



Organic Farming: Managing Scale Insects on Citrus

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This Agnote highlights the critical aspects of scale management on citrus from an organic perspective. Detailed descriptions of scale biology, monitoring and management can be found in 'Citrus pests and their natural enemies' (see References).

Scale insects

Scales are small insects that suck plant sap. In Australian citrus, scales are often the most common and significant pest. Effective management of most scale pests is necessary for the production of high quality fruit, and in some cases is necessary for tree health.

Two types of scale affect citrus:

- Armoured or hard scales, like the ubiquitous red scale, produce a hard waxy cover that protects their soft body. Some species inject toxins into the tree as they feed, resulting in dieback of twigs, branches and eventually the whole tree.
- Soft scales do not produce a hard cover, but some become quite tough and leathery when they mature. Soft scales produce honeydew, a sugary solution excreted by many insects that feed on plant sap. The honeydew forms a sticky coating on leaves, twigs and fruit, providing an ideal environment for certain fungi to develop. When the fungi produce black spores, they develop an unsightly black appearance referred to as 'sooty mould'.

Sooty mould is a common problem that reduces citrus fruit quality and is a concern to growers aiming for high value fresh markets. Severe infestations of sooty mould also affect tree health by covering leaves and reducing photosynthesis.

Honeydew causes additional problems by attracting ants onto citrus trees. Ants seek honeydew as an energy-rich food and while they forage for honeydew they disturb and attack beneficial insects. This disrupts biological control of hard and soft scales and other pests.



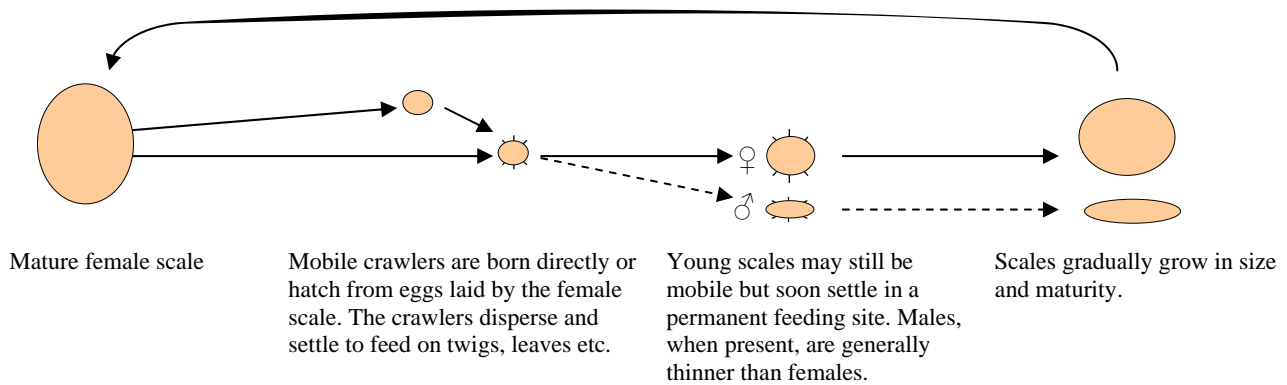
Figure 1. Oranges infested with sooty mould.

Scale life cycle

Males are unknown in some scale species in which case the females reproduce without mating. Some species produce several hundred eggs, others a few thousand – this gives them great potential for population increase. Eggs are usually laid under the female scale where they are well protected from sprays. It is not until crawlers leave the shelter of their mother that they are susceptible to applied treatments.

Cottony cushion scale and cottony citrus scale differ from other species by producing a waxy cottony sac under their body, into which the eggs are laid.

The life cycles of different scales varies slightly, but most generally follow the pattern in the following diagram.



Monitoring scales

The best time to monitor most soft scales to determine population levels and timing of reproduction is mid-late spring (mid-October to November) and late spring-early summer (February to March). Leaves, twigs and fruit stalks should be inspected, depending on the scale species.

For hard scales, fruit should be inspected from fruit set to harvest. The one exception is citrus snow scale for which the trunk and branches should be inspected during November/December.

Active reproduction in scale insects is indicated by the presence of eggs and/or crawlers under mature scales, and crawlers wandering around on leaves and twigs. A magnifying glass is useful as the crawlers and new scales are only about 0.2mm long.

Integrated Pest Management (IPM)

IPM, which also implies 'Intelligent Pest Management', aims to achieve effective control of pests through the most appropriate combination of control techniques. This approach emphasises the value of **biological** control of pests, but uses **cultural** techniques and **pesticides** when necessary. Any pesticides used are chosen carefully, applied efficiently and timed correctly to maximise their effect on the target pests and minimise any negative effects on beneficial species. An overarching theme of IPM is **monitoring**, which is necessary to determine the need, correct timing and result of any action taken against a pest.

IPM can be used to manage citrus scales very effectively and is an ideal approach for organic producers who need to rely more heavily on natural controls and have a very restricted range of pesticide options available.

Biological control

Scales are attacked by a wide range of parasites and predators including parasitic wasps, and predatory ladybirds, mites, wasps, caterpillars, lacewings and hoverflies. These natural enemies make a significant contribution to control of scales in citrus orchards, where it is common to find over 50% of scale are parasitised.



Figure 2. Ladybird larva eating soft scale.

Disease also helps to suppress scale populations in warm, wet coastal areas, where high levels of scale mortality can result from fungal infections.

Detecting beneficial activity

Many wasp parasitoids are less than 1mm long, so are difficult to see in action. Their activity is more easily detected through the tell-tale signs of parasitism.

Some scales become thin shells when they are parasitised, with wasp grubs or pupae visible inside the scale body. Other scales turn black and shiny when parasitised. Another obvious sign of parasitism is dead scales from which adult wasps have emerged after pupating. These scales are punctured by 'exit holes' cut by the wasps - a good sign that the natural cycle of parasitism is continuing.

Samples of scales on leaves and twigs may be collected from the orchard and stored for one to two weeks in a jar with fine gauze over the opening (facial tissue is suitable). This allows parasites that emerge from the scales to be seen easily. To keep the twigs fresh for longer, place their cut ends in water, but cover the water to prevent the parasites from drowning.



Figure 3. A black wasp parasitoid can be seen inside this soft brown scale.



Figure 4. Parasitoid exit holes chewed in a soft brown scale.

Predators like adult hoverflies, lacewings and ladybird beetles are often easily observed in the orchard. Closer inspection is needed to find their larvae, usually on shoots and leaves infested with scales, aphids and other soft-bodied pests.

Monitoring

It is important that natural enemies of scales and levels of biological control are observed and recorded as part of the orchard monitoring program. In many situations, the need for applied controls will depend upon the degree of biological control in action.

Releasing beneficial insects

Beneficial species may need to be reintroduced, or orchard management practices modified, to improve the level of biological control in some situations. Orchards should be assessed by a professional IPM adviser if good levels of beneficial insect activity are not obvious.

Biological control agents for a number of citrus pests are commercially available in Australia.

Parasitoids and predators of citrus pests are produced by several Australian insectaries - listed at the end of this Agnote. Details of the beneficial insects available, their biology, the pests they attack and how to use them effectively are provided in 'The Good Bug Book' (see References).

Cultural control

Cultural control usually involves modifying the orchard environment to make it less suitable for the pest. Cultural techniques sometimes affect the pest directly, but are often

aimed at improving biological control. Following are some key cultural control approaches for scales.

Reduce pesticide use, especially broad-spectrum contact insecticides that can have a significant impact on populations of parasitoid and predatory insects. These include some organically allowed inputs like pyrethrum, spinosad and sulphur. Preferred insecticides include microbial preparations (e.g. *Bacillus thuringiensis* for moth and butterfly pests) and petroleum oils for scales.

Reduce dust as it interferes with parasitoid behaviour, making it harder for parasitoids to locate and lay eggs in scale insects. Wherever possible, dust reduction on orchard tracks and roadsides should be carried out, by for example, reducing traffic and using windbreaks and cover crops.

Reduce wind as it reduces parasitoid and predator effectiveness by preventing them from flying or dislodging them from trees. Wind shelter is the only way to reduce this and other undesirable effects of wind in the orchard.

Alleviate high temperatures (upper 30s and above) as they seem to affect beneficial parasitoids more than pest insects. Irrigation, cover crops and wind management may help to maintain more favourable temperature and humidity conditions within the orchard.

Skirt trees and apply trunk bands where necessary to reduce disturbance of parasites and predators by ants (discussed below).

Maintain tree health. Trees with appropriate water and nutrition status are likely to withstand scale infestations more readily than stressed trees. Over-fertilising with nitrogen should be avoided as it is known to encourage higher levels of reproduction in some citrus scales.

Maintain orchard hygiene, especially with new plantings, to reduce the likelihood of infestation with scales. Scales can be introduced to clean sites through infested planting material or on workers' clothing, machinery etc.

Provide alternative food sources to benefit parasitoid and predatory species.

Scales themselves are often not the only food source required by their natural enemies:

- As well feeding on scales, adult wasps feed on nectar and honeydew.
- Larvae of lacewings and hoverflies are effective predators of soft scales, aphids and other pests, but the adults feed on nectar and possibly honeydew.
- In the case of predatory ladybirds, both the adults and larvae prey upon a range of scales and other insects.

Predators do not restrict their diet to insects on citrus and may eat for example, aphids on thistles and scales on oleander plants. Alternative sources of prey such as these help to maintain predator populations, especially when pest numbers on citrus trees are low because of sprays or time of season.

Flowering plants in and around citrus groves are likely to benefit parasitoid wasps and other useful species that feed on nectar and pollen, although it is not yet known which plants specifically will boost biological control of scales. More information on this aspect of pest management can

be found in the articles by Bugg, Dufour and Luna (see References).

Manage weeds appropriately. As indicated above, some 'weeds' provide food resources for beneficial insects. Ground cover vegetation also provides valuable shelter for these species. Weed management should therefore be a balance between minimising competition with citrus trees and maximising benefits to natural enemies of pests.

Chemical control

Spray materials

Mineral spray oils give very good control of most scale insects when timed and applied well, and they fit well with an IPM approach. Sulphur and lime sulphur are also used against citrus snow (white louse) scale. All three materials are allowed under Australian organic standards, but because of differences between products, certified growers should confirm the acceptability of specific products with their certifier.

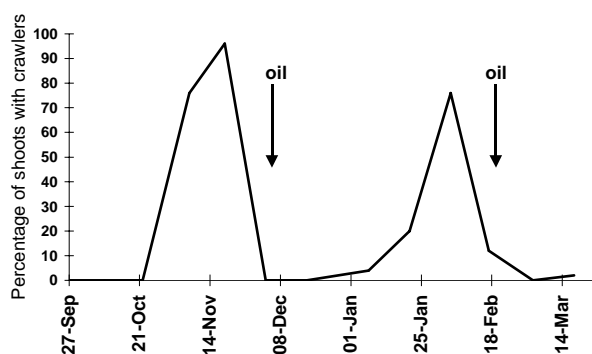
Spray timing

Correct spray timing based on field monitoring is essential for good control of scale insects.

The effectiveness of oil sprays varies greatly between different stages of a scale's life cycle. Scales are best targeted soon after a reproduction period while the new generation is very young and exposed. An oil applied at this stage will have greater effect than one applied to mature, well-established scales.

As the exact timing of reproduction varies seasonally, calendar-based spraying should be avoided as it can give unpredictable results. Regular monitoring will highlight reproduction periods and allow sprays to be timed accurately.

The following real-life monitoring data indicates how the percentage of shoots infested with soft scale crawlers peaked and dropped sharply during the reproduction period.



Based on this information, oil sprays were applied when the percentage of shoots with active crawlers had dropped markedly, i.e. when most crawlers had settled on leaves and shoots. By then the majority of crawlers had emerged from the safety of their parent scale and the new generation of scales (the newly settled crawlers) was very young, small and highly susceptible to the oil spray.

Spray application

Oil sprays work by suffocating insects, so spray applications must be thorough enough to coat the insects entirely with oil. High spray volumes are usually required to achieve this, with up to 10,000 litres/ha needed to fully wet the canopy in a mature orchard.

The high volumes needed for effective use of oil sprays can be achieved with specialised equipment such as oscillating boom sprayers or 'hydra' sprayers. Effective delivery of these high volumes cannot be expected from the more common air-blast sprayers.

Whichever type of sprayer is used, correct calibration and maintenance is vital if effective pest control is to be achieved

When growers have trouble managing scales, it is very likely that their spray units, including oscillating booms, are not set up adequately to achieve good spray coverage and distribution. Growers should contact their equipment supplier/manufacture, consultant or agriculture department for advice on sprayer calibration and set-up.

Up-to-date recommendations on application rates of petroleum oil (or any other spray), should always be obtained from the product label. Useful information on the use of oil sprays to manage honeydew-producing insects can also be found in 'Citrus pests and their natural enemies' (see References).

Monitoring spray effectiveness

IPM can be continually improved through monitoring the results and fine-tuning the system. One point that is often not clearly addressed is whether and why a spray application was or was not effective.

Questions to ask include:

- What was the **target** ? *white louse scale on the trunks ? black scale at the top of the trees ?*
- Did the spray **reach** the target ? *was the machine suitable ? was it set up correctly ? was spray coverage of high foliage adequate ? did the spray coat both sides of the leaves ?*
- Was the **spray mix** correct for the target pest ? *was the concentration correct ? was the tank mix well agitated ? – (especially important for oil sprays)*
- Was the **timing** optimal ? *did the spray target the most susceptible stage of the scale, e.g. new-generation crawlers and young scales ?*
- Did the spray have the **desired result** ? *was there a high kill rate of the target pest ?*

Oil sprays can be very effective against scale pests, so it is worth answering these questions as far as possible to determine if and how the efficiency of an existing spray program may be improved. Most of these issues have been addressed in more detail above or in the references, but the following basic monitoring ideas are a good start:

- Where non-toxic materials are used (e.g. a test spray of water), observation of freshly sprayed trees will help show the extent of spray coverage. Look for wet leaves and twigs high and low in the tree and throughout the canopy.

- Water and oil sensitive papers obtained through agricultural suppliers may be used to monitor spray distribution. These can be stapled to leaves throughout the canopy before spraying. They change colour when wet and their degree and pattern of colouring indicates the penetration and distribution of the spray at that point.
- The real test of spray effectiveness is the level of pest mortality. This will be determined from monitoring, but keep the following points in mind:
 - it may take several days for the death of young scales to become obvious, and up to two weeks for mature scales
 - insect mortality (especially of very young insects) can also result from high temperatures
 - to clearly determine the effect of a spray and distinguish it from temperature or other effects, scale mortality on sprayed trees needs to be compared to the mortality occurring at the same time on unsprayed trees.

Hot weather – friend or foe ?

Hot weather is an important factor in scale management:

- It may coincide with the best timing for oil sprays against scales. Oils can damage water-stressed trees, and water stress is more likely during hot, dry weather. Before applying oil during hot weather, check the label for temperature restrictions.
- High temperatures can kill crawlers and very young scales to the extent that a spray may be unnecessary. Where a planned spray is preceded by hot weather (eg several days over 39°C), scale survival should be monitored to determine whether the spray is still required.
- High temperatures can also kill tiny parasitoids that attack scales. During hot summers, citrus growers need to be particularly vigilant with their monitoring to ensure they detect decreases in parasitism or increases in scale populations at an early stage. This will allow the most appropriate action (parasitoid release or spray application) to be planned in a timely way.

Ants in the citrus orchard

While many species of ants are found in citrus orchards, most are of no concern. Many ants are general predators of a wide range of insects including some citrus pests. They also play a role in soil development through their underground nesting activity.

Interference by a few species though can severely reduce the effectiveness of biological control of scales and other citrus pests, and orchards with a history of sooty mould and considerable ant activity may require specific ant control measures.



Figure 5. Ants tending soft scale

High levels of ant activity on trees often indicate significant populations of honeydew producing insects. Ant activity can therefore be a useful indicator of which trees to check more closely for these and other pests. An exception is that ant activity may be high during flowering when the ants are attracted to nectar.

Unfortunately, there are no organically acceptable ant baits or sprays registered for use in citrus orchards. The only acceptable applied treatment is a sticky band (e.g. Tac-Gel® or Tanglefoot®) that prevents ants from climbing the trees.

For these bands to be effective, contact between the ground and tree foliage must be prevented (through skirting and weed management) and the bands must be kept clean of leaves, dust etc. Because this type of barrier requires regular maintenance and is messy and labour-intensive to apply, it may not be cost-effective for more than just a few trees.



Figure 6. Sticky band on citrus trunk

The most cost-effective way for organic producers to reduce ant activity on citrus trees appears to be a well-timed oil spray to reduce the numbers of honeydew producing insects on the trees.

A last word on IPM

Integrated Pest Management is a strategic collection of actions and inputs selected to best suit individual groves. The actions and inputs, such as weed control, parasitoids,

oil sprays or ant bands, need to be chosen on the basis of the net value they add to the system. Their potential negative impact, such as an insecticide disrupting biological control, and the cost of repairing that damage, needs to be taken into account.

Monitoring is a key element of IPM systems and is necessary to:

- locate and identify scale infestations
- determine the need for and correct timing of control treatments
- identify and gauge the level of beneficial insect activity
- assess levels of ant activity and the requirement for ant management
- check the effect of any control treatments applied, whether they be biological, cultural or chemical.

Effective monitoring is the tool that provides growers with the information required to fine-tune their IPM systems for the best possible crop, economic and environmental outcome.

Sources of biological control agents for citrus

Biological Services, Loxton SA

Tel: 08 8584 6977

email: info@biologicalservices.com.au

www.biologicalservices.com.au

Bugs for Bugs, Mundubbera Qld

Tel: 07 4165 4663

e-mail: info@bugsforbugs.com.au

www.bugsforbugs.com.au

IPM Technologies, Hurstbridge Vic

Tel: 03 9710 1554

e-mail: ipmtechnologies@bigpond.com

www.ipmtechnologies.com.au

These companies are members of Australasian Biological Control, an association of companies that produce biological control agents for a range of crop pests. More information is available at <http://www.goodbugs.org.au>

References & further reading

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Useful information & contacts

Organic Federation of Australia (OFA)

Australia's peak organic industry organisation.

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Internet: www.ofa.org.au

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Thanks to all those who contributed to 'Citrus pests and their natural enemies: integrated pest management in Australia'. This book is an essential companion for all citrus producers.

This Agriculture Note can be accessed through the DPI web site: <http://www.dpi.vic.gov.au/notes>

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