Pest management plan for aphids in production nurseries

BACKGROUND

Aphids are relatively small, bulbous, soft-bodied insects that are common pests in production nurseries across Australia. There are about 5000 described species of aphids worldwide but only about a few hundred are known to be present in Australia. Of these, only a small fraction are believed to be native to Australia (only a few dozen); the rest were accidentally introduced with many species probably incidentally transported to Australia on cultivated plants by early British settlers. This pest management plan compliments and builds upon the general aphid fact sheet. A detailed fact sheet specifically on green peach aphid is also available.

GENERAL BIOLOGY

The biology of aphids is quite complex and lends itself to rapid multiplication and dispersal. Most species are all female, do not need to mate and rarely lay eggs. Instead first instar nymphs are born, which begin feeding almost immediately. Each individual moults through a number of immature stages and eventually becomes an adult (female) that can then begin bearing young.

Some species will produce males just prior to winter in cooler climates. In this case, adults mate and females lay eggs. Eggs do not hatch until temperatures increase in spring. Green peach aphid, GPA, *Myzus persicae*, is one such species that has this type of biology (refer to the fact sheet on this species for more detail). In warmer climates, and in glasshouses that are artificially heated, this does not occur; the populations may reproduce asexually for the entire year.

Close up of *Aphis spiraecola* feeding on anthurium

Immature insects never have wings, only adults have wings. For most insects, the adults of each species either have wings, or do not. However, adult aphids sometimes have wings and sometimes do not. Wingless adults reproduce more quickly, but have limited dispersal ability. Winged adults reproduce generally at about half the rate of

wingless adults, but have great dispersal ability on wind currents. Most individuals become wingless adults. Winged adults are more likely to occur when the density of aphids becomes high or when the plant health of their host begins to decline.

Most species of aphids are highly host specific, having hosts from one or a small number of closely related genera. Only a small number of aphid species are highly polyphagous, feeding on a large number of host plant species from many plant families. Of course, these species are the ones most commonly encountered in production nurseries, giving the illusion that aphids feed on a large number of host plant species.

Most aphids are small, their bodies being no more than 1–2mm long, but some species can be a massive 6–7mm long (e.g. Cinara spp.). Most species are oval or almond shaped are often light to dark green, yellow or orange, but some species are relatively dark, e.g. cow pea aphid is black. Winged individuals are often black.

Aphis spiraecola and white caste off-skins (exuviae)

Most often, aphids become pests during mild conditions, in spring and autumn in Australia. High summer temperatures tend to reduce populations drastically and low temperatures cause populations to reproduce slowly or go into diapause. However, exceptions will occur when considering the entirety of Australia's climatic conditions, particularly in protected cropping with good environmental control systems.

During good conditions, aphids can complete their lifecycle in 5–10 days and females may lay 1–2 offspring per day. As such, populations can build up rapidly from even one aphid flying into a crop.

SYMPTOMS

Aphids produce damage from direct feeding, from injecting salivary secretions into the plant and from the production of black sooty mould. The exact damage depends upon where they are located on the plant. Many aphids are found on the underside of leaves, particularly new growth that has not fully expanded. Leaves that are fed upon by aphids as they expand may be deformed or stunted. Even small numbers of aphids growing on the growing tips can potentially cause abnormal, deformed and stunted growth that may cause the plant to be unsaleable. Aphids feeding on fully-expanded leaves may cause the leaves to become chlorotic, wilt and fall from the plant. In addition, large populations can cause much reduced plant growth rates.

The saliva injected into the plant by aphids may cause similar symptoms (i.e. retarded or stunted new growth) and, when in large numbers, stem dieback. Aphids produce honeydew, which is sugary and often attracts ants. Some species of aphids may be attended by ants that may protect them from predators and parasitoids and may move individuals. Black sooty mould also grows on honeydew and can cause plants to become unsaleable. Large populations may cause plants to become covered or dusted in white casts (skins from moulting individuals).

A small number of aphid species feed on roots. Such species appear similar to root feeding mealybugs and cause similar damage, i.e. reduced growth rates and plant vigour. Very heavy infestations may cause certain plants to wilt, collapse and die. In addition, there are a small number of aphids that produce galls (refer to the galling insect pest management plan). Many species may cause leaf curl or deformity of new growth.

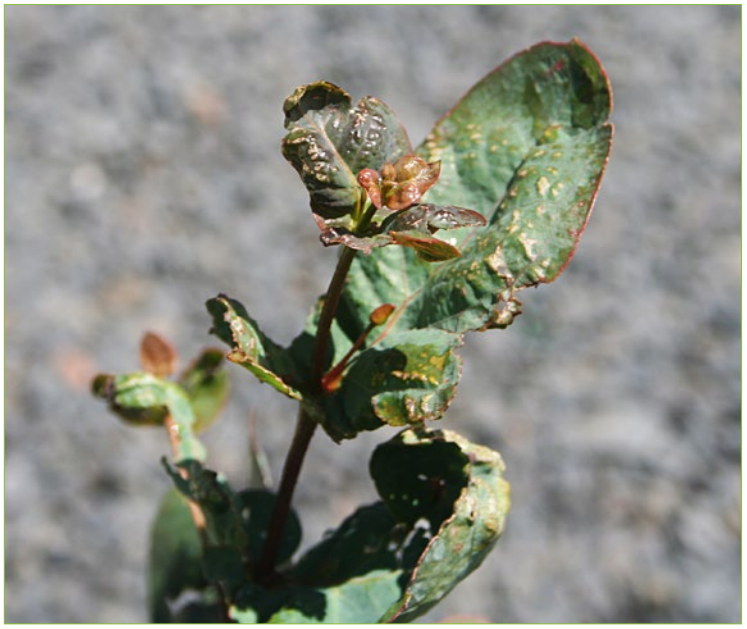
Deformed Abelia leaves caused by aphid feeding.

MONITORING FOR APHIDS

In general, it is recommended to inspect plant health on a weekly basis and record data. Modify monitoring effort based on risk of all pests and diseases, allocating greater effort to crop lines that are susceptible and to high risk periods. For aphids, spring and autumn tend to be high risk periods. Frequent monitoring will enable infestations to be spotted while populations are still low, and thus easier and cheaper to manage. Aphids can be monitored by visual inspection and beating plants, and winged aphids can be detected on sticky traps. It is important to note that aphids may be more difficult to detect on pale yellow or green leaves, particularly at low densities.

1. **Visual inspection**. Inspect a small percentage of each plant type by hand (generally 1 to 10%, depending upon the number of plants and their susceptibility). Examine leaves of plants that look stunted, chlorotic or have other unusual symptoms on both leaf surfaces using a hand lens. They are generally found on flowers, young foliage, stems and the undersides of leaves.
2. **Plant beating**. Gently but firmly hit foliage against a beating tray (which can be a folder, bucket or plastic plate). The beating tray should be a single colour; white or black is preferable as this will make moving organisms more visible. Beating plants is a relatively efficient way of monitoring for insects and mites that can be knocked from plants, including herbivorous and predatory mites, aphids, whitefly adults, thrips, lady beetles, small caterpillars and a variety of other insects. Sometimes the cast-off skins (exuviae) may be dislodged from plants and may provide evidence of the presence of aphids without finding living individuals. Once something is found, a 10–15x hand lens can be used to inspect the catch.
3. The presence of ants often provides an indication that aphids or another sap-sucking insect (such as scales or mealybugs) are present on a plant. Always investigate why ants are present on plants as they may lead you to a pest infestation.
4. Yellow sticky traps are useful tools for monitoring a variety of insects and can trap winged aphids. Traps should also be placed near doors, vents and any susceptible crops or areas. At least one trap per 100m^2 is recommended for greenhouse crops, more in varieties that are known to be susceptible to aphids or other flying pests. Inspect sticky traps at least weekly and change traps every 2 to 4 weeks. Presence of winged aphids, particularly if in large numbers, should trigger more detailed surveys to determine the extent of the infestation.
5. Parasitised aphids turn into 'mummies' (preserved corpse – see image in Biological Control section). An aphid that has been parasitised swells into a hard, brown or black ball which is distinctly different from normal living aphids. Mummified aphids will not reproduce and will give rise to wasps which parasitise or feed on subsequent aphids.

Record the level of aphid populations on each host plant in each area of your property. Accurate records can help determine long-term patterns of host use on the property and thus assist in allocating search effort. Keeping long-term records can help identify areas and varieties that are more susceptible to infestations. It is also important to continue monitoring following application of insecticides or release of biological controls to determine the effectiveness of treatments. These records can assist with making management decisions in the future. For example, wind patterns at your property may lead one to monitor certain areas more than others or greater monitoring effort during periods when key pests are likely to be present. In addition, monitoring can inform you of the level of natural enemies present in the crop, which may modify management actions. Insect monitoring data sheets are available in the BioSecure HACCP protocols which can be found on the NGIA website (www.ngia.com.au). Alternatively, simple spreadsheets can be created and modified to suit your property.



Damage from aphids feeding on the growing tip of *Eucalyptus leucoxylon*.

IDENTIFYING APHIDS

It can be very valuable to identify the species of aphid/s commonly found on your property and to educate staff on how to distinguish between them. There are a number of species that have a wide host range, however, many aphids are quite host-specific. This can be used to your advantage to gain an idea of what species may be present, particularly on native host plant species. Refer to the plant genus level listing on the Aphids on World Plants website. This can narrow down the list of aphids likely to be encountered. For example, *Myoporum acuminatum* has only two species of aphids reported, *Aphis gossypii* and *Myzus persicae*.

It may then be possible to examine pictures of the different species from trusted websites to assist in the identification. Keep in mind that you may be dealing with a species that has not been reported on a particular host plant. Therefore, unless the species has been confirmed by a diagnostician you should treat your identification as preliminary.

MANAGING APHIDS

The appropriate management technique will depend on a number of factors, such as the extent of the infestation, the presence of other pests and predators in the crop, presence of viruses, other host plants present at the property and environmental conditions. The exact management strategy therefore has to be tailored to each property. Adopt as many cultural practices as possible to decrease the likelihood of aphid infestations. If necessary, apply biological control agents or pesticides to reduce and eliminate aphid populations.

CULTURAL CONTROL

The prevention of aphid infestations and their spread is very important for successful management, as large populations can build up quickly and are more difficult to control. It is extremely important to prevent and manage aphids successfully to reduce economic impacts caused by aphid-vectored viruses.

1. Manage sources of infestation: control broad-leaf weeds and reduce other alternative hosts in the production area and surrounds. The use of weed matting, plastic or gravel on the floor can help in nursery situations. Good weed management will also help reduce a variety of other pest problems including whiteflies, thrips and mealybugs.

Print pictures of pests and beneficial species (either from a factsheet or from a web search on a particular species) and place them in a visible area, e.g. tea room or common area, to make staff more familiar with insects and mites on your property.

2. If necessary, establish wind breaks around the nursery, either with appropriate trees and shrubs or shade cloth to minimise the likelihood of aphids being blown into the crop.
3. Prune and thin plants with light to moderate infestations to reduce the pest load, increase airflow and access by insecticides. When pruning aphid infestations, be aware that some species drop off the plant when disturbed, e.g. rose aphid. Such species need to be treated with great care to avoid their spread while pruning and handling plants.
4. Remove and destroy heavily infested stock. Retaining unsaleable stock provides a source of further infestation. Infested material should be bagged and deep buried or placed in a black bag in the sun for several hours to kill pests. Leaving unbagged, infested plants or cuttings in the bin encourages pests to reinfest the property, particularly when winged aphids are present.
5. Be aware of winged and non-winged aphids; as the number of winged aphids increases so too does the risk of spread to other areas of the property.
6. Check incoming stock, new seedlings and other new planting material to ensure it is clean and to break the lifecycle of aphids and other pests. The guidelines for managing biosecurity in nursery production (BioSecure HACCP) has more information on inspecting incoming stock. A self-imposed quarantine area, where plants are kept apart from the rest of your stock, is a valuable strategy to reduce pest and disease infestations. The length of time the plants are kept separate will depend on a variety of factors including temperature, plant species, the biology of pests and diseases encountered on the plants, space available and the size and purpose of the plants. Returning stock that has arrived from a supplier infested with a pest or disease may be a valid action.
7. Screens placed over greenhouse vents and doors can be used to help prevent entry by aphids. However, placement of such screens can increase the humidity in the structure, causing ventilation problems. It is recommended to use a protected cropping consultant/ designer before retrofitting or building an insect-proof tunnel or glasshouse.

8. If infestations persist for long periods in a particular area or glasshouse, grow plants that are not susceptible for a season to break the life cycle.
9. Practice good crop hygiene to avoid contamination between greenhouses or production sites. Mark areas that are known to have infestations with visible signs so that workers can avoid moving through that area.
10. Most importantly, identify infestations early through regular monitoring.
11. Avoid broad spectrum, highly residual chemicals that will cause high mortality of naturalised parasitoids and predators (see section on biological control below).

APHIDS AS VIRUS VECTORS

Aphids are the most common group of insect vectors of plant viruses. The largest group of plant viruses (Potyviruses) are all vectored by aphids. Some species of aphids may only vector a small number of viruses, whereas green peach aphid can vector over 100 plant viruses and is considered by many to be the most efficient vector of plant viruses across all insect species. *Cucumber mosaic virus*, *Celery mosaic virus*, *Potato leaf roll virus*, *Potato virus Y*, *Beet western yellows virus* (and other beet yellow viruses), *Papaya ringspot virus*, *Watermelon mosaic virus*, *Lettuce mosaic virus* and many other viruses affecting vegetable and ornamental crops are all vectored by aphids. The host range of each virus varies but often includes ornamental species and weeds. If you are experiencing virus infection it is well worth having aphids and the virus identified to gain further information on virus and vector biology and host range. This will aid in management of both pest and disease. For more information read the viruses in production nurseries fact sheet and the aphid transmitted viruses fact sheet.

ADDITIONAL AND IMPORTANT STEPS TO MANAGE APHID TRANSMITTED VIRUSES

12. Do not supply plants to clients that are infected with viruses; they cannot be cured.
13. Dispose of virus infected plants promptly, ensuring that aphids will not migrate from the plants to other parts of your property. If necessary, apply an insecticide or oil spray to kill aphids before destroying the crops.
14. Reduce weeds around your property, as they can harbour viruses and may remain non-symptomatic.
15. If necessary, only use plants that have been tested and shown to be free of virus.
16. Plant non-host plants for a period of time to reduce the reservoir of virus on your property. This is particularly important if the virus has been continuously present for a relatively long period of time.
17. Insecticides will not always be able to manage aphid-vectored viruses. Some viruses are transmitted by aphids when they insert their mouthparts into plants (but before they start feeding). This can occur in less than a minute. Insecticides may agitate individuals, increase their movement and therefore increase spread of the virus.

BIOLOGICAL CONTROL

There are six natural enemies commercially available that consume or parasitise aphids; green lacewing, two ladybird beetles and three parasitoid wasps. The pirate bug (*Orius*) may also sometimes consume aphids. These products are available from Biological Services and Bugs for Bugs; these sites also have details on their biology. It is recommended to seek the advice of the biocontrol agent provider before releasing predators for the first time.

Most of these predators are ideally suited to manage aphids between 15–30°C. Management using solely predators will be difficult above or below these temperatures. Some of the predators will only feed on a small number of species, others are more general (Table 1). Having pollen sources in the area has been shown to improve biological control across a range of situations and assists in establishment of predators that naturally move into the growing area. This is because natural enemies can feed on pollen as an alternative food source in between feeding or parasitising pests. It is also important to ensure that pesticides that are toxic towards predators have not been applied to the crop. A general summary of toxicity

Parasitised aphids (mummies). Note the exit hole in the mummy at the top.

to aphid parasitoids and predators is included in Table 3. Virtually all pesticides have some impact on predators and parasitoids, even those that do not kill them outright. For example, predators that feed or are otherwise exposed to low-risk, aphid-specific pesticides may have reduced longevity, feeding rates or egg laying compared to those that have not been exposed. In other words, they may not be as good at managing aphids as individuals that were not exposed to the pesticide.

Before applying predators or parasitoids for the first time talk to the biological control agent producer (for aphid predators this is Biological Services or Bugs for Bugs). They can assist and make tailored recommendations to optimise releases to best manage the situation at hand. Some species are available in banker plants or release sleeves that may enhance establishment.

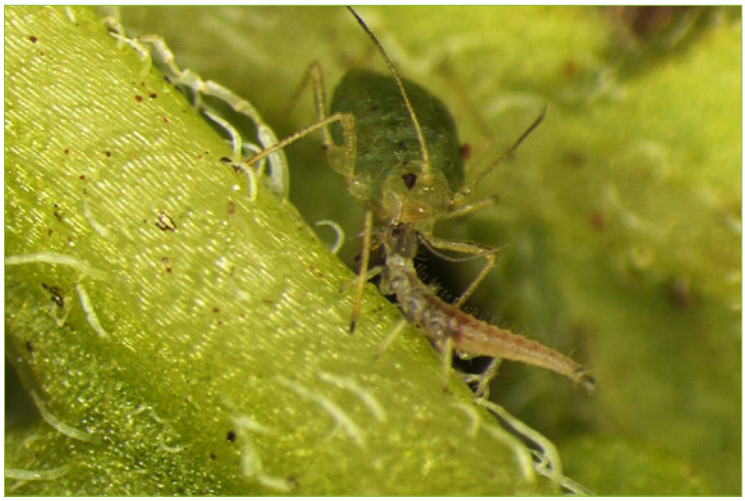
Table 1

Beneficial insects that can be used to manage aphids that are commercially available.

BENEFICIAL SPECIES	TYPE OF INSECT	BRIEF DESCRIPTION	APHIDS IT FEEDS/PARASITISES UPON	PROVIDER
Aphidius abdominalis	Tiny wasp	Stocky, about 3mm long, black head, yellow abdomen	Over 200 aphid species, mainly large species such as potato/foxglove aphid, green peach aphid, pea aphid, potato aphid. Lays eggs into aphids and may also cause considerable impact by feeding on other aphids.	Biological Services
Aphidius colemani	Tiny wasp	Slender, 2–3mm long. Looks similar to small, winged, black ants, but with long antennae.	Many aphid species, particularly green peach aphid, cotton/melon aphid and wheat aphid.	Biological Services
Aphidius ervi	Tiny wasp	Slender, 4–5mm long. Similar to small, winged, black ants, but with long antennae.	Many species, particularly foxglove aphid, potato aphid and pea aphids	Biological Services
Orius tantillus	Pirate bug	Nymphs are light brown to orange in colour wingless and have red eyes. They range in size from about 2-4mm. Adults are about 5mm in length, dark brown to black with a dark V-shaped region behind its head.	Mainly feeds on thrips, but will also feed on aphids, spider mites moth eggs, whiteflies and other insects.	Biological Services
Harmonia octomaculata	Ladybird	Typical ladybird beetle appearance. Nymphs are mainly black with yellow regions occurring in strips or spots along its back. Adults are mainly orange with black spots.	Mainly feeds on aphids, but has been known to feed on whiteflies.	Bugs for Bugs
H. conformis	Ladybird	Very similar to *H. octomaculata*	Feeds on aphids and psyllids.	Bugs for Bugs
Mallada signata	Green lacewing	Nymphs range in size from about 1–8mm. They are mostly brown, generally carry dead insects on their back and have very large, conspicuous mandibles projecting from their head. Adults have a green body (about 10mm long), very long antennae and hold their transparent wings tent-like over their body.	Aphids, spider mites, whiteflies, scale insects and various other small insects.	Bugs for Bugs

OTHER NATURALISED BENEFICIALS

There are many aphid predators and parasitoids that are not commercially available. This includes other ladybird beetles, hover fly larvae, various predatory bugs, native parasitoids and lacewing species. Such populations can be preserved if broad spectrum and highly residual pesticides are not applied to a crop, particularly early in the season. Monitoring for pest and beneficial populations is extremely important to ensure pest numbers do not build up to damaging levels and to avoid unnecessary chemical applications.



Aphid being eaten by a small brown lacewing larva.

PESTICIDES

There are many pesticides registered for the control of aphids in non-food nursery crops (Table 3). These include broad-spectrum, long residual products (e.g. organophosphate, neonicotinoid and synthetic pyrethroid products) and products that are specific to aphids (e.g. pirimicarb) or sucking insects. Oil products can also be very effective, particularly for smaller species. However, some species, e.g. rose aphid, are not managed effectively with oils.

Products available include those with contact, translaminar (moving across the leaf surface but not between leaves) and systemic modes of action. If a portion of the lifecycle is concealed within leaf curls, galls or other protected areas it is recommended to use a translaminar or systemic product.

Always monitor the crop before applying a pesticide to determine if there is a large population of predators or parasitoids present in the crop. Natural enemies can be present in production nurseries at high numbers precluding the need for a pesticide application, even when they have not been purposefully released.

The biopesticide *Beauveria bassiana* strain PPRI 5339 is also registered for use against aphids. Spores of this fungus that come in contact with a suitable insect may germinate, penetrate the exoskeleton and eventually kill the aphid. It has been tested and shown to be effective against a number of beetles and even two-spotted mite. However, to our knowledge, data have not been published on its efficacy managing aphids. Given that it can cause mortality on a range of insect groups it seems reasonable to assume that it may have high non-target impacts on natural enemies. If using this product, monitor pest populations closely to ensure that the product is effective. Furthermore, do not apply fungicide products to the crop as this will kill the fungi, rendering it ineffective.

RECOMMENDATIONS

Never solely rely on pesticides to manage any pest. Always put in place cultural management strategies to reduce pest pressure passively which will in turn reduce the number of pesticide applications required. This will reduce the risk of inducing pesticide resistance and management costs. For more detailed information on pesticide resistance management and insecticide mode of actions refer to the webinars devoted to these topics.

Where a particular aphid is regularly encountered during particular seasons it is recommended to take early action. Give greater monitoring effort to high risk crops and consider release of a suitable predator. Green lacewing is a good choice because it feeds on a wide range of prey, which may assist in early establishment and aphid suppression. *Aphidius* parasitoids are also very effective as long as you choose the appropriate species to manage the aphid in question. Biological Services also offers a product containing a mix of *Aphidius* species to cover a wider range of aphids. If using biological control, make multiple releases early in the infestation and monitor regularly to ensure that aphid numbers decline.

If aphid populations rise to a point where biological control is no longer feasible, pesticides can be used to lower or eradicate the population. Apply pesticides to hotspot areas whenever possible to conserve natural enemies that may be present in the rest of the nursery. Before applying a pesticide, consider the impact it may have on naturally occurring predators and parasitoids (Table 3) and whether you are likely to release predators in the future. If predators and parasitoids are to be conserved refer to the low risk products column in Table 2. Where the presence of predators and parasitoids is not considered important, a number of broad-spectrum and highly residual products may also be considered. Refer to the broad-spectrum, highly residual column in Table 2.

Table 2
Pesticide mode of action groups available for use against aphids in production nurseries

LOW RISK PRODUCTS	BROAD-SPECTRUM AND HIGHLY RESIDUAL PRODUCTS
» 1A product	» 1B products
» Group 9 product	» 3A products
» 12A product*	» 4A products
» Group 23 product	
» Oil products	
» K salts*	

* Products can cause high mortality to some natural enemies present in the crop, but have a very low residual period.

Where multiple applications are required rotate between the products. Always observe the pesticide resistance strategy on the label, if present, then continue the rotation as required. It is recommended to wait 1–3 days after the pesticide application to release predators or parasitoids to reduce the impact of the application on predators and parasitoids. As mentioned above, even low risk products impact predator and parasitoid populations.

Table 3

Pesticides registered for use against aphids relevant to the production nursery industry. Always read the label before applying a product to ensure that it is suitable for your situation.

MODE OF ACTION	ACTIVE INGREDIENT	EXAMPLE PRODUCT NAME	REGISTRATION INFORMATION	ACTION	TOXICITY TO BENEFICIALS
1A	Pirimicarb	Pirimor	PER84953. All aphids on non-food nursery stock.	C, T	L – <1 week
1B	Dimethoate	Rogor	All aphids on nursery plants, selected states only. Other labels are registered for all aphids on ornamentals in all states.	C, S	H – 4+ weeks residual
1B	Maldison	Hy-Mal	All aphids on ornamentals, specific aphids on certain fruit and vegetable crops.	C	H – at least 3 weeks residual
1B	Methidathion	Suprathion	All aphids on flower and vegetable seedings, ornamental trees and shrubs in nurseries.	C	H – 6–8 weeks
3A	Alpha-cypermethrin	Crop Care Dominex Duo	PER81707 All aphids on non-food nursery stock.	C	H – probably 8+ weeks
3A	Bifenthrin	Talstar	Aphids on roses carnations and other ornamental plants	C	High – 8–12 weeks residual
4A	Imidacloprid	Confidor	All aphids on ornamentals, specific aphids on certain fruit and vegetable crops.	S	H – 2–4 weeks residual as a foliar spray
4A	Imidacloprid	Suscon Maxi soil insecticide	PER81707 All aphids on non-food nursery stock.	S	L toxicity as a media application. Residual dependent on formulation and media
28 plus 4A	Chlorantraniliprole plus thiamethoxam	Durivo	PER81707 All aphids on non-food nursery stock.	S	M–H – probably moderate to long residual activity
9B	Pymetrozine	Chess	PER81707 All aphids on non-food nursery stock.	S	L – probably <1 week residual
9D	Afidopyropen	Versys	Specific aphids (green peach aphid, cabbage aphid, currant lettuce aphid and cotton aphid on ornamentals and selected vegetable crops. Not for use in protected cropping.	?*	Unknown
12A	Diafenthiuron	Pegasus	PER81707 All aphids on non-food nursery stock.	T	L–H, 1 week
23	Spirotetramat	Movento	PER81707 All aphids on non-food nursery stock.	S	Probably L – 0-1 week
NA	Beauveria bassiana strain PPRI 5339	Broadband OD	Green peach aphid, rose aphid and chrysanthemum aphid on protected vegetables and ornamentals.	C	Unknown**
NA	Botanical oils	Eco-oil	All aphids on tomatoes, cucumbers, capsicums, strawberries and ornamental plants	C	L–M – 0-1 week
NA	K salts of fatty acids	Natrasoap	All aphids on pot plants.	C	M–H – Low residual
NA	Paraffinic and Petroleum oils	Sacao BioPest, Biocover	All aphids on ornamentals and certain fruit or vegetable crops. Registration not always available in all states. Also, PER81707. All aphids on non-food nursery stock.	C	L–M – 0–1 week

* Afidopyropen is a new product that has not been researched to know whether it is systemic, translaminar or only contact. The extent of non-target impacts is also unknown.

** Refer to text under "Pesticides"

This document was prepared by Andrew Manners (Agri-science Queensland, Department of Agriculture and Fisheries, Ecosciences Precinct, GPO Box 267, Brisbane QLD 4001) as part of NY15002 Building the resilience and on-farm biosecurity capacity of the Australian production nursery industry in 2018. Thanks go to John Duff and Lindy Coates for helpful comments on previous versions of this factsheet. Photographs in this factsheet have been taken by DAF staff unless otherwise acknowledged.