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INSECTICIDE RESISTANCE MANAGEMENT AND INVERTEBRATE PEST IDENTIFICATION FACT SHEET

GRDC
Grains Research & Development Corporation
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SOUTHERN AND WESTERN REGIONS

APPROACHES TO KEY INSECT PESTS OF SOUTHERN AND WESTERN GRAINS

The use of prophylactic 'insurance' sprays as a pest management strategy leads to off-target effects and insecticide resistance. Explore integrated pest management (IPM) options and spray only when necessary. This will reduce economic and environmental costs and preserve insecticide efficacy into the future.

KEY POINTS

- Prophylactic or 'insurance' sprays can be an unnecessary cost and may speed up the development of resistance in pest populations.
- Consider carefully the need for insecticides. There may be beneficial insects present that will help control pests if crops are left unsprayed.
- IPM uses cultural, chemical, genetic and biological tactics to prevent pests from reaching damaging levels in crops.
- Only apply insecticides after monitoring and correctly identifying pest species.
- If insecticides are used, minimise chemical impact on beneficial insects by considering a selective spray and limited number of applications.
- Rotate chemical classes with different modes of action to minimise resistance problems. Use the correct rates and ensure good coverage.
- Base the choice of control strategies on economic thresholds.

The rationale for insurance sprays is that the cost of the insecticide is relatively cheap compared to crop damage at emergence – if it should occur. They also are often tank-mixed with herbicide sprays so that no additional application costs are incurred.

PHOTO: A WEEKS, CESAR

Resistance to synthetic pyrethroids in redlegged earth mites (RLEM) has been shown to have a genetic basis. This means it can be passed on to future generations and can be a long-term problem. Strategic crop rotations, careful weed control and grazing management are all useful non-chemical methods to suppress RLEM populations.

However, the short-term saving may come at a longer-term cost.

The routine use of 'insurance' sprays – cheap, broad-spectrum synthetic insecticides – can exacerbate resistance issues and knock out any beneficial insects that may be present.

Also, attempts to control one pest species may lead to other problem insects being repeatedly exposed to the chemical too, even though they are not the main target. This can lead to insecticide resistance developing and spray failures into the future.

Knock-on effects of broad-spectrum insecticide use may include:

- insecticide resistance;
- eradication of beneficial species that can assist pest control; and
- secondary pest outbreaks.

An IPM approach involves:

- correctly identifying the problem insect pest;
- monitoring pest numbers; and
- assessing damage to crop plants.

With this information an informed decision can be made on the damage or potential damage to the crop, the insects causing the damage and if control tactics are required.

Economic thresholds, which can be obtained from entomologists or advisers, will help with decision-making. Thresholds will vary with different cropping situations, grains prices, regions and choice of controls.

Insecticide resistance

If an insecticide repeatedly fails to control a pest species when used according to the label recommendations, suspect resistance, but do not discount other reasons.

Resistance develops through the overuse or misuse of an insecticide against a pest species. It results in the evolution of populations that are resistant to the insecticide.

Repeated insecticide application keeps increasing the proportion of resistant individuals in a pest population until the majority are resistant to that insecticide.

This not only makes this pesticide ineffective, but it can convey cross-resistance to other related chemical compounds.

Problem pests with resistance

Redlegged earth mites

Redlegged earth mites (RLEM) attack pastures and most crops, including cereals, canola and pulses, especially at crop emergence.

RLEM have confirmed resistance to synthetic pyrethroids (SPs), including bifenthrin and alpha-cypermethrin, in Western Australia. High levels of resistance can cause significant financial, labour and yield losses.

Resistance to SPs in RLEM has a genetic basis, so it can persist in a paddock indefinitely. Currently no resistance has been detected in New South Wales, Victoria and South Australia.

Correct identification of RLEM is essential as they can be easily confused with blue oat mites, Bryobia mites and Balaustium mites, all of which respond differently to commonly used insecticides.

If RLEM are at damaging levels, spraying can be effective, but the timing is critical. Insecticides used at or after sowing should be applied within three weeks of the first appearance of mites, before adults begin to lay eggs.

Crops such as chickpeas and lentils are poor hosts of RLEM. Including these crops in a rotation may limit the need for a insecticide spray in that year.

Weed control along fencelines and within paddocks can reduce mite numbers by limiting breeding sites.

PHOTO: SARAH CLARRY

RLEM damage in clover showing the characteristic silvering of leaves. High levels of insecticide resistance in RLEM populations have caused some significant economic and yield losses due to ineffective chemical applications and mortality of crop plants at seedling establishment.

Appropriate grazing management can also reduce RLEM populations. Shorter pastures increase mite mortality and limit food resources.

Alternatively, a 'spring-spray' in pastures can kill female RLEM before they produce diapause (over-summer) eggs. The optimum spring-spray dates for RLEM are available from the Timerite® website (see Useful Resources).

Decreasing RLEM in pastures is especially important if paddocks are to be sown to canola in the following year. If RLEM populations have been managed in the previous year, fewer sprays for RLEM will be needed in the following crop.

Diamondback moth

Diamondback moth (DBM) is a destructive pest of canola, brassica vegetables and forage crops. Larvae feed on plant foliage, stems, flower heads and pods, and can cause yield losses of up to 80 per cent.

DBM is an insect that has had substantial exposure to generalised pyrethroid applications, even though it is often not the primary target of the application. Consequently, DBM, have developed resistance to SPs.

Dry winters and early springs favour the outbreak of DBM. In years when outbreaks of large DBM populations occur, two spray applications 5-7 days apart give the greatest control of caterpillars and reduce yield loss. A two-spray strategy ensures DBM eggs and caterpillars that survive the first application are also controlled.

A number of beneficial insects attack DBM. These include parasitic wasps, brown and green lacewings, several bug predators and a range of spiders. In some years these insects may cause DBM populations to fall below economic damaging thresholds.

A fungus, *Zoophthora radicans*, is an occasional natural enemy of DBM and can cause a 90 per cent reduction in larvae numbers in large DBM populations.
The fungus is favoured by rainfall, humidity and warm temperatures.

Monitor DBM populations using an insect sweepnet periodically through the growing season; from early flowering to pod ripening. DBM larvae can graze canola pods but trials have shown this does not lead to yield loss from pods shattering. Once canola is swathed and pods start to dry off, DBM larvae stop feeding.

If there is a 'green bridge' in summer, control brassica weeds, such as wild radish, to suppress DBM. Be aware that if it is a warm start to the growing season DBM adults are migratory and may lay eggs in seedling canola crops.

Selective or 'soft' chemicals are less disruptive to beneficial insects. For instance, *Bacillus thuringiensis* (Bt), is effective in controlling DBM larvae if the majority of larvae are less than 5 millimetres in length. Bt is broken down by ultraviolet light so best results are achieved when applied at dusk.

Diamondback moth is an insect that has had substantial exposure to synthetic pyrethroid applications and has developed resistance.

Green peach aphid (GPA) tend to be found on the underside of leaves. GPA populations need to be large before economic losses are encountered as a result of direct feeding-damage. Monitor numbers before deciding whether a spray is necessary.

Green peach aphids

Green peach aphids (GPA) attack pulse and oilseed crops, and populations may have resistance to SPs and organophosphates (OPs).

Localised resistance to pirimicarb (carbamates) has also recently been detected in this species in WA. Pirimicarb is aphid-specific and therefore less harmful to other invertebrates. It is a useful part of the IPM toolkit when resistance is not present. It achieves excellent levels of control of GPA when applied according to label directions.

Aphids breed asexually so they do not share genes with other aphids. Therefore the risk of aphids developing resistance to multiple chemical groups is reduced.

If aphids with dual resistance are present, chemical rotation will not be a management option.

GPA can spread many damaging plant viruses, such as cucumber mosaic virus and beet western yellows virus. However, populations need to be large before they cause economic losses. Crops are most at risk from feeding damage if they are at the seedling stage and moisture stressed. GPA tend to be found on the underside of leaves. Monitor numbers before deciding if a spray is necessary.

If crops are left unsprayed there are a number of effective beneficial insects that will help control aphid populations. These include parasitic wasps, ladybird beetles, lacewings, hover flies and damsel bugs.

Corn earworm

Corn earworm (*Helicoverpa armigera,* also referred to as cotton bollworm) is primarily a pest of the northern grains region, but does occur in the south and mainly in horticultural regions of the west. It is particularly problematic for irrigated crops in southern New South Wales and northern Victoria.

Corn earworm attack several field crops, including cotton, sorghum, maize, sunflowers, chickpeas, lupins and lucerne. Damage from the larval stage is most notable as larvae grow beyond eight millimetres long and begin to burrow into seeds and pods.

Corn earworm has developed resistance to most older insecticide groups. Consequently, the number of sprays per crop of some newer insecticides is restricted to reduce the risk of further resistance developing.

Any IPM measures that reduce the need to spray for corn earworm also reduce the risk of this pest developing resistance to newer, more IPM-compatible insecticides.

Biopesticides such as nucleopolyhedrosis virus (NPV) and Bt can be effective options.

Beneficial insects that help to control corn earworm include parasitic wasps and several species of predatory bugs, which prey on the larvae and help transmit the NPV disease throughout the population.

Populations of cotton/corn earworm have been detected in WA with pesticide resistance, however, it is not a significant pest of WA grain crops.

Another species of helicoverpa, native budworm (*Helicoverpa punctigera*) is a major pest, however, it has not developed resistance to any class of insecticide.

What is IPM?

IPM uses a wide range of tactics to prevent pests of all kinds from reaching damaging levels in crops.

IPM tactics fall into the following categories:

- **cultural** – such as crop rotation, trap cropping, removal or destruction of diseased plants;
- **chemical** – use of insecticides as a last resort only and favouring those products that conserve pests' natural enemies;
- **genetic** – pest-resistant plant varieties; and
- **biological** – the conservation or release of natural enemies such as parasitic wasps, predators and pathogens that attack or feed on pests.

Corn earworm inflict the most damage once they are large enough to burrow into seeds and pods. Biopesticides are effective options, and a range of predators including parasitic wasps and predatory bugs may also keep numbers under control.

An effective broadacre IPM strategy reduces pest damage and control costs by:

- adopting cultural controls that reduce pest populations and boost beneficial insect populations;
- using selective insecticides and biopesticides that target specific pests;
- using economic thresholds to avoid unnecessary spraying and take advantage of a crop's ability to compensate for pest damage at certain crop stages; and
- encouraging beneficial species that act as natural pest biocontrols.

Putting IPM into action

1 Recognise your insects

Accurately identifying beneficial and pest species and understanding their biology and life cycle are fundamental to IPM.

Factors such as weather, presence of hosts, plant growth stage and the balance between pest and beneficial species can cause insect populations to fluctuate and so affect control decisions.

Peak populations of beneficial species generally occur after peak pest populations.

Understanding the behaviour of a pest can indicate when and where it is most likely to be found. For example, slugs tend to inhabit

Corn earworm moth. Problems in spring and summer generally arise from local populations that survive over winter as diapausing pupae.

PHOTO: CSIRO

heavier soils, especially those that form cracks and large clods, which they are able to use as refuges from hot and dry conditions.

When favourable moist conditions prevail, these pests become active.

To recognise your insects:

- establish which pests are most likely to be a problem in the region;
- be familiar with crop growth stages to determine when crops are at greatest risk;
- know the most appropriate monitoring technique, and when to monitor;
- use a 10-times magnification hand lens or basic dissecting microscope to accurately identify smaller pests and pests in their younger stages;
- refer to the GRDC's *Crop Insects: The Ute Guide Western Grain Belt Edition* OR *Southern Region Grain Belt Edition* or a similar illustrated reference guide to help identify pests; and
- maintain up-to-date records of observations.

Beneficial insects

Beneficial species help to control insect pests as part of a successful IPM strategy. Many beneficial species occur naturally and these populations benefit from reduced pesticide use.

Beneficial species can be divided into three main groups:

- **parasites (parasitoids)** – which lay their eggs on or in the host. The larvae feed off the host pest's body, larvae or eggs, eventually killing the host;
- **predatory insects** – generalist species, such as spiders, prey on a range of pests. Specialised insects, such as pasture snout mites, feed on lucerne fleas and earth mites; and
- **bacteria, fungi and viruses** – which can attack and cause disease in pests, under favourable conditions.

Beneficial Insects – Southern/Western Regions: The Back Pocket Guide i s available through GRDC (see Useful Resources).

2 Know the control thresholds for pests in your crops

Where possible, the decision to control a pest should be based on an economic threshold (ET). Thresholds are one of the cornerstones of IPM. They rationalise pesticide use and are a key to profitable pest management.

The development of economic thresholds requires an understanding of the pests, the damage they cause and the crop's response to that damage.

Before deciding to spray crops at establishment:

- identify the pests present;
- determine if seedling losses are significant; consider whether the crop is able to outgrow damage; and
- determine if pest populations are increasing, static or declining.

For crop establishment pests, relate the damage to the number of seedlings per metre of crop row still required for an optimum yield. This should be performed in a number of places in the paddock to determine if control is required.

Before deciding to spray crops at tillering, flowering or podding:

- identify pests and the densities at which they are present in the crop;
- determine if pest populations are increasing, static or declining; and
- determine if beneficial insects such as parasitic wasps and ladybird beetles are present.

For later season pests, relate these figures to an economic threshold. This is the point where pests outweigh beneficial insects to the extent that economic yield losses will be greater than the cost of control.

Models allow for variations in grain and insecticide prices which can also be factored into decisions on whether pesticide applications are warranted.

Economic thresholds will vary with different cropping situations, grain prices, regions and choice of controls. They are best obtained from local entomologists and agronomists.

Comprehensive IPM guidelines for Australian grains are being developed.

3 Monitor populations

Populations of pest and beneficial insects need to be monitored:

- prior to seeding;
- during crop establishment;
- during the growing season; and
- after control treatments, to establish success or the need for re-treatment.

Good monitoring will help to identify trends in species' population growth or decline over time. Monitor more than one spot in a paddock and record:

- key pests and beneficial species, ideally by life stage;
- insect location within a paddock;
- crop health and growth stage;
- paddock pesticide history;
- weed presence; and
- weather conditions.

Monitor the crop for pests and beneficial species:

- weekly during the vegetative stage of crop growth until it has outgrown the establishment pests; and
- regularly until harvest.

Prior to seeding

Check summer weeds, volunteer crops and vegetation near the paddock for pests and beneficial species. For instance, pest caterpillars and their predators can be found on host plants outside the crop, and aphids can breed-up on host plants and then move into a crop.

Pitfall, shelter and sticky traps are a low-cost and simple method of collecting insects in pre-seeding to early post-emergence.

Slug numbers can be estimated by laying a series of carpet squares or large tiles on the ground with baits underneath. Check underneath after a few days and count the dead slugs.

At crop emergence

In addition to insect counts, visual observation of feeding-damage to plants is very useful. Using markers, identify a one metre section of crop row in a number of spots in the paddock, then regularly inspect emerging plants for leaf damage and plant loss. Be sure to take random samples from within the crop and not just around the edge.

Correctly identifying the pest is critical to ensuring control measures are effective. If a pest can not be readily found, use pitfall and shelter traps to attract them. Be aware there may be more than one species of pest causing the damage.

Tillering, flowering or podding

Sweepnets are used to sample insects in broadacre crops that are flowering or podding. This is an effective way to determine densities of any caterpillar pests, or if aphids are present. If a sweepnet is not available, cut individual plants at the base and bang them inside a large pale-coloured container to shake pests loose. Any caterpillar pests will be visible.

Also look at the tiller or flowering spike to observe densities of any aphids present.

Sweepnetting and aphid observations are best done in a 'W-shaped' pattern in a number of locations in a paddock.

4 Select appropriate control methods

Cultural

Cultural control options:

- astute use of crop rotations by understanding which crops are susceptible to different pests and planning crop sequences that minimise pest pressures;

PHOTO: EMMA LEONARD

Sweepnets are effective in shorter crops with a soft canopy, and where pests are concentrated at the top of the canopy.

Table 1 Southern and western crop pests: what to check for, when.

Crop establishment	Vegetative stage	Flowering	Pod/seed set and grain fill
Winter cereals – wheat, barley			
Mites Cutworm Lucerne flea Scarabs Slugs Snails	Aphids Lucerne flea Slugs	Aphids	Armyworm Helicoverpa
Chickpea			
Cutworm			Helicoverpa
Pulses			
Aphids Brown pasture looper Mites Cutworm Earwig Lucerne flea Snails Slugs Weevils	Aphids Lucerne flea Slugs Snails	Aphids Helicoverpa Etiella moth Native budworm Pea weevil Thrips	Etiella moth Helicoverpa Native budworm Pea weevil Snails
Sunflower			
Cutworm Wireworm	Loopers	Helicoverpa Rutherglen bug	Rutherglen bug
Maize			
Cutworm Crickets Earwigs True and false wireworms	Jassids	Helicoverpa	
Canola			
Aphids Brown pasture looper Mites Cutworm Diamondback moth Earwig False wireworm Lucerne flea Weevils Millipede Rutherglen bug Slugs Snails	Diamondback moth Earwig Lucerne flea Mites Slugs Snails	Aphids Diamondback moth Native budworm Rutherglen bug	Aphids Diamondback moth Helicoverpa Native budworm Rutherglen bug

- conservation of remnant grasslands and native vegetation adjacent to cropping paddocks, which may provide a refuge for some beneficial species;
- removal of weeds or other plant materials that host pests both prior to cropping and during the growing season; and
- strategic grazing.

Biological

Biopesticides are insect diseases (fungal, bacterial and viral) that have been isolated and produced for use against insect pests.

One of the advantages of biopesticides is they are selective. Unlike many chemical insecticides that are broad-spectrum, biopesticides only kill a single pest species or distinct group of insects.

By specifically targeting pests without harming beneficial species, biopesticides allow predators and parasitoids to help suppress pest numbers.

Biopesticides have little or no effect on beneficial organisms, are harmless to humans and wildlife, and leave no toxic residues.

In addition to biopesticides, the use of more selective 'soft' pesticides such as pirimicarb, is an effective management tool that facilitates, rather than disrupts, the natural biological control that already exists in crops.

However, as is the case with any spray application for insect control, careful monitoring and identification of beneficial species should take place before making any decision to spray.

If the appropriate beneficial species are present in sufficient numbers, the need to spray at all, even with a selective product, should be carefully considered.

Chemical

IPM does not exclude the use of chemical insecticides, but encourages a more strategic approach to the use of chemicals for pest control.

Such an approach may include:

- the use of selective insecticides;
- targeting susceptible life stages of pests;
- spraying at certain times of the day to better target periods when pests are active or when beneficial insects are inactive and therefore protected;
- use of tools such as Timerite® to schedule spraying;
- spot spraying for sporadic pest incursions, for example, canola aphids;
- use of broad-spectrum insecticides as seed dressings to affect plant-feeding pests with minimal impact on beneficial insects;
- applying insecticides in-furrow to restrict the number of species exposed to the insecticide; and
- border spraying to control insects invading from vegetation outside the paddock boundary.

FREQUENTLY ASKED QUESTIONS

What should I spray?

You need to know the identity of the pest. Is it resistant to commonly applied insecticides? If so, consider using 'softer' insecticides and biopesticides. If you choose to use a broad-spectrum insecticide, be aware that you may have unwanted, off-target effects and secondary pest outbreaks. A comprehensive insect monitoring and identification program should be considered a vital part of a cropping program. Understanding the role of beneficial insects, as well as economic thresholds, will make the decision-making process easier.

When should I spray?

Spray timings will depend on the pest species targeted, its breeding cycle, plant growth stage and the balance of pest and beneficial species. Use insecticides when warranted, and time sprays to occur when pests are most active. Prophylactic or 'insurance' sprays represent unnecessary cost and speed up the development of resistant pest populations.

When are my crops at greatest risk?

Crops are most vulnerable to pests at establishment, with canola and pulses being the most susceptible to invertebrate damage. The seedling stage is typically when the greatest yield losses can occur. Knowing the minimum plant density required for a good crop yield is essential. Mites and aphids, if present, will feed on crops throughout the plant's life cycle. Other pests, such as caterpillars, are more commonly an issue from flowering onwards.

What is the likelihood I will have a spray failure?

The likelihood of spray failure will depend on past pest management practices and the presence of insecticide resistance in the target pest population. If resistance is suspected consult your agronomist or the person in your nearest state listed under *More Information*.

How do I prevent spray failures into the future?

Using the broadest range of IPM strategies is the best way to avoid future spray failures and prevent or delay the development of insecticide resistance. Make use of thresholds and spray only when necessary. Rotate insecticides across different chemical classes/modes of action.

I was told that SPs were only anti-feedants and therefore not as likely to select for resistance. Is this true?

SPs are not just anti-feedants. They have lethal effects and are therefore very likely to select for resistance. SP resistance is very common among some insect pests.

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GRDC PROJECT CODES

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USEFUL RESOURCES

GRDC Pest Links
www.grdc.com.au/pestlinks

pestIQ
www.pestIQ.com.au

Integrated Pest Management for Crops and Pastures
Paul Horne and Jessica Page, Landlinks Press, 2008, www.ipmtechnologies.com.au

Crop Insects: The Ute Guide Western Grain Belt Edition OR Southern Region Grain Belt Edition
www.grdc.com.au/director/events/bookshop, 1800 11 00 44, ground-cover-direct@canprint.com.au

Beneficial Insects – Southern/Western Regions: The Back Pocket Guide
www.grdc.com.au/director/events/bookshop, 1800 11 00 44, ground-cover-direct@canprint.com.au

PestFacts (Victoria, NSW)
www.cesaraustralia.com/sustainable-agriculture/pestfacts-south-eastern/

PestFacts (SA, western Victoria)
www.sardi.sa.gov.au/pestsdiseases/publications/pestfacts2

PestFax (WA)
www.agric.wa.gov.au/pestfax

Timerite® spray model for RLEM
www.wool.com/Grow_Timerite.htm

MORE INFORMATION

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