NORTHERN
MARCH 2018

GRDC GROWNOTES™

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

TRITICALE

SECTION 7

INSECT CONTROL

POTENTIAL INSECT PESTS | INTEGRATED PEST MANAGEMENT | DAMAGE CAUSED BY RWA | OTHER APHIDS | CUTWORMS | ARMYWORM | MITES | HELICOVERPA SPECIES | LUCERNE FLEA | SLUGS AND SNAILS | WIREWORMS AND FALSE WIREWORMS

Insect control

Key messages

- To date, triticale varieties are affected by only a few insect pests.
- Triticale has the same insect predators during growth as other cereals. In general, fewer insect control measures are required with the exception of grain storage insects, to which triticale is very susceptible.
- Triticale is vulnerable to grasshoppers, aphids, armyworms, earth mites, *Helicoverpa* and cutworms. Russian Wheat Aphid is also an emerging pest that could be a problem in triticale.
- Insects are not usually a major problem in cereals but sometimes they build up to an extent that control may be warranted.
- Integrated pest management (IPM) strategies encompass chemical, cultural and biological control mechanisms to help improve pest control and limit damage to the environment, and are suitable for use with triticale in the Northern Region.
- For current chemical control options refer to the Pest Genie or Australian Pesticides and Veterinary Medical Authority.

Although triticale varieties are affected by only a few insect pests, [1] where they are vulnerable, the risks from insect damage are similar to those for wheat. Hence, management practices for these insects are the same as for other cereals, and they should be applied only when continual scouting indicates that the problem has reached an economic threshold for control. [2]

Earth mites (redlegged and blue oat mites) can be a problem in early growth, and chemical control may be necessary depending on insect numbers and damage. Aphids may occur in late winter and spring and while usually not a cause of major damage themselves they do transmit Barley yellow dwarf virus (BYDV) and this may warrant control in severe infestations. Monitor seedling crops for lucerne flea, redlegged earth mite and blue oat mite. Seek local advice to determine if the application of insecticide is warranted and, if so, ensure grazing withholding periods are met. Aphids can infest early-sown crops and attack the crop again in spring. Early in the season they spread viral disease, while in spring they cause yield damage. Seek local advice on thresholds and management options. [3] Where chemical control is warranted, farmers are increasingly being strategic in their management and avoiding broad-spectrum insecticides where possible. Thresholds and potential economic damage are carefully considered.

7.1 Potential insect pests

Pest insects can damage agricultural production and market access, the natural environment, and people's lifestyles. They may cause problems by damaging crops (Tables 1, 2 and 3 [4]) and food production, parasitising livestock, or being a nuisance or health hazard to humans. Integrated pest management (IPM) guidelines provide an extensive collection of tools and strategies to manage pests in grain-cropping systems.

However, in winter cereals, insects are not normally a major problem, although there will be times when they build up to an extent that control may be warranted.

MORE INFORMATION

IPM in winter cereals

1 M Mergoum, H Gómez-Macpherson (eds) (2004) Triticale improvement and production. FAO Plant Production and Protection Paper No. 179. Food and Agriculture Organisation, http://www.fao.org/docrep/009/y5553e/y5553e00.htm

2 Alberta Agriculture and Forestry (2016) Triticale crop protection. Alberta Agriculture and Forestry, http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/fcd10572

3 Waratah Seed Company (2010) Triticale: planting guide. Waratah Seed Company, http://www.porkcrc.com.au/1A-102_Triticale_Guide_Final_Fact_Sheets.pdf

4 Queensland Government, GRDC (2016) Winter cereals: insect pest risk. In IPM Guidelines, http://ipmguidelinesforgrains.com.au/crops/winter-cereals/

Table 1: *Insect pest risk for winter cereals in the Northern Region.*

High risk	Moderate risk	Low risk
Soil insects, slugs and snails		
Some crop rotations increase the likelihood of soil insects: • cereal sown into a long term pasture phase; • high stubble loads; • above-average rainfall over summer-autumn. History of soil insects, slugs and snails Summer volunteers and brassica weeds will increase slug and snail numbers Cold, wet establishment conditions exposes crops to slugs and snails	Information on pest numbers prior to sowing from soil sampling, trapping and/ or baiting will inform management Implementation of integrated slug management strategy (burning stubble, cultivation, baiting) where history of slugs Increased sowing rate to compensate for seedling loss caused by establishment pests	Slugs and snails are rare on sandy soils
Earth mites		
Cereals adjacent to long-term pastures may get mite movement into crop edges Dry or cool, wet conditions that slows crop growth increases crop susceptibility to damage History of high mite pressure	Leaf-curl mite populations (which transmit Wheat streak mosaic virus) can be increased by grazing and mild, wet summers	Seed dressings provide some protection, except under extreme pest pressure
Aphids		
Higher risk of Barley yellow dwarf virus (BYDV) disease transmission by aphids in higher-rainfall areas where grass weeds are present prior to sowing Wet summer and autumn promotes survival of aphids on weed and volunteer hosts	Wet autumn and spring promotes the growth of weed hosts (aphids move into crops as weed hosts dry off) Planting into standing stubble can deter aphids landing Use of seed dressings can reduce levels of virus transmission and delay aphid colonisation Use of SPs and OPs to control establishment pests can kill beneficial insects and increase the likelihood of aphid survival	Low rainfall areas have a lower risk of BYDV infection. High beneficial activity (not effective for management of virus transmission)
Armyworms		
Large larvae present when the crop is at late ripening stage	High beneficial insect activity (particularly parasitoids) Rapid crop dry down	No armyworm present at vegetative and grainfilling stages

OPs = organophosphates; SPs = synthetic pyrethroids.

Source: IPM Guidelines

Table 2: *Impact of insect according to crop stage.*

Pest	Crop stage			
	Emergence	Vegetative	Flowering	Grainfill
Wireworms	Damaging	Present		
Cutworms	Damaging			
Blackheaded cockchafer	Damaging	Present		
Earth mites	Damaging	Present		
Slugs, snails*	Damaging			
Brown wheat mite		Damaging		
Aphids	Present	Damaging	Present	Present
Armyworms		Present	Present	Damaging
Helicoverpa armigera				Damaging

Present	Present in crop but generally not damaging
Damaging	Crop susceptible to damage and loss

* Snails are also a grain contaminant at harvest

Source: IPM Guidelines

Use Table 3 to help identify problem insects in northern crops.

Table 3: *Winter cereal pests affecting northern region crops.*

Insect	Pre-season	Establishment	Winter	Spring
Aphids (Note that information for Russian Wheat Aphid may be slightly different)	Remove green bridge (weed and volunteer hosts)	High risk: • wet summer/ autumn • history of virus If high risk, consider seed dressings Targeted early control along crop edges or infested patches may delay build-up in the crop	High risk: warm conditions favour aphids Monitor and record aphids and beneficials. Review to determine if populations increase/decrease or are stable. Rainfall >20 mm will reduce aphid populations. Consider delaying insecticide application if rain is forecast. If spray is required, use a selective insecticide.	A warm, dry spring encourages population growth. No yield loss will occur if infestations occur later than milky grain. Monitor and record aphids and beneficials. Use suggested thresholds. If spray required, use a selective insecticide. Use of broad-spectrum pesticides will kill beneficial insects and increase likelihood of aphid population resurgence.
Common armyworms	Control host weeds (especially ryegrass) Ensure correct ID (armyworm *v.* Helicoverpa)	Use traps to indicate moth activity (lures of 10% port, 15% raw sugar and 75% water)	High risk: good local rain following a dry period encourages egg laying Monitoring: • use traps to monitor for moth activity • monitor for larvae at dusk with a sweep net. • ground search for larvae and droppings • look for scalloped leaf margins Control larvae when small	Increase monitoring as crop starts to dry down Small larvae take 8–10 days to reach size capable of head lopping. Determine if crop will be susceptible (dry except for green nodes) when larvae reach damaging size. Control late in the day when larvae are actively feeding. Use of SPs to control armyworms early can increase likelihood of Helicoverpa survival and damage by killing beneficials that would control them.

Insect	Pre-season	Establishment	Winter	Spring
Helicoverpa armigera	If large numbers of *Helicoverpa* present in previous crop, pupae busting may reduce pest incidence		Monitor for larvae with sweep net (can be done when checking for armyworms), or with a beat sheet. Control small larvae (<7 mm) with NPV	Monitor for larvae using a sweep net or beat sheet. Large larvae are most damaging to developing grain. (Small larvae <7 mm can be controlled with NPV.) Be aware that *H. armigera* have resistance to SPs in all regions

NPV = nucleopolyhedrosis virus; SPs = synthetic pyrethroids

Source: IPM Guidelines

7.2 Integrated pest management

Integrated pest management is an approach that uses a combination of biological, cultural and chemical control methods to reduce insect pest populations. A key aim of IPM is to reduce reliance on insecticides as the sole or primary means of control. The use of IPM can improve growers' profitability while reducing environmental damage, reducing the incidence of insecticide resistance, and limiting the risk of pesticide exposure on the farm.

7.2.1 Key IPM strategies for winter cereals

- Where the risk of establishment pest incidence is low (e.g. earth mites) regular monitoring can be substituted for the prophylactic use of seed dressings.
- Where establishment pests and aphid infestations are clearly a result of invasion from weed hosts around the field edges or neighbouring pasture, a border spray of the affected crop may be sufficient to control the infestation.

Insecticide choices

- The redlegged earth mite (RLEM), blue oat mite (BOM), and other mite species can occur in mixed populations. Determine species composition before making decisions, as they have different susceptibilities to chemicals.
- Establishment pests have differing susceptibilities to insecticides, synthetic pyrethroids (SPs) and organophosphates (OPs) in particular. Be aware that the use of some pesticides may select for pests that are more tolerant.

Insecticide resistance

- RLEM has been found to have high levels of resistance to synthetic pyrethroids such as bifenthrin and alpha-cypermethrin.
- *Helicoverpa armigera* has historically had high resistance to pyrethroids and the inclusion of nucleopolyhedrosis virus (NPV) is effective where mixed populations of armyworms and Helicoverpa larvae occur in maturing winter cereals. [5]

Bees

As for all chemical use in the paddock, it is recommended that users consider the risks to bees of the chemicals against RWA. Chemical users are encouraged to contact hive owners as soon as possible so the owners can take steps to minimise the risks to their hives. Contact details can generally be found on the hives, or you can contact the land owner on which the hives are located.

Insecticides and beneficial insects

When deciding whether to use chemical control in managing crop pests, ensure to consider the effects of insecticides on beneficial insects (Table 4).

VIDEOS

WATCH: GCTV2: Integrated Pest Management

5 Queensland Government, GRDC (2016) Winter cereals: insect pest risk. In IPM Guidelines, http://ipmguidelinesforgrains.com.au/crops/winter-cereals/

Table 4: *Impact of common insecticides on beneficial insects. Note that the values provided here are generalisations and there may be exceptions (e.g. relating to specific species or time of application). Pest resurgence is included as there may be an increase in non-targeted pests following application of insecticides. This is mainly due to the demise of beneficials that may keep pests in check.*

Insecticide group*	Persistence	Overall ranking	Impact on beneficial insects				
			Predatory beetles	Predatory bugs	Parasitic wasps	Spiders	Bees
FOLIAR-APPLIED							
Bio-pesticides							
Bt	Short	Low	L	L	L	L	L
Helicoverpa NPV	Short	Low	L	L	L	L	L
Metarhizium	Short	Low	L	L	L	L	L
Petroleum spray oils	Short	Low	L	L	L	L	L
Organophosphates							
omethoate	Medium	Moderate	M	M	M	L	H
dimethoate (low rate)	Short	Moderate	M	M	M	L	H
dimethoate (high rate)	Short	High	M	M	H	M	H
methidathion	Short	High	H	H	H	H	H
Indoxacarb	Medium	Low	L	L	L	L	no data
Phenyl pyrazoles (fipronil)	Medium	Low	L	L	L	M	H
Carbamates							
pirimicarb	Short	Low	L	L	L	L	L
thiodicarb	Long	High	H	M	M	M	M
methomyl	Short	High	H	M	M	M	H
Avermectins (emamectin benzoate)	Medium	Moderate	L	H	M	M	H
Synthetic pyrethroids	Long	High	H	H	H	H	H
SEED DRESSINGS							
fipronil	Medium	Low	Limited data available. Seed dresings generally less disruptive than foliar-applied formulations.				
imidacloprid	Medium	Low					
imidacloprid + thiomethoxam	Medium	Low					

Symbols used in the table:

L–Low toxicity	nil or low impact on beneficials
M — Moderate toxicity	activity is significantly reduced but beneficial populations are able to recover in a week or so
H — High toxicity	high proportion of beneficial population killed and re-establishment will not occur for several weeks

Persistence of pest control: Foliar applications: short = <3 days, medium = 3–7 days, long = >10 days Seed treatments: short = 2–3 weeks, medium 3–4 weeks, long = 4–6 weeks *Insecticides and the groups they belong to can be found in the insecticide groups table.

Information in this table has been derived from the Cotton Pest Management Guide (2014–15).

7.2.2 Emerging insect threats in northern crops

Key points:

- Monitor crops frequently so as not to be caught out by new or existing pests.

MORE INFORMATION

Emerging insect threats in northern grain crops

VIDEOS

WATCH: Over the Fence North: Vigilance needed for changing insect patterns

- Look for and report any unusual pests and symptoms of damage—photographs are useful.
- Just because a pest is present in large numbers in one year doesn't mean it will necessarily be so in the next year: it may be the turn of another spasmodic pest, e.g. soybean moth, to make its presence felt.
- However, be aware of cultural practices that favour the harbouring of pests, and rotate cops each year to minimise the build-up of pests and plant diseases.

Recent seasons have seen a plethora of seemingly new pests and unusual damage in pulse and grain crops. The most notable examples are *Etiella behrii* up to 60/m^2 in vegetative and podding soybeans and mungbeans, severe scarab damage in sorghum and winter cereals, bean pod borer west of the Great Dividing Range, the appearance of soybean stem fly in regions adjoining the Darling Downs, well south of its 'normal' range, and plague numbers of a mystery plant hopper in mungbeans, sorghum and millet in the summer of 2014–15. [6]

7.2.3 Insect sampling methods

Monitoring for insects is an essential part of successful integrated pest management programs. Correct identification of immature and adult stages of both pests and beneficials, and accurate assessment of their presence in the field at various crop stages, will ensure appropriate and timely management decisions. Good monitoring procedure involves not just a knowledge of and the ability to identify the insects present, but also good sampling and recording techniques and a healthy dose of common sense.

Factors that contribute to quality monitoring

- Knowledge of likely pests and beneficials and their life cycles is essential when planning your monitoring program. As well as visual identification, you need to know where on the plant to look and the best time of day to get a representative sample.
- Monitoring frequency and pest focus should be directed at the crop at stages when you are likely to incur economic damage. Critical stages may include seedling emergence and flowering and grain formation.
- Sampling technique is important to ensure that a representative portion of the crop has been monitored, since pest activity is often patchy. Having defined sampling parameters (e.g. number of samples per paddock and number of leaves per sample) helps you maintain sampling consistency. The actual sampling technique, including sample size and number, will depend on crop type, age and paddock size, and is often a compromise between the ideal number and location of samples and what is practical regarding time constraints and distance to be covered.
- Balancing random sampling with areas of obvious damage is a matter of common sense. Random sampling aims to give a good overall picture of what is happening in the paddock, but any obvious hotspots should also be investigated. The relative proportion of hotspots in a field must be kept in perspective with less heavily infested areas.

Keeping good records

Accurately recording the results of sampling is critical for good decision making and being able to review the success of control measures (Figure 1). [7] Monitoring record sheets should show the following:

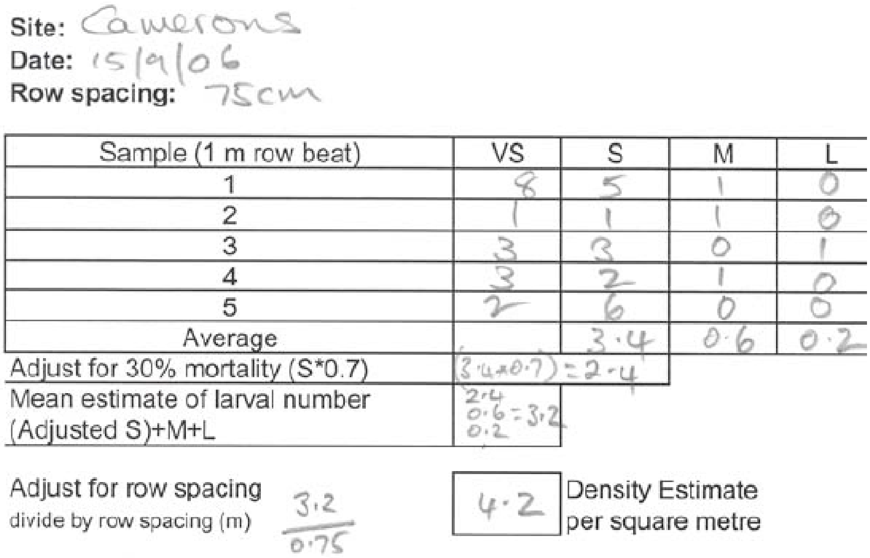
- numbers and types of insects found (including details of adults and immature stages)
- size of insects—this is particularly important for larvae

6 H Brier, M Miles (2015) Emerging insect threats in northern grain crops. GRDC Update Paper. 31 July. GRDC, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/07/Emerging-insect-threats-in-northern-grain-crops

7 DAF Queensland (2012) Insect monitoring techniques for field crops. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/help-pages/insect-monitoring

- date and time
- crop stage and any other relevant information (e.g. row spacing, weather conditions, and general crop observations)

Consider putting the data collected into a visual form that enables you to see trends in pest numbers and plant condition over time. Being able to see whether an insect population is increasing, static or decreasing can be useful in deciding whether an insecticide treatment may be required, and if a treatment has been effective. If you have trouble identifying damage or insects present, keep samples or take photographs for later reference.


Site: Camerons
Date: 15/9/06
Row spacing: 75cm

Sample (1 m row beat)	VS	S	M	L
1	8	5	1	0
2	1	1	1	0
3	3	3	0	1
4	3	2	1	0
5	2	6	0	0
Average		3.4	0.6	0.2
Adjust for 30% mortality (S*0.7)	(3.4*0.7) = 2.4			
Mean estimate of larval number (Adjusted S)+M+L	2.4 0.6 0.2 = 3.2			

Adjust for row spacing divide by row spacing (m): 3.2 / 0.75

4.2 Density Estimate per square metre

Figure 1: *An example of a field check sheet, showing adjustments for field mortality and row spacing.*

Source: DAF Qld

Records of spray operations should include:

- date and time of day
- conditions (wind speed, wind direction, temperature, presence of dew and humidity)
- product(s) used (including any additives)
- amount of product and volume applied per hectare
- method of application including nozzle types and spray pressure
- any other relevant details

Sampling methods

Beat sheet

A beat sheet is the main tool used to sample row crops for pests and beneficial insects (Photo 1). It is particularly effective for sampling caterpillars, bugs, aphids and mites. A standard beat sheet is made from yellow or white tarpaulin material with a heavy dowel on each end. Beat sheets are generally between 1.3–1.5 m wide by 1.5–2.0 m deep, with the larger dimensions being preferred for taller crops. The extra width on each side catches insects thrown out sideways when sampling and the sheet's depth allows it to be draped over the adjacent plant row. This prevents insects being flung through or escaping through this row.

To use the beat sheet:

- Place the sheet with one edge at the base of plants in the row to be sampled.

- Drape the other end over the adjacent row. This may be difficult in crops with wide row spacing (one metre or more) and in this case spread the sheet across the inter-row space and up against the base of the next row.
- Using a one metre stick, shake the plants in the sample row vigorously in the direction of the beat sheet 5–10 times to will dislodge insects from the sample row onto the sheet.
- Reducing the number of beat sheet shakes per site greatly reduces sampling precision. The use of smaller beat sheets, such as small fertiliser bags, reduces sampling efficiency by as much as 50%.
- Use data sheets to record type, number and size of insects found on the beat sheet.
- One beat does not equal one sample. The standard sample unit is five non-consecutive one-metre long lengths of row, taken within a 20m radius; i.e. 5 beats = 1 sample unit. This should be repeated at six locations in the paddock (i.e. 30 beats per paddock).
- The more samples that are taken, the more accurate is the assessment of pest activity, particularly for pests that are patchily distributed such as pod-sucking bug nymphs.

When to use the beat sheet:

- Crops should be checked weekly during the vegetative stage, and twice weekly from the start of budding.
- Caterpillar pests are not mobile within the canopy, and checking at any time of the day should result in reporting similar numbers.
- Pod-sucking bugs, particularly green vegetable bugs, often bask on the top of the canopy during the early morning and are more easily seen at this time.
- Some pod-sucking bugs, such as brown bean bugs, are more flighty in the middle of the day and therefore more difficult to detect when beat-sheet sampling. Other insects (e.g. mirid adults) are flighty no matter what time of day they are sampled, so it is important to count them first.
- In very windy weather, bean bugs, mirids and other small insects are likely to be blown off the beat sheet.
- Using the beat sheet to determine insect numbers is difficult when the field and plants are wet.

While the recommended method for sampling most insects is the beat sheet, visual checking in buds and terminal structures may also be needed to supplement beat sheet counts of larvae and other more minor pests. Visual sampling will also assist in finding eggs of pests and beneficial insects.

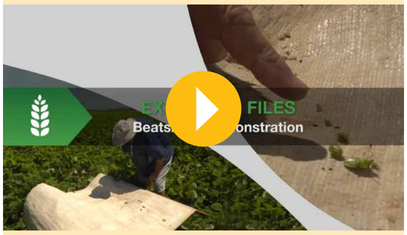
Most thresholds are expressed as pests per square metre (pests/m^2). Hence, insect counts in crops with row spacing less than one metre must be converted to pests/m^2. To do this, divide the average insect count per row metre across all sites by the row spacing (in metres). For example, in a crop with 0.75 m row spacing, divide the average pest counts by 0.75.

Other sampling methods

- **Visual checking** is not recommended as the sole form of insect checking, although it has an important support role. Leaflets or flowers should be separated when looking for eggs or small larvae, and leaves checked for the presence of aphids and silverleaf whitefly. If required, dig below the soil surface to assess soil-insect activity. Visual checking is also important for estimating how the crop is going in terms of average growth stage, pod retention and other agronomic factors.
- **Sweep-net sampling** is less efficient than beat-sheet sampling and can underestimate the abundance of pest insects in the crop. Sweep netting can be used for flighty insects and is the easiest method for sampling mirids in broadacre crops or crops with narrow row spacing (Photo 1). It is also useful if the paddock is wet. Sweep netting works best for smaller pests found in the tops

VIDEOS

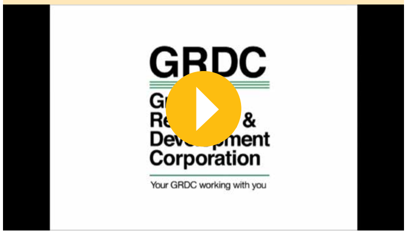
WATCH: GCTV16: Extension files—IPM beatsheet demo



WATCH: How to use a sweep net to sample for insect pests

WATCH: GCTV11: GRDC's Insect ID app

WATCH: Biopesticides emerge as an alternative cropping tool



of smaller crops (e.g. mirids in mungbeans), is less efficient against larger pests such as pod-sucking bugs, and it is not at all useful in tall crops with a dense canopy such as coastal or irrigated soybeans. At least 20 sweeps must be taken along a single 20 m row.

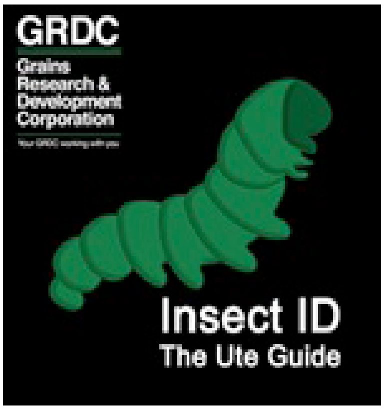
- **Suction sampling** is a quick and relatively easy way to sample for mirids. Its main drawbacks are unacceptably low sampling efficiency, a propensity to suck up flowers and bees, noisy operation, and high purchase cost of the suction machine.
- **Monitoring with traps** (pheromone, volatile, and light traps) can provide general evidence of pest activity and the timing of peak egg laying for some species. However, it is no substitute for in-field monitoring of actual numbers of pests and beneficials. [8]

Photo 1: *Sweep netting for insects (left) and use of a beat sheet (right).*

Sources: DAFWA and The Beatsheet

Identifying insects

For pest identification see the Queensland Department of Agriculture and Fisheries' A–Z pest list or consult the GRDC's app or online resource, Insect ID: The Ute Guide.



The ute guide is a comprehensive reference for insect pests that commonly affect broadacre crops across Australia, and includes the beneficial insects that may help to control them. Photos have been provided for multiple life-cycle stages, and each insect is described in detail, with information on the crops they attack, how they can be monitored, and other pests that they may be confused with. Use of this app should result in better management of pests, increased farm profitability and improved chemical usage. [9]

The app features:

- Region selection.
- Predictive search by common and scientific names.

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8 DAF Queensland (2012) Insect monitoring techniques for field crops. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/help-pages/insect-monitoring

9 GRDC. Apps, https://grdc.com.au/Resources/Apps

MORE INFORMATION

IPM Guidelines, Resources

IPM Guidelines, Monitoring tools and techniques

- Ability to compare photos of insects side by side with insects in the app
- Identification of beneficial predators and parasites of insect pests.
- An option to download content updates inside the app to ensure you're aware of the latest pests affecting crops for each region.
- Ensure awareness of international biosecurity pests.

Insect ID is available on Android and iPhone.

7.3 Russian wheat aphid

Key points:

- Triticale and rye are thought to be moderately resistant–resistant to Russian wheat aphid (RWA).
- Russian wheat aphid is a major pest of cereal crops that is found in all major cereal production regions around the world, but only recently in Australia.
- While it is feeding, the aphid injects toxins into the plant and these retards growth. Heavy infestations can kill the plant.
- Affected plants will show whitish, yellow and red–purple leaf markings and rolled leaves.
- Russian wheat aphid is approximately 2 mm long, and pale yellowish-green with a fine waxy coating. The body is elongated compared with other cereal aphid species (Photo 2). [10]

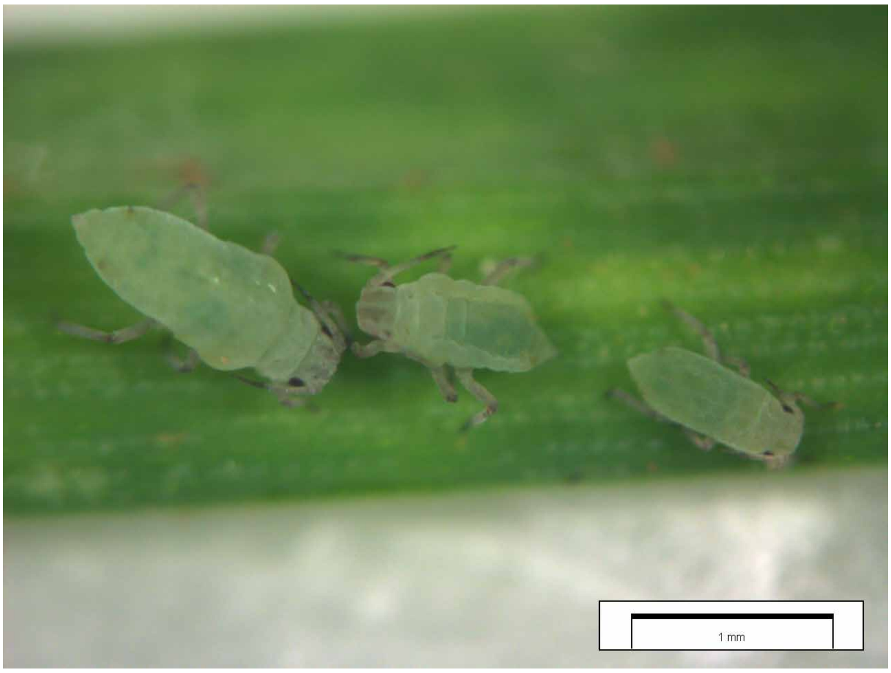

Photo 2: *The Russian wheat aphid (Diuraphis noxia).*

Photo: M. Nash

RWA is a major pest of cereal crops worldwide. It is easily spread by the wind and on live plant material.

It was not present in Australia until 2016. It was first identified in a wheat crop at Tarlee in South Australia on 13 May 2016, and has since been seen in many cropping areas in South Australia. At this time, the RWA National Management Group said that it was not technically feasible to eradicate it. The NSW Department of Primary Industries confirmed the first NSW detection of Russian wheat aphids *(Diuraphis*

10 A Lawson (2016) Paddock practices, Southern, June 2016: Monitor RWA numbers closely over winter. GRDC, https://portal.biosecurityportal.org.au/rwa/Documents/Paddock%20Practices%20Southern%20June%202016.pdf

noxia) in a wheat crop in the State's south. Scientists at NSW DPI Biosecurity Collections Unit confirmed the sample from the Barham area in the Murray region contained Russian wheat aphid. [11] Though Queensland is yet to report a case of RWA, Biosecurity Queensland has urged landholders to continue maintaining good biosecurity practices on their properties to prevent the introduction of the aphid to Queensland farms. [12]

Early research on triticale, rye and wheat resistance to RWA suggests that triticale and rye are moderately resistant–resistant to RWA. In this study, the highest level of resistance was found in three triticale cultivars that originated in Russia, the source of the RWA. [13] In descending order, RWA tends to prefer barley, durum wheat, bread wheat, triticale, cereal rye, then oats.

Grain growers and advisers are urged to monitor cereal paddocks closely for signs of damage caused by this aphid. Following national management group declaration, experts called on growers and advisers to find, identify, consider aphid numbers and economic thresholds and enact a management (FITE) strategy if needed. [14]

RWA is asexual, meaning it does not need males and females in order to breed. The aphid takes about three weeks in winter and 10–14 days in mid-spring to reach maturity. The female then produces about two nymphs a day for 2–4 weeks, totalling 30–60 nymphs. This means it has a great capacity to increase numbers rapidly.

Further research is required to determine the impact of local environment factors on RWA population dynamics. [15] Grain growers are encouraged to contact their agronomist or seek advice from NSW DPI or NSW Local Land Services, or refer to the GRDC website for information on how to manage the pest in cereal crops.

There are tools available to help manage the aphid, including an APVMA emergency use permit (PDF, 114.6 KB) for specific chemicals. Grain growers planning to spray are encouraged to adhere to all general chemical use practices. To limit the spread of the pests and diseases hygiene is important. It is important to put best practice biosecurity measures into place to reduce the risk of transport on clothing, footwear, vehicles and machinery when moving between paddocks and farm. [16]

The advice to growers and agronomists is to continue to monitor crops for aphids and symptoms, and if you suspect the presence of the Russian wheat aphid, take a sample for identification.

7.3.1 Damage caused by RWA

RWA differs from other common cereal aphid species in that it injects salivary toxins into the leaf of the host plant during feeding. The toxins kills the photosynthetic chloroplasts and causes chlorosis and necrosis of the infested leaves. This retards growth and, in cases of heavy infestation, kills the plant. The effect of the toxins is localised and hence only infested leaves will show symptoms. Once the RWA infestation has been controlled, the new leaf growth is unaffected. [17]

Yield losses are proportionate to RWA abundance, measured as either the percentage of plants infested or aphid numbers per shoot. According to overseas data, losses of one tonne per hectare occurred in plants 95% infested with RWA at

11 DPI NSW (2016) First case of Russian wheat aphid confirmed in NSW. http://www.dpi.nsw.gov.au/about-us/media-centre/releases/2016/first-case-of-russian-wheat-aphid-confirmed-in-nsw

12 DAFF. (2016). Industry alert: Russian wheat aphid found in South Australia. https://www.daf.qld.gov.au/plants/health-pests-diseases/industry-alert-russian-wheat-aphid-found-in-south-australia

13 KK Nkongolo, JS Quick, WL Meyer, FB Peairs (1989) Russian wheat aphid resistance of wheat, rye, and triticale in greenhouse tests. Cereal Research Communications, 227–232.

14 S Watt (2016) Gloves are up in sustained FITE against Russian wheat aphid. GRDC, https://grdc.com.au/Media-Centre/Media-News/South/2016/06/Gloves-are-up-in-sustained-FITE-against-Russian-wheat-aphid

15 Farming Ahead (2016) Monitor RWA numbers closely over winter. 29 June 2016. Farming Ahead, http://www.farmingahead.com.au/articles/1/12169/2016–06–29/cropping/monitor-rwa-numbers-closely-over-winter

16 DPI NSW (2016) First case of Russian wheat aphid confirmed in NSW. DPI NSW, http://www.dpi.nsw.gov.au/about-us/media-centre/releases/2016/first-case-of-russian-wheat-aphid-confirmed-in-nsw

17 Farming Ahead (2016) Monitor RWA numbers closely over winter. 29 June. Farming Ahead, http://www.farmingahead.com.au/articles/1/12169/2016–06–29/cropping/monitor-rwa-numbers-closely-over-winter

growth stage (GS) 59. In another overseas study, losses increased from 18% with 15–20 aphids per shoot to 79% with 185–205 aphids per shoot. [18]

7.3.2 Where to look and what to look for

According to entomologists at the South Australian Research and Development Institute (SARDI), RWA is being regularly found in early sown crops or those sown into paddocks containing volunteer cereals. There are also a number of grass weed and pasture hosts of RWA, including barley grass, brome grass (which it particularly likes, based on overseas information), fescue, ryegrass, wild oats, phalaris and couch grass.

Symptoms of RWA damage include longitudinal rolling of leaves where the aphids shelter, and whitish, yellowish to pink–purple chlorotic streaks along the length of the leaves. These symptoms can easily be confused with nutrient deficiency or herbicide damage from bleaching herbicides such as diflufenican, so care is needed in identifying the cause.

RWA is approximately 2 mm long, and a pale yellowish-green colour with a fine, waxy coating. The lack of visible cornicles and the elongated body distinguishes RWA from common cereal aphid species.

RWA can be confused with the rose grain aphid; however, RWA differs due to its dark or black eyes, double short 'tails' (caudal processes), short antennae and apparent lack of cornicles (Figure 2).

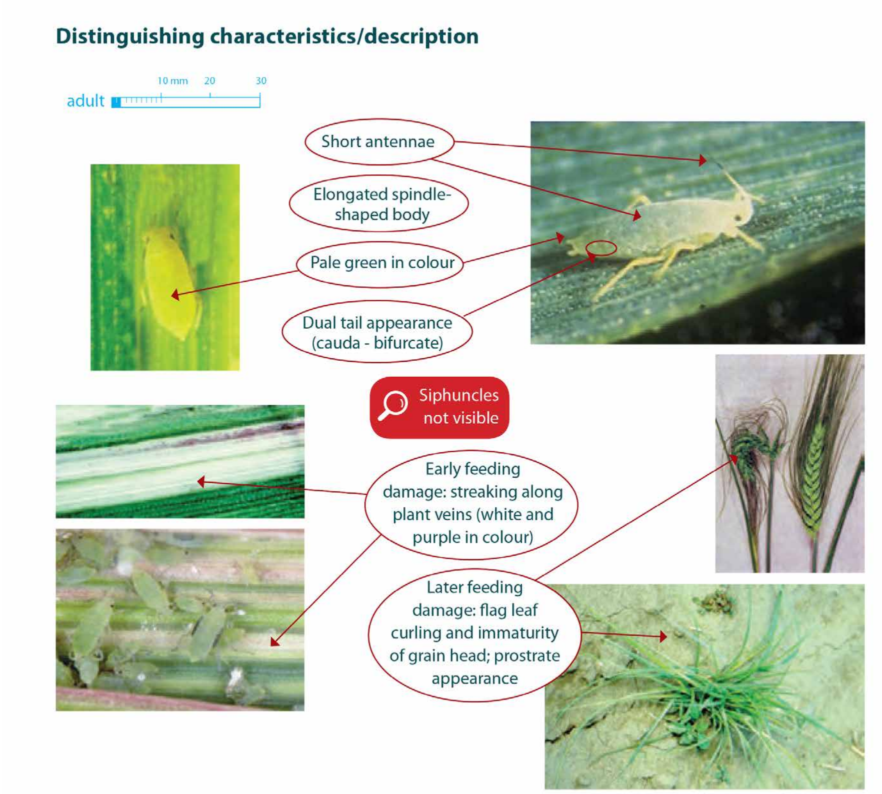

Figure 2: *Distinguishing characteristics of the Russian wheat aphid.*

Source: GRDC

Growers are encouraged to work with their agronomist or seek expert advice from an entomologist to help positively identify RWA if they are unsure. State agriculture departments are keen to take samples of RWA in order to build up scientific information about the pest, including by sampling different populations.

18 A Lawson (2016) Paddock practices, Southern, June 2016: Monitor RWA numbers closely over winter. GRDC, https://portal.biosecurityportal.org.au/rwa/Documents/Paddock%20Practices%20Southern%20June%202016.pdf

Measures to increase the likelihood of detecting RWA

- Target early sown cereal crops and volunteer cereals (and brome grass, if present), particularly along crop edges.
- Follow a repeatable sampling pattern which targets early sown and volunteer plants. A perimeter search and a W-shaped search pattern through each paddock will give a consistent sampling effort.
- Symptoms to look for:
- Rolling of terminal and sub-terminal leaves (GS 20 and above).
- Longitudinal whitish to pink–purplish streaking of leaves (GS 20 and above, Photo 3).
- Deformed ‘fish hook’ head as result of awn being trapped by unrolled flag leaves (GS 50 and above, Photo 4).

Photo 3: *Plants damaged by toxins from feeding Russian wheat aphid (Diuraphis noxia), showing stunting and longitudinal striping on tightly rolled leaves.*

Source: FAO

Photo 4: *'Fish hook' deformation of a cereal head (right) caused by feeding Russian wheat aphid, compared to normal cereal head (left).*

Source: FAO

- To find the RWA, search within:
- rolled leaves, particularly in the leaf base (Photo 5)
- leaf sheaths
- exposed parts of the plant at base of plants (when number of RWA are high)
- At low densities plant beating has proven to be a successful means of detection. [19]

Photo 5: *Colony of Russian wheat aphids.*

Photo: F. Peairs

MORE INFORMATION

Russian wheat aphid: Taking and submitting samples for identification

19 PIRSA (2016) Russian wheat aphid. PIRSA, http://www.pir.sa.gov.au/biosecurity/plant_health/exotic_plant_pest_emergency_response/russian_wheat_aphid

7.3.3 Thresholds for control

While registered chemical control tactics will be important in managing infestations of RWA, growers are encouraged to consider international economic thresholds (below) as a guide for when to spray for the pest, as economic thresholds still need to be determined under Australian conditions. In the meantime, the key message is not to implement prophylactic insecticide applications, and to avoid spraying where RWA is only present in very low numbers.

Current international advice suggests an economic threshold of 20% of plants infested up to the start of tillering and 10% of plants infested thereafter. These thresholds serve as a guide, and need to be considered based on the individual situation. The decision to spray should be based upon a wide range of factors including:

- aphid numbers
- growth stage of crop and time of season
- crop yield potential
- cost of the control option to be employed
- presence of populations of beneficial insects
- yield loss likely in Australian conditions
- forecast weather conditions
- other insect pest species present

In the majority of cases identified to date, RWA has been present in very low numbers and infestations have been well below international economic thresholds. Regular monitoring of aphid numbers through winter and spring will be required to ensure appropriate control measures can be implemented when required. Overseas data indicate that RWA is susceptible to heavy winter rainfall, and the combination of cold and wet weather will help check its build-up during mid-winter.

To ensure protection of the major yield-contributing leaves it is most important to control RWA to below threshold levels from the start of stem elongation, through flag leaf development and ear emergence (GS 30–60). As a result, vigilant monitoring for RWA is encouraged during these crop stages, and should continue through flowering to dough development. [20]

7.3.4 Management of RWA

Control options

An emergency Australian Pesticides and Veterinary Medicines Authority permit (PER82792) has been issued for the use of products containing 500 g/L chlorpyrifos (rate: 1.2 L/ha), with a LI700 surfactant (rate: 240 mL/ha), and products containing 500 g/kg pirimicarb (rate: 200–250 g/ha) to control RWA in winter cereals.

APVMA has also issued a permit (PER82304) for the use of products containing 600 g/L imidacloprid as their only active constituent. The application rate is 120 mL product per 100 kg seed. This is for seed treatment only for the control of Russian wheat aphid in winter cereals.

All sections of the chemical labels and permits must be read and understood by all persons before use, and used in accordance with instructions given:

- Permit 82792 PDF
- Permit 82792 Word
- Permit 82304 PDF
- Permit 82304 Word

VIDEOS

WATCH: GCTV20: Russian wheat aphid—recommendations for ongoing treatment

WATCH: Integrated pest management to combat the Russian wheat aphid

20 A Lawson (2016) Paddock practices, Southern, June 2016: Monitor RWA numbers closely over winter. GRDC, https://portal.biosecurityportal.org.au/rwa/Documents/Paddock%20Practices%20Southern%20June%202016.pdf

MORE INFORMATION

Russian wheat aphid a new pest for Australian cereal crops

Ramp up monitoring for Russian wheat aphid

Monitor RWA numbers closely over winter

Plant Heath Australia, Russian wheat aphid

Russian wheat aphid surveillance reporting sheet

NSW DPI, Russian wheat aphid exotic pest alert

Russian wheat aphid: paddock decontamination protocol

Russian Wheat Aphid Technical Group, RWA distribution map

A pictorial guide to distinguish winged aphids

There are numerous statements (e.g. 'do not' statements) on the product labels that it is critical to follow so as to properly manage the risks associated with the use of chemicals. Examples of such statements include:

- Do not spray any plants in flower while bees are foraging.
- Do not re-apply to the same crop within seven days (unless specifically recommended in the directions for use).
- Do not apply if heavy rains or storms that are likely to cause surface run-off are forecast in the immediate area within two days of application.
- Do not allow animals, including poultry, access to treated area within three days of application.

General instructions

- Read and follow the APVMA permit and labels of associated chemical products.
- Ensure all 'do not' statements and relevant withholding periods, export slaughter intervals (ESIs) and export grazing intervals (EGIs) are observed.
- Adopt best-practice farm-hygiene procedures to retard the spread of the pest between paddocks and adjacent properties.
- Keep traffic out of affected areas, and minimise movement in adjacent areas. [21]

7.4 Other aphids

Aphids are usually regarded as a minor pest of winter cereals, but in some seasons they can build up to very high densities. Aphids are most prevalent on cereals in late winter and early spring. High numbers often occur in years when there is an early break in the season and mild weather in autumn and early winter provide favourable conditions for colonisation and multiplication.

Four species of aphid infest winter cereals:

1. oat or wheat aphid
2. corn aphid
3. rose-grain aphid
4. rice root aphid

Aphids are a group of soft-bodied bugs commonly found in a wide range of crops and pastures. Identification of crop aphids is very important when making control decisions. Distinguishing between aphids can be easy in the non-winged form but challenging with winged aphids.

7.4.1 Oat or wheat aphid

The oat aphid (*Rhopalosiphum padi*) is an introduced species. It is a relatively common pest that is found in all states of Australia and is most prevalent in wheat and oats. Oat aphids typically colonise the lower portion of plants, with infestations extending from around the plant's base, up on to the leaves and stems.

This aphid has an olive green to greenish-black body with a characteristic rust-red patch on the end of the abdomen, although sometimes this is not apparent. Adults are approximately 2 mm long, pear-shaped, and have antennae that extend half the body length (Figure 3). [22] Adults may be winged or wingless and tend to develop wings when plants become overcrowded or unsuitable. [23]

Oat aphids are an important vector of Barley yellow dwarf virus (BYDV). They can affect cereals by spreading BYDV as well as by direct-feeding damage to plants when in sufficient numbers. Triticale is not as susceptible to BYDV as other cereals.

21 Agriculture Victoria (2016) Russian wheat aphid treatment advice. Agriculture Victoria, agriculture.vic.gov.au/__data/assets/word_doc/0017/321164/Final-RWA-Treatment-Factsheet.docx-.docx

22 P Umina, S Hangartner (2015) Oat aphid. cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Oat-aphid

23 P Umina, S Hangartner (2015) Oat aphid. cesar http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Oat-aphid

When populations exceed thresholds, the use of targeted spraying with selective insecticides is recommended.

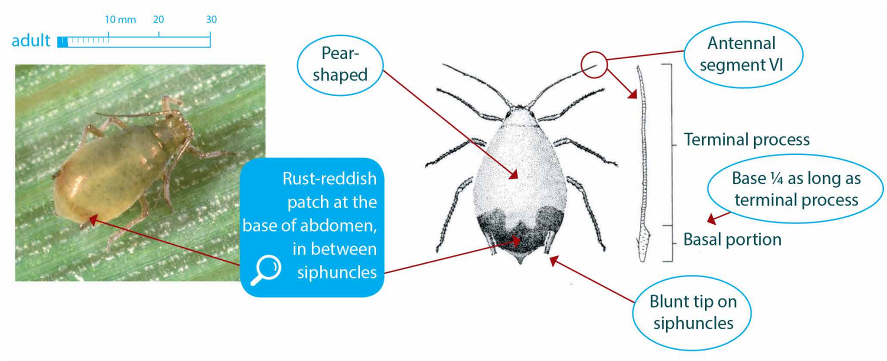

Figure 3: *Distinguishing characteristics of the oat or wheat aphid.*

Source: cesar

7.4.2 Corn aphid

The corn aphid (*Rhopalosiphum maidis*) is introduced, and is a relatively minor pest of cereal crops. It attacks all crop stages, but most damage occurs when high populations infest cereal heads. The corn aphid is most prevalent in years when there is an early break to the season followed by mild weather conditions in autumn. It transmits a number of plant viruses, which can cause significant yield losses.

Corn aphids are light green to dark green, with two darker patches at the base of each cornicle (siphuncle). Adults grow up to 2 mm long, have an oblong-shaped body, and antennae that extend to about a third of the body length (Figure 4). The legs and antennae are typically darker in colour.

Nymphs are similar to adults but smaller in size and always wingless, whereas adults may be winged or wingless. [24]

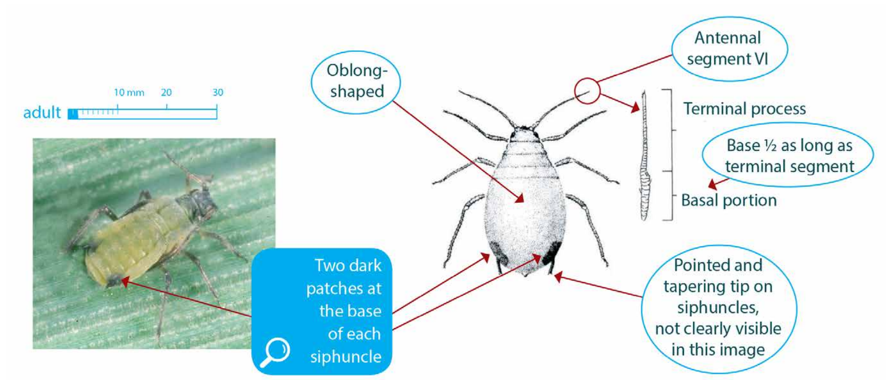

Figure 4: *Distinguishing characteristics of the corn aphid.*

Source: cesar

7.4.3 Rose-grain aphid

The rose-grain aphid (*Metopolophium dirhodum*) is an introduced species that has been recorded in New South Wales, Queensland, South Australia, Victoria and Tasmania.

Adults and nymphs are sap-suckers. Under heavy infestations, plant may turn yellow and appear not to thrive. They can spread Barley yellow dwarf virus in wheat and barley.

24 P Umina, S Hangartner (2015) Corn aphid. cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Corn-aphid

Adults are 3 mm long, green to yellow-green, with long and pale siphunculi (tube-like projections on either side at the rear of the body). They may have wings (Photo 6). [25] There is a dark green stripe down the middle of the back. Antennae reach beyond the base of the siphunculi. Nymphs are similar, but smaller in size. Because of its distinctive colour, it is unlikely to be confused with other aphids.

Photo 6: *Adult rose-grain aphid with nymphs.*

Source: DAF Qld

7.4.4 Rice root aphid

The rice root aphid (*Rhopalosiphum rufiabdominalis)* colonises the roots of the plants under the soil surface, although colonies may extend up to the base of the plant. They are most noticeable when the bases of plants are exposed, often during periods of moisture stress. [26]

Fully grown aphids are 1.2–2.2 mm long, and dark green to grey-brown (Photo 7). Nymphs are lighter in colour, with a reddish area at the tip of the abdomen. Rice root aphids suck fluids from the plant roots, but only do so when the bases of plants are exposed.

They cannot be controlled using contact insecticides because they are below the ground. Seed dressings may be effective. [27]

25 DAF Queensland (2011) Rose-grain aphid. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/a-z-insect-pest-list/aphid-overview/rose-grain-aphid

26 DAF Queensland (2010) Rice root aphid. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/a-z-insect-pest-list/aphid-overview/rice-root-aphid

27 DAF Queensland (2010) Rice root aphid. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/a-z-insect-pest-list/aphid-overview/rice-root-aphid

Photo 7: *Adult rice root aphid.*

Source: University of California

7.4.5 Damage caused by aphids

Aphids can impair crop growth in the early stages, and prolonged infestations can reduce tillering and result in earlier leaf senescence. Infestations during booting to the milky dough stage, particularly where aphids are colonising the flag leaf, stem and ear, will result in yield loss, and aphid infestations during grainfill may result in low protein grain (Photo 8). [28]

Photo 8: *Corn aphids are found in furled leaves and tillers any time from seedling to head emergence.*

Source: cesar

As aphids may compete for nitrogen (N) with the crop, crops grown with marginal levels of N may be more susceptible to the impact of an aphid infestation. In barley, aphids can spread BYDV. Significant yield losses occur when aphids transmit the virus in the first 8–10 weeks after emergence. While the virus can have a large effect

28 P Umina, S Hangartner (2015) Corn aphid. cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Corn-aphid

on barley yield in some areas, it is not considered a major problem in Queensland in most seasons. In virus-prone areas, use resistant plant varieties to minimise losses due to BYDV.

Adults and nymphs suck sap and produce honeydew. Very high numbers may cause stress in the plants, which will show up as yellowing or wilting in extreme infestations. The symptoms are more common in moisture-stressed crops.

Direct-feeding damage may occur when colonies develop on stems, heads or leaves. Aphids can affect root development, the number of tillers, seed set and grain size.

Aphid infestations may initially be detected on crop edges. Winged aphids will disperse throughout the field and colonise, creating hotspots across the field. As populations grow, infestations will become more uniform across the field. [29]

Inspect for aphids throughout the growing season by monitoring leaves, stems and heads as well as exposed roots. Choose six widely-spaced positions in the crop and at each position examine five consecutive plants. Research is under way into damage thresholds and control options for aphids that affect cereals. Some research indicates that aphid infestations can reduce yield by around 10% on average.

7.4.6 Conditions favouring aphid development

Aphids can be found all year round, often persisting on a range of volunteer grasses and self-sown cereals during summer and early autumn. Winged aphids fly into crops from grass weeds, pasture grasses or other cereal crops, and colonies of aphids start to build up within the crop.

Aphids are most prevalent on cereals in late winter and early spring. High numbers often occur in years when there is an early break in the season and mild weather in autumn and early winter provide favourable conditions for colonisation and multiplication.

The different species prefer different parts of the plant:

- Oat aphid—basal leaves, stems and back of ears of wheat, barley and oats.
- Corn aphid—inside the leaf whorl of the plant, where cast skins indicate their presence, but seldom on cereals.
- Grain aphid—the younger leaves and ears of wheat, oats and barley.
- Rose grain aphid—the underside of lower leaves and moves upwards as these leaves die. [30]

Aphids can reproduce both asexually and sexually, although in Australia the sexual phase is often lost and most aphids reproduce asexually, whereby females give birth to live young.

In the Northern Region, temperatures during autumn and spring are optimal for aphid survival and reproduction. During these times, several generations of aphids may breed. Populations peak in late winter and early spring; development rates are particularly favoured when daily maximum temperatures reach 20–25°C.

Young, wingless aphid nymphs develop through several growth stages, moulting at each stage into a larger individual.

Plants can become sticky with honeydew excreted by the aphids. When plants become unsuitable or overcrowding occurs, the population produces winged aphids (alates), which can migrate to other plants or crops.

29 IPM Guidelines (2016) Aphids in winter cereals. Queensland Government and GRDC, http://ipmguidelinesforgrains.com.au/pests/aphids/aphids-in-winter-cereals/

30 IPM Guidelines (2016) Aphids in winter cereals. Queensland Government and GRDC, http://ipmguidelinesforgrains.com.au/pests/aphids/aphids-in-winter-cereals/

7.4.7 Thresholds for control

Key points:

- Control may be warranted if populations reach 10–15 aphids per tiller. Though these thresholds have been designed for wheat, they can also be relevant to triticale.

When determining economic thresholds for aphids, it is critical to consider several other factors before making a decision. Most importantly, the current growing conditions and moisture availability should be assessed. Crops that are not moisture stressed have a greater ability to compensate for aphid damage and will generally be able to tolerate far higher infestations than moisture-stressed plants before a yield loss occurs.

Thresholds for managing aphids to prevent the incursion of aphid-vectored virus have not been established and will be much lower than any threshold to prevent yield loss via direct feeding. [31]

Aphid populations can decline rapidly, which may make control unnecessary. In many years aphid populations will not reach threshold levels.

Management decisions need to be based on a number of key criteria as well as some more obscure ones that are still valid parts of the system and therefore the decision framework. The obvious criteria are disease spread (barley yellow dwarf virus), aphid numbers per plant or per tiller on average across the field and their likely build up, predator and parasite numbers and their likely build up, cost of control including application costs, effectiveness of control choice, soil moisture and nutrient status, potential yield reduction caused, and expected value of the commodity at time of sale. Less obvious things to consider include: a crop with low vigour will not be as good a weed competitor, nor will it recover as well from being checked by an herbicide application or frost. Secondary root development (critical to subsoil moisture use and plant stability) appears to be affected by oat aphid. Stubble cover following the crop will be reduced in areas of heavy pressure. Management of operations on the farm must also be considered. Crop uniformity and timing to harvest can be affected.

A guide to thresholds being evaluated by the NGA in conjunction with the Qld DPI indicates that a level of 10–15 aphids per tiller–and increasing–appears a realistic trigger population for control. Early in the crop, during the establishment phase, sample the crown and sub crown roots for oat aphid, particularly in years with a dry start. This threshold number will be lower if application costs are reduced by piggy backing on another in-crop spray. If a spray is timed too early or does not clean up the population sufficiently their numbers may flare again later in the crop. [32]

7.4.8 Managing aphids

Controlling aphids during early crop development generally results in the roots and shoots recovering to the normal rate of development, but there can be a delay. Aphids are more readily controlled in seedlings and pre-tiller crops, which are less bulky than post-tiller crops. Corn aphids in the terminal leaf tend to disappear as crops come into head, and other species generally also decline in abundance about this time as natural enemy populations build up. A locally wet summer and autumn is generally a precursor to an aphid outbreak, as there are abundant alternative hosts to breed up on.

Chemical control

Seed treatments and foliar sprays can be used to control aphid infestations. Seed treatments frequently give 70–100 days suppression of aphid numbers. In heavy aphid years, particularly if the infestation occurs early in the crop, there is a clear

31 P Umina, S Hangartner (2015) Oat aphid. cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Oat-aphid

32 T Lockrey (2010) Aphids in wheat and barley–they are already there! Northern Growers Alliance. http://www.nga.org.au/results-and-publications/download/40/australian-grain-articles/pests-1/aphids-in-cereals-july-2010.pdf

advantage using an aphicide seed treatment against not treating at all. In recent NGA trials an economic advantage of $25-$50 per hectare was realised from seed treatment in a year with high pressure. However, if aphid pressure was very low there would be an economic disadvantage to treating seed. If aphids came late and in high numbers a foliar spray may still be required to top up control. It appears now that with a couple of seed treatment registrations to choose from, lower per hectare cost and more regular aphid pressure, the seed treatments are coming back into contention. They are soft on beneficial arthropods because they are only picked up by sap feeders. Seed treatments may also be effective in minimising the spread of Barley yellow dwarf virus.

Some useful foliar spray options also exist for in-crop control. Products include conventional chemistry with some systemic activity as well as pirimicarb that has some fumigant activity (if it is warm enough) and is softer on beneficials. Cost of products are approx $5-$8/ha plus application with returns similar to the seed treatments of a $25-$50 per hectare in recent trials under moderate to heavy aphid pressure. The advantage of a foliar spray is that money is not spent until there is a clear advantage in doing so. Careful monitoring is required to ensure timing is correct. The correct product and rate along with adequate coverage are the keys to getting good control.

Early control of infestations around the edge of the crop by using a border spray may delay or prevent more widespread infestation of the crop.

If rain is forecast, delay any planned chemical control, and check the crop again after rain before deciding on the control method, as intense rainfalls can reduce aphid infestations by dislodging aphids from the plants.

Foliar insecticides registered for aphid control are generally broad-spectrum, meaning that, as well as killing aphids, they also kill aphids' natural enemies, beneficial insects such as ladybird beetles and larvae, hover fly larvae, lacewing larvae or parasitic wasps. Broad-spectrum insecticides also increase the likelihood of aphid infestations later in the season. Refer to the beneficial impact table (Table 4, Section 7.2 Integrated weed management) from the IPM Guidelines website to identify products least likely to harm beneficials that aren't being targeted.

For up to date information for chemical registrations, see the APVMA website.

MORE INFORMATION

Aphid management in winter cereals–necessary or just an added cost?

IN FOCUS

Aphids in cereals–Northern region

Key point:

- Parasites and predators will control aphid populations but speed of control can be a problem
- Oat aphids appear to affect yield by reducing the number of viable tillers.
- Seed treatments give economic control. Average net benefit was up to $36/ha.
- Foliar sprays effective if timing is right.

The Northern Growers Alliance conducted two intensive 'in-house' trials at Moree and Edgeroi evaluating a range of management options on Grout and Fitzroy barley. In addition, eight trials were conducted in collaboration with I&I NSW and DEEDI at Dalby, Lundavra, Yallaroi, Bullarah, Cryon, Tamworth, Spring Ridge and Gilgandra. These trials compared the impact of aphids on a barley, bread wheat and durum under the same conditions. The imidacloprid seed treatment did not give season long control in 2008. In 2009, a higher rate of imidacloprid was included in all trials. All treatments had the equivalent loading of fungicide seed treatment

MORE INFORMATION

Aphids in cereals

(triadimenol (Baytan®) in barley and tebuconazole (Raxil®) in wheat and durum).

Key treatments in all 2009 trials were:

- Imidacloprid at 'low' label rate (Imid 1x) - Zorro® on barley, Hombre® on wheat and durum, both at 400 mL/100 kg seed
- Imidacloprid at 'high' label rate (Imid 2x) - Emerge® at 240 mL/ 100 kg seed on all crops
- Foliar applications of pirimicarb (Pirimor®) when the aphid population was at 10/tiller and rising

Crops were monitored for aphid populations, and the resulting expenses and yield was accounted for.

The results suggest that insecticidal seed treatments will give an economic benefit on all three cereal types. The seed treatments returned a net benefit, even at sites where the aphid pressure was low (average net benefit $14/ha). Where aphid pressure was higher a net $ benefit was achieved in 75% of cases, with an average return of $41/ha. These results show that foliar sprays for aphid control can give an economic benefit. If the sprays can be combined with other paddock operations or cheaper products used these benefits could be higher. In these trials a threshold of 10 aphids per tiller was used assuming the aphids were above ground and that the population was increasing. [33]

Biological control

In most seasons, aphids build up in winter cereal crops and then decline rapidly without any intervention. The activity of natural enemies–predators, parasitoids and occasionally disease–are responsible for this population decline.

Preserving natural enemies is important in managing aphid populations in the long term, as the beneficials can effectively control small to moderate aphid infestations. However, as they may not arrive early enough to prevent the build-up of aphids to above threshold, they are generally considered to be most useful in controlling individuals and small colonies that may survive an insecticide application, preventing the need for subsequent treatments. [34]. For this reason, the use of soft options (e.g. pirimicarb) for aphid control should be considered, particularly if the aphid infestation is being treated in the early stages of crop development (prior to grainfill) when there is the potential for aphid infestations to resurge. Beneficials may also control large aphid populations, but often not until the crop is maturing, which may be too late to prevent an impact on yield.

The presence of bloated aphids with pale gold or bronze sheen (mummies) indicates parasitoid activity in the crop.

Aphid fungal diseases can cause a rapid reduction in aphid population in wetter seasons. Fungal infection is detected by the presence of white, fluffy growth on aphids, particularly on the lower leaves and stems.

Cultural control

Control weeds and volunteers to minimise early infestation of crops. Aphids and BYDV survive over summer on self-sown cereal and perennial grasses.

33 L Price (2009) Aphids in cereals. Northern Grower Alliance. http://nga.org.au/results-and-publications/download/19/grdc-update-papers-pests/aphids-in-winter-cereals/

34 DAF Queensland (2012) Insect pest management in winter cereals. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/ipm-information-by-crop/insect-pest-management-in-winter-cereals

In some seasons, aphid may move over large distances, in which case local weed management will have little impact.

Encourage beneficial populations through the preservation of native vegetation which provides a refuge for them. [35]

7.4.9 Monitoring

Monitor all crop stages from seedling stage onwards. Look on leaf sheaths and stems, and within whorls and heads, and record the number of large and small aphids (adults and juveniles), beneficials (including parasitised mummies), and the impact of the infestation on the crop.

Stem elongation to late flowering is when the crop is most vulnerable to aphids. Frequent monitoring is required to detect rapid increases in populations.

Check regularly—and check at least five points in the paddock, sampling 20 plants at each point. Densities at crop edges may not be representative of the whole paddock, because populations can be patchy. When sampling, averaging the number of aphids per stem or tiller gives a useful measurement of their density. Repeated sampling will provide information on whether the population is increasing (lots of juveniles relative to adults), stable, or declining (lots of adults and winged adults). [36]

7.5 Cutworms

Several species of cutworms (*Agrotis* spp.) attack establishing cereal crops in Queensland and New South Wales (as well as South Australia, Tasmania, Victoria and Western Australia). They are sporadic pests. As their name suggests, cutworm larvae sever the stems of young seedlings at or near ground level, causing the collapse of the plant. The moths emerge in late spring and summer, and females lay. eggs onto summer and autumn weeds, from where the larvae emerge onto newly sown crops.

Cutworms are caterpillars of several species of night-flying moths, one of which is the well-known Bogong moth. All are similar in appearance, with the mature grubs being plump, smooth caterpillars up to 50 mm long. They have dark heads and usually darkish bodies, often with longitudinal lines and/or dark spots (Figure 5). [37] Larvae curl up and remain still if picked up (Photo 9). The moths are a dull brown–black colour, [38] with dark brown or grey–black forewings with dark arrow markings on either wing above a dark streak broken by two lighter-coloured dots (Figure 6). Moths of the pink cutworm have grey-brown forewings with darker markings and streaks and a large inner light mark and darker outer mark. Moths of the black cutworm have brown or grey–black forewings with a dark arrow-mark streak broken by two dark ring-shaped dots.

They are most damaging when caterpillars transfer from summer and autumn weeds onto newly emerged seedlings. Natural predators and early control of summer and autumn weeds will help reduce larval survival prior to crop emergence. If required, cutworms can be controlled with insecticides; spot spraying may provide adequate control.

An abundance of top growth that is poorly incorporated may cause poor seed-to-soil contact in the subsequent crop and may attract armyworms or cutworms.

35 IPM Guidelines (2016) Aphids in winter cereals. Queensland Government and GRDC, http://ipmguidelinesforgrains.com.au/pests/aphids/aphids-in-winter-cereals/

36 IPM Guidelines (2016) Aphids in winter cereals. Queensland Government and GRDC, http://ipmguidelinesforgrains.com.au/pests/aphids/aphids-in-winter-cereals/

37 S Hangartner, G McDonald, P Umina (2015) Cutworm. cesar, http://cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Cutworm

38 DAF Queensland (2010) Cutworm. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/a-z-insect-pest-list/soil-insects/cutworm

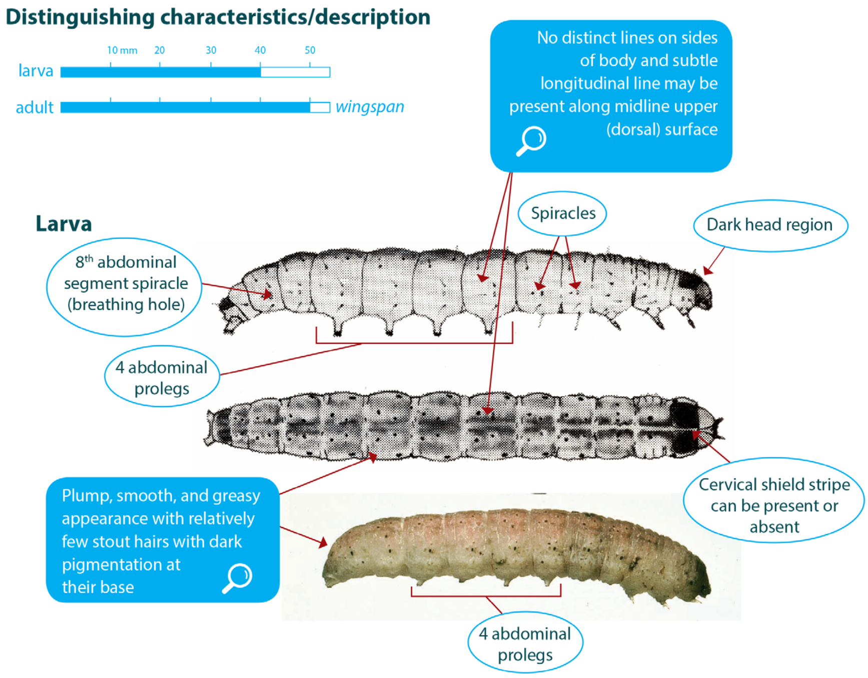

Figure 5: *Distinguishing characteristics of the cutworm.*

Source: cesar

Photo 9: *Cutworm larva in the typical curled position it assumes when disturbed.*

Source: cesar.

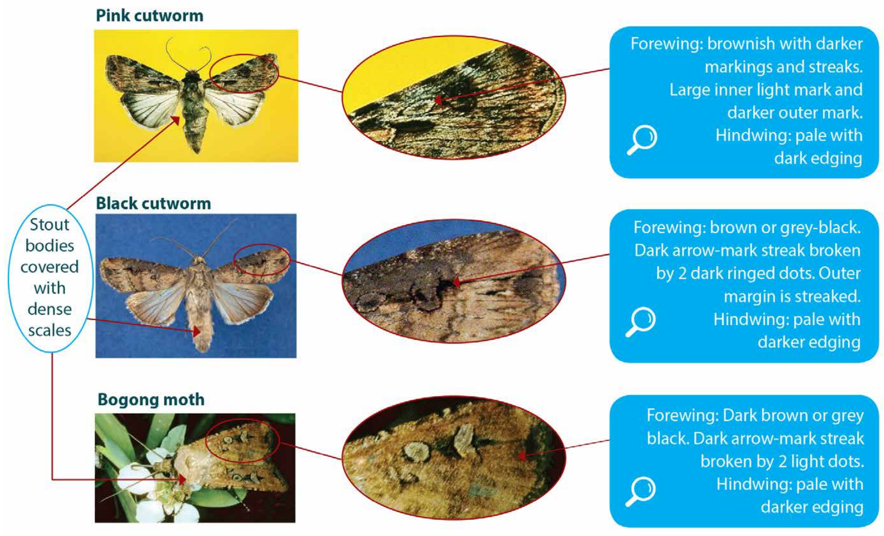

Figure 6: *Distinguishing characteristics of the adult forms of the pink, black and common cutworm.*

Source: cesar

Triticale has had mixed response to cutworm damage in Australia. In trials in WA, researchers found that triticale could regenerate quickly after being attacked by cutworm four weeks after sowing. [39] In the south-west slopes of New South Wales near Tarcutta, cutworms were reported to have caused severe damage to several germinating triticale crops. The damage observed was quite patchy, with some areas suffering 100% plant death. Most problems were observed in paddocks that had held weeds and stubble over summer, while 'clean' paddocks that had been cropped in previous years typically had few problems. Prolonged autumn green feed is likely to have allowed caterpillars to develop to a large size by the time crops started to emerge. Chemical control was required in the worse-affected paddocks, after which the crop was re-sown and emerged well. [40]

7.5.1 Damage caused by cutworms

All field crops can be attacked. Crops are at most risk during seedling and early vegetative stages. [41] Winter crops are most susceptible in autumn and winter, although damage can occur throughout the year, especially in irrigated crops. Larvae feed at ground level, chewing through leaves and stems, and stems are often cut off at the base. Damage mostly occurs at night, which is when the larvae are active. When numbers of larvae are high, crops can become severely thinned (Photo 10). When smaller larvae feed on the surface tissue of the leaf, they can cause similar damage to the lucerne flea. Young plants are favoured and are worse affected than older plants.

39 C Johnstone (2011) Triticale variety demonstration 2011. Online Farm Trials, http://www.farmtrials.com.au/trial/10587

40 G McDonald, A Govender, P Umina (2010) Cutworms. PestFacts. Issue 3, 21 May 2010. cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestfacts-south-eastern/past-issues/2010/pestfacts-issue-no-3-21st-may-2010/cutworms/

41 DAF Queensland (2010) Cutworm. DAF Qld, https://www.daf.qld.gov.au/business-priorities/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/a-z-insect-pest-list/soil-insects/cutworm

Photo 10: *Pink cutworm damage to the plant and paddock.*

Source: cesar

7.5.2 Conditions favouring development

Usually cutworms have a single generation during the early vegetative stages of the crop. Moths prefer to lay their eggs in soil in lightly vegetated (e.g. a weedy fallow) or bare areas. Early autumn egg-laying results in the most damage to young cereals. Larvae hatch, and feed on host plants right through to maturity, when they descend to the soil to pupate below ground. Under favourable conditions, the duration from egg-laying to adult emergence is 8–11 weeks, depending on the species. [42]

7.5.3 Thresholds for control

Inspect the crop twice weekly in the seedling and early vegetative stage. Larvae feed late afternoons and evenings.

Chemical control is warranted when there is a rapidly increasing area or proportion of crop damage.

Chemical control may be warranted if larval numbers exceed one per square metre in emerging crops. [43]

7.5.4 Management of cutworms

Controlling weeds in the fallow at least 3–4 weeks before planting will assist in reducing the cutworm population and therefore crop damage also.

The best time to monitor is late afternoons and evenings when larvae feed. If inspecting the crop during the day, scratch away soil around damaged plants to find larvae sheltering in the soil. For more information read how to recognise and monitor for soil insects. [44]

Biological control

Naturally occurring insect fungal diseases that affect cutworms can reduce populations. Wasp and fly parasitoids, including the orange caterpillar parasite (*Netelia producta*), the two-toned caterpillar parasite (*Heteropelma scaposum*) and the orchid dupe (*Lissopimpla excelsa*) can suppress cutworm populations. Spiders, which are generalist predators, will also prey upon cutworms.

42 DAF Queensland (2010) Cutworm. DAF Qld, https://www.daf.qld.gov.au/business-priorities/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/a-z-insect-pest-list/soil-insects/cutworm

43 DAF Queensland (2010) Cutworm. DAF Qld, https://www.daf.qld.gov.au/business-priorities/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/a-z-insect-pest-list/soil-insects/cutworm

44 DAF Queensland (2012) Insect pest management in winter cereals. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/ipm-information-by-crop/insect-pest-management-in-winter-cereals

Cultural control

As autumn cutworm populations may be initiated from populations harboured by crop weeds or volunteers in and around the crop, removal of this green bridge 3–4 weeks before crop emergence will remove food for the young cutworms.

If required, cutworms can be easily controlled with insecticides, and spot spraying may provide adequate control. Spraying in the evening is likely to be most effective.

Chemical control

If required, cutworms can be easily controlled with insecticides. Several chemicals are registered for controlling them, the choice depending on the state and crop of registration. Spot spraying often provides adequate control in situations where cutworms are confined to specific regions within paddocks. Spraying in the evening is likely to be more effective as larvae are emerging to feed and insecticide degradation is minimised. [45]

MORE INFORMATION

PestNotes: Cutworm

Insecticide application is cost-effective. The whole crop may not need to be sprayed if distribution is patchy; spot spraying may suffice. See Pest Genie or APVMA for current control options.

Refer to the beneficial impact table (Table 4, Section 7.2 Integrated weed management) from the IPM Guidelines website to identify products least likely to harm beneficials that aren't being targeted.

For up to date information for chemical registrations, see the APVMA website.

7.6 Armyworm

The armyworm is the caterpillar stage of certain moths (Photo 11) [46] and can occur in large numbers, especially after good rain follows a dry period. During the day armyworms shelter in the throats of plants or in the soil, and emerge after sunset to feed. They like to eat young leaf tissue, which gives the leaf margins a tattered appearance. After heavy feeding, only the midrib of the leaf is left. Control is rarely warranted except where large numbers attack small plants. [47]

Barley, oats and rice are most susceptible to economic damage, but armyworms are also commonly found in wheat, triticale and grass pastures where extreme defoliation or head loss does occasionally occur.

Larvae shelter in the throats of plants or in the soil and emerge after sunset to feed on the leaves of all winter cereals, particularly barley and oats, generally during September and October. Leafy cereal plants can tolerate considerable feeding, so control in the vegetative stage is seldom warranted unless large numbers of armyworms are distributed throughout the crop or are moving in a 'front', destroying young seedlings or stripping older plants of leaves. The most serious damage occurs when larvae feed on the upper flag leaf and stem node as the crop matures, or in barley when the older larvae start feeding on the green stem just below the head as the crop matures.

The most common species in the Northern Region are common armyworm and northern armyworm (*Leucania convecta* and *L. separate, respectively*), and lawn armyworm (*Spodoptera mauritia*). They are all native pests.

45 S Hangartner, G McDonald, P Umina (2015) Cutworm. cesar, http://cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Cutworm

46 The Beatsheet (2010) Avenge of the caterpillars ... The Beatsheet, https://thebeatsheet.com.au/avenge-of-the-caterpillars%E2%80%A6/

47 DAF Queensland (2010) Armyworms in field crops. DAF Qld, https://www.daf.qld.gov.au/business-priorities/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/a-z-insect-pest-list/armyworm-overview

Photo 11: *Common armyworm (Leucania convecta).*

Source: The Beatsheet

The common armyworm is found in all states of Australia and potentially will invade all major broadacre-cropping regions year round, but particularly spring and summer.

The caterpillars of the various armyworm species are similar in appearance. They grow from about 2 mm on hatching to 40 mm in length at maturity. They have three prominent white or cream stripes running down the back and sides of their bodies. These are most obvious where they start on the thoracic segment ('collar') behind the head, and become particularly apparent in larvae that are >10 mm. Armyworms have four abdominal prolegs. [48] They have no obvious hairs, and feel smooth to touch. They curl up when disturbed.

For an accurate identification, they must be reared through to the adult (moth) stage (Figure 7).

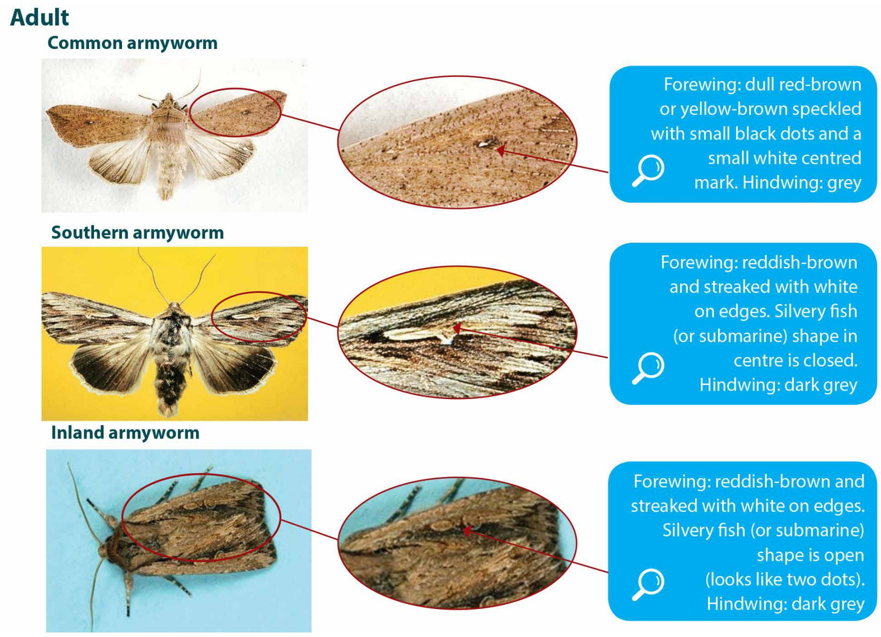

Figure 7: *Adult (moth) phase of the three armyworm species that can affect crops.*

Source: cesar.

48 G McDonald (2015) Armyworm. cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Armyworm

However, armyworms can be distinguished from other caterpillar pests that may be found in the same place by their stripes, which stay constant no matter what variation there may be in the colour of the body (Figure 8). Other species of caterpillar which may be confused with armyworms include:

- loopers (tobacco looper or brown pasture looper), which walk with a distinct looping action and have one or two pairs of abdominal prolegs—whereas armyworms have four pairs, and do not walk with a looping action once they are >10 mm.
- budworm larvae, which have prominent but sparse hairs and bumps on their skin, or anthelid larvae which are covered in hairs—whereas armyworms are smooth-bodied with no obvious hairs.
- cabbage moth larvae, which wriggle vigorously when disturbed—whereas armyworms curl up into a tight C.
- cutworm (brown or common cutworm) larvae, which have no obvious stripes or markings and are uniformly brown, pink or black. [49]

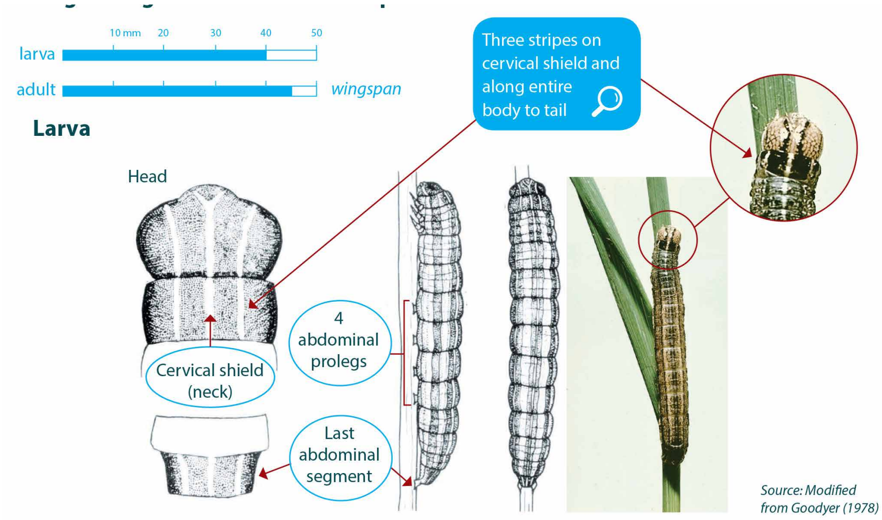

Figure 8: *Distinguishing characteristics of the armyworm larva.*

Source: cesar

7.6.1 Damage caused by armyworms

Armyworms:

- Prefer lush growth that provides good cover and protection.
- Feed on leaf tissue—leaf margins have a tattered, chewed or scalloped appearance, and in extreme cases whole leaves may be severed at the stem.
- Caterpillars produce green or straw-coloured droppings the size of a match head. These are visible between the rows.
- Bare patches adjacent to barley fields or damage to weeds may indicate armyworm presence before it is evident in crops. [50]

The young larvae feed initially from the leaf surface of pasture grasses and cereals. As the winter and spring progress and the larvae grow, they chew 'scallop' marks from the leaf edges. This becomes increasingly evident by mid to late winter. By the end of winter or early spring, the larvae are reaching full size and maximum food consumption. It is this stage that farmers most frequently notice that complete leaves and tillers may have been consumed or removed from the plant.

Damaging infestations or outbreaks occur in three situations:

49 G McDonald (1995) Armyworms. Note AG0412. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/armyworms

50 IPM Guidelines (2016) Armyworm. Queensland Government and GRDC, http://ipmguidelinesforgrains.com.au/pests/armyworm/

- In winter, when young tillering cereals are attacked and can be completely defoliated. The caterpillars may come from:
- the standing stubble from the previous year's cereal crop, in which the eggs had been laid; or
- neighbouring pastures which have dried out, resulting in the resident armyworms being forced to 'march' into the crop.
- In spring and early summer, when crops commence ripening and seed heads may be lopped.
- In early summer, when grass pastures are cut for hay.

The most damage is caused in ripening crops when the foliage dries off. The armyworms then begin to eat any green areas that remain. In cereals, the last section of the stem to dry out is usually just below the seed head. Armyworms, particularly the older ones, that chew at this vulnerable spot cause lopping of the heads, and they can devastate a crop nearing maturity in one or two nights: one large larva can sever up to seven heads of barley a day (Photo 12), [51] and one larva/m^2 can cause a loss of 70 kg/ha grain per day. In wheat and barley whole heads are severed, while in oats individual grains are bitten off below the glumes.

The crops affected include all Gramineae crops: cereals, grassy pastures, and maize.

Photo 12: *Ragged flag leaf and other leaves on a maturing cereal crop are an indication of the presence of armyworms.*

Source: The Beatsheet

7.6.2 Thresholds for control

The economic threshold is estimated at 10 grubs/m^2 for wheat and triticale, which is higher than for barley because the heads are rarely lopped. [52]

For winter outbreaks (during tillering), economic thresholds of 8 to 10 larvae per m^2 provide a guide for spraying decisions. For spring outbreaks (during crop ripening) spraying is recommended when the density of larvae exceeds 1 to 3 larvae per m^2 although this figure must be interpreted in the light of:

- timing of harvest;
- green matter available in the crop;
- expected return on the crop; and
- larval development stage (if most are greater than 35–40 mm or pupating, it may not be worth spraying). [53]

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51 The Beatsheet (2008) Armyworm in wheat. The Beatsheet, https://thebeatsheet.com.au/armyworm-in-wheat/

52 IPM Guidelines (2016) Armyworm. Queensland Government and GRDC, http://ipmguidelinesforgrains.com.au/pests/armyworm/

53 G McDonald (1995) Armyworms. Note AG0412. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/armyworms

Table 5 shows the value of yield loss incurred by 1 and 2 larva/m^2 per day, based on approximate values for wheat and an estimated loss of 70 kg/ha per larva. Based on these figures, and the relatively low cost of controlling armyworms, populations in ripening crops in excess of 1 large larva/m^2 will warrant spraying. This equates to the population of armyworms distributed through the crop causing the loss of 7–15 heads/m^2 (see Photo 13).

Table 5: *Economic thresholds for control of armyworms.*

Value of grain ($/t)	Value of yield loss ($/day)	
	1 larva/m^2	2 larva/m^2
140	9.80	19.60
160	11.20	22.40
180	12.60	25.20
200	14.00	28.00
220	15.40	30.80
250	17.50	35.00
300	21.00	42.00
350	24.50	49.00
400	28.00	56.00

Photo 13: *Armyworms feeding on grain heads.*

Source: World of Wheat

7.6.3 Managing armyworms

Sampling and detection

Signs of the presence of armyworms include:

- Chewing or leaf scalloping along the leaf margins.
- Caterpillar excreta (frass) which collects on leaves or at the base of the plant.
- Cereal heads or oat grains on the ground. Triticale heads may be severed completely, or hang from the plant by a small piece of stalk.

Early recognition of an armyworm problem is vital, as cereal crops can be almost destroyed by armyworms in just a few days, particularly when cereals and pasture seed or hay crops are at the late ripening stage. Although accurate estimates of caterpillar densities require considerable effort, the cost saving is worthwhile.

Check for larvae on the plant and in the soil litter under the plant. The best time to check is late in the day when armyworms are most active. Alternatively, during the day, check around the base of damaged plants where the larvae may be sheltering in the soil.

Sampling can be achieved by using a sweep-net or bucket, or visually searching the ground or crop for caterpillars or signs of damage.

Sweep sampling is particularly useful early in an infestation when the larvae are small and actively feeding in the canopy. The sweep-net or bucket method provides a rapid and approximate estimate of infestation size. The utensil should be swept across the crop in 180o arcs numerous times, preferably 100 times, at different sites in the crop, to give an indication of density and spread. Armyworms are most active at night, so sweeping will be most effective at dusk. Average catches of more than 5–10 per 100 sweeps suggest that further searches on the ground are warranted to determine approximate densities.

When ground sampling, it is necessary to do at least ten spot checks in the crop, counting the number of caterpillars within a square metre.

Most farmers fail to detect armyworms until the larvae are almost fully grown, by which stage 10–20% of the crop may be damaged. The earlier the detection, the less the damage. The young larvae (up to 8 mm) cause very little damage, and are more difficult to find. The critical time to look for armyworms is the last three to four weeks before harvest. [54]

While it is large larvae that do the head lopping, controlling smaller larvae that are still feeding on leaves may be more achievable. Prior to chemical intervention consider how quickly the larvae will reach damaging size and the development stage of the crops. Small larvae take 8–10 days to reach a size capable of head lopping, so if small larvae are found in crops nearing maturity or harvest, no spray may be needed, whereas small larvae in late crops which are still green and at early seed-fill may reach a damaging size in time to significantly reduce crop yield.

Biological control

Around 20 species of predators and parasitoids have been recorded attacking armyworms. The most frequently observed predators are predatory shield bugs, ladybeetles, carabid beetles, lacewings and common brown earwigs. Parasitoids include tachnid flies and a number of wasp species (e.g. *Netelia*, *Lissopimpla* and *Campoletis species*). Viral and fungal diseases are recorded as killing armyworms. Such outbreaks are more common when there are high densities of armyworms.

Cultural control

Control weeds to remove alternative hosts. Armyworm often feed on ryegrass before moving into cereal crops. Standing stubble from previous crops, dead leaves on crops, and grassy weeds are suitable sites for female armyworms to lay eggs.

Larvae may move into cereals if adjacent pastures are chemically fallowed, spray topped or cultivated in spring. Monitor for at least a week after doing any of these things. Damage is generally confined to crop margins.

Chemical control

To be effective, chemical controls require good coverage to ensure contact with the caterpillars. Control is more difficult in high-yielding crops with thick canopies where larvae rest under leaf litter at the base of plants.

As armyworms are active at night, spray in the late afternoon or early evening to maximise the likelihood of contact.

54 G McDonald (1995) Armyworms. Note AG0412. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/armyworms

Be aware of withholding periods when chemical control is used close to harvest. [55]

Refer to the beneficial impact table (Table 4, Section 7.2 Integrated weed management) from the IPM Guidelines website to identify products least likely to harm beneficials that aren't being targeted.

For up to date information for chemical registrations, see the APVMA website.

7.7 Mites

7.7.1 Brown wheat mite

Brown wheat mite (*Petrobia latens*) damage is only severe in dry seasons, and it is therefore a sporadic pest of winter cereals. It attacks wheat, barley, triticale, oats, cotton and grasses.

The mature wheat mite is about the size of a pinhead, up to 0.6 mm long, globe-shaped and brown (Photo 14), although it can appear to be a deep greenish-brown to black when on a green leaf. Being a mite, it has eight legs, the front legs being significantly longer than the others. It is significantly smaller than the blue oat mite, and has finer legs than, and is also much smaller than the redlegged earth mite, so is unlikely to be mistaken for these two pests. [56]

Adults and nymphs pierce and suck on leaves, giving them a mottled, drought-like appearance. Crops with heavy infestations appear bronzed or yellowish, and seedlings can die.

Monitor for brown wheat mite by checking the crop from planting to the early vegetative stage, particularly in dry seasons. Spray if mottled patches appear throughout the crop and if conditions are dry. Foliar treatments may sometimes be cost-effective. For current chemical control options see Pest Genie or APVMA.

There are no known natural enemies of the brown earth mite.

Photo 14: *Brown wheat mite, a serious pest of cereals it develops in a dry spring.*

Photo: P Sloderbeck, Kansas State University

7.7.2 Blue oat mite

The blue oat mites (*Penthaleus spp.*) are important pests of seedling winter cereals, but are generally restricted to cooler grain-growing regions (southern Queensland through eastern New South Wales, Victoria, South Australia and southern Western

55 IPM Guidelines (2016) Armyworm. Queensland Government and GRDC, http://ipmguidelinesforgrains.com.au/pests/armyworm/

56 DAF Queensland (2010) Brown wheat mite. DAF Qld, https://www.daf.qld.gov.au/business-priorities/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/a-z-insect-pest-list/mites-overview/brown-wheat-mite

Australia) (Figure 9). [57] The blue oat mite (BOM) was introduced from Europe, and first recorded in New South Wales in 1921. Management of these mites in Australia has been complicated by the recent discovery of three distinct species of BOM, which had previously been believed to be a single species. The three species are *Penthaleus major*, *P. falcatus* and *P. tectus*.

Figure 9: *The known distribution of blue oat mites in Australia.*

Source: cesar

Adult BOM are 1 mm in length and approximately 0.7–0.8 mm wide. They have a blue-black body with a characteristic red mark on the back, and eight reddish-orange legs. (Figure 10). Larvae are approximately 0.3 mm long, oval in shape, and with three pairs of legs. On hatching, BOM are pink–orange in colour, soon becoming brownish and then green.

57 P Umina, S Hangartner (2015) Blue oat mite. cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Blue-oat-mite

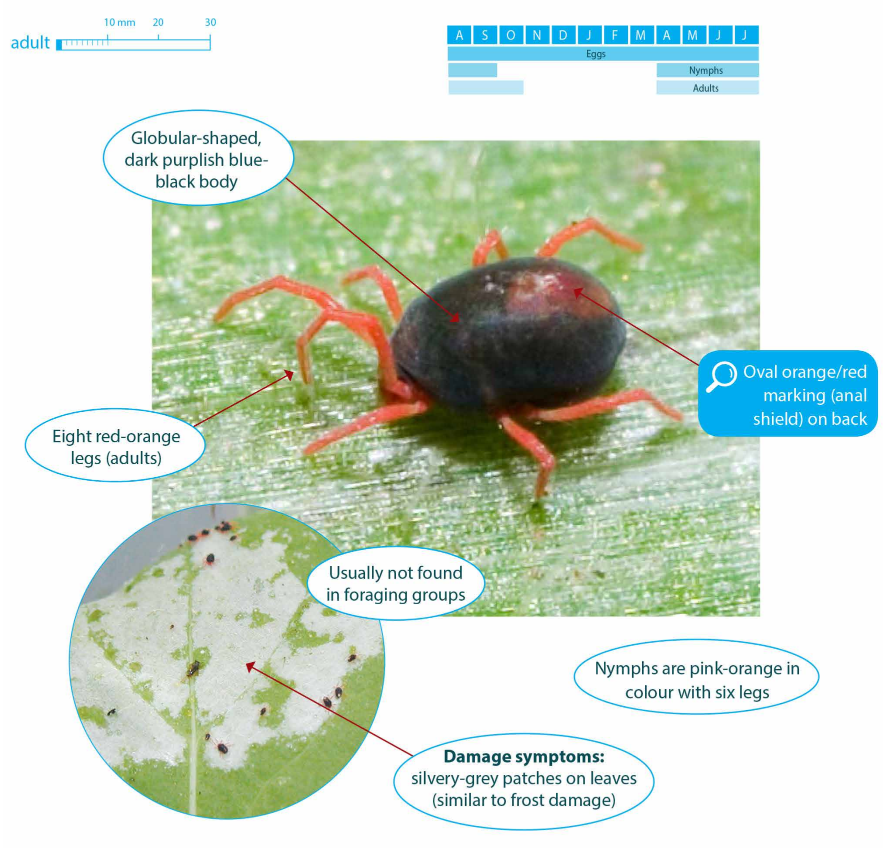

Figure 10: *Distinguishing characteristics of the blue oat mite.*

Source: cesar

BOM are often misidentified as redlegged earth mites (RLEM) in the field, which has meant that the damage caused by BOM has been under-represented. Despite having a similar appearance, RLEM and BOM can be readily distinguished from each other: RLEM have a completely black body, and tend to feed in larger groups of up to 30 individuals. BOM have the red mark on their back and are usually found singularly or in very small groups.

The blue oat mite is an important pest of seedling winter cereals and grass pastures, and will also eat pasture legumes and many weeds. [58] When infestations are severe, the leaf tips wither and eventually the seedlings die.

Eggs laid in the soil hibernate, allowing populations to build up over a number of years. This can cause severe damage if crop rotation is not practised. Check from planting to the early vegetative stage, particularly in dry seasons, monitoring a number of sites throughout the field. Blue oat mites are most easily seen in the cooler part of the day, or when it is cloudy. They shelter on the soil surface when conditions are warm and sunny. If pale green or greyish irregular patches appear in the crop, check for the presence of blue oat mite at the leaf base. [59]

Damage caused by BOM

Mites use adapted mouthparts to lacerate the leaf tissue of plants and suck up the discharged sap. Resulting cell and cuticle destruction promotes desiccation, retards photosynthesis and produces the characteristic silvering that is often mistaken as

MORE INFORMATION

PestNotes: Blue oat mite

58 DAF Queensland (2010) Blue oat mite. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/a-z-insect-pest-list/mites-overview/blue-oat-mite

59 DAF Queensland (2012) Insect pest management in winter cereals. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/ipm-information-by-crop/insect-pest-management-in-winter-cereals

frost damage (Photo 15). [60] BOM are most damaging to newly establishing pastures and emerging crops, greatly reducing seedling survival and retarding development.

Photo 15: *Typical blue oat mite damage to leaf.*

Source: Agriculture Victoria

Young mites prefer to feed on the sheath leaves or tender shoots near the soil surface, while adults feed on more mature plant tissues. BOM feeding reduces the productivity of established plants, and is directly responsible for reductions in the palatability of pastures to livestock. Even in established pastures, damage from large infestations may significantly affect productivity.

The impact of mite damage is increased when plants are under stress from adverse conditions such as prolonged dry weather or waterlogged soils. Ideal growing conditions for seedlings enable plants to tolerate higher numbers of mites.

There are no economic thresholds established for this pest.

Managing BOM

Though control is not often warranted, it is important to know the critical periods for control (Figure 11). Check from planting to the early vegetative stage, particularly in dry seasons. BOM are most easily seen in the late afternoon when they begin feeding on the leaves.

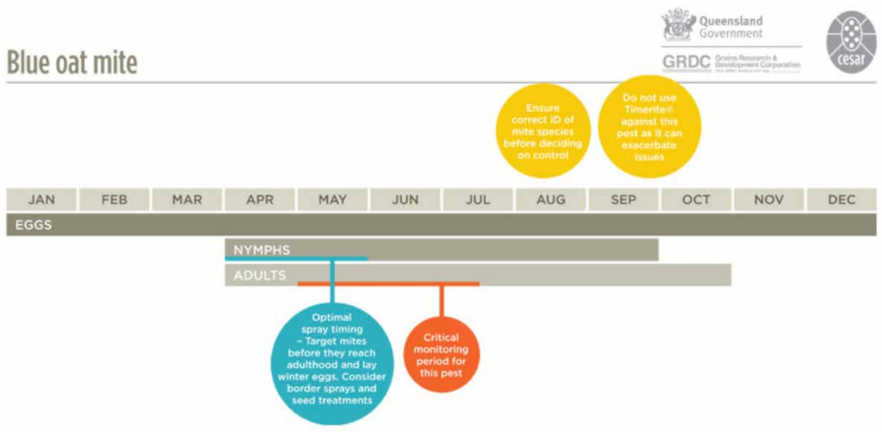

Figure 11: *Critical times for managing BOM.*

Source: cesar

Biological control

Integrated pest management programs can complement chemical control methods by introducing non-chemical options, such as cultural and biological controls.

60 Agriculture Victoria (2007) Blue oat mite. Note AG1300. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/blue-oat-mite

Although no systematic survey has been conducted to determine the natural enemies of BOM, a number of predator species are known to attack earth mites in Australia. The most important of these appear to be other mites, although small beetles, spiders and ants may also play a role. The French anystis mite is an effective predator but is limited in distribution. Snout mites will also prey upon BOM, particularly in pastures. Thrips and ladybirds are also natural enemies of BOM. The fungal pathogen, *Neozygites acaracida*, is prevalent in BOM populations during wet winters and could be responsible for observed population crashes.

Preserving natural enemies when using chemicals is often difficult because the pesticides generally used are broad-spectrum and therefore kill beneficial species as well as the pests. Impact on natural enemies can be reduced by using a pesticide that has the least impact and by minimising the number of applications. Although there are few registered alternatives for BOM control, groups such as the chloronicotinyls, which are used in some seed treatments, have a low–moderate impact on many natural enemies.

Cultural control

Cultural controls such as rotating crops or pastures with non-host crops can reduce pest colonisation, reproduction and survival, decreasing the need for chemical control. When *P. major* is the predominant species, canola and lentils are potentially useful rotation crops, while pastures containing predominantly thick-bladed grasses should be carefully monitored and rotated with other crops. In situations where *P. falcatus* is the most abundant mite species, farmers can consider rotating crops with lentils, while rotations that involve canola may be the most effective means of reducing the impact of *P. tectus*.

Many cultural control methods for BOM can also suppress other mite pests, such as RLEM. Cultivation will significantly decrease the number of over-summering eggs, while hot stubble burns can provide a similar effect. Many broad-leaved weeds provide an alternative food source, particularly for juvenile stages. As such, clean fallowing and the control of weeds within crops and around pasture perimeters, especially of bristly ox tongue and cats ear, can help reduce BOM numbers.

Grazing can also reduce mite populations to below damaging thresholds. This may be because shorter pasture results in lower relative humidity, which increases mite mortality and limits food resources. Grazing pastures in spring to less than 2 t/ha feed on offer (dry weight) can reduce mite numbers to low levels and provide some level of control the following year. [61]

Chemical control

Chemicals are the most common method of control against earth mites. Unfortunately, all currently registered pesticides are only effective against the active stages of mites; they do not kill mite eggs.

While a number of chemicals are registered in pastures and crops, differences in tolerance levels between species complicates management of BOM. *P. falcatus* has a high natural tolerance to a range of pesticides registered against earth mites in Australia and is responsible for many control failures involving earth mites. The other BOM species have a lower level of tolerance to pesticides and are generally easier to control with chemicals in the field.

Chemical sprays are commonly applied at the time of infestation, when mites are at high levels and crops already show signs of damage. Control of first generation mites before they can lay eggs is the best way to avoid a second spray. Hence, pesticides used at or after sowing should be applied within three weeks of the first appearance of mites, as adults will then begin laying eggs. While spraying pesticides in spring can greatly reduce the size of RLEM populations the following autumn, this strategy will generally not be as effective for the control of BOM.

61 Agriculture Victoria (2007) Blue oat mite. Note AG1300. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/blue-oat-mite

Pesticides with persistent residual effects can be used as bare-earth treatments. These treatments can be applied prior to, or at sowing to kill emerging mites and protect the plants throughout their seedling stage.

Systemic pesticides are often applied as seed dressings to maintain the pesticide at toxic levels in the plants as they grow. This can help minimise damage to plants during the sensitive establishment phase, although if mite numbers are high significant damage may still occur before the pesticide has much effect.

To prevent the build-up of resistant populations, spray pesticides only when necessary, and rotate chemical use by selecting pesticides from different chemical classes with different modes of action. To avoid developing multiple pesticide resistance, rotate chemical classes across generations rather than within a generation. [62]

Information on the registration status, rates of application and warnings related to withholding periods, occupational health and safety (OH&S), residues and off-target effects should be obtained before making decisions on which pesticide to use. This information is available from the chemical standards branch of your state agriculture department, chemical resellers, APVMA, and the pesticide manufacturer. Always consult the label and material safety data sheet (MSDS) before using any pesticide. For current chemical-control options, also refer to Pest Genie or APVMA.

Refer to the beneficial impact table (Table 4, Section 1.2 Integrated weed management) from the IPM Guidelines website to identify products least likely to harm beneficials that aren't being targeted.

7.8 Helicoverpa species

The name *Helicoverpa* refers to two species of moth, the larvae of which attack field crops in the Northern Region. The two species are *Helicoverpa punctigera* (native budworm) and *H. armigera (cotton bollworm or corn earworm)*. Together, they are the most economically damaging insect pests of field crops in Queensland and northern New South Wales.

Helicoverpa armigera is generally regarded as the more serious pest because of its greater capacity to develop resistance to insecticides, its broader host range, and the fact that it persists in cropping areas from year to year, whereas *H. punctigera* numbers fluctuate from year to year according to conditions in its inland breeding areas.

Helicoverpa armigera attacks all crops but is less common in wheat, triticale and barley. In contrast, *H. punctigera* only attacks broadleaf crops and is not found on grass or cereal crops such as wheat, barley, sorghum and maize. As it is not unusual to find both Helicoverpa larvae and armyworms in cereal crops, correct identification of the species present is important.

Life cycles of *Helicoverpa* spp. take 4–6 weeks from egg to adult in summer, and 8–12 weeks in spring or autumn. The stages are egg, larvae, pupa and adult (moth) (Figure 12); [63] the larva goes through several moults as it outgrows its skin, with each stage between moults called an instar.

62 Agriculture Victoria (2007) Blue oat mite. Note AG1300. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/blue-oat-mite

63 T Bray (2010) Managing native budworm in pulse crops. Southern Pulse Bulletin, http://www.pulseaus.com.au/storage/app/media/crops/2010_SPB-Pulses-native-budworm.pdf

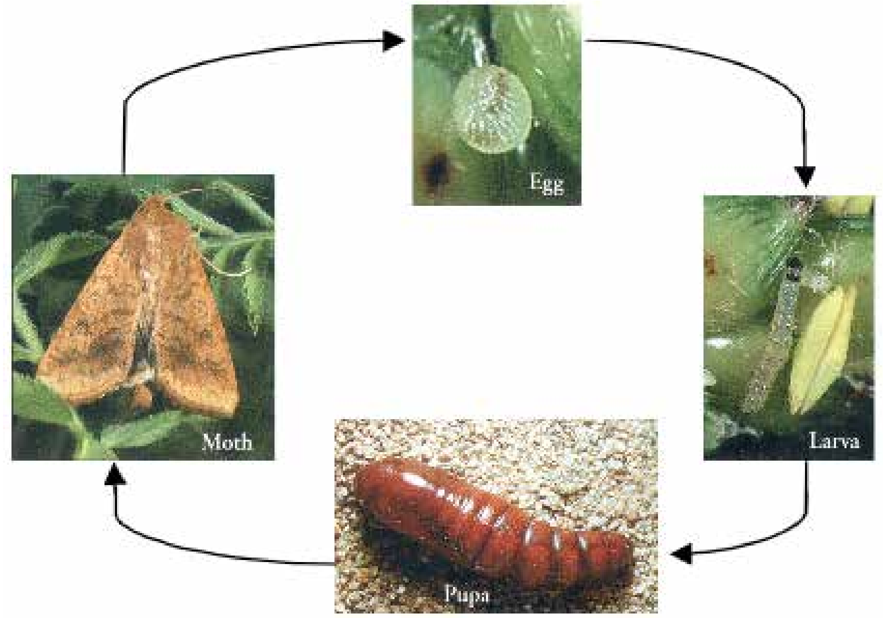

Figure 12: *Life cycle of Helicoverpa species.*

Source: Pulse Australia

Eggs are 0.5 mm in diameter and change from white to brown to having a black head before hatching. Newly hatched larvae are light in colour with tiny dark spots and dark heads. As the larvae develop, they become darker and the darker spots become more obvious. Both species look the same at the egg and small larvae stages (Photo 16). [64]

Photo 16: *Left to right: fresh white, brown ring and black larval head in nearly hatching eggs.*

Source: DAF Qld

Medium larvae develop lines and bands running the length of the body and become variable in colour. *H. armigera* larvae have a saddle of darker pigment on the fourth segment and at the back of the head, and dark-coloured legs. *H. punctigera* larvae have no saddle and light-coloured legs.

Large larvae of *H. armigera* have white hairs around the head (Photo 17) [65]; *H. punctigera* have black hairs around the head.

64 DAF Queensland (2012) Helicoverpa species. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/a-z-insect-pest-list/helicoverpa/helicoverpa-species

65 Centre for Agriculture and Biosciences International (2016) Helicoverpa armigera (cotton bollworm). CABI, http://www.cabi.org/isc/datasheet/26757

Photo 17: *H. armigera larvae showing white hairs on head.*

Source: CABI

H armigera pupal tail spines are more widely spaced than those of *H. punctigera.* The pupae of both species are found in soil underneath the crop; healthy pupae wriggle violently when touched.

Moths are a dull light brown with dark markings, and are 35 mm long. *H. armigera* has a pale patch in the dark section of the hindwing (Photo 18) while the dark section is uniform in *H. punctigera*. Forewings are brown in the female and cream in the male.

Photo 18: *Adult moth of H. armigera.*

Source: CABI

7.8.1 Varietal resistance or tolerance

Virtually all *Helicoverpa* spp. present are *H. armigera*, which has developed resistance to many of the older insecticide groups. [66]

7.8.2 Damage caused by *Helicoverpa* species

Helicoverpa larvae do not cause the typical head-cutting damage of armyworms. As they tend to graze on the exposed tips of a large number of developing grains, rather than totally consuming a low number of whole grains, they increase the potential losses. Most (80–90%) of the feeding and crop damage is done by larger larva in the final two instars. [67]

66 DAF Queensland (2012) Insect pest management in winter cereals. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/ipm-information-by-crop/insect-pest-management-in-winter-cereals

67 DAF Queensland (2012) Insect pest management in winter cereals. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/ipm-information-by-crop/insect-pest-management-in-winter-cereals

7.8.3 Thresholds for control

While there are no thresholds developed for Helicoverpa larvae in winter cereals, using a consumption rate determined for Helicoverpa feeding in sorghum (2.4 g/larva), it can be calculated that one larvae per m^2 can causes 24 kg grain loss/ha (Table 6). [68] Based on these figures, a crop worth $250/tonne will incur a loss of $6/ha from each Helicoverpa larvae. If chemical intervention costs $30/ha (comprising the chemical and the application costs) the economic threshold or break-even point is 5 larvae/m^2. These parameters can be varied to suit individual costs, and can incorporate a working benefit:cost ratio. A common benefit:cost ratio of 1.5 means that the projected economic benefit of the spray will be 1.5 times the cost of that spray. Spraying at the break-even point (benefit:cost ratio of 1) is not recommended. [69]

Table 6: *The value of yield loss incurred at several densities of larvae, using the estimated consumption of 2.4 g/larvae and a range of grain values for wheat. Note that larval damage is irrespective of the crops' yield potential (i.e. each larva will eat its fill whether it is 1 t/ha crop or a 3 t/ha crop).*

Cereal price ($/t)	Value of crop loss ($/ha)			
	4 larvae/m^2	6 larvae/m^2	8 larvae/m^2	10 larvae/m^2
150	14.4	21.6	28.8	36.0
200	19.2	28.8	38.4	48.0
250	24.0	36.0	48.0	60.0
300	28.8	43.2	57.6	72.0
350	33.6	50.4	67.2	84.0
400	38.4	57.6	76.8	96.0
450	43.2	64.8	86.4	108.0

Source: DAF Qld

7.8.4 Management of *Helicoverpa* species

The best approach to managing Helicoverpa is to use a combination of chemical and non-chemical tools. By considering the ecology of *H. armigera* and *H. punctigera*, several key principles emerge that will assist in the successful and sustainable management of these pests.

Chemical control

Presently there are few control options other than the use of chemical insecticides or biopesticides (such as NPV or *Bacillus thuringiensis* var. *kurstaki*, or Bt), for above-threshold populations of larvae in a crop. Spraying should be carried out promptly once the threshold has been exceeded. Controlling Helicoverpa effectively with insecticides depends on knowing which species are present in the crop.

Helicoverpa punctigera is easily killed by all registered products, including those to which *H. armigera* is resistant (e.g. synthetic pyrethroids). Because *H. punctigera* moths migrate annually into eastern Australian cropping regions, they lose any resistance they might have developed had they been exposed to insecticides in crops. In contrast, *H. armigera* populations tend to remain local, so their resistance to insecticides is maintained in the population from season to season. [70]

Helicoverpa armigera has historically had high resistance to pyrethroids, so control of medium–large larvae using pyrethroids is not recommended.

68 DAF Queensland (2012) Insect pest management in winter cereals. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/ipm-information-by-crop/insect-pest-management-in-winter-cereals

69 DAF Queensland (2012) Insect pest management in winter cereals. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/ipm-information-by-crop/insect-pest-management-in-winter-cereals

70 DAF Queensland (2012) Key management principles of helicoverpa. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/a-z-insect-pest-list/helicoverpa/helicoverpa-biology-and-ecology/key-management-principles

Where winter cereals have previously been treated with broad-spectrum insecticides to control aphids, fewer natural enemies may be present to attack Helicoverpa larvae, and the survival of caterpillar pests could be greater than in an untreated field. [71]

Attract-and-kill technology

Attract-and-kill products consist of a liquid insect lure based on floral volatiles that is mixed with an insecticide. The mixture is then able to be easily applied to large crop areas.

When the adult (and preferably female) moths are attracted to the treated rows, they feed on the mixture, and the insecticide component causes their death before all their eggs are laid. Because the aim is to concentrate the feeding moths in the treated rows, a key advantage of the attract-and-kill approach is that not every row of crop needs to be treated; in some cases, perhaps under 2% of the total crop area.

By reducing the pest moth population, the number of eggs laid into a crop can be significantly reduced. This reduction in egg lay can:

- delay the need for foliar insecticides
- reduce the subsequent pest pressure

Because the insecticide is confined to a small percentage of the crop, another key advantage is that most natural enemies will be unaffected. Research to date suggests that these products generally attract the target pest plus a range of other minor or non-pest moth species. [72]

For current chemical control options see Pest Genie or the APVMA.

Spray smart

Timing and coverage are both critical to achieving good control of Helicoverpa larvae, whether using a chemical insecticide or a biopesticide.

A poor level of control from inappropriate timing risks crop loss and the costs of re-treating the field. Poor timing also increases the likelihood of insects developing insecticide resistance by exposing larvae to sub-lethal doses of insecticide. Regular scouting of the crop enables the grower to assess both the number of Helicoverpa larvae in the crop and the age structure of the population.

Key points:

- Ensure crops are being checked when they are susceptible to Helicoverpa damage, as early detection is critical to ensure effective timing of sprays.
- Larvae that are feeding or moving in the open are more easily contacted by spray droplets. Target larvae before they move into protected feeding locations (e.g. flowers, cobs, pods or bolls).
- Ensure larvae are at an appropriate size to be controlled effectively with the intended product.
- Very small (1–3 mm) to small (4–7 mm) larvae are the most susceptible, and a lower dose is needed to kill them. Larvae grow rapidly: if a spray application is delayed more than two days, the crop should be rechecked and reassessed, so as to re-calibrate the amount of chemical needed.
- Assess if the larvae are doing economic damage, and only spray if the value of the crop that will be saved is more than the cost of spraying. Feeding on plants in the vegetative stages generally does not equate to significant yield loss.

Good coverage is increasingly important with the introduction of ingestion-active products because the larvae must eat plant material covered with an adequate dose of the insecticide or biopesticide.

71 DAF Queensland (2012) Insect pest management in winter cereals. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/ipm-information-by-crop/insect-pest-management-in-winter-cereals

72 DAF Queensland (2011) Attract and kill technology for helicoverpa management. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/a-z-insect-pest-list/helicoverpa/attract-and-kill

Note that due to the resistance that Helicoverpa has developed to major chemical groups, registered chemicals will not necessarily give adequate control in every situation. Local knowledge of which chemicals are work in the area should be sought from consultants and agronomists to ensure that you don't spray unnecessarily or promote the further development of resistance through your choice of insecticide.

Refer to the beneficial impact table (Table 4, Section 7.2 Integrated weed management) from the IPM Guidelines website to identify products least likely to harm beneficials that aren't being targeted.

For up to date information for chemical registrations, see the APVMA website.

Cultural control

While insecticides are an important tool for controlling and managing Helicoverpa, other management tools are also available.

- Pupae busting remains an important non-chemical tool to reduce both the size of overwintering *H. armigera* populations and the carryover of insecticide-resistant individuals from season to season. Cultivating to a depth of 10 cm before the end of August will kill a large proportion of overwintering pupae. Check paddocks that had larvae present after mid-March to assess numbers of pupae.
- Weed management in and around crops can prevent the build-up of *Helicoverpa* spp. and other insect pests.
- Spring trap crops have been successfully used as an area-wide management tool for reducing the size of the overall Helicoverpa population as it emerges from diapause in spring.
- Be smart with your beneficials. Be aware of the presence of beneficial insects and pathogens in the crop, and factor their likely impact into any management decisions.

Biological control

A variety of predatory and parasitic insects, spiders, birds, bats, rodents and diseases attack Helicoverpa at different stages of its life cycle.

Predators

Some predators (e.g. ants) are relatively permanent residents in paddocks, while others migrate from nearby paddocks or other vegetation. Many are opportunity feeders that also feed on other prey. Some predators found commonly in crops will not feed on Helicoverpa at all, and some may only feed on certain stages (for example, larvae of a particular size, or only eggs). Knowing what predators eat is important when making management decisions.

The predators of Helicoverpa eggs and larvae include the spined predatory shield bug, the glossy shield bug, the damsel bug and the bigeyed bug.

The most common predators of Helicoverpa in crops are:

- predatory bugs (e.g. spined predatory shield bug, assassin bug, and damsel bug)
- predatory beetles (e.g. ladybirds, red and blue beetle, carab beetle, and soldier beetle)
- spiders
- green lacewings and brown lacewings
- ants.

Parasitoids

Some wasps and flies attack Helicoverpa eggs, larvae and pupae; most of them are parasitoids, which kill their host to complete their development. The parasitoids most active in crops include:

- smaller wasp species such as *Microplitis demolitor*, *Trichogramma* spp. and *Telenomus* spp.

- relatively large parasitoid wasps (*Netelia producta*, *Heteropelma scaposum*, and *Ichneumon promissorius*)
- flies (*Carcelia* spp. and *Chaetopthalmus* spp.).

Parasitoids that attack Helicoverpa larvae do not kill their hosts immediately. However, they do stop or slow down caterpillar feeding, which reduces the impact of the pest on the crop. When parasitoids attack late-instar larvae or pupae, they stop moths from developing and going on to produce eggs and larvae (Photo 19).

Photo 19: *Normal Helicoverpa egg (left) and a black, parasitised egg (right).*

Source: DAF Qld

Pathogens

Pathogens are viruses, fungi or bacteria that infect insects. Many naturally occurring diseases infect and kill Helicoverpa larvae, among the most common being nucleopolyhedrovirus (NPV) and fungal pathogens (*Metarhizium anisopilae, Nomuraea rileyi and Beauveria bassiana*). Another disease, ascovirus, stunts larval development, and is spread by wasp parasitoids.

Two pathogens that affect Helicoverpa are available commercially as biopesticides:

- Helicoverpa NPV is a highly selective product that infects only Helicoverpa larvae and is harmless to humans, wildlife and beneficial insects.
- The bacterial toxin from *Bacillus thuringiensis* (Bt) is available as a selective spray that only kills moth larvae. Genes from the Bt organism have also been used to genetically modify cotton plants so that the toxin is expressed in the plant's tissues. When young Helicoverpa larvae feed on a Bt cotton plant, the toxin kills susceptible individuals.

Biopesticides can control small larvae (<7 mm), but are not effective on larger larvae, which are more difficult to control, although NPV is most effective when larvae < 13 mm in length are targeted.

Conserving natural enemies

Natural enemies will rarely eradicate all eggs or larvae, but predators and parasitoids may reduce infestations to below economic threshold if they are not disrupted by broad-spectrum insecticides. The amount of disruption that insecticides cause to natural enemy activity varies depending on which chemicals are used and which natural enemies are active.

Take a whole-farm or regional approach

There is no simple solution to Helicoverpa in a farming system that provides a wide range of food sources throughout the year, as the continuous availability of hosts potentially allows successive generations to build up in a cropping region. A whole-farm approach to Helicoverpa involves managing the local population by:

MORE INFORMATION

Important natural enemies of helicoverpa: *Microplitis demolitor* and ascovirus

- having a good knowledge of pest and life cycle
- checking crops regularly
- being familiar with the economic thresholds for different crops
- basing chemical choices on the latest insect resistance management strategy (IRMS)
- achieving appropriate timing and coverage of sprays
- conserving populations of predatory and parasitic insects
- using trap cropping if appropriate
- cultivating to destroy overwintering pupae
- destroying weed hosts in the crop and surrounding areas.

Area-wide management strategies are designed to manage Helicoverpa at a regional level rather than each farmer making Helicoverpa control actions in isolation. It requires high levels of communication and cooperation between farmers, consultants, and research and extension personnel. [73]

7.8.5 Helicoverpa and insecticide resistance

Insecticide resistance management strategy

An insecticide resistance management strategy (IRMS) is developed each year in order to contain the increase in resistance of *H. armigera* to insecticides including pyrethroids, carbamates, organophosphates and endosulfan. In its present form it applies mainly to summer crops, especially cotton, but as more insecticides are registered in grain crops the IRMS is being expanded into a farming systems IRMS (FS-IRMS) that considers insecticide use in all broadacre crops throughout the year.

The FS-IRMS aims to ensure that there is a sufficient break, of at least one *Helicoverpa* generation, in the use of each insecticide group, across all crops. For example, there is a recommended end-date for the use of Steward® (indoxacarb) in chickpeas, to allow a break in *Helicoverpa* exposure to indoxacarb before the product is available for use in cotton.

FS-IRMS guidelines

1. Currently there are no restrictions on the number of pyrethroid sprays that can be applied to non-cotton crops, but there are a number of considerations that apply to the use of pyrethroids in the farming systems.
2. It is strongly recommended that pyrethroids not be used on *Helicoverpa armigera*, as they are unreliable.
3. Pyrethroids should be targeted only on small larvae (i.e. < 7 mm long) as application on larger larvae will be ineffective and will increase levels of pyrethroid resistance. (Note: even for insecticide groups for which resistance is not established, small larvae are still more susceptible than larger larvae.)
4. If you are intending to spray a population of *Helicoverpa*, consider where the moths that laid the eggs may have originated. If they are likely to be survivors from a crop that was previously sprayed (e.g. with a pyrethroid), spraying again with the same insecticide will exacerbate resistance.
5. Avoid using broad-spectrum sprays such as organophosphates or pyrethroids early in the season. They reduce the numbers of beneficial insects and increase the chances of aphid, mite and further *Helicoverpa* outbreaks.
6. Be aware that in 2005 there were major changes to the registration for endosulfan. *Endosulfan has been withdrawn from use in grain crops*, with a few exceptions for controlling pests in seedling crops, and can no longer be used in soybeans, sunflowers, mungbeans or other summer grain crops.

73 DAF Queensland (2012) Key management principles of helicoverpa. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/a-z-insect-pest-list/helicoverpa/helicoverpa-biology-and-ecology/key-management-principles

7. *Do not use Steward® (indoxacarb) against Helicoverpa on chickpeas after 15 September (central Queensland) or 15 October (southern regions).* This cut-off date aids resistance management by allowing a full generation of *Helicoverpa* to develop between the last use in chickpeas and the first possible use in cotton.
8. The use of ovicides may be warranted in the event of high egg pressure: use methomyl before the black-head egg stage.
9. Use recommended larval thresholds to minimise pesticide use and reduce resistance selection. Sprays should only be applied if the larvae are doing economic damage (i.e. the value of the crop saved should exceed the cost of spraying).
10. Cultivate chickpeas and other host-crop residues as soon as possible after harvest to destroy pupae. Cultivation must be completed no later than one month after large larvae were observed in the paddock, otherwise the moths will emerge and move elsewhere.
11. Do not respray an apparent failure with a product of the same chemistry.

Helicoverpa control in an area

Farmers are faced with increasing problems of controlling resistant *Helicoverpa*. In response to this a Helicoverpa Regional Management Strategy (HRMS), or area-wide management (AWM) strategy, was formulated by producers, consultants, researchers and extension personnel, and was implemented in two pilot study areas on the Darling Downs in 1998–2001.

The HRMS was designed to manage *Helicoverpa* at a regional level rather than each farmer making *Helicoverpa* control actions in isolation. The HRMS pilot trial resulted in a high level of communication and cooperation between farmers and consultants in an effort to better manage *Helicoverpa*.

The basic principles of the strategy involve year-long cycle of management, and includes tactics that aim to reduce:

- the population of overwintering *Helicoverpa* pupae (March–June)
- the early season build-up of *Helicoverpa* on a regional or district scale (July–November)
- the mid-season population pressure on *Helicoverpa*-sensitive crops (December–March).

Key components of area-wide management include:

- crop checking
- pupae busting
- improved management for commercial chickpea crops
- chickpea trap crops
- using information from pheromone traps
- monitoring the contribution of beneficial insects
- insecticide management.

Many other areas are now implementing similar strategies. In the pilot study areas, many of the original HRMS and AWM groups continue to meet and discuss pest-management issues. Contact your local extension officer, consultant or Queensland Department of Agriculture and Fisheries IPM Development Extension Officer for information on existing groups in your region, or how to form a group.

Control considerations

Presently there are few control options other than the use of chemical insecticides or NPV for *Helicoverpa* larvae once they are in a crop. Spraying should be carried out promptly once the threshold for each insect has been reached.

Spray small or spray fail

Helicoverpa larvae grow rapidly and a few days' delay in spraying can result in major crop damage and also make them much more difficult to control. If a spray application is delayed for more than two days, the crop should be rechecked and reassessed.

Make sure that crops are checked when they are susceptible to *Helicoverpa* damage, as early detection of an infestation is critical in ensuring the timing of sprays is effective. Also ensure that *Helicoverpa* larvae are at the right size to control effectively with the product you intend to use. Spray only if the larvae are doing economic damage.

Seek professional advice

Seeking professional advice to ensure you are not:

- spraying unnecessarily (i.e. below threshold)
- planning to use an insecticide to which the pest is likely to be resistant
- promoting the further development of resistance through your choice of insecticide.

Common insecticides and registered application rates can be found by individual crop. These are not complete lists of all products registered in winter crops, and it is recommended that you also check Infopest before applying a chemical. As always, read the label, and follow the instructions on it.

Due to the resistance that *Helicoverpa* has developed to major chemical groups, it is important to remember that registered chemicals will not necessarily give adequate control in each situation. Local knowledge of which chemicals are working should be sought from consultants and agronomists in your area. [74]

MORE INFORMATION

Insect monitoring techniques for field crops

7.8.6 Monitoring

Check for larvae on the plant throughout the growing season; monitoring can be done in conjunction with sampling for armyworms. Using a sweep net, check a number of sites throughout the paddock.

7.9 Lucerne flea

The lucerne flea (*Sminthurus viridis)* is a springtail that is found in both the northern and southern hemispheres but is restricted to areas that have a Mediterranean climate. It is thought to have been introduced to Australia from Europe and has since become a significant agricultural pest of crops and pastures across the southern states. It is not related to the fleas that attack animals and humans.

Lucerne fleas are common pests in New South Wales, Victoria, Tasmania, South Australia and Western Australia (Figure 13). [75] Higher numbers are often found in the winter-rainfall areas of southern Australia, including Tasmania, or in irrigation areas where moisture is plentiful. They are generally more problematic on loam and clay soils. Lucerne fleas are often patchily distributed within paddocks and across a region.

74 DAF Queensland (2011) Helicoverpa and insecticide resistance. DAF Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/a-z-insect-pest-list/helicoverpa/insecticide-resistance

75 G McDonald (2016) Lucerne flea. Updated. cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Lucerne-flea

Figure 13: *The known distribution of the lucerne flea in Australia.*

Source: cesar

The springtails are a group of arthropods that have six or fewer, abdominal segments, and a forked tubular appendage or furcula under the abdomen. They are one of the most abundant of all macroscopic insects and are frequently found in leaf litter and other decaying material, where they are primarily detritivores. Very few species, among them the lucerne flea, are regarded as crop pests around the world.

The adult lucerne flea is approximately 3 mm long, light green–yellow in colour and often with mottled darker patches over the body. It is wingless and has an enlarged, globular abdomen (Figure 14). The newly hatched nymph is pale yellow and 0.5–0.75 mm long, and as it grows it resembles an adult, but is smaller.

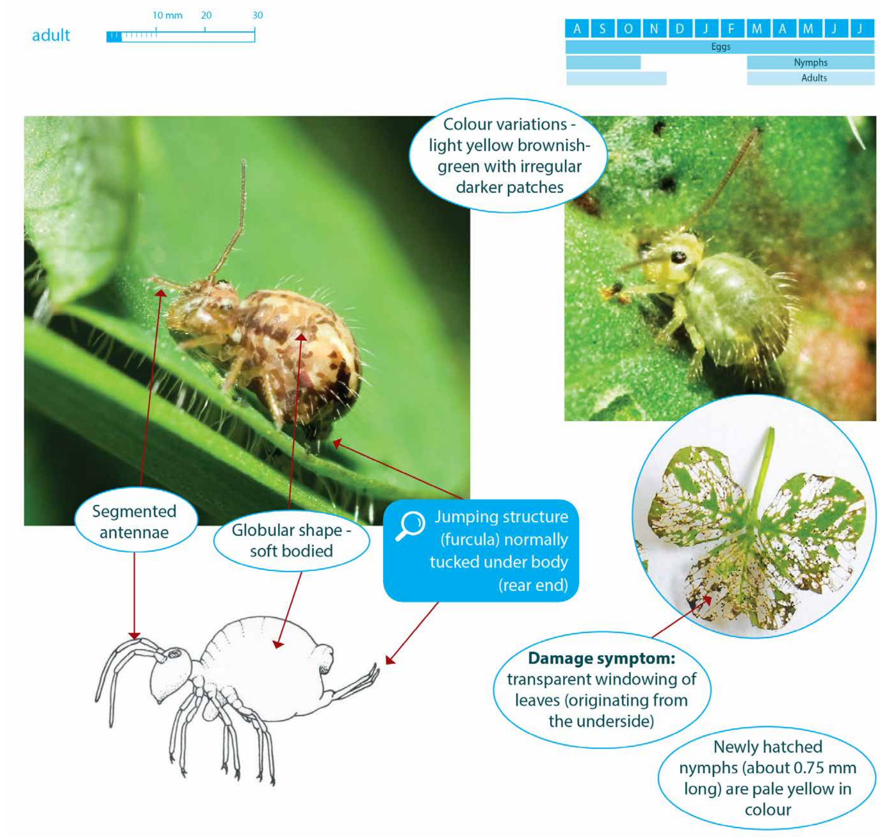

Figure 14: *Distinguishing characteristics of the lucerne flea.*

Source: cesar

7.9.1 Damage caused by lucerne fleas

Although grasses and cereals are not preferred hosts, lucerne fleas can cause damage to ryegrass, wheat and barley crops. Among the pasture crops, they prefer subterranean clover and lucerne.

Lucerne fleas move up plants from ground level, eating tissue from the underside of foliage. They use a rasping process to consume the succulent green cells of leaves, avoiding the more fibrous veins and leaving behind a layer of leaf membrane. This makes the characteristic small, clean holes in leaves which can appear as numerous tiny 'windows'. In severe infestations this damage can stunt or kill plant seedlings.

7.9.2 Managing lucerne fleas

Monitoring is the key to reducing the impact of lucerne fleas. Crops and pastures grown in areas where lucerne fleas have previously been a problem should be monitored fortnightly for damage from autumn through to spring. Weekly monitoring is better where there have been problems in previous years. Susceptible crops and pastures should also be carefully inspected for the presence of lucerne fleas and evidence of the damage they cause.

It is important to frequently inspect winter crops, particularly canola and pulses, in the first three to five weeks after sowing, as crops are most susceptible to damage immediately following the emergence of seedlings.

Lucerne fleas are often concentrated in localised patches or hot spots, so it is important to have a good spread of monitoring sites in each paddock. Examine foliage for characteristic lucerne flea damage and check the soil surface where insects may be sheltering.

Some sprays must be applied at a particular growth stage, so it is also important to note the growth stage of the population. Spraying immature lucerne fleas before they have a chance to reproduce can effectively reduce the size of subsequent generations.

Lucerne fleas compete for food and resources with other agricultural pests such as redlegged earth mites and blue oat mites. This means control strategies that target only one species may not reduce the overall pest pressure because other pests can fill the gap. It is therefore important to assess the complex of pests before deciding on the most appropriate control strategy.

Biological control

Several predatory mites, various ground beetles, and spiders prey on lucerne fleas. Snout mites (which have orange bodies and legs) are particularly effective predators of this pest (Photo 20). The pasture snout mite (*Bdellodes lapidaria*) and the spiny snout mite (*Neomulgus capillatus*), have been the focus of biological control efforts against lucerne flea.

The pasture snout mite was originally found in Western Australia but has since moved into eastern Australia, where there are some examples of it successfully reducing lucerne flea numbers. Although rarer, the spiny snout mite can also drastically reduce lucerne flea populations, particularly in autumn.

Photo 20: *Predatory adult snout mite.*

Photo: A. Weeks, cesar

Cultural control

Grazing can reduce lucerne flea populations to below damaging thresholds. This may be because shorter pasture lowers the relative humidity and limits food resources, which increase insect mortality.

Broad-leaved weeds can provide alternative food sources, particularly for juvenile stages. Clean fallowing and the control of weeds, especially capeweed, within crops and around pasture perimeters can therefore help reduce lucerne flea numbers.

Other cultural techniques such as cultivation, trap crops and border crops, and mixed cropping can help reduce overall infestations to below economically damaging levels, particularly when employed in conjunction with other measures. Grasses are less favourable to the lucerne flea and as such can be useful for crop borders and pastures.

In pastures, avoid clover varieties that are more susceptible to lucerne flea damage, and avoid planting susceptible crops such as canola and lucerne into paddocks with a history of lucerne flea damage. [76]

76 G McDonald (2008) Lucerne flea. Note AG0415. Updated. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/lucerne-flea

Chemical control

Lucerne fleas are commonly controlled post-emergence, usually after damage is first detected. Control is generally achieved with an organophosphate insecticide. In areas where damage is likely, a border spray may be sufficient to stop invasion from neighbouring pastures or crops. In many cases, spot spraying, rather than blanket spraying, may be all that is required.

If the damage warrants control, treat the infested area with a registered chemical approximately three weeks after lucerne fleas have been observed on a newly emerged crop. This will allow for the further hatching of over-summering eggs but will occur before the lucerne fleas reach maturity and begin to lay winter eggs.

In pastures, a follow-up spray may be needed roughly four weeks after the first spray to control subsequent hatchings, and to kill new insects before they lay more eggs. Grazing the pasture before spraying will help open up the canopy to ensure adequate spray coverage. The second spray is unlikely to be needed if few lucerne fleas are observed at that time.

Crops are most likely to be damaged where they follow a weedy crop or a pasture in which lucerne fleas have not been controlled. Therefore, controlling the fleas in the season prior to the sowing of susceptible crops is recommended.

Caution is advised when selecting an insecticide. Several chemicals registered for redlegged earth mites (i.e. synthetic pyrethroids such as cypermethrin) are known to be ineffective against lucerne fleas. When both lucerne fleas and redlegged earth mites are present, it is recommended that control strategies account for both pests: use a product registered for both at the higher rate of the two, to ensure effective control.

Information on the registration status, rates of application and warnings related to withholding periods, OH&S, residues and off-target effects should be obtained before making decisions on which insecticide to use. This information is available from the chemical standards branch of your state agriculture department, chemical resellers, APVMA and the pesticide manufacturer. Always consult the label and MSDS before using any insecticide. Also check PestGenie.

Refer to the beneficial impact table (Table 4, Section 7.2 Integrated weed management) from the IPM Guidelines website to identify products least likely to harm beneficials that aren't being targeted.

7.10 Slugs and snails

Slugs and snails can be a major pest in southern NSW (Table 7). [77] Damaging populations of slugs have also been reported in seedling crops in northern NSW and southern Queensland in recent years.

Increased slug and snail activity may be due to the increase in zero- and minimum-till and stubble-retention practices because the amount of organic matter in paddocks increases and gives young slugs and snails a bigger food source. Other risk factors include prolonged wet weather, trash blankets, weedy fallows and a previous history of slugs and snails. Slugs and snails are best controlled before the crop is planted.

77 IPM Guidelines (2016) Slugs and snails. Queensland Government and GRDC, http://ipmguidelinesforgrains.com.au/pests/slugs-and-snails/

Table 7: *Description of common slugs and snails.*

Species	Distinguishing features	Characteristic damage	Seasonal occurrence	Other characteristics
Slugs				
 Grey field or reticulated slug (*Deroceras reticulatum*) Photo: M. Nash, SARDI	Light grey to fawn with dark brown mottling 35–50 mm long Produces a white mucus	Rasping of leaves. (Complete areas of crop may be missing.)	Autumn to spring when conditions are moist, especially when soil moisture is >25%	Resident pest Surface active, but seeks moist refuge in soil macropores
 Black-keeled slug (*Milax gagates*) Photo: M. Nash, SARDI	Black or brown with a ridge from its saddle all the way down its back to the tip of the tail 40–60 mm long.	Rasping of leaves. (Complete areas of crop may be missing.) Hollowed out grains	All year round if conditions are moist, but generally later in the season in colder regions	Burrows, so cereal or maize crops fail to emerge Prefers sandy soil in high rainfall areas (>550 mm), heavier soils in low rainfall areas (<500 mm). Surface active (feeding), but seeks moist refuge in soil macropores
 Brown field slug (*Deroceras invadens, D. laeve*) Photo: M. Nash, SARDI	Usually brown all over with no distinct markings 25–35 mm long Produces a clear mucus	Rasping of leaves Leaves a shredded appearance	All year round if conditions are moist	Prefers warmer conditions and pastures Less damaging than grey field slug and black-keeled slug

Species	Distinguishing features	Characteristic damage	Seasonal occurrence	Other characteristics
Snails				
 Vineyard or common white snail (*Cernuella virgate*) Photo: M. Nash, SARDI	Coiled white shell with or without a brown band around the spiral Mature shell diameter 12–20 mm Open, circular umbilicus* Under magnification, regular straight scratches or etchings can be seen across the shell	Shredded leaves where populations are high Found up in the crop prior to harvest	Active after autumn rainfall Breeding occurs once conditions are moist (usually late autumn to spring)	Mainly a contaminant of grain Congregates on summer weeds and off the ground on stubble
 White Italian snail (*Theba pisana*) Photo: M. Nash, SARDI	Mature snails have coiled white shells with broken brown bands running around the spiral Some individuals lack the banding and are white Mature shell diameter 12–20 mm Semi-circular or partly closed umbilicus* Under magnification cross-hatched scratches can be seen on the shell	Shredded leaves where populations are high Found up in the crop prior to harvest	Active after autumn rainfall Breeding occurs once conditions are moist (usually late autumn to spring)	Mainly a contaminant of grain Congregates on summer weeds and off the ground on stubble
 Conical or pointed snail (*Cochlicella acuta*) Photo: M. Nash, SARDI	Fawn, grey or brown Mature snails have a shell of up to 18 mm long The ratio of the shell length to its diameter at the base is always greater than two	Shredded leaves where populations are high Found up in the crop prior to harvest	Active after autumn rainfall Breeding occurs once conditions are moist (usually winter to spring)	Mainly a contaminant of grain Can be found over summer on and in stubble and at the base of summer weeds

Species	Distinguishing features	Characteristic damage	Seasonal occurrence	Other characteristics
 Small pointed snail (*Prietocella Barbara*) Photo: M. Nash, SARDI	Fawn, grey or brown Mature shell size of 8–10 mm long The ratio of its shell length to its diameter at the base is always two or less	Shredded leaves where populations are high Found up in the crop prior to harvest	Active after autumn rainfall Breeding occurs once conditions are moist (usually winter to spring)	A contaminant of grain, especially hard to screen from canola grain as the same size Mainly found over summer at the base of summer weeds and stubble Similar to slugs will go into soil macropores. Especially difficult to control with bait at current label rates

*Umbilicus: a depression on the bottom (dorsal) side of the shell, where the whorls have moved apart as the snail has grown. The shape and the diameter of the umbilicus is usually species-specific.

Source: IPM Guidelines

7.10.1 Economic thresholds for control

Thresholds (Table 8) can be unreliable due to the interaction between weather, crop growth and snail activity. For example, high populations in the spring do not always relate to the number of slugs and snails harvested. Their movement into the crop canopy is dictated by weather conditions prior to harvest. [78]

Table 8: *Thresholds for controlling snails and slugs in a paddock. If there are more than the number specified per metre for a given pest then actions for controlled the pest should be taken.*

Pest	Number of pest per square metre
Round snails	20
Small pointed snails	40
Grey field slug	5–15
Black-keeled slug	1–2

Source: IPM Guidelines.

7.10.2 Managing slugs and snails

Biological control

Free-living nematodes when carrying bacteria that kill snails and slugs are thought to help reduce populations under certain paddock conditions.

Note that baits containing methiocarb are toxic to a number of other invertebrates and beneficials.

Natural enemies of slugs

Some species of carabid beetles can reduce slug populations, but generally not below established economic thresholds. Many other soil fauna, such as are protozoa, may cause high levels of slug egg mortality under moist, warm conditions. Biological controls alone cannot be solely relied on for slug control.

78 IPM Guidelines (2016) Slugs in seedling crops. Queensland Government and GRDC, http://ipmguidelinesforgrains.com.au/pests/slugs-and-snails/slugs-in-seedling-crops/

Cultural control

- Hard grazing of stubbles
- Cabling and/or rolling of stubbles when soil temperature is above 35°C
- Burning if numbers are very high and you can ensure hot, even burns
- Cultivation that leaves a fine, consolidated tilth
- Removal of summer weeds and volunteers

Chemical control

Snails

Molluscidial baits containing either metaldehyde or chelated iron are IPM compatible. Apply to the bare soil surface when snails are active after autumn rain, as early as March. Aim to control snails pre-season.

Mature snails over 7 mm in length or diameter will feed on bait while bait is less effective on juveniles. Baiting before egg lay is vital. Try to bait when snails are moving from resting sites after summer rains. Stop baiting eight weeks before harvest to avoid bait contamination in grain. Bait rates need to be at the highest label rate to achieve a greater number of bait points. As the actual number is yet to be determined, label rates may be revised ion the future. In cool, moist conditions, snails can move 30 m/week, so treated fields can be re-invaded from fence lines, vegetation and roadsides. Rain at harvest can cause snails to crawl down from crops.

Slugs

Baiting is the only chemical option available to manage slugs. Molluscidial baits containing metaldehyde or chelated iron are IPM compatible. Baits containing methiocarb are also toxic to carabid beetles, one of the few predators of slugs. Different responses to bait can be due to species behaviour. The value of applying bait after a significant rainfall event prior to sowing is still to be tested.

For black-keeled slugs, broadcast baits when dry or place with seed at sowing.

For grey field slugs, broadcast baits.

Do not underestimate slug populations: always use rate that gives 25–30 baits points per metre.

Calibrate bait spreaders to ensure width of spread, evenness of distribution and correct rate. Make sure to bait after/at sowing prior to crop emergence when soil is moist (>20% soil moisture). Re-apply baits to problem areas 3–4 weeks after first application if monitoring indicates slugs are still active.

Note that the number of baits/ha is more important than total weight of bait per hectare. The minimum baits needed for effective control is 250,000 bait points per hectare.

For up to date information for chemical registrations, see the APVMA website.

Monitoring snails

Monitor regularly to establish numbers, types and activity (Table 9), and measure success of controls. Look for snails early morning or in the evening when conditions are cooler and snails are more active.

Key times to monitor:

- 3–4 weeks before harvest to assess need for harvester modifications and cleaning
- after summer rains, check if snails are moving from resting sites
- summer to pre-seeding, check numbers in stubble before and after rolling, slashing or cabling

Monitoring technique:

- sample 30 x 30 cm quadrat at 50 locations across the paddock.

- if two groups (round and conical) are present, record the number of each group separately
- to determine the age class of round snails, place into a 7 mm sieve box, shake gently to separate into two sizes >7 mm (adults) and <7 mm (juveniles).
- make sieve boxes from two stackable containers, e.g. sandwich boxes, remove the bottom from one and replace by a punch-hole screen with screen size of 7 mm round or hexagonal
- use 5 sampling transects in each paddock, one each at 90 degrees to each fence line and the fifth running across the centre of the paddock, and take five samples (counts), 10 metres apart along each transect

Record the size and number of the snails in each sample. Average the counts for each transect and multiply this figure by 10 to calculate the number of snails per square metre in that area of the paddock.

Table 9: *Monitoring snails at different stages of crop development.*

Pre-sowing	Seedling–vegetative stages	Grain fill and podding stage	Harvest
High risk: • weedy fields • alkaline calcareous soils • retained stubble • wet spring, summer, autumn • history of snails All species congregate at the base of summer weeds or in topsoil. Pointed snails can also be found at the base of or up in stubble as well as inside stubble stems. Appear to build up most rapidly in canola, field peas and beans, but can feed and multiply in all crops and pastures. Most active after rain and when conditions are cool and moist Dormant in late spring and summer	**Damage:** • consume cotyledons, which may resemble crop failure • shredded leaves where populations are high • chewed leaf margins • irregular holes Wide range of sizes indicates snails are breeding in the area. If most snails are the same size, snails are moving in from other areas. Round snails favour resting places off the ground on stubble, vegetation and fence posts Pointed snails are found on the ground in shady places	Can be found up in the crop prior to harvest. Check for snails under weeds or shake mature crops unto tarps.	**Predominantly a grain contaminant** At harvest, snails move up in the crop and may shelter between grains or under leaves. They can also be found in windrows. The small pointed snail is especially hard to screen from canola grain due to similar size. Buyers will reject grain if: • more than half a dead or one live snail is found in 0.5 L of wheat • more than half a dead or one live snail is found in 200 g pulse sample

Source IPM Guidelines

Monitoring slugs

Monitor with surface refuges to provide an estimate of active density (Table 10). Refuges include:

- terracotta paving tiles
- carpet squares or similar

MORE INFORMATION

GRDC factsheet, Slug identification and management

Use a 300 mm by 300 mm refuge when soil moisture is favourable (more than 20%) as slugs require moisture to travel across the soil surface. Slugs are attracted to the refuges from approximately 1 m, so numbers found can be used as numbers per square metre.

Place refuges in areas of previous damage, after rainfall, on damp soil before sowing. Use 10 refuges per 10 hectares.

Check the refuges early in the morning, as slugs seek shelter in the soil as it gets warmer. Alternatively, put out metaldehyde bait strips and check the following morning for dead slugs. Monitor for plant damage.

Slug populations are not evenly distributed in the paddock and are often clumped. Where crop damage is evident inspect the area at night. [79]

Table 10: *Monitoring slugs at different stages of crop development.*

Pre-sowing	Germination–vegetative stages
High risk: • high rainfall areas >450 mm a year • above-average spring–autumn rainfall • cold, wet establishment conditions • no-till stubble retained • summer volunteers • previous paddock history of slugs • soils high in clay and organic matter Slugs are nocturnal and shelter during dry conditions and generally not visible	**Damage:** • rasping of leaves, • leaves have a shredded appearance • complete areas of crop may be missing Slugs will eat all plant parts but the seedling stage is most vulnerable and this is when major economic losses can occur Grey and brown field slugs are mainly surface-active but the black-keeled slug burrows and can feed directly on germinating seed

Source IPM Guidelines

7.11 Wireworms and false wireworms

Wireworms and false wireworms are common, soil-inhabiting pests of newly sown winter and summer crops. Wireworms are the larvae of several species of Australian native beetles which are commonly called click beetles. False wireworms are also the larval form of beetles, some of which are known as pie-dish beetles, which belong to another family, Tenebrionidae, and have distinctively different forms and behaviour.

Both groups inhabit native grassland and improved pastures where they generally cause little damage. However, cultivation and fallowing decimate their food supply, so any new seedlings that grow may be attacked and sometimes destroyed. They attack the pre-emergent and post-emergent seedlings of all oilseeds, grain legumes and cereals, particularly in light, well-draining soils with a high organic content. Crops with fine seedlings, such as canola and linola, are most susceptible.

The incidence of damage caused by wireworms and false wireworms is increasing with increasing use of minimum tillage and short fallow periods.

7.11.1 False wireworms

False wireworms are the larvae of native beetles which normally live in grasslands or pastures and cause little or no damage there. In crops, they are mostly found in paddocks with large amounts of stubble or crop litter, and may affect all winter-sown crops.

There are a large and varied number of species of false wireworms, but all species exhibit some common characteristics. Larvae are cylindrical, hard bodied, fast

79 IPM Guidelines (2016) Slugs in seedling crops. Queensland Government and GRDC, http://ipmguidelinesforgrains.com.au/pests/slugs-and-snails/slugs-in-seedling-crops/

moving, golden brown to black-brown or grey with pointed, upturned tails or a pair of prominent spines on the last body segment. There are several common groups (genera) of false wireworms found in south-eastern Australia:

- the grey or small false wireworm (*Isopteron punctatissimus* or *Cestrinus punctatissimus*)
- the large or eastern false wireworms (*Pterohelaeus* spp.)
- the southern false wireworms (*Gonocephalum spp.*) [80]

In the grey or small false wireworm, the larvae grow to about 9 mm in length. They are grey-green, have two distinct protrusions from the last abdominal (tail) segment, and tend to have a shiny exterior (Figure 15). [81] Hence, they are most easily recognised in the soil on sunny days when their bodies are reflective. The adults are slender, dark brown and grow to about 8 mm in length. The eggs are less than 1 mm in diameter. There are several species of this pest genus, although *I. punctatissimus* appears to be the one most associated with damage.

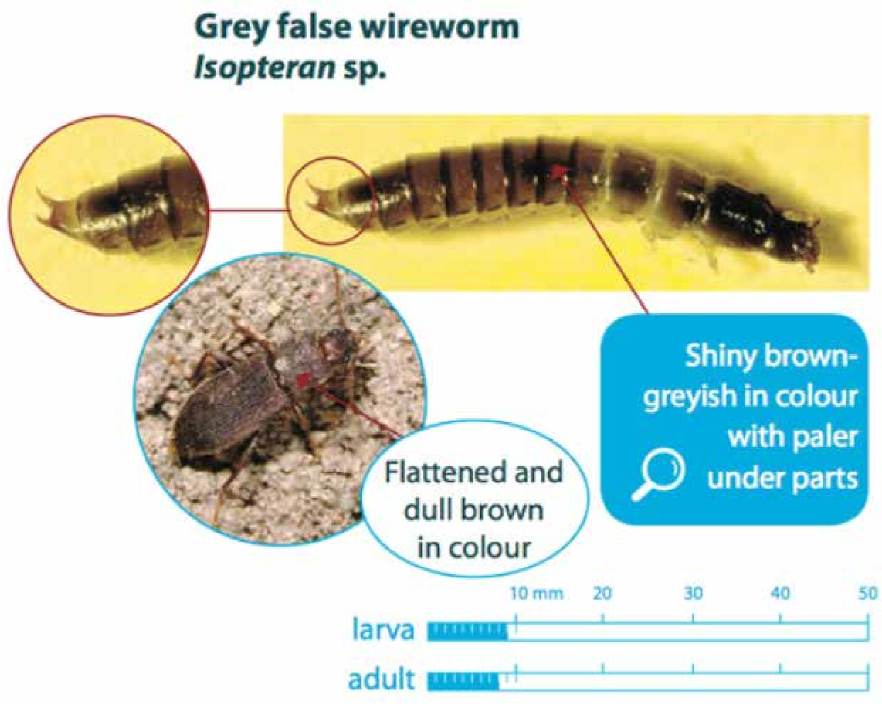

Figure 15: *Distinguishing characteristics of the grey false wireworm.*

Source: cesar

The large or eastern false wireworms are the largest group of false wireworms. They are the most conspicuous in the soil, and grow up to 50 mm in length. They are light cream to tan in colour, with tan or brown rings around each body segment, giving the appearance of bands around each segment. The last abdominal segment has no obvious protrusions, although, under a microscope, a number of distinct hairs can be seen. Adults are large, conspicuous and often almost ovoid beetles with a black shiny bodies (Photo 21). [82]

80 G McDonald (1995) Wireworms and false wireworms. Note AG0411. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/wireworms-and-false-wireworms

81 G McDonald (2016) Grey false wireworm. Updated. cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Grey-false-wireworm

82 G McDonald (2016) Eastern false wireworm. Updated. cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Eastern-false-wireworm

Photo 21: *Eastern false wireworm beetle (left) and larva (right).*

Source: cesar

The southern false wireworms grows to about 20 mm in length, and have similar body colours and marking to the large false wireworms. Adults are generally dark brown–grey, oval beetles, which sometimes have a coating of soil on the body (Figure 16). [83] The edges of adults' bodies are flanged, hence the common name pie-dish beetles.

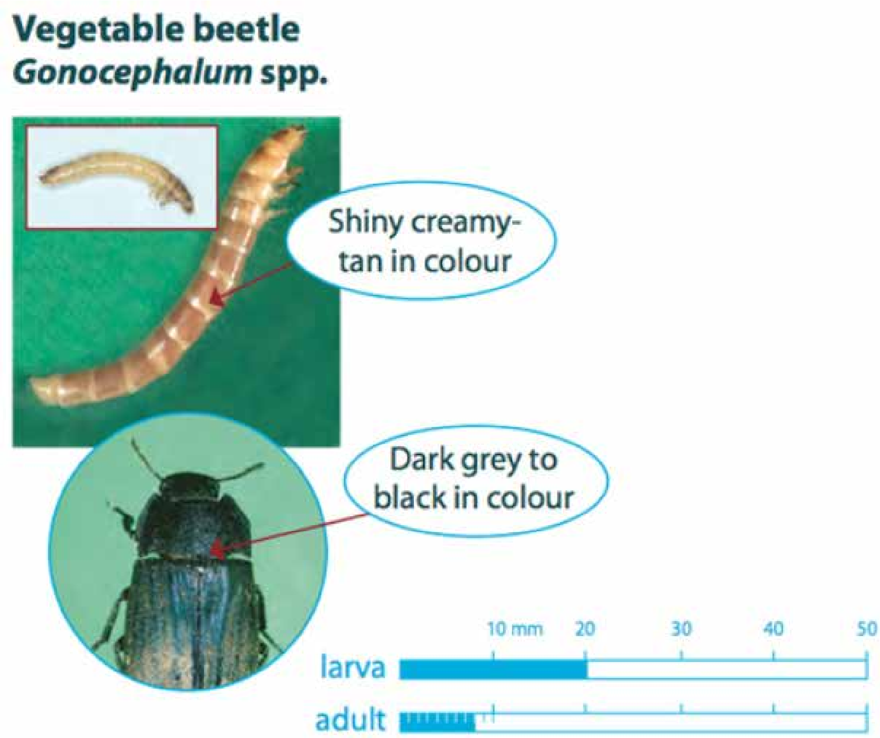

Figure 16: *Distinguishing characteristics of the southern false wireworm.*

Source: cesar

Biology

Usually only one generation occurs each year. However, some species may take up to 10 years to complete the life cycle. Adults emerge from the soil in December and January, and lay eggs in or just below the soil surface, mostly in stubbles and crop litter. Hence, larvae are most commonly found in paddocks where stubble has been retained.

Larvae of most false wireworm species prefer to feed on decaying stubble and soil organic matter. When the soil is reasonably moist, the larvae are likely to aggregate

83 P Umina, G McDonald (2015) Southern false wireworm. cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Southern-False-wireworm

in the top 10–20 mm where the plant litter is amassed. However, when the soil dries, the larvae move down through the soil profile, remaining in or close to the subsoil moisture, and occasionally venturing back to the soil surface to feed. Feeding is often at night when the soil surface is dampened by dew.

Nothing is known about what triggers the false wireworm to change from feeding on organic matter and litter to feeding on plants. However, it is recognised that significant damage to plants is likely to occur when soils remain dry for extensive periods. Larvae are likely to stop feeding on organic matter when it dries out, and when crop plants provide the most accessible source of moisture.

Damage caused by false wireworms

Affected crops may develop bare patches, which could be large enough to require re-sowing (Photo 22). [84] Damage is usually greatest when crop growth is slow due to cold, wet conditions.

Photo 22: *False wireworm damage to pasture.*

Source: cesar

Infestations of the small false wireworm can be as high as hundreds of larvae per square meter, although densities as low as five larger false wireworm larvae per square meter can cause damage under dry conditions.

The larvae of the small false wireworm are mostly found damaging fine seedling crops shortly after germination. They feed on the hypocotyl (seedling stem) at or just below the soil surface. This causes the stem to be ring-barked, and eventually the seedling may be lopped off, or it wilts in warm conditions. Larger seedlings (e.g. those of grain legumes) may also be attacked, but the larvae appear to be too small to cause significant damage.

The larger false wireworms can cause damage to most field crops. The larvae can hollow out germinating seed, sever the underground parts of young plants, or attack the above-surface hypocotyl or cotyledons. In summer, adult beetles may also chew off young sunflower seedlings at ground level. Damage is most severe in crops sown into dry seedbeds and when germination is slowed by continued dry weather.

7.11.2 True wireworm

The true wireworms are many species in the family Elateridae. The slow-moving larvae in this family tend to be less common in broadacre cropping regions, although they are always present. They are generally associated with wetter soils than the larvae of false wireworms.

84 P Umina, G McDonald (2015) Southern false wireworm. cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Southern-False-wireworm

Larvae grow to 15–40 mm, are soft-bodied, and flattened, and these characteristics help distinguish them from false wireworms. Their colour ranges from creamy yellow in the most common species to red-brown; their head is dark brown and wedge-shaped. The tail piece is characteristically flattened and has serrated edges. Adults are known as click beetles, due to their habit of springing into the air with a loud click when placed on their backs. The beetles are dark brown, elongated and 9–13 mm long (Figure 17). [85]

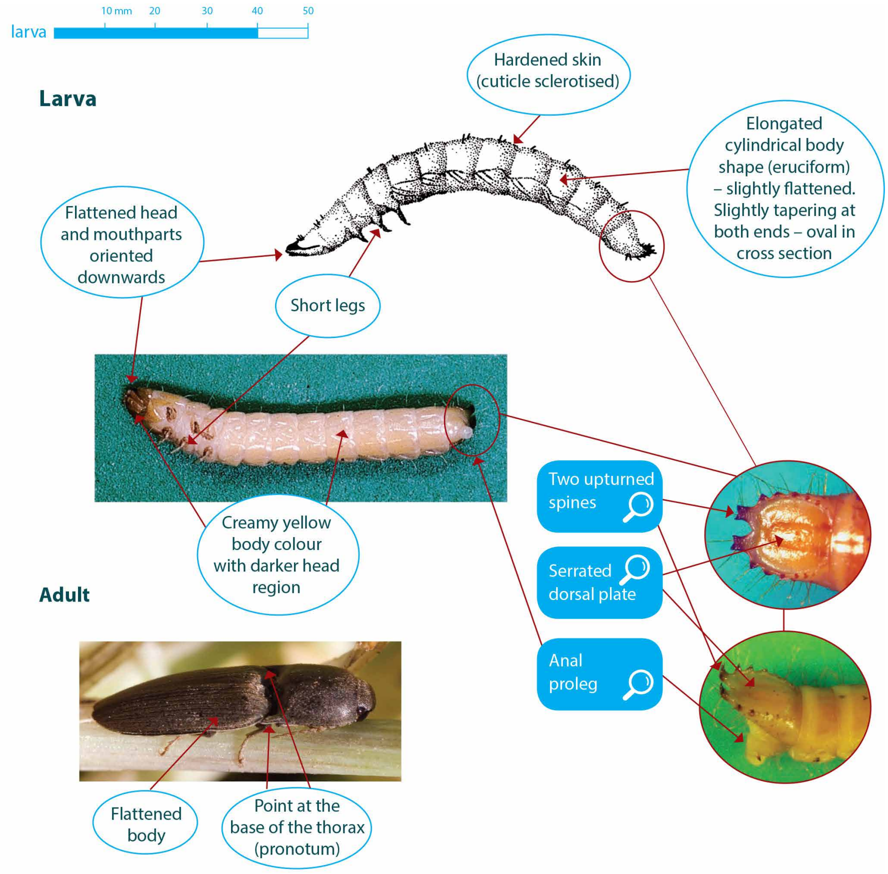

Figure 17: *Distinguishing characteristics of true wireworms.*

Source: cesar

Biology

There may be one or several generations per year, depending on the species. Wireworms prefer low-lying, poorly drained paddocks and are less common in dry soils. Larvae are reasonably mobile through the soil, and will attack successive seedlings as they emerge. Most damage occurs from April to August. Adults emerge in spring, and are typically found in summer and autumn in bark, under wood stacks or flying around lights.

There is little known of the biology of most species, although one species (*Hapatesus hirtus*) is better understood. It is known as the potato wireworm although it is found in many other crops and pastures, as well as in potatoes. It is very long-lived and probably takes five years or more to pass through all the growth stages before pupating and finally emerging as an adult beetle.

After emerging, adult click beetles mate and lay eggs, and then may spend a winter sheltering under the bark of trees. The connection between trees and adult beetles is probably why damage is often, but not always, most pronounced along tree lines. The wireworms have a long life in the soil and are active all year, even in winter.

85 B Kimber (2015) True wireworm. cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/True-wireworm

Damage

The damage caused by wireworms is similar to that of false wireworms, except that most of it is restricted to below the soil surface. Larvae eat the contents of germinating seeds, and the underground stems of establishing plants, causing wilting and death.

7.11.3 Sampling and detection of wireworms

The principles for detection and control of false and true wireworms are generally similar, although different species may respond slightly differently according to soil conditions.

Sampling

Paddocks should be sampled immediately before sowing. There are two methods, although neither is 100% reliable. This is because larvae change their behaviour according to soil conditions, particularly soil moisture and temperature. The two methods are:

- Soil sampling—take a minimum of five random samples from the soil. Each sample should consist of the top 20 mm of a 0.50 m x 0.50 m area. Carefully inspect the soil for larvae. Calculate the average density per square metre by multiplying the average number of larvae found in the samples by 4. Control should be considered if the average exceeds 10 small false wireworms, or 10 of the larger false wireworms.
- Seed baits—these have been used successfully to sample true and false wireworms in Queensland and overseas. Preliminary work has shown that they can be used to show the species of larvae present, and to give an approximation of density. Take 200–300 g of a large seed (e.g. any grain legume) and soak for 24 hours. Select 5–10 sites in the paddock and place a handful of the soaked seed into a shallow, 50 mm hole, and cover with about 10 mm of soil. Mark each hole with a stake, and excavate each hole after about seven days. Inspect the seed and surrounding soil for false wireworm larvae. This technique is most likely to be successful when there is some moisture in the top 100 mm of soil.

Detection

Larvae of the small false wireworms are relatively difficult, although not impossible, to see in grey and black soils because of their small size and dark colour. However, they can be found in the top 20 mm of dry soil by carefully examining the soil in full sun. Larvae of the other false wireworm species are more prominent because of their relatively pale colour and large size.

7.11.4 Control

Crop residues and weedy summer fallows favour survival of larvae and over-summering beetles. Clean cultivation over summer will starve adults and larvae and expose them to hot, dry conditions, thus preventing population increases. Suitable crop rotations may also limit increases in population numbers.

Seedbeds must be sampled before sowing if control is to be successful. Insecticides may be applied to soil or seed at sowing. Most chemicals registered to control false wireworm are seed treatments, although these may not be consistently reliable. They probably work best when the seedling grows rapidly in relatively moist soils. Adults may also be controlled with insecticide incorporated into baits. If damage occurs after sowing, no treatment is available other than re-sowing bare patches with an insecticide treatment. The critical periods for control of false wireworm are shown in Photo 18. [86]

86 G McDonald (1995) Wireworms and false wireworms. Note AG0411. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/wireworms-and-false-wireworms

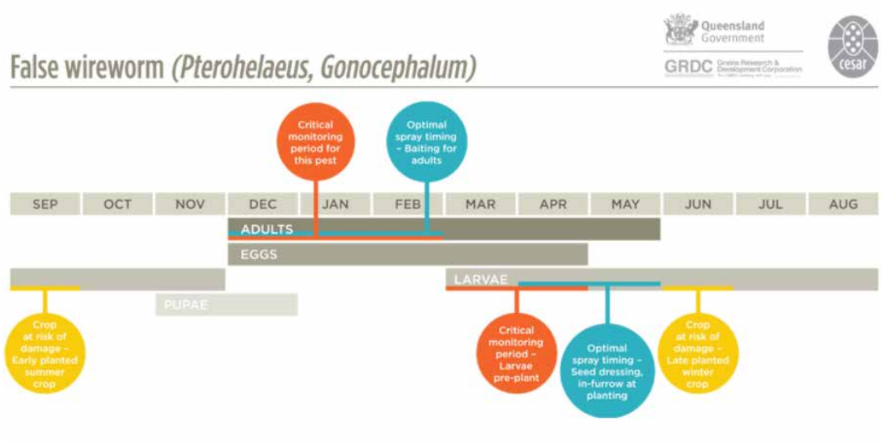

Figure 18: *Critical periods for controlling false wireworms.*

Source: cesar

For up to date information for chemical registrations, see the APVMA website.

MORE INFORMATION

False wire worms in seedling crops