NSW DEPARTMENT OF
PRIMARY INDUSTRIES

Readers' Note

Biological control

Biological control

Biological control occurs when the numbers of an insect pest or the severity of a disease are reduced because of the actions of a beneficial organism.

Orchardists can manipulate these beneficial organisms to maximise their effectiveness. In some cases biological control organisms are so efficient that they can replace the need to spray.

Biological control should not be used as an emergency cure for a problem. Orchardists should introduce and encourage biological control agents as a preventive strategy.

There are broadly two different types of biological control:

- natural enemies. Organisms that are present in the orchard and reduce pest numbers.
- commercial biological control agents. Organisms that can be purchased and released in orchards. These are often organisms that are already present in orchards but can be purchased and released to supplement natural populations.

Natural enemies

Within any orchard there are populations of beneficial organisms that attack pests. The numbers of these beneficial organisms affect how successful the organisms are at keeping pest species below damaging levels. Summerfruit orchardists should be aware of the presence of these organisms in their crops. If they are present in high numbers early in the season, their activity may mean it is possible to reduce the number of sprays applied. A gradual build-up of these species from season to season is a good indicator of the success of an IPDM program.

Unfortunately, many of the pesticides that are targeted at pests also have an effect on these beneficial organisms. These natural beneficials can be encouraged through minimising spray applications. When a spray application is necessary, use the 'softest' effective option. The relative toxicities of some commonly used pesticides to beneficials are shown in Tables 6, 7 and 8.

A larval lacewing attacking a green peach aphid.

Natural enemies

Ladybird beetles

Target pests: Aphids, mites, moths eggs and small larvae

Both adult and larval ladybird beetles are predators. Younger larval stages tend to pierce their prey and ingest their bodily fluids, whereas older larvae and adults chew and consume their entire prey.

In general, ladybird beetles are easily recognised by their shiny, convex, half-dome shape and short, clubbed antennae. They are often brightly coloured, with contrasting spots. There are many different species of ladybird and many look similar to one another. Differentiation is often a specialist job.

Ladybird larvae are elongated, often colourful, and have long legs and large feeding parts. They are active and voracious predators.

Adult lady beetles preying on black peach aphids

Stethorus beetle

Stethorus

Target pests: Mites and mite eggs

Stethorus is a tiny (2 mm in diameter) jet-black ladybird beetle. The larvae of this ladybird beetle have dull grey hairs, giving them a velvety appearance. *Stethorus* is a voracious feeder on many species of mites and is particularly effective against two-spotted mite (see page 91). It is likely to suppress mite populations if it is present at high enough levels early in the cropping season.

Hover flies

Syrphidae

Target pests: Aphids and mites

Adult hover flies have black and yellow bands around their abdomens and are often seen hovering above flowers early in the season. They feed on pollen and nectar and make no contribution to biological control at this stage of their life cycle. However, their larvae feed on aphids and mites. The presence of large numbers of adult hover flies early in the season is likely to mean fewer aphid and mite problems during the warmer months.

Female hoverflies lay their eggs amongst colonies of aphids and mites. The legless maggots that

Hover fly larva attacking a green peach aphid

Adult hover fly

emerge grope along the plant surfaces, lifting their heads in search of prey. When they find an aphid or mite they seize it, suck it dry and discard the skin. Each fly maggot can consume hundreds of aphids per month.

Parasitoids

Target pests: Aphids

A parasitoid is an organism that lays its eggs in the body of another organism. The developing young of the parasitoid derive their nutrition from their host, eventually killing it and finally emerging from its mummified body.

The most common parasitoids of aphids found in Australian summerfruit orchards belong to the genus *Aphidius*. The adult wasps are small and difficult to detect in orchards. They are sometimes seen flying around colonies of aphids looking for a suitable host. Orchardists wishing to monitor the activity of parasitoids in their orchards should look for the mummified bodies of aphids rather than the parasitoids themselves. Parasitised aphids bloat before they die and are therefore quite easily spotted. When the parasitoid leaves the mummified body of the aphid it cuts a small escape hole.

If 10% of aphids in a colony are mummified and have parasitoid escape holes, it is likely that all of the aphids in the colony have been parasitised and will die. In such cases it is not necessary to spray an insecticide. An insecticide application may damage the parasitoids, limiting their effectiveness.

Aphidius parasitising an aphid

Aphid mummies, showing the wasp escape hole

Predatory mites

Target pests: Pest mites

Predatory mites occur naturally on Australian summerfruit. A recent study identified eight species of phytoseiid mites on sugar plum blocks in Griffith and Young in NSW. The same study also identified populations of predatory stigmaeid mites.

Predatory mites should be encouraged through the use of chemicals that have low toxicity towards them. There is good evidence that even a single spray of a hard, broad-spectrum chemical such as tau-fluvalinate can reduce predatory mite populations to the point where secondary pest species such as two-spotted mite become a problem and require action.

Further information can be obtained from Horticulture Australia Limited Project No. DP99002, *Development of IPDM Strategies for the Prune Industry*. *Final Report*. May 2004, by Graham Thwaite.

A stigmaeid mite

Commercial biological control agents

In some cases, beneficial organisms that could control pest species in orchards are absent or are present only in low numbers. A number of Australian companies grow and supply beneficial organisms that can be used to supplement the natural beneficials in your orchard. The companies listed at the end of this chapter will provide information on the suitability of beneficials for control of your pests and on shipping and application of these beneficials.

Phytoseiulus persimilis

Target pests: Two-spotted mite

This predatory mite is best suited to warm, humid regions such as the Sydney Basin, NSW North Coast or coastal South East Queensland.

This mite is only slightly larger than its two-spotted mite prey but can be distinguished by its orange colouring and long, forward-pointing front legs. When examined using a hand lens or microscope it can be seen moving much more quickly than its prey.

It is an effective predator. A single predatory mite can eat two female two-spotted mites per day or dozens of two-spotted mite eggs.

Its levels should be monitored. This species often needs to be reintroduced, as it is so effective that it consumes all of its available prey.

Phytoseiulus persimilis adult (left); and two-spotted mite (centre); two-spotted mite egg (top right); and Phytoseiulus persimilis egg (lower right)

Typhlodromus adult feeding on two-spotted mite

It is tolerant of some insecticides and fungicides (see Tables 6, 7 and 8). This gives orchardists wishing to undertake IPDM some control options for other pests.

For further details on *Phytoseiulus persimilis* see:

Williams D (2000) *Integrated Control of Two-spotted Mite in Orchards*. Victorian Department of Primary Industries. AG0157. ISSN 1329–8062. Available at the DPIV website www.dpi.vic.gov.au[.]

Typhlodromus occidentalis

Target pests: Two-spotted mite

Typhlodromus occidentalis is a predatory mite that is better suited to drier inland regions than is *Phytoseiulus persimilis* (see above).

It feeds on all stages of two-spotted mite (including eggs) and should be inoculated onto infested trees early in the season, before populations of the pest mite have had a chance to build up.

Typhlodromus is approximately the same size as two-spotted mite but lacks the eyespots of the pest species. It ranges in colour from cream to amber-red, depending on what it has just eaten.

Commercial strains of this beneficial are resistant to organophosphate insecticides.

For further details on *Typhlodromus occidentalis* see:

Williams D (2000) *Integrated Control of Two-spotted Mite in Orchards*. Victorian Department of Primary Industries. AG0157. ISSN 1329–8062. Available at the DPIV website www.dpi.vic.gov.au[.]

Amblyseius victoriensis

Target pests: Various mites

Amblyseius victoriensis is a species of predatory mite. Its use as a biological control agent against mites in summerfruit is currently under development by several Australian companies (Biological Services, Bugs for Bugs; contact details below). It is a naturally occurring species that has been recorded from sub-coastal Queensland to South Australia.

Trichogramma wasps

Target pests: Eggs of lightbrown apple moth and oriental fruit moth

Trichogramma are tiny wasps that seek out the eggs of lightbrown apple moths and oriental fruit

moths. They pierce these eggs and lay their own eggs inside. The wasp larvae develop inside the moth eggs and a fully developed wasp emerges, rather than a caterpillar.

Trichogramma are supplied in the form of parasitised eggs that are released into the orchard. Following release of the eggs orchardists must be careful about pesticide applications, as several products are toxic to *Trichogramma*. The suppliers of these wasps recommend tebufenozide, fenoxycarb, indoxacarb, and spinosad because of their low toxicity towards *Trichogramma*. More details are available from the suppliers listed below.

Hippodamia variegata

Target pests: Aphids

The first discovery of *Hippodamia variegata* in Australia occurred in South East Queensland in November 2000. It is an efficient predator of aphids and has been developed commercially for use against this pest.

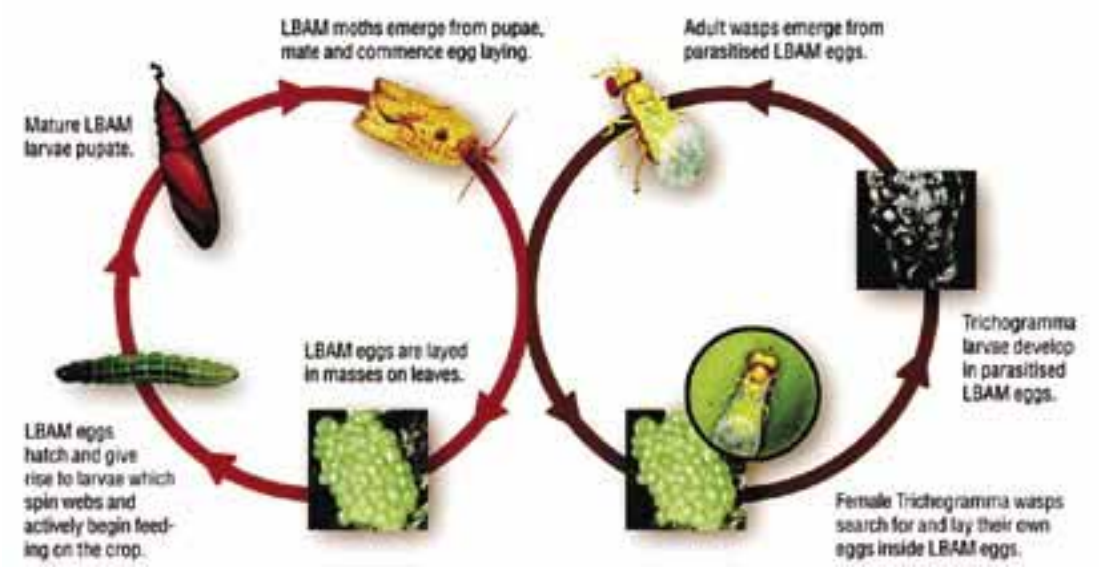
It is the only member of this genus (type) of ladybird beetle in Australia and has several characteristics that suit it to its predatory role in summerfruit. Breeding populations of this beetle can be found during winter and early spring, when other ladybird beetles are inactive. This would allow releases of this beetle to occur earlier in the season. Aphids feeding on green flushes of new growth at this time are more likely to be controlled by *Hippodamia*.

Hippodamia are sold as eggs on tape. This tape is placed near aphid infestations. Emerging *Hippodamia* larvae hunt down and eat the aphids.

Hippodamia eggs

Hippodamia larvae attacking an aphid

Hippodamia adult



Interaction between Trichogramma wasps and lightbrown apple moths

Because of this release strategy it is possible to place the predator very close to aphid outbreaks and it is not necessary to treat entire orchards.

Lace wings

Target pests: Aphids, two-spotted mite, scales (various species), mealybugs, moth eggs and small caterpillars

Both green and brown lacewings are common in Australian summerfruit orchards. Adult lacewings are approximately 15 mm long and feed on nectar and pollen. Monitoring for adults during blossom will give a good indication of the numbers of lacewing larvae present in the orchard later in the season.

Green lacewing egg

Winged adult aphid (left) being attacked by a lacewing larvae (right), which is camouflaged by dead aphids on its back

Adult green lacewing

Female lacewings lay their eggs on long stalks. These stalks reduce ant predation. A single female lacewing can lay up to 600 eggs during her 3 to 4-week adult life. Larvae hatch from the eggs and grow from 1 mm at first emergence up to 8 mm.

Lacewing larvae are generalists and feed on a wide range of orchard pests. Green lacewing larvae impale the remains of their prey and other detritus on short spines on their backs (see picture). This may provide them with a degree of camouflage for hunting.

Lacewing larvae are voracious feeders and can consume up to 60 aphids in an hour.

Adult lacewings tend to fly at night, and the larval stages are often camouflaged and inconspicuous. Therefore, scouting for these insects should rely on the presence of the stalked eggs. The presence of large numbers of stalked eggs early in the season is an indication that insecticide sprays can be reduced.

NoGall™

Agrobacterium radiobacter

The bacterium *Agrobacterium radiobacter* is used as a natural inoculant to prevent the disease crown gall, which is caused by a closely related bacterial species. Details of this product are presented in the section on crown gall (page 91).

DiPel®

Bacillus thuringiensis

Bacillus thuringiensis (Bt) is a bacterium that is the active component of DiPel® and similar products. This bacterium affects only the caterpillar stage of certain insects.

The product is applied in the same way as a conventional spray, preferably in the very early stages of infestation, so that it is on the leaf or fruit and will be eaten by the grazing caterpillar. Enzymes in the caterpillar's gut break down the natural 'capsule' surrounding the bacterium and the toxin is released. The caterpillar stops feeding and soon dies.

Bt is recommended for the control of lightbrown apple moth (LBAM) in summerfruit. It is not suitable as an emergency treatment, and its residual activity is short. However, if it is applied before an infestation becomes established, it will provide LBAM control that is non-disruptive to other beneficials.

Biological control agents and pesticides

Biological control agents vary in their susceptibility to the pesticides used in Australian summerfruit orchards. In general, biological control works best in orchards that have well established IPDM practices such as mating disruption and monitoring. When you are deciding to introduce biological control agents to an orchard it is important to consider the pesticides that have been used and their residual effects, as well as the pesticides that are likely to be used in the future.

Very little is known about the effect of agricultural pesticides on some of the natural beneficial organisms present in orchards. However, more is known about pesticides and commercially available biological control agents.

Notes on Tables 6, 7 and 8

- The following tables contain information on the effects of nearly all of the pesticides registered for use on Australian summerfruit (as at October 2005). The fungicide ziram and a number of copper formulations do not appear in these tables, as no information on their effect on beneficial organisms was available.
- The information is colour coded to reflect the toxicity of the pesticides towards common beneficial organisms in Australian summerfruit orchards:

Low toxicity: nil or low impact on beneficials

Moderately low toxicity: moderate impact on beneficials; but populations recover quickly

Moderately high toxicity: moderate impact on beneficials; populations slow to recover

A high proportion of beneficials killed; populations may not recover

- Numbers within the table indicate the approximate period in weeks for which the effect of the pesticide lasts. For example, '2' means that the harmful effects of this chemical last for 2 weeks. Biological control agents cannot be reintroduced during this period because of these harmful effects.
- The symbol '–' means that the effects of this chemical on the beneficial are unknown.
- The symbol '?' means that the length of time for which the harmful effects of this chemical last is unknown.
- The information for these tables is drawn from:

The Good Bug Book (see page 135 for more details)

Hetherington SD, Bright J, Mooney A (*2005/06, updated annually) The Orchard Plant Protection Guide for Deciduous Fruits in NSW. NSW Department of Primary Industries.*

Koppert Biological Systems, www.koppert.nl/e005.shtml

Biobest Biological Systems, www.biobest.be/

- Occasionally the information from these sources varied. In cases where this occurred, the most harmful rating and longest harmful period found are used in the tables.
- Use these tables as a guide only. In some cases the specific information was unavailable, and that provided is for the interaction between the pesticide and a closely related species. The length of time for which a pesticide remains harmful is also influenced by a range of factors, including climate.
- The lists of pesticides are separated into three tables according to their toxicity to beneficial organisms:

Table 6. IPDM-friendly pesticides. These pesticides are unlikely to harm beneficial organisms in your orchard and should not impede the introduction of commercial biological control agents. When a pest or disease requires a pesticide application and an effective alternative is present on this list, it should be preferred to those appearing in the other tables. On rare occasions these pesticides may harm beneficial organisms, and orchardists should check the table before application.

Table 7. Pesticides to be used with caution in IPDM programs. Because these chemicals are harmful to a number of different types of beneficial organisms, orchardists will need to know which beneficials are present in their orchards. Choose pesticides that are unlikely to cause secondary problems.

Table 8. Pesticides that should be considered only in emergencies when no other effective alternative exists. In some cases harsher chemicals will be required to treat pests (e.g. treatment of fruit fly for interstate export). Where no 'soft' option exists, orchardists should be aware of the possible emergence of secondary pests and plan ahead for their management.

Table 6. IPDM-friendly pesticides

			Predatory mites									Parasitoids				Predator	
			Phytoseiulus persimilis			*Typhlodromus occidentalis*			*Amblyseius* spp.			*Aphidius colemani*		*Trichogramma* wasps		Green lacewings	
	Chemical name	Trade names	*egg*	*nymph*	*adult*	*egg*	*nymph*	*adult*	*egg*	*nymph*	*adult*	*mummy*	*adult*	*pupa*	*adult*		Comments
Insecticides	pymetrozine	Chess		0									½	-		-	Systemic insecticide. Resistance grouping 9A.
Insecticides	thiacloprid	Calypso	2						-			-	?			-	Systemic insecticide with contact and stomach activity. Resistance grouping 4A.
Miticides	bifenazate	Acramite				-								-		-	Miticide with contact and residual activity against motile stages. Generally ladybird beetle friendly. Resistance grouping 2D.
Miticides	clofentezine	Apollo				-										-	Mite growth inhibitor. Resistance grouping.
Miticides	fenbutatin oxide	Torque														-	Miticide with contact and stomach action, controls motile stages. Resistance grouping 12A.
Fungicides	captan	Captan, Orthocide, Merpan				-			-			-		-		-	Protectant fungicide. Resistance grouping Y
Fungicides	chlorothalonil	Various												-		-	Protectant fungicide. Resistance grouping Y
Fungicides	cyproconazole	Garrison				-			-			-	?	-		-	Application method (wound dressing) minimises exposure to beneficials. Resistance grouping C

Table 6 (continued). IPDM-friendly pesticides

			Predatory mites									Parasitoids				Predator	
			Phytoseiulus persimilis			*Typhlodromus occidentalis*			*Amblyseius* spp.			*Aphidius colemani*		*Trichogramma* wasps		Green lacewings	
	Chemical name	Trade names	*egg*	*nymph*	*adult*	*egg*	*nymph*	*adult*	*egg*	*nymph*	*adult*	*mummy*	*adult*	*pupa*	*adult*		Comments
Fungicides	cyprodinil	Chorus		?													Protectant fungicide. Resistance grouping I.
	dithianon	Delan, Patrol	-			-			-					-		-	Fungicide with protectant and some curative action. Resistance grouping Y.
	fosetyl	Alliette				-			-			-		-		-	Systemic fungicide with protectant and curative action. Resistance grouping Y.
	propiconazole	Various				-			-						1		Systemic fungicide with protectant and curative action. Resistance grouping C.
	sulfur					1			?				?		2		Resistance grouping Y.
	thiram	Thiragranz	0			-								?			Protectant fungicide. Resistance grouping Y.
	triforine	Saprol		1		1				1				-			Systemic fungicide with protectant action. Resistance grouping C.
	zineb	Zineb	-									-		-			Protectant fungicide. Resistance grouping Y.

Table 7. Pesticides to be used with caution in IPDM programs

	Chemical name	Trade names	Predatory mites: *Phytoseiulus persimilis* egg	*P. persimilis* nymph	*P. persimilis* adult	*Typhlodromus occidentalis* egg	*T. occidentalis* nymph	*T. occidentalis* adult	*Amblyseius* spp. egg	*Amblyseius* spp. nymph	*Amblyseius* spp. adult	Parasitoids: *Aphidius colemani*	*A. colemani* adult	*Trichogramma* wasps pupa	*Trichogramma* wasps adult	Predator: Green lacewings	Comments
Insecticides	imidacloprid	Confidor		0*						2		?			2	4	Systemic contact and stomach insecticide. Resistance grouping 4A.
	indoxacarb	Avatar							-				?			1	Insecticide active by contact and ingestion. Does not harm larval *Stethorus* and *Hippodamia*. Resistance grouping 22A.
	parathion-methyl	Folidol, Penncap		1					-			-			3	3	Insecticide with contact, stomach and some respiratory action. Resistance grouping 1B.
	pirimicarb	Aphidex, Pirimor		½						½					<1		Selective systemic aphicide with contact, respiratory and stomach action. Resistance grouping 1A.
	spinosad	Entrust Naturalyte Success naturalyte	-	1*					-			-		-	2	1	Insecticide active by contact and ingestion. Does not harm larval *Stethorus* and *Hippodamia*. Resistance grouping 5A.
Miticides	propargite	Omite	0	0					-	?							Miticide with contact action against motile stages. Resistance grouping 14A.
	tebufenpyrad	Pyranica			2	2							2	-		-	Miticide with contact action. Resistance grouping 10A.
	benomyl	Benlate, Marvel		4*		2–3				2–3							Systemic fungicide with protectant and curative action. Resistance grouping A.

Table 7 (continued). Pesticides to be used with caution in IPDM programs

			Predatory mites									Parasitoids				Predator	
			Phytoseiulus persimilis			*Typhlodromus occidentalis*			*Amblyseius* spp.			*Aphidius colemani*		*Trichogramma* wasps		Green lacewings	
	Chemical name	Trade names	*egg*	*nymph*	*adult*	*egg*	*nymph*	*adult*	*egg*	*nymph*	*adult*	*mummy*	*adult*	*pupa*	*adult*		Comments
Fungicides	carbendazim	Various	2	1–2*		1				?					1		Systemic fungicide with protectant and curative action. Resistance grouping A.
	copper oxide	Various	-	?		-			-			-		-		-	Little information is available about the toxicity of copper formulations to beneficial organisms. As they are applied during dormancy, any effects would be on overwintering eggs or adults. Resistance grouping Y.
	copper oxychloride		-			-						-		-		-	
	mancozeb	Various	1*						-	?				-	1		Protectant fungicide. Resistance grouping Y.
	metiram	Polyram	-	?*		-			-						>4	-	Protectant fungicide. Resistance grouping Y.

Table 8. Pesticides that should be considered only in emergencies when no other effective alternative exists

			Predatory mites								Parasitoids				Predator	
			Phytoseiulus persimilis			*Typhlodromus occidentalis*			*Amblyseius* spp.			*Aphidius colemani*		*Trichogramma* wasps		Green lacewings	
	Chemical name	Trade names	*egg*	*nymph*	*adult*	*egg*	*nymph*	*adult*	*egg*	*nymph*	*adult*	*mummy*	*adult*	*pupa*	*adult*		Comments
Insecticides	alpha - cypermethrin	Various	8–12			-			8–12			-	4	-		-	Non-systemic insecticide with contact and stomach action. Resistance grouping 3A.
	azinphos-methyl	Gusathion	2						8–12			-	?	>4	>4	2	Insecticide with contact and stomach action. Resistance grouping 1B
	bifenthrin	Various	8–12			?			8–12			8–12		8–12		-	Contact insecticide. Resistance grouping 3A
	carbaryl	Bugmaster	-	2*		1*			-	4–8		-	4	3		2	Contact insecticide with stomach action. Resistance grouping 1A.
	chlorpyrifos	Various		½		0*			6–8			?		>4		2	Contact insecticide with stomach and vapour action. Resistance grouping 1B.
	diazinon	Diazinon	2							3		?		3		1	Non-systemic insecticide and miticide with contact, stomach and respiratory action. Resistance grouping 1B.
	dimethoate	Various	8			1			8–12			?		4–6		3	Broad-spectrum contact and systemic insecticide. Resistance grouping 1B.
	fenthion	Lebaycid	3			2–3*			-			-		4		2	Systemic insecticide with contact, stomach and respiratory action. Resistance grouping 1B.

Table 8 (continued). Pesticides that should be considered only in emergencies when no other effective alternative exists

	Chemical name	Trade names	*Phytoseiulus persimilis* egg	*Phytoseiulus persimilis* nymph	*Phytoseiulus persimilis* adult	*Typhlodromus occidentalis* egg	*Typhlodromus occidentalis* nymph	*Typhlodromus occidentalis* adult	*Amblyseius* spp. egg	*Amblyseius* spp. nymph	*Amblyseius* spp. adult	*Aphidius colemani* mummy	*Aphidius colemani* adult	*Trichogramma* wasps pupa	*Trichogramma* wasps adult	Green lacewings	Comments
Insecticides	maldison	Hy-Mal	1			0			?			4		3		1	Insecticide with contact, stomach and respiratory action. Resistance grouping 1B.
	methamidophos	Monitor, Nitofol	6–8			1			?			>4		4		3	Systemic insecticide and acaricide with contact and stomach action. Resistance grouping 1B.
	methidathion	Supracide, Suprathion	3			1			6–8			?		>4		3	Non-systemic insecticide and miticide with contact and stomach action. Resistance grouping 1B.
	methomyl	Lannate, Marlin, Nudrin	4			1			6–8			8–12		8–12		1	Systemic insecticide and miticide with contact and stomach action. Resistance grouping 1A.
	tau-fluvalinate	Mavrik aquaflow	6			-			4			-		4–6		-	Insecticide and miticide with contact and stomach action. Resistance grouping 3A.
	trichlorfon	Dipterex, Lepidex	2			-			2			-	?		?	-	Insecticide with contact and stomach action. Resistance grouping 1B.
Miticides	chlorfenapyr	Secure	2			2			-				>4	-		-	Miticide with stomach action. Resistance grouping 13A.
	dicofol	Kelthane, Miti-fol	2	2								-	?	3			Non-systemic miticide with contact action. Resistance grouping 2B.

Suppliers of biological control agents and more information

		Supplier								
Beneficial	**Used to control**	**The Beneficial Bug Company (NSW)**	**Bio-Protection (Vic)**	**Bio-Works (NSW)**	**Biological Services (SA)**	**Bugs for Bugs (Qld)**	**BioResources (Qld)**	**Horticultural Crop Monitoring (Qld)**	**IPM Technologies (Vic)**	**Manchil IPM Services (WA)**
Phytoseiulus persimilis	Two-spotted mite	●	●	●				●		●
Typhlodromus occidentalis	Two-spotted mite				●					
Amblyseius victoriensis	Mites				●	●				
Trichogramma wasps	LBAM[1] OFM[2]					●	●			
Lacewings	Aphids, two-spotted mite, scales, mealybugs, moth eggs and small caterpillars					●				
Hippodamia variegata	aphids								●	

● Beneficial available from this supplier
[1] Lightbrown apple moth
[2] Oriental fruit moth

The Beneficial Bug Company
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