the stem	6.5	32.1
3	Palms showing no further disease spread on the stem	12.3	12.5
4	Palms showing increased disease spread on the stem	18.9	17.9

CDB TMOC PROJECT ON MASS MULTIPLICATION OF PARASITOIDS, PREDATORS, BIO AGENTS AND LARGE SCALE DEMONSTRATION OF BIOLOGICAL CONTROL OF MAJOR INSECT PESTS AND DISEASES OF COCONUT IN ANDHRA PRADESH

- Large scale demonstration of biological control of insect pests and diseases of coconut in farmers gardens

- 50 acre coconut gardens at five locations, Kalavacharla, G.Pedapudi and Gannavaram villages of East Godavari district and Jagati and Borivanka villages of Srikakulam district

Horizontal Spread of basal stem rot disease after one year of treatment imposition at five demonstrated gardens

S.No	Name of the village	Number of diseased palms		Percent Disease Incidence	
		Aug 2012	Aug 2013	Aug 2012	Aug 2013
1	Kalavacharla	356	369	11.86	12.30
2	Jagati	104	54	3.46	1.80
3	Borivanka	101	70	3.36	2.33
4	G.Pedapudi	55	25	1.83	0.83
5	P. Gannavaram	194	163	6.46	5.43

Linear spread of the disease after one year of treatment imposition at five demonstrated gardens

S. No	Village	Number of plants showing dried symptom in August 2013	Per cent Recovery of the plants	No of plants showing reduced disease spread or no further spread	Percentage of palms showing reduction
1	Kalavacharla	2	0.32	220	35.94
2	Jagati	58	35.15	32	19.39
3	Borivanka	37	27.40	28	20.74
4	G.Pedapudi	30	46.87	20	31.25
5	P. Gannavaram	43	14.98	38	13.24

- In biological control based IDM, application of *T.viride* need to be taken up at periodic intervals.
- The response of the palms to the treatment depended on the stage of the disease development, good agronomic practices and soil characteristics.
- The treatment was more effective when the application was carried out at earlier stages of disease development i.e. when the bleeding patches were below 50cm on the stem.
- Management depends on effectiveness of *T. viride* isolate and pathogenic virulence of *Ganoderma* isolate

Stem bleeding disease: *Thielaviopsis paradoxa*

Soil type: Sandy soil

Cropping system: Sole coconut

Coconut + bottle gourd

coconut + Ground nut

Disease severity of Stem bleeding disease in East Godavari District

Village: Munganda
Soil type: Black soil
Cropping pattern: coconut + cocoa

Village: Kothapeta
Soil type: Black soil
Cropping pattern: coconut + banana

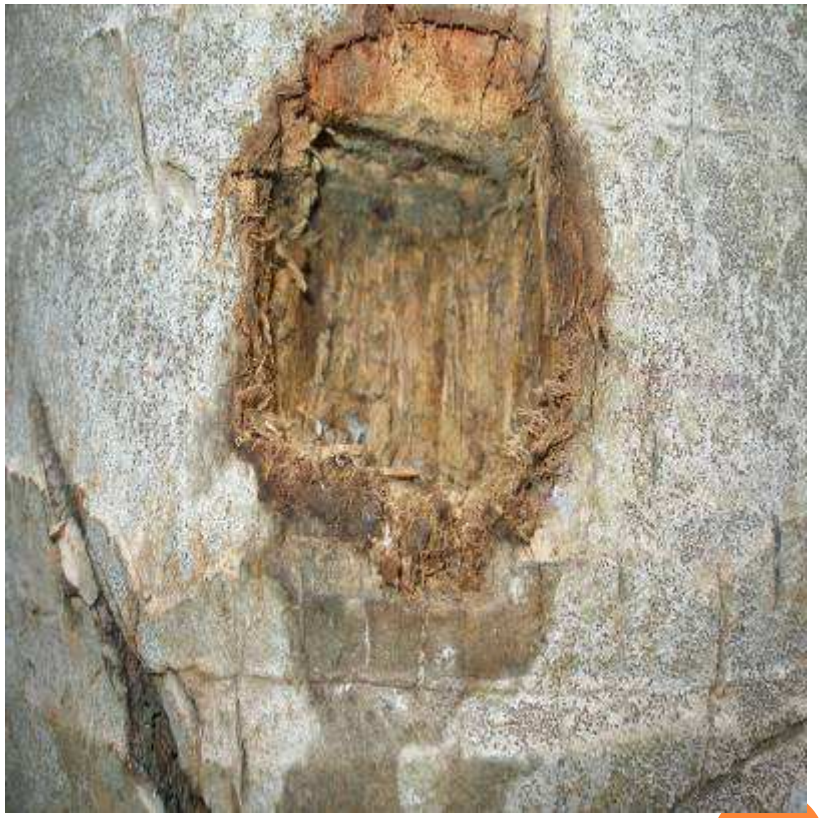
MANAGEMENT

- Avoid damage to the palms
- Apply Trichoderma viride paste on the diseased portion of the palm
- Application of 50g of *Trichoderma viride* in combination of 5kg of neem cake to the diseased palm to control the soil borne fungal spores and mycelium

Field evaluation of *Trichoderma virens* cake against stem bleeding disease in coconut

Field evaluation of *Trichoderma virens* cake against stem bleeding disease in coconut

Dried symptom of stem bleeding treated with *Trichoderma virens* cake formulation



Sporulation of *Trichoderma virens* on the palm treated with cake

BUD ROT

BUD ROT: Intensity was increased during last year because of continuous cyclones and heavy rains

MANAGEMENT

- Recommended spacing should be followed
- Provide better drainage facilities
- Trees dried due to bud rot should be removed and burnt
- Application of talc formulations of *Pseudomonas fluorescens* in crown region
- In extreme cases spraying of Copper oxy chloride 3g/lit of water

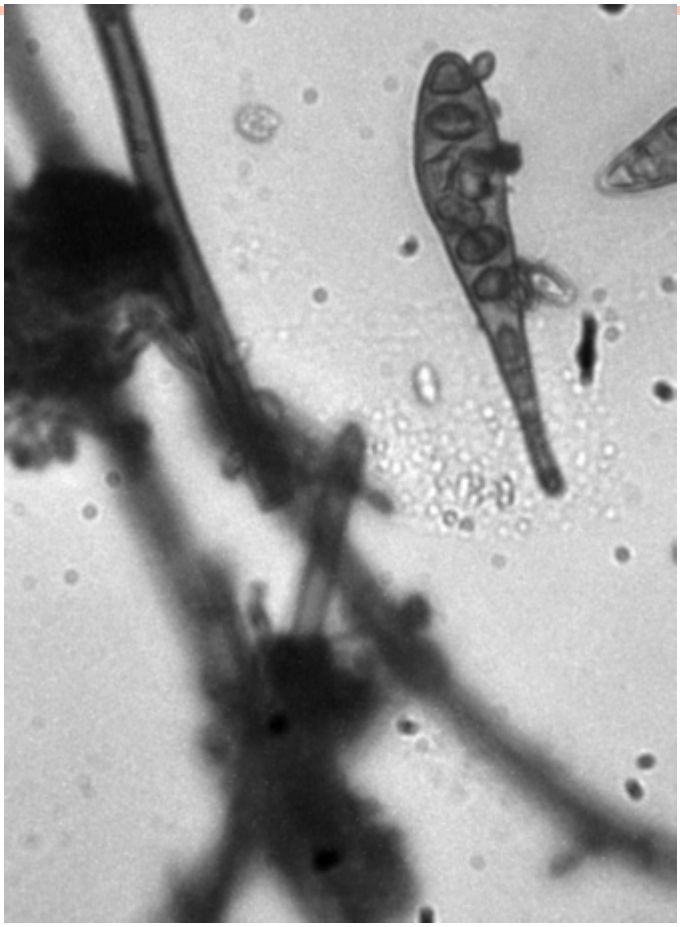
Grey leaf spot : *Pestalotiopsis palmarum*

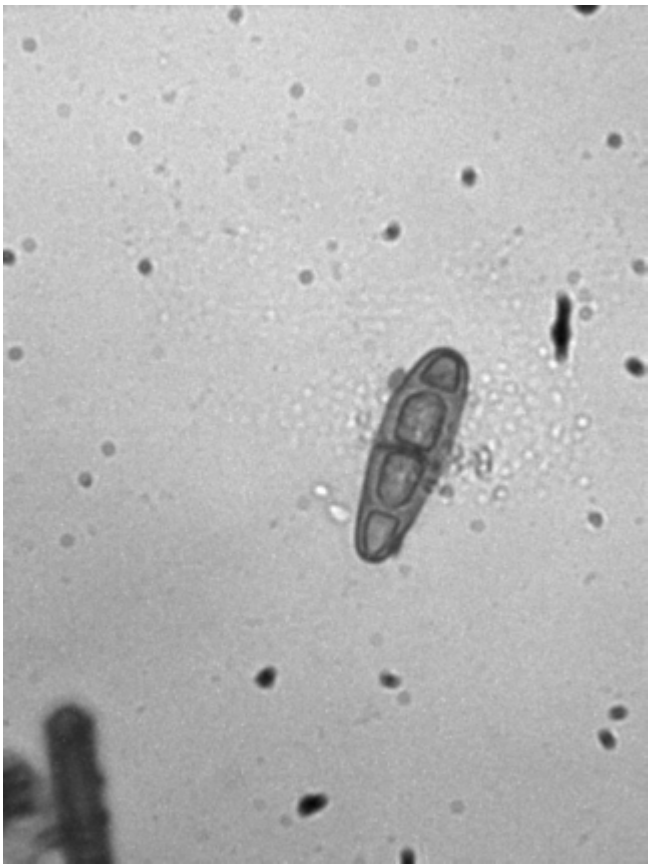
Removal of the older 2-3 disease affected leaves and spraying the foliage with 1% Bordeaux Mixture will check the spread of the disease

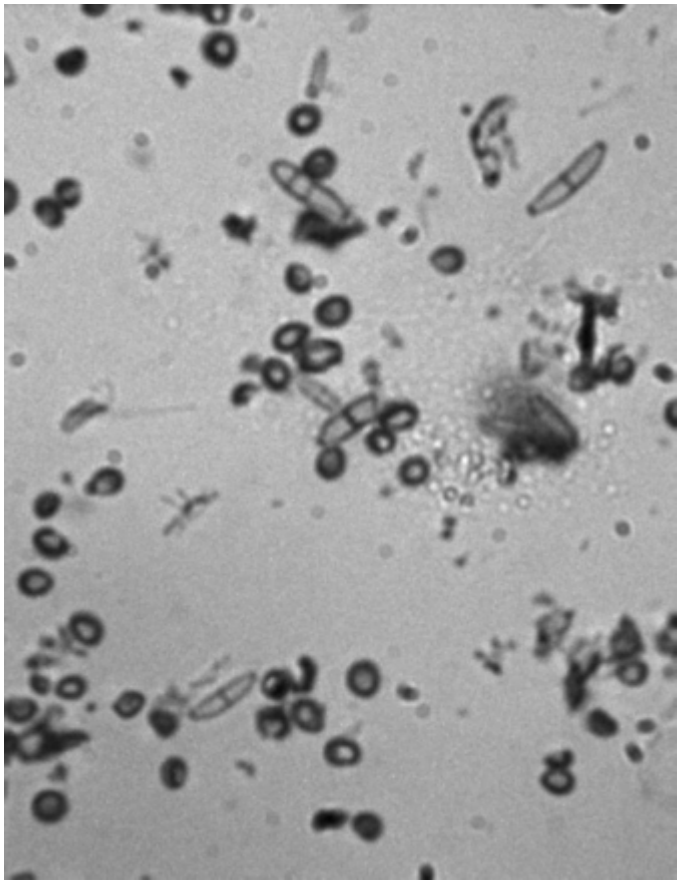
LEAF ROT : *EXHEROHILUM SP.*


Coconut samples/Visaka dist.


Coconut samples/Visaka dist.
9







Thank You

Lecture 6 & 7
Diseases of Sorghum / Jowar

Major diseases

1. Grain smut/Kernel smut / Covered smut / Short smut: *Sphacelotheca sorghi*
2. Loose smut/ kernel smut : *Sphacelotheca cruenta*
3. Long smut : *Tolyposporium ehrenbergii*
4. Head smut : *Sphacelotheca reiliana*
5. Downy Mildew : *Peronosclerospora sorghi*
6. Leaf blight : *Exerohilum turcicum* (Syn: *Helminthosporium turcicum*)
7. Rectangular Leaf spot : *Cercospora sorghi*
8. Anthracnose and red rot : *Colletotrichum graminicolum*
9. Rust : *Puccinia purpurea*
10. Ergot or Sugary disease : *Sphacelia sorghi*
11. Charcoal rot / Stalk rot / Hollow stem: *Macrophomina phaseolina*
12. Phanerogamic parasite : *Striga asiatica* and *Striga densiflora*

Bacterial diseases

13. Bacterial leaf Blotch : *Xanthomonas campestris* p.var. *rubrisorghi*
14. Bacterial leaf Stripe : *Pseudomonas syringae* p. var. *sorghicola*

1. Grain smut / Kernel smut / Covered smut / Short smut: *Sphacelotheca sorghi*

Most extensive disease and cause damage to grain. Disease is found both in rainfed and irrigated crops and estimated loss is 25%.

Symptoms

Individual healthy grains are replaced by smut sori which can be localized at a particular part of head or occur over the entire inflorescence. Smutted grains are larger than normal and the sori are oval or cylindrical with a dirty grey colour and are covered with a tough creamy skin (peridium) which often persists unbroken upto threshing. Ratoon crops exhibit higher incidence of disease.

Disease Cycle

Spores are borne on the surface of the grains and they germinate with the seed, infect the seedling and establish systemic infection and develop along with meristematic tissue of the host. At the time of flowering, fungal hyphae gets converted into spores, replacing ovary with the sori. At the time of harvest, the healthy grains will get contaminated with smut spores. These spores remain dormant on the seed for long periods until the next season. 'Hay Fever' in humans is caused due to allergic reaction of smut spores which is accompanied with sneezing, cold, itching, rhinitis, watery eyes etc.

2. Loose smut/ Kernel smut: *Sphacelotheca cruenta*

Symptoms

Affected plants can be detected before the ears come out. They are shorter than the healthy plants with thinner stalks and marked tillering. The ears come out much earlier than the healthy. The glumes are hypertrophied and the earhead gives a loose appearance than healthy. Sorus is covered by a membrane which ruptures very early, exposing the spores even as the head emerges from the sheath. Size of the sorus varies with variety of the host.

3. Long smut: *Tolyposporium ehrenbergii*

Symptoms

This disease is normally restricted to a relatively a small proportion of the florets which are scattered on a head. The sori are long, more or less cylindrical, elongated, slightly curved with a relatively thick creamy-brown covering membrane (peridium). Peridium splits at the apex to release black mass of spores (spore in groups of balls) among which are found several dark brown filaments which represent the vascular bundles of the infected ovary.

4. Head smut: *Sphacelotheca reiliana*

Symptoms

The entire head is replaced by large sori. The sorus is covered by a whitish grey membrane of fungal tissue, which ruptures, before the head emerges from the boot leaf to expose a mass of brown smut spores. Spores are embedded in long, thin, dark coloured filaments which are the vascular bundles of the infected head. Sometimes smaller sori develop on the leaves & lower part of the peduncle.

Management for all smuts

- Grow resistant varieties – CSH7R, CSH-5,SPV-245, SPV-138, RSV-1-R against grain smut and the local variety ‘Irungu’ is resistant to Long smut
- Follow crop rotation.
- Collect smutted ear heads in cloth bags and bury in soil or destroy by dipping in boiling water
- Early sowing of the crop
- Use disease free seeds.
- Immerse seed in 0.5% formalin for 2h followed by drying.
- Dipping in 0.5-3.0% copper sulphate for 5 min and drying
- Hot water treatment *i.e*., soaking in water at 55^{o}C for 15 min.
- Solar treatment - Soak seeds in cold water for 4 -10h & drain and spread in sun for 10-20h
- Treat seeds with Captan / Thiram / Sulphur @ 4 g/kg seed or carboxin (Vitavax) @ 2g /Kg seed

Differences between various smut diseases of sorghum

Sl.No.	Characters	Grain smut	Loose smut	Long smut	Head smut
1.	Causal organism	*Sphacelotheca sorghi*	*S. cruenta*	*Tolyposporium ehrenbergii*	*S. reiliana*
2.	Symptom	Apparent only at grain formation. Healthy grains replaced by smut sori. Sori are larger than normal grains. All or most of the grains are smutted	Affected plants stunted. More no. of tillers & flowering is earlier. All spikelets of infected ear are malformed & hypertrophied. The sorus replace pistil and stamen. Affected ear appears leafy and leathery.	Few grains in an ear are smutted & are scattered here & there. Sorus will be covered by a thick whitish yellow membrane. Sorus is larger than the other smuts.	Entire head replaced by large sori which is covered by whitish grey membrane. It ruptures before head emerges from boot leaf to expose a mass of brown smut spores. Spores embedded in long, thin, dark coloured filaments which are the vascular bundles of the infected head.
3.	Sori	Small 5-15x 3-5mm	Small 3-18x 6-8mm	Long 40x 6-8mm	Very long 7.5-10x 2.5-5cm
4.	Columella	Short	long	Absent but 8-10 vascular strands present	Absent but network of vascular tissue present
5.	Smut spore	Single, smooth walled, round to oval, olive brown 5-9µm diameter	Single, spherical / elliptical, dark brown spore wall pitted , 5-10 µm diameter	In balls, globose or angular, brownish green, spore wall warty, 12-16 µm diameter	Loosely bound in balls, spherical, dull brown , minutely papillate, 10-16 µm diameter
6.	Viability of spores	Viability of spores over 10 years	Viability of spores about 4 years	Viability of spores about 2 years	Viability of spores upto 2 years

7.	In culture	Yeast like growth with sporidia	In colonies with sporidia and resting spores 40x50 in diametre	In colonies with masses of sporidia	In colonies germ tubes and sporidia
8.	Spread	Externally seed borne	Externally seed borne	Air borne	Soil & Seed borne

5. Downy Mildew: *Peronosclerospora sorghi*

Symptoms

Fungus invades growing points of young plants, either through oospore or conidial infection. Leaf surface exhibit green to yellow discolouration. Abundant downy white growth is produced on the lower surface of the leaves, which consists of sporangiophores and sporangia. Normally 3-4 leaves develop chlorotic patches. Subsequent leaves show complete bleaching of the leaf tissue in streaks or stripes. Later these leaves turn necrotic and interveinal tissues disintegrate, releasing resting spores (oospores) which are linearly arranged and leaving the vascular bundles loosely connected to give typical shredded leaf symptom. Occasionally green ear symptom is observed whereby the floral parts are converted into green leafy structures.

Pathogen

P. sorghi is an obligate parasite systemic in young plant. The mycelium is intercellular, non-septate. Sporangiophores emerge through the stomata in single or in clusters which are stout and dichotomously branched. Spores are single celled, hyaline, globose and thin walled. Oospores are spherical, thick walled and deep brown in colour.

Favourable Conditions

- Maximum sporulation takes place at 100 % relative humidity.
- Optimum temperature for sporulation is 21-23°C during night.
- Light drizzling accompanied by cool weather is highly favourable.

Disease Cycle

Primary infection is by means of oospores which persist in soil for 5-10 years and germinate to initiate systemic infection. Secondary spread is by air-borne sporangia. Presence of mycelium of the fungus in the seeds is also a source of infection. The disease has been known to occur through a collateral host, *Heteropogon contortus* on which the fungus perpetuates in the host. Oospores either fall to soil or are wind blown. Conidia are formed at night in large numbers. Optimum temperature for production is 20-23^{0}C.

Management

- Crop rotation with other crops *viz*., pulses and oilseeds.
- Avoid the secondary spread of the disease by roguing out infected plants atleast upto 45 DAS since wind plays a major role in the secondary spread of the disease.
- Grow moderately resistant varieties like Co25 and Co26.
- Seed treatment with metalaxyl at 6 g/kg of seed.
- Spray metalaxyl 500 g or mancozeb 2 kg or Ziram 1 kg or Zineb 1kg/ha.

6. Leaf blight: *Exerohilum turcicum* (Syn: *Helminthosporium turcicum /Drechslera turcicum)*

Symptoms

Pathogen causes seed rot and seedling blight of sorghum. The disease appears as small narrow elongated spots in initial stage and in due course they extend along the length of the leaf. On older plants, the typical symptoms are long elliptical necrotic lesions, straw coloured in the centre with dark margins. The straw coloured centre becomes darker during sporulation. The lesions can be several cms long and wide. Many lesions may develop and coalesce on the leaves, destroying large areas of leaf tissue, giving the crop a burnt appearance.

Pathogen

The mycelium is localised in infected lesion. Conidiophores emerge through stomata and are simple, olivaceous, septate and geniculate. Conidia are olivaceous brown, 3-8 septate and thick walled.

Favourable Conditions

- Cool moist weather
- High humidity (> 90 %)
- High rainfall.

Disease cycle

The pathogen is found to persist in the infected plant debris. Seed borne conidia are responsible for seedling infection. Secondary spread is through wind-borne conidia.

Management

- Use disease free seeds.
- Treat seeds with Captan or Thiram at 4 g/kg
- Spray Mancozeb 1.25 kg or Captafol 1 kg/ha

7. Rectangular Leaf spot: *Cercospora sorghi*

Symptoms

The symptoms appear as small leaf spots which enlarge to become rectangular lesions (which can be 5-15 mm long by 2 to 5 mm wide) on the leaf and leaf sheath. Usually the lower leaves are first attacked. The lesions are typical dark red to purplish with lighter centers. The lesions are mostly isolated and limited by veins. The colour of the spots varies from red, purple, brown or dark depending upon the variety.

Pathogen

Mycelium of the fungus is hyaline and septate. Conidiophores emerge in clusters through stomata, which are brown and simple, rarely branched. Conidia hyaline, thin walled, 2-13 celled and long obclavate.

Favourable Conditions

- Cool moist weather.
- High humidity (> 90 %)
- High rainfall

Disease cycle

The conidia survive up to 5 months. The disease spreads through air-borne and seed borne conidia.

Management

- Use disease free seeds.
- Treat the seed with Captan or Thiram at 4 g/kg seed
- Spray Mancozeb 2 kg /ha

8. Anthracnose and red rot: *Colletotrichum graminicolum*

Symptoms

Fungus causes both leaf spot (anthracnose) and stalk rot (red rot). The disease appears as small red coloured spots on both surfaces of the leaf. The centre of the spot is white in colour encircled by red, purple or brown margin. Numerous small black dots like acervuli are seen on white surface of the lesions. Red rot can be characterized externally by the development of circular cankers, particularly in the inflorescence. Infected stem when split open shows discoloration, which may be continuous over a large area or more generally discontinuous giving the stem a marbled appearance.

Pathogen

The mycelium of the fungus is localised in the spot. Acervuli with setae arise through epidermis. Conidia are hyaline, single celled, vacuolate and falcate in shape.

Favourable Conditions

- Continuous rain
- Temperature of 28-30°C
- High humidity

Disease cycle

The disease spread by means of seed-borne and air-borne conidia and also through the infected plant debris.

Management

- Treat the seeds with Captan or Thiram at 4 g/kg
- Spray the crop with Mancozeb 2 kg/ha

Chief characters of three major leaf disease of sorghum

Sl.No.	Characters	Leaf Blight	Leaf spot	Anthracnose
1.	Pathogen	*Exerohilum turcicum*	*Cercospora sorghi*	*Colletotrichum graminicolum*
2.	Symptom	Spots are long, spindle shaped, several cm long and about 1 cm broad, straw coloured at the centre	Spots are rectangular or irregular bound by veins, red or dark brown coloured, 5-15 mm x 3-5mm depressed	Spots Are elliptical to spindle shaped with whitish centre and coloured margin, dark dots at the centre, 2-4x 1-2mm
3.	Conidiophores	Arise single or in groups through stomata. Conidiophores are long, septate, olivaceous, 150-250 X 7-9µ	Clusters of conidiophores arising through stomata. Conidiophores are long, septate, brown, 40-120 X 2.5-7.5 µ	Acervuli with setae arising through epidermis. Conidiophores are short, single celled and colourless
4.	Conidia	Spindle shaped, olivaceous brown, 3-8 septate, 45-132 X 15x 25 µ	Hyaline, septate, 2-3 celled, obclavate, 30-132 X 3-8 µ	Hyaline, single celled, falcate, vacuolated, 21-32 X 3-7 µ
5.	Spread	Air borne & to some extent seed borne	Air borne & through collateral hosts	Seed borne & air borne

9. Rust: *Puccinia purpurea*

Symptoms

Fungus affects the crop at all stages of growth but more when the plant is 2 months old. Initial symptoms appear as purple, tan or red small flecks on lower leaves. (Pustules (uredosori) appear on both surfaces of leaf as purplish reddish brown spots which rupture to release reddish powdery masses of uredospores. Teliopores develop later o the lower surface of the leaves sometimes in the old uredosori or in telisori, which are darker and longer than the uredosori. The pustules may also occur on the leaf sheaths and on the stalks of inflorescence. Plants remain stunted and remain unhealthy.

Pathogen

Uredospores are pedicellate, elliptical or oval, thin walled, echinulate and dark brown in colour. The teliospores are reddish or brown in colour and two celled, rounded at the apex with one germ pore in each cell. The teliospores germinate and produce promycelium and basidiospores. Basidiospores infect *Oxalis corniculata* (alternate host) where pycnial and aecial stages arise.

Favourable Conditions

- Low temperature of 10 - 12°C favours teliospore germination.
- A spell of rainy weather favours the onset of the disease.

Disease cycle

Uredospores survive for a short time in soil and in infected debris. Presence of alternate host helps in perpetuation of the fungus.

Management (Refer Wheat)

- Remove the alternate host *Oxalis corniculata.*
- Follow crop rotation
- Follow field sanitation
- Use certified seeds
- Avoid excess dose of nitrogenous fertilizers.
- Avoid late sowing
- Spray Zineb @ 2.5 kg/ha / Propiconazole @ 0.1 %.
- Seed treatment with Plantvax / Vitavax @ 2g / Kg seed / Vitavax Power (carboxin + Thiram) @ 3g / Kg seed
- Foliar application of Vitavax / Plantvax @ 500g / 500l/ ha / carbendazim 0.1% / mancozeb at 3 gm/l.

10. Ergot or Sugary disease: *Sphacelia sorghi*

Disease is severe in some parts of India especially in hybrid varieties.

Symptoms

The disease is confined to individual spikelets. The first symptom is the secretion of honey dew from infected florets which attracts insects and helps in spread of the disease Under favourable conditions, long, straight or curved, cream to light brown, hard sclerotia develop. Often the honey dew is colonised by *Cerebella sorghivulgaris* which gives the head a blackened appearance.

Pathogen

The fungus produces septate mycelium. The honey dew is a concentrated suspension of conidia, which are single celled, hyaline, elliptic or oblong.

Favourable Conditions

- High rainfall and high humidity during flowering season.
- Cool night temperature and cloudy weather aggravate the disease.

Disease Cycle

Primary source of infection is through germination of sclerotia which release ascospores that infect ovary. Secondary spread takes place through air and insect-borne conidia. Rain splashes also help in spreading the disease.

Management

- Adjust the date of sowing so that the crop does not flower during September- October when high rainfall and high humidity favour the disease.
- Spray any one of the following fungicides *viz*., Mancozeb 2 kg/ha (or) Carbendazim at 500 g/ha at emergence of ear head (5-10 % flowering stage) followed by a spray at 50 % flowering and repeat the spray after a week, if necessary.

11. Charcoal rot / Stalk rot / Hollow stem: *Macrophomina phaseolina*

Symptoms

Fungus causes seedling blight and stalk rot in older plants. Infected stalk splits longitudinally into a mass of fibre and tissues are severely weakened. Black sclerotial bodies are seen on infected tissues. Sometimes pycnidia measure 150-200 diametre. Fungus is soil borne and can survive saprophytically on crop residues.

Management

- Field sanitation
- Long crop rotation with crops that are not natural host of the fungus.
- Irrigate the crops at the time of earhead emergence to maturity.
- Treat seeds with *T. viride* @ 4g/ Kg seed
- Treat seeds with Carbendazim@ 2 g/kg/ Captan/ Thiram@ 4g/Kg

12. Head mould/Grain mould/Head blight

More than 32 genera of fungi were found to occur on the grains of sorghum.

Symptoms

If rains occur during the flowering and grain filling stages, severe grain moulding occurs. The most frequently occurring genera are *Fusarium*, *Curvularia*, *Alternaria*, *Aspergillus* and *Phoma*. *Fusarium semitectum* and *F. moniliforme* develop a fluffy white or pinkish coloration. *C. lunata* colours the grain black. Symptom varies depending upon the organism involved and the degree of infection.

Favourable Conditions

- Long wet weather following flowering favours grain mould development.
- Compact ear heads are highly susceptible.

Disease cycle

Fungi mainly spread through air-borne conidia. Fungi survive as parasites as well as saprophytes in the infected plant debris.

Management

- Adjust the sowing time.
- Spray any one of the following fungicides in case of intermittent rainfall during earhead emergence, a week later and during milky stage - mancozeb 1 kg/ha or Captan 1 kg + Aureofungin-sol 100 g/ha.

13. Phanerogamic parasite: *Striga asiatica* and *Striga densiflora*

Symptoms

It is a partial root parasite and occurs mainly in rainfed sorghum. It is a small plant with bright green leaves, grows upto a height of 15-30 cm. Plants occur in clusters of 10-20/host plant. *S. asiatica* produces red to pink flowers while, *S. densiflora* produces white flowers. Each fruit contains minute seeds in abundance which survives in the soil for several years. Root exudates of sorghum stimulate the seeds of the parasite to germinate. The parasite then slowly attaches to the root of the host by haustoria and grows below the soil surface producing underground stems and roots for about 1-2 months. The parasite grows faster and appears at the base of the plant. Severe infestation causes yellowing and wilting of the host leaves. The infected plants are stunted in growth and may die prior to seed setting.

Management

- Regular weeding and intercultural operation during early stages of parasite growth.
- Spray Fernoxone (sodium salt of 2, 4-D) at 450g /500 litre of water.

Grapes

Grapes
Buy Products for your crop
Crop Protection
Package of Practices
Expectation
BharatAgri Smart Farming
Standard Farming
Expected Fertilizer and Agrochemical Expenditure
$ 83,000
Expected Harvest
20 tones/Acre
Expected Income (Rs)
¥6,00,000
Expected Fertilizer and Agrochemical Expenditure
¥ 98,000
Expected Harvest
16 tonnes/Acre
Expected Income (Rs)
$ 4,80,000

Favourable climate

Temperature
In its natural habitat, the crop bears fruit during the hot and dry period and undergoes dormancy during the period of severe cold.
It tolerates frost during resting stage but is very susceptible during growing period.
Temperature ranging from 15-35 C is ideal for shoot growth and normal physiological processes of the grapevine.
Vines do not grow and fruit well when the temperature falls below 10 C.
Crop Water Requirement
Total seasonal requirements vary between 500 and 1200 mm, depending mainly on climate and length of growing period.

Favourable soil

Type
The best soil types for grapes are known to be well-drained loan to sandy loam with good organic matter.
Poorly drained, alkaline soils should be avoided. pH
Soils having pH value from 6.5 to 7.5 are most suitable.
If pH is < 6.5 add Lime.
If pH is >7.5 add Gypsum.

Planting material

Thompson seedless
Special Characteristic

Clusters are medium to large, cylindrical to conical shaped, heavily shouldered that ripen in about 130-140 days after pruning. The berries are seedless, small to medium-sized, oval to ellipsoidal in shape, soft berry skin, and greenish-white to golden in colour with firm, juicy pulp. The majority of exported grapes from India consist of this variety.

Anab-e-Shahi
Special Characteristic

Buy Agri Products
8%1
Package of Practices
This variety is grown in the states of Andhra Pradesh, Punjab, Haryana and Karnataka. It is widely adaptable to different Agro-climatic conditions. This variety is late maturing and heavy yielding. Berries are elongated, medium large, seeded and amber coloured when fully ripe. Juice is clear and sweet with TSS 14-16%. It is highly susceptible to downy mildew. Average yield is 35 t/ha. Fruits have a good keeping quality and mostly used for table purpose.

Red globe
Special Characteristic

Buy Agri Products

Package of Practices
Clusters are big, berries very bold (22-25 mm diameter), red round, seeded with meaty pulp. It is a late ripening variety and takes more than 135 days from pruning. It has good keeping qualities and can be cold stored for at least 3 months. Fruit yield is about 20-25 tons per hectare

Sharad seedless

The berries are bluish black with crisp pulp, oblong to elliptical in shape and highly responsive to Gibberellin treatment for berry size. The fruit quality is better when ripening coincides during cool climate. It has a medium maturity and takes about 125 days from pruning for harvesting. Quality yields of 15-18 tons per hectare can be obtained with proper canopy management, bunch and berry thinning and berry sizing. However, the berries are susceptible to the bleaching as a result of SO2 injury during storage in fruit boxes lined with grape guards. Hence the variety is not suitable for long duration storage/ shipment, but can be exported to short distant/ quick accessible markets.

Cheema sahibi

Open pollinated seedling Pandhani sahibi. Vigorous & High yielding, Bunches are long, Conical, Oral berries, Late ripening & shipping quality is poor due to weak pedical attachment

Land preparation
The land is tilled and laid into plots of 120 m x 180 m separated by 3 m wide roads.
Land within a plot is levelled perfectly to have a gradient of less than 1 percent in any direction to ensure uniform discharge of water through the emitters of drip irrigation systems.

Trenches of 75 cm width, 75 cm depth and 118 m length in a north-south direction with a gap of 3 m between trenches are opened with heavy machinery.
They are closed with topsoil, up to a height of 45 cm after 15 days exposure to sun.
The remaining gap is filled with a mixture of soil, cattle manure, single superphosphate, sulphate of potash and micro-nutrients.
Usually, 50 kg of cattle manure, 2.5 kg of superphosphate, 0.5 kg of sulphate of potash and 50 g each of $ZnSO_4$ and $FeSO_4$ are added to the soil for every running meter length of the trench.
Land is leveled by a tractor or bulldozer as per the requirement, soil type and gradient.
In case of drip irrigation, leveling need not be perfect.
The size of the plot will vary with the type of training system used.
In case of bower and telephone or "T" trellis the ideal size could be 60 X 80 m. and 90 X 120 m. respectively.

Spacing and Plant Population
Varieties

Row to Row	3.0 m
Plant to Plant	2.0 m
Plant Population	7,333

Nutrient Management
Package of Practices
As vineyard soils are either sandy loams or heavy clays, the usage of organic manure has assumed high importance in India.
A standard dose of 200:200:400 kg of N, P205 and K20 per acre is followed in light sandy soils, while 265:
350:265 kg per acre are applied for heavy clay soils.
The annual dose is fixed based on the petiole analysis carried out at 45 days after spur pruning.
While 40 percent of the annual dose is given through organic sources, 60 percent is given as inorganic fertilizer.
Calcium ammonium nitrate is usually not used.
Sulphate of potash is the only source of potash used in place of muriate, particularly in heavy clay soils.
Recently application of soluble fertilizers through drip irrigation is picking up.
40 percent of N, 50 percent of P205 and 33 percent of K20 of the annual dose is given during the growth season and the rest in the fruiting season.

Irrigation
Since grapes are grown in areas where the evapotranspiration exceeds the precipitation, irrigation is essential.
Less than 10 percent of the vineyard areas are surface irrigated, while the rest is irrigated by drip systems.
Water requirement is calculated based on the pan evaporation using 0.8 as the crop factor.
Water is applied at different rates at different stages of vine growth and berry development.

Intercultural Operations
Weed Management
Weeds between the rows of vines are removed mechanically by tractor drawn implements.
Within the rows, weeds are manually hoed and removed.

Harvesting
Number of harvests
In North India, plants start fruiting after two years of planting.
Berries start ripening from the end of May in early varieties.
However, most of the varieties are harvested after they have changed colour near the tip and have become sweet.
A day prior to picking, the broken, decayed, deformed, under-sized berries are removed.
The clusters are usually harvested during the early hours of the day before the temperature rises above
20 C.

Yield
Total harvest quantity
Yield varies according to variety and climatic conditions etc.
The average yield of Anab-e-Shahi and Bangalore blue is 40-50 tonnes/ha while that of seedless varieties is 20 tonnes/ha.
Average yield of 20-22 tonnes/ha.is considered good.

Grapes

By Certis Biologicals
Grape crops face a variety of diseases that can appear due to seasonal and environmental changes, and understanding the symptoms can help growers to stop disease pressure before it affects crop yield.

Let’s dig into root causes of fungal diseases in grapes, how you can solution for them using prevention and control, and how all of these measures will enable you to grow healthier grapevines, strengthen the health of crops, and increase yield in the long run.
Downy Mildew
Downy mildew is caused by the fungus Plasmopara viticola, which attacks all green parts of the vine, specifically targeting the leaves.

- The main symptoms include yellow to reddish brown, with angular or oily lesions.
- The fungus sporulates and appears as a delicate and dense white and cotton-like growth in the lesions, which causes infected shoot tips to thicken and curl into white sporulation, which eventually causes the leaves to turn brown and die.

In grapes, young berries are highly susceptible to powdery rot, and the fruit will appear gray when infected (called gray rot), and then become covered in a “downy” felt of fungus spores.
Downy mildew should be treated with a preventative product such as LifeGard® WG, and then grapevines can be sprayed with an effective fungicide just before blossoms open, and then 7-10 days later, followed by intervals of 10-14 days and a final application a few weeks later, depending upon label instructions and disease pressure.
Powdery Mildew
The fungus Uncinula necator causes powdery mildew, which has a narrow host range and attacks only grape crops and a few closely related species.

- The early signs include chlorotic spots on the upper leaf surface, and later as webby, white mycelium on the lower leaf surface.
- The fungus then takes on a “powdery” or dusty-like appearance that may take over the entire surface of the berry.
- On mature fruit, it appears as black or brown web scarring, and other symptoms may include red blotchy areas.

Preventative treatment will help prevent diseases as the crops grow, and fungicide treatments should begin promptly and repeated at appropriate intervals.

Bunch Rot / Botrytis

Bunch rot comes from the fungus Botrytis cinerea, and can occur anytime during the growing season due to common environmental causes, and it can overtake grape crops quickly.

- Early season shoot blight may occur prior to fruit ripening following prolonged warm, moist weather typically caused by spring rains.
- The fungus then causes patches of soft brown tissue, which kills the infected plant part.
- Individual berries can become infected due to infections from leaf axils, and then clusters can turn brown or reddish.
- Typical signs show epidermal cracks that form, and fungal growth produces mycelium and spores that results in a gray, velvet-like appearance of the berries.

Practice canopy management such as shoot thinning, hedging, and leaf removal of basal leaves to reduce incidence and severity of disease, but do not remove excessive leaves in warmer growing areas, as this can lead to sunburned fruit.

A fungicide will be more effective with good coverage, which is also affected by canopy and growth. Apply sprays before rainfall, at bloom, or at veraison. It's important also to control insect populations, as entry wounds from their feeding promote Botrytis infections.

Leafy Spot / Phomopsis

Leafy spot, or leafspot, is caused by the fungus Phomopsis viticola that was formerly known as "dead-arm."

- Early signs show small dark spots and yellowing on the edges of leaf blades and veins.
- Spots typically occur 3-4 weeks following a rain because moisture is required for infection, and leaves may die if too many spots build up.
- If basal leaves develop heavy infection, they may become distorted and never fully develop in size.
- Spots can also occur on the shoot and cause the shoots to crack and infect further, showing a scabby appearance, which can move to the flower cluster stems.
- Summer heat diminishes lesions, but rain can cause spots to occur on clean berries, which causes them to shrivel and mummify.

Be on guard to find the presence of lesions on spurs and canes in areas of the vineyard that might be exhibiting poor budbreak. Liquid lime sulfur can help at 10gallons/acre in 100 gallons of water before rainfall in winter to reduce overwintering Botrytis or powdery mildew spores to grow.

If disease symptoms show in spring, use foliar treatments if rainfall is predicted

after budbreak. Some contact products may need to be reapplied after significant rainfall to protect shoots up to 18 inches in length.

Black Rot / Xanthomonas ssp

Black rot can be one of the most damaging diseases in grapes if it is not managed early in the season. It is caused by the fungus Guignardia bidwellii and cam infect leaves, shoots, berries, tendrils, cluster stems, and more in grapes.

- Disease development favors warm, humid weather and symptoms first appear as small yellow spots on plant leaves.
- The spots become lesions, which have a dark reddish-brown border and tan or brown centers.
- Eventually, the spots become black in the lesion in a ring pattern, and the spores from these infect new plant tissue, thus spreading the disease when temperatures are warm.
- Fruit symptoms on grapes typically appear after the berries are larger than a pea size, when brown spots appear and then the fruit shrivels and turns black into a raisin-like appearance (fruit “mummies” which develop new spores that can spread through the air into new tissues).

Sanitation plays an important role in the control of black rot, so be sure to check the leaves throughout the season to prune leaves with lesions in the spring if they appear, because they will cause further infection if they are not removed. Also, check the vineyard ground for mummies to ensure that the disease does not get carried through the air to infect other vines or plants.

Use preventative measures to control disease, and fungicides can be sprayed during the period of early bloom through 3-4 weeks after initial bloom.

Shoot Blight / Sclerotinia spp.
Shoot blight occurs in grapevines from the fungus Sclerotinia sclerotiorum, which is a fungal pathogen of 400+ plant species that feeds on dead tissue and thrives when rainfall and cool weather occur in early spring.

- The disease can reduce yield by damaging or killing fruit-bearing shoots in the current season and in future years, and it can often be mistaken for Botrytis shoot infection in the early stages.
- It initially appears as light brown lesions on the shoot and develops at the shoot base or at a node.
- Symptoms develop into long cankered lesions surrounded by water-soaked tissues at the base of new shoots, and infection travels down the stems, making them break easily when bunches begin to develop.
- Distal shoots may wither, appear with white fungal growth after moist, warm conditions, and can form black sclerotes on the outside of the

shoot.
- The disease mainly infects the shoots, but can spread to the berries.

Warm conditions slow the spread of Sclerotinia shoot infection. If these symptoms occur in spring, the disease is unlikely to cause significant yield loss, but preventative measures should be taken to ensure that the berries stay disease-free throughout the growing season.

Blight

Bacterial blight in grapevines is caused by the bacterium Xylophilus ampelinus which survives in the vascular tissues of infected plants. It is a highly damaging systemic disease that affects commercial cultivars.

- It affects the leaf, petiole, stem, root, shoot, or flowers.
- Symptoms include linear reddish-brown streaks that expand upwards on the shoot.
- The streaks then darken, crack, and develop into cankers.

Understanding the symptoms will help you be able to treat disease pressure as it arises, but it's also important to put preventative methods into practice throughout the growing season to decrease disease pressure in grapes.

Disease-causing fungi can rapidly colonize a plant surface, so preventive fungicides are effective prior to the onset of diseases. Preventive fungicides have an upfront cost, but they also reduce the incidence of disease and minimize the need for costly post-infection practices after plants have been infected, which can also lead to greater loss in yield and profits.

LifeGard® WG is a biological stimulator that induces a natural immune response in the plant that reduces the occurrence and severity of disease. Double Nickel® LC is a technologically advanced broad spectrum biological fungicide and bactericide that can control or suppress over 90 different fungal and bacterial diseases and is tested to be effective on grapes. These products are ideal for organic production or in an integrated disease management program.

Grape

Content

Content

Diseases
- Fungal
- Bacterial
- Other
Pests
- Insects
See questions about 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 weathe 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 aslo 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 years 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 (Bird’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 intervenaial striping looks like tiger strips. White cultivars shows chlorotic and necrotic strips where as 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 in 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

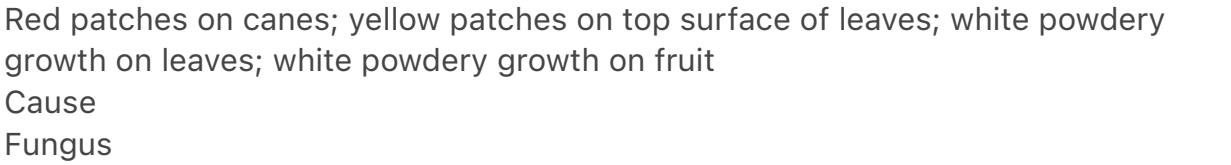
Use pathogens free planting material; if disease is present prune out dead and infected wood and plow under soil; apply an appropriate fungicide

Powdery mildew Erysiphe necator

Powdery mildew symptoms on fruit

Powdery mildew symptoms on fruit

Powdery mildew symptoms on cane



Powdery mildew symptoms on leaf

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

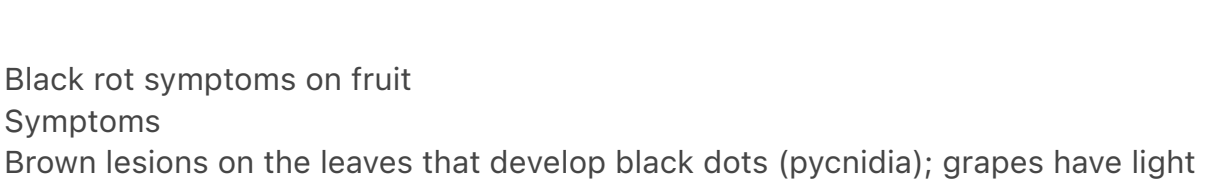
Management

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; collpsing 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 Ampeloglypter 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 me 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

CROP CALENDAR

Sorghum (Jowar)

Sorghum ranks as the fifth most significant cereal crop in the world, after rice, wheat, maize, and barley. You can grow sorghum or jowar as a grain crop for food or fodder. Yet if you're a farmer, you can grow sorghum both in the Kharif and the Rabi seasons.

India

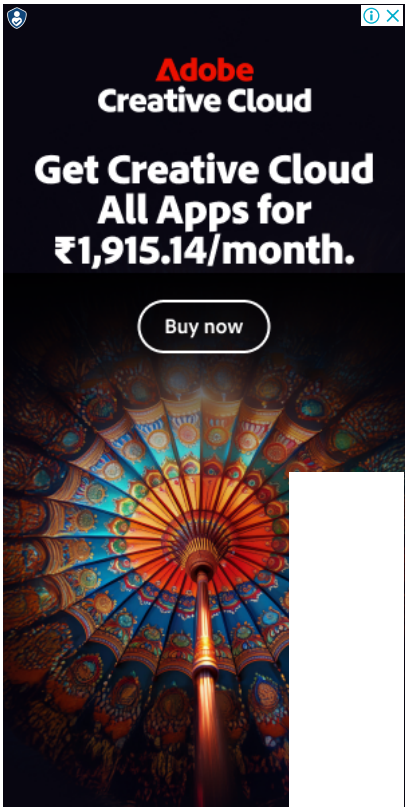
1 March - 15 August

Maharashtra | Karnataka | Andhra Pradesh | Tamil Nadu | Gujarat | Madhya Pradesh | Rajasthan

Jowar, which is also known as sorghum, is one of the most significant crops grown after the two main foodgrains, rice and wheat. In many places, it is regarded as a staple grain. The tropical or subtropical region produces sorghum as a crop. It can also flourish in dry areas. Jowar is mostly grown for human use. It is also used extensively as animal feed.

Botanical Classification:

Botanical Name: *Sorghum bicolor*



Family: Poaceae

Order: Cyperlaes

Class: Liliopsida

Chromosome Number: 10

Origin:

Sorghum, an indigenous crop to Africa, will continue to be a fundamental staple diet for many rural populations even if commercial requirements and applications alter over time. This is particularly true in South Africa's more drought-prone regions, where this robust crop offers more household food security than maize.

Climate for Growing Sorghum

Jowar crops thrive in hot, muggy weather. Regions with high temperatures throughout the year and humid conditions are ideally suited for growing Jowar plants. The optimal temperature for growing Jowar is 20-40 degree Celsius. However, you should avoid subjecting the crop to extremely high temperatures as this might reduce the yield. A 500–1000 mm yearly rainfall is ideal for agricultural cultivation. You must be careful to avoid exposing the Jowar plants to cold or frost because doing so might damage the plants. Waterlogging might result from excessive rain, which is bad for the crop.

Soil for Sorghum

In practically any type of soil, jowar can grow. Nevertheless, clay or loam soils could produce the finest outcomes. The optimal pH range for the soil is 5.5 to 8.0.

Sowing Method:

The best way to seed it is by drilling on the kera technique in lines that are 25–30 cm apart and 5–6 cm deep.

Seed rate:

For single-cut types, a seed rate of 16–20 kg per acre is recommended; for multicut kinds, 8–10 kg of seed is enough.

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Time of Sowing:

It can be sown all year round in South India and irrigated regions in North India from March to August. But, in rainy regions, it should be seeded as soon as the rains begin.

Manuring and Fertilizers:

Use 25 kg of urea after each cutting in the case of multi-cut types. In the absence of applying farmyard manure, 110 kg of urea per acre should be put in two separate applications. The remaining half should be administered after the first irrigation, with the first half being applied as a basal dose at the time of seeding. But, when planting multi-cut varieties, use 20 kg of urea after the first watering and 20 kg after each cutting.

Irrigation:

Throughout the summer, irrigation should be applied every 10 to 15 days, and every 20 to 25 days in the post-monsoon season. It should be watered as needed throughout the rainy season.

Weed Management:

Manual weeding and hoeing are effective methods for controlling weeds, but they are only feasible during the rabi and arid cropping seasons since rains prevent them from being done during the kharif season. So, it becomes evident that using herbicides like atrazine (0.5 kg a.i./ha) or propazine (1.0 kg a.i./ha) diluted in 900–1000 liters of water is necessary to manage weeds. Before the emergence of sorghum seedlings, these herbicides should be used.

Sorghum: Pests and Disease

- Use of lindane or carbaryl on leaves to combat stem borer
- Treatment of shoot fly seeds with carbofuran or disulfoton
- Endosulfan or lindane spray for midges
- Dithane-based downy mildew spray

In addition to all of the above-mentioned control techniques, you can also go for traditional methods to control pests and diseases.

Harvesting:

Single-cut varieties should be picked at the boot stage 70 to 90 days after sowing. If the variety can be cut many times, the initial cut should be made 55 to 60 days after seeding, and further cuttings can be taken every 45 to 50 days.

Yield:

Yields range from 150 to 200 quintals of green fodder per acre for single-cut types to 280 to 320 quintals per acre for multicut cultivars.

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Technical bulletin No. 5/2020

Integrated Nutrient Management in Coconut Based Cropping System under Konkan Region of Maharashtra

ICAR- AICRP on Palms
Regional Coconut Research Station,
Bhatye, Ratnagiri (M.S.) - 415 612
Dr. B.S. Konkan Krishi Vidyapeeth,
Dapoli, Dist. Ratnagiri

ICAR

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Compiled and Edited by,
Dr. Vaibhav V. Shinde
Dr. Sunil S. Ghawale
Dr. Santosh M. Wankhede
Dr. R. G. Khandekar
Dr. B. R. Salavi
Dr. Maheswarappa H. P.
Dr. P. M. Haldankar

About Bulletin :

*This is Technical bulletin on **Integrated Nutrient Management in Coconut Based Cropping System under Konkan Region of Maharashtra.** This includes how the coconut ecology, economy & changes with interppin of spices, banana & pineapple in coconut orchard.*

About AICRP :

All India Coordinated Research Project on palms started on 1972 at Regional Coconut Research Station, Bhatye which was established on 01st July 1955. The project on crop improvement, crop production and pest management are being studied under the project.

About University :

The Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth agriculture university Dapoli Dist. Ratnagiri. This University was established on 18th May 1972 for Konkan region. The Mango, Cashew, Coconut, Arecanut and Spices are the major crops studied under this university.

Type Setting and Cover design :
Dr. Sunil L. Ghavale
Smt. Priyanka Nagwekar

Phtographs :
Dr. Vaibhav V. Shinde
Dr. Sunil L. Ghavale

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CONTENT

INTEGRATED NUTRIENT MANAGEMENT IN COCONUT BASED CROPPING SYSTEM UNDER KONKAN REGION OF MAHARASHTRA

1) INTRODUCTION

Coconut is an important crop of economic importance to many of the Asian and Pacific countries in the world. The crop provides livelihood security and employment opportunities to a major segment of the rural mass of these countries. India being the largest coconut producing country in the world occupies 31% of global production. Widely acclaimed as Kalpavriksha or Tree of life, the coconut palm provides food security and livelihood opportunities to more than 10 million people in India. It is an important food crop for the major chunk of Indian population. Similarly it is an important cash crop for more than 10 million farm families and a fiber-yielding crop for more than 15,000 coir based industries which provides employment to nearly 6 lakhs workers of which 80 per cent are women folk. The coconut and coconut products are gaining global importance as a contributing factor to the health, nutrition and wellness of human beings. This is due to its multiple medicinal and nutraceutical properties being revealed day by day. This new development in health sector brought in unprecedented increase in demand of coconut products in domestic and international markets. It is estimated that there are 5 million coconut holdings and 12 million farmers in the country covering 17 states and 3 Union Territories.

Scenario of coconut cultivation in Maharashtra

The State of Maharashtra is a coconut growing state in the country with an extent of 27180 ha. with a production of 209 million nuts and productivity of 7687 nuts/ha (2018-2019). The coastal districts namely Sindhudurg, Ratnagiri, Raigad and Palghar covers the major coconut growing areas in the state. Within the state, these four districts command 94 percent of area under coconut.

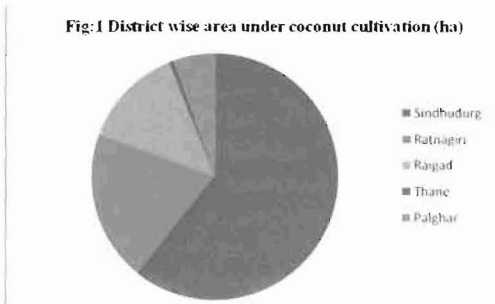


Fig. 1. District wise area (Ha) under coconut cultivation

Konkan region of Maharashtra is a long narrow strip of 720 kms, running North to South along the West coast of Maharashtra. The region comprises of Thane, Raigad, Ratnagiri, Sindhudurg and Greater Mumbai districts. It is characterized by hilly terrain receiving heavy rainfall ranging from 3000 to 4000 mm per annum usually during four months from June to September. The climate is warm and humid almost throughout the year. Coconut is a major irrigated horticultural crop of Maharashtra. The total productive area under Coconut cultivation in Maharashtra is 43320 ha with production of 209.87million nuts and productivity 4845 nuts/palm/year mainly grown in Konkan region of Maharashtra. Since 1990, the Government of Maharashtra has launched the Employment Guarantee Scheme (EGS) for number of horticultural crops which includes coconut plantation also. This helped to boost up area under coconut crop.

Generating and establishing more sustainable cropping system is need of today's era. Multispecies and multistoried cropping system ensures maximum utilization of resources for higher yield per unit area. There are many coconut based cropping systems in various countries and states of the nation. Effective and efficient utilization of available resources for higher yield is the modern concept of cropping system. Improvement in the soil properties and biological activities in the rhizosphere due to intercropping results in the modification of soil environment for the benefit of the plant growth. Studies revealed that natural resources i.e. soil water; air space and solar reclamation are not fully utilized under the spacing schedule 7.5 m x 7.5 m. Many of the coconut workers have reported that a well designed high density multispecies crop model suited to a given agro-climatic situation generates returns biomass output, yields, more economic returns and higher total income, additional employment opportunities for family labours and meets diversified needs of the coconut farmers, such as food, fruit, vegetables, fuel etc. The coconut based cropping systems are gaining importance as there are serious market fluctuations for coconuts and coconut products. Systematic mixed cropping of compatible crops under coconut to compensate the economic losses of sole cropping by increasing income per unit of cultivable land has become a necessity.

Integrated nutrient management involve intelligent use of organic, inorganic and biological resources so as to sustain optimum yield, improve or maintain soil chemical and physical properties and provide crop nutrition packages which are technically sound and economically attractive practically feasible and environmental safe. In recent days, nutrient management through organic source of manures is gaining momentum for sustaining the productivity and conserving the natural resources. In coconut based cropping system it is necessary to fertilize coconut and component crops according to make the system more productive and competitive. Hence field experiment on impact of integrated nutrient management and organics including biomass recycling in coconut based cropping system was initiated in 30 years old D x T coconut plantation at Regional coconut Research Station, Bhatye, Ratnagiri (M.S) during the year 2013-14 to 2018-19. The component crops were nutmeg, cinnamon, banana and pineapple.

The experiment consists of four treatments viz.

T_1: 75 % of recommended NPK + 25 % of N through organic recycling with vermi-compost.

T_2: 50 % of RDF + 50 % of N through organic recycling with vermi-compost + vermiwash application + bio-fertilizer application + in situ green manuring.

T_3: 100 % of N through organic recycling with vermi- compost + vermiwash application + bio-fertilizer application + in situ green manuring and green leaf manuring (glyricidia leaves) + composted coir pith, husk incorporation and mulching with coconut leaves.

T_4: Control: monocrop of coconut with recommended NPK and organic manure were imposed.

Table 2 : Physico-chemical properties of sandy loam soil at RCRS, Bhatye centre (Ratnagiri)

Content	Soil depth (cm)		
	0-30	30-60	60-90
Sand (%)	89.5	89.4	89.0
Silt (%)	3.4	3.6	3.9
Clay (%)	7.1	7.2	7.1
pH	5.58	5.52	5.38
Organic carbon (%)	0.22	0.19	0.10
Electrical conductivity (dsm-1)	0.186	0.171	0.164

2) COCONUT BASED CROPPING SYSTEM

a) Component crops

Current experiment was laid out in 32 year old coconut garden which was planted at a distance of 7.5 m × 7.5 m in a square system. The crops in the cropping system were managed with the recommended package of practices. The experimental block of each treatment was laid out in 0.11 ha. coconut garden and intercropping with released varieties of spices and fruit crops in Maharashtra State was adopted. The spice and fruit crops grown in the coconut garden are given in Table 3 and pictorial representation in Fig. 2 and Fig.3.

Table 3 : Details of the component crops in coconut based integrated nutrient management system

Sr. No.	Name of the crop	Varieties /hybrids	Number of plants/block	Number of plants/ha
1.	Coconut	D x T (COD x WCT)	20	175
2.	Nutmeg	KonkanSwad	12	135
3.	Cinnamon	KonkanTej	62	615
4.	Banana	KonkanSafedVelchi	62	615
5.	Pineapple	Kew	960	10800

b) Statistical design applied and system layout

As the experiment was laid out in a block of 0.45 ha area for each treatment, the weather parameters during the year influence the productivity of the system. Hence, in the analysis, year effect was taken as fixed effect in the ANOVA table, and treatment effect as error. The statistical analysis was performed using Statistical analysis system 9.3 computer software (SAS Institute Inc., 1995). DMRT procedure was used at P=0.05 level to determine the significance among the treatments.

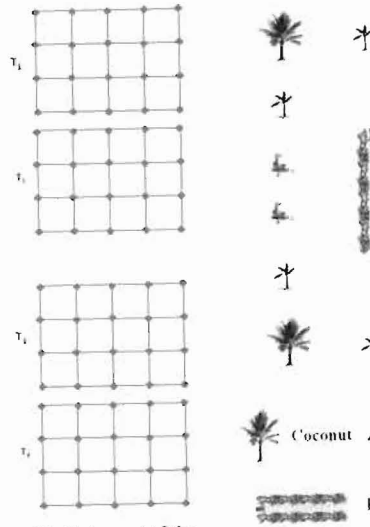


Fig.2- Layout of the experimental field

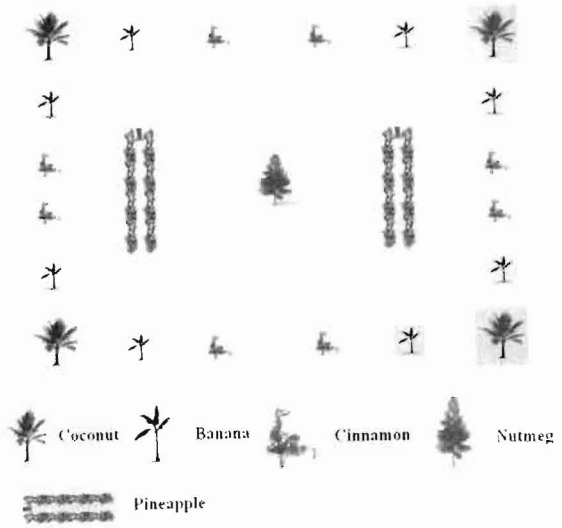


Fig. 3: Layout of single plot

c) Integrated nutrient management

Involves intelligent and judicious use of organic, inorganic and biological resources as source of nutrition to coconut plants so as to sustain optimum yield.

i) Fertilizer dose

The quantity of nutrient management for different crops in the system is presented in Table 4. The N, P and K were applied in the form of Urea, Single super phosphate and Muriate of potash respectively. As per the recommendation of the university fertilizers were applied in three splits to coconut viz. Full organic plus full phosphorous and one third (33%) nitrogen and potassium in June, Remaining one third Nitrogen and potassium in the month October and finally one-third Nitrogen and potassium in the month of January. However the component crops were applied with two split dose as shown below.

Table 4 : Manures and fertilizers application : NPK, vermicompost, bio-fertilizer (Azotobacter), vermiwash, green manuring (cowpea) and glyricidia leaf pruning

Rec. Dose of fertilizers (g/plant/ year)	Crops/ variety	T1		T2					T3				
		75 % of Rec. NPK	Recycl. Biomass (vermi-compost) (kg/plant)	50% of rec. NPK	Recycl. Biomass (vermi com.) (kg/pl.)	Biofert. (ml/plant) Azotob.	In situ green manuring (kg/plant)	Vermi wash (lit/ha)	Recycl. Biomass (vermi com.) (kg/pl.)	Biofert. (ml/ plant) Azotob.	In situ green manuring (kg/pl.)	Vermi wash (lit/ha)	Glyricida prunings (kg/pl.)
1000 N 500 P 2000 K g/plant	Coconut (DxT)	750 N 375 P 1500K g/plant	50	500 N 250 P 1000 K g/plant	50	100 (40+30+30)	20	100 (40+30+30)	50	100 (40+30+30)	20	100 (40+30+30)	10
400 N 600 P 200 K g/plant	Banana (Safed Velchi)	300 N 450 P 150 K g/plant	5	200 N 300 P 100 K g/plant	5	20 (20+20)	5	10 (5+5)	5	20	5	10 (5+5)	5
12 N 6 P 12 K g/plant	Pineapple (Kew)	9 N 4.5 P 9 K g/plant	1.9	6 N 3 P 9 K g/plant	1.9	10 (5+5)	1.9	10 (5+5)	1.9	20	1.9	10 (5+5)	1.9
20 N 20 P 50 K g/plant	Nutmeg (Konkan Swad)	15 N 15 P 37.5 K g/plant	10	10 N 10 P 25 K g/plant	10	10 (5+5)	10	10 (5+5)	10	10 (5+5)	10	10 (5+5)	10
20 N 20 P 20 K g/plant	Cinnamon (Konkan Tej)	15 N 15 P 15 K g/plant	3	10 N 10 P 10 K g/plant	3	10 (5+5)	3	10 (5+5)	3	10 (5+5)	3	10 (5+5)	3

T4 : RDF for coconut-FYM @ 50 kg/palm/year with 1.5 kg Ormichem / palm / year and 1000:500:2000 g NPK/palm/year (Applied in three splits; First-June, Second--Oct. and third-Feb). Manure applied to the component crops in two split dose (June and January). Ormichem is recommended micronutrient complex (Zn 3.15%, Mg 1.8 %, Cu 0.65%, Fe 1.97%, Mn 2%, Mo 0.05% and B 0.68%).

The quantity of fertilizers and organic manures applied based upon the N content in the respective material is as under,

Treatment	Quantity of nutrient
T_1	1.62 kg Urea + 8.92 kg Vermicompost + 2.34 kg SSP + 2.5 kg MOP
T_2	1.08 kg Urea + 8.92 kg Vermicompost + 10.92 kg in situ green manuaring + 1.5 kg SSP + 1.66 kg MOP
T_3	17.84 kg Vermicompost + 10.92 kg green leaf manuring + 20.16 kg composted pith
T_4	2.22 kg Urea + 3.0 kg SSP + 2.0 kg MOP + 50 kg FYM

ii) Irrigation

Sprinkler irrigation was followed for irrigating coconut and intercrops during the dry period (October to May) at IW/CPE 1.00. Husk incorporation was applied as per treatment details. Husk burial in the trenches was followed in each set of four coconut palms. Dried coconut leaves were used for mulching in summer months (February - May).

iii) Pre-experimental yield of coconut

The pre-experimental nut yield data was recorded and presented in Table 5. The data revealed that initially nut, copra and oil yield didn't differ in the coconut plants under the study.

Table 5 : Pre-experimental yield of coconut (Average of 2011-12 to 2012-13)

Treatments	Nut yield (nuts/palm)	Copra yield (kg/palm)	Oil yield (kg/palm)	Oil yield (tonnes/ha)
T_1	104.6	17.78	12.09	2.12
T_2	103.9	17.67	12.01	2.10
T_3	102.7	17.46	11.87	2.08
T_4	103.8	17.64	12.00	2.10
Mean	103.7	17.63	11.99	2.10
SEm. ±	0.65	0.11	0.07	0.012
CD (P=0.05)	NS	NS	NS	NS
CV (%)	11.4	13.7	1.40	1.74

Experimental results

1) Effect integrated nutrient management on the growth characters of the coconut in coconut based cropping system

The data regarding to the number of leaves on the crown, rate of leaf production, number of spadices, number of buttons and setting per cent is presented in Table 6.There is no significant difference in the production of number of leaves on the crown, rate of leaf production, number of spadices among the treatments was noticed in INM under coconut based cropping system.

i) Number of buttons

Number of buttons produced per palm/year did differ among the treatments. It was found that the treatment T_1 produced significantly highest female flowers (326.04 nos.) in the integrated nutrient management treatments followed by treatment T_2 and T_3 whereas lowest number (312.39 nos.) of buttons production was recorded in the treatment T_4.

ii) Setting per cent

It was found that the treatment T_1 recorded highest setting of flowers to fruits (43.69 %.) in the integrated nutrient management treatments followed by treatment T_2 and T_3 whereas lowest setting (35.08 %) of buttons was recorded in the treatment T_4.

Table 6 : Effect of integrated nutrient management system on growth characters of coconut (pooled data 2014-15 to 2018-19)

Treatment	Number of leaves on crown (nos./palm)	Rate of leaf production (nos./palm/ year)	Number of spadices (nos./palm)	Number of buttons (female flowers) (nos./palm)	Setting percent (%)
T_1	30.9	11.7	11.4	326.0	43.69
T_2	29.9	11.7	11.3	320.6	40.21
T_3	29.9	11.7	11.2	320.4	37.36
T_4	29.2	11.6	11.1	312.3	35.08
Mean	30.0	11.7	11.3	319.8	
SEm. ±	0.88	0.57	0.61	1.13	
CD(P=0.05)	NS	NS	NS	3.39	
CV (%)	3.16	1.25	0.71	7.41	

iii) Coconut nut yield

Yield is the index of the experimental assessment in almost all investigation. The coconut nut yield recorded among the treatments over six years and the data are presented in Table 7.

Table 7 : Effect of coconut based INM system on nut yield, copra and oil yield of coconut (pooled data 2014-15 to 2018-19)

Treatment	Nut yield (nuts/palm)	Nut yield (nuts/ha)	Copra yield (kg/palm)	Copra yield (tonnes/ha)	Oil yield (kg/palm)	Oil yield (tonnes/ha)
T_1	147.2	26054.4	25.73	4.55	17.11	3.03
T_2	138.4	24496.8	23.06	4.08	15.72	2.79
T_3	123.6	21877.2	20.37	3.60	13.60	2.41
T_4	97.2	17204.4	16.78	2.97	11.40	2.01
SEm. ±	5.14	1133.7	1.29	0.38	1.06	0.07
CD (P=0.05)	16.48	3402.1	3.88	1.15	3.18	0.21
CV (%)	6.87	11.14	7.87	3.21	6.46	5.67

In general, there was an increase in the yield of coconut and the yield obtained in different treatments was higher over the years than the pre-experiment yields, which was mainly owing to the effect of nutrients supplied through treatments and irrigation provided to coconut palms. Application of 75% of recommended NPK+25 % of N through organic recycling with vermicompost treatment recorded significantly highest nut yield (147.2 nuts) followed by 50% of RDF+50 % of N through organic recycling with vermicompost+vermiwash application + bio-fertilizer application + in situ green manuring treatment and was differed compared to the other treatments. Increase in yield under these treatments might be owing to better availability of required nutrients which resulted in improvement in yield. Additional increased in yield of coconut with farming system component could be due to synergistic effect of crop combination and nutrient status maintained in the system. Application of vermicompost alone could not result in increase in yield of coconut, as it could not provide the required P and K and application of inorganic fertilizer alone could not provide the suitable soil environment for the growth and development of coconut.

iv) Copra and oil yield

The coconut copra and oil yield recorded among the treatments over the years and the data are presented in Table 8. In general, there was an increase in the copra and oil yield of coconut and the yield obtained in different treatments was higher over the years than the pre-treatment yields, which was mainly owing to the effect of treatments and irrigation provided to coconut palms. During 2014-2018, application of 75% of recommended NPK+25 % of N through organic recycling with vermicompost (T_1) recorded higher copra and oil yield and was at par with 50% of RDF+50% of N through organic recycling with vermicompost+vermiwash application + bio-fertilizer application + in situ green manuring (T_2) and was differed as compared to the other treatments. The copra and oil yield obtained under 75% of recommended NPK+25% of N through organic recycling with vermicompost (T_1) and 50% of RDF+ 50 % of N through organic recycling with vermicompost + vermiwash application + bio-fertilizer application + in situ green manuring (T_2) was at par i.e. 25.73 and 23.06 kg/palm/year and 17.11 and 15.72 kg/palm/year respectively. Also the oil yield (tonnes/ha) obtained under 75% of recommended NPK + 25 % of N through organic recycling with vermicompost (T_1) and 50% of RDF+50 % of N through organic recycling with vermicompost + vermiwash application + bio-fertilizer application + in situ green manuring (T_2) was at par i.e. 3.03 and 2.79 tonnes/hectare respectively. Increase in copra and oil yield under these treatments might be owing to better availability of required nutrients which resulted in improvement in yield. Application of any single manure could

not result in increase in copra and oil yield of coconut, as it could not provide the required P and K and application of inorganic fertilizer alone could not provide the suitable soil environment for the growth and development of coconut.

II) Effect of INM on growth characters of component crops in coconut based cropping system

The growth of component crops as influenced by coconut based INM system in coconut is presented in Table 8. It was observed that the height of nutmeg plants increases after the 6th year of treatment initiation and the significantly maximum height of nutmeg plants was 318 cm in T_2 whereas the minimum was in treatment T_3 (253 cm). The significantly maximum number of nutmeg branches was recorded in treatment T_3 (10.3 nos.) whereas minimum in treatment T_2 (5.8 nos.). The significantly maximum height of cinnamon plants was (228.9 cm) in T_1 whereas the minimum was in treatment T_2 (206.4 cm). The significantly maximum number of cinnamon branches was in treatment T_3 (15.33 nos.) whereas minimum in treatment T_2 (7.77 nos.).

Table 8 : Effect of coconut based INM system on growth characters of component crops as an intercrops in coconut orchard

Treatment	Nutmeg		Cinnamon	
	Height (cm)	No. of branches (nos.)	Height (cm)	No. of branches (nos.)
T_1	304	6.56	228.82	11.35
T_2	318	5.83	206.20	7.77
T_3	253	10.21	221.42	15.33
S.Em. ±	0.17	0.73	3.11	1.81
CD (P=0.05)	0.56	2.19	9.35	5.44
CV (%)	19.67	11.34	17.63	22.24

III) Output from component crops

The yield of component crops as influenced by coconut based integrated nutrient management system in coconut was recorded and presented for last three years as of nutmeg and cinnamon yield consistently recorded in last three years after plantation and presented in Table 9.

Highest mean yield of component crops namely pineapple and banana were in the treatment T_3 such as 52.7 kg/block and 411 kg/block respectively whereas highest mean yield of component crops cinnamon bark and cinnamon leaves were in treatment T_1 such as 21 kg/block and 54.8 kg/block respectively.

Table 9 : Output from different component crops under coconut based cropping system model at Regional Coconut Research Station, Bhatye, Ratnagiri

Treatment/crops	2016-17	2017-18	2018-19	Mean
Cinnamon bark (g/plant)				
T_1	269.10	277.23	285.36	277.23
T_2	234.14	238.61	240.65	237.81
T_3	232.52	234.55	236.59	234.56
SEm. ±	9.19	8.78	10.26	5.91
CD (P=0.05)	27.60	26.36	30.80	17.74
C.V. (%)	11.58	13.86	9.31	6.37
Cinnamon leaves (g/plant)				
T_1	843.90	864.22	872.35	860.15
T_2	770.7	782.9	762.3	771.96
T_3	762.6	770.7	735.12	756.14
SEm. ±	19.91	17.43	21.32	15.82
CD (P=0.05)	59.72	52.29	63.96	47.48
C.V. (%)	17.43	19.33	18.54	17.22
Nutmeg (no. of fruits/plant)				
T_1	334.2	361.4	356.8	350.8
T_2	302.3	310.0	308.3	306.8
T_3	263.6	283.3	278.5	275.1
SEm. ±	13.34	12.48	14.71	0.32
CD (P=0.05)	40.02	37.44	42.24	1.02
C.V. (%)	6.12	11.23	14.67	9.32
Banana (kg/bunch)				
T_1	10.7	7.12	12.70	10.17
T_2	9.13	6.14	11.6	8.95
T_3	8.55	5.46	10.4	8.13
SEm. ±	0.03	0.03	0.49	0.51
CD (P=0.05)	NS	NS	1.47	1.53
C.V. (%)	5.18	9.34	11.26	6.48
Pineapple(kg/fruit)				
T_1	1.9	1.4	2.5	1.9
T_2	1.8	1.4	2.4	1.9
T_3	1.8	1.3	2.0	1.7
SEm. ±	0.043	0.037	0.02	0.058
CD (P=0.05)	0.138	0.112	NS	0.174
C.V. (%)	9.12	7.54	11.78	10.27

Different crops in integrated nutrient management system

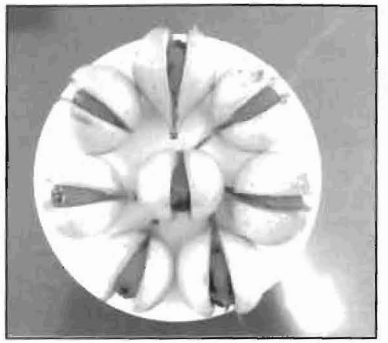
Coconut

Nutmeg

Cinnamon

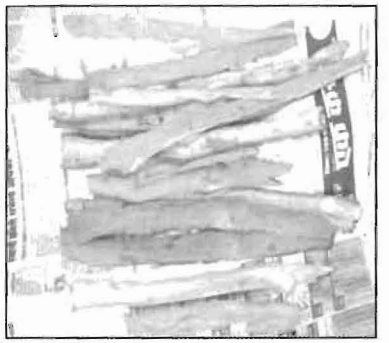
Pineapple

Banana



Nutmeg fruits

Nutmeg and mace



Cinnamon

Tej patta and black nagakeshar

IV) Biomass generation, vermicompost production and earthworm population in coconut based integrated nutrient management system

Table 10 : Biomass generation and vermicompost production in coconut based INM system

Treatments	Biomass generation (kg/ha/year)	Vermicompost production (kg/ha/year)
Open field	-	-
T_1	18654	10259
T_2	17670	9541
T_3	15708	8639
T_4	9344	4923
SEm. ±	2176	1611
CD (P=0.05)	6528	4833
C.V. (%)	19.43	22.65

a) Biomass generation, vermi-compost production

The biomass generation and accordingly vermi-compost production did differ significantly among the treatments (Table 10). Highest biomass production was registered with the treatment T_1 (18654 kg/ha/year) which is on par with the treatment T_2 (17670 kg/ha/year) and T_3 (15708 kg/ha/year) and lowest recorded in the monocrop T_4 (9344 kg/ha/year). Similarly the vermi-compost production was higher in the treatment T_1 (10259 kg/ha/year) which is on par with the treatment T_2 (9441 kg/ha/year), T_3 (8639 kg/ha/year) and significantly lowest was recorded in the treatment T_4 (4923 kg/ha/year). Also the generated biomass and vermi-compost production from different component crops which can be recycled in the coconut based INM system. The organic wastes are to be treated with cow dung at the rate of 10 per cent by weight in the form of slurry and must be allowed to undergo a preliminary decomposition for about 2 -3 weeks. The earthworms at the rate of 1000 worms per tonne of biomass are to be introduced. The compost bed should be mulched properly using any locally available plant material or gunny bags and has to be protected from direct sun light. Watering is to be done to maintain enough moisture. As full leaves are used for composting, compact mass is not formed, thus allowing free movement of air in the bed. In about 60-75 days compost will be ready. On an average, 70 per cent recovery of vermicompost was obtained. The same technology for vermicomposting was also tested in large pits taken in the inter spaces of four coconut palms in sandy loam soils and was found to work well.

b) Earthworm population

The data on earthworm population (nos./m^2) as influenced by coconut based integrated nutrient management system is presented in Table 11. The data indicated that the earthworm population did differ significantly at all soil depths. Significantly the highest number of earthworm population was noticed in the treatment T_3. This might be due to the availability of nutrients in form of 100% organic source.

Table 11 : Earthworm population (nos./m^2) as influenced by coconut based integrated nutrient management

Treatment	Soil depth		
	0-10 cm	10-20 cm	20-30 cm
T_1	12.56	5.7	2.4
T_2	9.36	3.6	1.7
T_3	15.38	9.4	3.8
T_4	6.7	2.7	1.4
SEm. ±	1.9	1.03	0.52
CD (P=0.05)	5.8	3.04	1.56
C.V. (%)	15.23	6.78	11.34

V) Influence on weather parameters

Treatment wise maximum and minimum temperature and humidity in integrated nutrient management under coconut based cropping system was recorded and presented in Table 12. Data revealed that there was mean reduction of temperature in the cropping system and mean increase in humidity. This may be due to the component crops in inter-space leads to microclimate modifications in the system.

Table 12 : Treatment influence on temperature and humidity in integrated nutrient management under based coconut cropping system

Treatments	Standard Week	Period	Temperature (°C)		Relative humidity (%)	
			Max	Min	Max	Min
Open field	1	1-7 Jan	28.6	15.6	85.6	43.8
	24	11-17Jun	32.7	25.4	87.0	75.8
	52	24-31Dec	33.6	19.8	82.4	52.0
Average			31.6	20.3	85.0	57.2
T_1	1	1-7 Jan	27.2	14.3	87.2	44.4
	24	11-17Jun	31.6	24.6	90.0	77.4
	52	24-31Dec	31.8	19.2	84.3	54.5
Average			30.2	19.4	87.2	58.8
T_2	1	1-7 Jan	27.2	14.4	87.2	44.0
	24	11-17Jun	31.7	24.8	89.8	77.0
	52	24-31Dec	32.0	19.4	84.4	54.2
Average			30.3	19.5	87.1	58.4
T_3	1	1-7 Jan	27.4	14.5	87.0	44.2
	24	11-17Jun	32.0	24.8	89.8	77.2
	52	24-31Dec	32.1	19.4	84.2	54.2
Average			30.5	19.6	87.0	58.5
T_4	1	1-7 Jan	28.0	15.3	86.4	43.8
	24	11-17Jun	32.8	25.2	82.4	76.8
	52	24-31Dec	33.0	19.8	83.2	52.0
Average			31.3	20.1	84.0	57.5

VI) Soil nutrient status as influenced by coconut based integrated nutrient management system

The data from Table 13 revealed that electrical conductivity of the soil (at 0-25 cm depth) did change due to the integrated nutrient management practices in the basins of the coconut, as seen during the pre-experiment (2012-2013) and the mean of 6th years after treatment initiation (2012-13 to 2018-19). After the 6th years of treatment initiation soil pH and organic

carbon content differed among the treatments. With the application of vermicompost, there was change in the pH of the soil, and the application of 75% of recommended NPK+25 % of N through organic recycling with vermicompost recorded higher pH (7.55) followed by the application of 50 % of RDF+50 % of N through organic recycling with vermicompost + vermiwash application +bio-fertilizer application+in situ green manuring (7.24) as compared to the other two treatments. The soil organic carbon also higher with the application of 75% of recommended NPK+25% of N through organic recycling with vermicompost (1.26%) followed by the application of 50% of RDF+50% of N through organic recycling with vermicompost+ vermiwash application+bio-fertilizer application+in situ green manuring (1.24%) as compared to the other two treatments. The soil nutrient content (NPK) was also highest with the application of 75% of recommended NPK+25% of N through organic recycling with vermicompost followed by the application of 50% of RDF+50% of N through organic recycling with vermicompost+ vermiwash application+ bio-fertilizer application+in situ green manuring as compared to the other two treatments. Increase in N, P and K, content of coconut cropping system from 2012-2013 to 2018-19 could be attributed to organic recycling of biomass glycricidia leaf lopping, vermiwash application in the system.

Table 13 : Soil nutrient status (coconut basin) as influenced by INM system

Soil depth	Treat-ment	Pre-experimental (2012-13)						Post-experimental (2018-2019)					
		pH	EC (dS/m^2)	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)	OC (%)	pH	EC (dS/m^2)	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)	OC (%)
0-25	T1	7.5	0.183	253	17	301	0.42	7.55	0.190	277	21.5	309.3	0.80
	T2	7.1	0.149	248	18	289	0.54	7.24	0.158	262	25.6	293.1	0.83
	T3	6.8	0.168	220	16	278	0.39	6.82	0.176	243	19.3	284.0	0.86
	T4	6.7	0.186	265	17	312	0.30	6.71	0.196	284	20.3	318.0	0.60
25-50	T1	7.4	0.170	234	17	277	0.31	7.43	0.181	248	21.6	286.0	0.78
	T2	7.1	0.168	217	15	242	0.51	7.11	0.173	241	18.1	256.0	0.81
	T3	6.9	0.178	167	9	269	0.44	6.9	0.181	178	13.0	276.1	0.83
	T4	6.8	0.190	240	12	265	0.30	6.81	0.198	251	16.0	278.1	0.58
50-100	T1	7.3	0.211	191	13	212	0.38	7.22	0.221	202	16.1	218.3	0.76
	T2	7.0	0.151	143	9	228	0.43	7.10	0.168	151	13.0	233.1	0.78
	T3	6.8	0.201	152	9	261	0.41	6.79	0.206	158	12.2	273.0	0.79
	T4	6.7	0.192	210	10	215	0.32	6.41	0.198	221	13.4	226.1	0.52

VII) Coconut leaf nutrient status and soil microbial population

Leaf nutrient status (%) and soil microbial population (CFU/g dry soil) in the coconut basin as influenced by coconut based INM system is

presented in Table 14. The nutrient content in the index leaf in respect of N, P and K differed among the treatments. After the 6th years of treatment initiation the mean N content was higher with the application of 75% of recommended NPK+25% of N through organic recycling with vermicompost (1.75%) followed by the application of 50% of RDF+50 % of N through organic recycling with vermicompost+vermiwash application + bio-fertilizer application + in situ green manuring (1.71%) as compared to the other two treatments. Also the P and K content were higher with treatment T_1 and T_2. It was observed that, as the recommended NPK was reduced, the leaf N, K content also found to be decreased, mainly because of the lower N and K supply through vermi-compost and reduced dose of recommended N. In general, it was found that, there was improvement in leaf nutrient status in respect of major and micronutrients due to different treatments compared to pre-experimental nutrient status. This is mainly attributed to timely application of nutrients and irrigation for the crop. It was observed from the data that N, P, K content of coconut leaf increased after four years from system.

Table 14 : Leaf nutrient status and soil microbial population (CFU/g dry soil) as influenced by coconut based INM system

Treat-ment	Leaf nutrient status						Soil microbial population (CFU/g dry soil) (2018-19)		
	2012-2013			2018-2019			Bacteria (10^5 CFU/g soil)	Fungi (10^4 CFU/g soil)	Actinomycetes (10^3 CFU/g soil)
	N (%)	P (%)	K (%)	N (%)	P (%)	K (%)			
T_1	1.50	0.12	1.2	1.75	0.18	1.31	95.0	153.0	134.0
T_2	1.40	0.14	1.0	1.71	0.16	1.26	89.0	148.0	136.0
T_3	1.38	0.13	0.9	1.53	0.11	1.24	77.0	166.0	112.0
T_4	1.48	0.14	1.1	1.49	0.10	1.20	42.0	59.0	67.0

VIII) Soil microbial population

The population of bacteria, fungi and actinomycetes in the basins of the coconut did differ among the various treatments, when analysed at 0-25 cm soil depth (Table 14). Though the top soil (0-25 cm depth) is the zone of intensive microbial activity and therefore, should have reflected changes undergoing in microbial community structure in response to extraneous inputs, which in present study are organic and inorganic fertilizers. However, the population of fungi were, in general, more in treatments T_3 where 100% of N through organic recycling with vermicompost + vermi-washapplication + bio-fertilizerapplication + in situ green manuring and green leaf manuring (glyricidia leaves) + composted coir pith, husk incorporation and mulching with coconut leaves was applied as compared to other treatments. The bacteria and actinomycetes present in top soil were higher in treatment T_1 and T_2 respectively. Also the earthworm population were highest in the treatment T_3 followed by the treatment T_1 and T_2 (Table 14).

3) CARBONSEQUESTRATION UNDER COCONUT BASED CROPPING SYSTEM

a) Above ground carbon sequestration of crops

From the data (Table 15) it was observed that, among the different integrated nutrient management systems, the above ground standing biomass (SDW) and above ground carbon stock (353.25 kg/plant and 31.06 t/ha, respectively) was significantly the highest in the treatment T_1 followed by T_2 (345.10 kg/plant and 30.34 t/ha) and T_3 (310.33 kg/plant and 27.27 t/ha), respectively. The lowest above ground biomass and carbon stock were observed in coconut monocrop (288.8 kg/plant and 25.6 t/ha, respectively). This is because the intercrops in coconut based cropping system have added additional biomass production than monocrop, hence the carbon stock was the highest in the cropping system plots compared to monocrop of coconut. Furthermore, the CO_2 sequestered also followed the same trend and accordingly, the highest CO2 sequestration was recorded in the treatment T_1 (114.02 t/ha) followed by T_2 (111.35 t/ha) and T_3 (100.22 t/ha). The lowest CO_2 sequestration was noticed in coconut monocrop (93.8 t/ha). Trees are carbon reservoir on earth and in nature, forest ecosystem act as a reservoir of carbon and store huge quantity of carbon and regulate the carbon cycle by exchange of CO_2 from the atmosphere. Thus, forest ecosystem plays significant role in the global carbon cycle by sequestering a substantial amount of carbon dioxide from the atmosphere by storing it in the biosphere.

Table 15 : Influence of intercrops and integrated nutrient management practices on above ground carbon sequestration under coconut garden

Crop	Treatment	Plant height (m)	Plant girth (m)	Stem dry weight (SDW) (Biomass) (kg/plant)	Carbon stock (kg/plant)	Carbon stock (t/ha)*	CO2 sequestered (t/ha)*
Coconut	T1	11.8	0.84	343.5	171.8	30.4	111.6
	T2	10.7	0.89	335.6	167.8	29.7	109.0
	T3	11.6	0.79	303.4	151.7	26.8	98.5
	T4	10.4	0.81	288.8	144.4	25.6	93.8
	Mean	11.1	0.83	317.8	158.9	28.1	103.2
	SE d±	0.39	0.05	5.8	3.07	0.7	0.67
	CD (P=0.05)	1.24	0.17	18.6	9.82	2.24	2.14
Nutmeg	T1	3.04	0.28	9.7	4.87	0.66	2.42
	T2	3.18	0.26	9.5	4.75	0.64	2.35
	T3	2.53	0.23	6.9	3.46	0.47	1.72
	Mean	2.92	0.26	8.73	4.36	0.59	2.16
	SE d±	0.16	0.01	0.35	0.25	0.02	0.17
	CD (P=0.05)	0.56	0.04	1.22	0.86	0.06	0.58

Note : * indicates 177 palms ha-1 in coconut and 135 nutmeg trees ha-1coconut garden. . SDW = stem dry weight, C = carbon

b) Soil bulk density and organic carbon

The data presented in Table 16 represents bulk density of soil (g/cm^3), soil organic carbon (%) and soil carbon stock (t/ha) at 0-30 and 31-60 cm depth in the rhizosphere of different crops in the system. With respect to bulk density, there was no significant difference found among the different cropping system and INM practices at both the depths during the course of study. Whereas, the organic carbon (OC) content differed significantly among the treatments at both thedepths. Among the different crops, the significantly the highest soil organic carbon (0.86% and 0.81%) was documented in coconut basin at 0-30 and 31-60 cm depth in the treatment T_3 which was on par with treatment T_2 and T_1. The coconut basin in the monocropping recorded significantly the lowest organic carbon at both the depths (0.60 and 0.51 %). The rhizosphere of intercrops like nutmeg, cinnamon, pineapple and banana also recorded higher organic carbon content, whereas in the interspace of monocropping, it was significantly lower (0.46 and 0.44 %). Growing intercrops in the coconut garden has lead to addition of recyclable biomass from the intercrops and which has resulted in improvement in the organic carbon content.

Table 16 : Effect of intercrops and integrated nutrient management practices on organic carbon, soil bulk density and soil carbon stock under coconut based cropping system

INM practices	Crop	Organic carbon (%)		Bulk density (gcm-3)		Soil carbon stock (t/ha)	
		0-30 cm	31-60 cm	0-30 cm	31-60 cm	0-30 cm	31-60 cm
T_1	Coconut	0.81a	0.77a	1.62	1.64	39.36a	37.88a
	Nutmeg	0.64b	0.61bc	1.60	1.63	30.72b	29.82b
	Cinnamon	0.61cd	0.56c	1.61	1.63	29.46bc	27.38c
	Banana	0.63b	0.57cd	1.62	1.64	30.61b	28.04cd
	Pineapple	0.60cd	0.54cd	1.60	1.62	28.80cd	26.24d
T_2	Coconut	0.83a	0.78a	1.63	1.64	40.58a	38.37a
	Nutmeg	0.66b	0.62bc	1.62	1.63	32.07b	30.31b
	Cinnamon	0.63cd	0.58d	1.62	1.64	30.61bc	28.53c
	Banana	0.67b	0.61cd	1.63	1.64	32.76b	30.01bc
	Pineapple	0.62cd	0.56d	1.60	1.62	29.76bc	27.21d
T_3	Coconut	0.86a	0.81a	1.64	1.64	42.31a	39.85a
	Nutmeg	0.67b	0.62b	1.62	1.63	32.56b	30.31bc
	Cinnamon	0.66b	0.60cd	1.62	1.64	32.07b	29.52c
	Banana	0.68b	0.63b	1.62	1.64	33.04b	30.99b
	Pineapple	0.65bc	0.60cd	1.62	1.64	31.59bc	29.52c
T_4	Coconut (monocrop)	0.60cd	0.51cd	1.58	1.60	28.44cd	24.17d
	Interspace	0.46e	0.44e	1.59	1.60	21.94e	21.12e
	CD (P=0.05)	0.048	0.79	NS	NS	2.14	3.32

c) Soil carbon stock

The soil carbon stock was significantly influenced by the coconut based cropping system and INM practices (Table 16). Among the different crops under investigation, the coconut rhizosphere in the treatment T_3 had significantly higher soil carbon stock (42.31 t/ha and 39.85 t/ha) in the depths of 0-30 and 31-60 cm followed by treatment T_2 (40.58 t/ha and 38.37 t/ha) and T_1 (39.36 t/ha and 37.88 t/ha). The lowest soil carbon stock of 28.44 t/ha and 24.17 t/ha at 0-30 and 30-60 cm depth was noticed in the coconut rhizosphere in monocrop (T_4). Among the different integrated nutrient management practices in coconut based cropping system, significantly the highest soil carbon stock was observed in the treatment T_3 at 0-30 and 31-60 cm depth in the rhizosphere of different crops followed by T_2 and T_1. The lowest soil carbon stock in the coconut monocrop (T_4) might be due to absence of intercrops in the interspace which might not have contributed to soil carbon pool. Furthermore, the coconut basin rhizosphere has recorded higher carbon stock at both depths (0-30 and 31-60 cm), which might be due to increase in organic carbon in the soil owing to decomposition of root system over a period of time as compared to other crops and organic manure incorporation to the coconut crop and interaction effect of organic manure and green manure incorporation.

4) ECONOMICS AND EMPLOYMENT GENERATION UNDER COCONUT BASED CROPPING SYSTEM

a) Economics

The total cost involved in maintaining the system under various integrated nutrient management was ranged from Rs. 123769.60 (T_3) to 63639.00 (T_4). The net returns (Rs. 131605.8) were highest in treatment T_1 i.e. application of 75% of recommended NPK +25% of N through organic recycling with vermicompost with the highest cost benefit ratio of 1: 2.69.

Table 17 : Economics (per ha) of coconut based INM system
(Average of five years data from 2013-14 to 2017-18)

Treatment	Cost of cultivation (Rs.)	Gross returns (Rs.)	Net returns (Rs.)	B:C
T_1	105185	283456	131605	2.69
T_2	113026	259871	122868	2.29
T_3	123769.6	238529	114759	1.92
T_4	63639.0	102374	38735	1.60

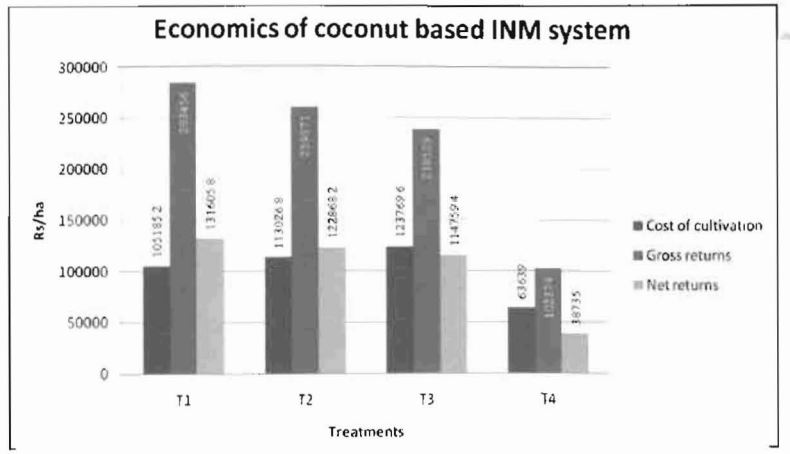


Fig 4: Economics of coconut based INM system

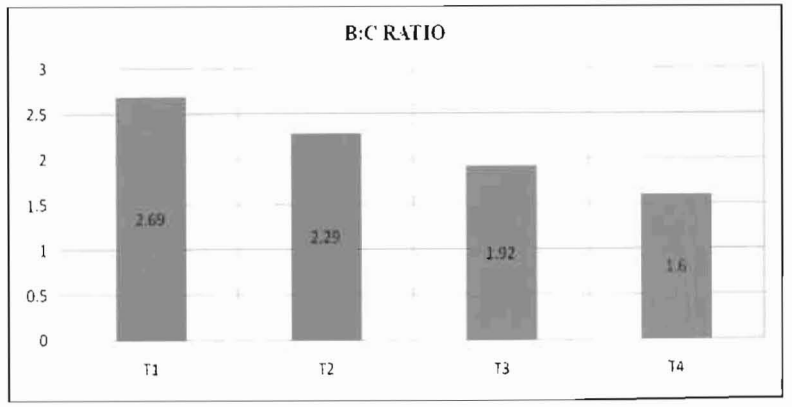


Fig 5: Benefit: cost ratio of coconut based INM system

b) Employment generation -

The employment potential of the coconut based cropping system is observed to be very high. The labour input utilization of irrigated monocrop of coconut (at its stabilized yield stage) is 157 man days/ha/year. The labour utilization in the coconut cropping system with banana, pineapple, cinnamon and nutmeg was 297 days/ha/year. In percentage term, the increase was about 189 per cent over the sole crop system. Since it is expected that the bulk of the labour force is available from the family source of the farmer, family labour income could therefore be considerably raised when coconut based cropping system was adopted.

5. CONCLUSION

Integrated nutrient management by using 2/3rd recommended fertilizer dose along with recycling of biomass by vermin composting gives the best economic benefit in a sustainable manner. INM on coconut based cropping system demonstrated model to the farmer to integrate nutrient management in a cropping system. The system is more sustainable and production and productivity will increase without affecting the ecosystem. There is a positive impact through improvement of soil health by recycling of waste products in the system as organic manures. Further it will be eco-friendly with nature which will enable to increase the production and productivity of the system.

Aerial view

1991

2019

ICAR- AICRP on Palms, Regional Coconut Research Station,
Bhatye, Ratnagiri (M.S.) 415 612

Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri

Jowar (Sorghum) Cultivation in India

JOWAR PRODUCTION

Table of Contents

Jowar Production in India: An In-Depth Overview

Jowar, known as **Sorghum** in English, is a cereal grain that plays a vital role in food security, especially in dryland areas of India. It is one of the most important crops in India after rice, wheat, and maize, primarily cultivated in regions with arid and semi-arid climates. Sorghum has a long history of

cultivation in India, with its resilient properties making it an essential part of the agricultural landscape, especially in rainfed areas.

1. Importance of Jowar in India

Jawar is an essential crop for food, fodder, and bioenergy production in India. It is primarily used as:

- **Food**: Jowar flour is used in the preparation of various traditional dishes, especially in southern and western India. It's used in making roti (flatbreads), porridge, and as an ingredient in several regional specialties.
- **Fodder**: It is a major livestock feed, as its stalks, leaves, and grains serve as valuable fodder, particularly in drought-prone areas.
- **Industrial Use**: Sorghum is used in the production of ethanol and biogas. Additionally, its gluten-free nature makes it a growing ingredient in health foods and specialty diets.

2. Distribution and Major Producing States

India is one of the largest producers of Jowar globally, contributing significantly to the world's production. The major states involved in jawar cultivation are:

- **Maharashtra**: The largest producer of Jowar, particularly in the Vidarbha, Marathwada, and Khandesh regions.
- **Karnataka**: Another key contributor, particularly in its dryland areas.
- **Andhra Pradesh** and **Telangana**: These states, particularly in their rainfed areas, also grow significant quantities of Jowar.
- **Rajasthan**: Has substantial production in arid regions.
- **Gujarat**, **Madhya Pradesh**, and **Tamil Nadu**: These states also contribute to the total production of jawar.

In these areas, Jowar is mainly grown under rainfed conditions, making it an ideal crop for regions with low irrigation availability.

3. Climatic Conditions for Jowar Cultivation

Jowar is well-suited to warm, dry conditions. It requires:

- **Temperature**: The ideal temperature range for Jowar cultivation is between 25°C to 32°C.
- **Rainfall**: While the crop thrives in dry conditions, it requires a minimum of 400-600 mm of rainfall per year, which is why it's grown in areas with monsoon-dependent rainfed agriculture.
- **Soil**: Jowar can grow in a variety of soils, particularly well-drained, sandy loam, and clay soils. It is known for its drought-tolerant properties and ability to grow in poor soil conditions.

The crop is particularly popular in regions with erratic rainfall, as it can survive with minimal irrigation compared to more water-intensive crops like rice and wheat.

4. Cultivation Practices and Sowing

Varieties of Jowar:

There are two major varieties of Jowar grown in India:

- **Grain Sorghum**: Grown for its edible seeds, primarily used for food.

Uttarakhand: Dev Bhoomi
Punjab
Uttar Pradesh
Haryana
Rajasthan

Cities of India

Cities/Towns/Villages of India
Chennai
Mumbai
Delhi
Kolkata
Lucknow
Bengaluru
Pune
Nagpur
Madurai

Current Affairs

Competitive Examinations
Quotes every Indian must know by heart
Public Sector Undertakings
Maharatna, Navratna, Miniratna Companies

- **Forage Sorghum**: Grown primarily for fodder, it has larger leaves and stalks.

for Jowar sowing in India is during the monsoon, typically from June to July.

- **Rabi Season**: In some regions with irrigation, Jowar can also be sown in the Rabi season (October-November), although this is less common than Kharif sowing.

Land Preparation:

- **Ploughing**: The land is ploughed and leveled to create a smooth seedbed.
- **Seed Treatment**: To prevent diseases, seeds may be treated with fungicides before sowing.

Sowing Methods:

Jowar is typically sown by **broadcasting** or in **rows** using a seed drill. The seed rate varies from 8 to 10 kg per hectare for grain varieties and higher for fodder varieties.

5. Fertilization and Irrigation

- **Fertilizer Application**: Jowar is a relatively low-input crop. However, balanced fertilization is recommended for higher yields. Typically, a dose of **40-60 kg of nitrogen**, **20-30 kg of phosphorus**, and **30-40 kg of potassium** per hectare is applied.
- **Irrigation**: While Jowar is drought-tolerant, supplemental irrigation may be provided during dry spells. In rainfed regions, it relies mostly on natural rainfall.

6. Pest and Disease Management

Jowar is susceptible to several pests and diseases, which can affect yield if not managed properly:

- **Pests**: Key pests include the **sorghum shoot fly**, **sorghum midge**, **stalk borer**, and **aphids**.
- **Diseases**: Sorghum can suffer from **downy mildew**, **grain mold**, and **rust** diseases. Crop rotation and the use of disease-resistant varieties can help mitigate these issues.

7. Harvesting and Post-Harvest Management

- **Harvesting**: Jowar is ready for harvest when the grains turn hard and the leaves start turning yellow. The crop is harvested using sickles or mechanical harvesters. Harvesting typically occurs in September to October for Kharif crops.
- **Post-Harvest Management**: After harvesting, the grains are dried in the sun to reduce moisture content, which helps prevent spoilage during storage. The harvested grain is usually stored in a cool, dry place in sacks or containers. Sorghum grains can be milled into flour for food purposes or used as livestock feed.

8. Challenges in Jowar Production

- **Climate Change**: Erratic rainfall patterns, prolonged droughts, and extreme weather events due to climate change pose a significant threat to Jowar production.
- **Low Productivity**: Despite its resilience, productivity of Jowar in India is lower compared to other countries, due to factors like outdated farming practices, pest infestations, and inadequate irrigation facilities.
- **Market Support**: While Jowar is an important crop for food and fodder, its market price often fluctuates, and the lack of a strong supply chain and storage infrastructure leads to price volatility.

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- **Shifting Preferences**: The popularity of rice and wheat has led to a decline in Jowar cultivation, particularly in states where more water-intensive crops are favored.

9. Future Prospects and Government Initiatives

To boost Jowar production and its marketability, the Indian government has taken several steps:

- **Promotion of Sorghum-Based Products**: There has been an increased focus on promoting sorghum as a health food due to its high fiber and antioxidant content, gluten-free properties, and suitability for diabetic diets.
- **Research and Development**: The government and agricultural universities are working to develop higher-yielding, pest-resistant, and drought-tolerant varieties of Jowar.
- **Agricultural Schemes**: Various schemes, such as the **National Food Security Mission (NFSM)**, provide subsidies and support for the development of rainfed agriculture, including sorghum production.

Conclusion

Jowar remains a crucial crop for India's food security, particularly in dryland and rainfed areas. It plays a vital role in the agricultural economy by providing both food and fodder. Despite challenges such as low productivity and climate change, with appropriate policy support, better farming techniques, and market linkages, the future of Jowar production in India looks promising. Further investment in research, infrastructure, and farmer education can help India achieve sustainable growth in Jowar production, ensuring that it remains a key staple for millions of people across the country.

Key Terms:

climate change impact on Jawar , drought-tolerant crops , government support for Sorghum , Jawar crop challenges , Jawar farming , Jawar for food and fodder , Jawar production in India , Jawar yield , Karnataka Sorghum , Maharashtra Jawar , rainfed agriculture , Sorghum crop India , Sorghum cultivation , Sorghum market in India , sustainable Jawar farming

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Jowar Crop Cultivation

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Introduction

Jowar Crop, scientifically known as Sorghum bicolor, is a versatile cereal crop widely cultivated for its grains, fodder, and biofuel potential. Originating from Africa, jowar has become a staple food crop in many regions of the world due to its adaptability to diverse agro-climatic conditions and nutritional value. In this detailed guide, we delve into the agronomy of jowar cultivation, covering its scientific background, geographic distribution, economic importance, seed characteristics, cultivation practices, water management, harvesting techniques, major diseases, and yield potential.

Scientific Background

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# of Jowar

- **Scientific Name**: Sorghum bicolor
- **Origin**: Africa
- **Geographic Distribution**: Cultivated worldwide, with major production regions in Africa, Asia, and the Americas.
- **Economic Importance**: Jowar is a significant food and fodder crop, providing sustenance for millions of people and livestock worldwide. It is also used for biofuel production and industrial applications.

Seed Characteristics and Seed Rate

- **Seed**: Jowar seeds are small, oval-shaped, and usually reddish-brown or white in color. They have a hard outer seed coat and contain a starchy endosperm.
- **Seed Rate**: The recommended seed rate for jowar varies depending on factors such as soil type, planting method, and spacing. Generally, the seed rate ranges from 8 to 10 kg per hectare for dryland cultivation and 12 to 15 kg per hectare for irrigated cultivation.

Advantages of Transplanted Jowar Crop

1. **Early Establishment**: Transplanted jowar crops establish earlier than direct-seeded ones, as seedlings have already developed roots and foliage before being transplanted into the main field.
2. **Uniform Planting**: Transplanting allows for precise spacing and distribution of jowar seedlings in the field, ensuring uniform plant density and arrangement. This uniformity promotes efficient use of resources such as water, nutrients, and sunlight, leading to more consistent growth and yield across the field.
3. **Optimized Plant Spacing**: With transplanted jowar crops, farmers have greater control over plant spacing and population density, allowing them to tailor planting patterns according to soil fertility, moisture availability, and crop variety. Optimal plant spacing facilitates better light interception, airflow, and nutrient uptake, maximizing crop productivity.
4. **Improved Crop Management**: Transplanted jowar crops are easier to manage in terms of irrigation, fertilization, and pest control compared to direct-seeded crops. Farmers can accurately monitor and adjust inputs based on the growth stage and condition of individual plants, optimizing resource use efficiency and minimizing crop stress.
5. **Reduced Weed Competition**: By establishing a dense and uniform crop stand early in the season, transplanted jowar crops suppress weed growth and competition more effectively than direct-seeded crops. This reduces the need for herbicide applications and manual weeding, saving labor and reducing production costs.
6. **Enhanced Stress Tolerance**: Transplanted jowar seedlings are

Cultivation of Sapota (Chikoo) Crop

better equipped to withstand environmental stresses such as drought, heat, and pest pressure compared to seeds sown directly into the soil. Their advanced root and shoot development provide resilience against adverse conditions, ensuring more consistent yield performance.

7. **Extended Growing Season**: Transplanted jowar crops often have a longer growing season and extended reproductive period compared to direct-seeded crops, allowing for additional tillering, flowering, and grain filling stages. This prolonged growth period enhances yield potential and grain quality, contributing to overall profitability.
8. **Facilitated Crop Rotation**: Transplanted jowar cultivation facilitates crop rotation and intercropping practices, as seedlings can be transplanted into prepared fields after the harvest of preceding crops. This rotational flexibility helps break disease cycles, improve soil health, and diversify farm income streams.

Nursery Practices for Transplanted Jowar

1. **Seedbed Preparation**:
   - Prepare a well-drained seedbed with fine tilth and adequate moisture retention capacity.
   - Level the seedbed surface to ensure uniform germination and seedling emergence.
   - Incorporate organic matter such as compost or farmyard manure to improve soil fertility and structure.
2. **Seed Treatment**:
   - Treat jowar seeds with fungicides or biocontrol agents to protect against seed-borne diseases such as damping-off and seedling blight.
   - Use recommended seed treatments and follow label instructions to ensure effective disease control without harming seed viability.
3. **Seed Sowing**:
   - Sow jowar seeds in nursery trays, seedbeds, or containers filled with well-prepared soil.
   - Maintain proper seed spacing and depth to facilitate seed germination and emergence.
   - Cover the seeds lightly with soil and gently firm the surface to ensure good seed-to-soil contact.
4. **Moisture Management**:
   - Maintain optimal soil moisture levels in the nursery to promote seed germination and early seedling growth.
   - Use drip irrigation, sprinklers, or manual watering methods to provide consistent moisture without waterlogging or drying out the soil.
   - Monitor soil moisture regularly and adjust irrigation frequency and duration as needed based on weather conditions and crop growth stage.
5. **Temperature and Light**:
   - Provide adequate light and warmth for seed germination and seedling development by placing the nursery in a sunny location or using artificial lighting.
   - Protect seedlings from extreme temperatures, frost, and wind damage by using shade nets or row covers as needed.
6. **Weed Control**:
   - Implement weed control measures in the nursery to minimize competition for nutrients, water, and light.

- Remove weeds manually or use herbicides judiciously following label instructions to avoid damage to jowar seedlings.

7. **Nutrient Management**:
   - Apply balanced fertilizer doses to nursery soil or use nutrient-rich compost to support healthy seedling growth.
   - Monitor nutrient levels in the soil and adjust fertilization practices based on soil test results and crop nutrient requirements.
8. **Thinning and Transplanting**:
   - Thin out overcrowded seedlings in the nursery trays or seedbeds to maintain optimum plant density and spacing.
   - Select healthy and vigorous seedlings for transplanting into the main field, discarding weak or diseased ones.
   - Transplant seedlings at the recommended age and growth stage (typically 3-4 leaf stage) to minimize transplant shock and ensure successful establishment in the field.

Water Management in Jowar Cultivation

- **Irrigation**: Provide timely and adequate irrigation during critical growth stages such as germination, tillering, flowering, and grain filling.
- **Water Conservation**: Implement water-saving techniques such as drip irrigation, mulching, and soil moisture monitoring to optimize water use efficiency.
- **Rainfed Cultivation**: Jowar is well-adapted to rainfed cultivation in regions with adequate rainfall and moisture-retentive soils. Proper soil and water conservation practices are essential for rainfed jowar production.

Table 1: Recommended Water Requirements for Jowar

Growth Stage	Water Requirement (mm)
Germination	20-30
Tillering	40-60
Flowering	80-100
Grain Filling	60-80

Main Field Preparation

1. **Land Selection and Clearing**:
   - Choose well-drained fields with good soil fertility, adequate sunlight, and proper water availability for jowar cultivation.
   - Clear the selected land of any debris, rocks, weeds, and crop residues to create a clean and uniform planting surface.
2. **Fertilizer Application**:
   - Apply balanced fertilizers based on soil test recommendations and jowar nutrient requirements.
   - Incorporate fertilizers evenly into the soil during land preparation to ensure uniform distribution of nutrients and promote healthy plant growth.
3. **Seedbed Preparation**:
   - Create seedbeds or planting rows with proper spacing and

orientation to facilitate jowar planting and subsequent crop management activities.
- Use row markers or planting guides to ensure straight and uniform rows, optimizing plant spacing and population density.

4. **Weed Control**:
   - Control weeds in the main field through pre-planting herbicide applications, manual weeding, or mechanical cultivation.
   - Maintain weed-free conditions during jowar establishment to reduce competition for nutrients, water, and light.

Harvesting and Threshing of Jowar

- **Harvesting**: Harvest jowar crops when grains are fully matured and moisture content is below 20%. Cut the panicles with sickles or mechanical harvesters and bundle them for threshing.
- **Threshing**: Thresh the harvested panicles to separate grains from the stalks using manual or mechanical threshers. Clean and dry the grains before storage.

Rainfed Jowar Cultivation

1. **Selection of Suitable Varieties**:
   - Choose jowar varieties that are well-adapted to rainfed conditions and have traits such as drought tolerance, early maturity, and good yield potential under moisture stress.
2. **Timing of Planting**:
   - Plant jowar seeds at the onset of the rainy season when soil moisture levels are sufficient for germination and early growth.
   - Timing may vary depending on local climate patterns and rainfall distribution, but planting typically occurs during the early monsoon months.
3. **Seed Rate and Spacing**:
   - Use appropriate seed rates and spacing to optimize plant population density and resource utilization in rainfed jowar fields.
   - Higher seed rates may be recommended to compensate for lower germination rates and establishment success under variable moisture conditions.
4. **Soil Preparation**:
   - Prepare the soil well in advance of planting to ensure good seed-to-soil contact and adequate soil moisture retention.
   - Implement soil conservation measures such as contour plowing, mulching, and soil bunds to minimize soil erosion and conserve moisture.

Ratoon Sorghum Crop

- **Definition**: Ratoon sorghum refers to the regrowth of jowar plants from stubble or rootstocks after the initial harvest.
- **Advantages**: Ratoon cropping allows for multiple harvests from a single planting, reducing production costs and increasing overall crop productivity. It also helps improve soil health and fertility by adding organic matter and enhancing nutrient cycling.

Yield Potential of Jowar

- **Yield**: The average yield of jowar varies depending on factors such as variety, agro-climatic conditions, and management practices. Under optimal conditions, jowar yields can range from 1 to 3 tonnes per hectare.

Table 2: Comparative Yield Potential of Jowar Varieties

Variety	Yield Potential (tonnes/ha)
Hybrid Varieties	2.5-3.0
Improved Varieties	2.0-2.5
Local Varieties	1.0-1.5

Major Diseases of Jowar

1. Grain Mould:

- **Symptoms**: Grain mould manifests as discolored, moldy, and shriveled jowar grains with a foul odor. Infected grains may have a slimy or powdery appearance, indicating fungal growth.
- **Survival and Spread**: Grain mould pathogens survive in soil and crop debris, infecting jowar grains during flowering and grain filling stages. Spread occurs through wind, rain splash, and contaminated seeds.
- **Favorable Conditions**: Warm and humid conditions during flowering and grain maturation favor grain mould development. Poor crop sanitation and high plant density increase disease incidence.

2. Charcoal Rot:

- **Symptoms**: Charcoal rot initially causes wilting and yellowing of jowar plants, followed by dark, sunken lesions on stems and roots resembling charcoal. Infected plants wilt and die prematurely.
- **Survival and Spread**: Charcoal rot survives in soil and plant debris as sclerotia, which germinate under warm and dry conditions.

Spread occurs through irrigation water, farm equipment, and infected seeds.
- **Favorable Conditions**: High temperatures (above 30°C) and water stress promote charcoal rot development. Sandy soils with poor drainage and low organic matter are conducive to disease.

3. Downy Mildew:

- **Symptoms**: Downy mildew appears as pale yellow to orange lesions on jowar leaves, accompanied by white to grayish fungal growth on the lower leaf surface. Severe infections cause leaf curling, stunting, and plant death.
- **Survival and Spread**: Downy mildew pathogens survive as oospores in soil and as sporangia on infected plant debris. Spread occurs through wind, rain splash, and infected seeds.
- **Favorable Conditions**: Cool and moist conditions (20-25°C) with high humidity favor downy mildew development. Overcrowded planting and poor air circulation increase disease severity.

4. Leaf Spot:

- **Symptoms**: Leaf spot diseases cause small, circular to irregular lesions on jowar leaves, which may coalesce and lead to extensive leaf necrosis and defoliation. Severe infections weaken plants and reduce yield.
- **Survival and Spread**: Leaf spot pathogens survive in soil and crop debris as spores or mycelium. Spread occurs through rain splash, wind, and contaminated farm equipment.
- **Favorable Conditions**: Warm and humid conditions with frequent rainfall favor leaf spot development. Dense plant canopy, poor air circulation, and prolonged leaf wetness increase disease severity.

5. Red Rot:

- **Symptoms**: Red rot causes reddish-brown discoloration and rotting of jowar stalks and panicles, with sunken lesions and black fungal structures (acervuli) on the surface. Infected panicles may show discoloration and decay.
- **Survival and Spread**: Red rot survives in soil and infected plant debris as mycelium and sclerotia. Spread occurs through rain splash, wind, and contaminated seeds.
- **Favorable Conditions**: Warm temperatures (25-30°C) and high humidity promote red rot development, especially during flowering and grain filling stages. Poor drainage and excessive irrigation exacerbate disease severity.

6. Loose Smut:

- **Symptoms**: Loose smut causes elongated, swollen structures filled

with dark brown to black spores on jowar panicles and seeds. Infected seeds may become distorted, discolored, or replaced entirely by smut spores.
- **Survival and Spread**: Loose smut survives in soil and infected seeds as teliospores. Spread occurs through wind, rain splash, and contaminated planting material.
- **Favorable Conditions**: Cool and moist conditions (15-20°C) during flowering and grain filling stages favor loose smut development. Overcrowded planting and poor seed quality increase disease incidence.

7. Rust:

- **Symptoms**: Rust diseases cause orange to reddish-brown pustules or lesions on jowar leaves, stems, and panicles, leading to yellowing, wilting, and premature senescence of infected tissues.
- **Survival and Spread**: Rust pathogens survive in soil and infected plant debris as spores or mycelium. Spread occurs through wind, rain splash, and contaminated seeds.
- **Favorable Conditions**: Moderate temperatures (20-25°C) and high humidity promote rust development, especially during cool, wet weather. Dense plant canopy and prolonged leaf wetness increase disease severity.

8. Ergot:

- **Symptoms**: Ergot infects jowar flowers and seeds, causing the development of elongated, dark purple to black sclerotia in place of seeds. Infected seeds may contain toxic alkaloids, posing health risks to humans and livestock.
- **Survival and Spread**: Ergot survives in soil and infected seeds as sclerotia. Spread occurs through wind, rain splash, and contaminated planting material.
- **Favorable Conditions**: Cool and moist conditions (15-20°C) during flowering and seed development stages favor ergot development. Overcrowded planting and poor seed quality increase disease incidence.

1.

Conclusion

In conclusion, jowar cultivation offers significant potential for sustainable food production, fodder supply, and economic development in diverse agro-ecosystems worldwide. By understanding the agronomy of jowar cultivation, farmers can adopt best practices to maximize yield, minimize risks, and enhance profitability. From seed selection to harvest, proper management of water, nutrients, pests, and diseases is essential for successful jowar production. By harnessing the resilience and adaptability of jowar crops, farmers can contribute to food security, livelihood improvement, and environmental sustainability in their communities.

References and Links

1. International Crops Research Institute for the Semi-Arid Tropics

Complete Process of Jowar Cultivation in India

1. Favorable Climate

- **Temperature**: Thrives best in temperatures **between 26°C and 33°C**.
- **Rainfall**: Requires **30–100 cm** of rainfall; excessive moisture can harm the crop.
- **Growing Season**:
  - **Kharif (June-July planting, October-November harvesting)** – requires moderate rainfall.
  - **Rabi (September-October planting, January-February harvesting)** – cultivated in low rainfall areas.
  - **Summer (January-February planting, May-June harvesting)** – requires irrigation support.

2. Suitable Soil

- **Best Soil Type**: Well-drained, **medium to deep black soil, sandy loam, or red soil**.
- **pH Range**: **6.0 to 7.5** is ideal.
- **Waterlogging**: Jowar is **drought-resistant** but sensitive to waterlogging.

3. Selection of Planting Material (Seeds)

- **Recommended Hybrid and Improved Varieties**:
  - **Kharif Varieties**: CSH-5, CSH-9, CSV-10, CSV-15
  - **Rabi Varieties**: M 35-1, CSV-216R
  - **Dual-Purpose (Grain + Fodder) Varieties**: CSH 13, CSH 16, SPV 462
- **Seed Rate**:
  - **Rainfed conditions**: **8–10 kg/ha**
  - **Irrigated conditions**: **12–15 kg/ha**
- **Seed Treatment**:
  - Treat with **Thiram or Captan (2 g/kg of seed)** to prevent fungal diseases.
  - Soak seeds in **1% Potassium Chloride solution** for 6 hours to improve germination.

4. Nursery Preparation

- Direct sowing is preferred; nursery raising is done only for **transplanting in high-yielding systems**.
- For nursery-based cultivation:
  - Use **raised beds** with well-decomposed organic manure.
  - Maintain **moist but not waterlogged soil conditions**.

5. Land Preparation

- **Plowing**: Deep plowing **twice** followed by harrowing.
- **Leveling**: Ensures uniform water distribution.
- **Soil Enrichment**: Apply **10-15 tons of FYM (Farmyard Manure) per hectare** before last plowing.

6. Sowing, Spacing, and Plant Population

- **Sowing Methods**:
    - **Broadcasting** (Traditional, uneven plant distribution).
    - **Line Sowing** (Recommended for better yield).
    - **Drilling** (Using seed drills for uniform depth).
- **Spacing**:
    - **Grain Purpose**: **45 cm × 12 cm** (ideal plant population of **1,85,000 plants/ha**).
    - **Fodder Purpose**: **30 cm × 10 cm** (higher plant density).
    - **High-Density Farming**: **22 cm × 5 cm** (for silage and biomass).

7. Root Dip Treatment (For Transplanting Systems)

- In cases where seedlings are raised in nurseries:
    - Dip roots in **Azospirillum biofertilizer** (to enhance nitrogen fixation).
    - Treat with **Bavistin (fungicide) at 0.2%** before planting.

8. Sowing/Transplanting Process

- **Best Time**:
    - Kharif: June-July
    - Rabi: September-October
    - Summer: January-February
- **Depth**: Sow at **2-4 cm depth**.
- **Water Management**: If rainfall is insufficient, apply **light irrigation immediately after sowing**.

9. Nutrient Management (Fertilization Schedule)

Growth Stage	Fertilizer Requirement (Per Hectare)
Before Sowing	10-15 tons FYM + 20 kg P_2O_5 + 40 kg K_2O
15-20 Days After Sowing	40 kg Nitrogen (Urea)
35-40 Days After Sowing	40 kg Nitrogen (Urea)

- **Micronutrient Spray**:
    - **Zinc sulfate (0.5%)** if zinc deficiency is observed.

- **Boron spray (0.2%)** improves grain quality.

10. Irrigation and Water Management

- **Critical Growth Stages for Irrigation**:
    1. Germination
    2. Flowering
    3. Grain Formation
- **Number of Irrigations**:
    1. **Rainfed crops**: 2-3 irrigations during drought.
    2. **Irrigated crops**: 5-6 irrigations, depending on soil type.
- **Water Conservation**:
    1. **Mulching** with crop residues helps retain moisture.
    2. **Intercropping** with legumes improves water-use efficiency.

11. Weed and Pest Management

- **Weed Control**:
    - **Pre-emergence herbicide**: Atrazine (0.5 kg/ha).
    - **Manual Weeding**: At 15 and 30 days after sowing.
- **Pests & Diseases**:
    - **Stem Borer**: Spray **Chlorantraniliprole (0.1%)**.
    - **Shoot Fly**: Apply **Carbofuran granules (5%)** in the soil.
    - **Grain Mold**: Spray **Mancozeb (0.3%)** during flowering.

12. Harvesting and Expected Yield

- **Maturity Duration**:
    - **Kharif Crop**: 100-120 days
    - **Rabi Crop**: 120-140 days
    - **Summer Crop**: 90-100 days
- **Signs of Maturity**:
    - Grains become **hard and glossy**.
    - Moisture content reduces to **20%**.
- **Yield per Hectare**:
    - **Rainfed conditions**: **15-20 quintals/ha**.
    - **Irrigated conditions**: **35-40 quintals/ha**.
    - **Fodder Yield**: **40-50 tons/ha**.

Financial Analysis of Jowar Cultivation in Maharashtra (Per Hectare)

1. Expected Cost of Cultivation

Input	Cost (Rs)
Land Preparation	6,000
Seed Cost (10-15 kg)	2,500
Fertilizers & FYM	8,000
Agrochemicals	3,500
Irrigation	5,000
Labor (Weeding, Harvesting)	10,000
Miscellaneous	5,000
Total Cost	**40,000**

2. Expected Income (Per Hectare)

Item	Details	Income (Rs)
Yield	**35 quintals (3500 kg)**	-
Market Rate	Rs **30/kg**	-
Total Income	**3500 × 30**	**1,05,000**

3. Profit Estimation

| Total Revenue | 1,05,000 |
| Total Cost | 40,000 |
| Net Profit | 65,000 |

2. Diseases of Sorghum

Downy Mildew - *Peronosclerospora sorghi*

Symptoms

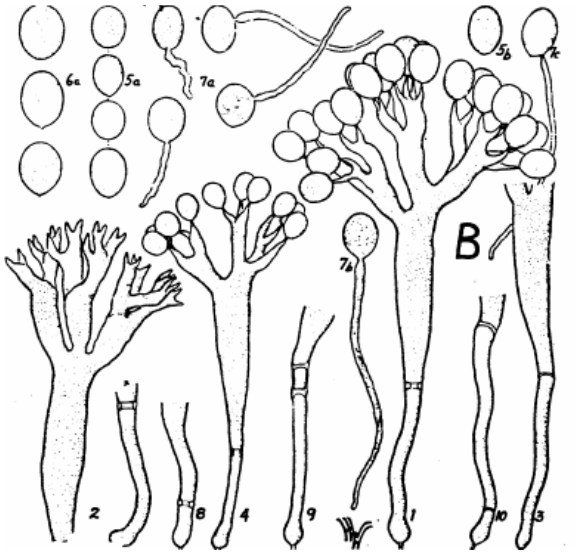
The fungus causes systemic downy mildew of sorghum. It invades the growing points of young plants, either through oospore or conidial infection. As the leaves unfold they exhibit green or yellow colouration. Abundant downy white growth is produced on the lower surface of the leaves, which consists of sporangiophores and sporangia.

Symptoms

Normally three or four leaves develop the chlorotic downy growth. Subsequent leaves show progressively more of a complete bleaching of the leaf tissue in streaks or stripes. As the infected bleached leaves mature they become necrotic and the interveinal tissues disintegrate, releasing the resting spores (oospores) and leaving the vascular bundles loosely connected to give the typical shredded leaf symptom.

Pathogen

P. sorghi is an obligate parasite systemic in young plant. The mycelium is intercellular, non-septate. Sporangiophores emerge through the stomata in single or in clusters which are stout and dichotomously branched. Spores are single celled, hyaline, globose and thin walled. Oospores are spherical, thick walled and deep brown in colour.



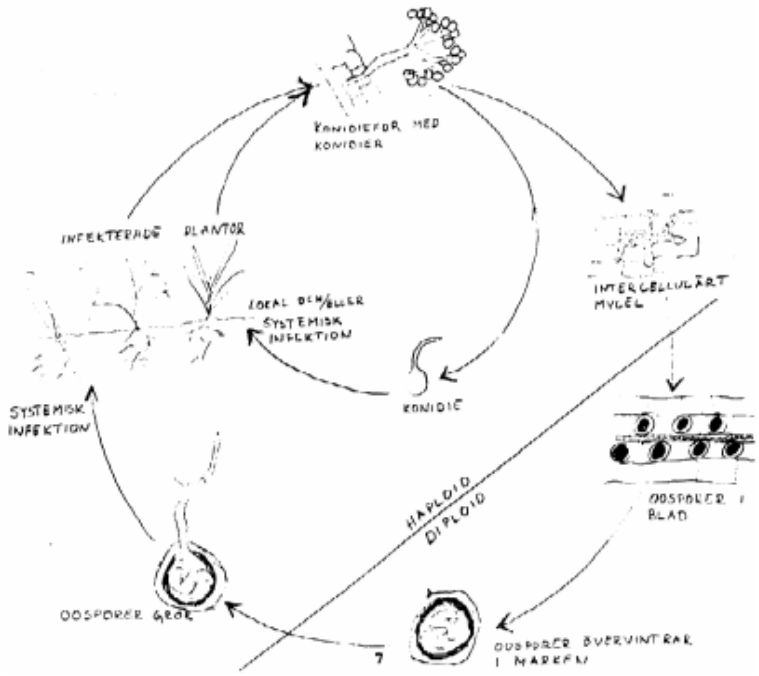
Sporangia and sporangiophores

Favourable Conditions

- Maximum sporulation takes place at 100 per cent relative humidity.
- Optimum temperature for sporulation is 21-23˚C during night.
- Light drizzling accompanied by cool weather is highly favourable.

Disease Cycle

The primary infection is by means of oospores present in the soil which germinate and initiate the systemic infection. Oospores persist in the soil for several years. Secondary spread is by air-borne sporangia. Presence of mycelium of the fungus in the seeds of systemically infected plants is also a source of infection.The disease has been known to occur through a collateral host, *Heteropogen centortus* on which the fungus perpetuates of the host. The breakdown of tissue causes shredding. The oospores either fall to the soil or are wind blown, often within host tissue. They can remain viable in the soil for 5-10 years. Conidia are formed at night in large numbers. The optimum temperature for production is 20-23^{0}C.



Management

- Crop rotation with other crops viz., pulses and oilseeds.
- Avoid the secondary spread of the disease by roguing out the infected plants since the wind plays a major role in the secondary spread of the disease.
- Grow moderately resistant varieties like Co25 and Co26.
- Seed treatment with Metalaxyl at 6 g/kg of seed.
- Spray Metalaxyl 500 g or Mancozeb 2 kg or Ziram 1 kg or Zineb 1kg/ha.

Leaf blight - *Exerohilum turcicum* (Syn: *Helminthosporium turcicum*)

Symptoms

The pathogen also causes seed rot and seedling blight of sorghum. The disease appears as small narrow elongated spots in the initial stage and in due course they extend along the length of the leaf. On older plants, the typical symptoms are long elliptical necrotic lesions, straw coloured in the centre with dark margins.

Symptoms

The straw coloured centre becomes darker during sporulation. The lesions can be several centimeters long and wide. Many lesions may develop and coalesce on the leaves, destroying large areas of leaf tissue, giving the crop a burnt appearance.

Pathogen

The mycelium is localised in the infected lesion. Conidiophores emerge through stomata and are simple, olivaceous, septate and geniculate. Conidia are olivaceous brown, 3-8 septate and thick walled.

Favourable Conditions

- Cool moist weather.
- High humidity (90 per cent)
- High rainfall.

Disease cycle

The pathogen is found to persist in the infected plant debris. Seed borne conidia are responsible for seedling infection. Secondary spread is through wind-borne conidia.

Management

- Use disease free seeds.
- Treat the seeds with Captan or Thiram at 4 g/kg.
- Spray Mancozeb 1.25 kg or Captafol 1 kg/ha.

Rectangular Leaf spot - *Cercospora sorghi*

Symptoms

The symptoms appear as small leaf spots which enlarge to become rectangular lesions (which can be 5-15 mm long by 2 to 5 mm wide) on the leaf and leaf sheath. Usually the lower

leaves are first attacked. The lesions are typical dark red to purplish with lighter centers. The lesions are mostly isolated and limited by veins. The colour of the spots varies from red, purple, brown or dark depending upon the variety.

Pathogen

Mycelium of the fungus is hyaline and septate. Conidiophores emerge in clusters through stomata, which are brown and simple, rarely branched. Conidia are hyaline, thin walled, 2-13 celled and long obclavate.

Favourable Conditions

- Cool moist weather.
- High humidity (90 per cent)
- High rainfall.

Disease cycle

The conidia survive up to 5 months. The disease spreads through air-borne and seed-borne conidia.

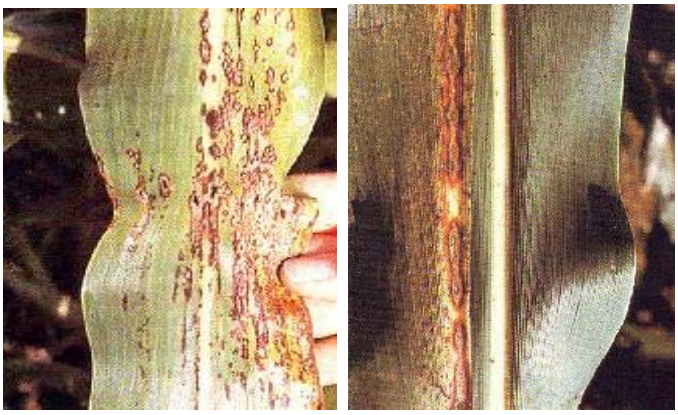
Management

- Use disease free seeds.
- Treat the seed with Captan or Thiram at 4 g/kg.
- Spray Mancozeb 2 kg /ha.

Anthracnose and red rot - *Colletotrichum graminicolum*

Symptoms

The fungus causes both leaf spot (anthracnose) and stalk rot (red rot). The disease appears as small red coloured spots on both surfaces of the leaf. The centre of the spot is white in colour encircled by red, purple or brown margin.



Symptoms

Numerous small black dots like acervuli are seen on the white surface of the lesions. Red rot can be characterized externally by the development of circular cankers, particularly in the inflorescence. Infected stem when split open shows discoloration, which may be continuous over a large area or more generally discontinuous giving the stem a marbeled appearance.

Pathogen

The mycelium of the fungus is localised in the spot. Acervuli with setae arise through epidermis. Conidia are hyaline, single celled, vacuolate and falcate in shape.

Favourable Conditions

- Continuous rain.
- Temperature of 28-30˚C.
- High humidity.

Disease cycle

The disease spread by means of seed-borne and air-borne conidia and also through the infected plant debris.

Management

- Treat the seeds with Captan or Thiram at 4 g/kg.
- Spray the crop with Mancozeb 2 kg/ha.

Rust - *Puccinia purpurea*

Symptoms

The fungus affects the crop at all stages of growth. The first symptoms are small flecks on the lower leaves (purple, tan or red depending upon the cultivar). Pustules (uredosori) appear on both surfaces of leaf as purplish spots which rupture to release reddish powdery masses of uredospores. Teliopores develop later sometimes in the old uredosori or in telisori, which are darker and longer than the uredosori. The pustules may also occur on the leaf sheaths and on the stalks of inflorescence.

Symptoms on leaves and stalk

Pathogen

The uredospores are pedicellate, elliptical or oval, thin walled, echinulated and darkbrown in colour. The teliospores are reddish or brown in colour and two celled, rounded at the apex with one germ pore in each cell. The teliospores germinate and produce promycelium and basidiospores. Basidiospores infect *Oxalis corniculata* (alternate host) where pycnial and aecial stages arise.

Favourable Conditions

- Low temperature of 10 to 12˚C favours teliospore germination.
- A spell of rainy weather favours the onset of the disease.

Disease cycle

The uredospores survive for a short time in soil and infected debris. Presence of alternate host helps in perpetuation of the fungus.

Management

- Remove the alternate host *Oxalis comiculata*.
- Spray the crop with Mancozeb at 2 kg/ha.

Grain smut/Kernel smut / Covered smut / Short smut - *Sphacelotheca sorghi*

Symptoms

The individual grains are replaced by smut sori. The sori are oval or cyclindrical and are covered with a tough creamy skin (peridium) which often persists unbroken up to thrashing. Ratoon crops exhibit higher incidence of disease.

Symptoms

Loose smut/ kernel smut - *Sphacelotheca cruenta*

Symptoms

The affected plants can be detected before the ears come out. They are shorter than the healthy plants with thinner stalks and marked tillering. The ears come out much earlier than the healthy. The glumes are hypertrophied and the earhead gives a loose appearance than healthy.

The sorus is covered by a thin membrane which ruptures very early, exposing the spores even as the head emerges from the sheath.

Symptom

Long smut - *Tolyposporium ehrenbergii*

Symptoms

This disease is normally restricted to a relatively a small proportion of the florets which are scattered on a head. The sori are long, more or less cylindrical, elongated, slightly curved with a relatively thick creamy-brown covering membrane (peridium). The peridium splits at the apex to release black mass of spores (spore in groups of balls) among which are found several dark brown filaments which represent the vascular bundles of the infected ovary.

Symptoms

Head smut - *Sphacelotheca reiliana*

Symptoms

The entire head is replaced by large **sori**. The sorus is covered by a whitish grey membrane of fungal tissue, which ruptures, before the head emerges from the boot leaf to expose a mass of brown smut spores. Spores are embedded in long, thin, dark colored filaments which are the vascular bundles of the infected head.

Symptoms

Management for all smuts

- Treat the seed with Captan or Thiram at 4 g/kg.
- Use disease free seeds.
- Follow crop rotation.
- Collect the smutted ear heads in cloth bags and bury in soil.

Ergot or Sugary disease - *Sphacelia sorghi*

Symptoms

The disease is confined to individual spikelets. The first symptom is the secretion of honey dew from infected florets. Under favourable conditions, long, straight or curved, cream to light brown, hard sclerotia develop. Often the honey dew is colonised by *Crerebella sorghivulgaris* which gives the head a blackened appearance.

Symptom

Pathogen

The fungus produces septate mycelium. The honey dew is a concentrated suspension of conidia, which are single celled, hyaline, elliptic or oblong.

Favourable Conditions

- A period of high rainfall and high humidity during flowering season.
- Cool night temperature and cloudy weather aggravate the disease.

Disease Cycle

The primary source of infection is through the germination of sclerotia which release ascospores that infect the ovary. The secondary spread takes place through air and insect-borne conidia. Rain splashes also help in spreading the disease.

Management

- Adjust the date of sowing so that the crop does not flower during September- October when high rainfall and high humidity favor the disease.
- Spray any one of the following fungicides viz., Mancozeb 2 kg/ha (or) Carbendazim at 500 g/ha at emergence of ear head (5-10 per cent flowering stage) followed by a spray at 50 per cent flowering and repeat the spray after a week, if necessary.

Head mould/Grain mould/Head blight

More than thirty two genera of fungi were found to occur on the grains of sorghum.

Symptoms

If rains occur during the flowering and grain filling stages, severe grain moulding occusr. The most frequently occurring genera are *Fusarium*, *Curvularia*, *Alternaria*, *Aspergillus* and *Phoma*. *Fusarium semitectum* and *F.moniliforme* develop a fluffy white or pinkish coloration. *C. lunata* colours the grain black. Symptom varies depending upon the organism involved and the degree of infection.

Symptoms

Favourable Conditions

- Wet weather following the flowering favors grain mould development.
- The longer the wet period the greater the mould development.
- Compact ear heads are highly susceptible.

Disease cycle

The fungi mainly spread through air-borne conidia. The fungi survive as parasites as well as saprophytes in the infected plant debris.

Management

- Adjust the sowing time.
- Spray any one of the following fungicides in case of intermittent rainfall during earhead emergence, a week later and during milky stage.
- Mancozeb 1 kg/ha or Captan 1 kg + Aureofungin-sol 100 g/ha.

Phanerogamic parasite - *Striga asiatica* and *Striga densiflora*

It is a partial root parasite and occurs mainly in the rainfed sorghum. It is a small plant with bright green leaves, grows up to a height of 15-30 cm. The plants occur in clusters of 10-20/host plant. *S. asiatica* produces red to pink flowers while. *S. densiflora* produces white flowers. Each fruit contains minute seeds in abundance which survives in the soil for several years.

The root exudates of sorghum stimulate the seeds of the parasite to germinate. The parasite then slowly attaches to the root of the host by haustoria and grows below the soil surface producing underground stems and roots for about 1-2 months. The parasite grows faster and appears at the base of the plant. Severe infestation causes yellowing and wilting of the host leaves. The infected plants are stunted in growth and may die prior to seed setting.

Symptoms

Management

- Regular weeding and intercultural operation during early stages of parasite growth.
- Spray Fernoxone (sodium salt of 2, 4-D) at 450g /500 litre of water.

Phase 1: Land Preparation (Weeks 1–6) (Month 1 - 2)

Week 1: Soil Testing and Analysis (Month 1)

- **Parameters:**
  - **Soil pH:** Ideal range 6.5–7.5.
  - **Nutrient Levels:** Test for N, P, K, organic matter, and micronutrients.
  - **Texture and Drainage:** Ensure loamy soil with good drainage.
- **Steps:**
  1. Collect soil samples from multiple locations at 15–20 cm depth.
  2. Send samples to an authorized lab or use a soil test kit.
  3. Apply amendments based on results (lime for acidic soils, gypsum for sodic soils).

Week 2–3: Field Clearing and Initial Plowing (Month 1)

- **Steps:**
  1. Clear weeds, stubble, and previous crop residues.
  2. Conduct deep plowing (30–40 cm) to break compact layers.
  3. Add **organic manure (10–12 tons/ha)** to enrich the soil.
  4. Level the field to facilitate uniform irrigation.

Week 4–5: Furrow Preparation (Month 1 - 2)

- **Parameters:**
  - **Row Spacing:** 90–150 cm (variety-dependent).
  - **Furrow Depth:** 10–12 cm.
- **Steps:**
  1. Use a furrow opener or tractor to prepare furrows at the required spacing.
  2. Add basal doses of fertilizers:
     - Nitrogen: 25 kg/ha (as urea or ammonium sulfate).
     - Phosphorus: 40 kg/ha (as DAP).
     - Potassium: 30 kg/ha (as MOP).
  3. Ensure uniform furrow alignment for easy irrigation.

Week 6: Seed Preparation (Month 2)

- **Parameters:**
  - Seed type: Healthy, disease-free, 3-budded setts.
  - **Seed Rate:** 35,000–40,000 two-budded setts/ha.
- **Steps:**
  1. Cut cane into setts (20–30 cm each).
  2. Treat setts with fungicide (carbendazim 0.1%) or hot water treatment (50°C for 2 hours).
  3. Keep setts moist in gunny bags for 24 hours before planting.

Phase 2: Planting and Germination (Weeks 7–12) (Month 3)

Week 7–8: Planting (Month 2)

- **Steps:**
    1. Lay setts horizontally in furrows with buds facing upward.
    2. Cover setts lightly with soil.
    3. Apply irrigation immediately after planting to ensure moisture.

Week 9–10: Germination Care (Month 3)

- **Temperature Requirements:**
    - Max temp: 32°C, Min temp: 20°C.
    - Relative humidity: 60–70%.
- **Steps:**
    1. Monitor germination (visible sprouts after 10–15 days).
    2. Apply pre-emergence herbicides like atrazine (1 kg/ha) to control weeds.
    3. Irrigate lightly every 7–10 days.

Week 11–12: Seedling Care (Month 3)

- **Steps:**
    1. Thin out weak seedlings if required to ensure uniform growth.
    2. Top-dress nitrogen (40–50 kg/ha) to promote healthy tillering.
    3. Perform light hoeing to break soil crust.

Phase 3: Tillering (Weeks 13–24) (Month 4 - 6)

Week 13–16: Early Tillering (Month 4)

- **Steps:**
    1. Perform inter-row cultivation to aerate the soil and control weeds.
    2. Apply post-emergence herbicides like 2,4-D (1 kg/ha) if weeds persist.
    3. Top-dress nitrogen (60 kg/ha) in split doses.

Week 17–20: Mid-Tillering (Month 5)

- **Steps:**
    1. Monitor crop for early signs of pests (e.g., borers) and diseases (e.g., red rot).
    2. Introduce **biological control agents** like Trichogramma for borers.
    3. Maintain soil moisture through irrigation every 10–12 days.

Week 21–24: Late Tillering (Month 6)

- **Steps:**
    1. Add micronutrients like zinc sulfate (25 kg/ha) and borax (10 kg/ha).
    2. Continue pest monitoring and implement IPM strategies.

Phase 4: Grand Growth Phase (Weeks 25–40) (Month 7 - 10)

Week 25–28: Stem Elongation Begins (Month 7)

- **Steps:**
    1. Irrigate every 12–15 days to avoid stress during critical growth.
    2. Intercrop harvest if any (e.g., pulses, vegetables).
    3. Apply remaining nitrogen (40 kg/ha) and potassium (30 kg/ha) for stem growth.

Week 29–32: Maximum Stem Elongation (Month 8)

- **Steps:**
    1. Ensure no water stress; this stage is critical for yield.
    2. Watch for diseases like smut and leaf scald; use fungicides if necessary.

Week 33–36: Canopy Development (Month 9)

- **Steps:**
    1. Apply green manure or additional organic matter for soil health.
    2. Conduct light hoeing to improve soil aeration.

Week 37–40: Early Maturity (Month 10)

- **Steps:**
    1. Stop nitrogen application to avoid lodging and delayed ripening.
    2. Focus on pest control to prevent damage to stalks.

Phase 5: Ripening and Harvesting (Weeks 41–52) (Month 11 - 12)

Week 41–46: Ripening (Month 11)

- **Steps:**
    1. Stop irrigation 3–4 weeks before harvest to enhance sucrose content.
    2. Use ripeners (e.g., Ethephon) if synchronized maturity is required.

Week 47–52: Harvesting (Month 12)

- **Steps:**
    1. Cut canes close to the ground with sharp tools.
    2. Remove dry leaves and transport to mills within 24 hours to prevent juice loss.

Key Considerations

1. **Water Management:**

    - Critical stages: Germination, tillering, and elongation.
    - Use drip irrigation to save water and enable fertigation.
2. **Weed Management:**
    - Use a mix of manual, chemical, and intercultural operations.
3. **Fertilizer Management:**
    - Split NPK applications based on crop stage.

This plan is adaptable for both **subtropical** and **tropical regions** in India, with slight modifications based on local conditions.

Key Strategies to Increase Production

1. **Adopt High-Yielding Varieties**: Based on regional recommendations.
2. **Integrated Nutrient Management**: Balance organic and inorganic sources.
3. **Integrated Pest Management (IPM)**: Minimize chemical use and adopt eco-friendly control methods.
4. **Mechanization**: Use sugarcane planters and harvesters to reduce labor costs.
5. **Intercropping**: Grow legumes, pulses, or vegetables to maximize land use efficiency.
6. **Water-Efficient Practices**: Drip irrigation with fertigation.

Expert System For Sugarcane

Irrigation Management

Categories

About Irrigation Management

- **Water requirement**
- **Irrigation Methods**
- **Drip irrigation**
- **Fertigation**
- **Drought management**

Water requirement

- Depending upon the agro climatic conditions, type of soil, methods of planting and use of manures and fertilizers and sugarcane yield the water requirement varies.The hot weather associated with dry winds and drought increases the water requirement of the crop.
- The crop sown in trenches needs relatively less water but sandy soils and application of more fertilizers increase the water uptake. On an average 1 ton cane needs about 60-70 tons of water or thin varieties of cane need 150 cm thick canes and need 200 cm water and Adsali planted canes 200 cm, in addition to 75 cm rainfall. The crop should be irrigated when available water reaches to 50% level.

- The soil must have sufficient moisture at the time of sowing. First irrigation should be done when about 20-25% plant have germinated or about 20 days after sowing and the irrigations are given at 10-15 days interval during summer, 25-30 days interval during winter and if there is drought the crop should be irrigated during rainy season also as and when needed. The crop needs maximum water at tillering stage and during elongation or grand growth phase.
- Under water logging conditions the root respiration becomes poor. Nutrients are leached down, activities of useful micro-organisms are reduced and the crop lodges down with an excessive branching. Thus the quality becomes poor along with very low crop yield. These all make it necessary to drain the excess water from the field.

Top of page

Average water requirement for sugarcane

- Average water requirement for sugarcane is 1800 to 2200 mm.

S.No.	Crops	Duration in days	Water requirement (mm)	No. of irrigations
1.	Sugarcane	365	2000	24

For 12 months sugarcane crop water requirement at each growth phase

Irrigation interval approach

Growth Phase	Duration of phase	Water Requirement
Germination	0-45 days	300mm
Tillering Phase	45-120 days	550mm
Grand Growth Phase	120-270 days	1000mm
Ripening Phase	270-360 days	650mm

Irrigation interval in different season and type of soil

Growth Phase	Irrigation Interval (days)		
	Coarse textured soil	Medium textured soil	Fine textured soil
Germination(0-45 days)	5-6	6-7	8-10
Tillering Phase(45-120days)	6-7	7-10	12-15
Grand Growth Phase(120-270days)	7	10	12-15

Ripening Phase(270-360 days)	10	12-15	15-20

Water Use Efficiency of Different irrigation systems

Irrigation system	Water applied (ha -cm)	Cane yield (mt/ha)	Water use efficiency	C. C.S. (mt/ha)
Rain gun sprinkler	175.26	126.56	0.72	17.87
Drip irrigation	132.14	128.64	0.97	18.29
Furrow irrigation	258.45	104.42	0.4	14.71

Poor irrigation leads to

- Decrease length of internodes
- Decrease amount of juice and increase percent of fiber
- Decrease rate of germination
- Decrease of sugar yield

Heavy irrigation leads to

- Death of buds,
- damage to roots,
- sugar content decreases,
- cane yield decreases
- plant can not adsorb elements from soil and becomes yellowish.

Top of page

Irrigation Methods

Flood irrigation:

- In Flood irrigation method, free flow of irrigation water is allowed in the fields in all directions.
- It is practiced in the flat planted cane, but water loss is high.

Furrow irrigation:

- Furrow irrigation is most commonly used and is particularly effective for early plant crop.
- In later crop growth periods and during ratoon crops, the water distribution may become increasingly problematic because of deterioration of the furrows.
- Reduced furrow length is sometimes used to allow better distribution of water over the field in a later stage.

Alternate skip furrow method:

- In skip-furrow method, sugarcane is planted in flat beds as usual and after germination, 45 cm wide and 15 cm deep furrows were made in alternate inter row spaces.
- There is considerable saving of water in this method of irrigation.
- In Autumn planting, there are 7 irrigations in plains (5 before rain and 2 after rain)
- In spring planting, there are 6 irrigations (4 before rain and 2 after rain) - one irrigation at tillering is must.

Sprinkler irrigation:

- For sprinkler irrigation, increasing use is made of spray guns, hand and automatically moved, replacing the cumbersome boom and labour-intensive hand-moved sprinkler laterals Prevailing winds of more than 4 or 5 m/sec will limit their usefulness.

Drip irrigation:

- Drip irrigation is defined as the precise, slow and frequent application of water through point or line source emitters on or below the soil surface at a small operating pressure (20-200 kPa) and at a low discharge rate (0.6 to 20 LPH), resulting in partial wetting of the

soil surface.

Top of page

Drip Irrigation

Drip Irrigation

- Drip irrigation is defined as the precise, slow and frequent application of water through point or line source emitters on or below the soil surface at a small operating pressure (20-200 kPa) and at a low discharge rate (0.6 to 20 LPH), resulting in partial wetting of the soil surface.
- Drip irrigation in sugarcane is a relatively new innovative technology that can conserve water, energy and increase profits.
- Drip irrigation may help in solving three most important problems of irrigated sugarcane - water scarcity, rising pumping (energy) costs and depressed farm profits
- Drip will be successful depends on a host of agronomic, engineering and economic factors.
- 12 mm drip laterals have to be placed in the middle ridge of each furrow with the lateral spacing of 240 cm & 8 'Lph' clog free drippers should be placed with a spacing of 75 cm on the lateral lines. The lateral length should not exceed more than 30-40 m.
- Drip Irrigation is given once in three days based on the evapo-transpiration demand of the crop.

Surface Drip:

- The application of water to the soil surface as drops or a tiny stream through emitters placed at predetermined distance along the drip lateral is termed as surface drip irrigation.
- It can be of two types - online or integral type surface drip system. Integral dripline is recommended for sugarcane.

Top of page

Subsurface Drip (SDI):

- The application of water below the soil surface through emitters molded on the inner wall of the dripline, with discharge rates (1.0 - 3.0 LPH) generally in the same range as integral surface drip irrigation.
- The integral dripline (thin or thick-walled) is installed at some predetermined depth in the soil depending on the soil type and crop requirements.
- There are two main types of SDI - "one crop" and "multicrop".
- Subsurface irrigation saves water and improves yields by eliminating surface water evaporation and reducing the incidence of disease and weeds.

Advantages

- Save 25-50% of water
- Low requirement of water.
- Evaporation losses get reduce.
- Decrease the number of weeds.
- Period of irrigation is low (2-3 hours)
- The growth of plants is homogeneous.
- Little application of water but gives more yield.
- Decrease the infestation with pests (insects, diseases and weeds).
- Increasing the area of planting by saving the area of canals.
- Decreasing man infection by contacting the water (bilharzia or Schistosomiasis).
- Decreasing the pollution in canals.

There is considerable saving of water in this method of irrigation.

Top of page

Sugarcane Drip Design Guidelines

Planting pattern	Drip system	Distance (m)			Dripline installation depth (cm)	Emitter distance (m)	Discharge (LPH)
		Two rows of a pair	Two paired rows / two rows	Two driplines			
Single row	Surface	---	1.2 to 1.5	1.2 to 1.5	---	0.4 to 0.6	1.0 to 3.0
Paired row	Surface	0.4 to 1.0	1.4 to 2.0	1.8 to 2.5	---	0.4 to 0.6	1.0 to 3.0
Paired row	Sub surface	0.4 to 1.0	1.4 to 2.0	1.8 to 2.5	0.15 to 0.30	0.4 to 0.6	1.0 to 2.3

Major benefits of drip irrigation

Water

- Saving irrigation water 40 - 70 %
- Low Labour cost for irrigation
- Increased water use efficiency
- Uniformity in water distribution (90%)
- Suitable for inferior quality irrigation water
- Use of saline water is possible

Soil

- Suitable for any type of soil
- Suitable for marginal and undulating land
- Low tillage requirement

Top of page

Fertigation

Fertigation

- Sugarcane being a giant crop producing huge quantity of biomass generally demands higher amounts of nutrient elements.
- The cost of chemical fertilizers has also increased and there is a need to improve fertilizer use efficiency for more benefits. The best answer to this challenge is "Fertigation", where both water and fertilizers are delivered to crop simultaneously through a drip irrigation system.

- Fertigation ensures that essential nutrients are supplied precisely at the area of most intensive root activity according to the specific requirements of sugarcane crop and type of soil resulting in higher cane yields and sugar recovery.

Concept of fertigation

- Fertigation is the judicious application of fertilizers by combining with irrigation water.
- Fertigation can be achieved through fertilizer tank, venturi System, Injector Pump, Non-Electric Proportional Liquid Dispenser (NEPLD) and automated system.
- Recommended Nitrogen & Potassium @ of 275 and 112.5 kg/ha may be applied in 14 equal splits with 15 days interval from 15 DAP.
- 25 kg Nitrogen and 8 kg K2O per ha per split.
- Urea and MOP (white potash) fertilizers can be used as Nitrogen and Potassium sources respectively.
- Fertigation up to 210 DAP can also be recommended.

Requirement & Type of Water soluble fertilizers in Sugarcane

Recommended dose: 275: 62.5:112.5 kg NPK / ha
For Fertigation recommended: 275:15:112.5 NPK / ha

Fertigation Schedule

Crop stage	Duration in days	Fertilizer grade	No. of times	Quantity (kg/time)
First stage	From planting to 70 days(5,10…. 70th day)	12-61-00	14	0.9
		13-00-45	14	1.8
		Urea	14	12.1
Second stage	71 days to 120 days	12-61-00	10	1.2
		13-00-45	10	5.0

		Urea	10	20.9
Third stage	121 days to 160 days	12-61-00	8	3.1
		13-00-45	8	5.6
		Urea	8	14.1
Fourth stage	161 day to 210 days	12-61-00	10	2.5
		13-00-45	10	6.8
		Urea	10	8.3

Fertigation Schedule for Seasonal (12 months)/Ratoon Sugarcane

Days After Planting	Nutrients (kg/ha/day)		
	N	P2O5	K2O
1-30 Days	1.20	0.10	0.20
31-80 Days	1.50	0.40	0.24
81-110 Days	2.00	1.00	0.40
111-150 Days	0.75	0.30	0.75
151-190 Days	--		1.50

Fertigation Schedule for Preseasonal (14 to 16 months) Sugarcane

Days After Planting	Nutrients (kg/ha/day)		
	N	P2O5	K2O
1-30 Days	1.5	0.15	0.25
31-80 Days	2.0	0.60	0.30
81-110 Days	2.5	1.50	0.50
111-150 Days	0.75	0.50	1.0
151-190 Days	--		1.80

Advantages of fertigation

- Ensures a regular flow of water as well as nutrients resulting in increased growth rates for higher yields
- Offers greater versatility in the timing of the nutrient application to meet specific

crop demands

- Safer application method which eliminates the danger of burning the plant root system
- Offers simpler and more convenient application than soil application of fertilizer thus saving time, labour, equipment and energy
- Improves fertilizer use efficiency
- Reduction of soil compaction and mechanical damage to the crops
- Convenient use of compound and ready-mix nutrient solutions containing also small concentration of micronutrients.
- Free from chlorides and sodium
- No salt build up in the crop root zone
- Most of the fertilizers are blended with micronutrients.

Fertigation Offers Several Distinct Advantages in Comparison to Conventional Application Methods:

- Distribution of plant nutrients more evenly throughout the wetted root zone resulting in increased nutrient availability & uptake contributing to higher crop growth rates and cane yields
- Supply of nutrients incrementally according to the crop developmental phases throughout the season to meet the actual nutritional requirements of the crop
- Careful regulation and monitoring the supply of nutrients
- Application of nutrients to the soil when crop or soil conditions would otherwise prohibit entry into the field with conventional equipment
- Minimal nutrient losses through consumption by weeds, leaching and runoff
- No damage to the crop by root pruning, breakage of leaves, or bending of leaves, as occurs with conventional fertilizer application methods/equipment
- Less energy is expended in application of the fertilizer
- Usually less labour & equipment are required for application of the fertilizer and to supervise the application
- Soil compaction is avoided because heavy equipment never enters the field
- No salt injury to foliage
- Allows rising of crop on marginal lands, where accurate control of water and nutrient ion in the plant's root environment is critical.

Fertilizers Suitable for Fertigation Via Drip Irrigation System

Nutrient	Water soluble fertilizers	Nutrient content
Nitrogen	Urea Ammonium Nitrate Ammonium Sulphate Calcium Nitrate Magnesium Nitrate Urea Ammonium Nitrate Potassium Nitrate	46-0-0 34-0-0 21-0-0 16-0-0 11-0-0 32-0-0 13-0-46

	Monoammonium Phosphate	32-0-0
Phosphorus	Monoammonium Phosphate Monopotassium Phosphate Phosphoric Acid	12-61-0 0-54-32 0-82-0
Potassium	Potassium Chloride Potassium Sulphate Potassium Nitrate Potassium Thiosulphate Monopotassium Phosphate	0-0-60 0-0-50 13-0-46 0-0-25 0-52-34
NPK	Polyfeed	19-19-19 20-20-20
Micronutrients	Fe EDTA Fe DTPA Fe EDDHA Zn EDTA Ca EDTA Rexolin CXK (B+Cu+Fe+Mn+Mo+Zn+Mg)	13 12 6 15 9.7 ---

Top of page

Drought Management

Drought

Drought is a meteorological term and is defined as a period without a significant rainfall. Infact, when evapo-transpiration exceeds soil moisture supply i.e. water uptake, the water deficit/drought is resulted.

Sugarcane being a long duration crop which requires more irrigation. In sugarcane, Germination and grand growth phase are the two important periods which requires more irrigation. In India this period comes on summer months and availability of water is poor. So the requirement of water is insufficient during those period which leads to drying of crop and yield loss.

Drought Management:

1. Planting of sugarcane in early season at the depth of 30 cm in furrow.
2. In drought area plant the setts with spacing of 60-75 cm instead of 90 cm.
3. Soak the setts in lime solution (80 kg Kiln lime in 400 lit water) for one hour.
4. Removal of dry trash at 5th month and leave it as mulch, in the field. This reduces the temperature upto 2ºC.
5. Spray potash and urea each at 25 gm in 1 litre of water during moisture stress period at 15 days interval.
6. Spray Kaolin (60 g in 1 ltr. of water) to alleviate the water stress.
7. Under water scarcity condition, alternate furrow and skip furrow irrigation method is beneficial.

8. Apply 125 kg of Muriate of Potash additionally at 120 day of planting.
9. Basal incorporation of coir waste @ 25 tonnes/ha at the time of last ploughing.
10. Use drought tolerant resistant varieties like Co 86032, Co 99004, Co 94008 and Co 86249

Top of page

Irrigation Management :: Sugarcane

Sugarcane

Water Management

Irrigate the crop depending upon the need during different phases of the crop.

Germination phase (0 - 35 days):

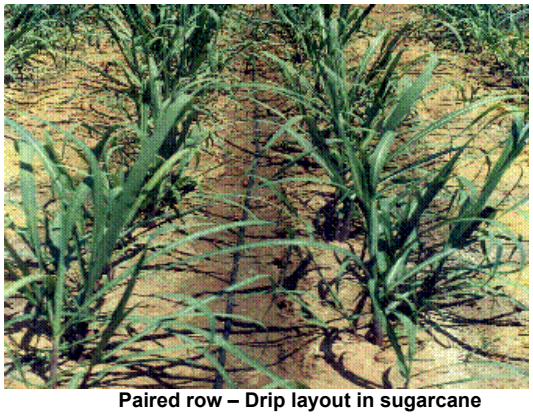
- Provide shallow wetting with 2 to 3 cm depth of water at shorter intervals especially for sandy soil for enhancing the germination.
- Sprinkler irrigation is the suitable method to satisfy the requirement, during initial stages.
- Later, irrigation can be provided at 0.75, 0.75 and 0.50 IW/CPE ratio during tillering, grandgrowth and maturity phases respectively.

The irrigation intervals in each phase are given below:

Stages	Days of irrigation interval	
	Sandy soil	Clay soil
Tillering phase (36 to 100 days)	8	10
Grand growth phase (101 - 270 days)	8	10
Maturity phase (271 - harvest)	10	14

Drip Irrigation:

- Planting setts obtained from 6-7 months old healthy nursery and planted in paired row planting system with the spacing of 30x30x30 / 150 cm.
- Nine setts per metre per row have to be planted on either sides of the ridge thus making it as four row planting system.
- 12 mm drip laterals have to be placed in the middle ridge of each furrow with the lateral spacing of 240 cm & 8 ‘Lph’ clog free drippers should be placed with a spacing of 75 cm on the lateral lines. The lateral length should not exceed more than 30-40 m.
- Phosphorus @ 62.5 kg ha-1 has to be applied as basal a the time of planting.
- Nitrogen and Potassium @ 275:112.5 kg ha-1 have to be injected into the system as urea and muriate of potash by using “Ventury” assembly in 10-12 equal splits starting from 15 to 150-180 days after planting.
- Low or medium in nutrient status soil to be given with 50 per cent additional dose of Nitrogen and Potassium.
- Irrigation is given once in three days based on the evapo-transpiration demand of the crop.



Paired row – Drip layout in sugarcane

Source:http://www.tnau.ac.in/tech/swc/fertigation.pdf

Concept of fertigation

- Fertigation is the judicious application of fertilizers by combining with irrigation water.
- Fertigation can be achieved through fertilizer tank, venturi System, Injector Pump, Non-Electric Proportional Liquid Dispenser (NEPLD) and Automated system
- .
- Recommended N & K @ of 275 and 112.5 kg. ha-1 may be applied in 14 equal splits with 15 days interval from 15 DAP.
- 25 kg N and 8 kg K2O per ha per split.
- Urea and MOP (white potash) fertilisers can be used as N and K sources respectively
- Fertigation up to 210 DAP can also be recommended

Advantages of Fertigation

- Ensures a regular flow of water as well as nutrients resulting in increased growth rates for higher yields
- Offers greater versatility in the timing of the nutrient application to meet specific crop demands
- Improves availability of nutrients and their uptake by the roots
- Safer application method which eliminates the danger of burning the plant root system
- Offers simpler and more convenient application than soil application of fertilizer thus saving time, labour, equipment and energy
- Improves fertilizer use efficiency
- Reduction of soil compaction and mechanical damage to the crops
- Potential reduction of environmental contamination
- Convenient use of compound and ready-mix nutrient solutions containing also small concentration of micronutrients.

Contingent plan

Gradual widening of furrow:

At the time of planting, form furrow at a width of 30 cm initially. After that, widen the furrow to 45 cm on 45th day during first light earthing up and subsequently deepen the furrow on 90th day to save 35% of water.

Subsurface irrigation in sugarcane

Pit method of sugarcane planting under drip fertigation system Technology

- Pit to pit spacing - 1.5 x 1.5 m
- Number of pits/ha - 4,444 pits
- Pit diameter - 0.9 m
- Pit depth - 0.38 m
- Number of budded setts / pit- 32 (single budded setts)
- Fill the pits to a depth of 15 cm with compost and native soil and mix it well. Place the healthy setts in circular fashion leaving 10 cm from the outer boundary of the pits with equal spacing between each setts and cover the setts with soil. On 50 to 60 days after planting give partial earthing up by sliding the soil from the outer boundary of the pit and full earthing up should be given leaving a depression of 2.5 cm from the ground level at 90 to 100 days after planting
- Fertilizer dose - 275:62.5:112.5kg NPK/ha
- The entire phosphorous dose can be applied as basal at the time of planting
- The nitrogen and potassium as urea and MOP (white potash) should be applied through fertigation system in 14 equal splits starting from 15 DAP upto 210 DAP
- Drip design -lateral to lateral spacing 3.0 m (alternate rows)
- 8 mm micro tubes on either side of the lateral to a length of 1.0 m with one 8 LPH drippers / pit
- Irrigation - daily or in alternative days

Benefits

- Higher cane yield
- Multi rationing is possible
- Suited in problem soils
- More water saving
- System maintenance is easy
- Less labour for after cultivation operations
- Higher net return

Economics

Pit planting of cane in 1.5 m x 1.5 m pit spacing registered the highest net return of Rs.1, 19,649 ha-1 and 1, 55,982 ha-1 with in BCR of 2.26 and 3.31 in plant and ratoon crops respectively compared to the net return of Rs.1,16,650 and 1,27,360 registered in conventional method of cane cultivation in plant and ratoon crops**.**

Source: TNAU, Coimbatore, 2006

Pit method of sugarcane planting under drip fertigation system

Expert System For Sugarcane

Crop Protection

About Crop Protection

- **Pest Management**
- **Disease Management**

Pest Management

Sugarcane crop is affected by more than 60 insects of which about 10 insects are rather more important as far as the yield loss is concerned. Among the major insects damaging sugarcane, borers, sucking pests, soil dwelling insects are more prevalent in Tamil Nadu and adjoining states which account 20% loss in cane yield 15% loss in sugar yield.

Sl.No	Common Name	Scientific Name	Family	Order
1	Early shoot borer	*Chilo infuscatellus*	Crambidae	Lepidoptera
2	Internode borer	*Chilo sacchariphagus indicus*	Crambidae	Lepidoptera
3	Top borer	*Scirphophaga excerptalis*	Pyralidae	Lepidoptera
4	Termites	*Odontotermes obesus*	Termitidae	Isoptera
5	White grubs	*Holotrichia Consanguinea*	Melolonthidae	COleoptera
6	Woolly aphid	*Ceratovacuna lanigera*	Phempigidae	Hemiptera
7	White fly	*Aleurolobus barodensis Neomaskellia bergii N . andropogonis*	Aleyrodidae	Hemiptera
8	Mealy bug	*Saccharicoccus sacchari*	Pseudococcidae	Hemiptera

Categories

9	Scale insects	*Melanaspis glomerata*	Diaspididae	Hemiptera
10	Nematode	*Reniform nematode* - *Rotylenchulus reniformis.* Root knot nematode – *Meloidogyne spp* Lance nematode – *Hoplolaimus indicus* Lesion nematode - *Pratylenchus coffeae*	Trichostrongylidae	Monhysterida
11	Grasshopper			

Early shoot borer, *Chilo infuscatellus snellen*

Discription:

Tamil Nadu, Andra Pradesh, U.P., Bihar, West Bengal, Maharastra, Madhya Pradesh, Punjab, Rajasthan. In Tamil Nadu, its occurance is noted in all sugarcane growing areas.

Symptom of damage:

Dead heart in 1-3 month old crop, which can be easily pulled out, rotten portion of the straw coloured dead – heart emites an offensive odour. A number of bore holes at the base of the shoot just above the ground level.

Life cycle:

- **Egg:** Flat – scale like eggs are laid in 3-5 rows on the lower surface of leaves in masses of 4-100. The masses are slightly overlapping like tiles. It hatches 4-6days.
- **Larva:** Larva is dirty white with five dark violet

longitudinal stripes and dark brown head. Duration 16-30days.

- **Pupa:** Pupation takes within the tunnel. Caterpillar before pupating makes a large exit hole in the stem and blocks the opening with silken discs.
- **Adult:** Pale greyish brown moth with black dots near the coastal margin of the forewings and with white hind wings.

Management:
Cultural method:

- Use resistant varities like CO 312, CO 421, CO 661, CO 917 and CO 853
- Early planting during December – January escapes the shoot borer incidence.
- Daincha intercropped sugarcane record the lowest early shoot borer incidence.
- Trash mulching along the ridges to a thickness of 10-15 cm 3 days after planting.
- Ensure adequate moisture to bring down the soil temperature and increase humidity (unfavourable condition for the multiplication of early shoots borer).

Physical method:

- Remove and destroy dead hearts.

Biological method:

- Apply granulosis virus 1.1 x 10 5 IBS / ml (750 diseased larvae / ha) twice on 35 and 50 DAP.
- Release 125 gravid females of sturmiopsis inferens a tachinid parasite per ac.

Chemical method

- Apply any one of the following insecticides if the pest crosses ETL.
- Carboryl +Lindane (Sevidol) 4% G 12.5 kg, lindane 10 G 12.5 kg, Carbofuron 3G 33 kg (Soil application). The granular application should be immediately followed by irrigation.
- Chlorpyriphos 1000 ml a sticker like Teepol (250 ml / 500 l of water) can also be added to make the solution stick on to the surface of the crop and it is preferable to use high volume sprayer to be most effective.

Internode Borer, *Chilo sacchariphagus indicus* (Kapur)

Distribution:

Major pest in tropical India

Symptom of damage:

Internodes constricted and shortened, with a number of boreholes and fresh excreta in the nodal region. Affected tissues reddened.

Nature of damage:

Caterpillars attack sugarcane plants after 3 months of planting. They bore into the canes near the nodes; entry holes are plugged with excreta. Entry is generally confined to the first five internodes.

Life cycle:

- **Egg:** Scale – like oval, flat, shiny and waxy white eggs are laid by female moths in batches of 9-11, near the midribs, on leaf sheaths or on stem.
- **Larva:** White larva with four violet longitudinal stripes and light brown head.
- **Pupa:** Pupation takes place in semi – dried sheath. Pupal period 7 - 10 days
- **Adult:** straw coloured with a dark spot on each of the forewings

Management:

Cultural method:

- Use resistant varities like CO 975,COJ 46 and CO 7304
- Select internode borer damage free setts for planting
- Detrashing & burying the trash during the 5th, 7th and 9th month

Physical method:

- Collect and destroy the eggs periodically.
- Detrash the crop on 150th and 210th day of planting. Detrashing dislodge the pupae that remain in the leaf sheath.

Biological method:

- Release egg parasite, Trichogramma chilonis at the rate of 2.5 cc / release / ha. Six release at fortnightly intervals starting from 4th month onwards.
- Setting pheromone traps at spindle level on 5th month of the crop at the rate of 6 traps per acre in a 15 metre grid. The pheromone septa need to be changed twice at 75

days interval.

Chemical method:

- Avoid the use of excessive nitrogenous fertilizers.

Top Borer, *Scirpophaa excerptalis (Fb.)*

Distribution:
Present in all states. In Tamil Nadu it is severe in Trichy, Tanjore and Cuddalore districts.

Symptom of damage:

- Dead heart arise on after sixth month grown up canes, which cannot be easily pulled.
- Parallel row of shot holes in the emerging leaves.
- Bore holes at the top of the shoot and shows bunchy top appearance.

Nature of damage:
Caterpillars are mainly found in the apical portion of the canes, boring through the growing point and down the upper joints until it reaches the sappy portion of the stem, there it feeds on the tissues and destroys the cane. They also bore into the unfolded leaves preferably into the midrib, mining its way to the base.

Life cycle:

- **Egg:** Eggs are laid on the lower surface of top leaves in clusters particularly near midribs. The clusters are covered with buff coloured hairs. : 10-80 eggs per egg mass
- **Larva:** Smooth, white or cream coloured with a red coloured mid – dorsal line and yellow head.
- **Pupa:** Pupation takes place within the larval tunnel in a chamber with an exit hole Constructed by the caterpillar. Pupal period 6 - 21 days
- **Adult:** White Coloured moth (with a buff Coloured anal tuft in the abdominal tip of female)

Management:

Cultural method:

- Use resistant variety CO 419, CO 745 and CO 6516 and tolerant varieties Co 859, Co 1158 and Co 7224.

Physical method:

- Collect and destroy the egg masses.

Biological method:

- Release Ichneumonid parasitized Gambroides (Isotima) javensis @ 100 pairs / ha as prepupal parasitoid.

Chemical method:

- Application of Carbofuran 3G 1 kg a.i/ha or Thimet 10G 3 kg a.i/ha

Termites, *Odontotermes obesus Rhamb*

Symptom of damage:

Poor germination of setts (after planting), characteristic semi – circular feeding marks on the margin of the leaves in the standing crop. Causes yellowing and drying of outer leaves first followed by the inner leaves Entire shoot dries up and can be pulled out. Setts hollow inside and may be filled with soil. Cane collapses if disturbed; rind filled with mud.

Life cycle:

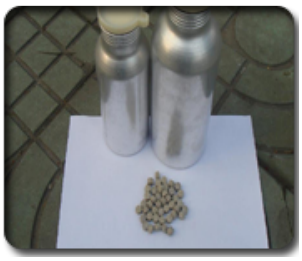
Eggs: Dull, kidney shaped and hatches in 30-90 days
Nymphs: Moult 8-9 times and are full grown in 6-12 months

Adult: Creamy coloured tiny insects resembling ants with dark coloured head

Management:

Cultural method:

- Flood irrigation at the time of planting.



Physical method:

- Locate and destroy the termite colony.
- Collect and destroy the termite affected setts from the field.

Chemical method:

- Fumigate the termite mounds with aluminium phosphate 2 tablets / 1 meter/Mounds.
- Dip the setts in imidacloprid 70WS 0.1% or chlopyriphos 20 EC 0.04% for 5min.
- Treat the soil with lindane 1.6 D @ 50 kg / ha or
- Apply 125 kg of heptachlor 3 % D per ha in the furrows at time of planting.

White Grub, Holotrichia consanguinea (Blanch)

Symptom of damage:

- Yellowing and wilting of leaves.
- Drying of entire crown.
- Affected canes come off easily when pulled.
- Cause extensive damage to roots and base of shoot.

Life cycle:

Egg: A female lays on an average of 27 eggs in the soil, which are pear like white enclosed in earthen cells.
Grub: Fleshy 'C' shaped, whitish yellow in colour found close to the base of the clump.
Pupa: Pupae are tan to brown, and occur deeper in the soil in earthen chambers.
Adult: Adult beetles are a rusty-red color just after emerging from the pupal stage, but turn nearly black.

Management:

Cultural method:

- Provide adequate irrigation.
- Deep ploughing immediately after harvesting.

Physical method:

- Set up light trap.
- Collect and destroy the adult beetles.

Chemical method:

- Apply lindane 1.6 D @ 50 kg/ha near the root zone.

Sugarcane Wooly Aphid, *Ceratovacuna lanigera*

Symptoms:

Adults and nymphs desap leaves by piercing styles through stomata. Whitish patches – coalesce to turn yellowish and drying from the tip along margins. Leaves become brittle and dries completely. Heavy secretion of honey dew – development of sooty mould. Deposition of wooly matter on ground / soil distinctly visible.

Life cycle:

Adult emerged after fourth moult and viviparous reproduction. Apterous (Wingless) female reproduce parthenogenetically. Each femal produced about 15 – 35 young ones within 24 hr after mating. Each female reproduces maximum of 217 nymphs during the period of 20 days. The female are more in the population, which leads to fast multiplication. Nymph takes 6 to 22 days to complete four instars and become adult.

The life cycle of female complete within one – month period. The longevity of adult is from 32 to 57 days. The life cycle may vary according to the climatic conditions and variety. In most of the affected fields at various locations all the nymphal instars and adults are noticed. In extreme cases, the winter is passed as eggs which are laid during the previous autumn by sexual females. In spring they hatch and give rise to apterous parthenogenetic viviparous females. The winged females appear in such swarms as to darken the sky and cover the vegetation. The non-migratory species, the whole life – cycle is spent on the same plant.

Management:

Cultural Method:

- Paired row system of planting.
- Avoid excessive use of nitrogenous fertilizers.
- Use of organic fertilizers.
- Rapping of canes all along the rows.
- Infested tops should not be transported.
- Infested canes should not be used as seed for planting.

Biological Method:

1. Encourage local predators like Diapha aphidivora Meyrick – Pyralidae
    a. Ishchiodon scutellaris
    b. Episyrphus baleatus – Syrphidae
    c. Chrysopa spp. – Chryospidae
    d. Schymnus sp.
    e. Cheilomeness sexmaculata, Coccinella

septempunctata, Synnonycha grandis

f. Brumus sp. and

g. Dideopsis aegrota – Coccinellidae

2. Pathogens like Cladosporium oxysporum, Metarhizium anisopliae, Verticillium lecanii and Beauveria bassiana

Chemical Method:
Dip the seed sets in Chlorpyripos 20 EC solution (2 ml / lit) before planting. Apply phorate 10 G @ 5kg / ac or Spray with acephate75 SP 1g / lit Chlorpyriphos 20 EC 2 ml / lit Malathion 50 EC 2 ml / lit Dimethoate 30 EC 1.7 ml / lit, Oxydemeton methyl 25 EC 1.3 ml / lit, Dusting with Malathion 5% dust @ 10 kg / ac.

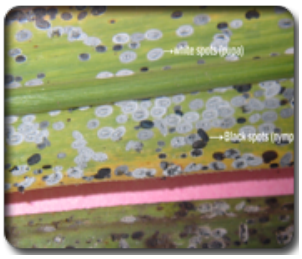
Whiteflies, *Aleurolobus barodensis*

Symptom of damage:

- Yellowing of leaves
- Leaf turns pinkish or purple and later gradually dry.
- Infested leaves look white and black dots.

Life cycle:

- **Egg:** Females lay eggs in a line near the midrib or any where on the lower surface of the leaves. Eggs are yellowish with a small curved stalk. Colour changes to black about two hours after the eggs are laid.
- **Nymph & Pupa:** Neonate nymphs are pale yellow in colour, flat and oval in shape, later turn shiny black. Its body is surrounded by fringes of wax.The fourth instar being the pupal stage, is flat, oval, grayish in colour and slightly bigger than the nymph. There is a 'T' shaped white marking on the thorax, which splits at the time of adult emergence.
- **Adult:** Pale yellow body with hyaline wings dusted with waxy bloom, exhibit brisk fluttering movements.



Management:

Cultural Method:
Avoid indiscriminate use of insecticides for control of other pests such as pyrilla, black bug, wooly aphids

Mechanical Method:
Detrashing the puparia bearing leaves and immediately disposing by burning or burying to prevent emergence of adult white flies

Chemical Method:
Spray fenitrothion 50 EC @ 2 lit / ha (1000 lit spray fluid)

Mealybug, *Saccharicoccus sacchari*

Symptom of damage:

Pinkish oval insects beneath leaf sheath on the nodes, with whitish mealy coating, main cane stunned also attack roots. Sooty mould develops on the honey dew giving blackish appearance on canes.

Life cycle:

Eggs: Eggs are retained in the female reproductive organs untils almost fully mature. Incubation period is short. The females may bring forth hundreds of young ones parthenogenetically. Egg is yellowish, smooth, cylindrical and rounded at both ends.
Nymph: Newly emerged nymphs are quite active with a pinkish transparent body.
Adult: White with mealy coating, sessile.

Management:

Cultural method:

- Use resistant varieties like CO 439, CO 443, CO 720, CO 730 and CO 7704
- Drain excess water from the field.

Physical method:

- Detrash the crop on 150 and 210 DAP

Chemical method:

- Apply any one of the following insecticides per ha and when the incidence is noticed spray on the stem only, methyl parathion 50 EC 1000 ml, malathion 50 EC 1000 ml.

Scale Insects, *Melanaspis glomerata* (Green)

Symptom of damage:

- The leaves of infested canes show signs of tip drying and unhealthy pale green colour and with continued infestation these turn yellow.
- Desapping leads to non-opening of leaves also, which also turn yellow and finally dry up.
- Nodal region is more infested than internodal region.
- Infested crop losses its vigour, canes shrivel, growth is stunted and the internodal length is reduced drastically.

- Ultimately cane dries up. Such canes when slit open appear brownish red.

Life cycle:

Nymph: Females multiply ovo-viviparously. The nymphs that hatch out from the eggs within the female's body come out through the genital aperture. They are called 'crawlers'. They settle after selecting suitable site for feeding.
Adult: Greyish black or brown circular scales, they cover the nodal region forming a thick encrustation.

Management:

Cultural method:

- Use resistant varieties like CO 439, CO 443, CO 453, CO 671, CO 691 and CO 692
- Select and plant the scale insect free setts.
- Keep the fields and bunds free from weeds.
- Avoid water stagnation in the field for the longer period.
- Avoid repeated ratoons.

Physical method:

- Detrash the crop at 150th and 210th day of planting.

Biological method:

- Release Chilocoris nigritus (or) Pharascymnus horni.

Chemical method:

- Presoak the setts in 0.1% solution malathion.
- Spray dimethoate 0.06% or 120th and 150th after detrashing.

Nematodes

Symptom:

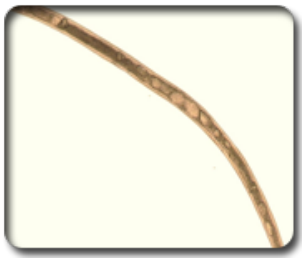
- Usually paling of leaves, first in the form of streaks, later complete yellowing-chlorosis, occurring in patches spread out all over the field. Chlorosis in severe cases, accompanied by drying up of margins and leaf tips is more common in ratoon and young crop.
- Stunting of crop, reduction in number and size of internodes.
- Roots are stubby and spares.
- Affected field shows pale green to whitish look.

Nematode types:

There are several nematodes present in the soil of which, four nematodes are mainly damaging the sugarcane crop. They are:

Lesion nematode - *Pratylenchus coffeae*

Root-lesion nematodes are migratory endoparasites Females of *P. penetrans* lay about 1 or 2 eggs/day for about 35 days, with a maximum of 68 eggs being laid by one female. Eggs are laid singly or in clusters in both soil and roots. Second stage juveniles hatch after eggs have incubated for 9 (30 C) to 25 (15 C) days. Males are required for reproduction by *P. penetrans* but not by *P. neglectus*.

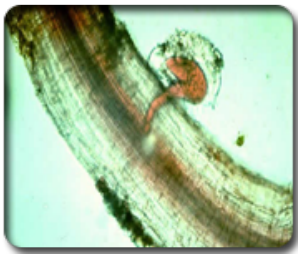


Lance nematode - *Hoplolaimus indicus*

Lance nematodes, Hoplolaimus spp., are ecto-parasites, sometimes semi-endo-parasites. Nematodes which are large and highly resistant to effects of temperature extremes and dry soil conditions. Larvae look similar to adults except that they are smaller.This group of nematodes is easily detected with soil sampling.

Root knot nematode - *Meloidogyne* spp.

Root knot nematodes are microscopic roundworms, obligate endo-parasites that complete most of their life cycle within their host roots. The nematodes survive in soil as eggs and also second stage larvae.



Reniform nematode - Rotylenchulus reniformis.

The term 'reniform' refers to the kidney-shaped body of the mature female. They are semi-endoparasitic (partially inside roots) species in which the females penetrate the root cortex, establish a permanent-feeding site in the stele region of the root and become sedentary or immobile.

Management:

Cultural method:

- Deep ploughing, solarisation, flooding, crop rotation and apply organic manure.
- Under wetland conditions, intercropping with sunnhemp or marigold or daincha
- Apply pressmud at 15 t/ha or poultry manure @ 2 t/ha or neem cake 2 t/ha or poultry manure @ 1 t/ha before last ploughing in garden lands.

Biological method:

- Application of biocontrol agents like *Pochonia chlamydosporia, Paecilomyces lilacinus* or *Trichoderma viride or Pseudomonas fluorescence* @ 20 kg/ha at the time of planting mixed with moist FYM or cured pressmud and distributed uniformly will help in suppressing the plant parasitic nematode.

Chemical method:

- Apply carbofuran 3G @ 33 kg/ha at the time of planting or 2 months after planting or Cartap 3 kg/ha (1.5 kg a.i./ha)

Grasshoppers, *Hieroglyphus banyan*

Symptom of damage:

- Adult and nymph grasshoppers feed on leaves from the margins of the leaf blades creating cutout areas during the solitary stage.
- finally it leaves only the leaf midrib.

Identification of pest:

Egg: Eggs in the form of egg pods, usually more than ten, either in the sand or among leaf litters. Each egg pod consists of about 10-300 eggs that are rice shaped.

Nymph:
Nymphs are miniature versions of adult grasshoppers, except that they are light in colour and do not possess wings. The nymphal stage may last for a period of 5-10 days.

Adult:
After about a month, a nymph becomes an adult. An adult grasshopper lives for 1-2 months.

Management:

Cultural method:

Tillage - Tillage controls grasshoppers primarily by eliminating the green plants on which grasshoppers feed.

Biological method:

Baits containing the protozoan *Nosema locustae* is a biological control option that may be considered for treating grasshopper breeding sites. This is sold under the trade names Nolobait or Semaspore and can produce infection of many species of grasshoppers. Because it is selective in effects, only affecting grasshoppers.

Sugarcane Diseases

Red rot

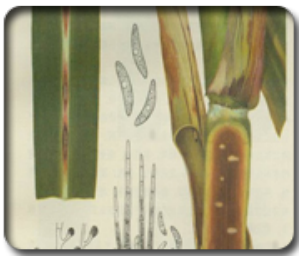
Symptoms

The affected canes exhibit leaf colour change, from green to

orange and then to yellow in the third or fourth leaf. Then the leaves start drying from bottom to top. The cane loses its normal colour and longitudinal discoloration spots / ribs are seen. The internode region shrinks with rupture of tissue in the root eye region and the spores are ejected from these spots. If the fungal spores enter the leaf sheath through the leaf midrib, then reddish spots can be seen on the backside of the leaf midrib also. The external symptoms appear only after16 - 21 days after infection and drying of entire cane takes another 10 days time. When the affected cane is split opened, the inner region is reddish in colour with intermittent white tinges across the cane length. If the variety is highly susceptible or disease incidence is severe, ash colour fungal growth is seen inside the cane. Sometimes, the pith inside the cane is filled with blackish brown liquid and exhibited alchohol odour.

Identification of pathogen

- Red rot disease is caused by the fungus *Glomerella tucumanensis*. An older name, *Colletotrichum falcatum*, is still preferred by some pathologists.
- Pathogen present on leaf sheaths and blades, solitary or aggregated, often forming short lines between vascular bundles, globose, immersed, dark brown to black 65-250 µm diam.; wall up to 8 cells thick, sclerotia on outside, pseudoparenchymatous within, ostiole slightly papillate, circular.



Management

Cultural method:

- The red rot affected field must be rotated with rice for one season and other crops for two seasons.
- Growing of recommended resistant and moderately resistant varieties *viz*., Co 86249, CoSi 95071, CoG 93076, CoC 22, CoSi 6 and CoG 5

Physical method:

- Removal of the affected clumps at an early stage and soil drenching with Carbandazim 50 WP (1 gm in 1 litre of water)

Chemical method:

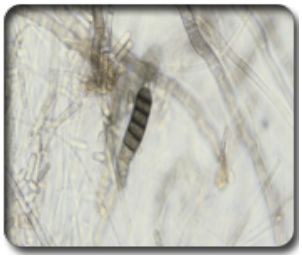
- Adopt sett treatment with Carbendazim before planting (Carbendazim 50 WP (0.5 gm in 1 litre of water) or Carbendazim 25 DS (1gm in 1 litre of water) along with Urea (10 gm in 1 litre of water) for 5 minutes)

Sett Rot

- When diseased setts are planted they may rot before germination, or the shoots may die after reaching a height of about 6-12 inches.
- As the setts get dried up, the reddish colour becomes black with lots of black coloured fungal spores adhering to it.
- If infected shoots survive, they are very much stunted and chlorotic.
- Eventually the leaves may wither and the shoots wilt.
- If the affected shoots and setts are examined the central portion of the shoots will be seen discoloured red and the contents of the sett rotting.
- When split opened, the affected setts exhibit pineapple odour.

Identification of pathogen:

Ceratocytis paradoxa were initially whitish, measuring about 5 mm in diameter. The colonies were turned black due to the production of chlamydospores, which are heavily pigmented, when mature.



Management

Cultural method:

- Proper drainage and planting of setts in 1-2 cm depth.

Chemical method:

- Sett treatment with Carbendazim or bavistin before planting (Bavistin @ 1per cent or Carbendazim 50 WP @0.5 gm in 1 litre of water or Carbendazim 25 DS @ 1gm in 1 litre of water along with Urea @10 gm in 1 litre of water for 5 minutes)

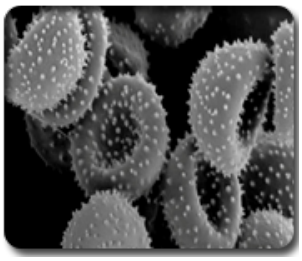
- Pre treatment the setts with hot water has been found to stimulate germination of buds and hasten growth soa s to help the young plants to overcome the competition with the pathogen.

Smut

Symptoms

- Production of whip like structure of 25 – 150 cm. from the growing point of the canes.
- Whip covered by translucent silvery membrane enclosing mass of black powdery spores.
- Initial thin canes with elongated internodes later become reduced in length.
- Profuse sprouting of lateral buds with narrow, erect leaves especially in ratoon crop.

Identification of pathogen



Ustilago scitaminea

The fungal mycelium spores are echinulate, light brown and spherical, measuring 6.5 – 8.5 µ in diameter.

- They germinate readily in water, producing 2-3 celled promycelia.
- sporidia arise terminally or laterally and they are hyaline, thin walled, single celled and elliptical to linear.

Management

Cultural method:

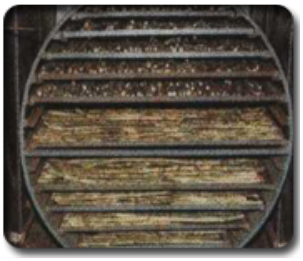
- Growing of resistant and moderately resistant varieties viz., Co 86249, CoG 93076, CoC 22, CoSi 6 and CoG 5
- Discourage ratooning of the diseased crops having more than 10 per cent infection
- *Cajanus cajan* is grown as a companion crop between rows of sugarcane, the secondary spread of the disease is substantially reduced.

Physical method:

- Treating the seed setts with Areated Steam Therapy (AST) at 50 ºC for 1 hour or in hot water at 50 ºC for 30 minutes or at 52 ºC for 18 minutes
- Roguing of smut whips with gunny bags/polythene bag and dipped in boiling water for 1 hour, and diseased clums must be uprooted and burnt

Chemical method:

- Sett treatment with fungicides *viz*., Triadimefon @ 1gm in 1 litre of water or Carbendazim @ 1gm in 1 litre of water for 10 minutes.



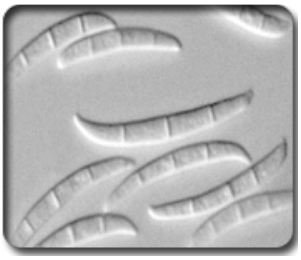
Wilt

Symptoms:

External: Gradual yellowing and drying of foliage, shrinkage/withering of canes.

Internal: Light to dark purplish or brown discolouration of ground tissue, pithiness and boat shaped cavities in the middle of the internodes.

Identification of Pathogen



Conidiosphores usually erect and branched. Macroconidia abundant, falcate to rather straight, 3-5-septate, with a distinct foot-cell, 27-73 × 3.4-5.2 mm. Blastoconidia straight or slightly curved, 2-3-septate, fusiform to lanceolate, with a somewhat pointed, often slightly asymmetrical apical cell and a truncate basal cell, 16-43 × 3.0-4.5 mm.

Management

Cultural method:

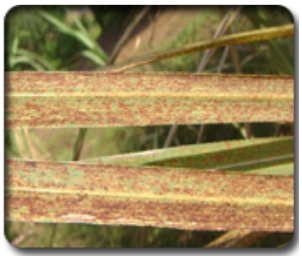
- Healthy seed, sett treatment with fungicides, resistant varieties, crop rotation, managing root borer, avoiding prolonged drought and water logging and hygienic practices.

Chemical Method:

- Dipping the setts in 40 ppm of boron or manganese, or spraying the plants with either of these minor elements reduces the disease intensity.

Rust

Sugarcane rust is mainly a disease of the leaf. The earliest symptoms are small, elongated yellowish spots that are visible on both leaf surfaces. The spots increase in length, turn brown to orange brown or red brown in color. Pustules, which produce spores, usually develop on the lower leaf surface.



Identification of pathogen

Puccinia erianthi

- Uredinia were elongate, reddish-brown, with capitate, hyaline to light brown paraphyses.
- Urediniospores were thick-walled, orange-brown, obovoid, measuring 26-34 x 16-20 µm. The urediniospore surface was echinulate with 4-5 equatorial pores.
- Teliospores were dark brown and measured 30-43 x 17-23 µm, clavate, two-celled and slightly constricted at the septum.

Management

Cultural method:

- Use resistant varieties like Co 91010 (Dhanush), Co 87025 (Kalyani)

Chemical method:

- Spray Tridemorph 1.0 litres or Mancozeb 2.0 kg/ha.

Grassy Shoot Disease

Symptoms

Initial symptom appears in the young crop of 3 – 4 months age as thin papery white young leaves at the top of the cane. Later, white or yellow tillers appear in large number below these leaves (profuse tillering). The cane becomes stunted with reduced internodal length. There is no millable cane formation. At times, one or two canes grow well in the affected tillers with greenish leaves. When these seemingly good canes are used for setts, the following crop produces only whitish leaves; these leaves dry early and gaps in the field.

Mode of spread

- The disease is spread by the use of affected setts for planting.
- Also, the black hopper (*Browtista moesta*) acts as a carrying agent of this disease.

Management

Cultural method:

- Growing resistant varieties viz., Co 86249, CoG 93076 and CoC 22
- Avoid ratooning if GSD incidence is more than 15 % in the plant crop

Physical method:

- Rogue out infected plants in the secondary and commercial seed nursery.
- Treat setts with aerated steam at 50°C for 1 hour to control primary infection.
- Treating them with hot air at 540C for 8 hours and spraying twice a month with aphidicides.

Chemical method

- Spray dimethoate @ 1ml in 1 litre of water to control insect vector

Yellow Leaf Disease

Symptom of Damage:

Yellowing of midrib and adjacent laminar region and subsequent leaf drying along the mid rib in 3 to 5 leaves from top. In some cases reddish discolouration is also seen and in severe cases drying of spindle along with leaves.

Pathogen:

- The virus is transmitted by aphids, *Melanaphis sacchari* and *Rhopalosiphum maidis,* in a semi-persistent manner.
- SCYLV is a member of the Luteoviridae family. The virus is localized within the phloem cells of the plant.

Management

Cultural method:

- Use healthy seed cane
- Field should be maintain with proper hygiene
- Application proper nutritional management and use resistant varieties.

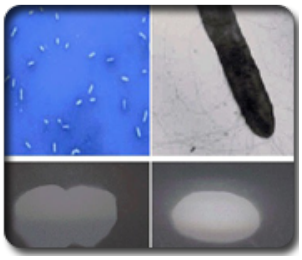
Chemical method:
Secondary transmission of the disease by insect vectors can be controlled by application of Malathion(0.1%) or Dimecron(0.2%).

Ratoon Stunting

The affected plants are stunted, the stunting being most severe in stubble and ratoon crops. Infected stocks is the presence of pin head like orange coloured dots of bacteria on the internal soft tissue in the nodal region The setts taken from diseased plants germinate poorly and the few shoots that are emerge grow very slowly. It is sap-transmissible and no insect vector has been found.

Pathogen

The organism that causes RSD is, *Leifsonia xyli* subsp. *xyli,* a small aerobic bacterium. The genus ofthe pathogen was previously called *Clavibacter.*



Management

Cultural method:

- Select healthy setts for planting.

Mechanical method:

Treat setts with hot water at 50°C for about 2 hours give 100 per cent control.

Sugarcane Farming Process (Step by Step Farming Process) Agriculture

Sugarcane plant is a coarse grass which is quite tall about 10-20 feet. A single plant bears many stems in a tuft. It is a rhizomatous, perennial plant with thick solid, aerial stem. The stem colour is variable from white, yellow, black, dark green, purple, and red or violet.

It is jointed and inter nodes are smaller at the base and increase in length, until it terminates in inflorescence. There are present prop or shit roots at the lower nodes to give mechanical strength to the stem on the nodes axial buds are present. Stem contains colored tissues in which many fibro vascular bundles lie. The inflorescence called an arrow or tarsal.

Soil Required for Sugarcane Cultivation:

Sugarcane grows best on the medium heavy soils, but can also be raised on the lighter soil sand heavy clay, provided there is adequate irrigation available in the former type of soils and drainage is good in the latter type of soils. In northern India, it is cultivated largely on the loams and clay loams of the gangetic and other alluviums, whereas in Peninsular India, it is grown on brown or reddish loams, laterites and black cotton soils.

In many places, dark rich clay loams, 120 to 150 cm deep and lying on a previous substratum of murum (disintegrated traprock) are used for this crop. The pH of the soil must be within 6.0-8.0.Sugarcane production is affected by unfavorable soil reaction (pH).The soil should be reclaimed according to acidity, alkalinity and other problems hindering the production of sugarcane.

The main characteristics of the soils suitable for sugarcane cultivation are that it must possess high contents of organic matter and is well drained. Therefore, heavy clay soil with proper drainage or light soils with irrigation facilities are also favorable for this crop.

Atmospheric Condition Required for Sugarcane Cultivation:

Sugarcane grows as well at a temperature of 21° to 26.2°C. A temperature of 20-23.7°C is ideal for good germination. Temperature above 32.2°C and below 18.3°C arrests the growth of the plant.

Sunlight is another key element which influences the yield and quality of cane. Sugarcane loves warmth and sunshine. Sugarcane requires long day for its vegetative growth and short day for its reproductive growth. Day length considerably influences

tillering. Short day length decreases number of tillers per plant and ultimately the tonnage.

Day length determines the flowering of the crop. Plant grows under long day conditions produces more dry matter. About 8-10hr of bright sunshine is conducive for yield and sugar output.
Shorter days favour tasselling or flowering. Bright sunshine is required the development stages of this crop. Under this condition, sugar content of this crop increases.
The physiological studies show that under good or bright sunshine, stems are thicker, shorter and leaves are broader and greener. Under less sunshine as is the case of cane grown as lower storey in coconut gardens, stems are slender, and taller having thinner and narrower leaves.

Rainfall:

Sugarcane does best in tropical and sub-tropical regions having rainfall of 75-100cm per annum. It requires heavy rainfall (150 cm) during its vegetative growth period. It grows well in an area receiving 100-175cm rainfall per annum.

In high rainfall areas (125-200 cm), this crop is grown without irrigation and thrives on the moisture conserved in the soil. Too heavy rainfall and prolong drought affects the crop adversely. Heavy rain lowers the sugar content and dry condition makes the cane fibrous.

Relative Humidity (RH):

High humidities (85 to 90%) are conducive for growth and development. But 45-65% RH is desired for sugar build up in cane stalks. In coastal areas high humidities and high temperature favour good growth and high yields. But sugar recoveries are low.

Atmospheric CO_2 Concentration:

Sugarcane benefits from increased atmospheric CO_2 concentration.
Generally photosynthetic rate increases as CO_2 concentration increases from 0.01 to 0.07% but becomes saturated at 0.06%. Varietal differences have also been observed. A strong and positive interaction is found between CO_2 and light. With increased sunlight, CO_2 fixation is also increased.

Frost:

Sugarcane experiences frost, which seriously reduces yield and quality. A temperature of -1 to -2 °C kills the plants. Severe cold conditions adversely affect ratoon sprouting and tiller formation. Irrigation just prior to frost and trash/polythene mulching mitigate frost to a great extent.

Effect of Climate on Ripening:

Ripening is influenced by rainfall, humidity, sunshine, night length, altitude, temperature and cultivar. For effective ripening, distinct cooler nights, and dry frost free sunny days are essential. High diurnal variation in temperature is not conducive for sugar accumulation. Ripening and maturity are influenced by the soil moisture.

Better drying-off strategy maximises the sugar output. Cane yield cannot increase after the Readily Available Water (RAW) has been extracted, but sugar yield can increase substantially while the remaining soil water is extracted. A mean dry temperature of 12-14 °C is desirable for proper ripening. At higher temperature during ripening, inversion takes place with considerably reduced sugar recoveries.

Preparation of Land for Sugarcane Cultivation:
The land is brought to fine tilt by ploughing with tractor or power tiller followed by planking after each ploughing. Plough the land thrice length wise and breadth wise and level properly. Prepare furrows 25 cm deep and 75 cm apart for short duration and 90 cm apart for medium duration varieties.

In hills tracts prepare pits in rows along the contour at spacing of 30 cm in the row and 75 cm between the rows. For mid late varieties, an inter row spacing of 75 cm is recommended.
Compost or F.Y.M @ 15-20 tonnes per hectare should be applied about 30 days before planting and thoroughly mixed with soil during land

preparation. The soil should be made free from stubbles, weeds and clods.

Sowing:

Efficient care and precautions should be taken while selecting the cuttings, treating it with chemicals at the time of planting.

Selection of Setts:

Stem cuttings or sections of the stalks are called “setts” or seed pieces. Each sett contains one or more buds.
Sugarcane crop is propagated by stem- cutting. The sugarcane sett should be taken from well matured, erect and healthy crop of not more than 10-12 months of age. The upper-half-portion of the plant bears buds of high viability and is best for raising new crop.

The top portion contains less sucrose and bud remains young and active due to which it germinates well. Cane setts of two or three nodes, bearing 3 or 4 vegetative buds are made from the healthy, free from insect pests and diseases, top portions of the plants after hand peeling. The sugarcane sett having red spot on the cut end should not be used for planting.

The implement used for cutting the sett

should be treated with spirit or solution of seed treatment chemical. Generally, three bud setts are used for planting throughout the world, while in some areas two-bud setts are also used. About 35,000 sets is required for one hectare.

Sett Treatment:

Cane-seed-setts are wet and sugary, therefore, while in soil, before sprouting into new plant, these are mostly damaged by insects (termites) and fungus. To avoid these losses, the sets, before planting, are treated before planting by different ways depending upon the condition of planting material.

(i) 1% Fish Oil Rosin Soap Treatment:

The sets are treated with 1 % fish oil rosin shop solution to stop spread of mealy bugs and scale insects.

(ii) 6% Mercurial Fungicide Treatment:

The sets are dipped for 2 to 3 minutes in a solution of 6 % mercurial fungicide like agallol or cerasan @ 500 gm. in 100 liter water. This treatment helps to prevent set borne diseases like smut

and to improve germination.

(iii) Hot Water Treatment:

The sets are kept in hot water at 50°C temperature for two hours to control red-rot, grassy shoots and other virus diseases.

(iv) Azotobacter Treatment:

Just before planting sets are dipped in azotobacter inoculant solution which is prepared by mixing 5 kg. azotobacter inoculants in 100 liter water for 2 to 3 minutes. This treatment helps in good germination and save nitrogenous fertilizers.

(v) Lime Water Treatment:

Sets are soaked in lime water solution prepared by dissolving 500 g lime in 200 liter water for 24 hrs to improve germination. This treatment is given only when dry scaled bud sets and staled cane sets are used for planting.

Time of Planting:

The best time of planting the sugarcane setts for spring crop is the period when the atmospheric temperature records an average of 25°C. Therefore, the time of sowing in Tamil Nadu, Andhra

Pradesh, Maharashtra and Karnataka is earlier (i.e. December – January) than the time of sowing in Punjab, Haryana, Uttar Pradesh (February – March).

The crop can be sown round the year. Crop planted before winter season gives less sprouting and tillers due to cold weather, during early sprouting stage. The duration of sugarcane crop in India ranges from 10-18 months. A 12 months crop is most common. Time of planting is governed by weather conditions. Sugarcane requires about 25-320 C temperature for good germination. Spring and autumn plantings are two important planting seasons.

Spring Planting:

In Northern India spring planting is done in February-March while in Peninsular India it is done in January- February. Spring planted crop is known as suru in Maharashtra and eksali in Gujarat and Andhra Pradesh.

Autumn Planting:

This planting is very popular in Northern India. This planting is done in September-October while in Bihar and Peninsular India it is done in

October – November. Autumn planting is also known as pre-seasonal planting in Maharashtra and Gujarat. The pre- seasonal crop matures in 13-15 months and supplies sugarcane in early crushing period.

Adsali Planting:

In Maharashtra and Karnataka, adsali planting is done in July-August and the crop matures in 16-18 months. Because of extended growing season, there is increase in yield as well as sugar recovery. Biggest advantage of adsali is that it passes through only one summer season. In the present scenario, area under adsali planting is declining because of less availability of irrigation water.

Late Planting:

Because of wheat crop is taken on large area in rabi season in Northern and Central India, planting of sugarcane is delayed until harvesting of wheat in March-April. Research data has been proved conclusively that delay in planting causes considerable yield reduction.

Method of Sowing:

Sugarcane crop is sown by various

methods, depending upon the field problems.

Common methods of planting are described here:

(i) Flat Planting:

Flat planting method is mostly common in intensive sugarcane growing areas where soil-moisture is available in plenty. Sets are kept in shallow (8-10 cm) deep furrows at 75 cm apart. On an average, one viable bud per ten centimeter length in each furrow is planted (i.e. one sett/feet). The field is heavily planked. This method of sowing is popular in North India.

(ii) Furrow Planting:

Furrow planting method is mostly common under low soil moisture condition. In this method the ridges and furrows are opened with the help of ridge by keeping 120 cm distance between furrows in heavy soil and 105 cm distance in light to medium soil. After sowing irrigation is given immediately. First sets are laid on the top ridges end to end and later planted in furrows by two ways known as wet method and dry method of planting.

a. Wet Method:

This method is followed in light to medium soil. Irrigation is given to the field before planting. Sets are planted by pressing 2.5 to 5 cm deep in furrows with feet or hand. The sets are placed end to end by facing buds on sides.

b. Dry Method:

This method is followed in heavy soil to avoid the pressing as sets deep into the soil. Sets are placed in the furrow end to end by facing eye buds on sides and covered by giving a layer of soil. After completion of planting irrigation is given to the field.

(iii) Trench Method:

In some coastal areas as well as in other areas where the crop grows very tall and the strong winds during rainy season cause lodging of cane, trench method is adopted to save the crop from lodging. Trenches at a distance of 75-90 cm are dug with the help of ridger or by manual labour. Trenches should be about 20-25 cm deep. After this already prepared mixture of fertilizers (NPK) should be spread uniformly in the trenches and mixed thoroughly in the soil.

The setts are planted end to end in trenches. Gamma BHC 20 EC at the rate of 5 liters in 800-1000 liters of water per hectare is sprayed over planted setts in trenches to control termites and shoot and root borers. Immediately after this, trenches are filled up with loose soil as in case of flat sowing. The tractor-drawn sugarcane planter is a very suitable device for planting cane in trenches.

After Care:

After sowing, the sugarcane field requires some immediate cares like hoeing and protection from insects and farm animals. The fields are irrigated within a few days after sowing to get required soil conditions for hoeing.

Hoeing assists in the emergence of sprouts and increases the plant population in the field. The new emerging shoots are tender and palatable for animals to eat. Therefore, a number of insects and farm animals are attracted towards it and they require due protection measures.

Manures and Fertilizers:

Sugarcane is a heavy feeder and it occupied the land for about twelve months. Sugarcane depletes large

quantity of plant nutrients and makes the soil infertile. In this condition, the growth of the plant as well as yield of sugarcane reduces considerably. So adequate manuring is essential for getting higher yield of sugarcane. The nutrient requirements have been found more important in three stages of growth except ripening phase.

The nutrient requirement of sugarcane varies accordingly to the growing region, variety and fertility status of the soil as follows:

(i) Manures:

Farmyard manure is added one month before planting at the rate of 10-12 tonnes of well decomposed manure, to improve the soil texture and water holding capacity. Mustard oilcake or Neem cake (Qty.: 300kg/ha), if possible should be applied. Organic manures are good for sugarcane crops the same provides nutrient throughout the growing period of this crop.

(ii) Fertilizers:

Fertilizers are applied based on the recommendation of the soil test. For general purpose 300 kg nitrogen, 80 kg phosphorus, 80 kg potash and 80 kg

calcium per hectare are applied. Half dose of nitrogen and full dose of other fertilizers are placed in furrows below or on the side of cane-sets, at the time of sowing as a basal dose.

The rest of the nitrogen is applied in two split doses as topdressing during plant growth period. The application of fertilizer at the early stage of plant growth is advantageous, and increases the sucrose contents in the juice.

Water Management:

Sugarcane needs optimum moisture during all stages of growth. The vegetative growth period of the sugarcane crop can be looked upon in four stages i.e. (i) Sprouting stage, (ii) Formative stage, (iii) Grand growth stage and (iv) Maturity stage.

The water requirement of sugarcane varies from 200- 300 depending upon the soil type and weather conditions, method of planting, timely irrigations result in more juice with high sucrose contents. After the monsoon, mostly 6- 7 irrigations are required for successful crop production.

Irrigation:

In the case of sugarcane, the

maintenance of optimum soil moisture during all stages of growth is one of the essential requisites for obtaining high yields. The crop should, therefore, be grown in areas of well-distributed rainfall or under an assured and adequate irrigation.

In tropical India, depending on the type of the soil, the seasonal conditions, the variety grown, the method of planting and the rate of manuring, the total water requirement of the crop for optimum growth varies from 200 to 300 cm, inclusive of rainfall.

The requirement of an adsali crop is proportionately higher. Where the soil is not retentive of moisture, and where there are no reserves of subsoil moisture, cane requires to be irrigated frequently. In tropical India, usually one or two waterings are given at intervals of three or four days after planting to help the setts to germinate and the seedlings to establish themselves.

Thereafter, in the absence of rains, cane is irrigated every 10 to 12 days during its growing period. In dry areas and in sandy-loams soils, irrigations may be needed at intervals as short as

eight days. In deep clay loams, irrigation can be withheld for longer periods, say, up to two or three weeks.

Frequent light irrigations, each 40 to 50 mm, adjusted to suit the growing period of the crop and the prevalent weather conditions, are very useful. Towards the time of harvesting, irrigation frequency is reduced, and just before harvest, irrigation is withheld for about a month.

In Northern India the summer being drier and hotter the crop needs water more frequently than in southern India, but actually, adequate water for frequent irrigation is not available and irrigations are, therefore, usually given at comparatively long intervals. In canal irrigated areas, the frequency of irrigation depends entirely on the running of the canals.

The severity of these conditions is slightly mitigated by the high water- holding capacity of the alluvial loam soil. In the Punjab State because of the lower rainfall, drier climate, and slightly coarser soils, the crop gets 8 to 10 irrigations during summer. In Central and Western Uttar Pradesh three to five irrigations are usually given, and they help the crop to tide

over the summer.

In the eastern Gangetic areas, cane subsists almost entirely on subsoil moisture and rainfall, and receives no irrigation at all. In the post-monsoon season the crop receives only one or two irrigations or none at all, however these post monsoon irrigations only help to keep the crop in good condition, for cane does not make growth in winter.

In areas where frost occurs, irrigations are applied to save the crop from them. Sugarcane responds to irrigation in northern India as it does in the south and it is profitable to apply frequent light irrigations to the crop during the hot weather. Where irrigation facilities are scarce in summer, trash-mulching in the interspaces of the cane rows is done for conserving the soil moisture.

Interculture:

As the crop remains in the field for a long period, intercultural operation such as hoeing, weeding, earthing up, wrapping and trashing needs to be done.

i. Hoeing:

Hoeing is done first by a week or so

after planting in order to break the surface crust, else light irrigation is followed by the same period in order to help emergence of sprouts.

ii. Weeding:

Weeds are undesirable plants growing within a crop and they compete for resources such as nutrients, water and light. Germination of crop completes in 20-30 days. As area is irrigated, it grows variety of weeds during the period.

Weed poses a serious problem in sugarcane cultivation as its lowers the productivity of land robbing it of available nutrients and moisture.
Weeds often serve as host for some virus and vectors and increase the incidence of insects, pests and diseases. Without weed control, crop yields can be significantly reduced. Weed control in sugarcane is done by adopting mechanical method or chemical method.

(i) Mechanical Method:

Fields are given a hoeing with help of kurpi or spade, after a month of sowing and the process is repeated frequently. This method not only removes the weeds but also increases the sprouting

and tillers and destroys insects and enhances aeration in the soil. Some growers make best use of this laborious operation by cultivation of second crop in between the sugarcane crop as a mixed crop.

(ii) Chemical Method:

Chemical method is most effective for controlling weed during pre – monsoon period. Weeds can be effectively controlled by the application of herbicides or weedicides. Herbicides are of particular value in keeping down weeds early in the season when weed competition can do the greatest damage to the young growing crop and when no interculture can be performed. Herbicides are applied at different times depending on their mode of action.

iii. Earthing Up:

Soil between the furrows of canes, is taken with the help of spade and applied to the sides of the plants.

This earthing up is advantageous in many ways (i) Acts as hoeing, (ii) Mixes the top dress fertilizers well in the soil, (iii) Support the plant, to save them from lodging, (iv) Help the bud to sprout profusely and (v) Makes

watering and drainage easy. This operation is done when the crop is 5 to

5.5 months old and 2 to 3 internodes are visible.

iv. Trashing:

Removal of loosely adhering dried and drying leaves from the sugarcane known as trashing. It is generally done to clean the sugarcane.

v. Propping:

The tying of cane plants to prevent lodging is known as propping. Some canes of two adjacent rows are brought together and tied by sugarcane leaves rope. It also helps in applying irrigation in a better way.

Maturity and Harvesting of Sugarcane:
Cane should be harvested only when it is mature.

Practical tests to judge maturity are-
(a) General yellowish colour of whole crop, (b) Cessation of growth, (c) Swelling of eye buds, (d) Metallic sound of cane, (e) Breaking of cane at the nodes and (f) Brix saccharometer reading between 21 and 24.

Irrigation should be held for about 10 to 15 days prior to harvesting. Harvesting should be done with sharp cane cutting knife and very close to ground. The cane should be crushed within 24 hours to get high recovery.

ENTOMOLOGY & PLANT PATHOLOGY

SORGHUM DISEASE- SYMPTOMS & CONTROL

March 30, 2022 / Shailesh Tiwari

SORGHUM DISEASE- SYMPTOMS & CONTROL

In this blog we will know the important disease of sorghum (Jowar).

Head Smut: *Sphacelotheca reiliana*

Symptom

- The fungal spores live in the soil and germinate in the spring.
- The **entire ear head is completely or partially replaced by a large whitish gall**.
- Spores move with wind and water to the soil and serve as inoculum for the next year.

Head smut

Management

- The best practice is to grow resistant cultivars.
- Seed treatment with Vitavax @ 2g/kg of seed.
- Collect infected ear heads in cloth bags and dip in boiling water to remove inoculum.

Covered Kernel Smut: *Sphacelotheca sorghi*

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.
- Ratoon crops exhibit a higher disease incidence.

Covered kernel smut

Management

- Same as head smut.
- Avoid rationing

Long Smut: *Tolyposporium ehrenbergii*

Symptom

- Relatively small proportion of the florets is infected.
- The spore (sori) sacs are cylindrical, elongate, usually slightly curved with a relatively thick creamy-brown covering membrane.

Long smut

Management

- Same as covered smut.

Loose smut: *Sphacelotheca cruenta*

Symptom

- The ears come out much earlier than the healthy. The affected plants are shorter than the healthy plants with thinner stalks and marked tillering.
- Ear head gives a loose appearance than healthy. The sorus is covered by a thin membrane which ruptures very early, exposing the spores even as the head emerges from the sheath.

Loose smut

Management

- Seed treatment with Carboxin (Vitavax) @ 2g/kg seed or Captan/Thiram 4g/kg of seed.
- Collect smutted earheads in cloth bags and destroy by dipping in boiling water.
- Avoid rationing.

Downy Mildew: *Peronosclerospora sorghi*

Symptoms

- Downy mildew spores germinate and invade the roots of sorghum seedlings.
- Infected seedlings may become chlorotic and die. Infected plants are usually sterile.
- Abundant downy white growth is produced nocturnally on the under surfaces of infected portions of leaves during humid weather.
- **Favourable Conditions**– Maximum sporulation takes place at 100% relative humidity; optimum temperature for sporulation is 21-23˚C during night while light drizzling accompanied by cool weather is highly favourable.

Downey mildew

Management

- Rogue infected plants up to 45 days of sowing.
- Spray fungicides like Metalaxyl + Mancozeb 500 g or Mancozeb 1000g/ha after noticing the symptoms of foliar diseases.

Rust: *Puccinia purpurea*

Symptom

- The pustules are elliptical and parallel with the leaf veins.
- In highly susceptible cultivars the pustules occur so densely that almost the entire leaf tissue is destroyed.
- Favourable Conditions are low temperature of 10 to 12˚C favours teliospore germination, while spell of rainy weather favours the onset of the disease.

Rust

Management

- Spray Mancozeb at 1kg/ha. Repeat fungicidal application after 10 days.

Anthracnose and Red Rot: *Colletotrichum graminicola*

Symptom

- Based on site where damage occurs, categorize into leaf anthracnose, panicle (grain) anthracnose, and anthracnose stalk rot. Lesions begin on the lower leaves and progress up the plant.
- Oval to elongate water soaked lesions may develop close together and coalesce to kill large portions of the leaf.
- Mid-rib infection often occurs and is seen as elongate-elliptical red or purple lesions on which the black acervuli can be clearly seen.
- Infected stems when split open show discoloration which may be continuous over a large area, or more marbled appearance.
- Favourable Conditions are ontinuous rain, temperature of 28-30˚C and high humidity.

Anthracnose

Management

- Seed treatment with Captan or Thiram @ 4g/kg of seed.
- Spray with Mancozeb 1 kg/ha.

Ergot or Sugary disease- *Sphacelia sorghi*

Symptoms

- The disease is confined to individual spikelets.
- The first symptom is the secretion of honey dew from infected florets. Under favourable conditions, long, straight or curved, cream to light brown, hard sclerotia develop. Often the honey dew is colonised by Crerebella sorghivulgaris which gives the head a blackened appearance.
- A period of high rainfall and high humidity during flowering season and cool night temperature and cloudy weather favours the disease.

Management

- Adjust the date of sowing so that the crop does not flower during September-October when high rainfall and high humidity favor the disease.
- Spray Mancozeb 2 kg/ha or Carbendazim at 500 g/ha at emergence of ear head (5-10 per cent flowering stage) followed by a spray at 50% flowering and repeat the spray after a week, if necessary.

Cereal Grain Molds: A complex of several fungal species

Symptom

- The most commonly isolated Fusarium species are *semitectum*and *F. moniliforme*. The grain infected with these fungi develops a fluffy white or pinkish coloration.
- Curvularia lunata is also frequently encountered and this fungus colors the grains black.

Management

- Spray Mancozeb 1 kg/ha or Captan 1kg + Aureofungisol 100g/ha.

See also…
SUGARCANE DISEASES- SYMPTOMS & CONTROL
MAIZE DISEASES- SYMPTOMS & CONTROL
WHEAT DISEASE- SYMPTOMS & CONTROL
RICE DISEASE- SYMPTOMS & MANAGEMENT

Tags: Anthracnose and Red Rot, anthracnose of sorghum, downey mildew of jowar, ergot of sorghum, head smut of sorghum, jowar disease, jowar rust

Tomato

Tomato
Buy Products for your crop
Crop Protection
Package of Practices
Expectation
BharatAgri Smart Farming
Standard Farming
Expected Fertilizer and
Agrochemical Expenditure
¥41,000
Expected Harvest
18 Tons/acre
900 crates/acre
Expected Income (Rs)
¥1,80,000
Expected Fertilizer and
Agrochemical Expenditure
¥48,000
Expected Harvest
14 Tons/acre
700 crates/acre
Expected Income (Rs)
¥1,40,000

Favourable climate

Climate
• Heavy rains, cloudy weather at the time of flowering and fruiting is harmful as it favours dropping of flowers and fruits.
• The plants cannot withstand frost and high humidity.
• High humidity leads to rotting of fruits.
• Bright sunshine at the time of fruit set helps to develop dark red coloured fruits.
Temperature
• Temperature below 10°C retards plant development.
• If temperature goes beyond 33°C, fruit development will be adversely affected.
• Temperature above 38°C at initial growth stage retard the growth.
• A temperature ranging from 21-24°C is ideal for tomato.
Crop Water Requirement
• Generally Grown in irrigated areas.
• To grow high quality tomato, drip with plastic mulching is recommended.
• Crop requires large amount of water at vegetative stage (upto 30 days).
• Crop water requirement- equivalent to 600-900 mm rainfall

Favourable soil

Favourable Soil
Type
• Loamy soil with good water holding capacity pH
• Required range- 6.0-7.5

- If pH is <6.0 add Lime.
- If pH is >7.5 add Gypsum.

Planting material

Abhilash F1
Duration
Special Characteristic
⑥ ②器.3%国

Package of Practices
Yield
150.0 Days
Recommended for Kharif season
Plant Type: Strong
Fruit Colour: Attractive Red
Average Fruit Weight: 80 - 100 gm
Fruit Shape: Flat Round Firmness & Shelf life:
Good
Days to First Harvest:65 - 70 days
180.0 Quintal/Acre
Shine tomato Jumbo F1 hybrid
Duration
150.0 Days
Special Characteristic
Yield
Recommended for all season
Variety type :
Determinant
Fruit Colour: Red
Fruit Shape: Flat Round
Days to First Harvest:55-60 days
Tolerant: Virus and diseases
180.0 Quintal/Acre

Nursery preparation

- For transplanting in 1 acre area, 0.08 acre (3 Guntha) nursery is required.
- Prepare six beds of size 3 m length X 1 m width X 15 cm height.
- Sow the seeds 2-3 cm deep in line at 10 cm apart and cover with soil.
- Water the nursery beds daily twice till germination and once after germination.
- 4-5 days before transplanting reduce the quantity of water application to the nursery beds to harden the seedlings and one day before transplanting give light irrigation.

OR

- Fill the protrays with Cocopeat @ 1.2 kg per protray.
- Sow the treated seeds in protrays @ 1 seed per cell.
- Cover the seed with cocopeat and keep the protrays one above the other and cover with a polythene sheet till germination starts (5 Days).
- After 6 days, place the protrays with germinated seeds individually on the raised beds inside a shade net.

Nursery Duration
- Duration- 25-30 days
- Plants are ready for transplanting when leaves become dark green in color and stem become thick.

Seed Rate
Varieties
150.0 - 160.0 gram/acre
Seed Treatment
50.0 - 60.0 gram/acre

Land preparation

Land preparation
• Plough the land 1 or 2 times based on soil type.
• Mix the following in field and keep it in open air for 10 days for proper decomposition -
FYM- 2 tons
Composting Bacteria- 3 kg
• Spread the above mixture over soil and run rotavator to the entire field making the soil as a fine tilth.
Bed preparation
• Bed preparation- Prepare beds of 120 cm width and 90 cm apart with the help of tractor.

Spacing and plant population
Varieties
Row to Row 2.9 ft
Plant to Plant 0.9 ft
Plant Population 16,858
Hybrid
Row to Row 2.4 ft
Plant to Plant 0.9 ft
Plant Population 20,370

Root Dip Treatment
• Take 20 liter water in flat container.
• Mix 40 gram Mancozeb + 40 ml Imidacloprid.
• Dip the roots for 15 mins in solution before transplanting.
• For plants in pro trays- Dip the pro trays in container for 5 min.

Transplanting
• Transplant the seedlings on the beds 30 cm apart.

Nutrient management

For varieties 80:40:40 N:P:K kg/acre.
•At transplanting apply-
Urea- 87 kg
Single Super Phosphate- 246 kg
Muriate of Potash- 67 kg
• 20 Days after transplant-Urea- 28 kg
• 40 Days after transplant-Urea- 28 kg
• 60 Days after transplant-Urea- 28 kg
• For Hybrids 120:60:60 N:P:K kg/acre.
• At transplanting apply-

Urea- 130 kg
Single Super Phosphate- 375 kg
Muriate of Potash- 100 kg

- 20 Days after transplant-Urea- 44 kg
- 40 Days after transplant-Urea- 44 kg
- 60 Days after transplant-Urea- 44 kg

Irrigation

Number of harvests

- 8 to 10

Harvesting duration

- 70 to 110 days after transplanting.

Harvesting interval

- 3 days

Yield
Each harvest quantity

- Varieties- 50 crates/acre
- Hybrid- 90 crates/acre

Total harvest quantity

- Varieties- 500 crates/acre
- Hybrid- 900 crates/acre

Horticulture

Ultimate Guide to Jowar (Sorghum) Farming: Beginner Tips fo Jowar Cultivation

Jowar farming, also known as Sorghum farming, is the cultivation of a versatile and nutritious grain crop. Jowar, scientifically nam Sorghum vulgare, belongs to the grass family Poaceae and offers numerous health benefits.

Understanding the Jowar Crop Varieties

There are various types of Jowar, such as Maldandi, SSG 59-3 (Shaktiman), Phule Vasundhara, CSV 15F, etc., each with its unique characteristics and growing requirements. With various Jowar varieties available, each with unique characteristics and benefits, farmers have the flexibility to choose the best fit for their needs. The popular variety is Maldandi, known for its high yield potential resistance to pests.

Another common type is SSG-59, preferred for its shorter duration to maturity and excellent grain quality. Other notable varieties include CSV 15MF, Phule Vasudha, Jawahar Jowar Hybrid-1, and others, each offering distinct advantages depending on your spec farming requirements. By selecting the right Jowar variety suited to your region's climate and soil type, you can optimize your cro yield while minimizing risks associated with adverse weather conditions or pest infestations.

Climate and Soil Requirements for Optimal Jowar Growth

Jowar, also known as Sorghum, thrives in warm climates with temperatures from 25°C to 32°C. It requires a good amount of sunlig to grow and develop properly. When it comes to soil preferences, Jowar grows best in well-drained soils. The ideal pH level for Jow cultivation is between 6.0 and 7.5. This slightly acidic to neutral pH range ensures that the plant can efficiently access essential nutrients from the soil. Additionally, excessively alkaline or acidic soils can hinder the plant's nutrient uptake, affecting its growth

Preparing Your Land for Jowar Cultivation: Step-by-Step Guide

Firstly, clear the field of debris or unwanted vegetation. This will help ensure that your Jowar plants have access to all the nutrient and sunlight they need to thrive. Next, plough the land thoroughly to break up any compacted soil and create a loose, fertile seed Proper soil preparation is crucial for optimal Jowar growth and development.

In case you missed it: **Pest Management in Sorghum: Major Insect Pests of Sorghum, Control, and Prevention**

After ploughing, level the field evenly to promote uniform water distribution during irrigation. This step helps prevent waterloggir certain areas of the field. Consider incorporating organic matter like compost or manure into the soil before planting your Jowar seeds. This will provide nutrients for healthy plant growth throughout the growing season.

Best Time to Plant Jowar: Seasonal Considerations

The best time to plant this versatile crop depends on the seasonal considerations and weather conditions in your region. In gener Jowar thrives in warm climates with temperatures. It requires adequate sunlight for optimal growth and development. For most regions, planting Jowar during the early summer months after the last frost has passed is ideal.

Avoid planting too late in the season. Inadequate growing conditions may result in stunted growth or reduced yields. By understanding the seasonal variations and requirements of Jowar cultivation, you can maximize your chances of a successful har

Seed Selection and Treatment: Ensuring Healthy Jowar Plants

Begin by choosing high-quality seeds from reputable suppliers or certified sources. Look for seeds that are disease-resistant and suited to your specific growing conditions. Before planting, treat the Jowar seeds with fungicides or biocontrol agents to protect them from soil-borne diseases. Seed treatment can help improve germination rates and overall plant growth, setting the stage fo successful harvest.

When selecting Jowar seeds, consider factors like seed size, color, and shape. Opt for uniform seed characteristics to ensure consistent growth and development across your field. Remember that healthy plants start with healthy seeds. Take the time to research different seed varieties and treatments to give your Jowar crop the best possible chance at thriving on your farm.

Sowing Techniques for Jowar: Methods and Best Practices

Ensure that the land is well-prepared and free of debris or weeds before planting. This will help promote plant growth and minim competition for nutrients. For optimal results, it is important to sow the seeds at the right depth—typically around 2-3 inches dee depending on soil moisture levels. Additionally, spacing between seeds should be adequate to allow each plant enough room to without overcrowding.

In case you missed it: **Weed Management in Sorghum Farming: Control with Chemical, Biological, Mulching, Herbicides, and C Rotation**

Another important aspect of sowing Jowar is ensuring proper seed placement and coverage. Seeds should be evenly spread acro the field to promote uniform germination and avoid patchy growth. Always consider factors such as soil temperature and moistu levels when deciding on the best time to sow your Jowar crop.

Fertilization Strategies for Jowar

Jowar plants thrive on a well-balanced diet of nitrogen, phosphorus, and potassium. Nitrogen is essential for leafy growth, while phosphorus aids in root growth and overall plant health. Potassium helps with disease resistance and fruit quality. A soil test can h to find the specific needs of your Jowar crop. Based on the results, you can choose the right type and amount of fertilizer to apply.

Organic options like compost or manure are great for sustainable farming practices. Chemical fertilizers can also be used but sho be applied carefully according to guidelines. Remember that over-fertilization can harm your crop and the environment. Proper timing and distribution of fertilizers are crucial for maximizing yield without causing harm.

Irrigation Practices for Jowar

Drip irrigation is highly recommended for Jowar cultivation. It helps deliver water to the plant roots, minimizing wastage and reducing fungal diseases. This method also promotes water efficiency and can result in higher yields. It's important to observe soi moisture levels regularly and adjust irrigation schedules accordingly.

Depending on your location and climate, different irrigation methods may be employed. These include sprinkler irrigation, drip irrigation, or flood irrigation. Additionally, incorporating mulching techniques can help retain soil moisture and improve overall so health. Consider using organic mulches for sustainable benefits.

Weed Control in Jowar Farming

Weeds compete with Jowar plants for nutrients, sunlight, and water, affecting overall productivity. Implementing effective weed management strategies can help maintain the health of your Jowar crop. The main method is manual weeding, using tools like h hoes or weeders to remove weeds from the field. This labor-intensive process helps prevent weed infestation and promotes bette Jowar growth.

In case you missed it: **Sorghum Farming in the Philippines: A Step-by-Step Production Guide**

Another approach is mulching, which involves covering the soil with organic materials to suppress weed growth. Mulching not or controls weeds but also retains soil moisture and regulates temperature. Herbicides are also commonly used in Jowar farming to control stubborn weeds efficiently. However, proper guidelines and safety measures must be followed while using herbicides to a any negative impact on the environment or crop quality.

Pest and Disease Management in Jowar

Some common pests that can affect Jowar plants include stem borers, shoot fly, aphids, and armyworms. These pests can cause damage if not managed effectively. On the other hand, diseases such as downy mildew, smut, anthracnose, and rust can also imp the growth of Jowar crops. Implementing preventive measures like crop rotation, maintaining proper spacing between plants, an using disease-resistant varieties can help minimize the risk of infections.

Regular scouting of fields for signs of pest infestations or disease outbreaks is essential for early detection and prompt action. Integrated pest management techniques combining cultural practices with minimal pesticide use are recommended to maintai balance between controlling pests and preserving beneficial insects in the ecosystem.

Intercropping and Crop Rotation with Jowar

By intercropping Jowar with legumes like pigeon peas or green gram, farmers can improve soil fertility and increase overall yield. Additionally, rotating Jowar with other crops, such as maize or soybean, helps in reducing pest and disease pressures while maintaining soil health. These practices also contribute to a more sustainable farming system by preventing nutrient depletion a promoting biodiversity on the farm.

Furthermore, intercropping efficiently uses resources like water and sunlight, maximizing productivity per unit area. Crop rotatior helps break the pests and diseases life cycle that target Jowar specifically, leading to healthier plants and higher-quality yields.

Harvesting Jowar: Timing and Techniques for Maximum Yield

The ideal time to harvest Jowar is when the grains are hard and difficult to dent with a fingernail. This ensures that the crop has reached its full maturity and will result in higher-quality yields. Harvesting techniques vary depending on the scale of your operati For small-scale farmers, hand tools like sickles or scythes can be used to cut the stalks close to the ground.

In case you missed it: **Sorghum Farming in Kenya: A Step-by-Step Production Guide**

On larger farms, mechanized equipment such as combine harvesters can significantly speed up the harvesting process. After harvesting, it's important to dry and store the Jowar grains properly to prevent spoilage. Threshing, winnowing, and cleaning are essential steps in preparing the harvested grains for storage or further processing.

Post-Harvest Management: Drying, Storage, and Processing of Jowar

Once you have successfully harvested your Jowar crop, the next crucial step is post-harvest management. Drying the Jowar grain essential to prevent mold growth and maintain quality. Spread the harvested grains in a thin layer under the sun for natural dryin use mechanical dryers for efficiency. Proper storage of dried Jowar grains is key to preserving their nutritional value.

Store them in a cool, dry place, away from pests and moisture. Plastic containers with tight lids can help protect against insect infestations. When it comes to processing Jowar, options include grinding it into flour for various culinary uses, such as rotis, brea porridge. You can also pop the grains as a healthy snack or use them to brew traditional beverages.

Marketing Your Jowar Crop: Strategies for Selling and Profit Maximization

The effective approach is to establish strong relationships with local markets and buyers who appreciate the quality of your produ Networking with wholesalers and retailers can help you secure better prices for your Jowar. Another key strategy is to leverage dig platforms and social media to showcase your Jowar crop to a wider audience. Creating an online presence through social media pages can attract potential customers looking for organic and sustainable produce.

Furthermore, participating in farmers' markets, food fairs, and agricultural exhibitions can also boost the visibility of your Jowar cr These events provide direct access to consumers interested in healthy eating options like Jowar. Another avenue worth exploring collaborating with restaurants, cafes, or health food stores that promote locally sourced ingredients. By highlighting Jowar's nutritional benefits, you can attract health-conscious consumers seeking alternative grains for their diets.

In case you missed it: **Sorghum Cultivation Income (Jowar), Yield, Project Report**

In addition, offering value-added products such as Jowar flour, flakes, or snacks can diversify your product range and appeal to different market segments. Packaging plays an important role in attracting customers—consider eco-friendly packaging that alig with the sustainability aspect of Jowar farming.

Organic Jowar Farming: Practices and Certification

Organic cultivation involves using natural fertilizers and pest control methods, ensuring healthier produce. To certify your Jowar c as organic, you need to adhere to strict guidelines set by certification bodies. These certifications add value to your product in the market. Organic Jowar farming focuses on maintaining soil health naturally through techniques like crop rotation and compostin This not only benefits the environment but also enhances the nutritional quality of the grain.

By avoiding synthetic chemicals, organic farmers contribute positively towards biodiversity and ecosystem preservation. It's a win for both nature and consumers seeking chemical-free food options. Embracing organic Jowar farming is a step towards sustainak agriculture while meeting the growing demand for organic produce globally.

Common Challenges in Jowar Farming and How to Overcome Them

Unpredictable weather patterns are a common challenge faced by Jowar growers, which can affect crop growth and yield. To overcome this obstacle, farmers can implement water harvesting techniques and invest in irrigation systems to ensure consistent moisture levels for the crops. Another challenge is pest infestations, which can damage the Jowar plants if not addressed prompt

Integrated pest management practices such as using natural predators or organic pesticides can help keep pests at bay without harming the environment. Additionally, soil fertility depletion over time can hinder Jowar production. Farmers can combat this iss by practicing crop rotation and applying organic matter into the soil to maintain its health and nutrient content.

Furthermore, market fluctuations and pricing uncertainties pose a challenge for Jowar farmers looking to maximize profits. Diversifying marketing channels and building relationships with buyers can help to control these risks while ensuring a steady income stream for their produce. By following these practices, you are equipped with the knowledge and tips needed to grow a healthy and profitable Jowar crop.