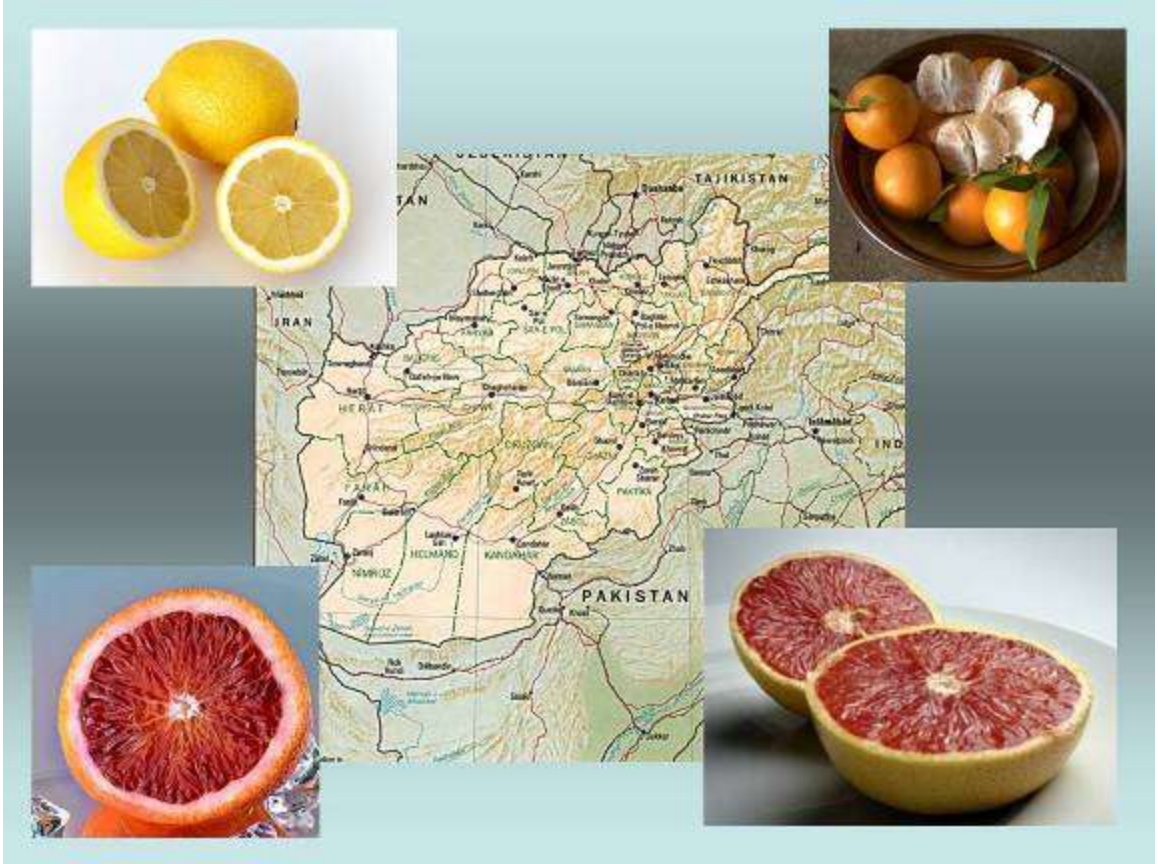
Citrus growing in Afghanistan



Developed by
Kitren Glozer and Louise Ferguson
Department of Plant Sciences

with

Mark Bell
International Programs

For more information visit: International Programs www.aes.ucdavis.edu/IntProg/Default.htm

Table of contents

1. DISTRIBUTION: Where does citrus grow?

Citrus are subtropical, with growing temperatures ideally at 24-27 ºC and are intolerant of frost. Cooler temperatures in winter and at night of 4-5 ºC are beneficial for rest, development of acidity, and fruit color. Growers should plant early season cultivars (fruit mature early) where there is a considerable risk of damage by cold so the crop can be harvested before there is a possibility of losing it to a freeze. Site selection is particularly critical in regions subject to cold winter temperatures.

Major crop production worldwide

Citrus crop	Metric tonnes	Major producing countries
Oranges	64,128	Brazil, United States, China
Tangerine	18,792	China, Spain, Japan
Lemon	11,227	Argentina, Spain, Egypt
Grapefruit	4,979	United States, South Africa, Cuba

Climate: The greatest danger in citrus production is the potential for frosts or freezes. Citrus cultivars vary in their sensitivity to frost.

Relative frost sensitivity of selected citrus.

Common name	Scientific name	Sensitivity to frost
TREES		
Citron	*Citrus medica*	High
Grapefruit	*Citrus x paradisi*	Medium
Kumquat	*Fortunella* spp.	Low
Lemon	*Citrus x limon* L.	High
Lime	*Citrus aurantiifolia*	High
Mandarin orange hybrids	*Citrus reticulata*	Medium
Sweet orange	*Citrus sinensis*	Medium
Satsuma mandarins	*Citrus reticulata*	Low
ROOTSTOCKS		
'Rough Lemon'	*C. macrophylla, C. jambhiri* Lush	High
Trifoliate orange	*Poncirus trifoliata*	Medium
Troyer or Carrizo citrange	*x Citronicirus Webberi*	Medium

Protecting trees and fruit from frost: Trees planted in open areas and trees exposed to cold prevailing winds are most likely to suffer frost damage. Low areas will collect cold air; avoid planting in depressions or basins. Planting near structures or walls, especially those with a southwest exposure, will take advantage of heat absorbed by the structure.

The best way to reduce cold damage is to maintain healthy trees. Use cultural practices that induce and maintain dormancy in winter. These methods include no late summer or fall fertilization or pruning. Vigorous trees may recover from cold injury. Weak trees that show disease, insect damage, or nutritional deficiencies are the most severely damaged and the slowest to recover.

Grass, weeds, and straw mulches prevent heat from entering the soil during the day, so less energy is stored for release at night. Keep the ground around the tree as clean and free from mulch, weeds and ground cover as possible. Avoid planting a cover crop in the orchard.

Prune trees in late spring to maximize tree growth and hardening before winter. Make cuts at branch crotches, leaving no stubs. If dead woods results from frost, wait several months before pruning away dead wood in order to assess the full extent of the damage and to allow the trees to recover during warm weather. As new foliage begins to grow in the spring and early summer, frost-killed twigs and branches will become more apparent and can be pruned out without removing viable portions of the tree. Postpone heavy pruning until the following year, so that the trees can regain their full canopy.

Apply fertilizer to citrus trees in late January or early February with a subsequent application of nitrogen only when good soil moisture exists and no later than late June.

Water: amount and quality: Citrus requires about 115-130 cm inches of water annually, depending on tree size, for optimum growth. Where annual rainfall is inadequate, irrigation must be used to supplement existing rainfall. Inadequate water will limit tree size and productivity.

Soils: The best citrus soils are coarse sandy loams to fine sandy clay loams, deep and well-drained, with a ground water table at or below the 150 cm depth. Soil pH normally will be in the range of 7.0 to 8.2. Soils containing more than 30% clay in the upper 60 cm generally restrict root development, tree size and orchard productivity. Sandy loam soils are good as they provide excellent water infiltration and percolation, however, they have a low water-holding capacity, provide lower fertility and tend to have nematodes. Clay and clay loams are opposite in that they provide excellent water-holding capacity, but have low percolation and infiltration rates.

2. COMMON CITRUS GROWN IN AFGHANISTAN

2.1 Blood Orange

Blood oranges are a type of sweet orange (*C. sinensis* Osbeck), with red coloration from anthocyanin pigments in the flesh and peel. Red color varies with climate and can be intense when blood oranges are grown in regions with hot days and cool nights. "Full-blood" oranges are the darkest with the flesh ranging from orange-veined with deep red color.

Origin: The sweet orange originated in China and is grown worldwide in tropical and subtropical climates with its range extending approximately 35-40Eon either side of the equator. Most commercial acreage is located in subtropical and Mediterranean climates where higher quality fruit is attained. Blood oranges have been grown in Italy and Sicily since ancient times, particularly in hilly and sub-mountainous areas. Temperatures in this region range from intense daylight to frigid temperatures at night, with modest rainfall and rich soil. The combinations of these factors are specific to cultivation of the blood orange. The fruit is easy to peel, and most cultivars are seedless. They achieve best pigmentation only in Mediterranean climates and require cooler weather than many other citrus. 'Torocco', 'Moro', 'Sanguinelli' are the main cultivated cultivars.

Description: Trees are 7 to 10 meters in commercial orchards, larger if unpruned. Branches are strong and usually do not require pruning except for tree size control. The trees do best in a consistently sunny, humid environment with fertile soil and adequate rainfall or irrigation. The leaves are evergreen, lasting two to three years and do not drop except when stressed. Most cultivars are self-pollinating because flowers have both female and male parts. However, bees improve pollination. Some cultivars have little or no viable pollen and/or few or no fertile ovules. Such fruit develop into seedless or near-seedless fruit. The trees flower in the spring, and fruit is set shortly afterward. Fruit begin to ripen in fall or early winter months, depending on cultivar, and develops increasing sweetness afterward.

Seasons of bearing: Sweet oranges mature over a relatively long period in mild climates. The earliest cultivars may mature in late fall (October) and the latest ones in early spring (March). The fruit of all cultivars can be "stored" on the tree for several months without losing quality, thus extending the sweet orange season to 10 to 11 months.

Cultivars:

'Sanguinelli' -- a "full-blood" orange, is close in characteristics to the 'Moro', originating in Spain in 1929. 'Sanguinelli' trees are vigorous, thornless, productive and medium in size. The fruit are oval in shape, with smooth, shiny peel which is pigmented over much of the surface. The peel is compact, clear yellow with a red tinge.

'Moro' -- The Moro cultivar is believed to have originated in Sicily as a bud mutation of the 'Sanguigno' sweet orange. The tree is of moderate vigor and size with a round and somewhat spreading growth habit. The fruit is round, of moderate size, and frequently borne in clusters. Moro are "full-blood" oranges. 'Moro' is the earliest ripening of the blood oranges and matures earlier than 'Tarocco'.

'Tarocco' -- The most popular table orange in Italy, the 'Tarocco', may be a mutation of the 'Sanguinelli'. It is referred to as "half-blood" because the flesh is not accentuated in red pigmentation as much as 'Mor'o and 'Sanguinelli'. It has thin orange skin, slightly blushed in red tones. The 'Tarocco' is one of the world's most popular oranges because of its sweetness (Brix to acid ratio is generally above 12.0) and juiciness.

Nutritional information		**% Daily adult requirement**	
1 medium	131g	Vitamin A	6%
Calories	62	Calcium	5%
Total Fat	0g	Vitamin C	116%
Sodium	0mg	Iron	1%
Total Carbohydrate	15g		
Dietary Fiber	3g		
Protein	1g		

2.2 'Kinnow' mandarin

The 'Kinnow' is a type of mandarin (*Citrus reticulata*), a small orange with a thin, loose peel that can be easily injured at picking. 'Kinnow' is a large tree (up to 7.5 m with a greater spread at great age) that grows vigorously and has an upright form, with a strong tendency to alternate bearing. The tree usually has thorns and slender twigs. The fruit is flattened at the ends, is seedy, matures in mid-season.

Mandarin oranges originated in south-eastern Asia and the Philippines. The mandarin has a wide range of adaptability and is grown under desert, semi-tropical and sub-tropical Mediterranean climatic conditions. Mandarin trees and their hybrids are usually the most cold-resistant of all commercially grown citrus. However, mandarin fruits suffer more frost damage than most oranges and grapefruit. This means that the tree of the mandarin is more cold hardy than other citrus trees, but the mandarin fruit are not particularly cold hardy. 'Kinnow' is very cold-hardy compared to other mandarins.

Nutritional information		% Daily adult requirement	
1 medium	84g	Vitamin A	11%
Calories	37	Calcium	1%
Total Fat	0g	Vitamin C	43%
Sodium	1mg	Iron	0%
Total Carbohydrate	15g		
Dietary Fiber	2g		
Protein	1g		

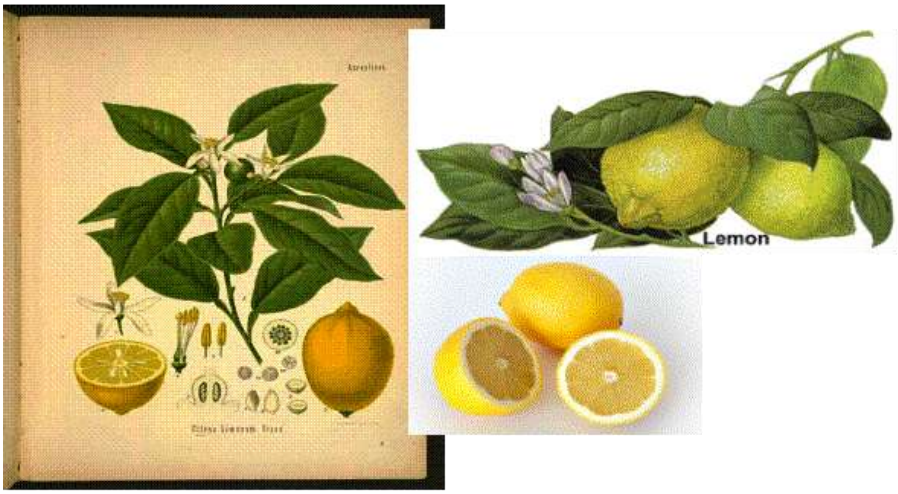
2.3 Lemon and lemon types

Lemon (*Citrus* x *limon* L.) trees are generally vigorous, upright spreading and open in growth habit. Lemon fruit are much more sensitive to cold than most other citrus. Lemons grow in tropical and sub-tropical climates and cannot withstand frosts and very cold temperatures. Because of its more or less continuous state of growth, the lemon is more sensitive to cold than the orange and less able to recover from cold injury. Optimal growing temperature is 15-30 ºC. The tree is defoliated at 4 to 5 ºC. A temperature drop to -6 ºC will severely damage the wood unless there have been 2 weeks of near-freezing weather to slow down growth. Flowers and young fruits are killed by 2 ºC and nearly mature fruits are badly damaged below that temperature. The lemon tree has the reputation of tolerating very infertile, very poor soil.

A lemon tree can grow up to 6 m, but they are usually smaller. The branches are thorny, and form an open crown. On a lemon tree, flowers and ripe fruits can be found at the same time. There are several cultivars of lemon including ‘Eureka’, ‘Lisbon’ and the ‘Meyer’ lemon, which is a hybrid of lemon and sweet orange , sweeter and more cold hardy than ‘Eureka’ or ‘Lisbon’ lemons.

The ‘rough lemon’ (*Citrus macrophylla*) is usually used only as a rootstock, but can be cultivated for its fruit.

Propagation: The ‘rough lemon’ is widely grown from seed. The 'Meyer' lemon is easily reproduced by rooting large cuttings in the nursery and planting them directly in the grove. They fruit 2 to 3 years sooner than budded trees and have a long life, remaining in full production for over 30 years, perhaps much longer. Commercial lemons have been budded onto 'rough lemon', sweet orange, and 'Cleopatra' mandarin rootstocks.



Nutritional information		% Daily adult requirement	
1 medium	58g	Vitamin A	0%
Calories	20	Calcium	2%
Total Fat	0g	Vitamin C	35%
Sodium	10mg	Iron	0%
Total Carbohydrate	6g		
Dietary Fiber	1g		
Protein	0g		

2.4 Grapefruit

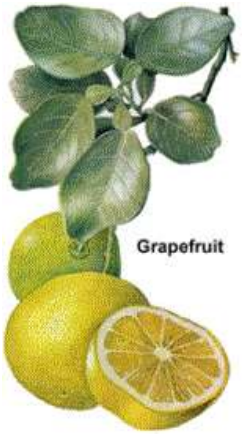
Grapefruit (*Citrus paradisi*) trees grow 5-6 m tall, although they can reach 13-15 m. The fruit is yellow-skinned, largely round with flattened ends, ranges in diameter from 10 to15 cm and has acidic yellow, pink or reddish segmented pulp. Grapefruit trees are highly resistant to heat and are similar in cold tolerance to sweet oranges. Grapefruit have a high heat requirement to obtain fruit maturity and high fruit quality.

Numerous cultivars are available. The ‘Marsh’ (white seedless) and ‘Red Blush’ or ‘Ruby’ (red seedless) cultivars are the most frequently planted. Fruits of ‘Marsh’ and ‘Ruby’ may be harvested as early as late September and October, but if allowed to remain on trees will improve in quality. Temperature differences affect the length of time from flowering to fruit maturity. Growth cycle can vary from 7 to 13 months. Ideal

rainfall for grapefruit is 91.4-111.7 cm rather evenly distributed the year around. The grapefruit is grown on a range of soil types.

Grapefruit can be "stored" on the tree for months, increasing in size and extending the marketing season. The fruits can be harvested until near the end of May when they begin to fall and seeds start sprouting in the fruit. The only adverse effect of late harvesting is a corresponding reduction in the following year's crop. It has been found that spot-picking of the largest fruits partially counteracts this effect of late harvest.

Nutritional information		**% Daily adult requirement**	
Half fruit	123g	Vitamin A	28%
Calories	52	Calcium	3%
Total Fat	0g	Vitamin C	64%
Sodium	0mg	Iron	1%
Total Carbohydrate	13g		
Dietary Fiber	2g		
Protein	1g		



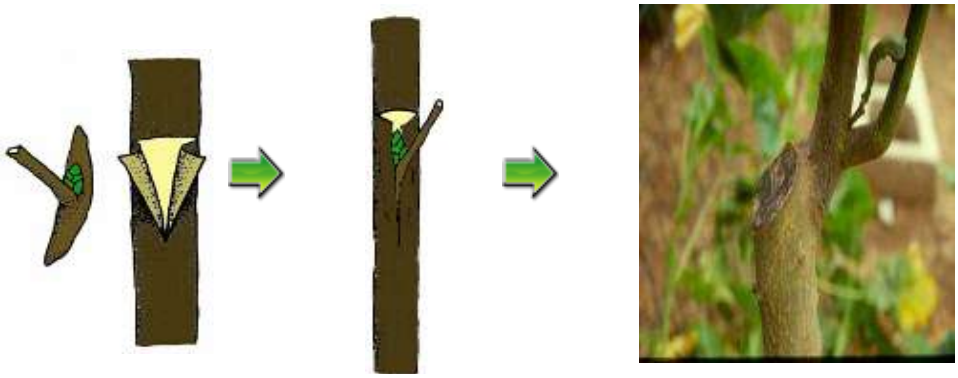
3. PLANNING THE ORCHARD

Production depends on tree size, vigor and ability to crop. The factors most limiting tree size in Nangahar citrus-growing areas include:

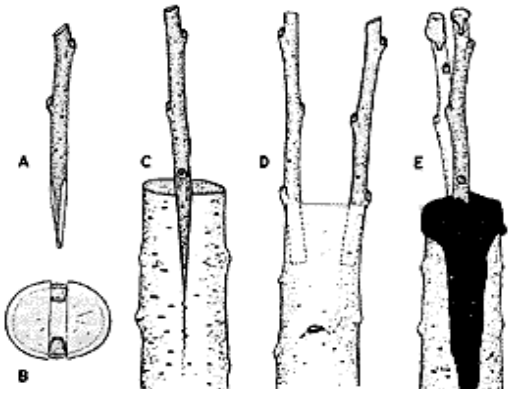
- climate, especially lack of abundant water by rain or irrigation and heat, where average high temperatures are often greater than 40 ^{o}C
- soil—deep, fertile soils optimize growth; poor soils restrict growth
- fertility—especially with applied fertilizers

3.1 Propogation

Most trees will be propagated in the nursery by T-budding. Cleft-grafting established trees allows change of cultivar and more rapid production than replanting the orchard.



T-Budding



Cleft-grafting

3.2 Rootstock

Traits most important in rootstock selection include:

- compatibility with scion
- adaptation to soil and climatic conditions, including winter hardiness
- ease and uniformity in propagation
- influence on vegetative vigor (how big the tree can be)

- influence on precocity, consistent cropping and yield, and fruit quality
- suckering tendency
- sensitivity to disease, pests, and replant problems.

Common rootstocks for citrus include 'rough lemon', which is adapted to light sandy soils, and 'Sour Orange'. The sour orange rootstock is the most common in Afghanistan for all citrus. It is cold-hardy, well-adapted to heavy soils and climate and is compatible with most citrus. The 'sour orange' is also called the 'Seville' orange and is used to produce a marketable crop.

Primary rootstocks for citrus:

Rangpur lime (*C. limonia* Osbeck)

Rough lemon (*C.macrophylla, C. jambhiri* Lush.)

Sour orange (*C. aurantium* L.)

Cleopatra mandarin (*C.reshni* Hort.)

Trifoliata (*P. trifoliata* [L.] Raf.)

Kumquat **(***Fortunella spp.*)

3.3 Site selection and preparation

Production depends on tree size, vigor and ability to crop. The factors most limiting tree size in Nangahar citrus-growing areas include:

- climate, especially lack of abundant water by rain or irrigation, and heat, where average high temperatures are often greater than 40 ^{o}C
- soil—deep, fertile soils optimize growth; poor soils restrict growth
- fertility—especially with applied fertilizers

Eliminating weeds: Many weeds compete strongly with new citrus trees and should be eliminated before tree planting.

Soil amendment/fertilization: Citrus can develop a large number of nutrient deficiencies, including N, P, K, Mg, Ca, Mn, Zn, Cu, Fe, B, and Mo (nitrogen, phosphorus, potassium, magnesium, calcium, manganese, zinc, copper, iron, boron and molybdenum). The level of N fertility has more influence on the growth, yield, and quality of citrus than any other single plant nutrient. Adequate supplies of N are necessary to optimize growth and development of newly planted citrus trees.

Pre-plant fertilization: Compost, animal manure and green manure can be worked into the soil to a depth of 1 m, however, this should not be added directly to the tree planting hole at the time of planting, but in advance of planting so that rotting can occur and be

completed prior to planting, otherwise root rot is likely. Organic sources of N, such as urea should be applied during winter and/or spring, to allow for timely decomposition and release of nutrients.

Designing the orchard: Local tree spacing is 6 x 5 m (between rows x between trees) for larger citrus such as blood orange and grapefruit. Large mandarin (Kinnow) may also have this spacing. Lemon trees are usually planted at a spacing of 5 x 3 m. Orienting the tree rows north to south will improve light exposure to the fruit.

Should the grower plant a second crop for income? Cover crops are sometimes planted in citrus orchards; in some cases other agronomic row (vegetable, fruit), forage or grain crops may be interplanted in citrus orchards. However, other plants will compete with citrus trees for water and nutrients, reducing citrus yields, fruit size and tree size. Use of a cover crop, such as clover or other legumes, however, can be of benefit if the cover crop is disked under (incorporated into the soil) at the end of the rainy season before water becomes a limited resource. This practice increases soil fertility and soil structure. Cover crops, like weeds, can increase the possibility of frost damage.

4. ORCHARD ESTABLISHMENT

During the first two or three years, the objective is to develop a sturdy tree of good size. Little or no training is given citrus trees, other than topping them at planting to assure development of low heads. It is advisable to allow the tree to grow its branches at a minimum height of 2/3-1 m to prevent fruit from touching the soil when on low limbs.

Timing of planting: The best time to plant citrus trees is after the danger of severe frost and before the ground dries out completely. Plant trees before an active growth flush has begun. Summer-planted trees experience severe shock at high temperatures and require frequent irrigation. Trees planted in the coldest months may need cold protection.

Planting the orchard: Citrus trees are taken from the nursery in two forms:

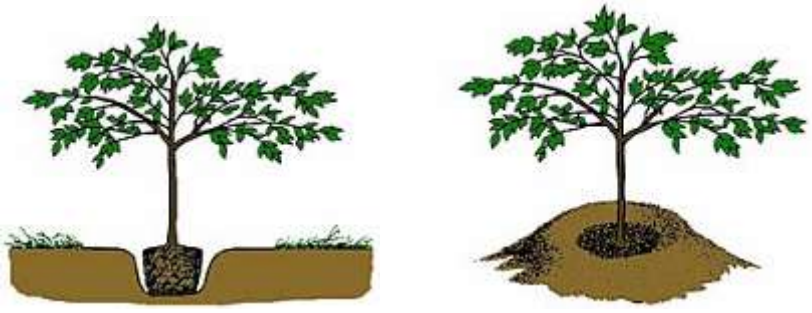
Bare-rooted trees: Care must be taken at all times to prevent roots from drying out. Tops should be cut back 40% to compensate for root loss during transplanting. The leaves may even be stripped from the trees for additional precaution.

Containerized tree: Trees in pots should be kept watered until planting. Plant before the hottest season so the tree has time to establish its root system in the ground.

4.1 How to plant

4.1.1 Prepare the planting hole

Dig a hole only as large as necessary to accommodate the root system. Trees should be planted with their top major roots even with the soil line. Prune any damaged roots back beyond the damaged area. If container-grown trees have a tap root curled in the bottom of a container, cut this root off at the point where it begins to curl. Separate and trim the roots of container trees that may be root-bound. Save the soil from the hole to use as backfill. If the hole is deeper than the measurement, prior to placing the tree in the hole, backfill with enough soil to hold the tree slightly higher than the measurement. Firmly press the soil before setting the tree on it. Be sure the root ball or container soil rests on solid ground to prevent settling. Do not add any other soil amendments to the hole, such as fertilizer or compost.



4.1.2 Position the tree

Carefully remove the tree from the container, supporting the root ball. Place the tree in the hole at the same depth it was growing previously. If holes are dug too deeply, and loose soil is placed at the bottom, trees may settle after watering. Trees set too deeply may die. Container trees should have the top of the soil ball flush with the top of the hole. Bare-rooted trees should have soil placed underneath them in a manner to allow the spreading of the roots in a natural position with no bending or crimping. Cut any circled or kinked roots and score the outsides of the root ball if it is compacted. Loose roots should be positioned facing down in the hole

4.1.3 Fill the hole

Remove any rocks, grass or debris from the dug-up soil. Break up clods. Back-fill with the same soil that was removed from the hole. Never back-fill with an amended soil mix of a lighter texture. Such a practice will create drainage problems and cause tree roots to suffocate during periods of excessive moisture. Firm the soil around the lower roots by hand. Continue filling and firming several cm at a time. Soil should be firmly, but not tightly, packed. Pull out all weeds surrounding the planting hole. Before completion of back-filling, add water to settle the soil and eliminate air pockets around the roots. After watering, fill the hole to completion and, if necessary, construct a basin (ridges of soil around the complete circumference of the tree) to hold water during subsequent irrigations. With trickle irrigation, this practice may not be necessary. Basins are not needed during excessive rains or if flood irrigation can be effective used at regular intervals after planting.

4.1.4 Water

After the tree is planted, water well. Check the original soil line one last time. If the tree does settle, now is the time to move it back to the correct position with the soil level against trunk at the same level that it was in the container.

5. Stake if needed:

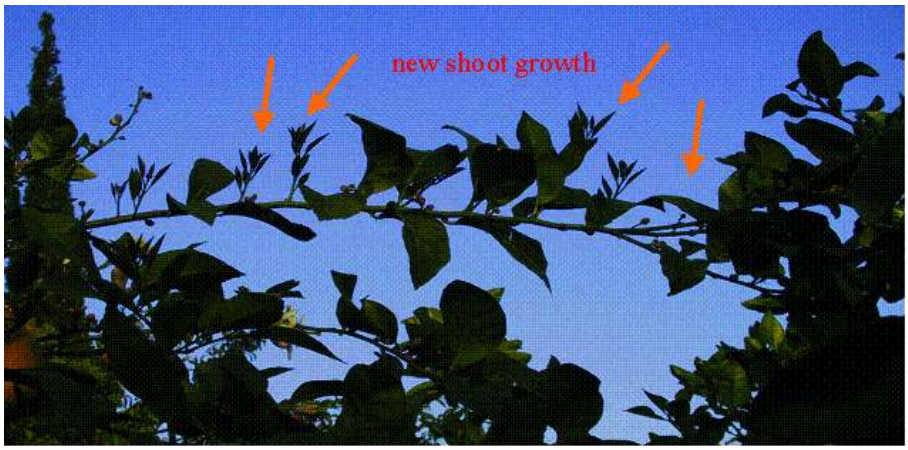
Unless the tree bends over, it will not need support from staking. If stakes are needed, place them on opposite sides of the tree, perpendicular to the direction of the prevailing wind. Stakes should be positioned outside the root ball area, but no further than the tree ties can reach. Drive stakes into soil so that the top of the stakes should be a couple of inches below the lowest main branch.

Place tree ties about 15 cm above the spot where the tree bends which will be about 2/3 to ½ of the way up the tree. In order to prevent ties from rubbing the tree's bark use rubber loops cut from automotive tires between the ties and the tree. Loop ties around the tree and attach one to each stake. Ties should be loose, so that the tree can sway, and the trunk can grow stronger.

4.2 Training young citrus trees

Growth of the citrus tree canopy: Older wood produced earlier in the tree's growth becomes shaded by new growth and becomes less productive and eventually dies. Unpruned citrus trees have an outer zone of vigorous green, fruit-producing foliage

covering an inner core of weak and dead branches. Citrus fruit is typically borne on one-year old shoots, as shown below. New shoots arising from buds on existing scaffold branches will not produce fruit for two to three years.



Pruning with initial planting

Prune young citrus to:

- remove shoots (i.e. suckers) originating from the rootstock and low on the scion (i.e. water sprouts)
- remove branches that cross from one side of the tree to the other
- to produce an abundance of vegetative growth that will, in turn, assist in producing new vegetative growth

The tree must produce a canopy of sufficient size before economic fruit production begins. Attempting to train very young branches as future scaffolds is difficult because growth over time results in a productive outer 'shell' and a nonproductive interior. As the tree ages and branches originating near the area where the tree was initially cut back in the nursery build strength and girth, good candidates for scaffolds will emerge. The dominance of these new scaffolds may be encouraged through thinning-out cuts and undercutting to remove shaded and dying branches. If a particular scaffold is not successful, citrus normally produces many more replacement branches. Once the young tree has produced sufficient leaf canopy to shade the trunk, sucker growth of many citrus cultivars is suppressed.

4.3 Irrigating young citrus trees

For proper growth and fruiting it is essential that trees receive water in 'on time'. To ensure adequate moisture the soil should be thoroughly wet before wilting occurs. To avoid over-watering, excess water must drain away. Alternate wetting and drying allows oxygen necessary for root growth to enter the soil.

Watering young trees may be more important than fertilizing. Young trees have a limited root system, and water should be applied frequently. As a general rule, if two weeks pass without at least 2.5 cm of rainfall on recent transplants, trees should be irrigated. Even though watering may be needed for several years, watering is most critical during

the first year of grove life. Young trees seldom need watering in the fall. Except in cases of extreme drought, it is better to encourage early winter dormancy by allowing the soil moisture to become low in the fall.

For young trees, it is best to water twice per week, from March through June is to maintain optimum moisture in the upper soil layer where most of the roots are, especially during the crucial period of leaf expansion, bloom, fruit set and fruit enlargement –(January/February to June, usually). Soil type will affect how well the soil holds the water.

Symptoms of too much water: yellowing leaves that drop; root rot.

Symptoms of too little water: yellowing leaves that drop, drop of small fruit

4.4 Fertilizing citrus trees: Young trees, mature trees

Mineral nutrients are classified as *macronutrients* and *micronutrients*. The term "macronutrients" refers to those elements that plants require in large amounts (N, P, K, Ca, Mg, S). The term "micronutrients" (or “trace elements”) applies to plant nutrients that are essential to plants but are needed only in small amounts [Fe, Zn, Mn, B, Cu, Mo, Ni (nickel), Cl (chlorine)].

Visual deficiency symptoms of N, P, K, Ca, Mg, Fe, Zn, Mn, B, Cu, and Mo (nitrogen, phosphorus, potassium, calcium, magnesium, iron, zinc, manganese, boron, copper and molybdenum) can usually be recognized by distinctive symptoms that most often occur in the leaves, but can sometimes be seen in the fruit, branches, or general growth of the tree.

4.4.1 Types of fertilizer to use

Generally, only two types of commercial fertilizers are required: a balanced fertilizer (8-8-8, 13-13-13), and a nitrogen fertilizer such as ammonium nitrate (33-0-0), or ammonium sulfate (21-0-0). Urea (46-0-0) is a good source of nitrogen. The balanced or complete fertilizer contains nitrogen, phosphorous, and potassium, the elements needed in the largest amounts by citrus trees. The nitrogen fertilizer stimulates vegetative growth later in the year. The numbers 8-8-8 or 13-13-13 represent the percentage of nitrogen-phosphorus-potassium the fertilizer has. DAP is diammonium phosphate (18-46-0).

4.4.2 When to apply a balanced fertilizer

Newly set trees should not be fertilized until they show signs of growth, usually six weeks after they are set in the spring. The first application should be light, not more than 250 g of 8-8-8 or 200 g of 13-13-13 per tree. Each succeeding application made at six-week intervals may be increased slightly until the tree receives about 375 g of 8-8-8 or 250 g of 13-13-13. Do not fertilize later than the last week of June or when soil is dry. If fertilized too late, trees may exhibit a late flush of growth exposing them to possible winter injury.

4.4.3 Average Balanced Fertilizer Recommendations Per Tree

Tree age	Early February	Mid March	Early May	Early June
Year of Transplanting		500 g. 8-8-8 or 0.15 kg. 13-13-13	0.34 kg. 8-8-8 or 0.2 kg.13-13-13	0.45 kg. 8-8-8 or 0.34 kg.13-13-13
Second Year	0.57 kg. 8-8-8 or 0.45 kg. 13-13-13	0.57 kg. 8-8-8 or 0.45 kg. 13-13-13	0.34 kg lb. 21-0-0 or 0.3 kg. 33-0-0	0.34 kg lb. 21-0-0 or 0.3 kg. 33-0-0
Third Year	0.57 kg. 8-8-8 or 0.45 kg. 13-13-13	0.57 kg. 8-8-8 or 0.45 kg. 13-13-13	0.34 kg lb. 21-0-0 or 0.3 kg. 33-0-0	0.34 kg lb. 21-0-0 or 0.3 kg. 33-0-0
Fourth Year & Bearing Age	0.9 kg. 8-8-8 or 0.8 kg.13-13-13 up to 12 years			0.15 kg. 21-0-0 or 0.11 kg. 33-0-0 up to 12 years

Nitrogen is the major nutrient required for proper tree growth and optimum yields. Two-thirds of the fertilizer applications to citrus each year should occur between January and early June, timed so that nutrients are available during the flowering and fruit-setting period. The remaining one-third can be applied in September or October. Foliar application of urea (28 kg per hectare) in late December or early January will increase flowering, fruit set, and fruit yield. In the first three years, ammonium nitrate (34-0-0) may be spread by hand near the base of the trees.

4.4.4 Recommended N fertilizer rates for citrus

Year in Grove	Oranges	Grapefruit	Tangerines	Lemons
		g N/tree/year		
1		140		
2		280		
3		350		
		kg N/hectare/year		
4+	135-225	135-180	135-225	135-225

4.4.5 Recommended DAP rates for citrus

For 1-2 year-old trees, apply 200 g per tree.
For 2-3 year-old trees, apply 300 g per tree.
For trees over 3 years old, apply 500 g per tree.

4.5 Weeds

Weed by hand frequently or with a hoe, working shallowly to prevent damage to roots.

4.6 Routine care of young trees

As trees begin to grow, pinch off young suckers or sprouts that occur on the rootstock (and lower trunk of the scion) in order to stimulate growth in the canopy of the tree. If sprouts have hardened off and become woody, use pruning shears to remove them. Tearing woody sprouts off will remove strips of bark that may later predispose the young tree to insect damage and/or soil-borne fungal diseases.

5. ORCHARD MANAGEMENT: TAKING CARE OF A MATURE ORCHARD

5.1 Pruning mature citrus trees

Suckering – trunk and root suckers: Remove these as soon as they appear.

Maintenance pruning: Citrus will be most productive if left unpruned or pruned annually rather than having large amounts of vegetation removed infrequently. If heavy pruning of large wood is required, pruning half of the trees in the first year, and the second half next year will reduce the impact of crop loss. Pruning selectively increases light penetration to the interior of the canopy and the lower portions of the canopy, increasing flower bud development, fruit set and fruit quality in those parts of the tree. 'Skirting', or cutting back the very lowest branches that droop toward the ground, is another form of maintenance pruning that controls disease and fruit quality. Prune dead or diseased limbs.

Citrus may be pruned at any time of the year, but some times are better than others:

- Heavy pruning before or during bloom will affect fruit yield less than heavy pruning in late spring after the fruit has set
- To avoid damage to the fruit, mature fruit trees should not be pruned immediately before harvest, or when mature fruit are on the tree in early spring
- Late summer and fall pruning should be avoided in most cold citrus growing areas to encourage winter semidormancy that will further protect the tree from freezes
    - Pruning in late summer or early fall increases production of freeze-susceptible new growth
    - Winter pruning should also be avoided in cold locations. A large, thick canopy has been shown to reduce injury to the tree from severe frosts, probably through better heat retention within the tree and improved heat absorption from the ground that the larger, thicker vegetative cover provides.

Diseases spread by pruning, how to prevent disease spread by pruning: Pruning may spread some diseases of citrus, such as psorosis, execortis, and some viral diseases. Dipping pruning equipment in dilute sodium chloride solution (5% dilution of a 5% sodium chloride solution such as laundry bleach) will reduce transmission of some diseases.

Tree rejuvenation by pruning

A declining tree can be pruned to remove a large portion of the canopy, or cut back to major scaffold limbs to rejuvenate the tree. Since citrus fruit are produced on younger wood this practice greatly reduces yield for two years or more and will probably increase the size and roughness of most of the remaining fruit to the extent they become unmarketable.

5.2 Irrigating mature citrus trees

Citrus, a perennial evergreen tree, requires available soil moisture throughout the year--generally a minimum of 115 to 130 cm of water annually. Mature trees require more water than young trees but young trees require more frequent irrigation because of limited root systems.

Mature citrus under flood irrigation

Surface irrigation by furrows and flooding (Gravity flow): Furrows should be filled with water and then drained, to ensure that the entire root system receives a sufficient amount of water. Larger borders in existing, mature orchards can damage the root system, damaging the tree growth and increasing loss from infections by soil-borne fungus.

Soil-based Scheduling Methods (How to know when to water): Irrigation should be done when about 50% of the water has been depleted from the soil. To check the water content in the soil, take a trowel, shovel, or soil tube and dig down 20 to 40 cm. A soil that has about 50% available water will feel as follows:

Soil texture

coarse - appears almost dry, will form a ball that does not hold shape;

loamy - forms a ball, somewhat moldable, will form a weak ribbon when squeezed between fingers, dark color;

clayey - forms a good ball, makes a ribbon an inch or so long, dark color, slightly sticky.

6. NUTRIENT SOURCES AND SYMPTOMS OF DEFICIENCY AND TOXICITY

6.1 Nitrogen (N)

Common nitrogen sources: Ammonium sulfate, ammonium nitrate, urea, calcium nitrate, ammonium phosphate; best to apply to soil

Nitrogen deficiency symptoms:

- loss of green color and uniform yellowing of the leaves
- first appears on older leaves and then younger leaves
- veins are only slightly lighter in color than the tissue in between
- new leaves are small, thin, fragile, and light green in color.

Biuret toxicity symptoms: Biuret is an impurity in urea fertilizer which may be avoided using only guaranteed low biuret urea products, particularly for foliar sprays

- Leaf symptoms: irregular, yellowish-green interveinal pale areas
- appearing first at leaf tips and spreading over the entire area of the leaf surface
- as severity increases, only the midribs and parts of the major veins remain green.

6.2 Phosphorus (P)

Superphosphate (0-20-0) is the fertilizer most often used when phosphorus is needed.

Phosphorus (Phosphate) deficiency symptoms

- Growth is reduced, including in young leaves
- First older leaves lose deep green color
- leaves are small and narrow with purplish or bronze discoloration; not shiny
- leaves may later develop necrotic (dead, brown) areas
- leaves shed prematurely and fruit can drop before normal harvesting time
- limited flower development with reduced fruit set and fruit yield
- fruit will be coarse and rough in texture with a coarse, thick rind and hollow core
- fruit have a high acidity
- fruit maturity delayed
- roots are stunted and poorly branched

6.3 Potassium (K)

Use balanced fertilizer (8-8-**8** or 13-13-**13**) last number is **K** to avoid deficiency. To correct deficiency, apply potassium chloride (muriate of potash) or potassium sulfate to the soil or potassium nitrate or mono-potassium phosphate applied to the leaves.

Potassium deficiency symptoms

- early sign is fruits remaining small while the leaves show no symptoms
- yellowing of leaf tips and margins, whole leaf turns yellow, first on older leaves
- slow growth, small leaves, fine branches, compact tree appearance, an increase in susceptibility to drought and cold, reduction in fruit size, very thin peel of smooth texture, premature shedding of fruit, and lower acid concentration in the fruit
- advanced stage: thickening and puckering of leaves, yellowed inner vein areas, necrotic spots; premature leaf fall and shoot die-

6.4 Calcium (Ca)

Various calcium fertilizers: calcium nitrate, calcium chelates, calcium ammonium nitrate, calcium phosphate, for example, applied to leaves

Or by soil application of lime as lime stone (calcium carbonate), dolomite (calcium carbonate + magnesium carbonate), or a combination of lime and gypsum (calcium sulfate)

Calcium deficiency symptoms

- loss of green color along leaf margins and between main veins during winter
- small, thickened leaves, loss of vigor, thinning of foliage and decreased fruit production
- twig dieback, undersized and misshapen fruit with shriveled juice vesicles

6.5 Magnesium (Mg)

Corrected by foliar application of magnesium nitrate1 kg/100 L as foliar spray in spring flush when leaves are 1/2 to 2/3 expanded, annually

Magnesium deficiency symptoms

- Symptoms of Mg deficiency at later stages can be confused with N deficiency; both produce yellow leaves
- Nitrogen deficiency can be distinguished by the general nature of the yellowing of the foliage over the entire tree with the absence of any distinctive leaf pattern
- Magnesium deficiency develops in the summer and may cause a complete yellowing of the leaves in the fall or early winter with no possible re-greening unless Mg fertilizer is applied.

- The first symptom is a yellowish green blotch near the base of the leaf between the midrib and the outer edge. The yellow area enlarges until the only green remaining is at the tip and base of the leaf as an inverted V-shaped area on the midrib. With acute deficiency, leaves may become entirely yellow-bronze and eventually drop.
- Mg deficiency occurs only on mature leaves that were previously normal in appearance and usually on limbs bearing a heavy crop. Limbs may even become completely defoliated, while limbs with little or no fruit may not show deficiency symptoms.
- Cultivars producing seedy fruit (like blood orange, kinnow, grapefruit, lemon) are more severely affected by Mg shortage than cultivars producing seedless fruit. Alternate bearing is common in seedy cultivars growing under Mg-deficient conditions.

6.6 Sulfur (S)

Apply either elemental sulfur (S) or a sulfate-containing fertilizer SO_4^-; develops most often with high nitrogen fertilizer use without added sulfur. Sulfate fungicides applied in spring or fall will control disease and correct/prevent sulfur deficiency.

Sulfur deficiency symptoms

- deficiency symptoms resemble those of N, but they first appear on the new growth
- Plants are stunted and pale green to yellow in color (chlorosis)
- chlorosis is worse on new growth

6.7 Iron (Fe)

Iron Chelates: the best way to correct iron deficiency, but effectiveness depends on soil pH

Iron Chelate examples	**Effective pH Range**
Fe-EDTA	4.0 to 6.5
Fe-HEDTA	4.0 to 6.5
Fe-DTPA (Sequestrene 330 or equivalent)	4.0 to 7.5
Fe-EDDHA (iron-ethylenediaminedi(*o*-hydroxyphenylacetic) acid)	4.0 to 9.0

Iron deficiency symptoms

- young leaves appear light yellowish to white in color, with the veins greener than the rest of the leaf

- leaves are reduced in size, fragile, very thin, and they can shed early.
- trees die back severely on the periphery and especially at the top
- fruit set and yield are reduced
- fruit small with poor quality
- Sometimes only a branch of a tree may be affected, or perhaps only a few trees in an orchard will be chlorotic (yellow or white, not green)

6.8 Zinc (Zn)

Use 23% zinc sulfate for prevention and correction. 150 g/100 L as foliar spray in spring flush when leaves are 1/2 to 2/3 expanded, annually

Zinc deficiency symptoms

- Zinc deficiency is the most widespread deficiency in citrus
- Early stages is small spots of yellow between green veins on the leaf = mottling
- leaves may become increasingly yellow except for green veins
- Mottling (spots of yellow) becomes more pronounced with more severe deficiency
- irregular green bands along the midrib and main veins on a background of light yellow to almost white

6.9 Manganese (Mn)

Use manganese sulfate 100 g/100 L as foliar spray in spring flush when leaves are 1/2 to 2/3 expanded, annually

Manganese deficiency symptoms

Manganese deficiency occurs commonly in many areas of the world. It is particularly evident in the spring after a cold winter. There has been a delay in the recognition of Mn deficiency symptoms due to masking by severe Zn or Fe deficiencies. Sometimes the deficiency can be confused with symptoms of Fe and Zn deficiency or B toxicity. Manganese deficiency leads to a chlorosis in the interveinal tissue of leaves, but the veins remain dark green. Young leaves commonly show a fine pattern or network of green veins on a lighter green background but the pattern is not so distinct as with Zn or Fe deficiencies because the leaf is greener. By the time the leaves reach full size, the pattern becomes more distinct as a band of green along the midrib and principal lateral veins, with light green areas between the veins. Symptoms of manganese deficiency are usually more noticeable on the north side of the tree, and are more pronounced in the spring growth flush.

6.10 Boron (B)

Usually boron is applied as a 10% foliar spray; boron deficiency is rare.

Boron deficiency symptoms

- fruit is hard and dry due to lumps in the rind caused by gum pockets (brown spots in white part of rind); unusually thick white part of rind
- premature shedding of young fruits with unusually thick rind
- Seeds fail to develop and gum pockets form around inside of peel.
- death of the terminal growing point of the main stem
- slight thickening of the leaves, a tendency for the leaves to curl downward, and sometimes chlorosis.

Boron toxicity symptoms

- Early stages appear as a leaf tip yellowing or mottling
- In severe cases, gum spots occur on lower leaf surfaces with leaf drop occurring prematurely and shoot dieback

6.11 Copper (Cu)

Copper fungicide sprays will control disease and copper deficiency.

Copper deficiency symptoms

- unusually vigorous large dark green foliage with a "bowing up" of the midrib
- twigs are also unusually vigorous, long, soft, angular, frequently "S" shaped, and somewhat drooping
- severe cases: weak twigs will bear very small leaves of yellowish-green color, which drop quickly; twig dieback with reddish brown droplets of gum covering the twigs
- Fruit symptoms are most pronounced on oranges. Brown-stained areas of hardened gum on the rind of the fruit
- Fruit splitting, turning black and dropping by summer

Copper toxicity symptoms

- thinning tree canopies, retarded growth and foliage with iron deficiency symptoms
- Feeder roots darkened, with poor growth

6.12 Molybdenum (Mo)

Correct by liming soil or use sodium molybdate or ammonium molybdate 100 g/1000 L per hectare as foliar spray between summer and early fall every 3 years.

Molybdenum deficiency symptoms

- leaves have large interveinal chlorotic spots in early summer

- On older leaves yellow spots show deposits of brown gum on the lower leaf surfaces, which may eventually turn black
- necrotic yellow spots enlarge and extend to leaf margins. Affected leaves eventually drop, and trees become almost defoliated during the winter.

6.13 Figures of deficiency, excess and sprayed fruit symptoms

(from T.W Embleton , W.P. Bitters and C.J. Lovatt)

Fig. 1. Grapefruit leaves with high (left), low (middle) and deficient (right) nitrogen concentrations

Fig. 2. Nitrogen deficient leaves grapefruit.

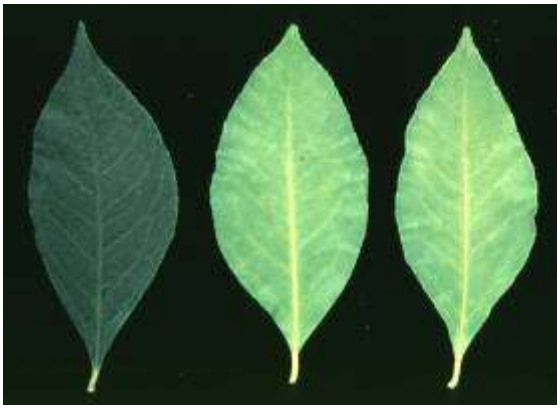


Fig. 3. Nitrogen sufficient (left) and deficient lemon leaves (right .

Fig. 4. Phosphorus deficient lemon leaves .

Fig. 5. Oranges from trees having excess, normal, and deficient phosphorus, note rough peel on deficient fruit

Fig. 6. Potassium deficient grapefruit leaves

Fig. 7. Potassium deficient lemon leaves

Fig. 8. Potassium deficient lemon leaves and fruit

Fig. 9. Magnesium deficient navel orange leaves.

Fig. 10. Magnesium deficient lemon leaves

Fig. 11. Magnesium deficient leaves from lemon

Fig. 12. Iron deficient orange leaves

Fig. 13. Iron deficient grapefruit leaves

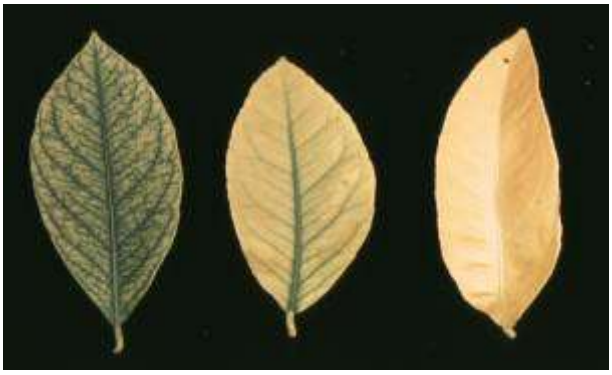


Fig. 14. Iron deficient lemon leaves

Fig. 15. Comparison of iron sufficient (left) and deficient (right) lemon leaves and fruit

Fig. 16. Boron deficient leaves of navel orange on trifoliate orange rootstock

Fig. 17. The corky vein symptom of boron deficient navel orange leaves

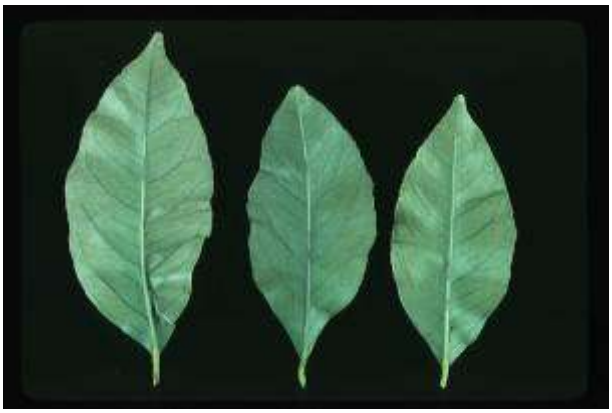


Fig. 18. Boron deficient leaves from lemon

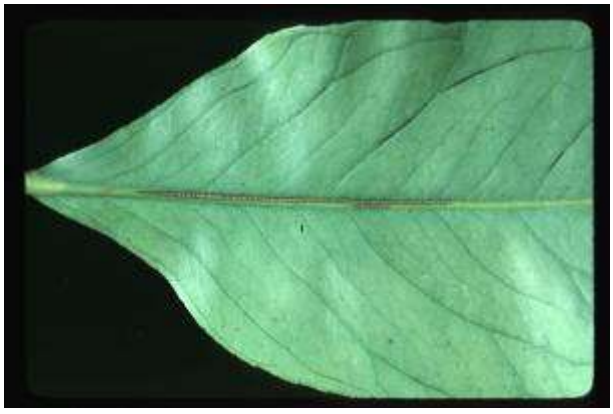


Fig. 19. A boron deficient lemon leaf with corking of the veins typical of boron deficiency

Fig. 20. Symptoms of boron excess in grapefruit leaves

Fig. 21. Symptoms of boron excess in leaves of navel orange.

Fig. 22. Symptoms of boron excess in lemon leaves

Fig. 23. Symptoms of boron excess in leaves of ‘Bears’ lime

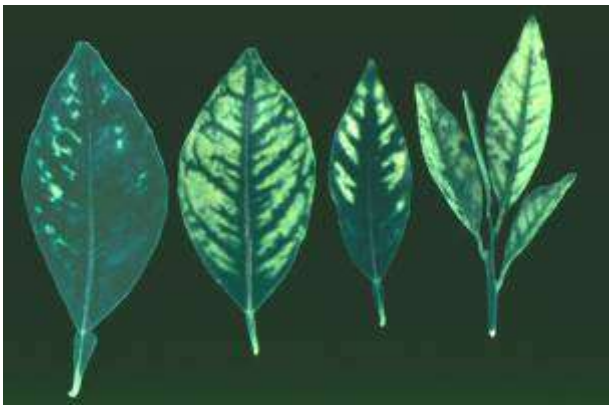


Fig. 24. Zinc deficient navel orange leaves.

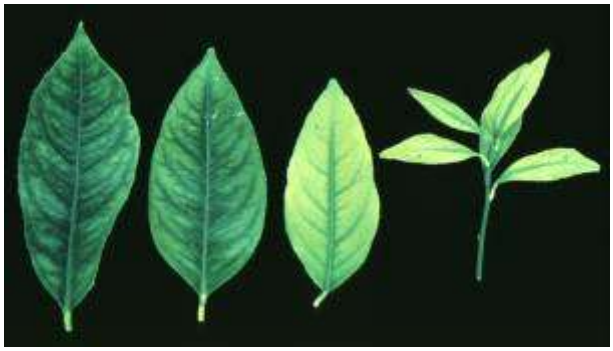


Fig. 25. Zinc deficient lemon foliage

Fig. 26. Copper deficient fruit of navel orange

Fig. 27. Copper deficient orange fruit.

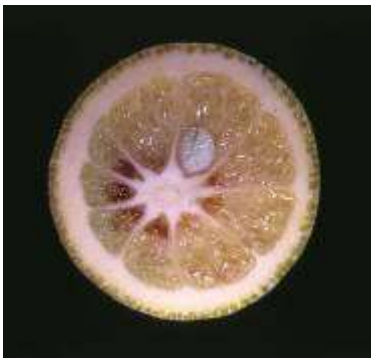


Fig. 28. Gum pockets in fruit caused by copper deficiency of orange

Fig. 29. Copper deficiency of lemon

Fig. 30. Copper deficient lemon fruit

Fig. 31. Gum pockets in shoots of copper deficient lemon

Fig. 32. Copper damage to orange fruit and leaves caused by a copper spray.

Fig. 33. Copper damage to a lemon leaf and fruit resulting from a copper spray.

Fig. 34. Copper damage to a lemon fruit caused by a copper spray.

6.14 Salt injury (chloride, sodium, high salt water)

Toxicity symptoms:

- May appear similar to drought stress symptoms, including reduced root growth, decreased flowering, smaller leaf size, and impaired shoot growth
- Chloride toxicity appears as burned necrotic or dry appearing edges of leaves
- Sodium toxicity shows overall leaf "bronzing" and leaf drop

Excessive fertilizer applications and highly saline irrigation water can result in salinity-induced phytotoxic symptoms.

7. DISEASES, NEMATODES AND PESTS OF CITRUS MOST LIKELY IN NANGAHAR

7.1 Fungal diseases

7.1.1 Damping-off Diseases in the Nursery

Pre- and post-emergence damping-off diseases in citrus seedbeds can be caused by a number of fungal pathogens including *Phytophthora* and *Rhizoctonia* spp. as well as occasionally *Thielaviopsis* and *Pythium* spp*.* Under warm conditions, typical of greenhouses, and with excessive moisture, damping-off can be a serious problem.
Symptoms: rapid seedling death, poor seed germination, cankers on seedling stems
Control: Sterilize soil by heat treating or chemical fumigation such as methyl bromide. Avoid over-fertilization with nitrogen, wet soils, high humidity, excessive shading, and crowding of seedlings. Soil pH should be adjusted to a range of 4 to 5.5 and soil temperatures should be maintained between 30 and 32°C to avoid these diseases. Temperatures can be lowered to 24 to 27°C once seedlings are 13 cm high.

7.1.2 Black Root rot in the Nursery

Symptoms: black or brown root lesions, interveinal leaf chlorosis, severe stunting and chlorosis of nursery-grown citrus seedlings
Control: Sterilize soil by heat treating or chemical fumigation such as methyl bromide. Maintain good drainage**,** avoid high pH, salt, low light, and cool temperatures, which reduce the vigor of citrus seedlings.

7.1.3 Armillaria Root rot

High soil moisture is a favorable environmental factor and thus, the disease is widespread along streambeds and flood plains where oak trees and other hosts grow.
Symptoms: *Armillaria mellea* infects, kills, and rots the major support roots and trunks of citrus trees. The tree undergoes a slow decline with the foliage becoming chlorotic, thinning, and eventually dying. The presence of clusters of mushrooms that develop at the base of the tree after rains during the late fall and early winter is a certain sign.
Control: Diseased trees and roots should be removed to prevent spread of the fungus by root-to-root contact. Several healthy trees surrounding disease centers should also be removed because the disease is invariably distributed well beyond trees showing visible symptoms. Remove roots greater than 1 cm in diameter and any wood or old stumps from the land before planting citrus.

7.1.4 Dry Root rot

Symptoms: Citrus trees infected with dry root rot will show a moist, dark decay in the bark of major roots or the root crown, which later have a cracked appearance. Dry rot lesions do not ooze gum as do *Phytophthora* trunk rot lesions. Trees infected with dry rot may appear thin. Some of the leaves may have an abnormal, curled appearance. A period of two to three years may pass from the time of invasion until noticeable wilt. Dry root rot-affected trees may suddenly wilt and die with the leaves drying in place after a period of prolonged summer heat.

Control: There are no effective control measures yet known for dry rot and all citrus rootstocks are susceptible to the disease.

7.1.5 Phytophthora Root rot, Foot rot, and Gummosis

High soil moisture content and poor drainage are associated with *Phytophthora* root rotsOn heavier soils, planting on berms or mounds can reduce the likelihood of root rot. Citrus gummosis is caused by *Phytophthora* species and is attributed to conditions that keep the trunks moist. The incidence can be minimized by avoiding wetting tree trunk, insuring good aeration around the trunk and preventing soil accumulation around the trunk.

Symptoms: *Phytophthora* root rot causes a slow tree decline that results in foliage yellowing, leaf drop, and twig dieback. In severe cases large limbs may succumb when a significant portion of the root system is damaged. Large amounts of amber to brown gum may be produced on the trunk and limbs. Badly infected trees have small, pale green leaves with yellow veins as is typical of girdled trees.

Control: Rootstocks resistant to *Phytophthora* spp. include Ponderosa lemon, Swingle citrumelo, Rubideaux trifoliate x African Shaddock, C-32 citrumelo, C-35 citrumelo and Schaub rough lemon. Fungicides applied with irrigation water or fungicides sprayed or painted on gummosis lesions.

7.2 Trunk and branch diseases

7.2.1 Botryosphaeria Diseases

Branch and twig diebacks are often caused by *Botryosphaeria* spp. Species of *Botryosphaeria* invade trees after pruning or other mechanical injuries, or when trees are under stress from extreme heat (i.e., sunburn), cold (frost injury), flooding, or drought.

Symptoms: Twig dieback and limb and trunk cankers that develop as the inner bark tissue dies, leaving elongated cavities or grooves in the bark next to the cambium that may ooze gum.

Control: pruning of dying branches well below the dead tissue will help manage the disease.

7.2.2 Sclerotinia Twig Blight

Symptoms: infected blossoms, fruit, roots, trunk or branches pass disease to twigs, which show lesions that are soft and ooze gum. Later the bark becomes gray or buff and is characteristically shredded into long fibrous strips

Control: remove diseased parts of tree.

7.2.3 Wood Decays (white rots and brown rots)

Symptoms: Trees with wood decay generally are non-vigorous and show signs of stress. Leaves are often chlorotic, and with progressive wood decay the trees begin to die back and may eventually die. Under the bark or in the decayed wood of infected roots, branches, or trunks, white to brown fibrous growth of the pathogen may be found. The two kinds of wood decay mentioned above have a distinctive appearance. With

white rots the wood turns spongy and soft and has a whitish appearance. With brown rots the wood turns into dry, brown cubicles resulting from cracks that develop across the grain.
Control: Keep trees healthy and vigorous. Avoid large pruning cuts or other wood-exposing injuries especially during wet periods during the year. If disease is spreading via roots (e.g., forming an infection center) remove trees or stumps surrounding the infection. Remove stumps and large roots and fumigate the soil before planting new trees.

7.3 Foliar and fruit diseases

7.3.1 Brown Rot

Brown rot of citrus fruits can be caused by some of the same species of Phytophthora that also cause Phytophthora root rot, foot rot, and gummosis. Trees may show symptoms of brown rot alone or in combination with symptoms of Phytophthora root rot, foot rot, or gummosis.
Symptoms: Brown rot develops mainly on fruit growing near the ground; rind shows an olive-brown discoloration. The fruit remain firm and leathery. Infected fruit usually fall to the ground. Infected fruit usually have a distinctive, pungent, aromatic odor.
Control: The most effective control for brown rot is a Bordeaux mixture spray [copper sulfate ($CuSO_4$ $5H_2O$), lime $Ca(OH)_2$ and water] prior to the rainy period.

7.3.2 Septoria Spot

Leaf and fruit spots caused by Septoria spp. have been reported from most citrus-growing regions in the world. Lemons and grapefruit are most frequently damaged but all citrus varieties are susceptible.
Symptoms: Infections on fruit begin when the fruit is green and become more conspicuous as the fruit ripens. On fruit still attached to the tree, lesions consist of small depressions or pits 1 to 2 mm in diameter on the surface of the rind. The pits are light tan or buff with narrow greenish margins that become reddish-brown as the fruit matures. Leaf infections result in raised, blister-like black spots, 1 to 4 mm in diameter and are surrounded by a yellow halo. Symptoms appear most commonly after cool or frosty weather and are more severe in years of higher than normal rainfall.
Control: Preventative copper treatments can be applied in late fall or early winter prior to rainfall (see brown rot).

7.4 Postharvest decays

7.4.1 Penicillium Fruit Rots

Penicillium decays are the most important decays of citrus fruits, but especially in areas with little summer rainfall.
Symptoms: Large areas of the fruit appear water-soaked and fruit begin to soften. Mold begins to form in the center of the lesions and may be green to olive-green or bluish.
Control: Clean up all dropped fruit from the orchard floor. Avoid injury to fruit. Keep storage building clean.

7.4.2 Sour Rot

Like *Penicillium* decays, sour rot is often initiated from wounds on the fruit that occur during harvest and handling. Ripe or overmature fruit are more susceptible to sour rot than green or immature fruit, especially when fruit are stored for extended times at high humidity or are shipped without adequate refrigeration.

Symptoms: Sour rot is first visible as a small water-soaked area on the peel and at this stage is not easily distinguished from decays caused by *Penicillium* species. The lesion enlarges and then becomes very soft, in contrast to Penicillium decays. At an advanced stage of infection the fruit is completely softened and mushy. The fruit collapses in a watery mass that drips onto underlying fruit causing a nest of decay.

Control: Keep fruit free from injury; keep soil off of fruit. Washing fruit with chlorinated water and disinfesting handling equipment with sanitizers (hot water, chlorinated water) will reduce the incidence of disease.

7.5 Bacterial diseases

7.5.1 Citrus Canker

Citrus canker is a leaf, fruit, and stem spotting disease.

Symptoms: Young lesions are raised on both surfaces of the leaf, but particularly on the lower leaf surface. The pustules later become corky and crater-like with a raised margin, sunken center and are surrounded by a yellow halo. Fruit lesions vary in size because the rind is susceptible for a longer time, and more than one infection cycle can occur on the fruit. Major outbreaks of citrus canker occur when new shoots are emerging or when fruit are in the early stages of development. Frequent rainfall in warm weather, especially during storms, contributes to disease development. Citrus canker is mostly a leaf-spotting and fruit rind-blemishing disease, but when conditions are highly favorable for infection, it causes defoliation, shoot die-back, and fruit drop.

Most spread of canker bacteria by wind and rain is for short distances, i.e., within trees or to neighboring trees. Canker is more severe on the side of the tree exposed to wind-driven rain.

Control: Frequent applications of copper-containing bactericide sprays have been shown to be effective for protection against fruit lesions. Because young fruit is particularly susceptible to canker, a protective coating of coppers should be maintained on the fruit surface in the first 90 days after petal fall. Copper fungicides are relatively ineffective in protecting new leaves and do little to reduce spread of the disease.

7.6 Virus and viroid diseases

7.6.1 Psorosis (*Citrus psorosis virus*, CPsV)

Psorosis is a bark scaling disease primarily on sweet oranges that results in the slow decline of affected trees.

Symptoms: Scaling and flaking of the bark on the trunk and limbs of sweet orange, grapefruit and mandarin. Large strips of bark will fall off. Ultimately, the tree dies. Symptoms on young leaves range from chlorotic flecking or clearing over the entire leaf or it may occur only in portions of the leaf.

Control: Use virus-free budwood for propagation. Using pruning and budding tools that have been disinfested in 1% sodium hypochlorite solution (bleach) will eliminate any possible transmission of the disease by mechanical contamination.

7.6.2 Tristeza (Citrus tristeza virus, CTV)

Found worldwide wherever citrus is grown. It is probably the most widely known disease of citrus; also called 'quick decline'.
Symptoms: This virus produces a wide variety of disease symptoms depending on rootstock and scion variety combinations and virulence of the particular virus strain. May occur on sweet orange varieties grafted on sour orange rootstock and can cause tree death within one to two weeks. Shriveled, dehydrated fruit may remain hanging on the tree. Stem pitting symptoms can occur in most citrus varieties regardless of the rootstock. In mild cases, the pits cannot be seen unless the bark has been peeled away. Often, the pits are stained light brown.
Control: Use virus-free budwood and rootstock material for propagation. Remove infected trees from the orchard.

7.6.3 Vein Enation or Woody Gall

Symptoms: Symptoms of this disease include enations (overgrowth or thickening) on the underside veins of sour orange and rough lemon, and galls (swellings) on rough lemon. Galls typically form near thorns or in association with wounds. This disease does not have an economic impact except where severe galling occurs on young trees budded to rough lemon seedlings. Older, established trees are not affected by gall formations.
Control: This disease can best be controlled by avoiding susceptible rootstock varieties and using budwood from disease-free sources.

7.7 Nematodes

Nematodes are roundworms that are mostly thread-like and typically about 0.4 to 1 mm long. Most nematodes live in soil. Some nematode species are specialized parasites of plants. Nematodes impact on agriculture results in large crop production losses. Damage to the root varies, depending on the nematode species and the response by the plant host.
The citrus nematode The highest nematode populations are typically found in late spring and late autumn following the citrus root flushes. Infection, growth and reproduction occur between 20 °C and 30 °C. Citrus nematodes can survive for several months to a year or more in moist cool soil.
Symptoms: Damage is 'citrus slow decline'. Early symptoms above ground are reductions in leaf and fruit size, followed by a decline in tree appearance, such as yellowing, leaf curling and dieback. Feeder roots heavily infested appear thicker and darker than those without nematodes. The roots are encrusted with soil particles sticking to the gel surrounding the nematode eggs.

Control: Nematode-resistant rootstocks. *Poncirus trifoliata*, a spiny, hardy citrus relative, has been used as a main source of resistance. Trifoliate orange and its hybrids are also good choices.
Cultural management: Minimizing other forms of stress such as disease or water- and nutrient-related deficiencies helps trees to tolerate low levels of nematode parasitism. Replanting of old citrus orchards requires special precautions because citrus nematodes can survive host-free periods of many months or even years if large citrus roots continue to live in moist soil. Dry aerated, warm soil promotes the citrus nematode population decline. Failure of citrus replants to grow as well as the previous plantings or as those grown in soil never before planted with citrus, is referred to as the "citrus replant problem." Most studies indicate that the build-up of citrus nematodes and deleterious root pathogens such as *Phytophthora* spp. and *Fusarium* spp. during prolonged cropping to citrus is the primary cause for the citrus replant problem.

7.8 Mites

7.8.1 Citrus Rust Mites

Rust mites are important pests of fruit grown for the fresh market. Damage may be particularly severe on fruit, stems and foliage, causing fruit and leaf injury and possible leaf drop. Mites can increase in early spring on new foliage, reaching a peak in summer. Mites can be hard to see as they are very small and often damage is severe before mites are detected.
Symptoms: Visible characteristics of injury differ according to variety and fruit maturity. Fruit may be misshapen, russeted or bronzed in color, showing reduced size, increased water loss, and increased drop. Leaf injury can include loss of glossy appearance on upper side, taking on a dull, bronze-like color, and/or exhibit patchy yellowish cells in areas of russeting. Lower leaf surfaces may show yellow degreened patches and necrotic spots. Both mature and developing leaves can show leaf distortion, curling under of leaf margins, crinkling of leaf tissues, and ultimate burn and leaf dieback occurring.
Control: Only by use of miticides typically during April, June, August, and October for fresh market citrus. No treatment needed for control of fruit damage when fruit are used for processing. Canopy density has an effect on rust mite populations and their ability to increase over a short period of time. The denser the canopy, the less favorable conditions are for a rapid rust mite increase.

7.8.2 Spider Mites

There are three species of spider mites that are potential pests on citrus, Texas citrus mite, citrus red mite, and six-spotted mite. The Texas citrus and citrus red mites occur on citrus throughout the year and usually are most abundant in groves between March and June. They are found most commonly on the upper leaf surface of recently mature flush, and all stages of the mites orient along the mid-vein. As populations increase, they move to leaf margins and fruit. The six-spotted mite is a sporadic pest occurring in colonies on the lower leaf surface and tends to be more abundant following cold winters, especially during December. Usually localized populations of this mite can be

recognized by characteristic yellow blistering on mature leaves between March and May. Populations decline rapidly in June and remain very low through the remainder of the year.
Spider mites feed primarily on mature leaves; leaf drop can result when trees are stressed by high spider mite infestations alone or in combination with sustained dry, windy conditions that may occur in the late fall, winter or early spring months. When populations of Texas citrus mite or citrus red mites are high, they will also feed on developing fruit. Spider mites prefer dry weather and low relative humidities in the range of 30 to 60%.
Need for controlling spider mites is based on temperature and humidity conditions, spider mite population levels, tree vigor, and time of the year. Petroleum oil provides some protection against spider mite eggs.

7.8.3 Broad Mites

The broad mite is an economic problem on lemons. The broad mite is only capable of feeding on very young, tender leaf or fruit tissues, causing distorted leaf shapes. A delayed terminal die-back can occur on infested citrus seedlings. Subsequent development of damaged buds can result in a rosette and formation of a witches' broom. Small fruit become silvered from intense feeding by the mite with subsequent reduced fruit growth.

7.8.4 Application of miticides

The only real control for any mite. Petroleum oil may be applied postbloom, summer, and/or fall.

7.9 Soft bodied insects attacking foliage and fruit

These insect species affect tree health and fruit quality, and can impact mature fruiting trees as well as newly planted groves and resets.

7.9.1 Scale insects:

Pest management of scale insects of citrus is based on natural enemies, including predators, parasites, and pathogens. These relatively specific natural enemies co-exist with their hosts in the citrus grove under most conditions and can respond to suppress pest numbers when they periodically increase in individual groves. However, there are conditions under which natural enemies may not function well. Populations of scale insects build gradually.
Control: Petroleum oils may give some control; do not apply under hot temperature conditions(33 ºC or above). Coverage must be thorough, providing direct contact.

7.9.2 Whiteflies

Whiteflies are dependent on new growth for their development and reproduction; consequently, they are active in citrus only during periods of flush. Large populations of these insects can deposit considerable volumes of honeydew, leading to sooty mold accumulation. These insects are constantly present in most groves in very low numbers and are normally under good biological control by various specialist parasitoids and

generalist predators. Populations are rarely heavy enough to warrant treatment unless biological control has been disrupted.

7.9.3 Aphids

Aphids are dependent on the availability of newly expanding leaves for their development and reproduction, so these insects may be problems during periods of new citrus growth, primarily spring and fall. Aphids are largely controlled by many natural enemies such as ladybeetles, hoverflies, and lacewings. Mature groves sustain little damage and should not need treatment.

7.9.4 Citrus Leafminer (CLM)

Citrus leafminer can occur on new flush throughout the growing season but typically affects little of the important spring flush. Nursery stock and young resets are most affected by CLM injury.
Natural enemies may be the best control.

7.9.5 Citrus root weevils

Adults appear most abundant in a tree in April/May, July/August, and October/November. The most visual plant damage resulting from adult feeding is notching of the margins of leaves of young, tender shoots. Prolonged leaf feeding by adults appears to cause no economic effects in mature groves; however, on occasion, feeding will cause virtual defoliation of small replants. Larval feeding injury to the roots by root weevils can have a devastating effect on citrus trees. Roots may be girdled and killed in the process or the crown may be girdled causing tree death..
Control: Citrus root weevil management begins with the selection of a *Phytophthora*-resistant rootstock as weevil damage increases the likelihood of *Phytophthora* infection. Root weevil resistant rootstocks are also beneficial, including trifolate orange and a hybrid "Swingle" citrumelo. Optimal soil drainage is fundamental to citrus root weevil management, particularly in heavier soils. Regular fertilization and irrigation are crucial to new root growth in weevil-infested groves. Skirt pruning and trunk banding can be effective in controlling flightless weevil species. Weed control is also needed to prevent movement into trees from stems of grasses and/or broadleaf weeds**. Foliar sprays** of petroleum oil is used to target adult weevils in the tree canopy. Root injury is less and overall tree health improved when two foliar sprays are used 4 weeks apart during peak summer flush in late-May through June.

7.10 Diagnosis of common citrus problems:

Symptom	First noticeable	Primary cause	Occurs	Control and/or comments
Fruit				
1. Premature rind coloring	late summer	plant bugs	mid-summer	Rarely serious enough to control
2. Creases in rind	harvest	physiological	spring	Follow irrigation and fertilization recommendations
3. Necrotic spots on rind, lower part	2 or 3 weeks after spraying	spray burn	after spraying	Excess spray accumulates near bottom of fruit
4. Thick rind, puffy fruit	harvest	excess vigor	since bloom	Follow good cultural practices, typical of off-bloom fruit
5. Rust colored or brown rind	anytime	citrus rust mite	since bloom	Does not affect eating quality, use miticide only if necessary
6. Silvery to tan irregular, smooth blemishes	harvest	wind scar	March-April	Not necessary, quality unaffected
7. Small, brown spots on rind, rough texture	harvest	melanose fungus	March-April	Affects grapefruit only, remove dead twigs inside canopy
8. Removable, small, colored, raised spots on rind	summer to harvest	scale insects	summer	Spray only if problem is extensive on the bark
9. Cottony masses near fruit stem	summer to harvest	mealybug or cottony cushion scale	summer	Rarely serious, hard to control
10. Black, sooty covering	harvest	sooty mold	since bloom	Whiteflies, blackflies, mealybugs and other insects, usually gone before problem is noticed
11. Fruit splitting on-tree	September	physiological	summer	Dry weather followed by good rain, proper irrigation lessens the problem

Leaves and twigs				
1. Leaf cupping and curling	after new flush	aphids	during each flush	Not serious, check new growth as it emerges
2. Silvery, scratchy appearance to leaf	summer, fall	spider mites	spring to fall	Could cause excessive fall leaf drop, spray if necessary
3. Small, brown spots, sand-papery texture	spring-summer	melanose fungus	after growth flush	Affects grapefruit, usually after spring rains; remove dead twigs
4. Irregular, oily spots on foliage	summer to winter	greasy spot fungus	summer	Remove fallen leaves, particularly in summer
5. Raised, irregular tar-like spots underleaf	anytime	sunburn	anytime	Not serious
6. Removable, small, colored spots on leaves or bark	anytime	scale insects	summer	Spray only if infestation is extensive
7. Fish-scale-like scales underleaf, translucent; small, white, flying insects	spring to fall	whiteflies	spring to fall	Leads to sooty mold; rarely requires control
8. Spirals of eggs or small black insects underleaf	anytime	blackfly	anytime	Leads to sooty mold; insecticides do not work, parasites normally in control
9. Black sooty coverings on leaves	anytime	sooty mold	anytime	Control causal insects or wash off with soapy water
10. Leaf yellowing, drop and twig dieback	anytime	root damage	anytime	Usually too much water, poor drainage
11. Leaf yellowing, tipburn marginal necrosis, drop	anytime	salt burn	anytime	Leach soil, be careful with fertilizer
12. Leaf yellowing, yellow area confined to veins	anytime	foot rot, water damage	anytime	Determine cause and correct, if possible
13. Marginal necrosis, leaf cupping, curling	spring flush	wind burn	during spring flush	Usually not serious, windbreaks may help

Limbs, trunk or entire tree				
1. Tree looks sick, sparse, yellow-veined foliage, dead bark on trunk near ground	anytime	foot rot	anytime	Remove dead tissues, disinfect and treat with pruning paint; follow recommended cultural practices
2. Hardened gum exudate on bark of trunk or limbs	anytime	gummosis	anytime	Follow good cultural practices, no control, not usually life-threatening
3. Young tree seemingly loses all its leaves quickly, fruit hangs on	anytime	foot rot	anytime	Check for foot rot (dead bark) completely around trunk at and above the bud union

Tree suffering from Armillaria root rot

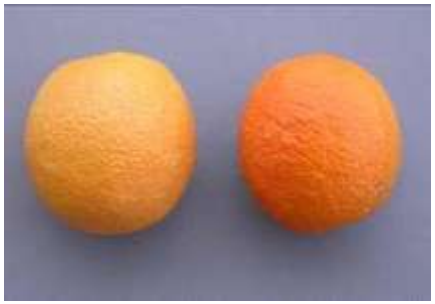
Frost damage to leaves and fruit

Phytophthora root rot and gummosis

Anthracnose

Early stages of brown rot on lemons and oranges

Citrus mealybug



Citrus Red Mite

Colony of mealybugs

Misshapen fruit and flowers from citrus mites

Glassy winged sharpshooter

Citrus Peelminer

Citrus Leafminer

Giant Whitefly

Texas Citrus Mite

Woolly Whitefly

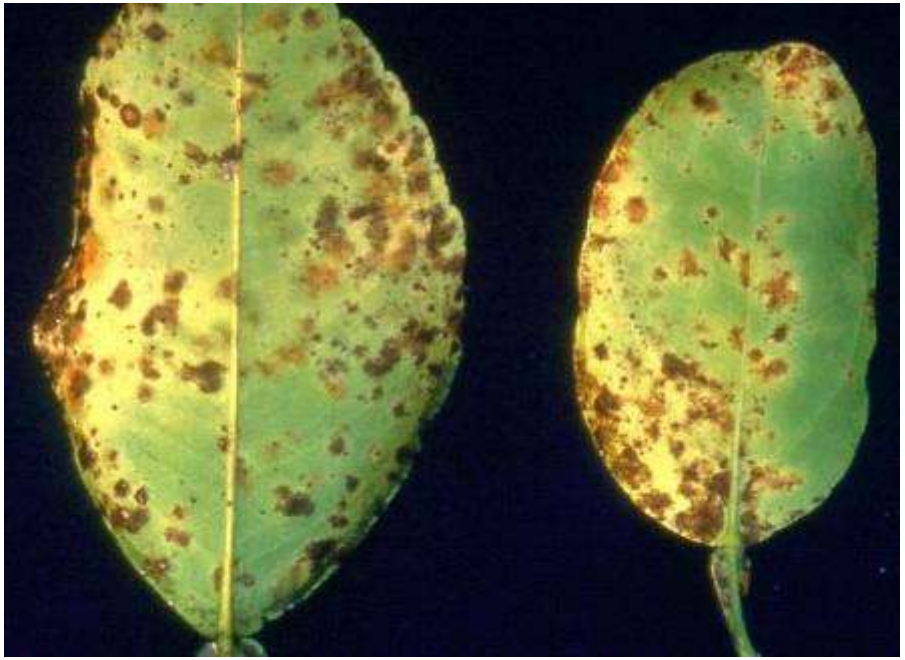
Potential Exotic Pests of Citrus


Fruit Flies


Diaprepes Root Weevil, *Diaprepes abbreviatus* and attack of citrus roots

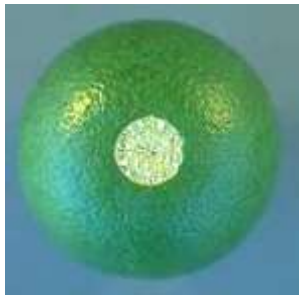
Brown Citrus Aphid *Toxoptera Citricida* and citrus tristeza virus


Asian Citrus Psyllid, *Diaphorina citri* and citrus greening



Septoria symptoms

Early Season Pests of Citrus
(primarily cosmetic damage)



Katydid

Citrus Thrips

Citrus Cutworm

Scale Pests of Citrus

8. HARVEST AND POSTHARVEST

8.1.1 Fruit maturity

All citrus ripen gradually over weeks or months and are slow to drop from the tree. Peel color changes during ripening, but that change is a function of climate more than ripeness, and a poor indicator of maturity. The best indices of maturity for citrus are internal: sweetness (Brix or %sugar) and acidity. External quality is a function of color and blemishes caused by wind scar, disease or insect damage. Mature fruit vary in size, even those on the same tree. With sweet oranges such as blood orange, harvesting should begin with the smaller fruit which mature first. With mandarins, it is the end of the fruit furthest from the stem which turns yellow first. Harvesting should begin with the large fruit. Smaller fruit, or those which are slow to turn color, should be harvested later on in the season.

8.1.2 Harvest method

Tangerines and some fresh oranges must be clipped, not pulled from the tree, to prevent plugging the peel. It is best to harvest citrus on a clear, sunny day with low humidity. The fruit should be harvested as soon as the dew has evaporated. On a cloudy day, the fruit should be harvested in the afternoon. Fruit should not be harvested at all on a rainy day.

8.1.3 Storage

Only fruit which have not been damaged in harvest should be stored. Citrus may be stored for periods of up to 1-2 months at low temperatures (0-4.4 °C). Chilling injury is common in grapefruit, lemons, and limes when stored below 10 °C, but rare in oranges and tangerines. Brown pitting and staining of the rind occur, sometimes with a watery breakdown of peel and pulp. Plastic crates or boxes are used for storing fruit. Mandarins and tangerines should be stored with only one or two layers per box. Sweet oranges such as blood oranges should be stored with three or four layers per box. Too many layers in one box may cause bruising of the fruit.

Boxes should be stacked inside the storage room in a way that maintains good ventilation. Sunlight should not be able to penetrate inside the storage room. Any rotting fruit that are found should be removed. The storage room should have a high roof, to allow better circulation of cold air at night. Ventilation windows should be small but there should be a large number of them, to allow better air circulation. Windows should be kept open on cool nights and closed during warm days. The roof and walls should have good heat insulation, to keep temperatures as cool as possible. The storage room should be insect-proof and rat-proof. Tangerines in general store poorly on the tree, while oranges and grapefruit hold up longer.