NSW DEPARTMENT OF
PRIMARY INDUSTRIES

Growing lemons in Australia- a production manual - Readers' Note

This document is part of a larger publication. The remaining parts and full version of the publication can be found at:

http://www.dpi.nsw.gov.au/agriculture/horticulture/citrus/lemon-manual

Updated versions of this document can also be found at the above web address.

12. Diseases

Sooty mould growing on honeydew produced from sap-sucking pests

INTRODUCTION

Lemons are susceptible to a range of diseases in Australia. Coastal areas and regions (e.g. Coastal and the Central Burnett of Qld, coastal NSW and NT) with high rainfall and humidity tend to have a higher incidence of fungal disease problems. The most common diseases in these areas are melanose, lemon scab, brown rot, collar rot, sooty blotch, *Phytophthora* root rots and Armillaria. In these regions lemon trees require regular application of protectant copper sprays in order to keep fruit clean.

The drier inland growing regions (e.g. Vic, SA and southern and inland NSW) have only a few disease pathogens that affect lemons. The most common diseases in these areas are brown rot, collar rot, septoria spot, greasy spot and citrus blast/black pit.

In Australia most fungal pathogens in citrus are controlled using applications of protectant copper based sprays. At present there are not a lot of other fungicides registered for use in citrus.

The most important cultural controls used to control disease are focused on removing or reducing the disease source. Trees should be kept free of dead wood with regular pruning. This also opens up the tree canopy for better air circulation and easier penetration of fungicide sprays. Skirting trees will reduce the likelihood of pathogens being carried from the soil into the tree in rain splash.

For information on control of diseases refer to the Pest and Disease Control section of this manual.

- ☑ There are more disease problems in areas of high rainfall and humidity
- ☑ Protectant copper fungicides are commonly used to reduce fungal diseases
- ☑ Prune trees regularly to remove dead wood and improve air circulation in the canopy
- ☑ Skirt trees

MELANOSE

In coastal and tropical regions of Australia this is one of the most important diseases causing downgrading of fruit. Melanose is caused by the fungus, *Diaporthe citri*.

Symptoms

Damage is superficial and does not affect internal fruit quality. On the fruit, leaves and small twigs, small, dark brown to black spots are produced which are raised and rough to touch. The incidence of melanose usually increases as trees age and the amount of dead wood in the canopy increases.

The melanose lesions on fruit can vary in size and appearance depending on the age of the fruit at the time of infection. 'Mudcake' melanose develops when the rind is heavily infected with numerous spores soon after petal fall. 'Flyspeck' melanose develops when fruit are either infected early with a few spores or well after petal fall. 'Tearstain' melanose forms when spore laden water drips over fruit during rain. (Whiteside, 1976)

The melanose fungus also causes a wood rot which occurs when trees are stressed, such as by drought. It causes a cinnamon brown discolouration of bark with a well defined margin between healthy and diseased tissue, often with streaks of yellow gum. The melanose fungus also causes one form of stem end rot of fruit (phomopsis stem-end rot).

Disease source and infection period

Spores of the melanose fungus arise from fruiting structures (pycnidia) that develop in dead citrus tissue, particularly small twigs that have died within the previous few months. The spores are released by rainfall and splashed on to the fruit, particularly those situated beneath the source of inoculum. At 25°C periods of continuous wetness exceeding 9 to 12 hours are required for spore germination and penetration of host tissue. Much longer periods of wetting are required for infection if the temperature drops below 20°C.

Susceptibility of citrus tissue

Melanose attacks foliage, fruit and twigs in the very immature stage. As these tissues mature they become resistant to infection. For example, immediately after petal-fall the young developing fruits are very susceptible to infection.

- ☑ Remove dead wood
- ☑ Fruit are susceptible from petal fall until 9 weeks later.
- ☑ At least 9 hours of continuous wetness is needed for infection
- ☑ Apply a copper spray at petal fall
- ☑ In older trees apply a second copper spray 4-8 weeks after the petal fall spray (depending on weather conditions)
- ☑ Ensure thorough spray coverage of fruit surfaces

Should wet weather conditions prevail for several days at this stage, serious disfigurement of fruit will occur. After several weeks the rind commences to become more resistant to infection, so that by eight or nine weeks after petal fall (Kiely, 1973), no further infection of fruit can occur.

The late summer leaf flush is often badly infected. Disease severity is greatly affected by tree vigour. Young vigorous trees need precautionary spraying in early years. But as dead wood increases, routine spraying against melanose is essential to produce fruit of satisfactory external appearance for the fresh market.

Control

The removal of dead wood, to reduce the inoculum load of the melanose fungus, is both time-consuming and costly.

Many fungicide materials have been tested for their efficacy in controlling infections of melanose, but none are as efficient as those of the copper group. Historically a copper spray applied at petal fall has given satisfactory results in controlling melanose in young trees in coastal areas. The copper forms a protective layer over the fruit protecting it from infection. However as the fruit grow and expand this leaves gaps in the protective copper layer. If conditions are favourable for infection this protective copper layer needs to be renewed with another spray.

Timing of sprays

Timing of spray applications is very important. With lemons where scab is frequently present as well as the melanose disease, the initial application should be made at half petal fall, that is when all the petals have dropped from the northern side of the trees (Kiely, 1973).

If a treatment is applied at petal fall, the fruit will be too small to retain much fungicide and what little material is retained will soon be dissipated through fruit enlargement, if not by rainfall or irrigation. With the petal fall treatment, only 3-4 weeks protection against melanose can be expected leaving another 5-6 weeks for the fruit to be attacked. In wet weather, especially if melanose is a serious problem, a follow-up spray application may be made 4-6 weeks after the initial spray.

The copper sprays act as protectants, preventing infection of the young developing fruit. The melanose fungus harboured in the dead wood throughout the framework of the tree, is little affected by the protectant copper sprays.

Applying copper fungicides before petal fall or even before bloom will not reduce the inoculum available from the dead wood. Copper fungicides have to be deposited on the fruit surface itself to provide melanose control.

Where melanose leaf infections are likely to be serious on foliage growth in the late summer, a further protectant spray can be applied.

LEMON SCAB

Lemon scab is a serious disease of all lemon varieties grown in coastal areas. The disease also affects Rangpur lime, and Rough lemon rootstocks. Lemon scab is caused by the fungus *Sphaceloma fawcettii* var. *scabiosa.*

Symptoms

Citrus scab attacks the fruit, leaves and twigs, producing slightly raised, irregular scabby or wart-like outgrowths. At first these outgrowths are grey or pinkish, becoming darker with age. They are more common on fruits than leaves. The raised lumps associated with scab can be confused with symptoms caused by the disease botrytis (which is uncommon) or windrub abrasions on young fruit.

Disease source

Spores of the fungus are readily produced on the surface of scab lesions on young fruits throughout the year. Spores of the fungus are spread by wind and rain. The fungus over-winters on the tree canopy, mostly in scab lesions on fruit. Rough lemon rootstock is also very susceptible to scab and can act as a source of the fungal inoculum. Moist conditions favour disease development. Most spores come from small infected lemon fruits.

Infection period

Lemon foliage is susceptible to infection when the new growth flush is less than 25% expanded. Immature lemon fruits are susceptible to infection from quarter petal-fall to about 12 weeks later (or 3-4 cm in diameter). Leaf wetness is the most important factor determining infection. For germination and infection to occur the scab spores need a wetting period from rain, overhead irrigation or spraying of at least 4 hours continuously or 1-2 hours followed by 3-4 hours within the next 24 hours. Brief wetting of foliage by non-fungicidal spray treatments has also been found to promote infection (Whiteside 1975). Temperature does not appear to have a major impact on the disease.

The severity of infection depends on the amount and frequency of wetting periods whilst the growth flush and fruit rind are susceptible to attack (Whiteside 1975). The extended bloom period in lemons makes accurate timing of sprays difficult.

Potential infection periods for scab

At a trial site at Kulnura on the Central Coast of NSW a weather station was installed to measure rainfall, temperature and leaf wetness at two positions on the tree. Using data from this site, the aim was to see if we could detect

- ☑ Rough lemon rootstocks are susceptible to scab and can act as a source of innoculum
- ☑ Moist weather favours disease development
- ☑ Fruit are susceptible from half petal fall until 12 weeks later
- ☑ Apply a copper spray at half petal fall and 4-6 weeks later
- ☑ Further copper sprays may be needed depending on weather conditions
- ☑ Especially a problem in prolonged cool wet conditions
- ☑ Copper sprays reduce infection
- ☒ Copper sprays darken any skin blemish

potential infection periods for citrus scab (as indicated by leaf wetness) that coincide with susceptible fruit and foliage being on the tree.

On the Central Coast of NSW the danger periods were late winter to early spring and during late summer. The main (winter) lemon crop was most susceptible to infection in the October period around flowering. The more valuable spring and summer crops developing from flowers in the December to April period were susceptible to infection throughout summer and autumn. In this period the wettest months tended to be January, February and March. This period is critical for monitoring weather conditions and making spray decisions. This work tends to support the fact that generally the spring/summer crop lemons are more likely to be infected by lemon scab rather than the main winter crop.

Spread of citrus scab in the orchard

Fungal spores are produced directly on scab pustules on leaves and fruit and are dispersed within an orchard by rain, overhead sprinkler irrigation and during spraying operations (Whiteside 1975). Dew may also cause liberation of conidia from the pustules but, due to the limited splashing action, there would only be localised dispersal (Whiteside 1975). Some dry spores can also be spread by winds in excess of 2 m/s (Whiteside 1975, 1980).

Control

Only copper sprays are currently registered to control scab. Timing is critical. Spray at quarter to half petal fall. A second copper spray applied 4-6 weeks later also helps to protect fruit. The fruit surface is protected from infection by the layer of copper. Once this copper layer is eroded away it may need to be renewed.

Due to the habit of lemon trees producing multiple crops (in warmer areas of Australia), copper sprays may need to be applied at other times of the year to protect spring and summer crops.

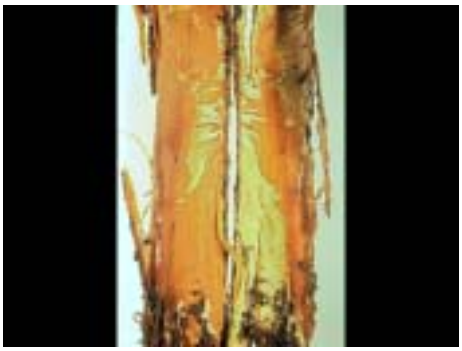
References

Whiteside, J.O. (1975) **Biological characteristics of *Elsinoe fawcettii* pertaining to the epidemiology of sour orange sca**b. *Phytopathology* 65: 1170-1177

Whiteside, J.O. (1980) **Epidemiology and control of citrus scab in Florida**. Pages 200-204. In: Proceedings of the International Society of Citriculture, Griffith, Australia. Florida Agricultural Experiment Station Journal Series 1270, University of Florida, Gainesville, United States.

OTHER DISEASES

Armillaria



Armillaria symptoms showing white fan like growth under bark.

Armillaria is one of the most important root rots of fruit trees in coastal areas and is caused by the fungus *Armillaria luteobubalina*, which is native to Australia and is common in coastal eucalypt forests. It occurs only occasionally in inland orchards.

The fungus survives for years in woody debris such as stumps and dead tree roots, especially the bloodwood type eucalypt trees. The fungus spreads from tree to tree by fungal strands (rhizomorphs) that grow out from the roots of infected trees. Infection occurs when the root of the lemon tree comes into contact with an Armillaria infected root.

- ☑ A problem in coastal orchards previously occupied by native eucalypt forests
- ☑ Soil borne fungus difficult to control
- ☑ White fan-like growth under the tree bark or on roots.
- ☑ Spread from tree to tree through infected roots.

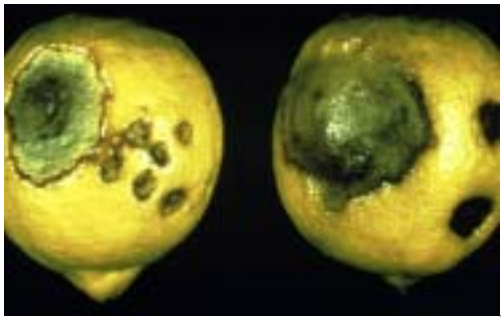
Armillaria root rot damages the root system of the tree causing leaf fall, twig dieback and eventually kills the entire tree. In citrus, this above ground deterioration of the tree is not usually seen until the disease is well established in the root system and trunk. Infected roots are often spongy and if the bark is removed a thin white fan-like growth can be seen on the wood surface. Freshly infected tissue has a strong mushroom smell. Black bootlace-like strands (rhizomorphs) are usually formed on the root surface and are a distinguishing feature of the disease. During autumn rains clusters of toad stools are produced around the tree trunk.

Control

Trees in the early stages of infection can be treated by exposing the butt and main roots to air. This slows down armillaria activity.

Badly infected trees should be removed and burnt. Unless all infected debris which harbours the fungus is removed it is pointless planting another citrus tree because it will also succumb to the disease. Deep ripping to remove any old roots or stumps of previous fruit trees or native vegetation is essential in treating infected sites. Be careful when removing infected trees so as not to spread the fungus around the orchard.

Black Pit



Black pit of lemon fruit is caused by the bacterium *Pseudomonas syringae*. The same bacterium also causes water soaked or reddish black lesions on the twigs and leaf petioles of mostly oranges, mandarins and grapefruit referred to as citrus blast.

- ☑ Apply copper sprays in mid-late autumn.
- ☑ Protect fruit from injury from dead twigs and thorns.
- ☑ Plant windbreaks

Black pit appears as small light brown to black pits or larger sunken spots (5-20mm) on fruit. The pits may enlarge during postharvest storage. Infection occurs when the bacterium (which is common on citrus leaves) invades injury sites such as those caused by wind, hail, heavy rain or thorns. The black pit bacterium prefers prolonged cool wet conditions at temperatures of 8-20°C.

Botrytis (Grey Mould)

The fungus *Botrytis cinerea* sometimes attacks the flowers (blossom blight) and the young fruit of lemons and is characterised by its typical grey to greenish-grey spores. The fungus may develop in blossoms or on small twigs. Botrytis reduces fruit set and injures young fruit resulting in the formation of raised areas or ridges on the rind. The disease is of minor importance.

Grey mould on lemon flowers

- ☑ Sometimes a problem in prolonged cool wet conditions
- ☑ Copper sprays help reduce infection

The fungus lives on decaying organic matter and its spores are carried by wind, water and insects. Infected petals are the main source of infection of fruit and twigs. The fungus is favoured by prolonged damp, wet and cool conditions and a temperature of 18^0C is optimal.

Control

Application of copper fungicides before rain is expected will reduce the incidence of Botrytis.

Brown Rot

The same fungus that causes root rot (*Phytophthora citrophthora)* and other *Phytophthora* species cause brown rot of maturing fruits. The decay is firm and light brown in colour with a distinctive smell. Fruit near the ground become infected first, after being splashed with soil or water containing the fungus. If wet conditions continue, which favour infection, the disease can spread to fruit throughout the canopy. Snails can also carry the spores throughout the canopy.

Brown rot

- ☑ Wet conditions favour the disease
- ☑ Skirt trees to prevent fruit and foliage from coming into contact with the soil
- ☑ Control snails

Control

Copper sprays applied particularly to the skirt and the under-tree area, are effective in preventing brown rot. Skirting of trees is also beneficial since it reduces the amount of foliage and fruit coming in contact with the soil and soil water splash.

- ☑ A copper spray to the skirts of trees reduces damage

Collar Rot

Collar rot is caused by the fungus *Phytophthora citrophthora, which* causes root rot and brown rot of citrus. Lemons are the most susceptible citrus variety. Collar rot is generally confined to the area above the bud union. The affected bark is discoloured and gum often exudes. Later the bark dries and cracks. Yellowing and dieback of limbs does not occur until the disease is well advanced. Collar rot often follows a period of damp weather.

- ☑ Keep the bud union above soil level
- ☑ Choose trees that have been budded high
- ☑ Keep sprinklers away from tree trunks

Control

Keep the bud union above soil level, do not plant trees too deeply and choose nursery trees that have been budded high. Ensure tree trunks are not standing in water for long periods of time and microsprinklers are not placed close to the tree trunk. On young trees with trunk guards ensure soil doesn't build up around the trunk. When collar rot occurs, pare away the infected bark to healthy tissue and paint with a copper based paint.

Phytophthora Root Rot

- ☑ Use resistant rootstocks
- ☑ Provide good drainage
- ☑ Choose trees that have been budded high

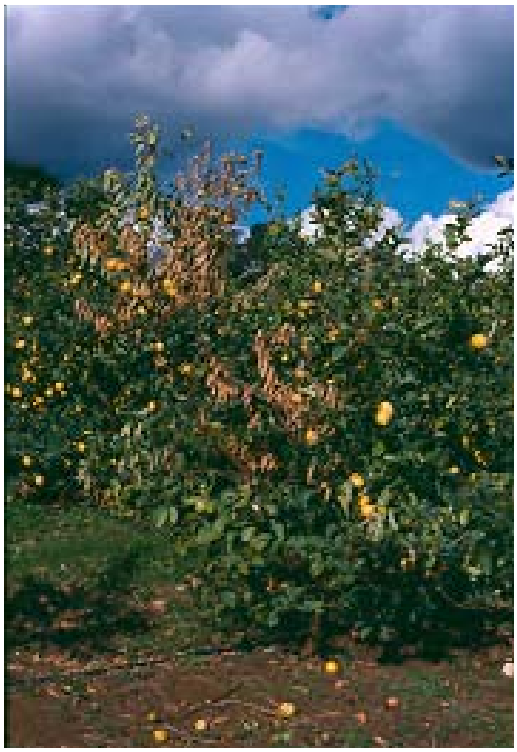
The first symptoms of a tree with *Phytophthora* root rot are a thinning out of the canopy at the top and failure to form vigorous new growth. As the disease progresses, the foliage turns yellow and twigs die back. Any new growth is usually weak. These symptoms result from attack of the feeder roots.

The causal fungus *Phytophthora* is present in the soil of citrus orchards in most areas. Severe outbreaks are associated with prolonged periods of wet weather, poor irrigation practices and poor soil drainage.

Control

A number of strategies can be used to reduce the incidence of root rot including:

- using resistant rootstocks such as *Poncirus trifoliata* and the citranges.
- high budding, so the bud union is well above soil level.
- provide good drainage.
- correct use of irrigation.
- buying healthy nursery trees.



Dieback of trees from Phytopthora

Septoria Spot

- ☑ Use protectant copper sprays before autumn rains
- ☑ Protect trees from frost

Septoria spot is caused by the fungus *Septoria citri*. It is an important disease of lemons in inland areas. The fungus survives on infected twigs, dead wood, leaves and in leaf litter. The spores are carried onto the fruit by rain splash .

Light tan to brown sunken spots up to 15mm in diameter on the fruit rind. The spots can be scattered or run together to form large irregular dark brown sunken areas. Small black spots of the fruiting bodies may occur on the brown lesions. Infection extends deep into the rind and diseased tissue is often bounded by a

thin red line. Symptoms often occur on over-mature fruit or stored fruit. Symptoms of Septoria spot can be confused with frost damage.

Infection is most common in autumn following cool damp conditions. Prolonged periods of moisture from rain, fog and dew are regarded as important for infection. The fungus can then remain dormant in the fruit until the onset of cold weather and frost in winter.

Control
Use a protectant copper spray in mid-March to mid-April prior to autumn rains. Protect trees from frost damage.

Sooty Blotch

☑ Improve the light and air penetration in trees with pruning.

Sooty blotch occurs as a superficial black covering on the rind of citrus fruits. The black colouring is due to the growth of fine fungal threads that live on the surface tissue of the fruit.

Sooty blotch is common on the coast after a wet autumn or winter. Both shade and high humidity are conducive to its development, with fruit on the southern sides and inside of trees most affected.

Although causing only superficial damage it makes the fruit unsightly. Good packing line procedures will normally remove the blemish.

Control
Copper sprays used for the control of other diseases will provide some protection.

Sooty Mould

☑ Control honey-dew excreting insects

☑ Control ants

Sooty mould is a black, superficial fungal growth that appears on the surface of leaves, stems and fruit, after trees become infected with honeydew-excreting insects. Although sooty mould does not penetrate the tissue, it may affect tree performance and fruit development by interfering with photosynthesis. The mould deposits may delay fruit colouring and can be difficult to remove in the packinghouse especially from cultivars with a rough rind.

Control
Sooty mould is prevented by controlling the honeydew excreting insects such as aphids, soft scales, and mealybugs and also the ants which protect them.

Other Diseases

Black spot on lemons

Key References

Barkley, P. **Citrus Diseases and Disorders.** 1988. NSW Agriculture.
A new edition of the text was released in mid 2004.