Pest Management Plan for Caterpillars in Production Nurseries

Helicoverpa caterpillar showing five paired fleshy prolegs (white arrow) and three paired legs near the head (black arrow).

Caterpillars can be serious pests to at least some nursery lines in most regions of Australia. The vast majority of pest caterpillars are the immature stages of moths, but immatures of a few butterfly species can also be pests, e.g. cabbage white butterfly and cycad blue butterfly. Moths and butterflies are from a single insect order, Lepidoptera, which translates from ancient Greek as 'scale wing'. There are about 10,000 species of moths and butterflies described in Australia and probably at least that many undescribed.

Hort Innovation Strategic levy investment | NURSERY FUND

Greenlife Industry Australia

Queensland Government

Most caterpillars feed on plants above ground, though some feed on below ground plant parts or feed on aquatic plants under water. Some caterpillars feed on dead and decaying plant matter and fungi and there are even a very small number of predatory caterpillars. This plan focuses on the management of caterpillars for the Australian production nursery industry with information on their diverse biology, cultural, biological and chemical control.

GENERAL BIOLOGY

Moths and butterflies have four stages in their lifecycle: egg, larva (caterpillar), pupa (or chrysalis) and adult (moth/butterfly). There is considerable variation in the lifecycle. Some species have only one or a small number of generations per year and may only be active during warmer months. Others may be active almost all year round (particularly in warmer climates) and have many overlapping generations such that all life stages are present at any given time. Some only feed on a small number of plant species within a genus or closely related plant genera. Others, however, may feed on plants from many families.

Eggs are laid either singly or in an egg batch that may have 50 to several hundred eggs, depending on the species. Egg batches are often covered in scales and are therefore the same colour as the moth that laid them, generally brown or grey. Whether laid singly or in a batch, moth and butterfly eggs are generally spherical to ovoid or may be somewhat flattened or cylindrical. Eggs often have ribbing or raised lines that can be seen with a hand lens; they can be quite intricate when observed at high magnification. They are laid on the upper or lower side of leaves on trunks, stems, branches, growing tips or on or near flower buds. Some species deposit egg batches rather indiscriminately on houses, posts and other inanimate objects or drop eggs onto their host plant while flying. For most species, eggs hatch within a few days to a week, depending on the species and environmental conditions. Some species take longer to hatch, up to a few weeks.

Caterpillars hatching from eggs are very small and often feed on their egg shell for their first meal. They have a very high mortality rate and only consume a small amount of plant material. Caterpillars of moths often have 5 instars (stages), moulting between each instar and increasing in size. As they become larger they consume an exponential amount of plant material. Caterpillars reach their largest size in the last instar. Relatively large moths and butterflies have relatively large caterpillars, very small moths will have very small caterpillars. Regardless, the last instar always consumes a relatively large amount of food (and therefore does more damage) compared to earlier instars.

Caterpillar feeding behaviour is diverse. In general, caterpillars that hatch from an egg batch stay in a group, at least while they are relatively small. As they moult and grow larger, they are more likely to become solitary. Most species will remain on plants day and night, even if they mainly feed at night and hide during the day. However, some species will feed equally during the day or night or may change their behaviour over time. Cutworms hide in the growing media during the day and mainly feed during the night.

Caterpillars all produce silk and often will do so continuously when moving on plants; this helps them grip the plant. Very small larvae sometimes drop from plants on a silk strand and may be blown to nearby plants in the wind. Even caterpillars within leaf rolls and boring through stems produce silk; this provides evidence that a caterpillar caused the damage, even if they are no longer present. Caterpillars produce characteristic frass (which is essentially their faeces) that is cylindrical and formed into a relatively firm pellet (particularly when it dries out). It will often stick to silk or land in clumps on leaves. Small larvae produce very small pellets, large larvae produce relatively large pellets.

Many caterpillars have hairs or spines that can cause a rash and burning sensation when touched. When large numbers are present in trees, e.g. processional caterpillar, hairs can fall onto people and laundry and become a skin irritant. Avoid touching hairy or spiny caterpillars!!!

Cup moths have sharp spines that deliver a poison when touched.

Larval development of some species occurs quickly, e.g. 2 weeks, particularly in warm weather. Such species are likely to have many generations per year. Other species complete 3–4 generations during warmer months only and overwinter during cooler months (where individuals effectively 'sleep' through colder months). Species that have only one generation per year (or longer) are unlikely to cause significant damage to nursery lines, except perhaps for advanced trees.

Just before pupating individuals cease feeding, will often change colour or shape slightly and find a place to pupate. Many moth species do so in leaf litter or dig a short distance underground. Other species may pupate on plants under leaves or within a leaf roll. Many produce some sort of silk cacoon that may have plant material woven into it and may act as physical protection or camouflage. The shape and colour of pupae can be very characteristic and assist in identifying the type of caterpillar present. Pupal development is highly species specific and may change depending on weather conditions. Moths may emerge after 10 days under good conditions or may be as long as several months if pupae overwinter.

Overwintering individuals are generally inactive, though overwintering adults that are disturbed may fly a short distance and then resettle.

There is substantial variation in the distance that adults can fly. Some moth species will fly only a few hundred metres or will be incidentally windblown a few kilometres. Such species have local populations that can monitored in production nurseries somewhat easily. Many moth species, however, have mass migrations flying hundreds of kilometres before landing and laying eggs. For these species, populations can be more at risk of appearing suddenly and without warning.

If caterpillars are a regular and damaging pest it may be worthwhile having them identified to gain information on their biology. This may assist in gaining answers to questions listed below that can help to break the lifecycle in the nursery and manage the pest (or suite of pests) proactively.

- How many generations do they have per year and over what seasons are they active?
- Where do adults lay eggs?
- Where are caterpillars during the day/night?
- Where do they pupate?
- What other host plant species do they feed on?
- How far do adults fly? Do they migrate and what season/s does it occur?
- Do they overwinter in your region and, if so, where do they do so (e.g. in the soil as pupae, on branches as eggs, etc)?

CATERPILLAR OR SOME OTHER INSECT LARVA?

A number of insect larvae can look very similar, e.g. caterpillars, beetles, sawfly and fly larvae.
All caterpillars have chewing mouthparts. Most caterpillars have 3 pairs of true legs just behind the head and have fleshy prolegs; all caterpillars have 5 or fewer pairs of prolegs. Prolegs occur on the abdominal segments and have a suction cup at the end. Some species may not have any prolegs, but this is rare. Sawfly larvae are similar, but have more than 6–7 pairs of prolegs (often with one pair on every abdominal segment). Beetle larvae never have paired prolegs. Fly larvae (maggots) do not have legs, prolegs or chewing mouthparts. For more information see the factsheet on identifying a range of insect larvae and other resources online.

Leaf curling caterpillars pull and hold leaves together using their silk (white sheet-like material).

DAMAGE

All caterpillars have chewing mouthparts; they physically remove plant tissue. The most common type of damage is therefore holes in leaves. Newly hatched larvae make very small holes, generally in the lower leaf; the top of the leaf often remains intact, giving a 'window-like' appearance. Small larvae may also feed on or within the growing tips, flowers and flower buds. As the tissue expands it can appear ragged and may interfere with flower set.

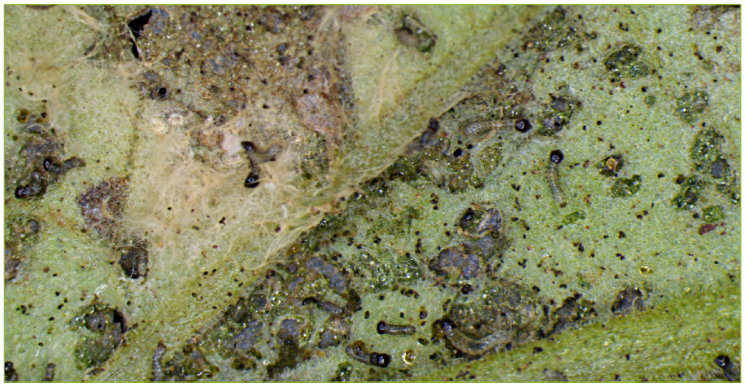
As larvae grow they remove more material, creating larger holes. After they moult twice, they begin to consume an exponentially greater volume of food. This increases damage at an ever-increasing rate. Large larvae can remove entire leaves and tender stems. Certain species may produce copious volumes of silk; when these are present in large numbers it may appear as though many spiders are infesting the plant. Frass can also be deposited on leaves and become stuck in silk causing the plant to appear dirty. Silk production and frass deposits can cause plants to appear unthrifty and unsaleable.

Some species live within the plant. Leaf curling caterpillars hold the leaf together with their silk and feed within it. Leaf miners feed within the leaf causing leaf necrosis in a meandering trail or blotch. Wood-boring caterpillars feed within stems causing dieback (refer to the wood-boring pest factsheet for more detailed information on this topic).

MONITORING FOR CATERPILLARS

In general, it is recommended to inspect plant health on a weekly basis and record data, preferably electronically. 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. Highest risk periods can be species specific, but is generally during warm seasons for caterpillars, i.e. spring to autumn. Frequent monitoring will enable infestations to be spotted while populations are still low, and thus easier and cheaper to manage. Egg batches, caterpillars and their damage can be monitored by visual inspection. Plant beating is also a good way to detect caterpillars that can be dislodged from plants, particular small individuals that can be difficult to detect by direct observation. Focus on detecting small larvae as they are easier to control and produce much less damage.

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). Preferentially examine leaves that have holes or a window effect or that have unusual symptoms; use a hand lens where relevant. Most moth eggs and small larvae can be seen without magnification and confirmed with a hand lens.
2. Plant beating. Gently but firmly hit foliage against a beating tray (which can be a folder, laminated card, 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. It should also be flat; plastic plates with small bumps or grooves are more difficult to use. 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, caterpillars and their frass and a variety of other insects. Once something is found, a 10–15x hand lens can be used to inspect the catch.
3. Specific lures or pheromone traps can monitor the activity of specific moths, e.g. codling moth, light brown apple moth, corn earworm, citrus leaf miner and others. Presence of the target organism in the trap indicates that they are likely to be present in the crop and assists in understanding pest pressure. These can be purchased from Bugs for Bugs, Biological Services and perhaps other suppliers.



Newly hatched caterpillars with small feeding sites. Brown material in the top left corner are scales and hatched eggs from the egg batch.

Large caterpillars can demolish plant material quickly.

4. Light traps, e.g. vortex traps, can monitor for the presence of migrating moths. Like the lure traps above, this is a monitoring tool to understand when pest pressure is likely to be increasing; light traps are unlikely to reduce moths flying into nurseries. They should be placed away from growing areas to reduce risk of attracting moths that may lay eggs in the nursery, and therefore increase pest pressure unnecessarily. Light traps are probably only recommended for growers that have to manage caterpillars of migratory species that vary considerably in the season that they migrate. Research the species regularly encountered to determine when light traps should be used both across seasons and during the night, i.e. some species are more likely to migrate during certain hours of the night.

Record pest 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. Monitor following the application of insecticides or release of biological control agents; this helps establish the efficacy of the action and future management decisions.

More information on monitoring pests and predators is available in the BioSecure HACCP protocols and the FMS website. The farm management system is developing an electronic system that can be used by multiple people per business simultaneously from tablets, smart phones and computers. The system can easily generate and report crop health issues. For more information on how to use this system contact Greenlife Industry Australia.

IDENTIFYING MOTHS AND CATERPILLARS

Common and distinctive moths and large caterpillars can be identified relatively easily by comparison to pictures online. There are quite a few photo galleries of moths, butterflies and their caterpillars that can be quite helpful, see links below and in further reading. Species that are without distinctive colouration or shape may be difficult for nursery managers to identify even to a group level. If a detailed identification is required it is recommended to talk to your diagnostic laboratory about the best way to submit a sample. In general, moths are required, preferably newly emerged. It may be possible to send plants with caterpillars that can be reared by the diagnostic laboratory.

- Australian caterpillars and moths and their eggs and pupae. Coff's Harbour Butterfly House.
- Australian moths online

Pink bellied moth (*Oenochroma vinaria*) caterpillar

MANAGING CATERPILLARS

Like all pests and diseases, put in place as many different actions to minimise pest infestations. Caterpillar infestations are best managed proactively such that the lifecycle of the pest is broken early. This prevents the pest from increasing through the season.

CULTURAL CONTROL

Cultural management actions are passive, reducing the risk of pests entering the nursery and decreasing pest pressure after they do become established.

1. Check incoming stock, new seedlings and other new planting material to ensure it is free of all pests and diseases. Monitor susceptible lines more closely than tolerant ones.
2. Keep plants apart from the rest of your stock for a period of time, monitoring plants for all pests and diseases. 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.
3. Manage weeds and reduce other alternative hosts in the production area and surrounds. Good weed management will also help reduce a variety of other pest problems including whiteflies, thrips, aphids and mealybugs.
4. Prune out heavily damaged leaves or stems if necessary, this is particularly important for leaf mining and wood-boring species. The larvae of some species will fall off plants and may hang on a silk thread when disturbed; take care to avoid their spread while pruning and handling plants.

5. Remove and destroy heavily infested, unsaleable 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.
6. Screens placed over greenhouse vents and closing doors can be used to help prevent entry by moths. In this case, extra care must be taken to ensure that pests do not continuously complete their lifecycle in the structure, as this defeats the purpose of excluding the pest. Also be aware that very fine screens can cause ventilation problems. It is recommended to use a protected cropping consultant/designer before retrofitting or building an insect-proof tunnel or glasshouse.
7. 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.
8. Practice good crop hygiene to avoid contamination between greenhouses or production sites. Remove crop organic matter that may have eggs. Crop debris in the growing area may also provide ideal sites for pupae to develop into moths.
9. Avoid broad spectrum, highly residual chemicals that will cause high mortality of parasitoids and predators (see section on biological control below).

BIOLOGICAL CONTROL

There are six species of commercially available caterpillar predators (Table 1). Of these, most are relatively specific and probably will only be recommended for nurseries that recognise that they have regular and serious problems with the indicated pest. Lacewings, however, feed on a wide range of small insects including moth eggs and small caterpillars. Focus on optimising the use of lacewings for biological management of regular caterpillar infestations; apply them before pest pressure occurs.

Regardless of the predator, it is recommended to seek advice from the supplier on best use to optimise application. Discuss pesticide usage that has been applied and applications to be made in the future. Some pesticides have a very long residual period that can negatively impact predators for months, particularly those with a mode of action group of 1, 2, 3 or 4 (Tables 2 & 3). Also discuss if climatic conditions are likely to be suitable for the predators success.

TABLE 1. PREDATORS AND PARASITOIDS THAT ARE COMMERCIALLY AVAILABLE FOR USE AGAINST CATERPILLARS.

BENEFICIAL SPECIES	BRIEF DESCRIPTION	TARGET PESTS	NOTES
Trichogramma pretiosum	Tiny egg parasitoid for specific pests.	*Helicoverpa* spp. and loopers	Only recommended if you have regular and serious *Helicoverpa* or looper problems.
T. carverae	Tiny egg parasitoid for specific pest.	Light brown apple moth only	Only recommended if you have regular and serious light brown apple moth problems.
T. cryptophelbiae	Tiny egg parasitoid for specific pest.	Macadamia nutborer only	Only recommended if you have regular and serious macadamia nutborer problems (which also feeds on many legumes, but only if seed pods are present).
Lacewings	Lacewing larvae are small to medium sized distinctive insects. They feed on a large range of insects, have very large mandibles and carry the remains of their prey on their back.	Moth eggs and caterpillars, aphids, scales and various other small insects	Can be applied proactively leading up to high pest pressure. They feed on a range of prey species.
Diadegma	Small black parasitoid for specific pest.	Diamond back moth only	Only recommended if you have regular and serious diamond back moth problems.
Steinernema carpocapsae	Microscopic nematode	Armyworm and cutworm	Only recommended if you have regular problems with armyworms and cutworms living in pots.

Some lacewings lay their eggs on the end of short stalks (left). Adult lacewings have transparent wings held tent-like over their body (right, photo by Whitney Cranshaw, Colorado State University, Bugwood.org).

OTHER NATURALISED BENEFICIALS

There are also many predators and parasitic insects that will kill caterpillars in production nurseries that will fly into the nursery naturally. These include assassin bugs, predatory shield bugs, ladybirds and other beetles, predatory and parasitic wasps and flies, spiders and even some large predatory mites. There are a number of insect pathogens that can kill caterpillars including various fungi, viruses and bacteria. *Bacillus thuringiensis* (Bt) products are bacteria that are very effective against caterpillars. They are commercially available through pesticide resellers and discussed in the pesticide section below.

Brown lacewing larva (this species does not carry its prey on its back).

Braconid wasp parasitising a caterpillar. Photo by Scott Bauer, USDA, Agricultural Research Service, Bugwood.org

Hawk moth caterpillar that has been parasitised by braconid wasps. Larvae have fed within the caterpillar and emerged as white pupae. Photo by David Cappaer, Bugwood.org.

PESTICIDES

There are many pesticides that can be used to manage caterpillars in production nurseries. Most of the products available are contact products that do not move into the plant. Many contact products also are active when caterpillars ingest the product that is present on the leaf. Translaminar products move from the upper to the lower leaf surface (or vice versa) but not between leaves. Systemic products available for use against caterpillars are upward systemic only (they will not move from leaves into roots). For caterpillars present on leaves, contact products can be sufficient. However, translaminar or systemic products will probably be required for species that roll leaves, feed within stems or leafmines (Table 3).

Always monitor the crop before applying a pesticide to determine if there is a large population of predators or parasitoids present. 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.

Btk and Btaz products are bacteria and should be treated as living organisms (check when they were produced when purchasing the product and store in a cool, dry place). When ingested by caterpillars they produce a toxin that causes their death. Small caterpillars are killed by ingesting a very small amount of product. Bt is unlikely to be effective if applied to plants infested with many large caterpillars because they must ingest a relatively large amount of product to be killed. Large caterpillars may not be killed before causing significant damage or completing larval development. Bt products begin to breakdown when exposed to sunlight or wavelengths more than about 400nm. Therefore, if caterpillars infesting the crop are nocturnal it is important to apply the product late in the day. Refer to this Bt factsheet for more information.

Always follow the pesticide resistance management strategy on the label. For certain crops and pests there are also resistance management strategies provided by Crop Life Australia. Where there is no resistance management plan it is recommended to rotate between mode of action groups. However, the method of rotation should be altered depending on the lifecycle of the pest .

For **pests that have only a small number of generations per year**, e.g. 1 generation per year, it is recommended to apply products from different mode of action groups on each subsequent application. This could involve applying a group 5 product, followed by a 7B product, followed by a group 28 product etc. This reduces risk of inducing pesticide resistance for long-lived pests.

For **pests that have many generations per season**, e.g. when each lifecycle may only take a few weeks to complete, pesticide resistance must be managed differently. Research indicates that risk of pesticide resistance is reduced if products from the same mode of action group are applied 2–3 times consecutively, every 7–10 days. If pesticide applications are required after this, apply 2–3 consecutive applications of a different mode of action group.

Use this information and active ingredients listed in Table 2 to create a rotation list to suit your business.

A factsheet specifically on insecticide resistance and resistance management will be written in 2020 available from the FMS website.

TABLE 2. PESTICIDE ACTIVE INGREDIENTS (MODE OF ACTION GROUP) AVAILABLE FOR USE AGAINST CATERPILLARS IN PRODUCTION NURSERIES. ALSO REFER TO TABLE 3 FOR MORE SPECIFIC INFORMATION ON EACH PRODUCT.

LOW RISK AND LOW RESIDUAL (RECOMMENDED IF YOU ARE PROMOTING BENEFICIAL POPULATIONS OR USING BIOLOGICAL CONTROL)	MEDIUM RISK, MEDIUM RESIDUAL	BROAD-SPECTRUM AND HIGHLY RESIDUAL PRODUCTS (NOT RECOMMENDED IF USING A BIOLOGICAL CONTROL PROGRAM)
• Spinetoram (5) • Fenoxycarb (7B) • Btk (11) • Btaz (11) • Methoxyfenozide (18) • Indoxacarb (22A) • Chlorantraniliprole (28) • Flubendiamide (28)	• Emamectin (6)	• Methomyl (1A) • Carbaryl (1A) • Chlorpyrifos (1B) • Dimethoate (1B) • Methidathion (1B) • Maldison (1B) • Fipronil (2B) • Bifenthrin (3A) • Pyrethrins(3A) • Alpha-cypermethrin (3A) • Acetamiprid (4A) • Imidacloprid (4A)

PESTICIDES AND BENEFICIAL INSECTS

Beneficial insects include predators, parasites (or parasitoids) and pollinators. Almost all pesticides have a negative impact on beneficials. Broad spectrum products tend to cause outright mortality. However, 'low risk' products, that are relatively soft on beneficials and have low residual activity, still can have a negative impact on beneficial populations, even if individuals survive the application. Non-lethal impacts can include shortened lifespan, reduced number of eggs laid and reduced feeding activity. Obviously, this will reduce the efficacy of beneficials in the crop and should be avoided whenever possible.

The negative impact of low risk products increases with frequency of application. In other words, increasing the number of pesticide applications magnifies the negative impact on beneficial populations. The rate of application also influences the impact. Higher doses will increase the negative impact on beneficial populations. For this reason, only apply pesticides when monitoring indicates that it is necessary to avoid crop loss. When making the application, use the lowest dose required to manage the pest population in question.

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 2019. Photographs in this factsheet have been taken by DAF staff unless otherwise acknowledged.

RECOMMENDATIONS

Encourage biological control when environmental conditions are suitable. Apply lacewings and grow banker plants that increase predator populations in the nursery. Apply BT products when caterpillar pressure is low but likely to increase. BT has virtually no negative effect on predators and is therefore safe to use while continuing to apply predators.

It is recommended to use biological control for as long as possible through the season. If it becomes too hot for predators or if pest populations increase unexpectedly, apply pesticides (Table 2 and 3). Rotate between products taking into account the presence of beneficial insects in the crop and the number of generations per season/year (as discussed in the pesticide section above).

FURTHER READING

- Pest ID tool
- Wood-boring moths and beetles factsheet
- Recognising insect larvae
- Butterfly and moth lifecycle including many images
- Australian caterpillars and moths and their eggs and pupae. Coff's Harbour Butterfly House.
- Australian moths online
- Bt factsheet
- Armyworm factsheet
- Cutworm factsheet
- Insecticide Resistance Action Committee and Crop Life Australia websites have a great deal of information on pesticides, resistance and their management.

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.

MoA[1]	ACTIVE INGREDIENT	EXAMPLE PRODUCT NAME	REGISTRATION INFORMATION	MOBILITY[2]	TOXICITY TO BENEFICIALS – RESIDUAL[3]
1A	Methomyl	Lannate	PER84953 lepidoptera larvae on non-food/non-bearing nursery stock. PER82428 Caterpillars on non-bearing ornamentals and nursery seedlings.	C, I	H – 4–8+ w
1A	Carbaryl	Bugmaster	Caterpillars on ornamentals and specific crop lines.	C, I	H – 4–6+ w
1B	Chlorpyrifos	Lorsban	PER84953 lepidoptera larvae on non-food/non-bearing nursery stock.	C, I	H – 6–8+ w
1B	Dimethoate	Saboteur	Moth larvae on ornamentals (exceptions apply).	C, S	H – 8–12 w
1B	Methidathion	Suprathion	Caterpillars on ornamentals, trees, shrubs in nurseries.	C, I	H – 6–8 w
1B	Maldison	Hy-Mal	Caterpillars on ornamentals.	C, I	H – 8–12 w
2B	Fipronil	Regent	PER81707 cutworms and wireworms on non-food nursery stock. Granular and liquid formulations.	C, I	H – 12+ w
3A	Beta-cyfluthrin	Tempo	Caterpillars on azaleas, hibiscus pelargoniums and roses only.	C, I	H – 8+ w
3A	Bifenthrin	Fivestar	Caterpillars and loopers on roses, carnations and ornamental plants.	C, I	H – 8–12 w
3A	Pyrethrins + piperonyl butoxide	Py-Bo	Caterpillars on fruit, vegetable, cut flower and ornamental plants. PER81707 specific pests on ornamental brassicas only.	C	M–H – 1–2 w
3A	Alpha-cypermethrin	Crop Care Dominex Duo	PER81707 cutworms on non-food nursery stock.	C, I	H – 8–12 w
4A +	Acetamiprid + Novaluron	Cormoran	PER86931 lepidoptera larvae on non-food/non-bearing nursery stock.	S, C, I + C, I	M–H – 1–6 w
4A + 3A	Imidacloprid + beta-cyfluthrin	Temprid	Caterpillars on ornamental plants.	S, I + C, I	H – 8+ w
5	Spinetoram	Success Neo	Caterpillars on ornamentals	T, C, I	L–H – 0–2 w
6	Emamectin	Proclaim	PER81707 cluster caterpillar, heliothos and lightbrown apple moth on non-food nursery stock; diamondback moth and loopers on ornamental brassicas only.	T, C, I	M–H – 0–1 w
7B	Fenoxycarb	Insegar	Heliothis[4] and Lightbrown apple moth on non-food nursery stock.	T, I	L–M – 0–2 w
11	Btk Btaz	Dipel Bacchus	Lepidopteran larvae on vegetables, fruits, vines, herbs, ornamentals forestry, amenity trees and turf. This product will break down in sunlight.	I	VL – 0
18	Methoxyfenozide	Prodigy	PER84953 lepidoptera larvae on non-food/non-bearing nursery stock.	I	L–H – 0–2 w
22A	Indoxacarb	Avatar	PER81707 Heliothis[4] and light brown apple moth only on non-food nursery stock.	C, I	Mostly L, some species H – 0–3 w
28	Chlorantraniliprole	Coragen	PER81707 Heliothis[4], light brown apple moth, apple looper and soybean looper only on non-food nursery stock.	S, C, I	L – 0 w
28	Flubendiamide	Belt	Certain caterpillars on various vegetable and fruit crops.	T, C, I	L – 0 w
28 + 4A	Chlorantraniliprole + thiamethoxam	Durivo	Cabbage white, diamondback moth, heliothis[4] and loopers on non-food nursery stock.	S, C, I S, C, I	M–H – 2–12+ w

[1] MoA is the pesticide mode of action group according to the Insecticide Resistance Action Committee.

[2] C, S, T, I refers to contact, systemic, translaminar and ingestion, respectively. Refer to the pesticide section above for more information.

[3] VL, L, M, H refer very low, low, medium and high toxicity and the number of weeks the product is likely to stay active against beneficial populations, as indicated by Koppert and Biobest.

[4] Heliothis has been renamed *Helicoverpa*.