Department of Primary Industries

Insect and mite control in field crops 2022

NSW DPI MANAGEMENT GUIDE

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www.dpi.nsw.gov.au

Department of Primary Industries

Insect and mite control in field crops 2022

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The product trade names in this publication are supplied on the understanding that no preference between equivalent products is intended and that the inclusion of a product name does not imply endorsement by the department over any equivalent product from another manufacturer.

Users are reminded of the need to follow safe work practice when applying any techniques described in this publication. This includes identifying, assessing and managing any occupational health and safety risks.

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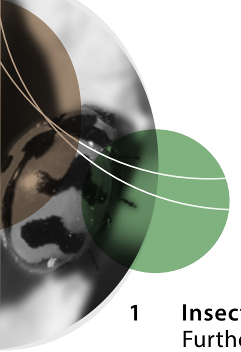
Always read the label
Users of agricultural chemical products must always read the label and any permit before using the product and strictly comply with the directions on the label and the conditions of any permit. Users are not absolved from any compliance with the directions on the label or the conditions of the permit by reason of any statement made or omitted to be made in this publication.

Acknowledgements
Jenene Kidston, (Technical Specialist, Farm Chemicals, Orange).

Front cover photos: Main image: Self-propelled sprayer (Grassroots Agronomy); Inset: Left – fall armyworm egg mass; Centre – trap and irrigation scheduling; Right – hoverfly larvae.



Contents

Insect and mite control

This guide contains information on how to control the more important insect and mite pests of azuki bean, canola, chickpea, cowpea, faba bean, field pea, lentil, linseed, lucerne, lupin, maize, millet, mungbean, navy bean, pigeon pea, safflower, sorghum, soybean, sunflower and winter cereal crops. Brief descriptions of some major pests and their damage are given to help you recognise them. It is important to check crops regularly for pest and beneficial insects and to get accurate identification of insects and mites in crops.

Most insects are not pests and there are many beneficials often present in crops that help keep a range of pests under control as well as performing other ecosystem services such as pollination and nutrient cycling. These are often destroyed by use of broad spectrum chemicals. In many cases natural enemies will keep pests in check, so monitoring the dynamics of pest and beneficial populations is needed to make decisions about the necessity to intervene.

The sections Integrated Pest Management (IPM) and Pest Management in Organic Systems describes sound environmental principles to achieve economic control of pests and reduction of chemical use at the same time. These systems require a holistic approach to the farming system to be successful, but are based on having a dynamic agroecosystem.

Further information

A range of publications on managing insects and crop damage are available from the NSW DPI Publications web page, the Tocal bookshop or the NSW DPI website.

Useful books

Good Bug? Bad bug?

Crop Insects: *Northern grain belt: The ute guide*

Crop Insects: *Southern grain belt: The ute guide*

Insects: *Southern region: The ute guide*

A field guide to insects in Australia

The good bug book

Pests of field crops and pastures: identification and control

Integrated pest management for crops and pastures

Useful internet sites

Government

Department of Primary Industries, NSW

Department of Agriculture and Fisheries, Queensland

South Australian Research and Development Institute (SARDI)

Department of Primary Industries and Regional Development, Western Australia

Department of Primary Industries, Victoria

Department of Primary Industries, Parks, Water and Environment, Tasmania

Department of Industry, Tourism and Trade, Northern Territory

Australian Plague Locust Commission (Department of Agriculture, Water and the Environment)

CSIRO Entomology

Australian Museum

Pest Facts – South Eastern

Pest Facts – Victoria and NSW

PestFax (Western Australia)

The Beat Sheet (Queensland DAF)

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NSW Department of Primary Industries (www.dpi.nsw.gov.au)

NSW DPI Publications (https://www.dpi.nsw.gov.au/about-us/publications)

Tocal bookshop (https://www.tocal.nsw.edu.au/publications)

Department of Agriculture, and Fisheries, Queensland (https://www.daf.qld.gov.au/)

South Australian Research and Development Institute (www.sardi.sa.gov.au)

Department of Primary Industries and Regional Development, WA (www.agric.wa.gov.au)

Department of Primary Industries, Victoria (www.dpi.vic.gov.au)

Department of Primary Industries, Parks, Water and Environment, Tasmania (www.dpipwe.tas.gov.au)

Department of Industry, Tourism and Trade (https://industry.nt.gov.au/)

Australian Plague Locust Commission (DAWE) (https://www.awe.gov.au/biosecurity-trade/pests-diseases-weeds/locusts)

CSIRO Entomology (https://www.csiro.au/en/research/animals/insects)

Australian Museum (https://australian.museum/?gclid=EAIaIQobChMInKaNrb3L9QIVmZNmAh3zxw_6EAAYASAAEgIPuPD_BwEs)

Pest Facts – South Eastern (www.cesaraustralia.com/sustainable-agriculture/pestfacts-south-eastern)

Pest Facts – Vic and NSW (https://www.agric.wa.gov.au/apps/pestfacts-victoria-and-new-south-wales)

The Beat Sheet (Queensland DAF) (http://www.thebeatsheet.com.au)

Industry organisations and information

Grains Research and Development Corporation (GRDC)
Cotton CRDC
Australian Entomological Society
International Working Group for Diamondback Moth
Kondinin Group – Farming Ahead
Pulse Australia
Australian Oilseeds Federation
Australian Entomology Supplies
pestIQ

Beneficial insects and IPM

Bugs for Bugs
Australasian Biological Control
Biological Services
Bio Resources
Ecogrow (turf and horticultural IPM products)

Insect identification and collection

NSW Department of Primary Industries
Australian National Insect Collection
What bug is that? CSIRO
Pest and disease image library

Chemical searches

Australian Pesticides and Veterinary Medicines Authority (APVMA)
Pest Genie

Smartphone and tablet apps

Apple

Pest Genie
APVMA mobile app
Pestbook (Dupont)
Field guide to Victorian fauna
Sipcam Australia

Android

Pest Genie
Sipcam Australia

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GRDC (www.grdc.com.au)

Cotton CRDC (https://www.crdc.com.au/)

Australian Entomological Society (www.austentsoc.org.au)

International Working Group for Diamondback Moth (www.nysaes.cornell.edu/ent/dbm)

Kondinin Group – Farming Ahead (www.farmingahead.com.au)

Pulse Australia (www.pulseaus.com.au)

Australian Oilseed Federation (http://www.australianoilseeds.com)

Australian Entomology Supplies (www.entosupplies.com.au)

pestIQ (www.pestiq.com.au)

Bugs for Bugs (www.bugsforbugs.com.au)

Australasian Biological Control (www.goodbugs.org.au)

Biological Services (www.biologicalservices.com.au)

Bio Resources (www.bioresources.com.au)

Ecogrow (www.ecogrow.com.au)

Australian National Insect Collection (www.csiro.au/places/ANIC)

What bug is that? CSIRO (http://anic.ento.csiro.au/insectfamilies)

Pest and disease image library (www.padil.gov.au)

APVMA (https://apvma.gov.au/node/11841)

Pest Genie (www.pestgenie.com.au)

Pestbook (https://appadvice.com/app/pestbook/549491646)

Field guide to Victorian fauna (https://apps.apple.com/au/app/field-guide-to-victorian-fauna/id423945031)

Sipcam Australia (http://m.sipcam.com.au)

Fall armyworm now in Australia

Key information

- Fall armyworm (*Spodoptera frugiperda*) was first found in northern Queensland in January 2020; it had spread to southern New South Wales by November 2020 and has now been detected in all Australian states except South Australia (as of 24 September 2021).
- Australian biosecurity organisations have determined it is unfeasible to eradicate.
- Early detection and correct identification will help to reduce its impact.
- Fall armyworm larvae have been recorded overseas as feeding on many crop species, including maize, sorghum, pulses, winter cereals, sugar cane, rice and cotton.
- It has a strong preference for maize and sorghum crops and can be highly destructive when not controlled.
- It is a migratory species that uses prevailing winds; it can also be spread by humans on infested plant materials.
- It has become resistant to many chemicals; laboratory tests show that control is limited.
- An integrated pest management (IPM) program is the best management approach, combining carefully selected insecticides with natural enemy conservation and good agronomic practices.
- Link to *The Beatsheet* for the latest research. (https://thebeatsheet.com.au/latest-faw-research-what-to-consider-when-making-management-decisions/)
- Report any suspected sightings of the pest immediately to the **Exotic Plant Pest Hotline 1800 084 881**.

The fall armyworm (FAW) feeds on a wide range of plant species and has the potential to damage important crop species including maize, sorghum, soybean, winter cereals, peanuts and sunflowers, as well as cotton and sugarcane. It will also feed on a wide range of horticultural crops.

Later stage larvae can be highly destructive, severing seedlings, or causing defoliation or damage to reproductive structures (Figure 1 below).

FAW has a high reproductive rate and dispersive capability. Females can produce up to 2,000 eggs in their lifetime (Figure 2 below); some estimates suggest that they can travel around 100 km in a night and 500 km in a generation.

Figure 1. Late instar FAW with damage caused to the whorl of maize plants. Photo: Melina Miles, DAF Queensland.

Figure 2. Spodoptera egg mass covered with scales from the female moth. Photo: Southern Growers.

Adult moths are nocturnal and most active during warm, humid evenings. Based on overseas information, the larvae are most active during late summer and early autumn, however they can be active year-round in tropical areas.

Larvae have distinctive spots on body segments and longitudinal stripes, with a Y shaped pattern on their heads (Figure 3 – right).

Figure 3. Inverted "Y" marking in the head area; 4 large dorsal spots in a near square arrangement on second last segment.

Early identification and treatment of economically significant infestations as part of an IPM program will minimise damage to Australian crop production.

Insecticide use should be considered as part of an overall IPM program, but there is evidence that insecticide resistance in the pest's native range is widespread. Increasing the number of insecticide applications will also affect resistance levels in other species such as *Helicoverpa armigera*. Increased insecticide use will also kill the natural enemies that will assist in keeping FAW, and other pest species, in check.

No affected country has managed to eradicate the pest to date. In other countries, biological control (predators, pathogens and parasitoids) is a key component of managing this pest. Preliminary surveys of FAW populations in North Queensland have already identified a number of natural enemies in our agroecosystems attacking FAW.

Initial forecasting predicts that FAW infestations could be severe in the first few years following incursion. Existing natural enemies might take some time to adapt to this new pest. Increased pesticide use will disrupt this process.

It is likely that managing FAW will improve as industries become more confident and experienced in dealing with the pest. It is also likely that persistent populations will occur from central Queensland northwards, with annual (or sporadic) migrations further south. It is possible that southern migrations could damage early sown winter crops at establishment in some years, but if FAW follows a similar geographic range to the cluster caterpillar (*Spodoptera litura*), it is unlikely to become a major pest in Victoria, Tasmania or South Australia. Populations will not survive frosts or temperatures below around 12 °C. It is estimated that a minimum of 600 day-degrees (above 12 °C) are needed to complete a generation.

In its native range, FAW is often referred to as comprising 2 sub-populations (rice and corn strains) that look the same and can interbreed, but differ in their distribution, host plant preference and certain physiological features. Due to hybridisation, these classifications are unlikely to be useful indicators of host preference in Australia.

Table 1. Chemical products for controlling fall armyworm.

Active/Product	Efficacy on fall armyworm
chlorantraniliprole (e.g. Altacor®; Group 28)	Similar level of toxicity in *H. armigera* and FAW.
emamectin benzoate (e.g. Affirm®; Group 6A)	Similar level of toxicity in *H. armigera* and FAW.
indoxacarb (e.g. Steward®; Group 22)	Toxicity is significantly lower in FAW compared with susceptible *H. armigera*, but this is unlikely to be due to resistance and probably represents a naturally higher tolerance to indoxacarb in FAW.
synthetic pyrethroids (SPs; Group 3A)	FAW is 30–60 times less sensitive to alpha-cypermethrin and gamma-cyhalothrin compared with susceptible *H. armigera*. Based on our experience with *H. armigera* with similar levels of SP resistance, it is therefore highly unlikely that field rates of these insecticides will control FAW, even under optimal spray conditions. There is strong evidence to support metabolic (not target site) resistance to SP in FAW. Metabolic resistance is an important mechanism, which is also known to confer very high levels of SP resistance in *H. armigera*.
methomyl (carbamate; Group 1A)	There is a small but significant reduction in sensitivity to methomyl in FAW larvae compared with *H. armigera* which might result in unsatisfactory control, particularly if spray conditions are not optimal.

Diagnostic concentrations of indoxacarb, chlorantraniliprole and emamectin benzoate have now been established for detecting future changes in resistance to these insecticides.

Regular monitoring and management of FAW with selective insecticides targeted on early instars (before larvae become entrenched in whorls and ears of maize) will provide the best results. Adapted from: The Beatsheet

Further information

Plant Health Australia

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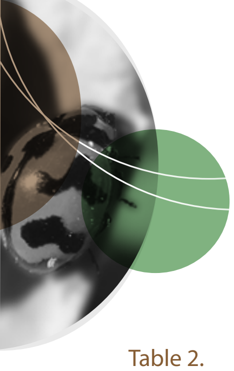
The Beat Sheet (Queensland DAF) (http://www.thebeatsheet.com.au)

Plant Health Australia (https://www.planthealthaustralia.com.au/fall-armyworm/)



Insecticide modes of action

Table 2. Insecticide modes of action. (Page 1 of 3)

Group	Activity group	Chemical grouping	Active constituent	Trade name
1A	**Acetylcholine esterase inhibitors** Inhibits the enzyme acetylcholinesterase, interrupting nerve impulse transmissions. Contact and stomach poisons.	Carbamates	aldicarb (S)	Temik®
			bendiocarb	Ficam®
			carbaryl	Carbaryl®
			carbofuran	Furadan®
			carbosulfan (S)	Marshal®
			methomyl (S)	Lannate®
			methiocarb	Mesurol®
			oxamyl (S)	Vydate L®
			pirimicarb (S) (Re)	Pirimor®
			propoxur (Rd)	Blattanex®
			thiodicarb	Larvin®
1B		Organophosphates	acephate (S) (Rd)	Orthene Xtra®
			azamethiphos (Rd)	Alfacron®
			azinphos-methyl	Gusathion®
			cadusafos	Rugby®
			chlorfenvinphos (Rd)	Birlane®, Barricade S®
			chlorpyrifos (Re)	Lorsban®
			chlorpyrifos-methyl	Reldan®
			diazinon (Re)	Diazinon 800®, Di-Jet®
			dichlorvos (Re)	Dichlorvos®
			dimethoate (S)	Rogor®
			disulfoton (S)	Disulfoton®
			ethion	Mustang®
			fenamiphos	Nemacur®
			fenitrothion	Sumithion®
			fenthion (Re)	Lebaycid®
			maldison/malathion (Re)	HyMal®
			methamidophos (S)	Nitofol®
			methidathion	Suprathion®
			mevinphos (S) (Rd)	Phosdrin®
			omethoate (S)	Le-mat®
			parathion-methyl (Re)	Folidol®
			phorate (S)	Thimet®
			phosmet	Imidan®, Poron®
			primiphos-methyl	Actellic®
			prothiofos	Tokuthion®
			profenofos	Curacron®
			temephos	Abate®
			terbufos (Rd)	Counter®
			trichlorfon	Dipterex®, Neguvon®
2B	**GABA-gated chloride channel antagonists** Interferes with GABA receptors of insect neurons, leading to repetitive nervous discharges. Contact and stomach poisons.	Phenylpyrazoles (fiproles)	fipronil (S) (Rd)	Regent®

Table 2. Insecticide modes of action (page 2 of 3).

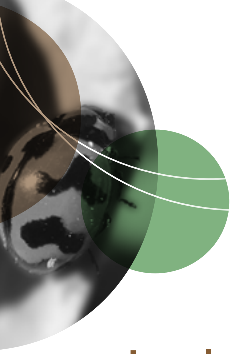
Group	Activity group	Chemical grouping	Active constituent	Trade name
3	**Sodium channel modulators** Act as an axonic poison by interfering with the sodium channels of both the peripheral and central nervous system stimulating repetitive nervous discharges, leading to paralysis. Non-systemic contact and stomach poisons.	Pyrethroids	allethrin (Re)	Roach Tox®
			alpha-cypermethrin	Fastac®, Vanquish®
			beta-cyfluthrin (Rd)	Bulldock®
			bifenthrin	Talstar®
			cyfluthrin (Rd)	Tugon®
			cypermethrin (Rd)	Scud®, Outflank®
			deltamethrin	Decis®, Coopafly®
			esfenvalerate	Hallmark®, Outlaw®
			fenvalerate	Sumifly®
			lambda-cyhalothrin (Rd)	Karate®
			flumethrin	Bayticol®
			gamma-cyhalothrin	Trojan®
			permethrin	Ambush®, Permoxin®
			resmethrin	Reslin®
			tau-fluvalinate	Mavrik®
			tetramethrin	Raid®
			zeta-cypermethrin	Python®
		Pyrethrins	pyrethrins	Mortein®
4	**Nicotinic acetylcholine receptor agonists/ antagonists** Binds to nicotinic acetylcholine receptor, disrupting nerve transmission. Systemic, contact and stomach poisons.	Neonicotinoids	imidacloprid	Confidor®
			acetamipirid	Supreme®
			thiacloprid	Calypso®
			thiamethoxam	Cruiser®
			clothianidin	Samurai®
5	**Nicotinic acetylcholine receptor modulators** Induces acetylcholine-like activity. Contact poisons.	Spinosyns	spinosad spinetoram	Success®, Extinosad®, Delegate®
6	**Chloride channel activators** Interferes with the GABA nerve receptor of insects. Translaminar contact and stomach poisons.	Avermectin	abamectin	Agrimec®, Virbamec®
			emamectin benzoate	Proclaim®
		Milbemycin	milbemycin/milbemectin	Interceptor®
7A	**Juvenile hormone mimics**	Juvenile hormone mimics	methoprene	Grain-Star®
7B			fenoxycarb	Insegar®
7C	IGR – Mimic juvenile hormones that prevent moulting from the larval to the adult stage.		pyriproxifen	Sumilarv®
8A	**Miscellaneous non-specific (multisite) inhibitors** Unknown or non-specific target site	Alkyl halides	methyl bromide	Methyl Bromide®
8B			chloropicrin	Larvacide®
8C			sulfuryl fluoride	Profume®
9B	Selective feeding blockers/disrupters	Feeding blockers/ disrupters	pymetrozine	Chess®
10A	**Mite growth inhibitors** Contact and stomach poisons that inhibit different growth stages. Some have translaminar activity.	Tetrazine	clofentezine (Rd)	Apollo®
		Thiazolidine	hexythiazox	Calibre®
10B			etoxazole	Paramite®
11	**Microbial disrupters of insect midgut membranes** Organism has protein inclusions that are released in the gut of the target pest resulting in gut paralysis and stops feeding. Includes transgenic crops expressing Bt.	Bacillus thuringiensis (Bt) microbials (biological insecticide/larvicide – dipteran specific)	Bt israelensis	Vectobac®
			Bt kurstaki	Dipel®
			Bt aizawai	Xentari®
12A	**Inhibition of mitochondrial ATP synthase** Non-systemic contact and stomach poisons.	Thiourea	diafenthiuron	Pegasus®
12B		Organotin miticides	fenbutatin oxide	Torque®
12C			propargite	Omite®
12D			tetradifon	Masta-Mite®
13	**Uncoupler of oxidative phosphorylation via disruption of H proton gradient** Translaminar contact and stomach poison.	Pyrrole compound	chlorfenapyr	Intrepid®
15	**Chitin biosynthesis inhibitors, Lepidopteran** IGR – inhibits moulting.	Benzoylureas	triflumuron	Zapp®
			diflubenzuron	Fleececare®
16	Chitin biosynthesis inhibitors, Homopteran IGR – inhibits moulting.	Thiadiazine	buprofezin	Applaud®
17	**Inhibit chitin bioysnthesis type 2 – Dipteran** IGR – systemic, interferes with pupation and moulting.	Triazine	cyromazine	Vetrazin®
18	**Ecdysone agonists** IGR – disrupts moulting by antagonising the insect hormone ecdysone.	Diacylhydrazines	tebufenozide	Mimic®
			methoxyfenozide	Prodigy®

Table 2. Insecticide modes of action (page 3 of 3).

Group	Activity group	Chemical grouping	Active constituent	Trade name
19	**Octopaminergic agonist** Non-systemic with contact and respiratory action.	Triazapentadiene	amitraz	Taktic®
20A	**Mitochondrial complex II electron transport inhibitors** Non-systemic with stomach action.		hydramethylnon	Amdro®
21A	**Mitochondrial complex I electron transport inhibitors** Contact and stomach poison.	Mite growth inhibitors	fenpyroximate	Acaban®
			pyridaben	Sanmite®
			tebufenpyrad	Pyranica®
21B		Botanical	rotenone	Derris®
22A	**Voltage dependent sodium channel blockers** Contact and stomach poison.	Oxadiazine	indoxacarb	Avatar®
24A	**Mitochondrial complex IV electron transport inhibitors**	Fumigants	phosphine	Eco2Fume®
			aluminium phosphide	Fostoxin®
			magnesium phosphide	Pestex®
28	**Ryanodine receptor modulators** Interruption of normal muscle contraction.	Diamide	chlorantraniliprole	Altacor®
			flubendiamide	Belt®
UN	**Unknown mode of action**		azadirachtin	Neemazal®
			bifenazate	Acramite®
			dicofol	Miti-Fol®

Source: CropLife Australia and CropLife International. Notes on how poisons act from *The Pesticide Manual*, 12th edition.

Contact	contact with the pest.
Stomach	the pesticide on the plant has to be eaten.
Systemic (S)	taken up by the plant. Systemic is NOT the same as residual. Systemic insecticides can have short- or long-term (residual) activity. Where only some insecticides in a group are systemic, they are marked with (S).
(Rd)	strong residual activity.
(Re)	respiratory – a volatile insecticide that kills insects as they inhale the vapour.
Translaminar	absorbed through the leaf.



Pesticides, your legal responsibilities and safety

Legal responsibilities in applying pesticides

**Farm Chemicals Section,
Biosecurity and Food Safety, NSW DPI**

The Australian Pesticides and Veterinary Medicines Authority (APVMA), NSW Environment Protection Authority (EPA), SafeWork Australia and SafeWork NSW are the government agencies that regulate pesticides in NSW.

Agricultural and Veterinary Chemicals Code Act 1994 (Commonwealth)

The APVMA administers the *Agricultural and Veterinary Chemicals Code Act 1994*. Under the Act, the APVMA is responsible for import, registration and labelling of pesticides.

States and territories regulate pesticide use.

Permits for off-label use

Where there is a need to use pesticides outside the registered use pattern, the APVMA can approve off-label use by issuing a **minor use**, **emergency** or **research permit**.

In NSW, the Pesticides Act does not allow off-label use unless the APVMA has approved a permit.

The APVMA has a list of current permits and registered products.

Any individual or organisation can apply for a permit. The APVMA can be contacted on 02 6770 2300 or enquiries@apvma.gov.au

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APVMA (https://apvma.gov.au/)

APVMA contact (enquiries@apvma.gov.au)

APVMA list of permits (https://portal.apvma.gov.au/pubcris)

The label

Chemical labels are legal documents. The *NSW Pesticides Act 1999* requires all chemical users to read and comply with label instructions.

Signal heading

Pesticides fall into 3 of the 10 schedules in the Poisons Standard. All pesticides carry a signal heading. Signal headings for pesticides include:

- Caution (Schedule 5)
- Poison (Schedule 6)
- Dangerous Poison (Schedule 7).

Re-entry intervals

The re-entry interval is the time that must elapse between applying a pesticide and re- entry into the sprayed crop, unless the person is wearing full personal protective equipment.

Pesticides and the environment

Many pesticides are toxic to aquatic organisms, bees and birds. Following label instructions will minimise the risk to off-target organisms.

Many labels carry the warning: **Dangerous to bees. DO NOT spray any plants in flower while bees are foraging**. It is often safe to spray early in the morning or late in the afternoon when bees are not foraging.

For more information, go to Pesticides and the environment (page 13).

Withholding periods (WHPs)

The withholding period (WHP) is the minimum time that must elapse between the last application of a pesticide and harvest, grazing or cutting the crop or pasture for fodder. The purpose of the WHP is to minimise the risk of residues in agricultural commodities and in foods for human and animal consumption.

Some export markets have a lower residue tolerance than Australian maximum residue limits (MRL). Contact your packing shed or buyer to determine their market requirements.

Managing spray drift

Spray drift is the physical movement of chemical droplets onto a non-target area. However, some chemicals can also travel long distances as a vapour, following spraying. There could be a risk of injury or damage to humans, plants, animals, the environment or property.

Buffer zones reduce the risk of chemical drift reaching sensitive and non-target areas. Applicators must adhere to buffer zones and other drift reduction instructions on labels.

Safety instructions

Safety instructions on labels provide information about personal protective equipment and other safety precautions that are essential when using the product.

Note: Before opening and using any farm chemical, read the label and the safety data sheet (SDS) for safety directions. The hazardous chemicals section of the Work Health and Safety (WHS) Regulation requires resellers to provide end users with an SDS.

Applying pesticides by aircraft

Product labels indicate which products are suitable for application by aircraft. They also provide a recommendation for the minimum water volume for aerial application. **Drones are also aircraft**.

More information on the legal requirements for aerial application is available on the EPA website.

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EPA website (www.epa.nsw.gov.au/pesticides/aerialapplicators.htm)

Pesticides Act 1999 (NSW)

The Environment Protection Authority administers the *Pesticides Act 1999* and Pesticides Regulation 2017, which control pesticides in NSW. The aim is to minimise risk to human health, the environment, property, industry, and trade.

The primary principle of the Pesticides Act is that pesticides must only be used for the purpose described on the product label. **Label instructions must be followed**.

The Act and Regulation require pesticide users to:

- only use pesticides registered or permitted by the APVMA
- obtain an APVMA permit if they wish to use a pesticide in a way that is not listed in the label instructions
- read the approved label and/or APVMA permit for the pesticide product (or have the label/ permit read to them) and strictly follow the directions on the label
- keep all registered pesticides in containers bearing an approved label
- prevent damage to people, property, non-target plants and animals, the environment and trade when applying pesticides.

Training

The minimum prescribed training qualification is the AQF2 competency unit, **Apply chemicals under supervision**. However, chemical users are encouraged complete the AQF3 competency units: **Prepare and apply chemicals** and **Transport, handle and store chemicals**.

Record keeping

All people who use pesticides for commercial or occupational purposes must make a record of their pesticide use.

Records must be made within 24 hours of applying a pesticide and include the:

- date, start and finish time
- operator details – name, address and contact information
- crop treated e.g. apples/oats/pulses
- property address and a clear delineation of the area where the pesticide was applied
- type of equipment used to apply the pesticide, e.g. knapsack, air blast sprayer, boom spray
- full name of the product or products (e.g. Bayfidan® 250 EC Fungicide – not just 'Bayfidan')
- the total amount of concentrate product used
- the total amount of water, oil or other products mixed in the tank with the concentrate
- size of block or paddock sprayed and order in which they were treated
- an estimate of the wind speed and direction at the start of spraying.
- weather conditions at the time of spraying and weather conditions specified on the label
- changes to wind and weather conditions during application
- records must be made in English and kept for 3 years.

SPRAY RECORD FORMS

EPA has a spray record form (epa.nsw.gov.au/resources/pesticides/130814PestFmEg.pdf)

Croplands (https://www.croplands.com.au/Products/Application-Tools/Record-Keeping/Spraywise-Log-Book#.W77HDHszayo)

Environment Protection Authority (epa.nsw.gov.au/pesticides/pestrecords.htm)

RECORD MUST BE:

- made within 24 hours of application
- written in legible English
- kept for 3 years
- pesticide users must be trained.

Globally Harmonised System of classification and Labelling of Chemicals – GHS (International)

The GHS is an international system for classifying hazards and communication information about dangerous goods and hazardous substances.

The GHS replaced the old hazardous substances and dangerous goods classification.

The SafeWork Australia website lists all the codes of practice you will need including *Labelling of workplace hazardous chemicals* and another for *Preparation of safety data sheets for hazardous chemicals* to provide industry with guidance on how to comply with the GHS.

Work Health and Safety Act 2011 (Commonwealth)

SafeWork Australia administers the *Commonwealth Work Health and Safety Act 2011* and the WHS Regulation 2011.

The Act defines the responsibilities of employers or the person conducting a business or undertaking, and workers' responsibilities.

The Regulation covers hazardous substances and dangerous goods, including applying the GHS in Australia.

SafeWork Australia has published several codes of practice for different industries and situations to provide guidance for industries.

Work Health and Safety Act 2011 (NSW)

SafeWork NSW administer the *Work Health and Safety Act 2011* and the Work Health and Safety Regulation 2011.

The Act implements the Commonwealth WHS Act in NSW. It outlines the primary responsibility of the employer or the person conducting a business or undertaking (PCBU) to maintain a safe workplace. There is emphasis on consultation with workers, risk assessment and management, and attention to worker training and supervision.

The WHS Regulation 2017 addresses hazardous substances management, including most pesticides. It covers identifying hazardous substances in the workplace, assessing and managing risks associated with their use.

The WHS Regulation *92017 includes responsibilities for managing risks to health and safety at a workplace including:

- correctly labelling containers
- maintaining a register of hazardous chemicals
- identifying risk and ensuring the stability of hazardous chemicals
- ensuring that exposure standards are not exceeded
- information, training, and supervision for workers
- spill containment kits to be kept on site
- SDS for chemicals kept on site
- controlling ignition sources and accumulation of flammable and combustible materials
- providing fire protection, firefighting equipment, emergency and safety equipment
- developing and displaying an emergency plan for the workplace
- stability, support and appropriate plumbing for bulk containers.

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SafeWork Australia (https://www.safework.nsw.gov.au/resource-library/list-of-all-codes-of-practice)

Work Health and Safety Act 2011 (WHS Act; https://www.legislation.nsw.gov.au/#/view/act/2011/10/part8/div1)

Work Health and Safety Regulation 2011 (https://www.legislation.nsw.gov.au/#/view/regulation/2017/404)

Dangerous Goods (Road and Rail Transport) Act 2008

The Environment Protection Authority (EPA) and SafeWork NSW administer the *Dangerous Goods (Road and Rail Transport) Act 2008* and Regulation. The EPA deals with transport while SafeWork NSW is responsible for classification, packaging and labelling.

This act regulates the transport of all dangerous goods except explosives and radioactive substances.

Acknowledgements

Bruce Browne, formerly Farm Chemicals Officer, Biosecurity and Food Safety,
Brian McKinnon, Lecturer Farm Mechanisation
Natalie O'Leary, Profarm Trainer

Analytical laboratories

Below is a list of commercial laboratories that analyse food commodities and other materials for chemical residues.

Eurofins Agroscience Testing
Phone 02 9900 8442

National Measurement Institute
Phone 1800 020 076
Email: info@measurement.gov.au

National Association of Testing Authorities
PO Box 7507, Silverwater NSW 2128
Phone 02 9736 8222, Fax 02 9743 5311
Email (general inquiries): corpcomm@nata.com.au

Information sources

APVMA Australian Pesticides and Veterinary Medicines Authority
Australian Code for the Transport of Dangerous Goods by Road & Rail Edition 7.7, 2020
Environment Protection Authority
Hazardous Chemical Information System
Managing risks of hazardous chemicals in the workplace
National Association of Testing Authorities
NSW DPI resources on QFF
Safe use and storage of chemicals in agriculture
Work Health and Safety Act 2011
Work Health and Safety Regulation 2011

How to complete your Pesticide Application Record Sheet

The application record form includes more than the Pesticide Regulation requires, so compulsory information is in italics below each heading.

Property/holding. Attaching a property map or line drawing, showing adjoining sensitive areas, with paddocks and other features clearly identified can be helpful. Fill in the residential address.

Applicator details. The person applying the pesticide must fill in their contact details. If the applicator is not the owner, e.g. a contractor or employee, then the owner's details must also be completed. In the case of a contractor, one copy of the record should be kept by the applicator and another given to the owner.

Sensitive area identification. If there are sensitive areas, either on the property or on land adjoining, these should be identified in advance, and marked on the sensitive areas diagram, together with any precautions or special instructions. When using a contractor or giving the job to an employee, this section should be filled in and given to the person doing the application BEFORE the job starts. The property map with sensitive areas marked should be shown to them, and the job fully discussed.

Paddock identification. Identify the paddocks/blocks and order of treatment (if there is more than one) in the 'paddock' row of the form. This should be filled in before starting application, along with the residential address. If using a contractor or employee, this information should also be given to them BEFORE they start the job. Applicators using GPS systems could include a GPS reading as well as the paddock number/name.

Crop/animal identification. The left hand side of the Crop/situation section of the table is for crops, pastures and plants (non-crop, e.g. bushland and fallow), the right hand side for animals. As a minimum, identify the host (crop/situation) and the weed. It would be helpful to provide as much detail about the weed as possible, e.g. 4 leaf. Additional details such as crop variety and growth stage are often important for quality assurance schemes, but could also be necessary to positively identify the area treated as required by the Regulation.

Product details. Transcribe the product name and rate or dose from the label, including all products and additives included in tank mixes. If the use pattern is on a permit, include the permit number, expiry date and label details. A permit rate or dose might vary from the label. Water rate might come from the label, or from your standard practice or calibration. The total litres (L) or kilograms (kg) can be calculated when the application is finished.

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Eurofins Agroscience Testing (https://www.eurofins.com.au/locations/eurofins-agroscience-testing-lane-cove/)

National Measurement Institute (https://www.industry.gov.au/strategies-for-the-future/national-measurement-institute)
Email: info@measurement.gov.au

National Association of Testing Authorities (https://www.nata.com.au)

APVMA (www.apvma.gov.au)

Australian Code for the Transport of Dangerous Goods (https://www.ntc.gov.au/sites/default/files/assets/files/ADG-Code-7.7.pdf)

EPA (www.epa.nsw.gov.au/)

Hazardous Chemical Information System (HCIS; http://hcis.safeworkaustralia.gov.au/)

Managing risks of hazardous chemicals in the workplace (https://www.safeworkaustralia.gov.au/doc/model-code-practice-managing-risks-hazardous-chemicals-workplace)

NSW DPI resources on QFF (https://www.dpi.nsw.gov.au/biosecurity/insect-pests/qff)

Safe use and storage of chemicals in agriculture (http://www.safework.nsw.gov.au/__data/assets/pdf_file/0004/52870/Safe-use-and-storage-of-chemicals-including-pesticides-and-herbicides-in-agriculture.pdf)

Work Health and Safety Act 2011 (https://www.legislation.gov.au/Details/C2017C00305)

Work Health and Safety Regulation 2011 (https://www.legislation.gov.au/Details/F2011L02664)

EPA application record form (https://www.epa.nsw.gov.au/your-environment/pesticides/compulsory-record-keeping)

Withholding periods. (WHP): Labels often have a number of different withholding periods. They may be different harvest WHP for different crops, grazing WHP or Export Slaughter Interval (ESI). All WHP's are the minimum number of days after treatment before harvest, grazing or livestock slaughter for export markets can take place.

Equipment details. As a minimum, you have to fill in what equipment you used. Specifying the setting used for the application can help positive identification, e.g. nozzle type and angle, and pressure. The nozzle type will usually include the angle. With pressure, the reading should be as close to the nozzle as possible. Other details e.g. date of calibration and water quality, are useful as a reminder for future use, or as a check on your set-up should you have a treatment failure. Water quality is important for pesticide efficacy. At the most basic level, water quality can be described in terms of its source, e.g. rainwater, dam water, bore water.

Weather. As a minimum, you have to record wind speed and direction. It is better to measure with instruments than estimate. Record any changes during application.

You must also record the time when you started, and the time when you finished.

You will need to record weather information for all equipment that distributes pesticide through the air.

Rainfall should be recorded for the 24 hours before and the 24 hours after application, unless a different figure is given in the restraints or critical comments sections of the label. Rainfall before or after application can affect efficacy.

Temperature and relative humidity should also be recorded, particularly if either or both are referred to in the restraints or critical comments sections of the label. Temperature and relative humidity can affect efficacy, increase the risk of off-target drift or could damage the host (e.g. phytotoxicity) or a combination of all three.

Pesticides and worker safety

Pesticides can have both immediate (acute) effects and chronic (long term) effects on the health of people who are exposed to them.

Acute toxicity

The acute or immediate toxicity of a farm chemical is reflected in the Poisons Schedules or poison warnings which appear on the pesticide product label. Acute toxicity is assessed in terms of the potential of the active ingredient of the chemical to poison an individual by the route of exposure which is most lethal, e.g. oral ingestion.

Chronic toxicity

The effects of long-term exposure to small doses of chemical is referred to as chronic toxicity. Some of these chronic toxicity effects include:

- neurotoxic effects – on the brain and central nervous system;
- reproductive;
- carcinogenic – cancer causing, and
- endocrine disruption.

The best way to manage any long term risks of chronic pesticide effects is to minimise exposure by following all the directions on pesticide labels.

Signal warnings on pesticide labels

Schedule 5	**Caution** – Substances with a low potential for causing harm, the extent of which can be reduced through the use of appropriate packaging with simple warnings and safety directions on the label.
Schedule 6	**Poison** – Substances with a moderate potential for causing harm, the extent of which can be reduced through the use of distinctive packaging with strong warnings and safety directions on the label.
Schedule 7	**Dangerous Poison** – Substances with a high potential for causing harm at low exposure and which require special precautions during manufacture, handling or use. These poisons should be available only to specialised or authorised users who have the skills necessary to handle them safely. Special regulations restricting their availability, possession, storage or use may apply.

If you suspect a poisoning, contact the NSW Poisons Information Centre emergency phone (24 hour)
131 126

RECORDS MUST INCLUDE:

- the full product name
- a description of the crop or situation
- the rate of application and quantity applied
- a description of the equipment used
- the address of the property, identification of the area treated and order of paddocks treated
- the date and time of the application (including start and finish)
- the name, address, and contact details of the applicator and of the employer or owner if an employee or contractor is the applicator
- the estimated wind speed and direction (including any significant changes during application)
- other weather conditions specified on label as being relevant (e.g. temperature, rainfall, relative humidity).

Pesticides and the environment

Most insecticides are toxic to aquatic organisms, bees and birds. Fungicides and herbicides are relatively safe to bees in terms of their active ingredients, but their carriers and surfactants can be toxic. The risks that a particular product poses to the environment are reflected in statements on the label under headings such as ‘Protecting wildlife, fish, crustacea and the environment’.

Protecting the aquatic environment

The risk to aquatic organisms can be managed by:

- preventing drift into surface waters during application
- locating mixing/loading and decontaminating facilities away from surface waters and providing those facilities with bunding and sumps to prevent neither concentrate nor rinsate moving into surface waters
- installing valves that prevent back-flow when filling spray tanks from surface waters, and in suction lines for chemigation systems that draw directly from surface waters
- avoiding aerially applying spray onto fields under irrigation
- building sufficient on-farm storage capacity (including provision for storm run-off) to contain pesticide-contaminated tailwater from irrigation
- spraying in an upstream direction, when it is necessary to spray near surface waters, to reduce the maximum concentration at any one point in the watercourse
- using only registered products to control aquatic weeds, e.g. Roundup Biactive® rather than Roundup®
- not disposing of used containers in surface waters and on flood plains and river catchments.

Protecting bees

Many pesticides are toxic to bees and can damage the hive productivity if the bees or hives are contaminated. Some pesticides are particularly toxic to bees and are identified with the following special statement on the label.

Dangerous to bees.

DO NOT spray any plants in flower while bees are foraging.

Reduce the pesticide risk to bees by:

- applying pesticides toxic to bees early in the morning or in the evening when bees are not foraging
- notifying the apiarist to allow hives to be removed from the crop’s vicinity before spraying
- using, where possible, emulsifiable concentrates and granular formulations in preference to wettable powders, which are particularly hazardous to bees. Note that micro-encapsulated formulations such as that used for methyl parathion are particularly hazardous to bees because of their persistence in the environment and because bees transport the micro-capsules back to the hive along with the pollen
- using ground rigs in preference to aerial application to minimise drift, especially when crops and adjacent plants are flowering
- avoiding drift and contaminating surface waters where bees might drink (see Protecting the aquatic environment above).

Figure 4. Flowering canola is an important food source to maintain healthy beehives; regular communication between growers and beekeepers is essential to avoid damage to hives.

Protecting birds

The organophosphate and carbamate insecticides can be particularly toxic to birds, especially in granular formulations. Bird kills from diazinon have been well documented in Australia and overseas. Insecticidal seed dressings can pose similar risks. Just a few treated seeds and pesticide granules can be lethal to birds. Spillages can also be very hazardous to birds as they can easily ingest a toxic dose from a small area.

Manage risks to birds from granular products by:

- ensuring complete incorporation beneath the soil surface, particularly at row ends where spillage can occur
- immediately clean-up spillage, however small.

Bait materials for rodent or soil insect pest control can also be hazardous to birds, either through directly consuming the bait or from feeding on bait-affected animals or pests.

Manage the risks to birds from baits by:

- ensuring even bait distribution, with no locally high concentrations
- not baiting over bare ground or in more open situations, such as near crop perimeters, where birds can see the baits
- not baiting near bird habitat such as remnant native vegetation
- using bait stations that prevent access by birds, particularly near bird habitat
- only baiting where pest pressure is high
- baiting late in the evening when birds have finished feeding
- promptly collecting and burying rodent carcasses when in open situations
- immediately cleaning up spillage, however small.

Insecticide sprays can also be hazardous to birds, either because of direct contact with the sprayed chemical, or by feeding on sprayed insect pests or crops. Even where birds are not killed, they can be sufficiently affected to make them more vulnerable to predation. Contaminated seed and insects collected from sprayed fields by parent birds can also be lethal to young chicks still in the nest.

Manage risks to feeding and nesting birds by:

- minimising drift into remnant vegetation, wildlife corridors, nesting sites, or other bird habitats
- actively discouraging birds from feeding in crops that are to be sprayed
- spraying late in the day when birds have finished feeding
- using only low toxicity chemicals when large concentrations of birds are nesting nearby.

Carefully consider whether or not to use a pesticide in the first place.

All pests are associated with a range of natural enemies that are often capable of reducing pest populations below the economic thresholds, where pests are affecting the yields or produce quality.

Many cultural controls, e.g. earlier or later crop sowing to avoid pest occurrence, using seed dressing products rather than topical sprays to avoid contact with non-target organisms can be used effectively.

Using specific chemicals that only affect the pest, rather than broad-spectrum products, is preferable. If it is considered absolutely necessary to use a chemical treatment the best way to manage any long-term adverse environmental risks is to follow the protection statements on labels, minimise spray drift, and to dispose of chemical containers and waste in accordance with label directions and codes of practice.

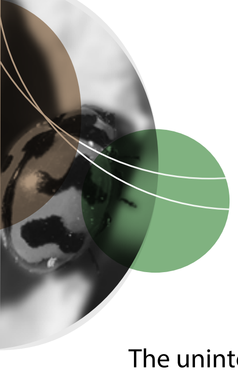
GO TO WEB PAGES

Spray drift (https://apvma.gov.au/node/10796)

Practical tips for spraying (https://grdc.com.au/resources-and-publications/all-publications/factsheets/2014/08/practical-tips-for-spraying)

Further information

APVMA Spray drift
GRDC Practical tips for spraying



Protecting honeybees from harmful insecticides

The unintended consequence of spraying for grain pests could be the loss of beehives and pollination services in oilseed and horticultural crops, particularly almonds.

During cold winter months, bees have relatively low food reserves.

When crops such as canola begin flowering, honeybees are moved in to pollinate and to exploit the excellent source of nectar. From mid August onwards, hives are moved into almond orchards and other horticultural tree crops where they play a critical role in pollination.

The accidental poisoning of bees can cause bee colonies to collapse, followed by the loss of pollination services to both grains and horticultural industries and the loss of income for apiarists.

Foraging habits of honeybees

Bees become active at temperatures ranging from about 13 °C to 37 °C, with an optimum range of 19 °C to 30 °C. When temperatures allow, they can be active from about 8 am to 4 pm. In late winter and early spring, most foraging occurs between 10 am and 3 pm when temperatures are above about 15 °C.

Bees typically forage within 2–4 km of their hive, but can travel up to 7 km in search of pollen and nectar when nearby pollen and nectar sources are in short supply or are poor quality.

Because flowering canola is so attractive to honeybees, it is highly likely that bees from hives situated many kilometres away will be foraging in canola crops when temperatures exceed 15 °C.

Pesticides hazardous to bees

Most insecticides registered in Australia for oilseed and pulse crops will kill honeybees.

The registered carbamates (except pirimicarb) (Group 1A), organophosphates (Group 1B), synthetic pyrethroids (Group 3A), neonicotinoids (Group 4A), sulfloxaflor (Group 4C), spinetoram (Group 5), emamectin benzoate (Group 6), and indoxacarb (Group 22A) are either toxic or highly toxic to honeybees after direct contact with spray or dust.

For neonicotinoids the Australian Pesticides and Veterinary Medicines Authority (APVMA) reports that:

> Australian honeybee populations are not in decline and Australia has robust regulatory and surveillance measures to monitor … the link between the use of neonicotinoids and declining health of honeybees. All neonicotinoids registered for use in Australia are considered safe and effective – provided products are used as per the label instructions.

Some surfactants are also toxic to bees and, when mixed and sprayed with bee-safe chemicals, can cause bee poisoning. In Australia, surfactants and other adjuvants are regarded as pesticides in their own right.

Some insecticides such as *Bacillus thuringiensis* (Bt), *Nuclear polyhedrosis virus* (NPV) and pirimicarb have a very low impact on bees.

Insecticides known to be hazardous to bees generally contain a warning on the label under '**Protection of Livestock**'. This is a mandatory instruction –'DO NOT spray any plants in flower whilst bees are foraging'.

This mandatory instruction applies to both the target crop and any flowering weeds throughout the target crop and/or within the surrounding headland buffer zone. This means that in most instances, spraying insecticides on canola while in flower during daylight where temperatures exceed 12–15 °C could be both illegal and potentially hazardous to beehives within 7 km.

The insecticide risk

Honeybee poisoning may occur when:

- an insecticide is applied directly to a flowering crop
  - while bees are foraging
  - where bees subsequently forage on contaminated nectar, pollen or water
  - when bees land on a contaminated plant part
- an insecticide is applied to a crop not in flower, but is also applied to non-target flowering plants such as weeds
- insecticide drifts
  - onto bees
  - onto flowering plants
  - onto hives
  - onto the bees' water source
  - within the bees' flight path
- a worker bee carries contaminated nectar, pollen or water back to the hive, contaminating the colony
- two or more insecticides are combined, which although might be bee safe in their own right, could be harmful to bees when mixed.

Being proactive to reduce the risk of honeybee poisoning

Choice and use of insecticides

- Growers should note product warnings when reading the label,when planning a spray application and when spraying.
- Understand the residual risk to bees. Microencapsulated forms of insecticides have significantly longer residual toxicity than other forms.
- Select chemicals that pose the lowest risk to bees with the lowest residual toxic effect yet still achieve the required outcome for the crop.
- Chemicals vary in the period of residual toxicity. Bees should not be moved into a crop that was treated pre-flowering until the residual toxicity has dissipated. Similarly, bees moved from an area to be treated should not be returned until it is safe to do so.

Conditions for spraying

- Before spraying, ensure that bees are not foraging in the target area. This is a condition of many product labels and is therefore a legal requirement. Monitor the target crop and area to determine:
  - if flowering plants are present in the target crop, including the target crop and/or weeds throughout the target crop and/or within the surrounding headland buffer zone
  - if honeybees are on flowering plants at 4 locations including those close to native vegetation, areas of flowering weeds, the edge of the crop and some distance into the crop.
- Where possible, if you have to apply insecticides harmful to bees, do so in the evening when bees are not foraging.
- Choose appropriate spraying conditions to reduce the chance of spray drift affecting non-target flowering crops, hives, and water sources.
- Use a kestrel anemometer to measure wind speed rather than estimating it.

Communication

- Contact the owners of any beehives in the area well before spraying so that they have an opportunity to relocate or protect their hives. Also consider owners of hives on adjacent properties.
- Beekeepers require as much notice possible, preferably 48 hours, to move hives.

If using spray contractors, inform them of the location of any hives that could be affected and ensure that they understand the importance of reducing the risk of honeybee poisoning.

These communications can be facilitated through the BeeConnected website. This initiative connects registered beekeepers with registered farmers and contractors, enabling two-way communication on hive location and proposed pesticide activities.

Adapted from PestFacts south-eastern.

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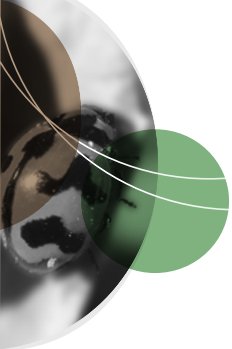
More information: Cesar Australia, *PestFacts*; south-eastern (https://cesaraustralia.com/pestfacts/)

BeeConnected (https://beeconnected.org.au/)



Insecticide resistance management

Resistance

'Resistance' is when a pest species has developed a strain that is no longer controlled by a previously successful chemical. The level of resistance can vary markedly between species and also between strains or populations of the same species found in different localities. Resistance can be localised or general.

In cases where the level of resistance is high, pest populations can be unaffected by many times the normal rate of application. All resistance has a basis in genetic changes within the population.

Genetic resistance

Genetic resistance occurs naturally within any population and can be transferred from one generation to the next. Continuing to use a single pesticide, or pesticide group, with a common mode of action over several generations will 'select' for resistance. 'Select' means that while most pests will be killed, a small number will survive (resist the chemical) and reproduce, their proportion increasing with each generation.

Economic damage

The main consideration with resistance in insects and other pest organisms is the high numbers in any population and the short lifespan of the generations measured against cropping seasons. Because of the vast numbers that can proliferate in favourable conditions over one season, even small percentages that are resistant can be economically destructive. For example, a 5% resistance level in a population of 1000 pests per square metre under normal conditions would only amount to 50 individuals, which probably would not cause serious damage. If favourable conditions increased the population to 10,000/m^2, the same 5% would amount to 500 individuals, at which point the damage can become significant.

Similarly, selection pressure means the proportion of resistant individuals compounds from generation to generation. If there were 3 generations of an insect in a growing season this would give 15 generations in 5 years. With a treatment regime reliant upon a single chemical or group of chemicals, the original 5% would compound dramatically over the 5 years (commonly by a factor of more than 10), creating a substantial proportion of resistant organisms ($10 \times 5\% = 50\%$).

Fast-developing resistance

Resistance can develop surprisingly quickly following the introduction of a new chemical. At first, the chemical is highly effective, achieving an apparent 100% kill. Because it is so effective, the farmer uses nothing else. As the chemical begins losing its effectiveness, the farmer either increases the rate of application or the frequency of application or both. **While a natural response, this is the worst thing to do**. This will make the pests more resistant more quickly and increase the proportion of resistant pests.

DO✓✓✓

- change the chemical group used
- investigate alternative methods of control such as biological options
- target a specific, susceptible, part of the life cycle.
- use unsprayed refuges to attract non-resistant pests to dilute the resistant population.

DON'T!! ✗ ✗ ✗

- increase the chemical's rate
- increase application frequency
- use a chemical from the same group.

What you can do to avoid or delay resistance

Susceptible individuals migrating from other areas can dilute resistant pest populations in the field, e.g. insects on crops. In other words, the resistant and non-resistant populations can mix. Unsprayed refuges are planted for this purpose.

In highly resistant organisms, it is critical to kill as many as possible in the one treatment. For this reason, timing and rate are very important when using chemicals, to target the most susceptible stage of development. Alternative controls at susceptible life cycle stages should be considered.

To delay resistance development when using chemicals in either rotation or combination, it is important that the 2 chemicals complement one another. If the pests are resistant to the first chemical, the second chemical must be capable of killing the survivors. If there is resistance to the second chemical also, then it will only select for a highly-resistant population of survivors, thereby not solving the problem but making it worse.

Adapted from : SMARTtrain *Chemical Risk Management Reference Manual*.

Heliothis resistance management strategy

Corn earworm (*Helicoverpa armigera*) has developed resistance to the pyrethoid chemical group. e.g. decis options®, Karate®, and the carbamate group, e.g. Lannate® L. However, very small caterpillars (up to 5 mm long) can still be controlled with these and other pesticides. New chemical groups are now available for controlling *H. armigera*, but often control is slower.

H. armigera caterpillars are found in all irrigation areas. Their main activity is in summer and autumn. Local overwintering pupae are the main source of new infestations each year. The following strategies are recommended across all grain industries. In cotton growing regions check that these strategies are consistent with the Insecticide resistance management strategy for cotton.

Destroying the overwintering pesticide-resistant pupae

Corn earworm overwinters as pupae in the soil under crop stubble and moths emerge from the pupae in the following spring. Insecticide resistance is carried over between seasons in the pupae.

- Where large heliothis caterpillars are present in crops during March, resistance carryover is a risk to the next season. Cultivate these paddocks to destroy the pupae as soon after harvest as possible and complete by the end of August.
- Check no-till late season crops for pupae. Consider busting if detectable numbers (one pupae per 10 m^2) are present.
- Ensure cultivation creates full disturbance to at least 10 cm deep as follows:
  - on hills: to 10 cm each side of the plant line
  - on beds: right across the bed to 20 cm beyond the outside rows
  - on the flat: the whole area.

Scout crops regularly

Infestations are often associated with heavy rainfall.

- Monitor crops twice weekly during heliothis danger periods to detect eggs and very small (up to 5 mm long) caterpillars.
- Discuss monitoring strategies with an experienced agronomist:
  - moth activity alone cannot be taken as a guide for spraying
  - eggs are not readily seen with the naked eye because they are small and often hidden.
- Pay closer attention to late season *H. armigera* activity on susceptible crops (cotton, summer pulses, late sorghum and late sunflower).

Spray eggs and very small caterpillars

Egg laying is usually confined to the period from flower bud formation (or head-emergence/tasselling) until flowering ends. At 25 °C it takes 8–10 days from egg lay to 5 mm long caterpillars.

- Spray to control the eggs and very small (up to 5 mm long) caterpillars. It is important that the chemical contacts the eggs and caterpillars.

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Insecticide resistance management strategy (https://www.cottoninfo.com.au/publications/stewardship-insecticide-resistance-management-strategy)

Resistance: redlegged earth mite in Australian grains and pastures (https://grdc.com.au/resources-and-publications/all-publications/factsheets/2018/06/resistance-management-strategy-for-the-redlegged-earth-mite-in-australian-grains-and-pastures).

Resistance: green peach aphid in Australian grains and pastures (https://grdc.com.au/resources-and-publications/all-publications/factsheets/2015/07/grdc-fs-greenpeachaphid).

Resistance: diamondback moth in Australian canola (https://grdc.com.au/__data/assets/pdf_file/0024/244239/GRDC-Factsheet-Resistance-Management-Strategy-For-Diamondback-Moth-In-Australia-Canola.pdf?utm_source=website&utm_medium=download_link&utm_campaign=pdf_download&utm_term=National&utm_content=Resistance%20Management%20Strategy%20For%20Diamondback%20Moth%20In%20Australian%20Canola).

Resistance: Helicoverpa armigera in Australian grains (https://grdc.com.au/resources-and-publications/all-publications/publications/2018/resistance-management-strategy-for-helicoverpa-armigera-in-australian-grains).

IPM guidelines: Insect resistance management strategies (http://ipmguidelinesforgrains.com.au/ipm-information/resistance-management-strategies/).

Table 3. Comparison of *Helicoverpa* species (resistance levels, crops and seasonality).

	Corn earworm	Native budworm
Insecticide resistance	Moderate to high levels of resistance to many insecticides, but: very small caterpillars (up to 5 mm long) can still be controlled larger caterpillars are unlikely to be controlled.	No resistance. Large caterpillars (larger than 5 mm) can be controlled provided the correct rate is used.
Crops attacked	Azuki bean, chickpea, cotton, maize, millet, navy bean, sorghum, soybean and sunflower.	Canola, chickpea, cotton, faba bean, field pea, linseed, lupin, lentil, safflower, soybean, sunflower, and winter cereals. Lucerne. Occasionally azuki bean and navy bean.
Seasonal behaviour	Found in all irrigation areas. Main activity is in summer and autumn. Local overwintering pupae are main source of new infestations each year.	Found in all irrigation areas. Main activity is in spring and early summer. Spring infestations originate from moths blown in from semi-arid inland areas. Local overwintering pupae are of little importance.

Table 4. *Helicoverpa* species crop monitoring.

Crop	Egg laying sites
Azuki bean and navy bean	Mainly on the upper leaves and on the flowers.
Lucerne	Upper leaves, flower buds and flowers.
Maize	Upper two-thirds of the plant – on the stems, leaves (both sides), but predominantly on tassels, silks and husks.
Millet and sorghum	Upper leaves and stems, but predominantly on flower heads.
Soybean	The terminals at budding and flowering stages, flower buds and flowers.
Sunflower	On the leaves and bracteoles surrounding and close to the developing flower head.

Pesticide management

- Conserve beneficials by using the most selective pesticide available, including using *Nuclear polyhedrosis virus* (NPV) products (e.g. Vivus Max) appropriately.
- Monitor natural enemies and be aware that their activity varies in crop types. For example, they are not very active in chickpea.
- Delay using disruptive pesticides (pyrethroids, carbamates and organophosphates) in all crops for as long as possible. Review spraying threshold figures as a guide to spray timing.
- Where *Helicoverpa* populations are present and above the threshold, control them within the limits of insect resistance and available registrations.
  - Ensure spray applications are accurate and timely.
  - Do not spray in the heat of the day.
  - Use an NPV product e.g. Vivus Gold® where appropriate to reduce selection for insecticide resistance, but caterpillars must be small (5–10 mm); it must be applied in the evening, and there should be no rainfall within 24 hours. Apply NPV as high volume spray (with a wetting agent) at 30 L/ha aerially or 100 L/ha with a ground rig.
- Biopesticides have an increasingly important role to play in managing *Helicoverpa* spp. in grain crops. NPV and *Bacillus thuringiensis* (Bt) can be effective pesticides, but are often not robust enough to handle high density infestations, a large range of larval sizes and persistent egg lays.
- Milk powder additives such as Denkavit® at 1 kg/ha improve NPV and Bt performance on chickpea and other crops. Bio assays on mungbeans and cotton have shown that Amino-feed®, a liquid additive, is the equivalent of milk powder additives and gives fewer problems with mixing and blocked nozzles.
- Rotate chemical groups when spraying crops. If you have to spray more than once, use a pesticide from each of the 3 available groups (organochlorines, synthetic pyrethroids and carbamates) in rotation. Never apply 2 consecutive sprays from the same chemical group. For example, if a pyrethroid is used to control sorghum midge do not use a pyrethroid to control heliothis.
- Remove all farm vegetation likely to encourage insect pest breeding. For example as soon as the decision has been made to abandon the crop, destroy it by cultivation or by using herbicides. Avoid sowing commercial chickpea crops after June. Late flowering crops are a known host for the next generation of *H. armigera*.
- Use ovicide rates of pesticides only where crops are monitored regularly for eggs and larvae and where eggs are targeted.
- Use larvicide (highest) rates where there is no regular crop monitoring and where larvae are targeted.

Use information from pheromone traps

During August, September and October pheromone traps will be in place in some districts. Information from these will indicate whether more detailed sampling of spring host crops (e.g. winter cereals, pulses and weeds) is necessary.

- Advisors or growers wanting assurance on the numbers of corn earworm moths laying eggs in their crops should catch moths in a sweep net and determine their identity. (Moths collected in pheromone traps are a poor indicator of which species of larvae will predominate in crops.)
- As a guide, catch a total of at least 30 heliothis moths at random throughout the crop and on flowering weeds in the paddock (ignore the other moths such as tobacco loopers, brown cutworms and common armyworms – that might fly in company with the native budworms).

Further information

Resistance management strategy for the redlegged earth mite in Australian grains and pastures.

Resistance management strategy for the green peach aphid in Australian grains and pastures.

Resistance management strategy for diamondback moth in Australian canola.

Resistance management strategy for Helicoverpa armigera in Australian grains.

IPM guidelines: Insect resistance management strategies.

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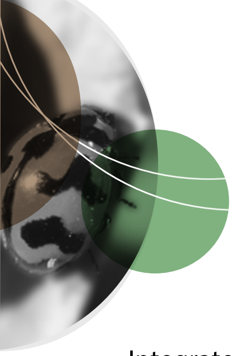
Resistance management strategy for the redlegged earth mite in Australian grains and pastures. (https://grdc.com.au/resources-and-publications/all-publications/factsheets/2018/06/resistance-management-strategy-for-the-redlegged-earth-mite-in-australian-grains-and-pastures)

Resistance management strategy for the green peach aphid in Australian grains and pastures. (https://grdc.com.au/resources-and-publications/all-publications/factsheets/2015/07/grdc-fs-greenpeachaphid)

Resistance management strategy for diamondback moth in Australian canola. (https://grdc.com.au/__data/assets/pdf_file/0024/244239/GRDC-Factsheet-Resistance-Management-Strategy-For-Diamondback-Moth-In-Australia-Canola.pdf?utm_source=website&utm_medium=download_link&utm_campaign=pdf_download&utm_term=National&utm_content=Resistance%20Management%20Strategy%20For%20Diamondback%20Moth%20In%20Australian%20Canola)

Resistance management strategy for Helicoverpa armigera in Australian grains. (https://grdc.com.au/resources-and-publications/all-publications/publications/2018/resistance-management-strategy-for-helicoverpa-armigera-in-australian-grains)

IPM guidelines: Insect resistance management strategies. (http://ipmguidelinesforgrains.com.au/ipm-information/resistance-management-strategies/)



Integrated pest management

Integrated pest management (IPM) is a system that uses a range of control tactics to keep pest numbers below the level where they are causing economic damage. It is primarily based around biological pests controlled either by encouraging natural enemies or releasing biocontrols.

Other methods of control that support these biological controls can include:

- cultural methods, which include farm hygiene, weed control, strategic cultivation (pupae busting) physical barriers, quarantine areas, different planting times, crop rotations, trap crops, using attractants for beneficials or repellants for pests, and keeping plants healthy so they resist attack
- host plant resistance such genetically resistant varieties or physical features that repel pests
- genetic control measures such as releasing sterile male insects
- pheromones to confuse mating or aggregation
- using microbial pesticides such as *Bacillus thuringiensis* (Bt), Nuclear polyhedrosis virus (NPV) or *Metarhizium*.
- manipulating micro-environmental conditions to make it less suitable for pests or more suitable for beneficials (planting density, row spacing, row orientation)
- using chemicals as a last resort; use 'soft' chemicals or pest-specific chemicals in preference to broad-spectrum pesticides, especially early in the growing season when it is important to preserve beneficials.

IPM relies on monitoring the crop regularly, correctly identifying pests and beneficial insects, and making strategic control decisions according to established damage thresholds.

Many growers are adopting aspects of IPM and are increasingly aware of the effects chemicals can have on the environment and their negative effects on beneficial invertebrates. In general, there is an attitude to increase IPM adoption; use fewer insecticides, manage resistance risk and improve knowledge of beneficial invertebrate species and the roles they play in cropping systems. Some growers perceive the costs and complexity of adopting IPM in a multi-pest system as a major barrier. The relationships between agronomic practices, pests, agrichemical use and the role of beneficials are complex and often incur higher short-term operational costs than the sole use of insecticides. These are the constraints to the uptake of IPM among growers.

IPM can be a more complex process than other pest reduction systems. Given that an IPM approach seeks to draw on a variety of control practices to manage (but not necessarily eliminate) pests, taking small steps to reduce insecticide usage is a good place to start, particularly in the context of resistance management. Growers who use IPM often start on a smaller scale, splitting off an area of the property where they may test IPM principles in a low-risk situation and increasing the scale as knowledge and confidence grows.

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Metarhizium spp. (https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/metarhizium) in the order Hypocreales (https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/hypocreales), family Clavicipitaceae (https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/clavicipitaceae) are best known as insect pathogens

Area wide management

Area wide management (AWM) is basically IPM that operates over a broad region and attacks the pest when and where it is ecologically weakest without regard to economic thresholds. It is a system currently used in managing resistance in *Helicoverpa armigera* in cotton. AWM coordinates farmers implementing management strategies on their own farms to control local populations of *H. armigera* and prevent high numbers building up later in the season. AWM strategies involve a detailed understanding of the pest's biology and life cycle and how it moves around in a region.

Strategies can include:

- coordinating operation timing such as pupae busting
- sowing and destroying trap crops
- spraying certain chemical types including soft or biological insecticides.

Biological control

Biological control can simply be defined as using natural enemies to control pest outbreaks, where the pest is not usually eradicated, but brought down to levels where it is not causing economic damage.

Biological control success has been varied in many situations. Complete success, where the pests do not exceed the economic thresholds, have only occurred in <20% of cases. Many biocontrol agent releases have had no significant effect. There have been more successes in long-term agro-ecosystems such as orchards and forests where pest and natural enemy populations are more stable.

In annual cropping systems maintaining resources promote building up natural enemies to help keep pest in check, include:

- greater plants biodiversity
- retaining stubble and groundcover
- limiting broad spectrum insecticide use.

Types of biological control include:

- **Natural**. An already existing control agent is encouraged to control pests. This means avoiding using chemicals that can destroy these control agents.
- **Single release (classical)**. The control agent is released aiming to establish it as a permanent part of the ecosystem. This is usually carried out for introduced pests.
- **Multiple release**. Here the control agent is not usually perfectly adapted to the environment (e.g. drought or frost intolerant) and so needs to be re-released. This could be to:
  - top-up numbers after unfavourable conditions
  - as a regular seasonal release
  - or to flood the crop where the control agent does not survive well. In this case, the agent is used as a living insecticide released in large numbers to reduce pest numbers before the agent dies.

Biological control agents for insect pests can include:

- **Predators**. These actively capture their prey. Beetles, lacewings, bugs, flies, spiders and vertebrates are predators (Figure 5).
- **Parasitoids**. These are host specific and need only one host to complete their life cycle. They lay eggs in their host and insects emerge after using the host as a food source. The host is nearly always killed. They differ from parasites which will co-exist with the host. Parasitoids include wasps such as the parasitic wasp which will lay eggs inside lucerne aphids, white cabbage moth caterpillars and scarab larvae, and flies, such as the technid fly.
- **Pathogens**. These include bacteria, viruses, fungi, protozoa and nematodes. A few of these organisms can enter and multiply rapidly within the host, e.g. *Metarhizium*, Bt and NPV.

Parasite control agents are usually more successful than predators because they are more host specific.

Table 5. Examples of biological control

Pest targeted	Biological control
Heliothis	*Trichogramma pretiosum*
	Bacillis thuringiensis
	Nuclear polyhedrosis virus
Diamondback moth	Egg and larval parasitoids
Other moth species	Predatory bugs and beetles
	Green lacewings
Loopers	*Trichogramma pretiosum*
Aphids	Green lacewings
	Mallada signata
	Aphid parasitoides
	Ladybeetles
	Hoverflies
Green vegetable bug	*Trissolcus basalis*
	Trichopoda
	Predatory bugs
Two spotted mite	*Phytoseiulus persimilis*
	Predatory mites
	Stethorus beetles

Figure 5. Hoverfly larvae attack and eat aphids.

Trichogramma wasps

Trichogramma pretiosum wasps prey on the eggs of a range of insect larvae pests including:

- *Helicoverpa* spp.
- loopers
- cabbage moths

and are suitable for use:

- in minimally sprayed field crops
- in sweet corn
- in vegetables
- for heliothis in fruit crops.

It is a tiny wasp less than 0.5 mm long and lays its eggs into moth eggs. The wasp larva develops into a fully formed wasp inside the moth egg, killing the developing insect larva in the process.

As a biocontrol, *Trichogramma* are despatched in the form of parasitised moth eggs. The eggs are distributed in capsules and are sold by the sheet. One sheet comprises 60 capsules, each containing 1000 parasitised moth eggs.

Drop each capsule into a leaf whorl (sweet corn). The wasps will gradually move downwind, so place any extra capsules along the crop's windward boundary.

Nuclear polyhedrosis virus (NPV)

Insect viruses are naturally occurring insect-specific pathogens that have been part of the environment for millions of years; they play an important role in natural insect population control.

Insect larvae consume the virus from the leaves as they eat. The virus then moves through the insect's gut wall and invades its body, causing it to stop feeding and die within 5 days due to internal organ breakdown. The body ruptures after death, releasing virus particles that infect other insect larvae.

Vivus Max and Gemstar® LC are commercial products that control *Helicoverpa punctigera* and *H. amigera* in cotton and selected crops with a liquid concentration of virus particles. Typically they provide 60–90% control of larvae. Both products fit best within an IPM program using natural enemies such as ladybeetles and parasites, but can be alternated with synthetic insecticides.

As a biological insecticide, NVP efficacy depends on environmental conditions for good performance. It needs to be ingested, so covering the complete target area is essential.

Bacillus thuringiensis

Bacillus thuringiensis (Bt) is a naturally occurring, soil-borne bacteria that has been used since the 1950s for natural insect control. It consists of a spore, which gives it persistence, and a protein crystal within the spore, which is toxic.

The Bt bacteria produce proteins that are characterised by their potency and specificity to certain lepidopteran species, most of which are agronomically important pests. Mixtures of crystals and spores have been sprayed like a chemical pesticide for many years in horticultural industries, but with variable success in broadacre field crops.

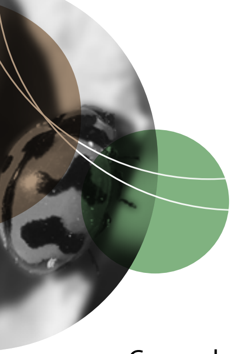
Bt must be eaten to be effective; good coverage is essential for good results. Sheltered sites are favourite places for insect larvae to feed. Sufficient spray must reach these parts of the plant for the larvae to eat enough spores and crystals to be killed. High water volume spraying and a non-ionic wetting agent are recommended to ensure good coverage. Insect larvae are more easily killed when they are small. Use Bt at an early stage of crop development before damage is severe, when larvae are small and good coverage is easier. Using 'soft' Bt sprays at this stage of the crop also encourages the presence of beneficial parasites and predatory insects.

The insect larva ingests the protein, which then attacks the gut wall, causing holes and the insect larva to stop feeding. The bacterial spores contained in the protein then leak through the gut wall and cause a bacterial infection. The insect larva will die either from this bacterial infection or starvation. This is the process that makes the Bt protein highly specific and environmentally desirable.

Inserting the Bt gene into cotton plants has taken many years to develop and there is continued plant breeding to express higher levels of the Bt toxin.

Management programs and new research on multiple insect resistance genes will help to delay or prevent resistance to Bt.

Novel strains of Bt are being isolated for a wide range of pest families including beetles, flies and locusts.



Insect and mite monitoring

Crops should be checked frequently throughout the growing season. Infestation can occur at any time, but crops are most susceptible to serious damage during emergence to establishment, from budding to flowering or from head emergence until harvest maturity. Severe insect attack during the pre-flowering or pre-heading period can also significantly reduce yield.

Major pest incidences vary from year to year and locality to locality, so you will not have to contend with all of them every year. Occasionally, one or more of the minor pests might become numerous and cause serious damage.

Pest control must be a planned part of successfully managing field crops. Integrated pest management (IPM) requires careful and early thought before sowing about which pests are likely to be found in crops by looking at:

- paddock history
- stubble loads
- if a 'green bridge' is present.

WHAT IS A GREEN BRIDGE?

The green bridge provides a 'between season' host for insects (e.g. green peach aphid) and diseases (particularly rusts) that pose a serious threat to future crops and can be expensive to control later in the season. (GRDC *Green bridge factsheet;* https://grdc.com.au/resources-and-publications/all-publications/factsheets/2020/grdc-fs-greenbridge)

All these conditions will either favour or disadvantage particular pest populations, so there should be no surprises when pests occur.

Ideally, the range of natural enemies can be monitored along with pests, so monitoring population dynamics, if populations are increasing or decreasing, is most important when deciding if alternative chemical treatment will be needed.

The growth stage or condition of the plant, or both, will also determine whether treatment is justified; in many cases plants can tolerate or grow out of superficial pest damage.

Growers who regularly inspect crops for pest activity will be better able to decide if and when treatment is needed. Usually crops are most at risk at establishment and during flowering or grain fill, but the damage caused is not always directly related to pest abundance. Other factors such as weather, seedbed conditions and sowing depth can also influence germination rate and seedling emergence, and therefore the ability of young plants to outgrow pest damage.

The cause of crop damage must be correctly identified for effective control and to avoid killing harmless or beneficial insects. Collect specimens of suspect pests and damaged plants and ask your local agronomist or adviser to identify them and suggest appropriate control strategies.

Sampling insect and mite populations

All insect population samplings are subject to error. Sampling result reliability depends on 2 factors:

1. **The extent of other effects**. For example, wireworms and false wireworms move up and down in the soil in response to changes in soil moisture and temperature; distribution of wind-borne pests such as bugs and thrips, in the sheltered zone on the leeward side of a windbreak; and the sheltering effect of trees on aphids.
2. **The number of samples taken**. A large number of small samples will provide a more reliable result than a small number of large samples. However, you must be prepared (and able) to let the sampling continue long enough to reduce the risk of error to a level you are prepared to accept.

You should continue sampling until a decision can be made by careful judgement rather than by guesswork. If, when sampling, you find that the pests are restricted to only a small section of a paddock you might wish to sample that area more intensively to see whether it should receive special treatment.

Monitoring using remote sensing and unmanned aerial vehicle (UAV) technology

There is the potential for various autonomous or remote sensing technologies to help with pest and beneficial monitoring including:

- multispectral, nanospectral or hyperspectral sensors
- autonomous robotic vehicles
- drones, UAVs or remote-piloted aircraft systems
- light aircraft (manned or unmanned)
- satellites (conventional and micro).

There are also smart insect traps, lure-based technology, suction traps and molecular technologies for onsite pest identification.

These methods will not replace the need for ground truthing, but will complement existing methods, increase the effective area that can be monitored, and indicate high risk areas within paddocks for pest attacks. This will lead to a better picture of what is actually happening, can be used to map areas of higher risk and give historical records for endemic pests.

These methods are emerging technologies, some already in the early stages of commercialisation. Advantages include greater monitoring and insect identification accuracy, and earlier detection of potential problems leading to easier decision making.

Monitoring and scouting techniques

There is a variety of monitoring techniques for checking pest and beneficial numbers in different crops:

- sweep nets in pastures and in standing crops that you can easily walk through
- sticky traps for small flying insects
- pitfall traps for mobile ground-dwelling insects and spiders
- suction samplers for small mites and insects on plants or soil
- delta traps (pheromone) to attract specific pests e.g. codling moth or light brown apple moth (LBAM)
- light traps for nocturnal flying insects
- beat sheets for standing crops hard to walk through (cotton, canola and soybeans)
- fruit fly traps (with different attractants).

There is a variety of recording sheets that can be used as well as some designed specifically for particular crops. A diary note can also be a useful way of recording these pest monitoring results.

More information

Green Bridge Fact sheet *The essential crop management tool – green bridge control is integral to pest and disease management*.

Podcasts and YouTube videos to help with these techniques:

IPM Guidelines: Monitoring tools and techniques.

Tips on monitoring for insects in early season canola.

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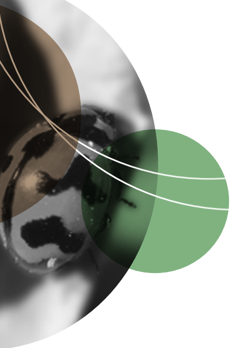
The essential crop management tool – green bridge control is integral to pest and disease management (https://grdc.com.au/__data/assets/pdf_file/0027/201978/green-bridge.pdf).

Monitoring tools and techniques (http://ipmguidelinesforgrains.com.au/ipm-information/making-informed-control-decisions/monitoring/monitoring-tools-and-techniques/)

Tips on monitoring for insects in early season canola (https://grdc.com.au/news-and-media/audio/podcast/tips-on-monitoring-for-insects-in-early-season-canola).



Insect control thresholds

Insect control thresholds provide guidelines to allow well-timed decisions for crop spraying. This can reduce unnecessary spraying and keep populations from reaching a level where damage is high.

The most common threshold used is an economic threshold (ET), which involves control at the density that will prevent the pest numbers from reaching an economically damaging population. Economic thresholds can be enhanced by adding costs of control and grain price matrices to give a more accurate indication of when it is economic to treat pests (dynamic ET). The aim of pest management is to keep pest populations below this economic threshold.

Based on research, guideline thresholds exist for some pests, but most thresholds fluctuate depending upon a number of factors. Monitoring and sampling crops is essential to determine these factors and their influence on where the threshold lies. Farmers who maintain a close watch on pest activity through regular crop inspections and thorough sampling, are in a better position to decide if, and when, treatment is needed.

The following factors should be monitored and considered when using thresholds and making spray decisions:

- environmental conditions and the condition of the crop
- extent and severity of the infestation and how quickly the population increases
- prevalence of natural control agents such as parasitic wasps, predatory shield bugs, ladybirds and diseases
- type and location of pest damage and whether it affects yield indirectly or directly
- stage in the life cycle of the pest and the potential for damage
- crop stage and ability of the crop to compensate for damage
- amount of damage which has already occurred and the additional damage that will occur if the crop is not sprayed
- value of the crop (high value crops cannot sustain too much damage as a small loss in yield or quality could mean a large financial loss), the cost of the spray and its application and the likely yield or quality benefit gained from control.

Role of natural enemies (beneficials) in controlling pest species

Natural enemies include:

- **predators** such as spiders, lady beetles, ground beetles (carabids) and hoverfly larvae
- **parasitoids**, which include many large to very small wasps and flies
- **pathogens** that cause invertebrate diseases.

Predators consume vast amounts of prey over the course of their development. They are free-living and are usually as big as, or bigger, than their prey. Predators can be generalists, feeding on a wide variety of prey, or specialists, feeding on a few closely related species.

Parasitoids are similar to parasites, but where true parasites usually weaken but rarely kill their hosts, parasitoids always kill the host insect. In contrast to predators, parasitoids display a high level of host-specificity, and develop on or within a single host.

Pathogens are diseases that attack pest insects. Pathogens of agricultural pests are usually bacterial, fungal or viral.

Integrated pest management with beneficials

A key aim of an integrated pest management (IPM) approach is to reduce insecticide effects on all 3 groups of these beneficial invertebrates. Most importantly, natural enemies provide a cornerstone to IPM and sustainable pest management for many key pest groups. They work to naturally lower pest numbers and thereby reduce the required number of insecticide applications, which in turn extends the time to reach chemical resistance and reduces costs for growers.

WARNING

Broad-spectrum insecticides invariably kill many non-target organisms such as beneficials, which can lead to pest flare-ups later in the season.

There are many naturally-occurring species that keep pest invertebrate populations in check, which is helpful since the life cycle and seasonal activity of different natural enemies varies markedly. Beneficials, these natural enemies, play a vital biological control role in many cropping systems.

In part, IPM strategies aim to balance beneficials' contribution with the need to protect the crop from significant loss. The terms 'soft' or 'selective' are frequently applied to insecticides that kill target pests, but have minimal impact on non-target organisms.

Where insecticide use is warranted (based on monitoring and the thresholds), it is preferable to choose the most selective or soft insecticides that are less harmful to beneficial invertebrates e.g.:

- biopesticides such as *Bacillus thuringiensis* (Bt) sprays and *Nuclear polyhedrosis virus* (NPV) for caterpillars
- synthetic insecticides such as sulfloxaflor for green peach aphid
- chlorantraniliprole for corn earworm.

In practice, there are varying degrees of 'softness' and some insecticides are selective or safe for one group of natural enemies, but not another. A guide to the relative harshness or softness of major chemical groups is shown in Table 1.

Unfortunately, soft chemical control options are not available for all pests and selective insecticides are not expected to always provide 100% mortality of the target pest. Their aim is to suppress population numbers, allowing biological and cultural methods to further contribute to keeping pest numbers at acceptable levels. Selective insecticides are also more expensive than the broad-spectrum alternatives. Biopesticides are often the softest options.

Bacillus thuringiensis is a naturally occurring bacteria that produces spores containing an invertebrate toxin. There are a number of different strains, each usually specific to an invertebrate group. The major advantage is that it is essentially non-toxic to people and animals. Bt-based insecticides are often applied as liquid sprays on crop plants, where the insecticide must be ingested to be effective. It is susceptible to degradation by sunlight. Most formulations only persist on foliage less than a week after application. Rain or overhead irrigation can reduce effectiveness by washing Bt from crop foliage. Bt is most suited for small caterpillars, including diamondback moth and corn earworm, no larger than 5–8 mm long.

Nuclear polyhedrosis virus is a viral disease of native budworm (*H. punctigera*) and corn earworm (*H. armigera*) caterpillars that occurs naturally in the Australian environment. The commercial NPV product can be used in a variety of field crops, including all pulses and cereals. NPV is an excellent product for corn earworm management, not only because it is very effective (frequently giving more than 90% control), but because it preserves the full range of beneficial insects in the crop (such as *Microplitis* and *Trichogramma* wasps).

Insecticide seed dressings (such as Gaucho®, Cosmos® and Poncho® Plus) can also be an alternative control option. These are relatively more directed at the pest than foliar sprays and smaller quantities of chemical are applied per hectare. They are also popular because they persist for longer than foliar sprays and can offer a wider spectrum for controlling other pests. Their use could delay the need for foliar spray applications, giving beneficial insects time to build up. Nevertheless, seed dressings should only be used if the risk of potential pest pressures is high. They are not benign to beneficial invertebrates and the risk of resistance development to seed dressings is significant.

Native vegetation – promoting and enhancing beneficial numbers

Perennial native vegetation is an important alternative habitat for beneficials. The stability of perennial vegetation provides habitat (shelter, flowers/nectar, alternative hosts) otherwise not found in cropping fields, especially when in fallow. While pest species can be found in native vegetation, most pests do not persist on native hosts, so native vegetation has a low risk of contributing to pest numbers. Areas containing native vegetation (grasses, shrubs and trees) such as fenceline tree plantings, windbreaks, riparian corridors, open grasslands and roadside verges all provide habitat for beneficials.

RESIDENT BENEFICIALS

These permanently live within the system and usually having limited dispersal capabilities. Some resident species, such as ground beetles and spiders, have an annual life cycle and so can be quite effective in the early stages of the crop cycle, although early season foliar insecticides can devastate their populations.

TRANSIENT BENEFICIALS

These move in and out of crops, often following the movement patterns of pests. These more transient species such as hover flies, parasitoids and lady beetles gradually accumulate in the crop over winter and early spring, when their impact becomes noticeable.

Landscape ecology can be manipulated in such a way that promotes natural enemies and supports IPM strategies. Using windbreaks to provide a reservoir for key functional invertebrates and their impact on pest species is a relatively new area being examined. Research has demonstrated that predators and other beneficials with the option of sheltering in windbreaks, can reduce pest numbers in adjacent paddocks such as (but not limited to) red-legged earth mite.

The plant composition of windbreaks is important, with long grasses, shrubs and flowering plants offering complexity and nutrition sources for adult beneficials, such as the hoverfly. Complexity, in turn, provides more niches for important beneficial invertebrates such as spiders, predatory mites, parasitoids and pollinators. Thus, relatively simple measures, such as managing the windbreak understorey, can be used to maximise naturally occurring biological control.

Monitoring for beneficials

Factoring in the contribution, or potential contribution, of beneficials to a management decision is not easy. Identifying which ones might have an impact on the pests in that crop and estimating how much effect they might have is important when determining whether beneficials are likely to suppress the pest population below threshold, or whether you will need to treat the pest infestation to prevent crop loss.

It is possible to monitor the presence and activity of some beneficial species, particularly larger predators and some parasitoids. Monitor for these beneficials at the same time as monitoring for pests. In general, the same sampling techniques will work for both pests and beneficials.

Beneficial species that are very small, that are active at night or that dwell below ground can be difficult to monitor. IPM Guidelines for grains provides some handy indicators of key beneficial invertebrate activity in crops.

Insecticide toxicity on key beneficials

Cesar Australia has recently released a new guide Impact of insecticides on beneficial insects in Australian grain crops.

Approaches to better manage beneficials

- Tolerate some pest damage early in the season (beneficials require prey as food).
- Delay spraying if the beneficials are increasing at a comparable or faster rate than pests and if pest damage is below economic threshold levels.
- Leave some areas unsprayed if these areas are harbouring beneficial species.
- Spray in the late evening to minimise direct exposure to some beneficials.
- Use refuge areas (such as shelterbelts with shrubs/trees) or nursery crops, which help to conserve sources of natural enemies.

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IPM Guidelines (https://ipmguidelinesforgrains.com.au/ipm-information/making-informed-control-decisions/economic-thresholds/economic-threshold-ready-reckoners/)

Helicoverpa in chickpea (https://ipmguidelinesforgrains.com.au/wp-content/uploads/Helicoverpa-in-chickpea.pdf)

Impact of insecticides on beneficial insects in Australian grain crops (https://cesaraustralia.com/resources/beneficials-toxicity-table/).

More information

IPM Guidelines

IPM guidelines: Helicoverpa in chickpea

Seasonal pest updates

PestFacts and *The Beatsheet*

PestFacts and The Beatsheet are free electronic services designed to keep consultants, growers and researchers informed about pest outbreaks, effective controls and supply current information about relevant research findings as they emerge during the growing season.

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The *PestFact* services, produced by Cesar (an independent company formed out of 3 Melbourne universities) draw on consultant, grower and industry specialist field observations from across the southern grain belt region. There is an on-line observational reporting proforma that has been developed to help reporting and to track pest occurrences, distribution and insect pressures over time.

The information that *PestFacts* generates can also be used to gain an idea of the occurrence and location of pest problems. This provides an opportunity for awareness, discussion and ongoing evaluation of changing pest importance.

Through feedback from the diagnostic services and the insect identification workshops that have been previously conducted, a training manual has been developed to complement identification workshops.

Each *PestFacts* edition is available as a free podcast and newsletter subscription. To subscribe go to the PestFacts subscription web page.

The Beatsheet blog is a website about insect pest management issues relevant to Australia's northern grain region (Queensland and New South Wales). The blog provides technical information, pest risk alerts, research highlights, and practical management tools and options for a range of insect pests that have the potential to significantly reduce crop productivity and profitability.

This interactive website allows users to communicate and share pest management experiences with the Entomology Team from the Queensland Department of Agriculture and Fisheries (DAF). The blog is supported by investment from the grains and cotton industries.

More information

Invertebrate pests of grain crops and integrated management: current practice and prospects for the future, a special issue in the *Australian Journal of Experimental Agriculture*.

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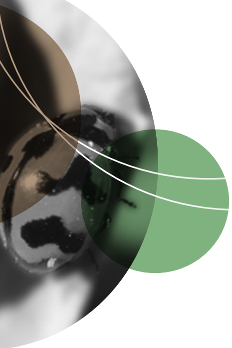
PestFacts (https://www.pir.sa.gov.au/research/services/reports_and_newsletters/pestfacts_newsletter)

PestFacts subscription web page (https://www.pir.sa.gov.au/research/services/reports_and_newsletters/pestfacts_newsletter/subscribe_to_pestfacts)

Cesar *PestFacts South-eastern* (http://cesaraustralia.com/sustainable-agriculture/pestfacts-south-eastern/)

Australian Journal of Experimental Agriculture (www.publish.csiro.au/nid/73/issue/4062.htm)



Organic pest management

Organic standards prohibit using synthetic insecticides and, while some organic (naturally derived) products are permitted, direct substitution of organic with synthetic pest control products is discouraged. Under the standards, a more holistic approach needs to be adopted, which essentially comes down to an integrated pest management (IPM) strategy, but without the aid of synthetic chemicals. Instead of using pesticides, organic farmers adopt system design and cultural practices that encourage healthy plant growth with natural enemies present.

When creating an organic pest management strategy it is important to:

- determine which pests might become a threat
- gain a thorough knowledge of their ecology and dispersal characteristics
- understand how they are likely to affect the crop.

Using IPM principles, organic farmers consider the paddock history, surrounding vegetation, stubble loads and crop rotation to identify the pests that are likely to threaten the current crop. These variables will have a range of natural enemies that can be encouraged to have the greatest effect in controlling the pest or disease.

Some key features of organic pest management systems are discussed below.

Cropping system design

The cropping system design and its relationship with other natural features on and adjoining the farm will influence the ability to effectively manage pests, weeds and diseases organically. Consider these design aspects for your crop layouts:

- **Paddock selection**. Producing a crop where pests and diseases are known to be endemic, or where there are vast monocultures, can make organic pest and disease management more problematic.
- **The crop rotation sequence**. Crop choices and their relationship with one another can interrupt the pest or disease life cycle. Using a range of broadleaf and cereal crops will break pest cycles that are attracted to particular crops. When deciding crop rotation sequences, it is important to use crops that are complementary, so that pests (diseases and weeds) will not build up to economically damaging levels.
- **The layout within a rotation**. Row spacing, sowing density, intercrop spacing and interplanting with other species can influence the occurrence and dispersal of pests and their natural enemies. For example, to limit damage from aphids and aphid-transmitted viruses, crops can be inter-row sown into standing stubbles that discourage aphids from landing on newly emerged crops. Some planting layouts can also confuse pests and thus reduce egg laying or dispersal.
- **The relationship of the crop to other natural features on the farm**.
  - For example, encourage natural enemies through locating and designing shelter belts and insectaries planted as a border surrounding the main crop.
  - Research has shown that substantial numbers of beneficial insects can move up to 113 m from insectary hedgerows into adjacent crops.
  - In New Zealand and the United Kingdom, beetle banks have been successfully used around crops to prevent pests moving into the crops.
  - Incorporating a wetland or areas with native understorey plantings into the farm design can encourage pest-eating bird species such as ibis, wrens and silvereyes, which consume large numbers of insects each day.

Crop monitoring

Regular monitoring gives information about whether pests are increasing, or kept in check by natural enemies.

It is essential to continually monitor crops and surrounding vegetation to determine:

- if either pests or predators are present
- when, if any, intervention is required to keep pests at an acceptable level
- if it is necessary and feasible, to introduce predators into the system to boost predator numbers.

Cultural and mechanical controls

Organic producers use a range of cultural and mechanical controls, both as preventative and interventionary pest management strategies.

Choice and variety of crop

Among the crop features that will give an organic crop an advantage are inherited disease and pest resistance, seedling vigour, and other physiological features such as hard seed coats that deter pests. Varieties selected on the basis of their maturity can be planted to avoid periods of high pest and disease incidence. Note that genetically modified (transgenic) varieties/crops are **not** permitted in organic systems.

Timing sowing

Crops can be sown to avoid periods of high pest and disease incidence. If there is a choice of sowing times, choose times when pest pressure is likely to be lowest.

Water and nutrition management

Plants growing with optimum water and nutrition tend to be less susceptible to pest attack and might be better able to compensate for damage. Both over and under supplying water or nutrients will stress the plant and increase its vulnerability.

Trap crops

Secondary crops strategically used within the main crop can deter or act as trap crops for pests, or can attract predatory species. For example pigeon peas (*Cajanus cajan*) have been used as an effective trap crop for heliothis (*Helicoverpa armigera*) in soybeans.

Insectary crops

Given that many beneficial insects require nectar or pollen as an alternative food source to pests, providing a neighbouring flowering crop to act as an insectary crop can help increase the numbers of beneficials working the main crop. Other insectary crops could be those that host a related non-pest species, such as an aphid, to support aphid parasitoids and predator establishment. These predators can then move into the main crop as a beneficial.

Inter-cropping

Alternating rows of different crops has been used to reduce pest pressure. Inter-cropping on its own does not reduce pest pressure, but some combinations of crops work well together and result in less pest pressure.

Sanitation

- Many key pests have many host plants. If those host plants are weeds on your property or are volunteers, then you might be contributing to supporting the pest population on your property. Controlling weeds, particularly flowering weeds, is crucial to successfully manage, for example, western flower thrips (*Franklienella occidentalis*).
- Mites are often spread through properties or from crop to crop by machinery or on the clothes of people walking the paddocks.

Cultivation

Burying crop refuse can help to prevent carryover of some pests and diseases. Pupae busting is the term used for cultivating soil to destroy the exit holes for heliothis (*H. armigera*) moths after pupation. Normally it is done after harvest and before the over-wintering larvae or pupae are due to emerge as moths. Cultivation to 10 cm deep is sufficient. Although some pupae might be physically destroyed, the main purpose is to destroy the exit tunnels. Pupae busting is essential to keep the number of spring emerging heliothis to a minimum.

Light or bait traps

Moths and some beetles are attracted to black light and thus may be caught in a light trap. These traps are not very selective, so a large number of non-pest and possibly beneficial insects can also be trapped. Pest-specific pheromones can greatly enhance the trap's attractiveness to the target pest.

Biological control

Biological control uses beneficials, habitat manipulation and/or products derived from natural organisms to control pests. Natural enemies (beneficials) are organisms that feed on or otherwise kill the target pest. These can be predatory insects (including ladybirds, lacewings, spiders and mites), parasitoids, fungi, bacteria, viruses, nematodes, or animals (e.g. insect-feeding birds). Biological control is often best used as a preventative method, but some components of biological control are useful as direct intervention, including:

Introducing beneficials

- Predators or parasitoids of a specific pest can be released into the problem area. Perhaps they are absent because:
  - they are not naturally occurring in your area
  - for some reason they have been killed
  - their populations are not sufficiently high to adequately control the pest.
- Some predator and parasitoid species are available from commercial insectaries for releasing into a crop to control a specific pest outbreak.

Habitat manipulation

Although this is normally a preventative method, slashing neighbouring insectary crops can encourage beneficials to move across into the target crop and, hopefully, control the pest. Yeast sprays can encourage lacewings and some other predatory bugs into a crop area to control a specific pest.

Autocidal control

Mass-reared pest insects are released following sterilisation by radiation or chemosterilants. When the sterilised males mate with wild females, no progeny is produced. This tool is being used to control fruit fly.

Semiochemical control

Synthetically-produced chemicals imitate sex or aggregation (grouping) pheromones to disrupt pest behaviour, or prevent mating, to reduce the number of pest offspring. Both sex and aggregation pheromones can lure pests into a sticky or pesticide trap. This is commonly used in orchards as a preventative method.

Biocidal control

Natural products or organisms have a toxic or lethal effect on the target pest. These include products derived from plants such as Neem or natural pyrethrum, and pathogens, bacteria, viruses, protozoa, fungi, nematodes, and animals. Biocidal control can really only be used as a direct control method once pest numbers have reached damaging levels, as the kill rate is generally high, but the carry-over effect is low.

Chemical control

Chemical control is usually associated with synthetically-derived poisons, which are not allowed under organic standards. However, some chemicals are permitted; they tend to be biologically-derived products with some inorganic products or minerals.

It should be noted that even if the product is acceptable under the organic standards, it might not be safe or legal for you to use. Using any pesticide, whether it is biologically based or not, is regulated by the Australian Pesticides and Veterinary Medicines Authority (APVMA) and regulations covering pesticide safe use and application should be followed.

The regulation of all chemicals, including 'allowable organic inputs' is to ensure that there are no residues that will affect consumers in produce. The international system, Codex, sets maximum residue limits (MRLs) based on the acceptable daily intake of any product used. This code determines the use rate and withholding period before harvest. Consequently, it is important to follow all the directions for use on any of these products.

Pest management in an organic system uses many of the same principles that are used in IPM in conventional farming systems, including:

- monitoring pests and beneficial species
- correctly identifying species present
- thorough knowledge of the control methods that can be used are essential to maintain adequate pest control to give marketable produce.

An holistic approach must be taken that involves sound ecological principles so that the system is in balance.

Table 6. Registered organic plant protection products as allowable inputs.

Active ingredient	Registered trade names	Comments
Ammonium chloride	Path-X™ agricultural disinfectant	Sanitiser
Amorphous silica	ABRADE™ abrasive barrier insecticide Absorba-cide sorptive dust insecticide	IGR (insect growth regulator), abrades insect cuticle
Azadirachtin (Neem extract)	AzaMax®	IGR, relatively non-toxic, good IPM fit
Botanical oil	Eco-Oil emulsifiable botanical oil Synetrol Horti Botanical Oil emulsifiable botanical oil	For use in fruit, vegetable and broadacre crops
Bacillis thuringiensis (Bt)	DiPel®	Wide use pattern
Canola oil	Nexus™ spray adjuvant	Claims to be a wetter, sticker, spreader; more likely a penetrant
Fatty acid ethoxylates	Deluge 1000 wetting agent	Non-ionic surfactant
Metarhizium	Green Guard®	Fungal spores to control locusts in organic crops; toxic to bees
Nuclear polyhedrosis virus of *H. armigera*	Vivus Max	Virus spray for *Helicoverpa* spp. in a range of crops
Petroleum oil	Summer Oil Winter Oil Vicol Summer Oil insecticide	Wide use pattern
Potassium salts	Hitman™ soap insecticide ; Natrasoap	Wide use pattern
Pyrethrins	PyGanic® organic insecticide	Broad spectrum (including beneficials), short residual (breaks down quickly in sunlight)
Spinetoram	Success® Neo	Caterpillar pests in a wide range of crops

Source: Pesticides and Veterinary Medicines in Organic Farming, *SMARTtrain Chemical Notes 5*.
ACO Certified Ltd

Note: There is not one single organic standard. Products acceptable under one standard may not be acceptable under another. Check with your organic certifier before using any product.

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SMARTtrain Chemical Notes 5 (http://www.smarttrain.com.au/___data/assets/pdf_file/0010/351865/Pesticides-in-organic-farming.pdf)
ACO Certified Ltd (https://aco.net.au/Pages/Search/SearchProducts.aspx)

Pesticide application technology

To achieve full benefit from insecticides, it is essential that they be properly applied. This will ensure minimum off-target effects and maximum control, user safety and the best return on investment for the pesticide.

The aim when applying insecticides is to effectively distribute the correct amount of product to the target. This will give the required results and minimise non-target area contamination.

This can only be achieved by using efficient and properly calibrated equipment.

Getting the spray rig set up before the season starts is critical in achieving results through appropriately timed spraying, and saves money.

The first step is to read, fully understand and accurately follow the label instructions. The instructions will include recommended application rates, nozzle information, and details on recommended pressure and flow rates.

Droplet size

Most insecticides are contact chemicals rather than systemics (like most herbicides) and therefore it is more important to have complete coverage of the target. This means small droplet sizes are necessary. Larger droplets tend to strike an object in their path because of their momentum, while smaller and lighter droplets tend to flow around the object with the airstream, particularly at low airflow rates. This increases their chances of striking an object deeper into the canopy, or landing on the reverse side of the target. Small droplets are necessary if a uniform, complete coverage is required. They are, however, more subject to drift, the consequences being poor target coverage, and possible environmental damage. Chemical users will often need to compromise between coverage and reducing spray drift, particularly when weather conditions are less than ideal. *Weed control in winter crops* has details about the appropriate weather conditions for spraying.

The best droplet size required for the target is produced by carefully selecting spray nozzle and operating pressure. Most insecticide spraying should be carried out using a medium droplet spectrum. Labels will sometimes specify the droplet size along with water volumes.

Insecticides should not be applied using flat fan nozzles. Air induction/inclusion or venturi nozzles should be used, or special low-drift flat fan nozzles. Information about nozzles is in *Weed control in winter crops*.

When choosing a nozzle size, farmers need to decide on the application rate or water rate, and determine what speed or speed range is required. Application rates and speeds vary considerably depending on the type of chemicals used, availability and condition of water, weather and field conditions, and the type of sprayer used.

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Weed control in winter crops (https://www.dpi.nsw.gov.au/agriculture/broadacre-crops/guides/publications/weed-control-winter-crops)

Water volume rates

The water volumes nominated on the label are a good guide. They can range from 30–200 L/ha, depending on the chemical and the way it is being used. Rates between 50 L/ha and100 L/ha are the most common.

Applying high rates results in a significant amount of time being lost in refilling. When spray is applied at low volumes, significant savings in time carting and mixing are achieved.

However, there are problems with applying chemicals at low volumes:

- nozzles must be in good condition
- finer filters might be needed for the smaller openings
- drift can be more of a problem
- good tank agitation is essential because the mix concentration is higher.

Coverage/volume

As the droplet size is reduced, many more droplets can be produced from the same volume of spray.

When using **large droplets**, the total spray volume must be **increased** to maintain acceptable target coverage. With **smaller droplets**, the total spray volume must be **decreased** to maintain acceptable target coverage.

Boomspray height

Matching boomspray height with nozzle angle will ensure the spray overlap between nozzles is correct, allowing spray coverage to be maximised and remain even.

If the boom height is set too low only the area beneath each nozzle is sprayed, which means there will be unsprayed gaps due to insufficient overlap. Bouncing when the boom is too low will cause the same uneven coverage.

Fewer problems occur when the boom is too high as the pattern evens out, however, drift and evaporation losses can be a problem. Nozzle tips should be angled at 10°–15° to the boom.

Nozzle manufacturers specify a suitable height, depending on the angle of the resulting spray fan. Most agricultural nozzles have spray fans in the 80° to 110° range – the proportion of fine droplets increases with the angle of the fan.

Drift potential

Very fine droplets (< 95 µm) pose the highest risk of spray drift. Under normal spraying conditions, the prevailing wind will move large droplets only a short distance. Small droplets can get caught up in turbulence and be carried a considerable distance from the target.

The following influence the potential of spray droplets to drift:

- **Height of spray release**. The greater the height above the canopy, the higher the risk of drift as there is more time for the droplets to be exposed to air currents. There is also more time for evaporation to reduce droplet size.
- Droplet size and behaviour.
- **Chemical formulations**. Ultra low volume and other formulations can affect the size of the droplet produced and hence its drift potential. Insecticides are more prone to drift than herbicides because of the smaller droplet size required.
- **Weather conditions**. Temperature, wind speed, wind direction and humidity determine the likely extent of drift. Stable atmospheric conditions are best for minimising drift potential, but no spraying should be undertaken when there is an inversion layer as it can move the spray a long distance from the target. This effect can be seen when smoke gets trapped and moves horizontally. Spraying is best carried out with wind speeds of 3–15 km/hr. High humidity is also preferred to reduce evaporation and water-based spray drift.

Speed

High speeds can be used provided boom bounce is not a problem and, with ground-driven sprayers, pressure is not higher than is acceptable for the nozzles fitted. At speed, air flow over the boom can help to force droplets into the spray canopy, but air turbulence can add to drift.

For large booms, e.g. >30 m wide, speeds over 25 km/hr will result in boom bounce. Speeds over 25 km/hr also increase the drift risk. It is essential that forward speed does not vary from that used for calibration when sprayers are fitted with power take-off or engine driven pumps. Any change in speed will result in overdosing (going slower) or underdosing (going faster).

Evaporation risk

Small water-based droplets will evaporate rapidly under hot conditions and can cause considerable losses in spray volume.

Adjuvants

An adjuvant is an approved product that is added to a spray formulation to improve its properties, e.g. better spreading, sticking or penetration. It can also be used to reduce application rates by improving activity or improving product performance in adverse conditions. If an adjuvant is needed, the manufacturer's label will generally mention the type and rate of adjuvant.

Generally, oils increase viscosity and produce a coarser droplet size. Common surfactants and wetters produce smaller droplets because the liquid surface tension is reduced.

Water quality

The quality of water used as a carrier for chemicals can significantly affect the level of chemical effectiveness. It is advisable to use rainwater, but this is not always possible. Rainwater stored in concrete tanks will be alkaline and can reduce efficacy.

Muddy water, hard water, alkaline water, salty water and water containing organic matter such as algae can cause blockages and reduce the effectiveness of some groups of chemicals. Water temperature can also have a significant effect on the properties of some chemicals. There are several solutions for problem water. *Primefact 1337* has details.

Tank mixing pesticides

Where there is no such prohibition on the label, growers can use whatever tank mix they believe appropriate, provided they can comply with the instructions on each of the product labels in the mix. This means that each component of the tank mix must be used at or below the rate which appears on its label as if it was being used on its own. All tank mixes, other than those mentioned on the product label, are at the user's risk.

Table 7. BCPC/ASAE nozzle rating

Category	Nozzle size flat fan	Pressure (bar)	Volume mean diameter (microns)	Typical uses in crops
Very fine	11001	4.5	<100	Greatest drift risk
Fine	11002	3.5	100–200	Insecticides Fungicides Herbicides (grass weeds)
Medium	11004	2.5	200–300	Insecticides Fungicides Herbicides (broadleaf weeds)
Coarse	11008	2	>300	Soil-applied herbicides

Note: Volume mean diameter (VMD) means that 50% of the droplets are less than the stated size and 50% greater.
Source: *Spray drift management: Principles, strategies and supporting information*

Table 8. Nozzle outputs and ISO colour coding

Nozzle	Output at 3 bar in litres/minute	ISO colour
01	0.4	orange
015	0.6	green
02	0.8	yellow
03	1.2	blue
04	1.6	red
05	2.0	brown
06	2.4	grey

Source: *Pesticide application methods*, third edition.

More information

Spray application manual.

GRDC Nozzle selection guide.

GRDC *Nozzle selection for boom, band and shielded spraying: The back pocket guide*.

References

Matthews G, Bateman R and Miller P. 2014. *Pesticide application methods* 4th edition. John Wiley & Sons Inc. New York, USA.

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Primefact 1337 (https://www.dpi.nsw.gov.au/agriculture/irrigation/quality/pubs-and-info/treatment)

Spray application manual (https://grdc.com.au/resources-and-publications/grownotes/technical-manuals/spray-application-manual)

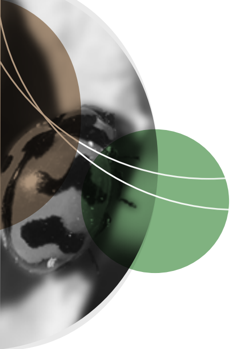
Spray drift management: Principles, strategies and supporting information (https://www.publish.csiro.au/book/3452/)

Spray application manual (https://grdc.com.au/resources-and-publications/grownotes/technical-manuals/spray-application-manual)

GRDC Nozzle selection guide (https://grdc.com.au/resources-and-publications/all-publications/publications/2019/grdc-nozzle-selection-guide)

GRDC *Nozzle selection for boom, band and shielded spraying: The back pocket guide* (https://grdc.com.au/resources-and-publications/all-publications/publications/2017/07/nozzle-selection-for-boom,-band-and-shielded-spraying)

Pesticide application methods (https://www.wiley.com/en-au/Pesticide+Application+Methods,+4th+Edition-p-9781118351307)



Conservation farming and emerging pest challenges

Insect pests and retained stubble

Over the past 20 years many farmers in cropping areas across Australia have adopted conservation farming systems that include minimum and zero tillage practices that retain stubbles. The result is a change in the arthropod pest spectrum, with farmers having to deal with a different range of pests that are associated with higher levels of organic matter and the retained moisture in cropping paddock topsoil.

Many of these arthropods are commonly found around the farm, but the more favourable conditions that minimum tillage and stubble retention create, means they have emerged as significant pests. Research on their life cycles and control is continuing. Some examples of emerging pests include:

- **Slugs**. Slugs are a significant pest in crops during emergence and establishment. They are opportunistic breeders so the more favourable conditions that minimum soil disturbance and stubble retention create means the extent and level of slug damage is continuing to increase.

  Two species responsible for major damage are the grey field slug (*Deroceras reticulatum*) and the black keeled slug (*Limax cinereaniger*). It is important for growers and consultants to monitor population dynamics (species and age distribution) and numbers at key times throughout the season. This information is critical for determining the most effective approach to manage slugs and forms the basis for making decisions about crop sowing options.

  Research and development is ongoing, assessing the effectiveness of integrated management strategies including cultural practices such as stubble rolling and tillage, and tactical baiting.

- **Snails**. Snail distribution continues to extend across the higher rainfall (HRZ) zones of NSW (500–900 mm average annual rainfall). Managing this pest is generally well understood and integrated snail management has been widely adopted. However, the small pointed conical snails (*Prietocella barbara*) cannot be effectively managed and can cause significant crop damage and grain contamination.

  Baiting is often ineffective as the juveniles will not take baits. In the HRZ it is often not possible to control the late spring hatchings of this species, which then go on to become a grain contaminant. The small pointed conical snail is well adapted to the HRZ environment where climatic conditions and perennial pasture and weed species increase the survival rate and breeding opportunities.

- **Wireworms**. True wireworms (*Agrypnus* spp.) and false wireworms (*Orondina* spp.) attack cereals, oilseeds and pulses. Wireworm problems are often associated with stubble retention and trash from previous crops, which provide a refuge that favours survival and breeding.

  Detecting these pests early is important. Once feeding damage has become obvious it is often too late to implement effective control.

  In paddocks with a history of wireworm, cultivation just before seeding could reduce pest pressure. Rotations, including continuous cropping or short pasture phases will often limit population increases.

- **Slaters**. Slaters can attack broadacre crops, and in some instances cause serious damage. There have been reports of slaters causing damage to cereals, canola, lentils and pastures in NSW and Victoria. However, having slaters within a paddock (even in high numbers) does not necessarily mean a pest issue.

  Slaters typically feed on decaying organic matter and only rarely feed on emerging crop seedlings. Feeding results in uneven rasping-type damage that often appears as windows of transparent leaf membrane.

  There appears to be a strong correlation between damage and minimum tillage and/or stubble retention. Stubble provides a cool, moist refuge that enhances survival and population development. Slaters need damp conditions and will die if exposed to open and dry situations. Crumbly clay soil surfaces and cracking clays also seem to favour their survival.

- **European earwigs**: European earwigs can cause significant damage to emerging canola crops. In NSW they are readily found in crops in the South West Slopes region, but are likely to be more widespread. Damage is often sporadic and requires specific circumstances of female egg laying and hatching coinciding with later establishing canola seedlings. Retained stubble, combined with wet springs and summers and an early autumn break, appear to favour the build-up of these insects.

  The damage earwigs cause can be difficult to identify and, as control can also be difficult, growers should seek advice if they either suspect or see earwigs. European earwigs can easily be confused with the common brown earwig which is a resident beneficial. The common brown earwig can be identified by an orange triangle on the body just behind the head. See *Insect pests of establishing canola in NSW* for identification.

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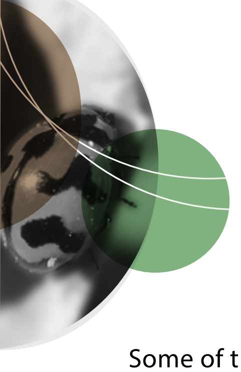
Insect pests of establishing canola in NSW (https://grdc.com.au/resources-and-publications/all-publications/publications/2019/insect-pests-of-establishing-canola-in-nsw)

Figure 6. Severe European earwig damage, Cootamundra 2021.



Permits

Some of the chemical use patterns quoted in this publication are approved under Permits issued by the APVMA and are in force at the time the publication was prepared. Persons wishing to use a chemical in a manner approved under a Permit should obtain a copy of the relevant Permit from the APVMA and must read all the details, conditions and limitations relevant to that Permit, and must comply with the details, conditions and limitations before use.

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APVMA pesticide permit search (https://portal.apvma.gov.au/permits)

Abbreviations used in the tables

Abbr.	In full
CS	capsule suspension
EC	emulsifiable concentrate
FL or F	flowable concentrate
G (GR)	granular
LC	liquid concentrate

Abbr.	In full
OL	oil miscible liquid
P	pellet
SC	suspension concentrate
SL	soluble concentrate
SP	soluble powder

Abbr.	In full
ULV	ultra-low volume
WP	wettable powder
WG	water dispersible granule

Table 9. Permits as at January 2022# (Page 1 of 3)

Active ingredient	Registered trade name	Permit number	Date	Crops	Pests	Rate (per ha)
Chlorpyrifos 500 g/L EC	Lorsban 500 EC plus other registered products	PER8522	9 March 2006 to 31 May 2024	Pulse crops including: adzuki bean, cowpea, mungbean, faba bean, lentil and navy bean	Wireworm, black field earwig, field cricket, false wireworm	100 mL product plus 125 mL sunflower oil per 2.5 kg cracked sorghum or wheat seed per hectare
	All registered insecticide products that include directions for use for canola on the approved label for the product	PER13353 Version 2	15 March 2012 to 31 August 2022	Mustard (oilseed cultivars) (*Brassica juncea*)	As approved for canola	As per current use rates, timing, frequency and method of application defined on product labels registered for use on canola.
Deltamethrin 27.5 g/L	decis options plus other registered products	PER83724	5 September 2017 to 30 September 2022	Safflower	Rutherglen bug (*Nysius vinitor*)	0.5 L
Abamectin 18 g/L	Titan Abamectin 18 plus other registered products	PER81373	18 August 2015 to 30 June 2026	Maize, popcorn	Two-spotted mite (*Tetranychus urticae*)	0.3 L
Abamectin 36 g/L	Vantal Upgrade plus other registered products	PER81373	18 August 2015 to 30 June 2026	Maize, popcorn	Two-spotted mite (*Tetranychus urticae*)	0.15 L
Etoxazole 110 g/L	ParaMite plus other registered products	PER88259	20 June 2019 to 30 August 2026	Maize, popcorn	Two-spotted mite (*Tetranychus urticae*)	0.35 L
Imidacloprid 350 g/L	Nuprid 350 SC plus other registered products	PER81609	1 March 2016 to 31 January 2024	Navy bean (*Phaseolus vulgaris*)	Silverleaf whitefly (*Beisis tabaci*)	14 mL/100 m of row
Chlorantraniliprole 350 g/kg	Altacor plus other registered products	PER82103	21 September 2016 to 31 July 2026	Linseed	Cotton bollworm (*H. armigera*) and native budworm (*H. punctigera*)	70 g
Dimethoate 400 g/L	Dimethoate plus other registered products	PER82378	1 June 2016 to 31 March 2026	Faba bean	Mirid bugs	0.5 L
Pirimicarb 500 g/kg	Aphidex WG aphicide plus other registered products	PER85152	11 July 2018 to 31 July 2023	Adzuki bean, mungbean, soybean	Cowpea aphid (*Aphis craccivora*) and green peach aphid (*Myzus pesicae*).	0.3 kg
Pymetrozine 500 g/kg	Fulfill plus other registered products	PER85363	2 August 2018 to 31 August 2026	Faba bean	Green peach aphid (*Myzus pesicae*) and faba bean aphid (*Megoura crassicauda*)	0.2 kg
Pymetrozine 250 g/kg	Metro 250 WP plus other registered products	PER85365	17 December 2018 to 31 December 2023	Lupins	Green peach aphid (*Myzus pesicae*), pea aphid (*Acyrthosiphon pisum*), cotton aphid (*Aphis gossypii*) and cowpea aphid (*Aphis craccivore*).	0.4 kg
Dimethoate 400 g/L	Rover Systemic plus other registered products	PER85448	23 March 2018 to 31 March 2025	Grain legumes	Aphids, leafhoppers, thrips	0.8 L

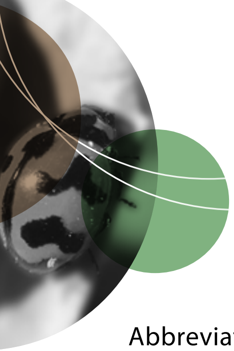
Table 7. Permits as at November 2021# (page 2 of 3).

Active ingredient	Registered trade name	Permit number	Date	Crops	Pests	Rate (per ha)
Abamectin 18 g/L EC	Vantal 18 EC plus other registered products	PER86185	12 April 2018 to 30 April 2023	Soybean	Soybean moth (*Aproaerema simplexella*)	0.3 L
Clothianidin 200 g/L	Shield plus other registered products	PER86221	27 August 2018 to 31 October 2024	Mungbean, navy bean	Redbanded shield bug (*Piezodorus oceanicus*), green vegetable bug (*Nezara viridula*)	0.125–0.375 mL product/ha plus MAXX Organosilicone Surfactant™ at 2 mL per litre of water
Pirimicarb 500 g/kg	Pirimicarb 500 WG plus other registered products	PER86808	1 February 2019 to 28 February 2024	Sesame seed	Aphids including cowpea aphid (*Aphis craccivora*) and green peach aphid (*Myzus pesicae*).	0.25–0.3 kg
Emamectin 17 g/L	Affirm plus other registered products	PER87597	4 June 2019 to 30 June 2024	Adzuki bean, mungbean and pigeon pea	Bean pod borer (*Maaruca vitrata*)	0.25 L
Indoxacarb 150 g/L	Steward EC plus other registered products	PER88057	15 October 2019 to 31 October 2022	Pigeon pea	Cotton bollworm (*H. armigera*) and native budworm (*H. punctigera*)	0.4 L
					Soybean looper (*Thysanoplusia orichalcea*) and red-shouldered leaf beetle (*Monolepta australis*)	0.2 L
Fipronil 200 g/L	Fipronil 200 SC plus other registered products	PER88226	18 July 2019 to 31 July 2022	Soybean (at planting to the planting furrow)	Lucerne crown borer (*Zygrita diva*)	322.5 mL product/ha
Fipronil 800 g/L	Fipronil 80 WG plus other registered products	PER88226	18 July 2019 to 31 July 2022	Soya bean (at planting to the planting furrow)	Lucerne crown borer (*Zygrita diva*)	80 g product/ha
Fipronil 500 g/L	Legion insecticidal seed treatment plus other registered products	PER88231	4 July 2019 to 31 July 2024	Soybean	Lucerne crown borer (*Zygrita diva*)	0.2 L product/100 kg of seed
7.5 × 109 occlusion bodies of SPODOPTERA FRUGIPERDA MULTIPLE NUCLEOPOLYHEDROVIRUS STRAIN 3AP2 per millilitre as the only active constituent.	Fawligen	PER90820	30 March 2021 to 31 March 2024	All cereal grains (including coarse grains), oilseeds, pulses and forage and fodder crops	Fall armyworm (*Spodoptera frugiperda*)	50–200 mL/ha
Spinetoram 120 g/L	Success Neo	PER89241	6 March 2020 to 31 March 2023	Soybean Pulses (excluding chickpeas)	Fall armyworm (*Spodoptera frugiperda*)	0.3 L
Spinetoram 120 g/L	Success Neo	PER89241	6 March 2020 to 31 March 2023	Chickpeas	Fall armyworm (*Spodoptera frugiperda*)	0.2 L
Spinetoram 120 g/L	Success Neo	PER89241	6 March 2020 to 31 March 2023	Canola	Fall armyworm (*Spodoptera frugiperda*)	0.15 L
Chlorantraniliprole 350 g/kg	Altacor	PER89259	6 March 2020 to 31 March 2023	Winter and summer pulse crops	Fall armyworm (*Spodoptera frugiperda*)	70 g
Chlorantraniliprole 350 g/kg	Altacor	PER89457	18 November 2020 to 30 November 2022	Sunflower, safflower	Fall armyworm (*Spodoptera frugiperda*), *Helicoverpa* spp.	70–90 g
Chlorantraniliprole 600 g/L	Vantacor	PER89457	18 November 2020 to 30 November 2022	Sunflower, safflower	Fall armyworm (*Spodoptera frugiperda*), *Helicoverpa* spp.	40–55 mL
Chlorantraniliprole 600 g/L	Vantacor	PER91616	5 October 2021 to 31 October 2024	Sorghum and millet	Fall armyworm (*Spodoptera frugiperda*)	55–90 mL
Chlorantraniliprole 350 g/kg	Altacor	PER91386	6 September 2021 to 31 May 2023	Maize, popcorn, teosinte	Fall armyworm (*Spodoptera frugiperda*)	70–90 g
Chlorantraniliprole 600 g/L	Vantacor	PER91386	6 September 2021 to 31 May 2023	Maize, popcorn, teosinte	Fall armyworm (*Spodoptera frugiperda*)	40–55 mL
Alpha-cypermethrin 100 g/L	Accensi alpha-cypermethrin 100 plus other registered products	PER89279	11 March 2020 to 31 March 2023	Maize, sorghum and sweet corn	Fall armyworm (*Spodoptera frugiperda*)	0.4 L
Methomyl 225 g/L	Lymo 225 plus other registered products	PER89279	11 March 2020 to 31 March 2023	Maize, sorghum and sweet corn	Fall armyworm (*Spodoptera frugiperda*)	2.0 L plus wetter as per product label
Zeta-cypermethrin 100 g/L	Fury 100 plus other registered products	PER89279	11 March 2020 to 31 March 2023	Maize, sorghum and sweet corn	Fall armyworm (*Spodoptera frugiperda*)	0.5 L

Table 7. Permits as at November 2021# (page 3 of 3).

Active ingredient	Registered trade name	Permit number	Date	Crops	Pests	Rate (per ha)
Alpha-cypermethrin 100 g/L	Accensi alpha-cypermethrin 100 plus other registered products	PER89279	11 March 2020 to 31 March 2023	Millet	Fall armyworm (*Spodoptera frugiperda*)	0.22–0.28 L
Alpha-cypermethrin 100 g/L	Fastac Duo plus other registered products	PER89403	8 May 2020 to 31 May 2023	Millet	*Helicoverpa* spp.	0.3–0.4 L
					Common armyworm, inland armyworm, southern armyworm, *Spodoptera* spp.	0.22–0.28 L
Alpha-cypermethrin 100 g/L	Accensi alpha-cypermethrin 100 plus other registered products	PER89279	11 March 2020 to 31 March 2023	Chickpea, faba bean, field pea, soybean, mungbean, navy bean		0.3 L
Methomyl 225 g/L	Lymo 225 plus other registered products	PER89279	11 March 2020 to 31 March 2023	Soybean and peanut	Fall armyworm (*Spodoptera frugiperda*)	2.0 L plus wetter as per product label
Indoxacarb 150 g/L	Steward EC plus other registered products	PER89279	11 March 2020 to 31 March 2023	Soybean	Fall armyworm (*Spodoptera frugiperda*)	0.4 L
Zeta-cypermethrin 100 g/L	Fury 100 plus other registered products	PER89279	11 March 2020 to 31 March 2023	Sunflower	Fall armyworm (*Spodoptera frugiperda*)	0.5 L
Alpha-cypermethrin 100 g/L	Accensi Alpha-cypermethrin 100 plus other registered products	PER89279	11 March 2020 to 31 March 2023	Winter cereals (including triticale and wheat)	Fall armyworm (*Spodoptera frugiperda*)	0.24 L
Alpha-cypermethrin 100 g/L	Fastac Duo	PER85447	16 April 2018 to 30 April 2026	Maize, chickpea, faba bean field pea, mungbean, navy bean, soybean, sorghum, millet	Fall armyworm (*Spodoptera frugiperda*)	220–280 mL
				Winter cereals		220–240 mL
Alpha-cypermethrin 250 g/L	Titan Alpha-cypermethrin 250 SC	PER85447	16 April 2018 to 30 April 2026	Maize, chickpea, faba bean field pea, mungbean, navy bean, soybean, sorghum, millet	Fall armyworm (*Spodoptera frugiperda*)	88–112 mL
				Winter cereals		88–96 mL
Emamectin 17 g/L	Affirm	PER89300	9 April 2020 to 30 April 2023	Canola (for grain production)	Fall armyworm (*Spodoptera frugiperda*)	0.47–0.7 L
				Pulses		
Emamectin 17 g/L	Affirm	PER89371	14 Augustl 2020 to 31 August 2023	Wheat, similar grains, maize cereals	Fall armyworm (*Spodoptera frugiperda*)	0.6–0.9 L
Indoxacarb 150 g/L	Steward EC plus other registered products	PER89311	20 April 2020 to 30 April 2023	Pigeon pea refuge crops	Fall armyworm (*Spodoptera frugiperda*)	0.4 L
Indoxacarb 150 g/L	Steward EC plus other registered products	PER89530	13 May 2020 to 31 May 2023	Maize, popcorn, teosinte	Fall armyworm (*Spodoptera frugiperda*)	0.4–0.5 L
Spinetoram 120 g/L	Success Neo	PER89390	24 April 2020 to 30 April 2023	Maize, popcorn, teosinte, grain sorghum, hungry rice, Job's tears, teff	Fall armyworm (*Spodoptera frugiperda*)	0.25–0.3 L

All current APMVA pesticide Permits are available at the APVMA website (https://portal.apvma.gov.au/pubcris).



Pest tables

Abbreviations used in the tables.

Abbr: pesticide type	In full
CS	capsule suspension
EC	emulsifiable concentrate
FL or F	flowable concentrate
G (GR)	granular
LC	liquid concentrate
OL	oil miscible liquid
P	pellet
SC	suspension concentrate

Abbr: pesticide type	In full
SL	soluble concentrate
SP	soluble powder
ULV	ultra-low volume
WP	wettable powder
WG	water dispersible granule

Abbreviation	In full
BBB	Brown bean bug
BOM	Blue oat mite
GVB	Green vegetable bug
RLEM	Redlegged earth mite
TSM	Two-spotted mite
Biological products	**In full**
Bt	*Bacillus thuringiensis*
NPV	*Nuclear polyhedrosis virus*

Winter crops

Table 10. Canola – pests.

Pest	Threshold	Crop growth stage	Crop damage	Comments	Frequency
Aphids	>50% of plants with clusters 25 mm long on stem or 4–5 stems/m^2 with clusters 50 mm long on stems.	Flowering/early pod set.	Prevents pod set. Dries out stem. Can attract heliothis moth.	Check for presence of predators e.g. ladybird larvae, hoverfly larvae, fungal diseases. Heavy rain can wash aphids off plants. Infestations most likely in hot, dry weather when plants are stressed.	Intermittent
BOM and RLEM	Newly emerged seedling can be killed by low mite numbers. Preventative treatment is recommended.	Germinating seeds/seedling to 4-leaf stage. Mite oversummers as an egg in dead adult's body.	Mottles and whitens cotyledons and leaves by rasping and sucking. Can stunt and kill seedlings. RLEM more common in southern NSW.	Mostly feeding during the cooler part of day/night. Can kill seedlings as they germinate. Bare earth treatment after sowing is most effective. BOM and RLEM have different tolerances to some pesticides.	Annual
Cutworm	Usually in patches in a crop. Treat at the first sign of damage. Treat while feeding.	Seedling to 2–8 leaves.	Eats leaves and cuts stems near ground level.	Inspect crops late evening or night for presence of the large, dark grey–green caterpillars.	Rarely
Diamondback moth (cabbage moth)	Using cone or beat sheet: Foliage to mid-flowering: 8–12 larvae/10 plants. Mid to late flowering: 17–23 larvae/10 plants. Pod maturation: 43 to 57 larvae/10 plants. Thresholds are conservative.	Vegetative/flowering/ pod set/pod filling.	Makes clear membranous windows in leaves and graze stems and pods.	Threshold measures 3–4th instars (5–6 mm larvae) for visibility reasons. Sample 10 plants in 3 locations. Sweep nets are not suitable to sample dense crops. Rainfall >5–8 mm in 24 hours often reduces larvae density and re-sampling might be necessary before deciding to spray.	Intermittent
False wireworm	No threshold established. Paddocks should be inspected the spring before sowing as there is no post sowing control.	Newly emerged seedling.	Ringbarks and severs the seedling hypocotyl below the soil surface.	Most common in soils high in organic matter but might feed on seedlings if soils and organic matter dry out. Inspect in spring.	Intermittent
Heliothis caterpillar	Five or more 10 mm long larvae/m^2 (mid podding). At first pod damage.	Late flowering and early pod set, up to windrowing.	Caterpillars <10 mm eat foliage. Caterpillars >10 mm chew pods and eat seeds. Assess caterpillar size and crop maturity.	Observe crop for moths during late flowering. *H. punctigera* most common in spring. *H. armigera* can be found in low numbers within 30 km of summer irrigation.	Annual
Lucerne flea	Treat if 50% of leaf area is likely to be damaged.	Seedling/early vegetative growth.	Eats leaves, leaving clear membranous windows in foliage.	Eliminate weeds on headlands. Lucerne fleas 'hop' when disturbed.	Intermittent
Rutherglen bug	Ten adults or 20 nymphs/plant.	Flowering. Pod filling and windrowed crops.	Sucks sap reducing pod set, pod fill, oil quantity and seed viability.	Infestations most likely in hot, dry weather. Adults 5 mm long narrow, grey–brown. Nymph reddish–brown, pear shaped, wingless. Infestations can be confined to the edge of crop. Check for bugs 15–20 m into crop.	Intermittent
Slugs	Bait at first sign of damage. Species determines damage and bait effectiveness.	Newly emerged seedling.	Chews off seedlings. Leaf damage can look like hail damage.	Damage starts in damp areas of paddock. Check presence by setting wet hessian or tile traps. Most effective are combined control strategies of burning, cultivation, weed control and baiting.	Intermittent
Wireworm	No threshold established. No after sowing treatment.	Germination/seedling.	Attacks the germinating seed or the underground stem causing plants to wither and die shortly after emergence.	Press wheels reduce crop damage. Wireworms are present in the top 50 mm of moist soil.	Rarely
Weevil (sitona, mandalotus and vegetable)	No threshold established.	Seedling.	Adults and larvae feed on foliage, giving the leaves a serrated appearance; can eat plants down to the ground.	Hosts: capeweed (vegetable weevil); medic and lucerne (sitona weevil). Damage is usually most severe on crop edges so a border spray at crop emergence is often sufficient.	Intermittent

Table 11. Canola – pesticide use (rate per ha). (Always read the label in conjunction with this table). Numerous other products and formulations are also registered.

Chemical formulation	Toxicity to beneficials	Example registered trade name	Aphid	Blue oat mite	Cutworm	Diamondback moth	Heliothis	Lucerne flea	Redlegged earth mite	Rutherglen bug	Vegetable weevil
Alpha-cypermethrin 100 g/L EC	High–very high	Alpha Scud® Elite	–	50 mL	–	0.4 L	0.2 L or 0.3 L [1]	–	100 mL [2]	–	0.4 L
Bacillus thurgingiensis (Bt) *sub-species kurstkai*	Very low	DiPel® SC	–	–	–	1.0–4.0 L	1.0–4.0 L	–	–	–	–
Bifenthrin 250 g/L	High–very high	Talstar® 250 EC [3]	–	40 mL	–	–	–	–	20–40 mL	–	40–80 mL
Beta-cyfluthrin 25 g/L	High–very high	Bulldock® Duo	–	0.2 L	–	–	0.2 L or 0.4 L	–	–	–	–
Chlorpyrifos 500 g/L EC	High–very high	Lorsban® 500 EC	–	0.14–0.3 L	0.9 L	–	–	–	0.14–0.3 L	–	–
Chlorpyrifos 400 g/L + bifenthrin 20 g/L	High–very high	Pyrinex® Super [4]	–	0.5 L	1.0 L	–	–	0.175–0.375 L	0.25–0.5 L	–	0.5–1.0 L
Chlorpyrifos 300 g/L + lambda-cyhalothrin 15.4 g/L	High–very high	Cobalt® Advanced	–	0.15 L	–	–	–	–	0.15 L	–	–
Cypermethrin	High–very high	Scud Elite®	–	–	–	–	0.2–0.25 L [1]	–	50–75 mL	–	–
Deltamethrin 27.5 g/L EC	High–very high	decis options® [5]	–	–	0.2 L	–	0.5 L	–	–	–	–
Dimethoate 400 g/L EC	High–very high	Dimethoate 400 EC	–	–	–	–	–	55–85 mL	85 mL	–	–
Emamectin 17 g/L	Moderate	Affirm®	–	–	–	0.15–0.3 L	–	–	–	–	–
Esfenvalerate 50 g/L EC	High–very high	Sumi-Alpha® Flex	–	50–70 mL	–	–	0.13–0.33 L [6]	–	50–70 mL	–	0.4–0.5 L [6]
Flonicamid 500 g/kg	Moderate	MainMan® 500 WG	100 g [12]								
Gamma-cyhalothrin 150 g/L CS	High–very high	Trojan®	–	–	–	20 mL	20 mL or 30 mL [7]	–	8 mL [8]	–	–
Lambda-cyhalothrin 250 g/L	High–very high	Karate Zeon®	–	–	–	24 mL	24 mL or 36 mL [7]	36 mL	9 mL [8]	36 mL	–
Methidathion 400 g/L EC	High–very high	Suprathion® 400 EC [9]	–	0.2 L	–	–	–	0.2 L	0.2 L	–	–
Methomyl 225 g/L SL	High–very high	Lannate®-L	–	–	–	–	1.5–2.0 L [10]	–	–	–	–
Nuclear polyhedrosis virus of *H. armigera*. 5 × 109/mL (obs)	Very low	Vivus Max	–	–	–	–	0.15 L	–	–	–	–
Omethoate 290 g/L	High–very high	Le-Mat® 290 SL	–	100 mL [13]	–	–	–	100 mL	100 mL [13]	–	–
Pirimicarb 500 g/kg WG	Very low	Pirimor® WG	0.5 kg or 1.0 kg [11]	–	–	–	–	–	–	–	–
Sulfoxaflor 240 g/L	High–very high	Transform®	100 mL	–	–	–	–	–	–	–	–

1. Registered for native budworm (*H. punctigera*) only. Use the higher rate if larvae longer than 10 mm are present.
2. Registered at 100 mL/ha only before crop emergence. Apply by ground rig only when the soil is moist. See label for application rate.
3. Also registered for Bryobia mite at 80 mL/ha and pasture webworm (*Hednota* spp.) at 40 mL/ha.
4. Also registered for Bryobia mite and Balaustium mite at 1.0 L/ha, brown pasture looper (*Cismpa arientaria*) at 0.25–0.5 L/ha, and pasture webworm at 0.5 L/ha.
5. Also registered for looper at 0.5 L/ha.
6. Southern NSW only.
7. Native budworm (*H. punctigera*) only.
8. Blue oat mite often co-occurs with redlegged earth mite and this rate might be less effective against blue oat mite.
9. Apply as a ground spray immediately before seedling emergence.
10. Registered as an ovicide/larvicide at 0.5–1.0 L/ha (Refer to label).
11. Use higher rate if temperature falls below 20°C.
12. Registered for green peach aphid and cabbage and turnip aphid.
13. Also registered for Bryobia mite (*Bryobia* spp.) at 120 mL/ha.

Toxicity to beneficials

(red)	High–very high
(orange)	Moderate
(green)	Very low

Table 12. Chickpea – pests.

Insect	Threshold	Crop growth stage	Crop damage	Comments	Frequency
Aphids	No threshold established.	All growth stages especially seedling.	No damage observed. Suck sap and transmit virus.	Aphids do not breed on chickpea due to malic acid in leaves. Retained cereal stubble repels aphids. Species that transfer viruses are unknown.	Rarely
Armyworm	No threshold established.	Later vegetative stages and pod filling.	Defoliates and causes pod drop.	Rarely a problem in chickpea. Build up often occurs after heavy rain. Usually present in large numbers. Most active in the late afternoon and night.	Rarely
BOM and RLEM	No threshold established.	Most susceptible just as seedling emerges if large numbers are present.	Mottles and whitens leaves and suppresses seedling emergence.	Chickpea is the least susceptible crop to these insects. Treatment is rarely necessary. Chickpea normally repels these insects due to malic acid in leaf glands.	Rarely
Cutworm	When large number are present.	Early plant growth stages. Often present as sowing.	Chews leaves and stems. Can cut plants off at ground level.	Feeds evening and night, hide during day. Usually present in the crop in large numbers in patches. Spot spraying might be best option. Check and spray late evening. Rarely a problem.	Rarely
Heliothis caterpillar	1–4/m^2 (beat sheet) or 5/m^2 (sweep net). Use formula below to fine tune threshold. See *The Beatsheet* for threshold calculators. Refer to Qld DAF publication Helicoverpa *management in chickpea*	Flowering to pod filling. Examine crops twice/week.	Caterpillars <10 mm eat foliage and flowers. Large caterpillars eat seed in pods.	Most damage done by caterpillars >20 mm. *H. punctigera* most common in spring. *H. armigera* in low numbers within 30 km of summer irrigation.	Annual
Looper	No threshold established.	Early plant growth stages.	Defoliates plants.	Capeweed is the preferred host. Caterpillars have distinct looping motion. Rarely a problem. Moves in from edge of the crop.	Rarely
Lucerne flea	No threshold established.	Early plant growth stages.	Eats leaves, leaving clear membranous windows in foliage.	Eliminate weed growth on headlands. Lucerne fleas hop when disturbed. Liming reduces numbers on acid soils. Rarely a problem.	Rarely
Thrips	1–2 thrips/flower.	Flowering.	Feeds on young buds and flowers. Reduces pod set and distort pods.	Shake flowers into white container to dislodge thrips or open and inspect flowers.	Rarely

Table 13. Chickpea – pesticide use (rate per ha). (Always read the label in conjunction with this table). Numerous other products and formulations are also registered.

Chemical formulation	Toxicity to beneficials	Example registered trade name	Blue oat mite	Cutworm	Green vegetable bug	Heliothis	Looper	Lucerne flea	Redlegged earth mite	Thrips
Alpha-cypermethrin 100 g/L EC	High–very high	Alpha-Scud® Elite	50 mL	75 mL	–	0.2 L or 0.3 L (1)	–	–	50-100 mL (2)	–
Bt sub-species *kurstkai*	Very low	DiPel® SC	–	–	–	1.0–4.0 L	1.0–4.0 L	–	–	–
Beta-cyfluthrin 25 g/L	High–very high	Bulldock® Duo	–	–	–	0.2 L or 0.4 L	–	–	–	–
Chlorantraniliprole 350 g/L	Very low	Altacor®	–	–	–	70 g	–	–	–	–
Chlorpyrifos 500 g/L EC	High–very high	Lorsban® 500 EC	0.14–0.3 L	–	–	–	–	–	0.14–0.3 L	–
Chlorpyrifos 300 g/L + lambda-cyhalothrin 15.4 g/L	High–very high	Cobalt® Advanced	–	–	–	–	0.2 L (3)	–	–	–
Cypermethrin 200 g/L EC	High–very high	Scud Elite®	–	–	–	0.2–0.25 L (1)	–	–	–	–
Dimethoate 400 g/L EC	High–very high	Dimethoate 400 EC	–	–	–	–	–	–	–	0.8 L
Deltamethrin 27.5 g/L EC	High–very high	decis options®	–	0.2 L	0.5 L	0.5 L	0.5 L	–	–	–
Emamectin 17 g/L	High–very high	Affirm®	–	–	–	0.15–0.3 L	0.15–0.3 L	–	–	–
Esfenvalerate 50 g/L EC	High–very high	Sumi-Alpha® Flex	50–70 mL (5)	–	–	0.13–0.33 L (4)	–	–	50–70 mL (5)	0.13 L (6)
Gamma-cyhalothrin 150 g/L CS	High–very high	Trojan®	–	–	50 mL	50 mL or 60 mL (7)	–	–	8 mL (8)	–
Indoxacarb 150 g/L	Very low	Steward® EC	–	–	–	0.3 L	–	–	–	–
Lambda-cyhalothrin 250 g/L CS	High–very high	Karate Zeon®	–	–	24 mL	24 mL or 36 mL (1)	–	–	9 mL (9)	–
Methomyl 225 g/L SL	High–very high	Lannate®-L	–	–	1.5 L	1.5 L or 2.0 L	–	–	–	–
Nuclear polyhedrosis virus of H. armigera. 5 × 109/mL (obs)	Very low	Vivus Max	–	–	–	0.15 L	–	–	–	–
Omethoate 290 g/L	High–very high	Le-Mat® 290 SL	–	100 mL (10)	–	–	–	100 mL	100 mL (10)	–
Spinetoram 120 g/L	Very low	Success® Neo	–	–	–	0.15–0.2 L	–	–	–	–
Thiodicarb 375 g/L SC	High–very high	Larvin® 375	–	–	0.5 L	0.5 L or 0.75 L	–	–	–	–

(1) Registered for native budworm (*H. punctigera*) only.
(2) Registered at 100 mL/ha before crop emergence. Apply when soils moist. Do not apply as a ULV application.
(3) Registered for brown pasture looper (*Ciampa arientaria*) only.
(4) Registered for native budworm only in southern NSW.
(5) Also registered at 100 mL/ha as a bare earth pre-emergent application.
(6) Registered for southern NSW only.
(7) Northern NSW rate only. Registered for native budworm (*H. punctigera*) in southern NSW at 20 mL or 30 mL/ha.
(8) Registered rate might be less effective against blue oat mite (*Penthaleus major*).
(9) Blue oat mite often co-occur with redlegged earth mite and this rate might be less effective against blue oat mite.
(10) Also registered for Bryobia mite (*Bryobia* spp.) at 120 mL/ha.

Toxicity to beneficials

(red)	High–very high
(amber)	Moderate
(green)	Very low

Table 14. Faba bean – pests.

Pest	Threshold	Crop growth stage	Crop damage	Comments	Frequency
Aphids	Treat low levels of aphids as soon as possible to prevent virus transmission.	Seedling to flowering.	Sucks sap, stunts plants and transmits virus.	Retained cereal stubble repels aphids. Check for natural predators such as ladybirds, hover flies and lacewings.	Rarely
Armyworm	No thresholds established.	Later vegetative stages and pod filling.	Defoliates and causes pod drop.	Rarely a problem in faba bean. Build up often occurs after heavy rain. Usually present in large numbers. Most active late afternoon and night.	Rarely
BOM and RLEM	Normally only large numbers require treatment.	Seedling (can prevent emergence).	Mottles and whitens cotyledons and leaves by rasping and sucking. Can stunt and kill seedlings.	Bare earth spraying preferred in high risk paddocks.	Intermittent
Cutworm	No thresholds established.	Seedling to 6 leaf stage.	Eats leaves, cuts stems at ground level or just below.	Check for presence in late evening or night. Eliminate weeds from paddock perimeter. Usually present in large numbers in patches of the crop.	Rarely
GVB	1–2 bugs/m^2.	Flowering to maturity.	Suck sap, distort pods, destroy seeds, cause pod drop.	Rarely a problem as they develop in late spring and summer.	Rarely
Heliothis caterpillar	2–4 larvae/m^2 (less than 10 mm long) or 1/m^2 for human consumption.	Flowering to pod setting.	Prevent pod set, bore into pods and destroy seeds.	Inspect crops twice weekly. Spray caterpillars while small. *H.punctigera* most common in spring. *H. armigera* can be found in low numbers within 30 km of summer irrigation.	Annual
Looper	No threshold established.	Seedling and vegetative stages.	Defoliates plants.	Usually occurs in patches. Spot or perimeter spraying effective. Characteristic looping movement.	Rarely
Lucerne flea	Spray if seedling leaf area is likely to be reduced by 50%.	Early plant growth stages.	Eats leaves, leaving clear membranous windows in foliage.	Eliminate weed growth on headlands. Lucerne fleas hop when disturbed. Liming reduces numbers on acid soils.	Intermittent
Thrips	4–6 thrips/flower.	Pre-flowering to early pod filling.	Feeds on young buds and flowers, which reduces pod set and distorts pods.	Shake flowers to dislodge thrips into a white container. A slender-bodied feathery-winged insect 1–1.5 mm long.	Rarely

Table 15. Faba bean – pesticide use (rate per ha). (Always read the label in conjunction with this table).

Numerous other products and formulations are also registered.

Chemical formulation	Toxicity to beneficials	Example registered trade name	Aphid	Blue oat mite	Cutworm	Green vegetable bug	Heliothis	Looper	Lucerne flea	Redlegged earth mite
Alpha-cypermethrin 100 g/L EC	High–very high	Alpha-Scud® Elite	–	50 mL	75 mL	–	0.2 L or 0.3 L (1)	–	–	50 mL (2)
Bt sub-species *kurstkai*	Very low	DiPel® SC	–	–	–	–	1.0–4.0 L	1.0–4.0 L	–	–
Beta-cyfluthrin 25 g/L	High–very high	Bulldock® Duo	–	0.2 L	–	–	–	0.2 L	–	–
Bifenthrin 250 g/L EC	High–very high	Talstar® 250 EC r	–	40 mL	–	–	–	20–40 mL	–	20–40 mL
Chlorantraniliprole 350 g/L	Very low	Altacor®	–	–	–	–	70 g	–	–	–
Chlorpyrifos 500 g/L EC	High–very high	Lorsban® 500 EC	–	0.14–0.3 L	–	–	–	–	–	0.14–0.3 L
Chlorpyrifos 300 g/L + lambda-cyhalothrin 15.4 g/L	High–very high	Cobalt® Advanced	–	–	–	–	–	0.2 L (3)	–	–
Deltamethrin 27.5 g/L EC	High–very high	decis options®	–	–	0.2 L	0.5 L	0.5 L	0.5 L	–	–
Dimethoate 400 g/L EC	High–very high	Dimethoate 400 EC	0.8 L	0.8 L	–	0.8 L	–	–	–	0.8 L
Emamectin 17 g/L	High–very high	Affirm®	–	–	–	–	0.15–0.3 L	0.15–0.3 L	–	–
Esfenvalerate 50 g/L EC	High–very high	Sumi-Alpha® Flex	–	50–70 mL	–	–	0.13–0.33 L (5)	–	–	50–70 mL
Gamma-cyhalothrin 150 g/L CS	High–very high	Trojan®	–	–	–	–	50 mL or 60 mL (5)	–	–	8 mL (6)
Indoxacarb 150 g/L	Very low	Steward® EC	–	–	–	–	0.3 L	–	–	–
Lambda-cyhalothrin 250 g/L CS	High–very high	Karate Zeon®	–	–	–	–	24 mL or 36 mL (1)	–	–	9 mL (6)
Nuclear polyhedrosis virus of *H. armigera*. 5 × 109 /mL (obs)	Very low	Vivus Max	–	–	–	–	0.15	–	–	–
Omethoate 290 g/L	High–very high	Le-Mat® 290 SL	100 mL or 200 mL	100 mL (4)	–	–	–	–	100 mL	100 mL (4)
Pirimicarb 800 g/kg	Very low	Aphidex® 800	160–190 g	–	–	–	–	–	–	–
Spinetoram 120 g/L	Very low	Success® Neo	–	–	–	–	0.2–0.3 L	0.2–0.3 L	–	–

(1) Registered for native budworm (*H. punctigera*) only.
(2) Registered at 100 mL/ha before crop emergence. Apply by ground rig only when the soil is moist. Do not apply as a ULV application.
(3) Registered for brown pasture looper (*Ciampa arientaria*) only.
(4) Also registered for Bryobia mite (*Bryobia* spp.) at 120 mL/ha.
(5) Registered in southern NSW for native budworm (*H. punctigera*) only.
(6) Blue oat mite often co-occur with redlegged earth mite and this rate might be less effective against blue oat mite

Toxicity to beneficials

Red	High–very high
Orange	Moderate
Green	Very low

Table 16. Field pea – pests.

Pest	Threshold	Crop growth stage	Crop damage	Comments	Frequency
Aphids	None established. Number of plants infected rather than numbers of aphids is important for control.	Before flowering.	Sucks sap, stunts plants and transmits viruses.	Direct crop damage unlikely. Check for predators. Retain cereal stubbles. Rarely seen in large numbers.	Rarely
BOM and RLEM	Check seedlings for mite presence after the autumn break. Spray if growth is retarded.	Seedling emergence to 4 nodes. Pea emergence can be suppressed.	Mottles and whitens cotyledons and leaves by rasping and sucking. Can stunt and kill seedlings. RLEM more common in southern NSW.	Mostly feeding during cooler part of day/night. Often present under clods or underside of weeds such as capeweed/saffron thistles during day. Higher numbers after pasture.	Intermittent
Cutworm	Usually in large numbers in patches in crop. Treat at first sign of damage.	Seedling up to 4 nodes.	Eat leaves and cut stems at or below ground level. Remain in soil during the day.	Inspect crops late evening or night for presence of large dark grey–green caterpillars. Consider over-row spraying (night) or treat patches only.	Rarely
Heliothis caterpillar	Four or more 4–9 mm larvae/10 sweeps for stock feed. 1–2 larvae (4–9 mm)/10 sweeps for human consumption. Larvae over 10 mm can enter pods and not be controlled.	Flowering and pod filling.	Prevents pod formation. Bores into pods, eat and damage seeds.	Observe crop for presence of moths during flowering. *H. punctigera* most common in spring. *H. armigera* can be found in low numbers within 30 km of summer irrigation.	Annual
Looper	No threshold established.	Early plant growth stages.	Defoliate plants.	Capeweed preferred food plant. Caterpillars have distinct looping motion and move in from the edge of the crop.	Rarely
Lucerne flea	Spray if seedling leaf area is likely to be reduced by 50%.	Seedling up to 4 nodes. Crops on heavy acidic soils most prone to damage.	Eat leaves, leaving clear membranous windows in foliage.	Eliminate weeds on headlands. Lucerne fleas hop when disturbed. Liming reduces flea numbers on acidic soils. Control might be necessary in southern NSW.	Intermittent
Lucerne seed web moth	At the first sign of damage. Treatments for heliothis caterpillar or pea weevil will give some control.	Flowering and podding.	Small caterpillars bore into seeds, leaving webbing and excrement on pods.	Attack can go unnoticed until damage has occurred. No recommended treatment.	Rarely
Pea weevil	Take 25 sweeps at each of 6 sites on crop edges. Border spray if there is average of 2 or more weevils/site.	First flowers onwards.	Larvae bore into pods, enter seeds, reduce seed weight by 25%; reduce germination by 75%.	Fumigate all purchased seed in gas tight silo for 21 days with phosphine. Spray adults in crop before egg laying starts.	Annual
Thrips	4–6 thrips/flower.	Budding to flowering.	Feeds on young buds and flowers. Reduces pod set and distorts pods.	Shake flowers into white container to dislodge thrips, or open and inspect flowers.	Rarely

Table 17. Field pea – pesticide use (rate per ha). (Always read the label in conjunction with this table).

Numerous other products and formulations are also registered.

Chemical formulation	Toxicity to beneficials	Example registered trade name	Aphid	Blue oat mite	Cutworm	Green vegetable bug	Heliothis	Looper	Lucerne flea	Pea weevil	Redlegged earth mite	Thrips
Alpha-cypermethrin 100 g/L EC	High–very high	Alpha Scud® Elite	–	50 mL	75 mL	–	0.2 L or 0.3 L (1)	–	–	0.16 L or 0.2 L	50 mL (2)	–
Bt sub-species *kurstkai*	Very low	DiPel® SC	–	–	–	–	1.0–4.0 L	1.0–4.0 L	–	–	–	–
Beta-cyfluthrin 25 g/L	High–very high	Bulldock® Duo	–	–	–	–	0.4 L or 0.5 L	–	–	0.4 L	–	–
Chlorantraniliprole 350 g/L	Very low	Altacor®	–	–	–	–	70 g	–	–	–	–	–
Bifenthrin 250 g/L EC	High–very high	Talstar® 250 EC	–	40 mL	–	–	–	20–40 mL	–	–	20–40 mL (3)	–
Chlorpyrifos 500 g/L EC	High–very high	Lorsban® 500 EC	–	0.14–0.3 L	–	–	–	–	–	–	0.14–0.3 L	–
Chlorpyrifos 400 g/L + bifenthrin 20 g/L	High–very high	Pyrinex® Super (4)	–	0.5 L	–	–	–	0.25–0.5 L	0.25–0.5 L	–	0.25–0.5 L	–
Chlorpyrifos 300 g/L + lambda-cyhalothrin 15.4 g/L	High–very high	Cobalt® Advanced	–	–	–	–	–	0.2 L	–	–	–	–
Cypermethrin 200 g/L	High–very high	Scud Elite	–	–	–	–	0.2–0.25 L (1)	–	–	0.16 L or 0.2 L	–	–
Deltamethrin 27.5 g/L EC	High–very high	decis options®	–	–	0.2 L	–	0.25–0.5 L (5)	–	–	0.4–0.5 L	–	–
Dimethoate 400 g/L EC	High–very high	Dimethoate 400 EC	0.8	–	–	0.8 L	–	–	–	–	0.8 L	0.8 L
Emamectin 17 g/L	Moderate	Affirm®	–	–	–	–	0.15–0.3 L	0.15–0.3 L	–	–	–	–
Esfenvalerate 50 g/L EC	High–very high	Sumi-Alpha® Flex	–	50–70 mL (2)	–	–	0.13–0.33 L (6)	–	–	0.33 L (6)	50–70 mL (2)	0.13 L (6)
Gamma-cyhalothrin 150 g/L CS	High–very high	Trojan®	–	–	–	20 mL	20 mL or 30 mL (1)	–	–	20 mL	8 mL (7)	–
Lambda-cyhalothrin 250 g/L CS	High–very high	Karate Zeon®	–	–	–	24 mL	24 mL or 36 mL (1)	–	–	24 mL	9 mL (7)	–
Methomyl 225 g/L SL	High–very high	Lannate®-L	–	–	–	1.5 L	1.5–2.0 L	1.5 L	–	–	–	1.0 L
Nuclear polyhedrosis virus of *H. armigera*. 5 × 109 /mL (obs)	Very low	Vivus Max	–	–	–	–	0.15 L	–	–	–	–	–
Omethoate 290 g/L	High–very high	Le-Mat® 290 SL	–	100 mL (8)	–	–	–	–	100 mL	–	100 mL (8)	–
Permethrin 500 g/L EC	High–very high	Axe®	–	–	–	–	0.15–0.25 L (1)	–	–	–	–	–
Pirimicarb 800 g/kg WG	Very low	Aphidex® 800	160–190 g	–	–	–	–	–	–	–	–	–
Spinetoram 120 g/L	Very low	Success® Neo	–	–	–	–	0.2–0.3 L	0.2–0.3 L	–	–	–	–

(1) Registered for native budworm (*H. punctigera*) only. Use the higher rate if larvae longer than 10 mm are present.
(2) Registered at 100 mL/ha before crop emergence. Apply by ground rig only when soil is moist. Do not apply as a ULV application.
(3) Registered at 80 mL/ha for bryobia mite. Apply before crop emergence. Apply by ground rig only when soil is moist.
(4) Also registered for pasture webworm at 0.5 L/ha.
(5) Use the higher rate for large infestations and/or where larvae are larger than 5 mm.
(6) Registered at these rates against nominated pests in southern NSW only.
(7) Blue oat mite often co-occur with redlegged earth mite and this rate might be less effective against blue oat mite.
(8) Also registered for Bryobia mite (*Bryobia* spp.) at 120 mL/ha.

Toxicity to beneficials
- High–very high
- Moderate
- Very low

Table 18. Lentil – pests.

Insect	Threshold	Crop growth stage	Crop damage	Comments	Frequency
Aphid (pea, cowpea, blue green, spotted alfalfa and green peach aphids)	None established. Number of plants infected rather than numbers of aphids used for control decisions.	Before flowering.	Suck sap, stunt plants and transmit virus.	Direct crop damage unlikely. Check for predators. Retain cereal stubbles. Rarely seen in large numbers.	Rarely
Mites (redlegged earth mite, blue oat mite, *Balaustium* and *Bryobia* mites)	Check seedlings for presence of mites after the autumn break. Spray if growth is retarded.	Seedling emergence to 4 nodes. Pea emergence can be suppressed.	Mottle and whiten cotyledons and leaves by rasping and sucking. Can stunt and kill seedlings. RLEM more common in southern NSW.	Feed mostly during cooler part of day/night. Often present under clods or underside of weeds such as capeweed and saffron thistles during day. Higher numbers after pasture.	Intermittent
Cutworm	Usually in large numbers in patches in crop. Treat at first sign of damage.	Seedling up to 4 nodes.	Eat leaves and cut stems at or below ground level. Remain in soil during the day.	Inspect crops late evening or night for presence of large dark grey-green caterpillars. Consider over-row spraying (night) or treat patches only.	Rarely
Helicoverpa caterpillar	1–2 larvae (4–9 mm) per 10 sweeps. Larvae over 10 mm can enter pods and not be controlled.	Flowering and pod filling.	Prevent pod formation. Bore into pods, eat and damage seeds.	Observe crop for presence of moths during flowering. *H. punctigera* most common in spring. *H. armigera* in low numbers. Pheromone traps will assist monitoring.	Annual
Brown pasture looper caterpillar	No threshold established.	Early plant growth stages.	Defoliate plants.	Often coming from nearby weeds or pastures. Caterpillars have distinct looping motion. Move in from edge of crop.	Rarely
Lucerne flea	Spray if seedling leaf area is reduced by 50%.	Seedling up to 4 nodes. Crops on heavy acidic soils most prone to damage.	Graze leaves, leaving clear membranous windows in foliage.	Eliminate weeds on headlands. Lucerne flea hops when disturbed. Liming reduces flea numbers on acidic soils. Control may be necessary in southern NSW.	Intermittent
Lucerne seed web caterpillar (*Etiella* sp.)	At the first sign of damage. Treatments applied against heliothis caterpillar will give some control.	Flowering and podding.	Small caterpillars bore into seeds, leave webbing and excrement on pods.	Attack may go unnoticed until damage has occurred. No recommended treatment.	Rarely
Weevils (*Mandalotus* spp.)	No threshold established. Usually occurs in patches.	Seedling and early plant growth stages.	Adults eat seedling leaves.	Monitor in evening or at night. Spot spraying may be required at night.	Rarely
Thrips (onion, plague and western flower thrips)	4–6 thrips per flower.	Budding to flowering.	Feed on young buds and flowers. Reduces pod set and distort pods.	Shake flowers into white container to dislodge thrips or open and inspect flowers.	Rarely
Slugs (grey field or black keeled)	Bait at first sign of damage. Species determines damage and bait effectiveness.	Newly emerged seedlings.	Chew off seedlings. Leaf damage may look like hail.	Damage starts in damp areas of paddock. Check presence by setting wet hessian or tile traps. Combined control strategies of burning, cultivation, weed control and baiting are most effective.	Intermittent, (favoured by wet seasons)

Table 19. Lentil – pesticide use (rate per ha). (Always read the label in conjunction with this table). Numerous other products and formulations are also registered.

Chemical formulation	Toxicity to beneficials	Example registered trade name	Aphid	Blue oat mite	Cutworm	Etiella	Green vegetable bug	Heliothis	Looper	Lucerne flea	Pea weevil	Redlegged earth mite	Thrips
Chlorantraniliprole 350 g/L	Very low	Altacor®	–	–	–	–	–	70 g	–	–	–	–	–
Chlorpyrifos 300 g/L + lambda-cyhalothrin 15.4 g/L	High–very high	Cobalt Advanced®	–	–	–	–	–	–	0.2 L (1)	–	–	–	–
Deltamethrin 27.5 g/L EC	High–very high	decis options®	–	–	0.2 L	0.5 L	0.5 L	0.5 L	0.5 L	–	–	–	–
Dimethoate 400 g/L EC	High–very high	Dimethoate 400 EC	–	–	–	–	–	–	–	–	–	90 mL	–
Emamectin 17 g/L	Moderate	Affirm®	–	–	–	–	–	0.15–0.3 L	0.15–0.3 L	–	–	–	–
Esfenvalerate 50 g/L EC	High–very high	Sumi-Alpha® Flex (4)	0.1–0.3 L (5)	50–70 mL (2)	–	0.33 L	–	0.13–0.33 L (3)	–	–	–	50–70 mL (2)	0.13 L
Gamma-cyhalothrin 150 g/L	High–very high	Trojan®	–	–	–	–	20 mL	20 mL or 30 mL (3)(4)	–	–	–	8 mL (6)	–
Lambda-cyhalothrin 250 g/L EC	High–very high	Karate Zeon®	–	–	–	–	24 mL	24 mL or 36 mL (7)	–	–	–	9 mL (6)	–
Methomyl 225 g/L	High–very high	Lannate®-L	–	–	–	–	–	1.5–2.0 L	–	–	–	–	–
Nuclear polyhedrosis virus of *H. armigera*. 5 × 109/mL (obs)	Very low	Vivus Max	–	–	–	–	–	0.15 L	–	–	–	–	–
Omethoate 290 g/L	High–very high	Le-Mat® 290 SL	–	100 mL (8)	–	–	–	–	–	100 mL	–	100 mL (8)	
Pirimicarb 800 g/kg	Very low	Aphidex® 800	0.16–0.29 kg	–	–	–	–	–	–	–	–	–	–
Spinetoram 120 g/L	Very low	Success® Neo	–	–	–	–	–	0.2–0.3 L	0.2–0.3 L	–	–	–	–

(1) Registered for brown pasture looper (*Ciampa arientaria*) only.
(2) Also registered at 100 mL/ha before crop emergence. Apply by ground rig only.
(3) Registered for native budworm (*H. punctigera*) only. Rate dependent on larvae size. Registered for southern NSW only.
(4) Registered for southern NSW only.
(5) Registered for bluegreen aphid at 0.1–0.2 L/ha, and cowpea aphid at 0.2–0.3 L/ha.
(6) Blue oat mite often co-occur with redlegged earth mite and this rate might be less effective against blue oat mite.
(7) Registered for native budworm (*H. punctigera*) only.
(8) Also registered for Bryobia mite (*Bryobia* spp.) at 120 mL/ha.

Toxicity to beneficials

Red	High–very high
Orange	Moderate
Green	Very low

Table 20. Linseed – pests.

Pest	Threshold	Crop growth stage	Crop damage	Comments	Frequency
Aphids	No threshold established.	Flowering and boll filling.	Sucks sap, stunts plants and transmits virus.	If aphids are present check for predators before spraying. Not known to transmit any virus diseases.	Rarely
Armyworm	No threshold established.	Boll filling.	Chews off sections of head.	Heavy rain precedes development. Usually present in large numbers. Most active in the afternoon and night.	Rarely
BOM and RLEM	Check seedlings for mites after autumn break. Spray if crop growth is retarded.	Seedling emergence until 4-leaf stage. Seedling emergence can be inhibited.	Mottles and whitens cotyledons and leaves by rasping and sucking. Can stunt and kill seedlings. RLEM common in south, BOM in north.	Mostly feeds during the cooler part of the day and night. During the day often present under clods or the undersides of weeds such as capeweed, Paterson's curse and saffron thistle.	Annual
Cutworm	Control required if there are large numbers in patches in crop.	Early plant growth stages; often present at sowing.	Chews leaves and stems. Can cut plants off at or below ground level.	Feeds in the evening and at night. Hides in soil during the day. Check and spray late afternoon. Spot spraying might be sufficient.	Rarely
Heliothis caterpillar	Consider spraying if there has been a big egg lay or if there are more than 2–4 larvae/m^2.	Late flowering and boll formation.	Destroys flower buds, eats holes in or destroys developing bolls.	Linseed is very susceptible to attack, sometimes 2 sprays necessary. *H. punctigera* most common in spring. *H. armigera* can be found in low numbers within 30 km of summer irrigation. Crops needs to be inspected until bolls have ripened.	Annual
Lucerne flea	Spray if seedling leaf area is likely to be reduced by 50%.	Seedlings up to 4–6 leaf stage. Crops on heavy acidic soils most prone to damage.	Eats leaves, leaving clear membranous windows in foliage.	Eliminate weeds on headlands. Lucerne fleas hop when disturbed. Liming reduces flea numbers. Most likely found on acid soils in southern NSW.	Intermittent
Thrips	Rarely a problem in linseed. 1–2 thrips/flower.	Budding to flowering.	Feeds on young buds and flowers reducing boll set and distorts bolls.	Shake flowers into white container to dislodge thrips or open and inspect flowers.	Rarely

Table 21. Linseed – pesticide use (rate per ha). (Always read the label in conjunction with this table). Numerous other products and formulations are also registered.

Chemical formulation	Toxicity to beneficials	Example registered trade name	Armyworm	Blue oat mite	Cutworm	Green vegetable bug	Heliothis	Lucerne flea	Redlegged earth mite
Alpha-cypermethrin 100 g/L EC	High–very high	Alpha Scud® Elite	–	–	75 mL	–	0.2 L or 0.3 L ❶	–	–
Bt sub-species *kurstkai*	Very low	DiPel® SC	1.0–4.0 L	–	–	–	1.0–4.0 L	–	–
Chlorpyrifos 500 g/L EC	High–very high	Lorsban® 500 EC	–	0.14–0.3 L	0.9 L	–	–	–	0.14–0.3 L
Deltamethrin 27.5 g/L EC	High–very high	decis options®	–	–	0.2 L	0.5 L	0.5 L ❷	–	–
Dimethoate 400 g/L EC	High–very high	Dimethoate 400 EC	–	–	–	–	–	55–85 mL	85 mL
Esfenvalerate 50 g/L EC	High–very high	Sumi-Alpha® Flex	–	50–70 mL ❸	–	–	0.13–0.5 ❹	–	50–70 mL ❸
Methidathion 400 g/L EC	High–very high	Suprathion® 400 EC ❺	–	0.2 L	–	–	–	0.2 L	0.2 L
Nuclear polyhedrosis virus of *H. armigera*. 5 × 109 /mL (obs)	Very low	Vivus Max	–	–	–	–	0.15 L	–	–
Permethrin (40:60) 500 g/L EC	High–very high	Axe®	–	–	–	–	0.2–0.3 L ❶	–	–
Trichlorfon 500 g/L SL	High–very high	Lepidex® 500	1.2 L	–	–	–	–	–	–

❶ Registered for native budworm (*H. punctigera*) only. Use the higher rate if larvae longer than 10 mm are present.
❷ Apply to larvae less than 5 mm.
❸ Registered at 100 mL/ha before crop emergence. Apply by ground rig only. Do not apply as a ULV application.
❹ Registered for native budworm (*H. punctigera*) at 0.13-0.33 L/ha in southern NSW and 0.5 L/ha for *H. armigera* in northern NSW only to larvae less than 5 mm long.
❺ Registered for ground spray, immediately before crop emergence.

Toxicity to beneficials

(red)	High–very high
(orange)	Moderate
(green)	Very low

Table 22. Lupin – pests.

Pest	Threshold	Crop growth stage	Crop damage	Comments	Frequency
Aphids	Treat at first sign of virus-infected plants or appearance of aphid clusters on flowering spikes.	Late vegetative, budding and flowering.	Reduces pod set and transmits viruses. Causes stunted plants.	Eliminate weeds such as Hexham scent, fumitory and stagger weed. Retained cereal stubble repels aphids from crop. Aphid treatment has not always prevented virus transmission.	Intermittent
Armyworm	Control when monitoring indicates numbers are increasing.	Pod filling.	Chews off pods which drop on ground.	Prefers winter cereals, especially barley. Build up often occurs after heavy rain.	Rarely
BOM and RLEM	Check seedlings for mites after the autumn break. Spray if growth is retarded.	Seedling emergence to 4-leaf stage. Look for damage to cotyledons. Can kill seedling.	Mottles and whitens cotyledons and leaves by rasping and sucking. Can stunt and kill seedlings. RLEM more common in southern NSW.	Mostly feeding during the cooler part of day/night. During the day often present under clods or underside of weeds such as capeweedand saffron thistle.	Annual
Cutworm	Treat at first sign of damage, preferably in late afternoon.	Early plant growth stages.	Eats leaves and cuts stems at or below ground level. Remains in soil during the day.	Inspect crop in the late afternoon or night for large dark grey–green caterpillars. Over the row band spraying (night) or spot treatment.	Rarely
Heliothis caterpillar	Depends on value of lupins and stage of pod filling. Albus lupins more susceptible. 1–2 larvae/m² less than 5 mm long for human consumption; 1–2 larvae/10 sweeps for stock feed.	Can cause flower and pod abortion at early flowering. More commonly present in late flowering and pod filling.	Small caterpillars feed inside flowers (1–5 mm). Large caterpillars (25 mm) eat holes in pods and seeds.	Examine crops weekly during flowering. Seed for stock feed can tolerate some damage. *H. punctigera* most common in spring. *H. armigera* can be found in low numbers within 30 km of summer irrigation.	Annual
Looper	Control when monitoring indicates numbers are increasing.	Early plant growth stages.	Defoliates plants.	Capeweed is the preferred host. Caterpillars have a distinct looping motion and move in from the edge of the crop. Border spray or spot spray might be needed.	Rarely
Lucerne flea	Spray if seedling leaf area is likely to be reduced by 50%.	Seedling up to 4-leaf stage. Crop on heavy acidic soils most prone to damage.	Eats leaves, leaving clear membranous windows in foliage.	Eliminate weeds on headlands. Lucerne fleas hop when disturbed. Liming reduces flea numbers on acidic soils in southern NSW.	Intermittent
Lucerne seed web moth	At the first sign of damage. Treatments for heliothis will give some control.	Flowering and podding.	Small caterpillars bore into seeds, leave webbing and excrement on pods.	Attack can go unnoticed until damage has occurred. No recommended control measure.	Rarely
Thrips	Check for presence in flowers. 1–2 thrips/flower.	Budding and flowering.	Reduces flowering and causes pod abortions.	Shake flowers into white container to dislodge thrips, or open and inspect flowers.	Rarely

Table 23. Lupin – pesticide use (rate per ha). (Always read the label in conjunction with this table). Numerous other products and formulations are also registered.

Chemical formulation	Toxicity to beneficials	Example registered trade name	Aphid	Armyworm	Blue oat mite	Cutworm	Green vegetable bug	Heliothis	Looper	Lucerne flea	Redlegged earth mite	Thrips
Alpha-cypermethrin 100 g/L EC	High–very high	Alpha Scud® Elite	–	0.24 L	50 mL	75 mL	–	0.2 L or 0.3 L (1)	–	–	50 mL (2)	–
Bt sub-species *kurstkai*	Very low	DiPel® SC	–	1.0–4.0 L	–	–	–	1.0–4.0 L	–	–	–	–
Bifenthrin 250 g/L EC	High–very high	Talstar® 250 EC (4)	–	–	40 mL	–	–	–	20–40 mL	–	20–40 mL (3)	–
Beta-cyfluthrin 25 g/L	High–very high	Bulldock® Duo	–	–	0.2 L	0.2 L or 0.4 L	–	0.2 L or 0.4 L	–	–	0.2 L	–
Chlorantraniliprole 350 g/L	Very low	Altacor®	–	–	–	–	–	70 g	–	–	–	–
Chlorpyrifos 500 g/L EC	High–very high	Lorsban® 500 EC	–	–	0.14–0.3 L	–	–	–	–	–	0.14–0.3 L	–
Chlorpyrifos 400 g/L + bifenthrin 20 g/L	High–very high	Pyrinex® Super (4)	–	–	0.5 L	–	–	–	–	0.25–0.5 L	0.25–0.5 L	–
Chlorpyrifos 300 g/L + lambda-cyhalothrin 15.4 g/L	High–very high	Cobalt® Advanced	–	–	–	–	–	–	0.2 L	–	–	–
Cypermethrin 200 g/L EC	High–very high	Scud Elite®	–	–	–	75 mL	–	0.2–0.3 L (1)	–	–	–	–
Deltamethrin 27.5 g/L EC	High–very high	decis options®	–	–	–	0.2 L	0.5 L	0.2–0.5 L (5)	0.5 L	–	–	–
Dimethoate 400 g/L EC	High–very high	Dimethoate 400 EC	0.5 L	–	–	–	–	–	–	–	–	0.8 L
Emamectin 17 g/L	Moderate	Affirm®	–	–	–	–	–	0.15–0.3 L	0.15–0.3 L	–	–	–
Esfenvalerate 50 g/L EC	High–very high	Sumi-Alpha® Flex	–	–	50–70 mL (2)	70 mL	–	0.13–0.33 L (1)	–	–	50–70 mL (2)	0.13 L
Lambda-cyhalothrin 250 g/L EC	High–very high	Karate Zeon®	–	–	–	–	–	24 mL (6)	12 mL	–	9 mL (7)	–
Methomyl 225 g/L SL	High–very high	Lannate®-L	–	–	–	–	–	1.5–2.0 L (1)	–	–	–	–
Nuclear polyhedrosis virus of *Helicoverpa armigera*. 5 × 109 /mL (obs)	Very low	Vivus Max	–	–	–	–	–	0.15 L	–	–	–	–
Omethoate 290 g/L	High–very high	Le-Mat® 290 SL	–	–	100 mL (8)	–	–	–	–	100 mL	100 mL (8)	–
Pirimicarb 500 g/kg WG	Very low	Pirimor® WG	0.25 kg	–	–	–	–	–	–	–	–	–
Spinetoram 120 g/L	Very low	Success® Neo	–	–	–	–	–	0.2–0.3 L	0.2–0.3 L	–	–	–
Trichlorfon 500 g/L SL	High–very high	Lepidex® 500	–	1.2 L	–	–	–	–	–	–	–	–

(1) Registered for native budworm (*H. punctigera*) only. Use the higher rate if larvae longer than 10 mm are present.
(2) Registered at 100 mL/ha before crop emergence. Apply by ground rig only.
(3) Registered at 80 mL/ha for bryobia mite (*Bryobia* spp.).
(4) Also registered for pasture webworm at 40 mL/ha.
(5) Registered for corn earworm (*H. armigera*) at 0.5 L/ha.
(6) Registered for native budworm (*H. punctigera*) only.
(7) Blue oat mite often co-occur with redlegged earth mite and this rate might be less effective against blue oat mite.
(8) Also registered for Bryobia mite (*Bryobia* spp.) at 120 mL/ha.

Toxicity to beneficials

- High–very high (red)
- Moderate (orange)
- Very low (green)

Table 24. Safflower – pests.

Pest	Threshold	Crop growth stage	Crop damage	Comments	Frequency
Aphids	20% plants with 20 or more aphids/growing point, bud or flower head. Check for natural enemies.	Most common during budding and flowering. Can also infest seedlings.	Feeds on growing points, buds and flower heads. Causes mottled appearance, distortion and shrivelled heads.	Most commonly green peach, leaf curl and plum aphids. Check for presence of natural enemies.	Intermittent
BOM and RLEM	Usually present in large numbers. Later sowing allows time for control before planting.	Seedling emergence to 4-leaf stage. Look for damage to cotyledons.	Mottles and whitens cotyledons and leaves by rasping and sucking. Can stunt and kill seedlings. RLEM more common in southern NSW.	Most feeding during cooler part of day and night. Often present under clods or underside of weed leaves such as capeweed and saffron thistles.	Intermittent
Cutworm	Treat at first sign of damage, preferably in late afternoon.	Early growth stages, spot spraying may be sufficient.	Eatss leaves and cut stems at or below ground level killing plants. Remains in the soil during the day and feeds at night.	Inspect crop in late afternoon or night for large dark grey–green caterpillars. Usually in large numbers in patches Spot spraying might be effective.	Rarely
False wireworm	Check for larvae before sowing. No after sowing treatment.	Newly emerged seedling.	Larvae chew seed and seedling roots and shoots, resulting in patchy stands. Adu-lts chew seedlings at or above ground level, ring-barking or cutting the stem.	Vary from 8–40 mm in length. Check at junction of loose cultivated soil and undisturbed soil before sowing.	Intermittent
Rutherglen bug (RGB) and grey cluster bug	Well grown crops can tolerate up to 40% bud loss.	Budding and flowering. Invasion from outside crop.	Sucks sap from buds, flowers and stems. Causes wilting and death of heads. Nymphs feed on developing seeds.	Reduce oil content. Adults 5 mm long, narrow bodied grey colour. Nymphs reddish brown and pear-shaped. Damage worse under moisture stress and hot conditions.	Intermittent
Heliothis caterpillar	4–8 larvae 5–7 mm long/m^2. Only damage to flower buds. Well grown crops can tolerate up to 40% damage to buds and developing flower heads.	Budding and flowering.	Caterpillars chew flower buds and flowers, prevent seed set.	Check to identify *H. punctigera* or *H. armigera*. Later in season greater possibility of *H. armigera* within 30 km of summer irrigation.	Annual
Lucerne flea	Rarely a problem in safflower as sown later and mostly on higher pH soils. (See details for canola on page 42.)				
Thrips	1–2 thrips/flower or 25% buds killed. Well-grown plants might tolerate greater losses.	Budding and flowering. Buds become bronzed and die.	Kills buds, causes flower abortions. Greater damage in dry conditions.	Shake flowers into white container to dislodge slender-bodied, feathery-winged 1–1.5 mm long insect.	Intermittent

Table 25. Safflower – pesticide use (rate per ha). (Always read the label in conjunction with this table). Numerous other products and formulations are also registered.

Chemical formulation	Toxicity to beneficials	Example registered trade name	Blue oat mite	Cutworm	Heliothis	Lucerne flea	Redlegged earth mite
Bt sub-species *kurstkai*	Very low	DiPel® SC	–	–	1.0–4.0 L	–	–
Chlorpyrifos 500 g/L EC	High–very high	Lorsban® 500 EC	0.14–0.3 L	–	–	–	0.14–0.3 L
Deltamethrin 27.5 g/L EC	High–very high	decis options® ❶	–	0.2 L	0.5 L	–	–
Dimethoate 400 g/L EC	High–very high	Dimethoate 400 EC	–	–	–	55–85 mL	85 mL
Esfenvalerate 50 g/L EC	High–very high	Sumi-Alpha® Flex	50–70 mL ❷	–	0.13–0.33 L ❸	–	50–70 mL ❷
Methidathion 400 g/L EC	High–very high	Suprathion® 400 EC ❹	0.2 L	–	–	0.2 L	0.2 L
Nuclear polyhedrosis virus of *H. armigera*. 5 × 109 /mL (obs)	Very low	Vivus Max	–	–	0.15 L	–	–

❶ Also registered for green vegetable bug (*Nezara viridula*) and looper at 0.5 L/ha.
❷ Registered at 100 mL/ha as a bare earth treatment. Apply before crop emergence. Do not apply as a ULV application.
❸ Registered for the control of native budworm (*Helicoverpa punctigera*) in southern NSW only.
❹ Apply as a ground spray, immediately before seedling emergence.

Toxicity to beneficials

(red)	High–very high
(orange)	Moderate
(green)	Very low

Notes

Table 26. Winter cereals – pests.

Pest	Threshold	Crop growth stage	Crop damage	Comments	Frequency
Aphids (corn aphids, oat aphids)	More than 15 aphids/tiller on 50% of tillers if the expected yield will exceed 3 t/ha.	Varies from 2–3-leaf stage through to heading. Potential for damage is higher if present during tillering than after booting.	Diverts carbohydrates and transmits Barley yellow dwarf virus. Hot spots of high aphid numbers are seen in winter months.	Look for infestations in leaf sheath of young plants. Aphids move in from surrounding pasture areas. Aphids are attracted to early sown crops. Look for natural enemies.	Intermittent
Russian wheat aphid	Treatment required when >10% plants show symptoms.	Seedling to head emergence in hot spots where plants are stressed.	Severe yield losses if left unchecked. Heavy infestations can kill plants	Typically symptoms will be rolled leaves with chlorotic streaks. Natural enemies are often effective controls.	Intermittent
Armyworm	2–3 caterpillars/m^2.	Normally attacks ripening crops but can defoliate plants during earlier growth stages.	Initially eats lower leaves on plant. Move to heads when ripe. Chews through parts of head which drop onto ground. Prefers oats and barley.	Look for caterpillars during evening or at night. More numerous in heavy areas of crop. Larvae size in relation to crop stage should be considered before spraying. Spray late afternoon or evening for best results.	Barley–annual Wheat–intermittent
Australian plague locusts	Presence of locusts in or near crops.	Seedling through to maturity.	Eats young seedlings in autumn and chews off ripening heads in spring.	If locusts are seen, contact your Local Land Services authority.	Rarely
BOM and RLEM	Oats more susceptible than barley or wheat. Spray if growth is retarded.	1–5-leaf stage. Most severe on newly emerged crops.	Causes greyish and silvery streaks by rasping and sucking sap. Tips of leaves turn brown.	BOM cause more severe damage to cereals. Crop damage usually observed from 10–14 days after autumn break.	Annual
Brown wheat mite	Treat before damage becomes severe. Damage occurs during abnormally dry/warm conditions in autumn/spring.	From seedling to flowering.	Pierce leaves, suck sap. Leaves appear bronzed or yellowish.	Control does not always produce economic improvements in yield. Mature mites are 0.5–0.7 mm long. Immature mites are orange/red colour.	Rarely
Curculionid larvae	Usually patchy. Treatment after sowing not effective.	Seedling.	Larvae feed on germinating seed; bore into underground stems, kill growing points.	Examine soil before sowing. Use treated seed if present.	Rarely
Cutworm	Usually in large numbers in patches moving in from edges. Treat at first sign of damage.	1–2 leaf stage through plant tillering.	Eats leaves and stems, cuts off plants at ground level or underground. Mostly feeding evening and night. Caterpillars hide in soil during day.	Inspect crops in late evening or night for large dark grey–green caterpillar. Spray late in afternoon. Caterpillars hide in soil during the day.	Rarely
False wireworm	Caterpillars present before sowing. No after-sowing treatment.	Newly emerged seedling.	Feeds on seed and underground stems and roots of young plants. Plants wither and die.	Vary from 8–40 mm in length. Check at junction of loose cultivated soil and undisturbed soil.	Rarely
Spur-throated locusts	Locusts in or near crops.	Seedling through to maturity.	Eats young seedlings in autumn and winter and chews off ripening heads in spring.	If locusts are seen, contact your Local Land Services authority.	Rarely
White curl grubs (scarab grubs)	No after sowing treatment. Treat if 2–5 larvae/m^2. Treat seed before sowing.	Seedling from 2–5-leaf.	Feeds on roots and underground stems. Crop often appears moisture stressed and unthrifty. Causes stunting and seedling death. Often seen as bare patches around trees.	Larvae curl up in semi-circle 20–60 mm long. Treat seed or fertiliser before sowing. Check near trees in paddocks. More common after pasture and in wetter seasons.	Intermittent
Wireworm	Larvae present before sowing. No post-sowing treatment.	Larvae feed on germinating seed; bore into stem of young seedling.	Kills seedling by destroying growing points. Damage is more severe in dry cool growing conditions.	Clean cultivation can reduce wireworm in summer and autumn. Wireworms are present in the top 50 mm of moist soil. Treat seed before sowing.	Rarely

Table 27. Winter cereals – pesticide use (rate per ha). (Always read the label in conjunction with this table).
Numerous other products and formulations are also registered.

Chemical formulation	Toxicity to beneficials	Example registered trade name	Aphid	Armyworm	Blue oat mite	Cutworm	Heliothis	Lucerne flea	Pasture webworm	Redlegged earth mite
Alpha-cypermethrin 100 g/L EC	[High–very high]	Alpha-Scud® Elite	125 mL	240 mL	50 mL	75 or 150 mL	–	–	75 mL	50 mL ❶
Bt sub-species *kurstkai*	[Very low]	Delfin® WG	–	25–100 g	–	–	25–100 g	–	–	–
Bifenthrin 250 g/L EC	[High–very high]	Talstar ®250 EC ❷	–	–	40 mL	–	–	–	40 mL	20–40 mL
Beta-cyfluthrin 25 g/L	[High–very high]	Bulldock® Duo	0.5 L or 1.0 L	0.4 L	0.2 L	–	–	–	–	0.2 L
Chlorpyrifos 500 g/L EC	[High–very high]	Lorsban® 500 EC	–	0.7 L or 0.9 L	0.14–0.3 L	0.9 L	–	70 mL	0.7 L	0.14–0.3 L
Chlorpyrifos 400 g/L + lambda-bifenthrin 20 g/L	[High–very high]	Pyrinex® Super ❸	–	–	0.5 L	–	–	0.25–0.5 L	0.5 L	0.25–0.5 L
Chlorpyrifos 300 g/L + lambda-cyhalothrin 15.4 g/L	[High–very high]	Cobalt® Advanced ❹	0.2 L or 0.3 L	–	0.15 L	0.2 L or 0.3 L	–	0.12 L	0.2 L	0.15 L
Cypermethrin 200 g/L EC	[High–very high]	Scud Elite®	–	0.17 L	50–75 mL	75 mL	–	–	–	50–75 mL
Deltamethrin 27.5 g/L EC	[High–very high]	decis options®	–	0.2 L	–	0.2 L	0.5 L	–	0.2 L	–
Dimethoate 400 g/L EC	[High–very high]	Dimethoate 400 EC	0.5 L	–	90 mL	–	–	55–85 mL	–	85 mL
Esfenvalerate 50 g/L EC	[High–very high]	Sumi-Alpha® Flex	0.1–0.3 L ❺	0.33 L ❻	50–70 mL ❻	70 mL	0.13–0.33 L ❻	–	70 mL	50–70 mL ❻
Gamma-cyhalothrin 150 g/L CS	[High–very high]	Trojan® ❼	10 mL or 15 mL ❺	–	10 mL	10 mL or 15 mL	–	–	10 mL	8 mL ❽
Lambda-cyhalothrin 250 g/L	[High–very high]	Karate Zeon® ❼	12 mL or 18 mL ❾	–	12 mL ❽	12 mL or 18 mL	–	–	12 mL	9 mL ❽
Methomyl 225 g/L SL	[High–very high]	Lannate®-L	–	1.0 L or 1.5 L	–	–	1.5–2.0 L	–	–	–
Nuclear polyhedrosis virus of *H. armigera*. 5 × 109 /mL (obs)	[Very low]	Vivus Max	–	–	–	–	0.15 L	–	–	–
Omethoate 290 g/L	[High–very high]	Le-Mat® 290 SL	–	–	100 mL ⓫	–	–	100 mL	–	100 mL ⓫
Permethrin 500 g/L EC	[High–very high]	Ambush®	–	0.1–0.2 L	–	–	–	–	–	–
Phosmet 150 g/L EC	[High–very high]	Imidan®	–	–	0.25–0.35 L	–	–	0.25–0.35 L	–	0.25–0.35 L
Pirimicarb 500 g/kg WG	[Very low]	Pirimicarb® 500 WG	0.15 kg	–	–	–	–	–	–	–
Sulfoxaflor 240 g/L	[High–very high]	Transform®	50–100 mL ❿	–	–	–	–	–	–	–
Trichlorfon 500 g/L SL	[High–very high]	Dipterex® 500 SL	–	1.2 L	–	1.2 L	–	–	–	–

❶ Registered at 100 mL/ha before crop emergence (bare earth application). Apply by ground rig only. Do not apply as a ULV application.
❷ Registered for bryobia mite (*Bryobia* spp.) at 80 mL/ha.
❸ Wheat and barley only. Also registered for bryobia mite at 1.0 L/ha.
❹ Also registered for blackheaded pasture cockchafer at 0.35 or 0.7 L/ha.
❺ Registered for *Rhopalosiphum* spp. Only (*Barley yellow dwarf virus* vectors).
❻ Registered at 100 mL/ha before crop emergence (bare earth application). Apply by ground rig only. Do not apply as a ULV application. Armyworm suppression only, *H. punctigera* only and anthelids.
❼ Also registered for the control of blackheaded pasture cockchafer (*Aphodius tasmaniae*) See label for application rate.
❽ Blue oat mite often co-occur with redlegged earth mite and this rate might be less effective against blue oat mite.
❾ Registered for Russian wheat aphid at 40 mL/ha.
❿ Registered for Russian wheat aphid at the higher rate.
⓫ Also registered for Bryobia mite (*Bryobia* spp.) at 120 mL/ha.

Toxicity to beneficials

[red]	High–very high
[orange]	Moderate
[green]	Very low

Table 28. Canola, mustard and linseed (rate per ha). (Always read the label in conjunction with this table)

Chemical formulation	Toxicity to beneficials	Example registered trade name	European earwigs ❷	Portuguese millipedes ❷	Slaters ❷	Snails and slugs
Metaldehyde 100 g/kg + fipronil 1.5 g/kg	[High–very high]	Transcend® ❶	Low rate 2–4 kg High rate 4–8 kg	Low rate 2–4 kg High rate 4–8 kg	Low rate 2–4 kg High rate 4–8 kg	4–8 kg

❶ Apply up to 6 leaves unfolded.
❷ Low rate for low density infestations; high rate for high density infestations.

Toxicity to beneficials mammals, birds, aquatic life and honey bees

[red]	High–very high
[orange]	Moderate
[green]	Very low

Summer crops

Table 29. Azuki bean, cowpea and pigeon pea – pests.

Pest	Threshold	Crop growth stage	Crop damage	Comments	Frequency
Aphids	Consider control when colonies are large.	Flowering and podding usually under hot dry conditions.	Distort and stunt leaves. Reduce pod set.	Control rarely necessary. Look for presence of predators. Honey dew could attract heliothis moth.	Intermittent
Cutworm	At first sign of damage. Usually in large numbers in patches or moving in from edges of crop.	Seedling. Check for presence when sowing crop and at emergence (particularly on weedy fallows).	Eat leaves and cut stems at or below ground level killing plants. Remain in the soil during the day and feed at night.	Inspect crops late in evening or night for presence of large dark grey–green caterpillars. Caterpillars hide in soil during the day. Spot treatment of affected patches only may be necessary. Favour light soils.	Intermittent
Podsuckers – rated in terms of green vegetable bug (GVB) equivalents. GVB = 1 GVB; redbanded shield bug = 0.75 GVB; brown bean bug (BBB) = 1 GVB	Threshold will depend on damage allowed by market and crop potential. For azukis: 0.1 bug/m^2 in a poor yielding crop, 0.7–0.8 bug/m^2 in a high yielding crop.	Flowering to harvest.	Suck pods and seeds. Damage developing seeds. Reduce seed quality.	Nymphal green vegetable bugs (GVB) are distinctly different in colour to adults. Treat early morning when bugs are near top of plant. GVB and BBB are the biggest problem.	Intermittent
Heliothis caterpillar	40% defoliation pre-flowering. 1 larva up to 5 mm long/m^2 post-flowering. Apply *Nuclear polyhedrosis virus* (NPV) (e.g. Vivus Max) at sub-threshold levels of 0.3–0.5/m^2. Seed for human consumption should not be damaged.	Budding, flowering and podding.	Small caterpillars <10 mm long feed on leaves, flower buds, flowers and young pods. Caterpillars >10 mm make holes in seeds or pods.	Presume caterpillars are corn earworm (*H. armigera*) and potentially resistant. Check crop twice weekly during flowering/podding. Control by spraying caterpillars up to 5 mm long and eggs. Aphid honeydew attracts moth to lay eggs in crops. Pupae-bust azuki bean fields after harvest.	Annual
Looper	40% leaf area loss pre-flowering; 3/m^2 after flowering.	Early growth stages, damage often moving in from edges of crop.	Defoliate plants.	Caterpillars have a distinct looping action distinguishing them from heliothis. *Bt* will control small to medium loopers.	Problem mainly for coastal areas and QLD
Lucerne seed web moth (inland districts only)	None validated. Should be moth based not larvae based. No specific control measures. Treatments for heliothis, pod sucking bug and thrips give some control.	Flowering and podding.	Small caterpillars bore into pods. Small pods wither. Caterpillars develop inside large pods, chew out grain, fill pod with excrement and webbing.	Damage might not be noticed until excrement discolours pods. Favoured by hot dry weather, often in proximity to lucerne stands. Adequate irrigation reduces caterpillar entry into pods.	Rarely
Mirids	0.3–1.3/m^2 depending on chemical choice, application method and cost.	Budding/flowering stage.	Damages buds and flowers causing them to abort. Poor seed set.	Large numbers suspected of causing crop failure. Use a sweep net to monitor.	Annual
Thrips (onion, plague and tomato)	Lack of data on flower damage. Current Qld DAF threshold in mungbean is 4–6/flower.	Budding and flowering stages. Moisture stressed crops more vulnerable.	Feed on young buds and flowers. Reduces pod set and distorts pods.	Shake flowers into white container to dislodge thrips, or open and inspect flowers.	Annual
Two-spotted mite (TSM)	None established.	Late vegetative, flowering and pod setting. Worse under hot, dry conditions.	Forms fine web on the leaf underside. Causes premature maturity, reduced seed size and yield by rasping and sucking action.	Moves in from maturing maize and broadleaf perimeter vegetation. Avoid synthetic pyrethroids or carbamates on nearby maize early in the season. Avoid planting next to earlier maturing hosts.	Intermittent

All thresholds based on beat sheet method. See *Azuki beans: Irrigated planting guide 2004–2005* for more detailed information.

Table 30. Azuki bean, cowpea and pigeon pea – pesticide use (rate per ha). (Always read the label in conjunction with this table).
Numerous other products and formulations are also registered.

Chemical formulation	Toxicity to beneficials	Example registered trade name	Aphid	Green vegetable bug	Heliothis	Looper	Mirid	Thrips
Bt sub-species *kurstkai*	Very low	DiPel® SC (azuki bean & pigeon pea only)	–	–	1.0–4.0 L	1.0–4.0 L	–	–
Chlorantraniliprole 350 g/L	Very low	Altacor® ❻	–		70 g	70 g	–	–
Chlorpyrifos 300 g/L + lambda cyhalothrin 15.4 g/L	High–very high	Cobalt® Advanced	–	–	–	0.2 L	–	–
Deltamethrin 27.5 g/L EC	High–very high	decis options®	–	0.5 L	0.5 L	0.5 L	–	–
Dimethoate 400 g/L EC	High–very high	Dimethoate 400 EC ❶	–	–	–	–	0.5 L	0.8 L
Emamectin 17 g/L	Moderate	Affirm®	–	–	0.15–0.3 L	0.15–0.3 L	–	–
Esfenvalerate 50 g/L EC	High–very high	Sumi-Alpha® Flex (pigeon pea only)	–	–	0.13–0.33 L ❷	–	–	0.13 L
Indoxacarb 150 g/L EC	Very low	Steward® EC (azuki bean only)	–	–	0.4 L	0.2 L	0.4 L ❸	–
Methomyl 225 g/L SL	High–very high	Lannate®-L	–	1.5 L	1.5–2.0 L ❹	1.5 L	–	1.0 L
Nuclear polyhedrosis virus of *H. armigera*. 5 × 109 /mL (obs)	High–very high	Vivus Max	–	–	0.15 L		–	–
Thiodicarb 375 g/L SC	Moderate	Larvin® 375 (pigeon pea only)	–	–	0.5 or 0.75 L ❺	–	–	–
Spinetoram 120 g/L	Very low	Success® Neo	–	–	0.2–0.3 L	0.2–0.3 L	–	–
Sulfoxaflor 240 g/L WG	Moderate	Transform®	0.1 L	–	–	–	–	–

❶ Also registered for control of bean fly, leafhoppers and green peach aphid.
❷ Registered for control of native budworm (*H. punctigera*) only.
❸ Add salt 5 g/L spray volume by ground rig (100 L/ha) and 10 g/L spray volume by air (30 L/ha)
❹ Also registered as an ovicide at 0.5–1.0 L/ha in azuki bean and cowpea only.
❺ Registered as an ovicide at 0.5 L/ha and larvicide at 0.75 L/ha.
❻ Registered also for bean podborer at 70 g/L.

Toxicity to beneficials

(red)	High–very high
(orange)	Moderate
(green)	Very low

Table 31. Maize – pests.

Pest	Threshold	Crop growth stage	Crop damage	Comments	Frequency
African black beetles	When adult beetles are detected in springtime before sowing. Spraying is effective up to 5 beetles/m^2. If beetle numbers are >10/m^2 damage will occur in spite of spraying.	Normally early growth stages. Sometimes large numbers of beetles will fell mature plants. Most severe attacks in spring and on old pasture land.	Chews roots and underground stems killing growing point. Surviving plants are weak and stunted and can lodge.	Dry conditions favour beetle attacks. Plague numbers after 2 dry springs/summers in a row. Treatment necessary at planting. Beetle barriers and delayed sowing can reduce attacks.	Intermittent (coastal)
Aphids	When large colonies form in the crop.	Tasselling to grain filling.	Sucks sap from leaves, stems and cobs. Reduces seed set. Honeydew attracts heliothis moth.	Control rarely necessary. Predators such as ladybird larvae, hoverfly larvae, lacewings and parasitoids control aphid numbers.	Intermittent
Armyworm	Causes problems when present in large numbers. Consider stage of growth and potential damage.	Attacks seedling through to tasselling and silking.	Feeds on leaves in the funnels of growing point. Plants defoliated, stunted or killed. Severe leaf area loss at silking reduces cob size and seed yield.	Feed during evening and night. Caterpillars hide near ground during day. Build up often occurs after heavy rain. Broad spectrum sprays will disrupt the activity of natural enemies.	Rarely
Black field earwigs	Causes damage when present in large numbers. Examine soil before sowing for nymphs and adults. A number of species including black field earwigs can be beneficial predators as well as pests.	Attacks germinating seed and roots of young seedling and tap roots of older plants.	Destroys roots and causes plants to fall over in wind.	Populations regulated by soil moisture, favoured by moist soils. Sow treated seed and band spray. Reduce damage with shallow direct drilling into moist warm soils using press wheels.	Intermittent (coastal)
Cutworm	At first sign of damage. Usually in large numbers in patches or moving in from crop edges.	Seedling.	Eats leaves and cuts stems at or below ground level killing plants. Remains in the soil during the day and feeds at night.	Inspect crops late evening or night for presence of large dark grey–green caterpillars. Spot treatment can be effective.	Rarely
False wireworm	Check at junction of loose cultivated soil and undisturbed soil underneath before sowing. Treat seed or soil if 3 or more larvae present/metre of row (90 cm row spacing).	Newly emerged seedling. Can attack dry sown seed. More damage when dry weather delays emergence.	Larvae chew seed and seedling roots and shoots, resulting in patchy stands. Adults chew seedlings at or above ground level, ring-barking or cutting the stem.	Often feed on decaying plant matter. Warm soils, zero till and press wheels reduce damage.	Intermittent
Heliothis caterpillar	Hybrid maize seed crops: 1–2 sprays at tasselling and silking. Processing maize: 0–1 spray during silking.	Foliage damage before tasselling does not warrant control. Main damage occurs to the cobs and tassels during tasselling and silking.	Eats holes in leaves, often in the plants' funnels. Attacks the tassels, moves to the cobs, attack silks which prevents pollination, eat tops out of cobs. Allows other insects and moulds to enter.	Early sowing can reduce damage. Maize crops tolerate some damage and tight husk cover helps prevent caterpillar entry. Usually not worth spraying in commercial crops. Pupae bust during winter to reduce survival.	Annual
Redshouldered leaf beetles (*Monolepta*) (North Coast)	Control when monitoring indicates numbers are increasing.	Tasselling and silking.	Feeds on foliage, tassels and silks, open husks at top of cobs, Impairs seed set.	Usually swarming in hot spots. Lets other insects and diseases into cobs. Spot spraying might be sufficient.	Intermittent (coastal)
Sugar cane and maize stem borer	No threshold established.	Larvae enters maize stem through lower internodes during vegetative stages.	Eats internal structures of stem causing lodging. If infested early in crop development it can reduce grain weight. Generally occurs on edge of crops.	Native insect which can cause minor damage in other crops such as wheat or rice. No control possible. Insect might favour softer stem varieties.	Rarely
Two spotted mite	None established as there are no effective chemicals registered.	Tasselling and silking.	Sucks sap, leaves lose colour, reduces plant vigour, cob size and seed development. Promotes lodging and premature death.	Avoid using synthetic pyrethroids and carbamates on other insects as they 'flare' TSM. Natural enemies (predatory mites) will often keep mites in check.	Intermittent
Wireworm	Presence of larvae before sowing. Treat if more than 1 larvae/metre of row. No post sowing treatment.	Larvae feed on germinating seed and bore into stem of young seedling. Larvae are 15–25 mm long.	Kill seedlings by destroying growing point. Damage more severe under cool and wet conditions when growth is retarded. Damage stops when top 50 mm of soil dries out and warms up.	Clean cultivation can reduce wireworm numbers. Later sowing using press wheels into warm moist soils reduces damage. Many farmers apply routine control measures at sowing. The common brown earwig is a natural enemy.	Intermittent

Table 32. Maize – pesticide use (rate per ha). (Always read the label in conjunction with this table).
Numerous other products and formulations are also registered.

Chemical formulation	Toxicity to beneficials	Example registered trade name	African blackbeetle (1 m row)	Armyworm	Cutworm	Heliothis	Rutherglen bug	Wireworm (1 m row)
Alpha-cypermethrin 100 g/L EC	High–very high	Alpha-Scud Elite® ❶	–	–	–	0.3 L or 0.4 L	–	–
Bt sub-species *kurstkai*	Very low	DiPel® SC	–	1.0–4.0 L	–	1.0–4.0 L	–	–
Chlorpyrifos 500 g/L EC	High–very high	Strike-Out® 500 EC	2.0 L ❷	0.7 L or 0.9 L	0.9 L	–	–	0.5–1.5 L ❸
Cypermethrin 200 g/L	High–very high	Scud Elite® EC	–	–	–	0.3 L or 0.4 L ❹	–	–
Deltamethrin 27.5 g/L EC	High–very high	decis options®	–	0.5 L	0.2 L	0.5 L	–	–
Esfenvalerate 50 g/L EC	High–very high	Sumi-Alpha® Flex	–	–	–	0.5 L ❺	–	–
Methomyl 225 g/L SL	High–very high	Lannate®-L	–	1.5 L	–	1.5–2.0 L ❻	–	–
Nuclear polyhedrosis virus of *H. armigera*. 5 × 109 /mL (obs)	Very low	Vivus Max	–	–	–	0.15 L	–	–
Thiodicarb 375 g/L SC	Moderate	Larvin® 375	–	–	–	1.5–2.0 L ❹	–	–

❶ Also registered for ultra low volume (ULV) application by aircraft to control corn earworm (*H. armigera*). See label for details.
❷ Rate registered for row spacing of 1 m. Otherwise rate is registered at 20 mL/100 m of row
❸ Rate registered for row spacing of 1 m. Otherwise rate is registered at 5–15 mL/100 m of row.
❹ Registered for corn earworm (*H. armigera*) only.
❺ Apply only to larvae less than 5 mm long
❻ Also registered as an ovicide at 1 L/ha.

Toxicity to beneficials

Red	High–very high
Orange	Moderate
Green	Very low

Table 33. Mungbean – pests.

Pest	Threshold	Crop growth stage	Crop damage	Comments	Frequency
Bean flies	Seedling: spray if more than 1 tunnel/plant is detected.	Emergence to mid vegetative.	Larvae hatch from eggs on leaves and burrow down through the stem to just below ground level or to nodes in older plants.	Early infestations can destroy seedling crops. Check crops particularly after emergence. Check for flies, larvae tunnels and egg laying marks in leaves.	Rarely. Intermittent in coastal crops
Cutworm	Large numbers in patches in crop. Treat at the first sign of damage.	Seedling up to 4-leaf stage.	Eats leaves and cuts stems at or below ground level killing plants. Remains in the soil during the day and feeds at night.	Inspect crop late in evening or at night for large dark grey–green caterpillars. Over-the-row band spraying might be effective.	Rarely
Pod suckers – rated in terms of GVB equivalents. GVB = 1 GVB; brown bean bug (BBB) = 1 GVB	0.3–0.8 GVB adult equivalents (AEq)/m^2. See *The Beatsheet* for threshold calculators.	Just before flowering through to harvest maturity.	Sucks sap from pods and damages seeds in pods. Reduces seed yield, quality and viability.	Bugs present on upper leaves early in morning, the best time for spraying. Instars different colour to adults. Economic thresholds reflect changes in seed damage penalties.	Intermittent
Heliothis caterpillar	Refer to Qld DAF threshold tables; 0.5–3 larvae/m^2 from budding to podding.	Normally during flowering and podding. Attack before flowering can cause leaf area loss and stunting of growing points.	Caterpillars feed on the leaves, flower: bugs on flowers, young pods and seeds in pods. Reduces pod set, seed quality and yield.	Presume caterpillars are corn earworm (*H. armigera*). Control by spraying eggs and small caterpillars up to 5 mm long; 1–2 sprays might be necessary.	Annual
Jassids	Spray if the plants are young and stressed and there are more than 20 jassids/plant (vegetable jassids); more than 22% of leaves in the top half of the canopy have hopper burn (lucerne jassids).	Any stage but particularly slow growing seedling crops or stressed crops.	Causes white spots on leaves (vegetable jassids) or yellowing leaves from the tip (hopper burn) from injected toxins (lucerne jassids).	Older plants tolerate larger numbers of vegetable jassids. Large numbers are needed to justify spraying as it will decrease beneficial insect populations.	Rarely
Looper	None established so look for foliage damage. Legumes tolerate 30–40% leaf loss pre-flowering, but only 16% during pod fill.	Early growth stages. Often moving in from crop edges.	Defoliates plants.	Caterpillars have a distinct looping movement distinguishing them from heliothis.	Rarely
Mirids	When using indoxacarb, the threshold is 1.1–1.3 mirids/m^2 for ground and aerial applications respectively. Indoxacarb is not recommended when more than 2 mirids/m^2 are present. Refer to QDAF *Mirids in mungbeans* for thresholds if using dimethoate. See the permit table to check if permit is currently valid.	Budding/flowering.	Mirids damage buds and flowers causing them to abort resulting in uneven crop maturity and reduced pod set.	Sample with beat sheet before 9 am. Large populations can cause crop failure but pod/flower shedding also likely in heat wave conditions. Spraying with the full rate of broad spectrum insecticide predisposes the crop to heliothis attack – 2 low rate sprays 5–10 days apart could be used instead.	Intermittent
Thrips (onion and tomato)	When more than 4 thrips/flower are seen. Examine crops twice weekly budding–flowering.	Budding to flowering. Moisture stressed crops more susceptible.	Feed on leaves, flower buds, flowers and young pods. Reduce flowering and pod setting, distort pods.	Shake flowers into white container to dislodge thrips or open and inspect flowers. First treatment pre-flowering might be necessary.	Intermittent
Silverleaf whitefly	Not considered to be an economic mungbean pest and there is no need to apply insecticides for silverleaf whitefly control.				

Table 34. Mungbean – pesticide use (rate per ha). (Always read the label in conjunction with this table).

Numerous other products and formulations are also registered.

Chemical formulation	Toxicity to beneficials	Example registered trade name	Aphid	Green vegetable bug	Heliothis	Looper	Mirid	Thrips
Alpha-cypermethrin 100 g/L EC	High–very high	Alpha-Scud® Elite ❶	–	–	0.3 L or 0.4 L	–	–	–
Bt sub-species *kurstkai*	Very low	DiPel® SC	–	–	1.0–4.0 L	1.0–4.0 L	–	–
Chlorantraniliprole 350 g/L	Very low	Altacor® ❷	–	–	70 g	70 g	–	–
Cypermethrin 200 g/L	High–very high	Scud Elite®	–	–	0.3 L or 0.4 L	0.3 L or 0.4 L ❸	–	–
Deltamethrin 27.5 g/L EC	High–very high	decis options®	–	0.5 L	0.5 L	–	–	–
Dimethoate 400 g/L EC	High–very high	Dimethoate 400 EC	–	–	–	–	0.5 L	0.8 L
Emamectin 17 g/L	Moderate	Affirm®	–	–	0.1–0.3 L	0.1–0.3 L	–	–
Gamma-cyhalothrin 150 g/L	High–very high	Trojan®	50 mL	–	50 or 60 mL ❹	–	–	–
Indoxacarb 150 g/L EC	High–very high	Steward® EC	–	–	0.4 L ❺	–	–	–
Lambda-cyhalothrin 250 g/L EC	High–very high	Karate Zeon	60 mL	–	60 mL or 70 mL	–	–	–
Methomyl 225 g/L SL	High–very high	Lannate®-L	–	1.5 L	1.5 –2.0 L ❻	–	–	–
***Nuclear polyhedrosis virus* of *H. armigera*.** 5 × 109 /mL (obs)	Very low	Vivus Max	–	–	0.15 L	–	–	–
Thiodicarb 375 g/L SC	Moderate	Larvin® 375	–	–	0.5 –0.75 L	–	–	–
Spinetoram 120 g/L	Very low	Success® Neo	–	–	0.2–0.3 L	0.2–0.3 L	–	–
Sulfoxaflor 240 g/L	Moderate	Transform®	0.1 L ❼	–	–	–	–	–

❶ Also registered for ultra low volume (ULV) application by aircraft to control corn earworm (*H. armigera*) and native budworm (*H. punctigera*). See label for details.
❷ Registered also for bean podborer at 70 g/L.
❸ Use the highest rate when canopy is dense. Registered for soybean looper only.
❹ Registered for northern NSW only.
❺ Add salt (NaCl) at 5 g/L spray volume by ground (100 L/ha) or 10 g/L spray volume by air (30 L/ha).
❻ Registered for native budworm (*H. punctigera*) only. Also registered as an ovicide at 1 L/ha.
❼ Including green peach aphid, cow pea aphid and blue green aphid.

Toxicity to beneficials

Red	High–very high
Orange	Moderate
Green	Very low

Table 35. Sorghum – pests.

Pest	Threshold	Crop growth stage	Crop damage	Comments	Frequency
Aphids	None established.	Just before head emergence, flowering up to harvest.	Reduces head emergence, seed set and quality. Honeydew interferes with harvest.	Rarely economic to spray. Aphids can encourage natural predators to build up. A pre-harvest spray with a knockdown herbicide will usually avoid the harvest problems that aphids cause. Dryland crops under moisture stress most severely affected.	Annual
Armyworm	Consider stage of growth and potential damage.	Attacks young plants through to head emergence and flowering.	Feeds on leaves in funnels or throats of plants. Can kill young plants. Severe leaf area loss at flowering can reduce yields.	Feeding during evening and night. Caterpillars hide near ground during the day. Build up often occurs after heavy rain. Usually present in large numbers.	Rarely
Black field earwigs	Examine soil before sowing for nymphs and adults.	Attacks germinating seed, roots of young seedling and tap roots of older plants.	Destroys roots and causes plants to fall over in wind.	Populations regulated by soil moisture, favoured by moist soils. Sow treated seed and band spray. Damage reduced by shallow sowing into moist warm soils using press wheels. Usually in large numbers.	Rarely
Cutworm	At first sign of damage.	Seedling.	Cuts off leaves and stems at ground level, causing plant death. Mostly feeding in evening and night. Caterpillars hide in soil during day.	Inspect crops late evening or night for large dark grey–green caterpillars. Spot treatment might be effective. Usually in large numbers in patches or moving in from edges.	Rarely
False wireworm	Treat seed or soil if 3 or more larvae/metre row.	Newly emerged seedling. Can attack dry sown seed. More damage when dry weather delays emergence.	Feeds on dry seed and eats into the stems of young plants just above ground level.	Check at junction of loose cultivated soil and undisturbed soil before sowing. Vary from 8–40 mm long. Often feed on decaying vegetable matter. Warm soil and press wheels can reduce damage.	Intermittent
Heliothis caterpillar	See The Beatsheet for threshold calculators. https://thebeatsheet.com.au/economic-threshold-calculators/	Infestations on vegetative plants do not cause economic damage. Eggs are laid on heads just before flowering from December to March.	Small caterpillars (<10 mm) eat flower spikelets, larger caterpillars eat developing seed reducing yields and allowing fungal entry. Each larva destroys about 2.4 g of grain.	To determine heads/m row, count 10 m of row at 10 sites. Sample larvae by shaking sorghum heads into a bucket. Compact headed varieties suffer more serious damage than open headed types. Cultivating stubble over winter reduces pupae survival.	Annual
RGB and grey cluster bug	Undetermined. For RGB the provisional threshold is 20–25 bugs/head at flowering to soft dough stage. No yield loss post hard-dough to physiological maturity.	Head emergence, flowering and grain filling.	Sucks sap from leaves, stems, heads and grain, reducing yield and quality.	Attacks are rarely a problem and confined to small areas. Monitor from booting to milky dough stage by shaking 10 heads into a bucket and averaging RGB present. Spot spraying might be necessary. RGBs are very mobile in front of storms. Attacks are more common in hot, dry weather.	Intermittent
Sorghum midges	See *The Beatsheet* for a threshold calculator.	Head emergence and flowering.	Midge larvae suck fluid from developing seed, shrivel seed and reduce yields.	Check crops early in the day for newly emerged midges. Spraying could be necessary every 3–4 days under severe conditions. Maximum midge numbers are 10 am–12 noon.	Annual
Wireworm	Treat before sowing if more than 2 larvae/metre of row.	Larvae feed on germinating seed and bore into stems of young seedling. Larvae are 15–25 mm long.	Kills seedling by destroying growing point. Damage is more severe under cool and wet conditions when growth is retarded. Damage stops when top 50 mm of soil dries out and warms up.	Clean cultivation can reduce wireworm numbers. Later sowing using press wheels into warm moist soils reduces damage. Use treated seed.	Intermittent

Table 36. Sorghum – pesticide use (rate per ha). (Always read the label in conjunction with this table). Numerous other products and formulations are also registered.

Chemical formulation	Toxicity to beneficials	Example registered trade name	Aphid	Armyworm	Cutworm	Heliothis	Rutherglen bug	Sorghum midge	Wireworm and false wireworm (1 m row)
Alpha-cypermethrin 100 g/L EC	High–very high	Alpha-Scud® Elite [1]	–	–	–	0.3 L or 0.4 L	–	0.1 L or 0.2 L	–
Bt sub-species *kurstkai*	Very low	DiPel® SC	–	1.0–4.0 L	–	1.0–4.0 L	–	–	–
Beta-cyfluthrin 25 g/L	High–very high	Bulldock® Duo	–	–	–	0.6 L	–	0.3 L	–
Chlorpyrifos 500 g/L EC	High–very high	Strike-Out® 500 EC [2]	0.5 L [3]	0.7–0.9 L	0.9 L	–	–	0.5 L	0.5–1.5 L [4]
Cypermethrin 200 g/L	High–very high	Scud Elite® EC	–	–	–	0.3–0.4 L	–	0.19–0.38 L	–
Deltamethrin 27.5 g/L EC	High–very high	decis options®	–	0.5 L	–	0.5 L	–	0.2–0.4 L	–
Esfenvalerate 50 g/L EC	High–very high	Sumi-Alpha® Flex	–	–	–	0.45 L [5]	–	0.1–0.3 L	–
Gamma-cyhalothrin 150 g/L CS	High–very high	Trojan®	–	–	50 mL	50 mL or 60 mL [5]	15 mL	15 mL or 30 mL	–
Lambda-cyhalothrin 250 g/L EC	High–very high	Karate Zeon®	–	–	60 mL	60 mL or 70 mL [5]	18 mL	18 mL or 36 mL	–
Methomyl 225 g/L SL	High–very high	Lannate®-L	–	1.5 L	–	1.5–2.0 L [6]	–	–	–
Nuclear polyhedrosis virus of *H. armigera*. 5 × 109 /mL (obs)	Very low	Vivus Max	–	–	–	75–150 mL	–	–	–

[1] Also registered for ultra low volume (ULV) application by aircraft to control corn earworm (*H. armigera*) and native budworm (*H. punctigera*). See label for details.
[2] Do not use on Sugar Drip or Alpha sorghum. Check new varieties before applying to the whole crop.
[3] Registered for corn aphid only.
[4] Rate registered for row spacing of 1 m. Otherwise rate is registered at 5–15 mL/100 m of row.
[5] Registered for control of corn earworm (*H. armigera*) only.
[6] Registered as an ovicide at 0.5–1.0 L/ha. See label for details.

Toxicity to beneficials

(red)	High–very high
(orange)	Moderate
(green)	Very low

Notes

Table 37. Soybean – pests.

Pest	Threshold	Crop growth stage	Crop damage	Comments	Frequency
Aphids	250 aphids/plant from budding to podding.	Before flowering. Thick clusters on stems.	Sucks sap, stunts plants and transmits virus.	Check for predators before spraying.	Rarely
Cluster caterpillar (North Coast only)	None established. Look at amount of damage to foliage. Most legumes can tolerate 33% leaf area loss. During early pod fill only 15% leaf area loss is tolerable. Once pods are filled leaf area loss is of no consequence.	Most common during flowering and podding, sometimes earlier infestations can occur.	Young caterpillars feed on underside of leaves. Skeletonise leaves. Older caterpillars eat holes in leaves, can also eat flowers and pods. Can defoliate plants.	Only present on the North Coast. Can migrate from adjacent pastures.	Rarely
Cutworm	Treat at first sign of damage.	Seedling.	Eats leaves and cuts stems at or below ground level killing plants. Remains in the soil during the day and feed at night.	Inspect crops in the late evening or at night for large darkish coloured caterpillars. Treat in late afternoon. Spot spraying might be effective. Usually large numbers in patches in crop.	Rarely
Grass blue butterfly	Before flowering 33% leaf area loss, 10–25% growing points lost. Flowering onwards 15% leaf area loss.	Can damage crop from early vegetative through to pod filling. Irrigation reduces damage.	Chews off growing points of plants. Eats leaves, flowers and young pods and damages seeds in pods.	Distinct small grey–blue butterfly produces caterpillar with slug-like appearance, which grow to 10 mm long. Inspect crop twice weekly for damage.	Intermittent
GVB, BBB and RBSB	For GVB, 1 GVB or GVB equivalent/m^2 (crushing) or 0.3/m^2 (seed or human consumption). For BBB, 1.5 GVBEQ/m^2 (crushing) or 0.5/m^2 (human consumption). For RBSB, 3 GVBEQ/m^2 (crushing) or 1/m^2 (human consumption).	From just before flowering until harvest. Examine crop twice weekly for bugs during early morning (7–9 am).	Adults and late stage nymphs suck sap from pods and seeds, cause new pods to shed. Damages seeds, which shrivel, discolour, reducing size and viability.	A number of different bug species can be present in crops. Examine seeds in pods for damage during pod fill. Yield loss worst during early pod fill. Quality requirements for edible type much higher.	Annual
Heliothis caterpillar	Vegetative threshold is 6 larvae/m^2. Check twice/week during pod setting and treat if 6 or more (Riverina), 2 or more (North Coast) 5 mm long larvae/m^2.	Most damage during flowering, pod setting. Before flowering caterpillars will defoliate the crop.	Defoliates plants. (Do not confuse with common armyworm). Eats flowers, young pods and seeds in pods. Causes pod shedding.	Refer to Qld DAF threshold tables. Assume caterpillars are corn earworm (*H. armigera*). Control by spraying eggs and caterpillars up to 5 mm long. Larger caterpillars difficult to control.	Annual
Lesser armyworm (inland districts only)	Spray if plants likely to lose 33% or more of leaf area.	Early vegetative stages before flowering.	Defoliates plants, causes stunting and retards growth. Skeletonises leaves.	Caterpillars vary in colour from green to dark brown or blackish with yellowish lines along centre and sides of back.	Rarely
Looper (tobacco, green and soybean)	None established. Assess amount of damage to foliage. Most legumes can tolerate 33% leaf area loss before flowering, less than 20% from budding to podding.	All growth stages, often moving in from edges of crop. Can attack flowering crops.	Defoliates plants.	Caterpillars have a distinct looping movement, distinguishing them from heliothis.	Rarely
Mirids	Little control needed when >5 mirids/m^2.	Flowering to podding. Plant is less able to compensate for damage from late flowering to mid pod fill.	Causes buds, flowers and small pods to abort. On larger pods, severe damage results in brown and distorted pods with reduced seed size and seed staining.	Indoxacarb is not recommended where there are >2 mirids/m^2. Shortening flowering periods can reduce the risk of mirid damage. Sample with beat sheets at 5×1 m lengths at 6 sites.	Intermittent
Lucerne seed web moth (inland districts only)	None established. Check the Permits as at January 2022 on page 39 and the APVMA for new permits.	Vegetative stages from flowering to pod filling.	Kills growing points, tunnels into stems, bores into pods, causes small pods to shrivel and die. Caterpillars develop inside larger pods, chew out grain, fill pod with excrement and webbing.	Pods can appear normal until caterpillars mature when discolouration and excrement seen. More likely in hot dry weather, often in proximity to lucerne stands. Adequate irrigation reduces caterpillar entry into pods.	Intermittent
Silverleaf whiteflies (B-biotype) (SLWF) (North Coast)	Don't spray! SLWF is moderately to highly resistant to all commonly used pesticides. Spraying will promote further resistance to develop. IPM options are currently under development.	Can damage crops from seedling/early vegetative through to pod filling.	Crop damage is the result of both direct sap-sucking insects and secondary losses from sooty mould that develops on the SLWF secreted honey dew reducing photosynthesis.	SLWF are found on the underside of leaves. Accurate identification is essential to avoid confusion with greenhouse whitefly. Adults have a distinctive gap between their powdery white wings. Adults are smaller (about 1.5 mm long) than greenhouse whitefly.	Annual
Soybean moth	No registered pesticides; 33% total leaf area during vegetative stages or >15% total leaf area loss during flowering/pod formation and pod filling.	Infestations can occur from seedling stage until maturity. Attacks during vegetative stages most severe.	Initially caterpillars mine leaves (blisters). Leaves cup and fold together to form cocoons for pupation. Leaflets shrivel and die.	Sometimes parasitic wasps reduce infestations. Attacks more likely in hot dry weather, lighter soils and moisture stress.	Intermittent
Two-spotted mite (*Tetranychid* spp.)	An average 5 mites/cm^2 of leaf under surface of leaves are visible. Select 60 random leaves from crop, during flowering pod formation and filling.	Flowering, pod formation and filling.	Mites form a fine web on the leaf underside. Sucks sap, causes leaves to discolour and eventually die. Hastens plant maturity, reduces yield and seed size.	Mites are very small and might not easily be detected with the naked eye. Damage often starts on edge of the crop and is favoured by hot, dry conditions. Pyrethroids and carbamates encourage build up by killing natural enemies.	Intermittent (annual in cotton areas)

Table 38. Soybean – pesticide use (rate per ha). (Always read the label in conjunction with this table).

Numerous other products and formulations are also registered.

Chemical formulation	Toxicity to beneficials	Example registered trade name	Aphid	Green vegetable bug	Heliothis	Jassid	Looper	Mirid	Two-spotted mite
Abamectin 18 g/L EC	Moderate	Wizard® 18 EC	–	–	–	–	–	–	0.3 L
Alpha-cypermethrin 100 g/L EC	High–very high	Alpha-Scud® Elite (1)	–	–	0.3 L or 0.4 L	–	–	–	–
Bt sub-species *kurstkai*	Very low	DiPel® SC	–	–	1.0–4.0 L	–	1.0–4.0 L	–	–
Chlorantraniliprole 350 g/L	Very low	Altacor® (8)	–	–	70 g	–	70 g	–	–
Cypermethrin 200 g/L EC	High–very high	Scud Elite® EC	–	–	0.3–0.4 L	–	0.3–0.4 L (2)	–	–
Deltamethrin 27.5 g/L EC	High–very high	decis options®	–	0.5 L	0.5 L	–	–	–	–
Dimethoate 400 g/L EC	High–very high	Dimethoate 400 EC	–	0.34 L	–	0.34 L	–	–	–
Emamectin 17 g/L	High–very high	Affirm®	–	–	0.1–0.3 L	–	0.1–0.3 L	–	–
Esfenvalerate 50 g/L EC	High–very high	Sumi-Alpha® Flex	–	–	0.13–0.33 L (3)	–	–	–	–
Gamma-cyhalothrin 150 g/L CS	High–very high	Trojan®	–	50 mL	50 mL or 60 mL	–	–	–	–
Indoxacarb 150 g/L	Very low	Steward® EC (4)	–	–	0.4 L	–	0.2 L	0.4 L (5)	–
Lambda-cyhalothrin 250 g/L	High–very high	Karate Zeon®	–	60 mL	60 mL or 70 mL	–	–	–	–
Methomyl 225 g/L SL	High–very high	Lannate®-L	–	1.5	1.5–2.0 L (6)	–	–	–	–
Nuclear polyhedrosis virus of *H. armigera*. 5 × 109 /mL (obs)	Very low	Vivus Max	–	–	0.15 L	–	–	–	–
Thiodicarb 375 g/L SC	Moderate	Larvin ®375	–	–	0.5 L or 0.75 L	–	–	–	–
Trichlorfon 500 g/L SL	High–very high	Lepidex® 500	–	1.2	–	–	–	–	–
Spinetoram 120 g/L	Very low	Success® Neo	–	–	0.2–0.3 L	–	0.2–0.3 L	–	–
Sulfoxaflor 240 g/L	High–very high	Transform®	0.1–0.2 L (7)	–	–	–	–	–	–

(1) Also registered for ultra low volume (ULV) application by aircraft to control corn earworm (*H. armigera*) and native budworm (*H. punctigera*). See label for details.
(2) Registered for soybean looper only.
(3) Registered in southern NSW only for native budworm (*H. punctigera*). In northern NSW apply 0.4–0.5 L/ha for control of *H. punctigera* and 0.5 L/ha for *H. armigera*.
(4) Also registered for control of monolepta beetle (*Monolepta australis*) at 0.2 L/ha.
(5) Add salt (NaCl) at 5 g/L spray volume by ground (100 L/ha) or 10 g/L spray volume by air (30 L/ha).
(6) Also registered as an ovicide at 0.5–1.0 L/ha. See label for details.
(7) Registered for soybean aphid only. Also registered at 0.4 L/ha for greenhouse whitefly.
(8) Registered also for bean podborer at 70 g/L.

Toxicity to beneficials

(red)	High–very high
(orange)	Moderate
(green)	Very low

Table 39. Sunflower – pests.

Pest	Threshold	Crop growth stage	Crop damage	Comments	Frequency
Aphids	No registered pesticides.	Seedling to before flowering.	Sucks sap from stem, reduces head size and stunts growth.	Check for predators. Honeydew on plants can attract heliothis moth.	Rarely
Cutworm	Treat seedlings when crop damage rapidly increases (more than 10% seedling loss). Treat older plants if more than 90% of plants are infested or more than 50% of plants have 75% or more leaf tissue loss.	Seedling up to 4 weeks after emergence. Severe damage if present in soil at sowing.	Eats leaves and cuts stems at or below ground level killing plants. Remains in the soil during the day and feeds at night.	Inspect crops in the late evening or at night for large dark grey–green caterpillars. Spot treatment can be effective.	Rarely
False wireworm	Treat seed if 3 larvae/m row before sowing.	Newly emerged seedling. Can attack dry sown seed. More damage when dry weather delays emergence.	Larvae chew seed and seedling roots and shoots, resulting in patchy stands. Adults chew seedlings at or above ground level, ring-barking or cutting the stem.	Vary from 8–40 mm in length. Check at junction of loose cultivated soil and undisturbed soil before sowing.	Intermittent
Green vegetable bug	One or more late stage nymphs or mature bugs/plant.	Budding, flowering and seed filling.	Sucks sap from stem close to developing flower buds, causing heads to wilt and shrivel.	Can also feed on developing seeds. Treat early in the morning when bugs are on the upper sides of leaves.	Rarely
Heliothis caterpillar	Treat when >2, 5 mm long larvae/plant at early budding. At flowering to grain fill stage, the plant can tolerate higher densities (more than 20/head).	Budding, flowering and seed filling.	Eats foliage, buds, petals, head bracts and seed. Chews holes in back of heads allowing head rot fungi to enter.	Presume caterpillars are corn earworm (*H. armigera*) and follow resistance management strategy. Control by spraying eggs and caterpillars up to 5 mm. Check crops twice weekly from budding onwards.	Annual
Rutherglen bug and grey cluster bug	Early (spring) – budding: 10 bugs/head; flowering to seed fill 20–25 bugs/head. Late (Jan–April) – budding: 20–25 bugs/head; flowering to seed fill 50 bugs/head.	Budding, flowering and seed filling.	Sucks sap from stem under buds causing wilting, reduced head size or death. Reduces yield, oil content and seed viability.	Yield losses range from 10% (irrigation) to 30% (dryland) depending on moisture content. Several sprays might be needed under severe conditions.	Annual
Wireworm	Larvae present before sowing. No after sowing treatment. Treat seed if 2 larvae/metre of row at sowing. Use treated seed.	Larvae feed on germinating seed. Bore into stem of young seedling.	Kills seedlings by destroying growing point. Damage is more severe under cool and wet conditions when growth is retarded.	Clean cultivation can reduce wireworm numbers. Press wheels reduce crop damage. Damage stops when top 50 mm of soil dries out and warms up.	Intermittent

Table 40. Sunflower – pesticide use (rate per ha). (Always read the label in conjunction with this table). Numerous other products and formulations are also registered.

Chemical formulation	Toxicity to beneficials	Example registered trade name	Armyworm	Cutworm	Green vegetable bug	Heliothis	Jassid	Rutherglen bug	Grey cluster bug	Wireworm and false wireworm (1 m row)
Alpha-cypermethrin 100 g/L EC	High–very high	Alpha-Scud Elite® (1)	–	–	–	0.3 L or 0.4 L	–	0.3 L or 0.4 L	0.3 L or 0.4 L	–
Bt sub-species *kurstkai*	Very low	DiPel® SC	1.0–4.0 L	–	–	1.0–4.0	–	–	–	–
Chlorpyrifos 500 g/L EC	High–very high	Strike-Out® 500 EC	–	–	–	–	–	–	–	0.5–1.5 L (2)
Cypermethrin 200 g/L	High–very high	Scud Elite® EC	–	–	–	0.3 L or 0.4 L	–	0.3 L or 0.4 L	0.3 L or 0.4 L	–
Deltamethrin 27.5 g/L EC	High–very high	decis options®	–	–	–	0.5 L	0.5 L	0.5 L	–	–
Esfenvalerate 50 g/L EC	High–very high	Sumi-Alpha® Flex	–	–	–	0.13–0.3 L (3)	–	–	–	–
Gamma-cyhalothrin 150 g/L CS	High–very high	Trojan®	–	–	–	60 mL or 70 mL (4)	–	30 mL	30 mL	–
Lambda-cyhalothrin 250 g/L EC	High–very high	Karate Zeon®	–	–	–	60 mL or 70 mL (5)	–	36 mL	36 mL	–
Methomyl 225 g/L SL	High–very high	Lannate®-L	–	–	1.5–2.0 L	1.5–2.0 L (6)	–	–	–	–
Nuclear polyhedrosis virus of *H. armigera*. 5 × 109 /mL (obs)	Very low	Vivus Max	–	–	–	0.15 L	–	–	–	–
Trichlorfon 500 g/L SL	High–very high	Lepidex® 500	1.2 L	1.2 L	–	–	–	1.1 L	–	–

(1) Also registered for ultra low volume (ULV) application by aircraft to control native budworm (*H. punctigera*). For corn earworm apply only is larvae are less than 5 mm long.
(2) Rate registered for row spacing of 1 m. Otherwise rate is registered at 5–15 mL/100 m of row.
(3) Registered in southern NSW only for native budworm (*H. punctigera*). In northern NSW apply 0.4–0.5 L/ha for control of *H. punctigera* and 0.5 L/ha for *H. armigera*.
(4) Rate for northern NSW only. Also registered at 40 mL or 50 mL/ha in southern NSW.
(5) Registered rate for northern NSW. Registered at 48 or 60 mL/ha in southern NSW.
(6) Also registered as an ovicide at 0.5–1.0 L/ha. See label for details.

Toxicity to beneficials

- High–very high
- Moderate
- Very low

Notes

Table 41. Lucerne – pests.

Pest	Threshold	Crop growth stage	Crop damage	Comments	Frequency
Aphids (spotted alfalfa aphids, pea aphids, blue-green aphids)	For low resistance varieties: 2 aphids/plant for seedlings, 5 aphids/stem for plants >10 cm before first harvest, 20 aphids/stem after first harvest.	All growth stages.	Sucks sap, stunts plants and transmits virus.	Active in autumn, winter and spring. Sow resistant varieties. Parasites are very effective. Graze/cut if crop is less than half grown.	Annual
Armyworm	Consider stage of growth and potential damage.	Young plants most susceptible.	Can kill young plants. Plants defoliated.	Heavy rain often precedes development. Caterpillars hide near ground during day, feeding mainly at night. Treat in evenings.	Rarely
Black-headed pasture cockchafers	Examine pastures in April–May. Control if average young larvae density exceeds 300/m^2.	All growth stages.	Plants cut off at ground level. Heavy infestations can eat out large areas. The casts make the pasture unattractive to stock.	Larvae forage at night when soil surface is moist following rain. Spray late evening.	Intermittent
BOM and RLEM	Newly emerged seedlings can be killed by low mite numbers. Preventative treatment is recommended such as seed treatment or bare earth sprays.	Most severe on young seedlings. Seedling emergence can be inhibited.	Causes greyish and silver streaks by rasping and sucking sap.	Weedy fallows promote mite survival. Look for mites in the early morning or late evening. During the day often present under clods or undersides of weeds such as capeweed, Paterson's curse and saffron thistle.	Annual
Cutworm	Treatment required if large numbers present.	Early plant growth stages.	Chews leaves and stems. Can cut plants off at ground level.	Feed in the evening and night. Check and spray late evening. Often occurs in patches. Spot spraying might be required.	Rarely
Heliothis caterpillar	When monitoring indicates numbers are increasing.	Late budding to flowering and pod fill. Spring pest in hay crops.	Destroys developing buds and flowers. Eats holes in and destroys seed pods.	Early cutting or grazing can induce movement into nearby crops. Can affect seed crops at any stage during flowering. Many natural enemies.	Annual
Lucerne flea	Inspect at weekly intervals after autumn break and spray as soon as flea numbers begin to increase.	Seedling and young plants most commonly affected but can also damage established plants.	Eats leaves, leaving clear membranous windows in foliage.	Lucerne fleas hop when disturbed. Clean fallows and eliminate weeds from around the paddock perimeter at least 4 weeks before sowing to reduce flea numbers.	Intermittent
Lucerne leaf-rollers	Control when 25–30% of terminals are rolled in haymaking or grazing stands. Less if a seed crop.	All growth stages. Shortly before and during flowering, but more important in seed crops.	Caterpillars feed on terminal leaves and flowering stems. Fertilisation and pod set can be severely reduced.	Damage is most often important in moisture-stressed, dryland stands. Graze/cut in preference to spraying if lucerne stand is approaching maturity.	Intermittent
Sitona weevil	Spray established stands if weevils are numerous and damage is noticeably worsening and causing excessive leaf loss. Early season sprays can reduce subsequent numbers.	Young plants most susceptible. Older plants can appear pale and unthrifty.	Adults make scallop-shaped notches along leaf margins and chew stems. Early stage larvae can cause more serious damage through feeding on roots and root nodules.	Damage is generally most serious in spring and autumn, but adults can feed actively during warm weather in winter.	Intermittent
Thrips (onion, plague and tomato)	At least 2 thrips/flower in seed crops.	Budding to flowering.	Feeds on young buds and flowers preventing seed set.	Shake flowers into white container to dislodge thrips, or open and inspect flowers.	Intermittent

Table 42. Lucerne – pesticide use (rate per ha). (Always read the label in conjunction with this table). Numerous other products and formulations are also registered.

Chemical formulation	Toxicity to beneficials	Example registered trade name	Aphid	Armyworm	Blue oat mite	Cutworm	Green mirid	Heliothis	Lucerne leaf-roller	Lucerne flea	Redlegged earth mite	Sitona weevil	Thrips	Pasture webworm
Alpha-cypermethrin 100 g/L EC	High–very high	Alpha-Scud® Elite (1)	–	–	50 mL	–	0.16 L	0.16 L (2)	–	–	50 mL (3)	–	–	–
Bt sub-species *kurstkai*	Very low	DiPel® SC	–	1.0–4.0 L	–	–	–	1.0–4.0 L	–	–	–	–	–	–
Bifenthrin 250 g/L EC	High–very high	Talstar® 250 EC (4)	–	–	40 mL	–	–	0.16–0.24 L (5)	–	–	20–40 mL	–	–	40 mL
Beta-cyfluthrin 25 g/L	High–very high	Bulldock® Duo	–	–	0.2 l	–	–	–	–	–	0.2 L	–	–	–
Chlorpyrifos 500 g/L EC	High–very high	Strike-Out® 500 EC (6)	0.2 L or 0.3 L	0.7 L	0.14–0.3 L	0.9 L	–	–	0.3 or 0.4 L	–	0.14–0.3 L	0.35 L	–	–
Chlorpyrifos 300 g/L + lambda-cyhalothrin 15.4 g/L	High–very high	Cobalt® Advanced (7)	0.3 L or 0.5 L	–	0.15 L	0.2 L or 0.3 L	–	0.4 L or 0.6 L (5)	0.4 L or 0.6 L	0.12 L	0.15 L	0.6	–	0.2 L
Dimethoate 400 g/L EC	High–very high	Dimethoate 400 EC	–	–	–	–	–	–	–	55–85 mL	85 mL	–	–	–
Esfenvalerate 50 g/L EC	High–very high	Sumi-Alpha® Flex	100 mL (8)	–	50–70 mL (9)	–	–	0.13–0.33 L (10)	–	–	50–70 mL (9)	–	0.13 L (11)	–
Fenitrothion 1000 g/L EC	High–very high	Fenitrothion® 1000 (12)	–	–	–	–	–	–	–	–	–	0.65 L	–	–
Gamma-cyhalothrin 150 g/L	High–very high	Trojan® (13)	20 mL	–	–	10 mL or 15 mL	–	20 or 30 mL (5)	20 mL or 30 mL	–	8 mL (14)	–	–	10 mL
Lambda-cyhalothrin 250 g/L EC	High–very high	Karate Zeon® (15)	24 mL (16)	–	–	12–18 mL	–	24 or 36 mL (5)	24 mL or 36 mL	–	9 mL (14)	–	–	–
Methomyl 225 g/L SL	High–very high	Lannate®-L	–	1.5–2.0 L	–	–	–	1.5–2.0 L (6)	–	–	–	–	–	–
Nuclear polyhedrosis virus of *H. armigera.* 5 × 109/mL (obs)	Very low	Vivus Max	–	–	–	–	–	0.15 L	–	–	–	–	–	–
Omethoate 290 g/L	High–very high	Le-Mat® 290 SL	100 mL	–	100 mL (17)	–	–	–	–	100 mL	100 mL (17)	–	–	–
Phosmet 150 g/L EC	High–very high	Imidan®	–	–	0.25–0.35 L	–	–	–	–	0.25–0.35 L	0.25–0.35 L	–	–	–
Pirimicarb 500 g/kg WG	Very low	Pirimor® WG	0.1–0.15 kg	–	–	–	–	–	–	–	–	–	–	–

(1) Also registered for control of brown pasture looper (*Ciampa arientara*) at 50 mL/ha, blackheaded pasture cockchafer (*Aphodius tasmaniae*) at 100 mL/ha and wingless grasshopper at 0.16 L/ha .
(2) Registered for native budworm (*H. punctigera*) only.
(3) Registered as a pre-emergent application at 100 mL/ha. Apply by ground rig only.
(4) Also registered for bryobia mite (*Bryobia* spp.) at 80 mL/ha and brown pasture looper (*Ciampa arientaria*) at 20–40 mL/ha.
(5) Registered for native budworm (*H. punctigera*) only.
(6) Also registered for control of blackheaded pasture cockchafer (*Aphodius tasmaniae*) at 0.9 L/ha, web spinner caterpillar at 0.7 L/ha and wingless grasshopper at 0.5 L/ha.
(7) Also registered for control of blackheaded pasture cockchafer (*Aphodius tasmaniae*) at 0.3 or 0.7 L/ha.
(8) Registered for blue-green aphid (*Acyrthosiphon kondoi*) in southern NSW only.
(9) Also registered for bare earth application before crop emergence at 100 mL/ha. Apply by ground rig only. Do not apply as a ULV application.
(10) Registered for native budworm (*H. punctigera*) in southern NSW only.
(11) Registered for plague thrips only in southern NSW.
(12) Also registered for pasture cockchafer at 0.7 L/ha.
(13) Also registered for control of blackheaded pasture cockchafer (*Aphodius tasmaniae*) and brown pasture looper (*Ciampa arientaria*). See label for details.
(14) Blue oat mite often co-occurs with redlegged earth mite and this rate might be less effective against blue oat mite.
(15) Also registered for blackheaded pasture cockchafer (*Aphodius tasmaniae*). See label for details.
(16) Registered for pea aphid (*Acythosiphon pisum*) only.
(17) Also registered for Bryobia mite (*Bryobia* spp.) at 120 mL/ha.

Toxicity to beneficials

(red)	High–very high
(orange)	Moderate
(green)	Very low

Seed dressings

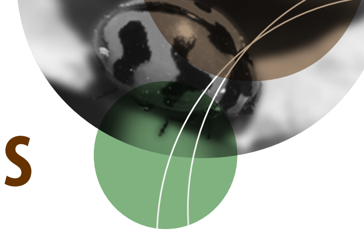


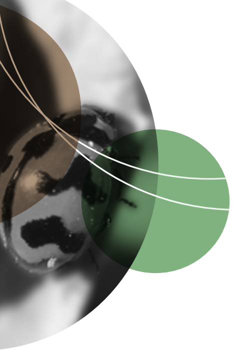
Table 43. Grain crop insecticidal seed dressings – 2022. (page 1 of 3)

Example seed treatment, trade name and manufacturer	Active ingredient of fungicide or insecticide	Rate to apply to each 100 kg of seed	Canola	Field pea	Faba bean/lentil	Lupin	Winter cereals	Maize	Sorghum	Sunflower
Gaucho® 600 Red Flowable – Bayer CropScience	imidacloprid (600 g/L)	300 mL (lupin) 400 mL (canola) 120 mL (faba bean) 60 mL (field pea) 120 or 240 mL (cereals)	Redlegged earth mite, blue oat mite, aphids	Aphids	Aphids	Redlegged earth mite, blue oat mite	Cereal aphid Corn aphid Spread of *Barley yellow dwarf virus* (BYDV)	–	–	–
Emerge™ Flowable Seed Treatment – Syngenta	imidacloprid (600 g/L)	300 mL (lupin) 400 mL (canola)	Redlegged earth mite, blue oat mite, aphids	–	–	Redlegged earth mite, blue oat mite	–	–	–	–
Senator® 600 – Nufarm	imidacloprid (600 g/L)	400 mL (canola)	Aphids	–	–	–	–	–	–	–
		300 mL (lupin)	–	–	–	Aphids	–	–	–	–
		120 mL or 240 mL (cereals)	–	–	–	–	Cereal aphid Corn aphid Spread of BYDV	–	–	–
		430 mL (sorghum, sunflower)	–	–	–	–	–	–	Sugarcane wireworm False wireworm, black field earwig Wingless cockroach Field cricket Black sunflower scarab	Sugarcane wireworm False wireworm, black field earwig Wingless cockroach Field cricket Black sunflower scarab
		1.4 mL/1000 seeds (maize)	–	–	–	–	–	Sugarcane wireworm False wireworm, black field earwig Wingless cockroach Field cricket Black sunflower scarab	–	–
Hombre® Ultra – Bayer	Imidacloprid (360 g/L) + tebuconazole (12.5 g/L)	200 mL	–	–	–	–	Cereal aphid Corn aphid Spread of BYDV	–	–	–
VETERAN® Plus 600 – Nufarm	Imidacloprid (180 g/L) + flutriafol (6.25 g/L)	400 mL	–	–	–	–	Cereal aphid Corn aphid Spread of BYDV	–	–	–

Table 40. Grain crop insecticidal seed dressings – 2022. (page 2 of 3)

Example seed treatment, trade name and manufacturer	Active ingredient of fungicide or insecticide	Rate to apply to each 100 kg of seed	Canola	Field pea	Faba bean/lentil	Lupin	Winter cereals	Maize	Sorghum	Sunflower
Pontiac	Imidacloprid (180 g/L) + metalaxyl-M (15 g/L)+ flutriafol (6.25 g/L)	400 mL	–	–	–	–	Cereal aphid Corn aphid Spread of BYDV	–	–	–
Cosmos® – BASF	fipronil (500 g/L)	400 mL	Redlegged earth mite	–	–	–	–	–	False wireworm	False wireworm
		150 mL (sorghum and sunflower)							Protection from black field earwig	Protection from black field earwig
Cruiser® Opti – Syngenta	thiamethoxam (240 g/L) + Lambda-cyhalothrin (37.5 g/L)	500–1000 mL canola)	Green peach and grey cabbage aphid	–	–	–	–	–	–	–
		1000 mL (canola)	Suppression of: redlegged earth mite, lucerne flea Protection from wireworm	–	–	–	–	–	–	–
		165–330 mL (cereals)	–	–	–	–	Oat/wheat aphid Corn aphid	–	–	–
		330 mL (cereals)	–	–	–	–	Suppression of redlegged earth mite, lucerne flea	–	–	–
		165 mL (cereals)	–	–	–	–	Protection from wireworm	–	–	–
Cruiser® 600FS – Syngenta	Thiamethoxam (600 g/L)	0.82 mL/1000 seeds (maize)	–	–	–	–	–	Control of false wireworm Protection from sugarcane wireworm	–	–
		2.3 L/1,000 kg seed (sorghum)	–	–	–	–	–	–	Control of false wireworm Protection from sugarcane wireworm, black field earwig	–
		0.18 mL/1000 seeds (sunflower)	–	–	–	–	–	–	–	Control of false wireworm, sugarcane wireworm
Poncho® Plus – BASF	clothianidin (360 g/L) + imidacloprid (240 g/L)	500 mL (canola)	Wireworm, cutworm, aphids, lucerne flea, redlegged earth mite, blue oat mite	–	–	–	–	–	–	–
		1.7 mL/1000 seeds (maize)	–	–	–	–	–	Wireworm, cutworm, aphids	–	–
		500 mL (sorghum)	–	–	–	–	–	–	Wireworm, cutworm aphids	
		500 mL (sunflower)	–	–	–	–	–	–	–	Wireworm, cutworm

Seed dressings



Withholding periods

Table 44. Withholding periods

Active ingredient	Example trade name	Azuki bean	Canola	Chickpea	Cowpea	Faba bean	Field pea	Lentil
Dimethoate 400 g/L EC	Dimethoate 400	14H	14H	–	14H 1G	–	–	–
Alpha-cypermethrin 100 g/L EC	Alpha-Scud® Elite	–	21H 21G	21H 35G	–	28H 35G	28H	–
Emamectin 17 g/L	Affirm®	21H 14G	14H 14G	21H 14G	21H 14G	21H 14G	21H 14G	21H 14G
Chlorantraniliprole 350 g/L	Altacor®	28H	–	14H	28H	28H	28H	28H
Permethrin 500 g/L EC	Axe®	–	–	–	–	–	2H	–
Beta-cyfluthrin 25 g/L	Bulldock® Duo	–	14H 14G	14H 7G	–	14H 7G	7H 7G	–
Chlorpyrifos 300 g/L + lambda-cyhalothrin 15.4 g/L	Cobalt® Advanced	–	14G	14H 28G	–	14H 28G	14H 28G	14H 28G
Deltamethrin 27.5 g/L EC	decis options®	7H	7H	7H	7H	7H	7H	–
Bt sub-species *kurstkai*	DiPel® SC	NR						
Phosmet 150 g/L	Imidan®	–	–	–	–	–	–	–
Fenitrothion 1000 g/L	Fenitrothion®	–	–	–	–	–	–	–
Lambda-cyhalothrin 250 g/L	Karate Zeon®	–	7H 7G	7H 7G	–	7H 7G	7H 7G	–
Thiodicarb 375 g/L SC	Larvin® 375	–	–	21H 21G	–	–	–	–
Omethoate	Le-mat® 290 SL	–	1H 1G	1H 1G	–	1H 1G	1H 1G	–
Trichlorfon 500 g/L SL	Lepidex® 500	–	–	–	–	–	–	–
Methomyl 225 g/L SL	Lannate®-L	7H	7H	–	7H	–	7H	–
Chlorpyrifos 500 g/L EC	Lorsban® 500 EC	–	10H 2G	10H 2G	–	10H 2G	10H 2G	–
Pirimicarb 500 g/kg WG	Pirimor® WG	–	14H 14G	–	–	–	–	–
Chlorpyrifos 400 g/L + bifenthrin 20 g/L	Pyrinex® Super	–	10H 28G	–	–	–	10H 28G	–
Cypermethrin 250 g/L	Scud Elite®	–	21H 21G	21H 35G	–	–	28H	–
Indoxacarb 150 g/L	Steward® EC	21H 21G	–	21H 21G	–	21H 21G	–	–
Spinetoram 120 g/L	Success® Neo	14H 14G	14H 7G	14H 14G	14H 14G	14H 14G	14H 14G	14H 14G
Esfenvalerate 50 g/L EC	Sumi-Alpha® Flex	–	14H 7G	14H 7G	–	–	14H 7G	–
Methidathion 400 g/L EC	Suprathion® 400 EC	–	7H	–	–	–	–	–
Bifenthrin 250 g/L	Talstar® 250 EC	–	28G	–	–	28G	28G	–
Sulfoxaflor 240 g/L	Transform®	14H 14G	14G	–	–	–	–	–
Gamma-cyhalothrin 150 g/L SC	Trojan®	–	2H 7G	2H 7G	–	2H 7G	2H 7G	–
Nuclear polyhedrosis virus of *Helicoverpa armigera* 5 x 109 mL (obs)	Vivus Max	NR	–	–	–	–	–	–
Abamectin 18 g/L EC	Wizard® 18 EC	–	–	–	–	–	–	–

Note: Maximum withholding periods are expressed where withholding periods vary due to targeted pest and application rates. Check label. Some labels do not specify withholding periods for either grazing or harvest. Check with manufacturer for details.

Note: Do not graze or cut for stockfeed. H – Harvest. G – Grazing. NR – Not required when used as directed.

Linseed	Lucerne❶	Lupin	Maize	Mungbean	Pigeon pea	Safflower	Sorghum	Soybean	Sunflower	Winter cereals
14H	7H 7G	14H	–	14H	14H 1G	–	–	7H	14H 1G	28H 1G
14H	See label	28H	7H	7H	–		7H	7H	21H	7H 14G
–	–	21H 14G	–	21H 14G	–	–	–	21H 14G	–	–
–	–	28H	–	14H	28H	–	–	14H	–	–
7H	–	–	–	–	–	–	–	–	–	3H
–	3H 3G	14H 7G	–	–	–	–	14H 14G	–	–	14H 7G
–	28H 28G	14H 28G	–	–	–	–	–	–	–	14H 14G
7H	–	7H	7H	7H	7H	7H	7H	7H	7H	7H
–	2G	–	–	–	–	–	–	–	–	7G
–	14G	–	–	–	–	–	–	–	–	–
–	14H 14G	14H 14G	–	See label	–	–	14H 14G	21H 21G	28H	14H 14G
–	–	–	7H 7G	21H 21G	21H 21G	–	–	21H 21G	–	–
1H 1G	1H 1G	1H 1G	–	–	–	1H 1G	–	–	–	1H 1G
2H	–	2H	–	–	–	2H	–	2H	2H	2H
–	3G	7H	–	7H	–	–	14H 14G	7H	7H	14H 14G
10H 2G	2H 2G	10H 2G	10H	–	–	10H 2G	2H 2G	–	10H 2G	10H 2G
–	3G	42H 42G	–	–	–	–	–	–	–	42H 42G
–	10H 28G	10H 28G	–	–	–	–	–	–	–	10H 28G
–	–	28H	7H	7H	–	–	14H	7H	21H	21H 35G
–	–	–	–	21H 21G	–	–	–	21H 21G	–	–
–	–	14H 14G	–	14H 14G	14H 14G	–	–	14H 14G	–	–
14H 7G	7G	14H 7G	7H 7G	–	14H 7G	14H 7G	7H 7G	14H 7G	14H 7G	7H 7G
7H	See label	–	–	–	–	7H	–	–	See label	See label
–	28H 28G	28G	–	–	–	–	–	–	–	28G
–	–	–	–	14H 14G	–	–	–	14H 7G	–	14G
–	14H 14G	7H 14G	–	7H 14G	–	–	7H 14G	21H 21G	28H	7H 14G
–	–	–	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	28H 28G	–	–

If the crop is to be cut for stockfeed do not sell any stock that have been fed cut material for export slaughter until the Export Slaughter Interval (ESI) has been observed. The ESI is the minimum period that must elapse between the removal of grazing livestock to clean pasture or clean feed and slaughter.

❶ Lucerne withholding period may vary with:
(a) Its role as seed crop or hay production.
(b) Pesticide application rate.
Check label.

Scientific names

Table 45. Scientific names

Scientific name	Common name
Acyrthosiphon kondoi	blue-green aphid
Acyrthosiphon pisum	pea aphid
Agrotis spp.	cutworm
Agrypnus variabilis	sugarcane wireworm
Anoplognathus spp.	christmas beetle
Aphis craccivora	cowpea aphid
Aphis glycines	soybean aphid
Aphodius tasmaniae	blackheaded pasture cockchafer
Austracris guttulosa	spur-throated locust
Austroasca alfalfae	lucerne leaf hopper
Bathytricha truncata	sugarcane and maize stemborer
Bemisia tabaci	silverleaf whitefly
Brevicoryne brassicae	cabbage aphid
Bruchophagus roddi	lucerne seed wasp
Bruchus pisorum	pea weevil
Bryobia spp.	bryobia mite
Ciampa arietaria	brown pasture looper
Chortoicetes terminifera	Australian plague locust
Chrysodeitis angentifena	tobacco looper
Chrysodeitis eriosoma	green looper
Contarinia sorghicola	sorghum midge
Deroceras spp.	slugs
Diachrysia oricalcea	soybean looper
Diuraphis noxia	Russian wheat aphid
Etiella behrii	lucerne seed-web moth
Frankliniella schultzei	tomato thrips
Graphognathus leucoloma	White-fringed weevil
Halotydeus destructor	redlegged earth mite
Hednota pedionoma	pasture webworm
Helicoverpa armigera	corn earworm
Helicoverpa punctigera	native budworm
Helix spp.	snails
Heteronychus arator	African black beetle
Leucania convecta	common armyworm
Lipaphis erysimi	turnip aphid
Listroderes difficilis	vegetable weevil
Maruca vitrata	bean pod borer
Melanacanthus scutellaris	brown bean bug
Merophyas divulsana	lucerne leaf roller
Monolepta australis	red-shouldered leaf beetle
Mythimna convector	common armyworm
Myzus persicae	green peach aphid
Nala lividipes	black field earwig
Nezara viridula	green vegetable bug
Nysius vinitor	Rutherglen bug
Nysius clevelandensis	grey cluster bug
Oncopera rufobrunnea	underground grass grub
Orondina spp.	false wireworm
Othnonius batesi	black soil scarab
Penthaleus major	blue oat mite
Persectania ewingii	southern armyworm
Petrobia latens	brown wheat mite
Pieris rapae	cabbage white butterfly
Piezodorus hybneri	redbanded shield bug
Plutella xylostella	cabbage moth/diamondback moth
Rhopalosiphum maidis	corn aphid
Sericesthis spp.	small brown cockchafer
Sitona discoideus	sitona weevil
Sminthurus viridis	lucerne flea
Spodoptera exigua	lesser armyworm
Spodoptera letura	cluster caterpillar
Spodoptera mauritia	lawn armyworm
Spodoptera frugiperda	fall armyworm
Stomopteryx simplexella	soybean moth
Tetranychus ludeni	bean spider mite
Tetranychus urticae	two spotted mite
Therioaphis trifolii f. maculata	spotted alfalfa aphid
Trialeurodes vaporariorum	greenhouse whitefly
Thrips tabaci	onion thrips
Thrips imaginis	plague thrips
Zizina labradus	grass blue butterfly
Zygrita diva	lucerne crown borer

Directory: main suppliers

Table 46. Directory of the main pesticide manufacturers/distributors[#]

Distributo/ Manufacturer	Contact details	Website address	Phone contact
4Farmers Pty Ltd	35A McDowell Street, Welshpool WA 6106	www.4farmers.com.au	1800 038 445
AgBiTech Pty Ltd	8 Rocla Court, Glenvale QLD 4350	www.agbitech.com.au	1800 242 519
BASF Australia	12/28 Freshwater Place, Southbank VIC 3006	www.crop-solutions.basf.com.au/	1800 558 399
Bayer CropScience Pty Ltd	875 Pacific Highway, Pymble NSW 2073	www.bayercropscience.com.au	1800 636 001
Imtrade Australia Pty Ltd	Suite 12, 11 Preston Street, Como WA 6142	www.imtrade.com.au	1800 171 799
Conquest Crop Protection	1/4 Collingwood St, Osborne Park WA 6017	www.conquestag.com.au	1800 033 111
Corteva Agriscience	Locked Bag 2002, Baulkham Hills NSW 2057	www.corteva.com.au	1800 700 096
Adama Australia	Level 1, Building B 207 Pacific Highway, St Leonards NSW 2065	www.adama.com/australia/en	1800 423 262
FMC Australia	12 Julius Avenue, North Ryde NSW 2113	www.fmccrop.com.au	1800 901 939
Nufarm Australia Ltd	103-105 Pipe Road, Laverton North VIC 3026	www.nufarm.com.au	(03) 9282 1000
Sipcam Pacific Australia Pty Ltd	Level 1, 191 Malop Street, Geelong VIC 3220	www.sipcam.com.au	1300 130 633
Sumitomo Chemical Australia Pty Ltd	Level 5, 51 Rawson Street, Epping NSW 2121	www.sumitomo-chem.com.au	(02) 8752 9000
Syngenta Australia Ltd	Level 1, 2–4 Lyonpark Road, Macquarie Park NSW 2113	www.syngenta.com.au	1800 022 035
United Phosphorus Ltd	Level 3, 70 Hindmarsh Square, Adelaide SA 5000	www.upl-ltd.com/au	1800 078 007

[#]There are a number of smaller manufacturers/distributors of pesticide products.