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CHICKPEA

SECTION 7

INSECT CONTROL

KEY INTEGRATED PEST MANAGEMENT (IPM) STRATEGIES FOR CHICKPEAS | PEST MANAGEMENT PROCESS | LEGAL CONSIDERATIONS OF PESTICIDE USE | NATIVE BUDWORM

Insect control

Key messages

- Native budworm (*Helicoverpa punctigera*) is a major pest of pulse crops in the south west of Western Australia.
- Chickpea is highly susceptible to native budworm. Crops need to be monitored from flowering through to pod fill. Small grubs less than 1 cm are damaging. Economic threshold for control can be as low as 1 grub per 10 sweeps of a sweep net.
- The crop will need to be sprayed with an appropriate insecticide if caterpillars are present and pods have started to form.
- Regular monitoring will help determine whether the crop needs to be sprayed. An insecticide application will be necessary if one caterpillar is found in 10 sweeps of the crop. Sweeps should be made while walking through the paddock and consist of a standard sweep of around two metres, sampling the top 15 cm of the crop canopy.
- Synthetic pyrethroids are most effective for native budworm control and will prevent reinfestation for up to six weeks after application.
- Chickpeas are less susceptible to red legged earth mite, lucerne flea and aphids than other pulses, though these pests should be monitored and controlled. [1]

Chickpea has only one major pest, the native budworm caterpillar *Helicoverpa punctigera*. Caterpillars do most damage at pod set through to maturity, and can reduce both grain yield and quality (Table 1).

Insects other than native budworm are rarely a problem in chickpeas post establishment. Chickpeas secrete an organic acid (malic acid) from hairs on their leaves, stems and pods, making the crop unattractive to insects.

Seedlings are most vulnerable to damage:

- before they develop three to four 'true' leaves;
- during periods of moisture stress; and
- when other factors such as low soil temperature or soil compaction limit plant growth.

Table 1: *Chickpea crop stage vulnerability to insect pests.*

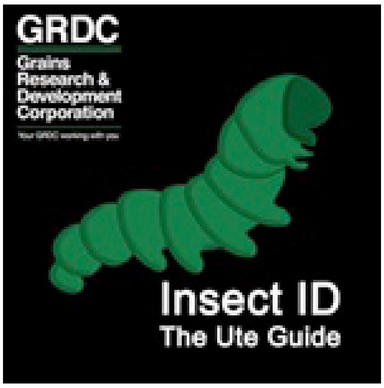
Pest	Crop stage				
	Emergence/ Seedling	Vegetative	Flowering	Podding	Grainfill
RLEM	Damaging	Present	Present		
Lucerne flea	Damaging				
Cutworms	Damaging				
Aphids	Damaging	Present	Present		
Thrips	Present	Present	Present		
Native budworm		Present	Present	Damaging	Damaging

Present: Insect pest present in crop but generally not damaging
Damaging: Crop susceptible to damage and loss caused by insect pest

Source: IPM Guidelines

1 DAFWA. Production packages for kabuli chickpea in Western Australia—post planting guide. https://www.agric.wa.gov.au/chickpeas/production-packages-kabuli-chickpea-western-australia-post-planting-guide

Insect ID: The Ute Guide



The Insect ID Ute Guide is a comprehensive reference guide for insect pests commonly affecting broadacre crops and growers 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. [2]

App Features:

- Region selection.
- Predictive search by common and scientific names.
- Compare photos of insects side by side with insects in the app.
- Identify beneficial predators and parasites of insect pests.
- Opt to download content updates in-app to ensure you are aware of the latest pests affecting crops for each region.
- Ensure awareness of international bio-security pests.

Insect ID, The Ute Guide is available on Android and iPhone.

7.1.1 Key Integrated pest management (IPM) strategies for chickpeas

- Tolerate early damage. Chickpeas can compensate for early damage by setting new buds and pods to replace those damaged by pests. Excessive early damage can reduce yields and delay harvest.
- Damage to pods is of more concern than damage to the plant. The grubs chew holes into the soft pod and feed on the developing and filling seed. Yield loss will occur at larval densities lower than those causing a reduction in grain quality (% defective seed). This is because *Helicoverpa* consumes most of a chickpea seed—the remaining damaged seed is generally lost during harvest.
- Monitor larval infestations as mortality of small larvae can be high. Refer to records from successive checks to help interpret check data and make decisions about the need for, and timing of, control.
- Aim for one well-timed spray: chickpea can tolerate moderate to high numbers of native budworm larvae (10–20 larvae/m^2) through late vegetative and early flowering stages. Yield loss is sustained from damage at pod fill—the most critical stage for protecting the crop.
- Post-treatment checks are critical to determine efficacy and possible reinfestation prior to harvest. [3]
- Chickpea is unique in that it does not host significant numbers of beneficial insects. Small numbers of parasitic flies (tachinids) have been recorded on

2 Insect ID, The Ute Guide: https://grdc.com.au/Resources/Apps

3 GRDC. IPM Guidelines. Chickpea—Southern region. http://ipmguidelinesforgrains.com.au/crops/winter-pulses/chickpea-southern-region/

chickpea, but little else. Therefore, in relation to IPM, there are no in-crop management opportunities via beneficial insects.

7.2 Pest management process

Figure 1 outlines the steps in the pest management process.

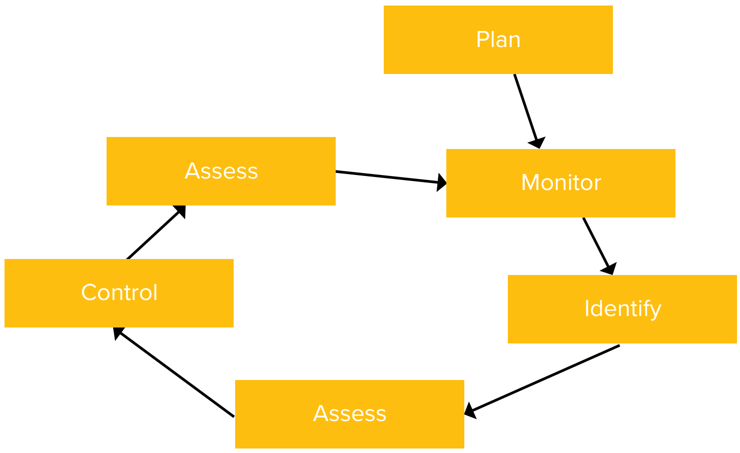


Figure 1: *Pest management process.*

1. Planning
- Be aware of which pests are likely to attack the crop in your region and become familiar with when to monitor for particular pests, what the pests look like, and damage symptoms.
- Assess sampling protocols and plan how you will cope with the logistics of sampling.
- Be aware of the latest management options, pesticide permits and registrations in chickpeas, and any use and withholding-period restrictions.

2. Monitoring
- Scout crops thoroughly and regularly during 'at-risk' periods, using the most appropriate sampling method.
- Record insect counts and other relevant information with a consistent method to allow comparisons over time.

3. Correct identification of insect species
- Identify the various insects present in your crop, whether they are pests or beneficial species, and their growth stages.
- Identify the different larval instars of *Helicoverpa* (very small, small, medium, large).
- Other minor pests of chickpeas should be recorded. These might include locusts, aphids, cutworms, false wireworms, thrips and loopers.

4. Assessing options
- Use the information gathered from monitoring to decide on the control action (if any) required.
- Make spray decisions based on economic threshold information and your experience. Other factors such as insecticide resistance and area-wide management strategies may affect spray recommendations.

5. Controlling

- Ensure that your aerial operators and ground-rig spray equipment are calibrated and set up for best practice guidelines.
- If a control operation is required, ensure that application occurs at the appropriate time of day.
- Record all spray details, including rates, spray volume, pressure, nozzles, meteorological data (relative humidity, temperature, wind speed and direction, inversions and thermals) and time of day.

6. Re-assessing and documenting results

- Assess crops after spraying and record data for future reference.
- Post-spray inspections are important in assessing whether the spray has been effective, i.e. if pest levels have been reduced below the economic threshold. [4]

7.3 Legal considerations of pesticide use

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 about which pesticide to use. This information is available from state government department chemical standards branches, chemical resellers, the Australian Pesticide and Veterinary Medicine Authority (APVMA), and the pesticide manufacturer.

This section provides background to some of the legal issues surrounding insecticide usage, but it is not exhaustive. Specific questions should be followed up with the appropriate staff from your local state department.

7.3.1 Registration

All pesticides go through a process called registration, where they are formally authorised (registered) by APVMA for use:

- against specific pests;
- at specific rates of product;
- in prescribed crops and situations;
- where risk assessments have evaluated that these uses are:
- effective (against the pest, at that rate, in that crop or situation), and
- safe, in terms of residues not exceeding the prescribed maximum residue level (MRL); and
- not a trade risk.

7.3.2 Labels

A major outcome of the registration process is the approved product label—a legal document that prescribes the pest and crop situation in which a product can be legally used, and how.

MSDS

Material Safety Data Sheets are also essential reading. These document the hazards posed by the product, and the necessary and legally enforceable handling and storage safety protocols.

Permits

In some cases a product may not be fully registered but is available under a permit with conditions attached, which often requires the generation of further data for eventual registration.

4 Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

Always read the label

Apart from questions about the legality of such an action, the use of products for purposes or in manners not on the label involves potential risks. These risks include reduced efficacy, exceeded MRLs and litigation. Pesticide-use guidelines are on the label to protect product quality and Australian trade by keeping pesticide residues below specified MRLs.

Residue limits in any crop are at risk of being exceeded or breached where pesticides:

- are applied at rates higher than the maximum specified;
- are applied more frequently than the maximum number of times specified per crop;
- are applied within the specified withholding period (i.e. within the shortest time before harvest that a product can be applied); or
- are not registered for the crop in question. [5]

7.4 Native budworm

The native budworm (*Helicoverpa punctigera* or, as it was known, *Heliothis punctigera*) is indigenous to Australia and is distributed, particularly during spring, throughout much of the central and southern regions of the country. Native budworm is a major pest of pulse and canola crops in the south west of Western Australia and can develop large populations over extensive areas on native plants. In 2014 large populations swept through the southern wheatbelt, found in pulse and canola crops from Boyanup to Kojonup and Esperance. [6] These populations often migrate into agricultural regions in late winter and spring, causing damage to crops. Migratory flights are unpredictable, as moths may be carried hundreds of kilometres from breeding areas by high altitude air currents.

Effective control requires understanding when the crop is at risk and the economic threshold for when to spray. In terms of production losses, chickpeas, field peas, lentils, faba beans, tomatoes and lucerne are probably the most important hosts. [7]

Eggs

Budworm eggs can be found singly on the growing tips and buds of plants. They are small (about 0.5 mm in diameter) but quite visible to the naked eye on close inspection of the plant. They are white when first laid but change colour to yellow and brown as they get closer to hatching (Figure 2).

5 Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

6 DAFWA (2014) Native budworm sweeps southern wheatbelt. https://www.agric.wa.gov.au/news/media-releases/native-budworm-sweeps-southern-wheatbelt

7 DAFWA. Management and economic thresholds for native budworm. https://www.agric.wa.gov.au/grains/management-and-economic-thresholds-native-budworm

Figure 2: *Left to right: fresh white, brown ring and black larval head in nearly hatching eggs.*

Source: QDAF

Larvae/caterpillars

The newly hatched caterpillars (larvae) are very small and are often easily missed when inspecting a crop. When first hatched, they are about 1.5 mm long with dark brown heads and white bodies. The young caterpillars feed on leaf or pod material for about two weeks before they become large enough (5 mm long) to be noticed in the crop.

It takes a further four weeks until they are fully grown (40 mm long), which is about seven weeks from the time of egg laying.

These development times are based on average spring temperatures when caterpillars are active in central cropping areas of Western Australia. Later in the season, or in more northerly areas, developmental rates for caterpillars will be faster.

The caterpillars vary greatly in colour from green through orange to dark brown and are often seen with their heads inside pods. They usually have dark stripes along the body and are sparsely covered with fine bristles. [8]

During full development they will pass through six or seven growth stages, or instars, until they are 35 to 40 mm long (Figure 3).

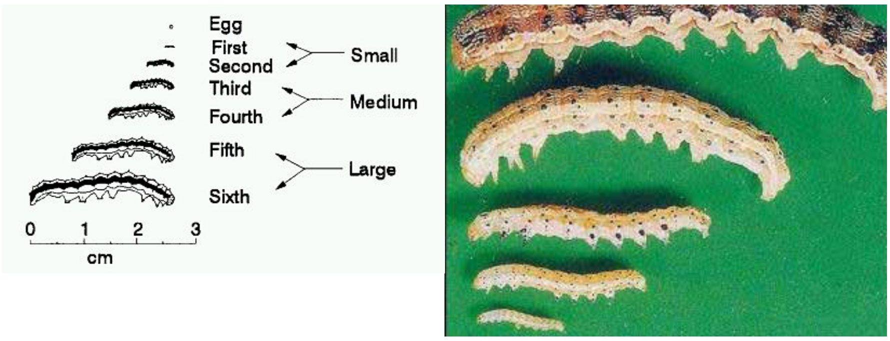


Figure 3: *Approximate instar sizes of the budworm.*

Source: Agriculture Victoria, DAFWA

When fully grown, their colour ranges from green, yellow, buff, red or brown to almost black, with a broad yellow-white stripe down each side of the body and a dark stripe down the centre of the back. The skin of the caterpillars feels rough to touch, due to long dark hairs on prominent bumps on the body surface (Figures 4 and 5).

8 DAFWA. Management and economic thresholds for native budworm. https://www.agric.wa.gov.au/grains/management-and-economic-thresholds-native-budworm

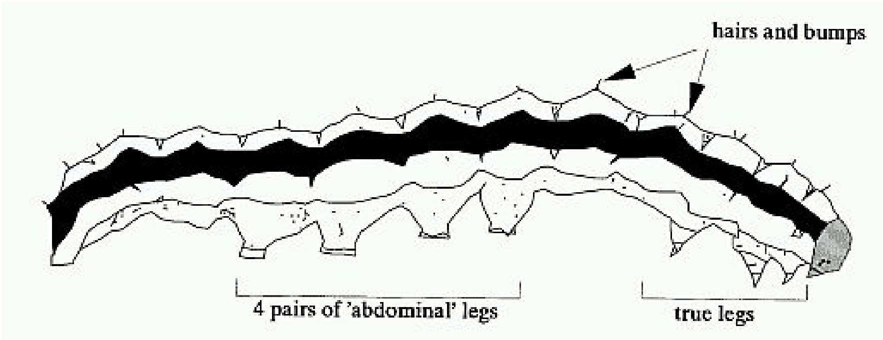


Figure 4: *Distinguishable features of native budworm larva.*

Source: Agriculture Victoria

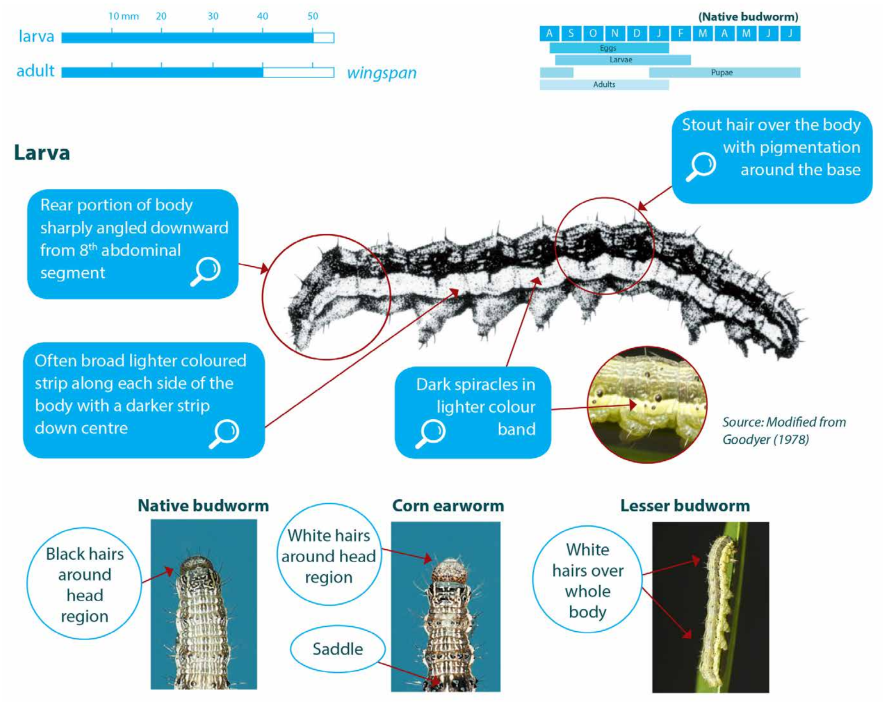


Figure 5: *Distinguishing characteristics/description of native budworm*

Source: cesar - Bellati *et al.* 2012

New moth flights and egg laying will result in caterpillars of varying sizes in a crop. Caterpillars eat increasing quantities of seed and plant material as they grow, with the last two growths stages (fifth and sixth instar) responsible for eating over 90% of their total grain consumption.

Pupa

When fully mature, the caterpillars crawl to the ground, burrow from 20–150 mm in depth into the soil, and pupate. Pupae are cigar-shaped, 12–22 mm long, and during development change in colour from a yellow-orange to a shiny dark brown. The length of the pupal stage depends on several environmental factors and varies from two weeks to several months.

Adult

Adult moths are medium-sized (wingspan 30–40 mm) and stout-bodied. The forewings are buff-olive to red-brown with numerous dark spots and blotches (Figures 6 and 7). The hind wings are pale gray with dark veins and a dark band along the lower edge. Moths are usually active during the evening and night.

Figure 6: *Native budworm larvae showing prominent hairs (left) and buff coloured adult (right)*

Source: cesar

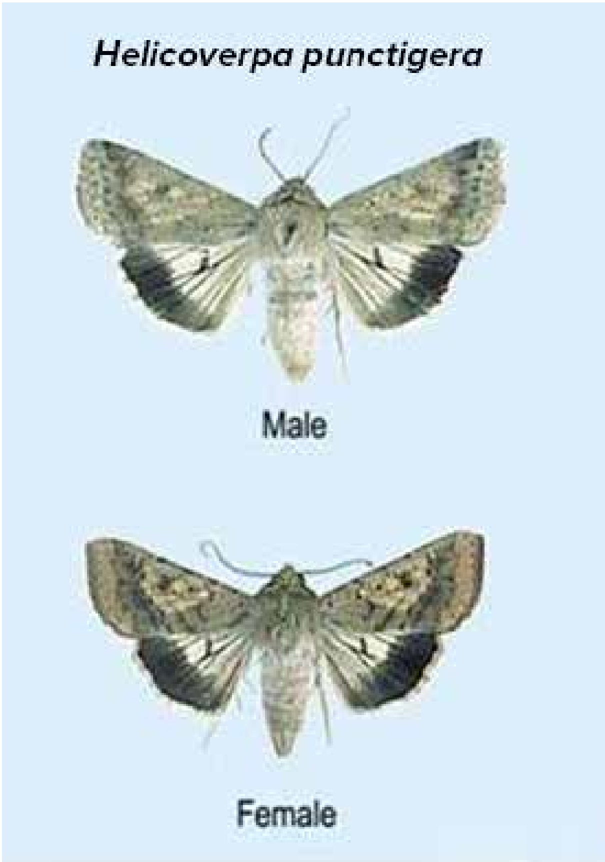


Figure 7: *Helicoverpa punctigera male (top) and female (bottom).*

Source: GRDC

Mortality of eggs and caterpillars

Only a small proportion of eggs laid by moths survive to the damaging large caterpillar stage. Eggs may be dislodged and small caterpillars may become stuck or drown due to wet weather.

Predators and parasitoids also affect population numbers and can suppress them below economic damage thresholds. If numbers of native budworm are high, populations can crash due to viruses and disease. [9]

9 DAFWA. Management and economic thresholds for native budworm. https://www.agric.wa.gov.au/grains/management-and-economic-thresholds-native-budworm

7.4.1 Varietal resistance or tolerance

Crops vary in their attractiveness to moths as sites for egg laying. Crop density and crop growth stage (flowering and podding) will affect the number of eggs laid by the native budworm moths. The feeding behaviour of caterpillars also changes according to the type of crop the caterpillars are feeding upon.

Chickpea, field pea, lentil and faba bean crops:

- Are very susceptible to all sizes of caterpillars during the formation and development of pods.
- Tiny caterpillars can enter emerging pods and damage developing seed or devour the entire contents of the pod.

7.4.2 Damage caused by native budworm

Native budworm caterpillars most frequently attack the fruiting parts of plants (Figure 8) but also feed on the terminal growth, flowers and leaves. All pulse crops grown in Western Australia are susceptible to attack, especially when pods are present. This includes chickpea, field pea, faba bean, lentil, lupin and canola.

Figure 8: *Large helicoverpa larva feeding on a chickpea pod.*

Source: QDAF in CropIT

Cost of native budworm

Losses attributed to native budworm come from direct weight loss through seeds being wholly or partly eaten. Grain quality may also be downgraded through unacceptable levels of chewed grain or fungal infections introduced via caterpillar entry into pods. The percentage of broken, chewed and defective seed found in grain samples affects the final price of pulse crops marketed for human consumption. This applies particularly to the large-seeded crops such as kabuli chickpea, faba bean, lentil and field pea. [10]

10 DAFWA. Management and economic thresholds for native budworm. https://www.agric.wa.gov.au/grains/management-and-economic-thresholds-native-budworm

7.4.3 Conditions favouring development

Native budworm is the major pest of grain legumes in spring (Table 2). At this time of year, the adult moths fly from inland breeding areas, on weather systems, and lay eggs in pulse and canola crops. Early spring is the time when grain growers should be checking all pulse and canola crops for native budworm eggs and larvae as crops reach the susceptible flowering and podding stages.

Table 2: *Conditions leading to risk of damage and loss from native budworm in chickpeas.*

High risk	Moderate risk	Low risk
Wet winters in breeding areas of central Australia + suitable weather conditions that bring moths in spring migrations. Repeated influxes of moths over long periods, resulting in need for continuous monitoring and potentially repeat infestations.	Broadleaf weeds hosting cutworm and helicoverpa that move into the crop as large, damaging larvae. Hot weather in spring can cause small larvae to burrow into pods. Wet harvest weather resulting in pods that are 'softer' for longer and susceptible to damage right up to harvest.	Dry winters in breeding areas. Low source population. Absence of frontal wind systems that provide opportunities for migration.

Source: IPM Guidelines

Species composition in the crop will be influenced by a number of factors, such as:

- Winter rainfall in inland Australia, which drives populations of *H. punctigera*, and the occurrence and timing of wind systems that carry *H. punctigera*.
- Relative timing of flowering–podding (attractive and susceptible) stages and the immigration of *H. punctigera* and emergence of *H. armigera* from overwintering diapause.
- Geographic location. In temperate regions, most of the *H. armigera* population overwinters from mid-March onwards and emerges during September–October. *H. punctigera* is usually the dominant species through September when moths are migrating into eastern cropping regions. Seasonal variation can lead to *H. armigera*-dominant early infestations in some years. [11]

7.4.4 Thresholds for control

Thresholds depend on crop value, cost of control and tolerance of feeding damage.

Suggested thresholds (check 5–10 sites) are:

- Chickpea (Kabuli): 2–3 larvae in 10 sweeps.
- Chickpea (Desi): 5 larvae in 10 sweeps (note that this threshold is subject to crop pricing).

Threshold tables

The number of caterpillars present in a crop is the major factor determining whether economic damage will occur. Results from many trials conducted by DAFWA have been used to generate Figure 9 to give a personalised and more precise measure of potential loss from native budworm damage.

Crop loss (kg per hectare) for each caterpillar netted in 10 sweeps (or found per m^2) is shown in Figure 9. For one caterpillar netted in 10 sweeps is equivalent to about 20,000 caterpillars per hectare for most pulse crops.

11 M Miles (2013) Chickpea insect pest management. Department of Agriculture, Fisheries and Forestry, Queensland, http://ipmworkshops.com.au/wp-content/uploads/Chickpea_IPM-Workshops_north-March2013.pdf

The losses given in Figure 9 are for the number of caterpillars netted in crops during early pod formation for all crops except lupins and canola.

To use the table you need to substitute:

- control costs with your own actual costs;
- expected grain price per hectare based.

This will calculate the economic threshold or the number of caterpillars that will cause more financial loss than the cost of spraying.

The on-farm value of field peas is $185 per tonne (t)
The cost of control is $12 per hectare (ha)

ET = C ÷ (K x P)
Where:
ET = Economic threshold (numbers of grubs in 10 sweeps)
C = Control cost (includes price of chemical + application) ($ per ha)
K = Kilogram per hectare (ha) eaten for every one caterpillar netted in 10 sweeps or per square metre (see Table 2)
P = Price of grain per kg (price per tonne ÷ 1000)

Therefore economic threshold for field pea = 12 ÷ (50 x (185 ÷ 1000)) = 1.3 grubs per 10 sweeps

Figure 9: *Example to calculate the economic threshold or the number of caterpillars that will cause more financial loss than the cost of spraying.*

Source: DAFWA

Economic thresholds for the control of native budworm in chickpea crops is given in Table 3.

Table 3: *Economic thresholds (ET) for native budworm on chickpeas.*

P Grain price per tonne	C Control costs including chemical + application	K Loss for each grub in 10 sweeps (kg/ha/grub)	ET Grubs in 10 sweeps	ET Grubs in 5 lots of 10 sweeps	ET Grubs (>15 mm) per m^2
420	10	30	0.8	4	-

Note: Growers using this table to calculate spray thresholds should substitute their own control costs and the current on-farm grain price expected.

Where:
ET = Economic threshold (numbers of grubs in 10 sweeps)
C = Control cost (includes price of chemical + application) ($ per ha)
K = Kilogram per hectare (ha) eaten for every one caterpillar netted in 10 sweeps or per square metre
P = Price of grain per kg (price per tonne ÷ 1000).

Source: DAFWA

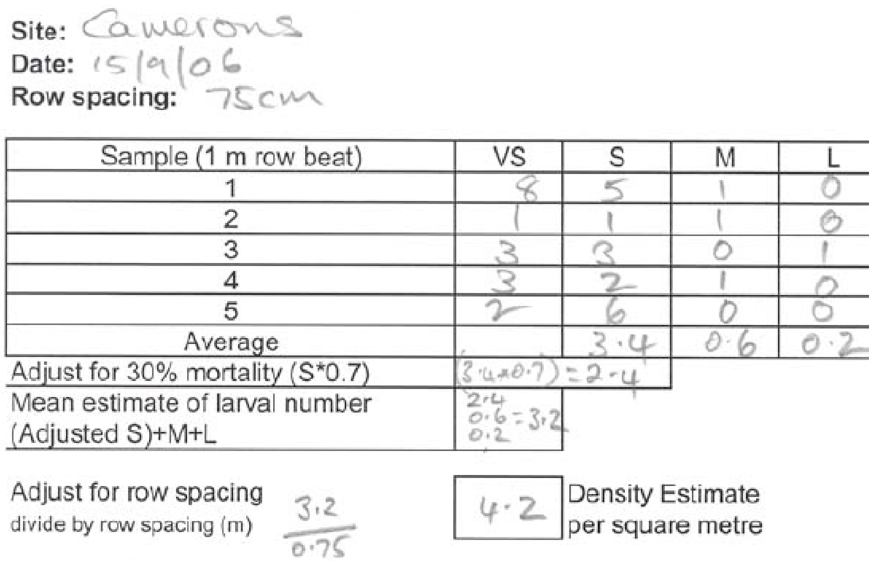
The ready-reckoner table (Table 4) works for a range of larval densities, and crop prices. Putting a dollar value on the predicted yield loss if nothing is done to control the *Helicoverpa* infestation is a useful way to assess the economic benefit (or otherwise) of spraying.

Table 4: *The value of yield loss ($/ha) caused by Helicoverpa larvae in chickpea for a range of larval densities (determined by beat sheet sampling) and grain prices.* [12]

Chickpea price ($/t)	1 larva/m^2	2 larva/m^2	3 larva/m^2	4 larva/m^2	5 larva/m^2
200	4	8	12	16	20
300	6	12	18	24	30
400	8	16	24	32	40
500	10	20	30	40	50
600	12	24	36	48	60

NOTE: Control is warranted if the cost of control is less than the value of the yield loss predicted.

In Figure 10, the field has an average of 4.2 larvae per m^2 (adjusted for mortality of small larvae). Assuming a chickpea price of $400/t, the table of potential yield loss (refer to Table 4) shows the cost of not controlling to be $32/ha. In this example, if the cost of control is less than $32/ha then it is economic to spray.


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 10: *Example of a field check sheet with sampling data recorded for Helicoverpa larvae in chickpea.*

Source: DAFF

Adjusting thresholds

Use of the table and calculations will provide a personalised and more precise measure of potential loss from native budworm damage. Sometimes the loss would turn out to be less than predicted, if, for example, the season is shortened by a lack of moisture.

Premiums paid for exceeding quality standards for high value and large-seeded pulses (like Kabuli chickpea) may necessitate even lower thresholds than those provided in the table. [13]

7.4.5 Making a decision to control

Several factors (in addition to number of larvae) will influence a decision on whether to spray, timing and product choice:

12 M Miles (2013) Chickpea insect pest management. Department of Agriculture, Fisheries and Forestry, Queensland, http://ipmworkshops.com.au/wp-content/uploads/Chickpea_IPM-Workshops_north-March2013.pdf

13 DAFWA. Management and economic thresholds for native budworm. https://www.agric.wa.gov.au/grains/management-and-economic-thresholds-native-budworm

- Age structure of the larval population may need to be considered in relation to time to desiccation or harvest. For example, a late egg-lay is unlikely to result in economic damage if the crop is 7–10 days away from harvest.
- Proportions of *H. punctigera* making up the total population are important and can be determined by visual identification, time of year, pheromone trap catches and local experience.
- Spray conditions and drift risk must be considered.
- Information on insecticide options, resistance levels for *Helicoverpa* and recent spray results in the local area should be sought.
- Residual of the products may have implications.

Selecting control options

Growers depend on insecticides for the management of *Helicoverpa* in chickpea, and the high usage of a limited group of compounds against successive pest generations imposes severe selection pressure. Invariably, selection is for individuals in a population that are not killed by normal application rates of insecticides. With continued insecticide application, the frequency of resistant individuals in the population increases, leading to field-control failures.

The potential for natural enemies of *Helicoverpa* (predators, pathogens and parasitoids) to limit the development of damaging populations of larvae—while typically low in chickpea—may also influence product selection.

'Spray small or spray fail'

Spraying should be carried out promptly once the threshold has been exceeded. Insects grow rapidly under warm spring conditions, and a few days' delay in spraying can result in major crop damage and increased difficulty in control.

If a spray application is delayed for more than two days, for any reason, the crop should be rechecked and reassessed before any control action is implemented. [14]

7.4.6 Management of helicoverpa

Monitoring

All crops should be scouted weekly during flowering for moth activity and eggs, then at least two times per week during pod-fill for eggs and larvae. The main egg-laying period is often around the flowering period when moths can be quite abundant. Eggs can often be found on the vegetative or floral growing points, new leaves, stems, flowers, flower buds and young pods. They may not be obvious to the untrained eye unless there is a heavy egg-lay or until small larvae can be found. [15]

Sampling of crops to determine the abundance of caterpillars is essential. Light traps & pheromone traps can indicate presence of adults in spring. Monitor crops 1–2 weekly until podset, then increase frequency when moths and/or larvae are detected:

- Use beat sheet (wide rows), sweep net (narrow rows) and/or visual sampling (Figure 11). Where border sprays were used to control pea weevil, start sampling well into the crop.
- Look for eggs on leaves, buds and flowers. Start looking for eggs in mid-August or when the crops start flowering and moths are detected.
- Repeat sampling at 5–10 sites across the field; more sites give greater level of confidence.
- Assess pod burrowing by looking for holes and splitting open 20–40 pods and look for larval damage.
- Record number, sizes, and crop development stage. Record /m^2 to compare numbers with appropriate thresholds. In southern grain regions, average

14 M Miles (2013) Chickpea insect pest management. Department of Agriculture, Fisheries and Forestry, Queensland, http://ipmworkshops.com.au/wp-content/uploads/Chickpea_IPM-Workshops_north-March2013.pdf

15 Bray T (2010) Managing native budworm in pulse crops. Pulse Australia, Southern Pulse Bulletin PA 2010 #18, http://www.pulseaus.com.au/storage/app/media/crops/2010_SPB-Pulses-native-budworm.pdf

number of caterpillars per 10 sweeps of an insect sweep net is the standard for comparison and thresholds.

The quickest and easiest method to sample most crops is to sweep with an insect net, taking 2 m long sweeping arcs, using the standard net size (380 mm diameter).

Multiples of 10 sweeps should be taken in several parts of the crop. If more than 10 consecutive sweeps are made, there are likely to be too many dead flowers and leaves in the sample to locate the small caterpillars easily.

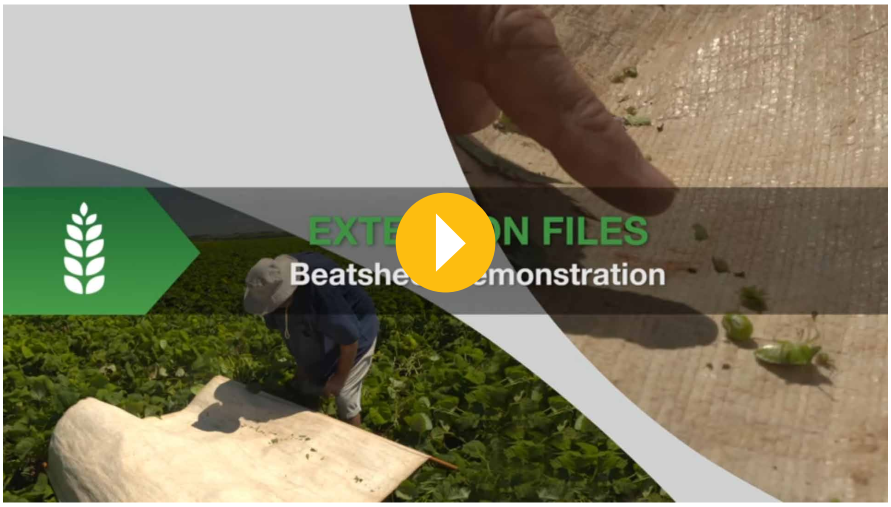
Netting is most efficient in short and thin crops and less efficient in tall dense crops. It is very important to keep the lower leading edge of the sweep net slightly forward of the net opening, so that dislodged grubs are picked up and carried into the net.

Figure 11: *Sweep-netting a chickpea crop (left) and use of a beatsheet (right).*

Source: DAFWA and The Beatsheet

In years of large moth influxes or wet springs where crops continue to flower/pod, monitoring should continue until pods are dry and no longer able to be penetrated by larvae.

WATCH: GCTV16: Extension files – IPM Beatsheet Demo.



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

How to use a beat sheet

Place the beat sheet with one edge at the base of a row. On 1 m row spacing, spread the sheet out across the inter-row space and up against the base of the next row. Draping over the adjacent row may be useful for row spacing less than 1 m, or where there is canopy closure. It also minimises the chance of larvae being thrown off the far side of the sheet. With a 1 m long stick (dowel, heavy conduit), shake the row vigorously 10 times to dislodge larvae from the plants. Measure and count larvae on the sheet. A standard beat sheet is made from plastic or tarpaulin material with heavy dowel on each end to weigh down the sheet. The beat sheet is typically 1.3 m wide by 1.5 m long. The extra 0.15 m on each side catches insects thrown out sideways.

Using a sweep net to monitor Helicoverpa

A standard sweep net has a cloth bag and an aluminium handle. With heavy use, the aluminium handle can shear off; more robust, wooden handles are often fitted by agronomists.

Where crops are sown on narrow row spacings and it is not possible to get a beat sheet between the rows, a sweep net can be used to sample *Helicoverpa*. Hold the sweep net handle in both hands and sweep it across in front of your body in a 180° arc. Take a step with each sweep. Keep the head of the net upright so the bottom of the hoop travels through the canopy. Use sufficient force in the sweep to pass the hoop through the canopy and dislodge larvae. Take 10 sweeps and then stop and check the net for larvae. Record the number and size of larvae in each set of 10 sweeps. Repeat at additional sites across the field. [16]

Monitoring for adult moths

Male moths are easily captured in pheromone (female sex scent) traps (Figure 12). These traps are maintained by Department of Agrilculture and Food, Western Australia (DAFWA) staff and volunteer farmers and provide an early warning of moth arrival and abundance.

Results from native budworm traps together with other pest and disease alerts are published weekly throughout the growing season in PestFax. The PestFax newsletter is distributed via email and requests for free subscription can be sent to pestfax@agric.wa.gov.au.

16 M Miles (2013) Chickpea insect pest management. Department of Agriculture, Fisheries and Forestry, Queensland, http://ipmworkshops.com.au/wp-content/uploads/Chickpea_IPM-Workshops_north-March2013.pdf

Figure 12: *Pheromone trap used for detecting moths.*

Source: Pulse Australia

Pheromone trap catches—data updates

Stay up to date with native budworm numbers in your local areas. Weekly trap catch data for *H. punctigera* and *H. armigera* from locations across all states can now be viewed online. The adjustable bar below the map allows selection of a time period (1 week, 2 weeks, 1 month etc.). [17]

Recording of monitoring data for decision-making

Keeping records should be a routine part of insect checking. Successive records of crop inspections will show whether pest numbers are increasing or decreasing, and will help in deciding whether a control is necessary.

Records of insect checking should include as a minimum:

- date and time of day
- crop growth stage
- average number of pests detected, and their stage of development
- checking method used and number of samples taken
- management recommendation (economic threshold calculation)
- post spray counts

The *Helicoverpa* size chart (Table 5) is an essential reference for decision-making, particularly in chickpea where larval size is taken into account in the economic threshold (beat sheet threshold), and is important in ensuring that any control action is well targeted against susceptible larvae.

Eggs and very small larvae are not included in the economic threshold for *Helicoverpa* (beat sheet threshold) due to high natural mortality.

17 The Beatsheet. https://jamesmaino.shinyapps.io/MothTrapVis/

Table 5: *Helicoverpa larval size categories and actual sizes.*

Helicoverpa larval size categories and actual sizes		
Actual larval size	**Larval length (mm)**	**Size category**
	1-2 mm	very small
	4-7	small
	8-23	medium
	24-30+	large

Source: IPM Guidelines for Chickpeas)

Chemical control

Key points:

- Aim to control larvae before they enter pods—target small larvae less than 7 mm.
- Synthetic pyrethroids are very effective but their broad spectrum activity has a negative impact on any beneficial insects present.
- Commercially available NPV gives up to 80% control in chickpeas.
- Bt (*Bacillus thuringiensis*) is a naturally occurring bacteria which produces spores that contain a toxin. It is effective against *Helicoverpa,* but can be broken down in high light intensity conditions.
- There is usually a range of rates on the insecticide label to allow for varying conditions such as the size of the caterpillars. The choice of rate should not be solely driven by the lowest price. Also consider the impact of chemical use on other pests and beneficial species.
- Inspect crops after spraying to ensure chemical applications have been effective and to detect further infestations until the crop is no longer susceptible. [18]

The decision to spray for chickpea needs to be considered from the time of first podding.

If caterpillar numbers are below the threshold levels provided, the decision to spray should be delayed and periodic sampling continued. One well-timed spray to control native budworm caterpillars should be sufficient in most situations.

Sweep netting of the crop should be carried out after spraying to confirm that the required level of control has been obtained. One well-timed spray with a synthetic pyrethroid should prevent reinfestation for up to six weeks after spraying. Late season hatchings are often too late to cause economic damage. [19]

Synthetic pyrethroid insectides are very effective but their broad spectrum activity impacts negatively on beneficial insects. [20]

Refer to the beneficial impact table for more information.

There are several insecticides registered for the control of native budworm. Timing and coverage are both critical to achieving good control. Try to target small larvae up to 7 mm in length and apply insecticides before larvae move into flowering pods. IPM options include the use of Bt (*Bacillus thuringiensis*) and nuclear polyhedrosis virus (NPV)-based biological insecticides. Small larvae are generally easier to control because they are more susceptible to insecticides, and leaf feeding makes them susceptible to ingestion of active residues on the plant surface. Larvae entrenched in buds and pods will be more difficult to control and chemical residual will be important in contacting them.

18 GRDC, IPM Guidelines. Native budworm in winter pulses. http://ipmguidelinesforgrains.com.au/pests/helicoverpa/native-budworm-in-winter-pulses/

19 DAFWA. Management and economic thresholds for native budworm. https://www.agric.wa.gov.au/grains/management-and-economic-thresholds-native-budworm

20 GRDC. Budworm in Western Australia. https://grdc.com.au/Media-Centre/Hot-Topics/Budworm-in-Western-Australia

The crop should be re-inspected 2–4 days after spraying to ensure enough caterpillars have been killed to prevent future damage and economic loss. In years of very high moth activity and extended egg lays, a second spray may be required. [21]

Be aware of insecticide withholding periods (WHP) close to harvest and remember that windrowing is classified as harvest.

Many traditional pyrethroid insecticides (e.g. alpha-cypermethrin) have a 21-day WHP in canola, however there are newer generation pyrethroids available (e.g. Trojan®or Karate®) with a shorter 7-day WHP. [22]

Unlike other parts of Australia or overseas where *Helicoverpa armigera* is abundant (the cotton bollworm or corn earworm), the control of native budworm poses no great problem in southern winter-growing areas of WA. There is no known resistance to chemicals, and temperatures during the growing season do not allow for a high level of activity until the crop is podding.

Biological control

A key component to any IPM is to maximise the number of beneficial organisms and incorporate management strategies that reduce the need for pesticides. Correct identification and monitoring is the key when checking for build up or decline in beneficials. There are many natural enemies that attack native budworm. The egg stage is susceptible to the parasite *Trichogramma ivalae*, a minute wasp that has been recorded in up to 60% of eggs along with egg predators such as ladybird beetles, lacewings and spiders. Beneficials attacking larvae include shield bugs, damsel bugs, assassin bugs, tachinid flies (their larvae prey on caterpillars), orange caterpillar parasite, two-toned caterpillar parasite, orchid dupe, lacewings and spiders. Naturally occurring fungal diseases and viruses also play an important role in some seasons.

Beneficials

- Be aware of key beneficials before larvae infest the crop.
- *Trichogamma* wasps parasitise helicoverpa eggs and *Microplitis*, *Heteropelma*, *Netelia* sp. and other wasps parasitise helicoverpa larvae.
- Predatory bugs such as *Geocorris* and *Nabis* prey on eggs and small larvae while *Cermatulus* and *Oechalia* also attack larger larvae.
- Ants and spiders also eat helicoverpa eggs and larvae.
- NPV is a virus which only infects *Helicoverpa* species. This occurs naturally but can also be applied— see chemical control. [23]

7.4.7 Management nearing dessication and harvest

Hot, dry weather will rapidly advance a chickpea crop (Figure 13) which means that very small and small larvae are unlikely to survive on leaves of rapidly deteriorating quality. As the pods dry they also become more resistant to damage by small to medium larvae. In summary, this means that the major source of damage in a senescing crop is late medium and large larvae.

21 Cesar. Native Budworm. www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Native-budworm

22 GRDC. Budworm in Western Australia. https://grdc.com.au/Media-Centre/Hot-Topics/Budworm-in-Western-Australia

23 GRDC. IPM Guidelines. Native budworm in winter pulses. http://ipmguidelinesforgrains.com.au/pests/helicoverpa/native-budworm-in-winter-pulses/

Figure 13: *Chickpea crop nearing desiccation and harvest.*

Source: The Beatsheet

Therefore, the recommended approach to managing *Helicoverpa* populations in the later stages of a chickpea crop is to continue to monitor both number and size of larvae. If the population of medium and large larvae exceeds the economic threshold, and the crop is still susceptible, then treatment may be warranted.

At this stage of the crop, a wait-and-see approach (continue checking the crop 1–2 times a week) is recommended, principally because it is difficult to predict a week or two ahead how fast a crop will dry down, and what the *Helicoverpa* population will be whilst the crop is still susceptible. The alternative approach is to treat above threshold populations of small larvae when they are detected. This approach is likely to result in treatment of fields that subsequently would not have been at risk of damage, particularly if the crop dries faster, or larval mortality is higher than expected.

The options available for the treatment of *Helicoverpa* infestations late are limited because of withholding periods (WHP). Methomyl has a 1-day WHP while thiodicarb has a 21-day WHP. Indoxacarb (StewardTM) has a 21-day WHP, but no more than one application is permitted per crop growth cycle. Check with others in your local area on their experience with the efficacy of options when making a choice. [24] Dow Trojan® has a shorter WHP to harvest of only 7 days.

7.4.8 Broader management considerations

Close monitoring can pay off. In many cases, the larval infestation may not progress past the 'small' stage and, therefore, control is unwarranted. Regular close checking, and reference to records from successive checks, will enable you to determine larval survival.

Aim for one well-timed spray. Chickpea can tolerate moderate to high numbers of *Helicoverpa* larvae (10–20 larvae/m^2) through late-vegetative and early-flowering growth stages. However, agronomists may suggest that numbers this high during flowering would warrant immediate spraying. Even with mortality, an economic threshold may be exceeded as soon as podset begins. This situation potentially leads to high numbers of advanced stage larvae, resulting in more costly and less reliable control.

Most yield loss will be sustained from damage caused during pod-fill, and this is the most critical stage for crop protection. Larval infestations are likely to be of mixed ages by the time the crop is well into podding. Products such as Steward™ and Larvin® will adequately control a wide range of larval sizes, and offer around 10–14 days of residual protection if applied to plants that are not actively growing. [25]

24 The BeatSheet (2008) Managing Helicoverpa larvae in chickpea crops close to dessication and harvest. http://thebeatsheet.com.au/crops/pulses/chickpeas/managing-helicoverpa-larvae-in-chickpea-crops-close-to-dessication-and-harvest/

25 M Miles (2013) Chickpea insect pest management. Department of Agriculture, Fisheries and Forestry, Queensland, http://ipmworkshops.com.au/wp-content/uploads/Chickpea_IPM-Workshops_north-March2013.pdf

7.4.9 Checking compatibility of products used in mixtures

With the fungicide spray programs recommended for Ascochyta blight control, mixing of fungicides with insecticides is becoming more common. However, some product formulations are NOT compatible with available fungicides.

Check compatibility of potential mixing partners before recommending and applying.

Always read the label supplied with each product before use.

Compatibility of insecticides with mancozeb formulations

It is the responsibility of the agronomist ultimately to ensure that any recommendation is safe for the crop.

Table 6 outlines some considerations when using chlorothalonil within 10 days of an insecticide application. These lists are by no means exhaustive. Always check with individual companies and read product labels for specific information.

Note that formulations can vary between companies or they may be changed without notice. Compatibilities provided are a guide only and should be followed up with companies if problems occur.

Always read the label supplied with the product before each use.

Always ensure that a product (or mixture) is safe for the crop before recommending and applying. [26] Microencapsulated insecticides like Karate Zeon® or FMC Trojan® at very low use rates may not affect fungicide efficacy or crop effects.

Table 6: *Compatibilities of various insecticides with chlorothalonil.*

Product	Chlorothalonil compatibility	Considerations
Steward™ (indoxacarb)	Yes. Widely used with chlorothalonil and no know compatibility issues	
Oil-based emulsifiable or flowable pesticides	Some incompatibilities. The excerpt (right) is from the Crop Care Barrack 720 label. Also see labels of other chlorothalonil products available under permit.	DO NOT tank mix Crop Care Barrack 720 with EC formulations when spraying after shuck fall. COMPATIBILITY: This product is compatible with wettable powderformulations of the most commonly used fungicides, insectcdes and miticides. Do not combine with oil-based emulsifiable or flowable pesticides, unless prior experience has shown the combination to be physically compatible and non-injurous to your crop. This product should not be mixed with spraying oils or sprayed on to crops that have been sprayed with oil for at least 10 days after the oil spray. Oils should not be sprayed on crops treated with this product for at least 10 days after the last spray. Wetting agents have not improved performance. Under some conditions, certain surfactants may cause injury.

Source: compiled with the assistance of Bayer CropScience, Sumitomo Chemical Australia, DuPont, Crop Care Australasia and Infopest

26 Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

7.4.10 Post spray assessments

After applying a spray to control a pest infestation, a post-spray assessment or follow-up check is essential to ensure that pest numbers were successfully reduced to below the threshold.

Sometimes sprays fail to work as effectively as required or expected. This can occur for a variety of reasons, such as inadequate application (coverage, timing), insecticide resistance, or too-high expectations of the product selected. Poor application is sometimes mistaken as resistance.

Where a spray failure is suspected, detailed records can assist in determining the cause of the apparent failure.

With products such as Steward™, the phenomenon of growth dilution is often evident in chickpea. That is, the growth that was present at the time of application may still have residual activity from the insecticide but new growth will not. It has been observed that small larvae can feed on this new growth but incur no crop damage. Rechecking fields sprayed with Steward™ or Larvin® can be complicated and will require regular assessment.

Record spray decision and re-check to confirm control success or failure. Record details of application equipment (nozzle size, etc.) as well as time of day and weather conditions. This may help interpret what might have gone wrong where poor control is achieved. [27]

7.5 Aphids

Aphids are small insect pests with oval-shaped green, brown or black bodies. Often occurring in colonies, aphids suck on sap, causing loss of vigour, and in some cases yellowing, stunting or distortion of plant parts (Table 7). Honeydew (unused sap) secreted by the insects can cause sooty mould to develop on leaves. When aphids transmit viruses, the impact on crop growth and yield can be significant. The earlier the transmission of virus, the greater the potential impact.

Direct aphid feeding rarely causes major damage to broadacre crops, and control measures are generally unnecessary, as parasitoids and predators keep populations in check. Exceptions occur when aphid populations are extreme (particularly early) or the compensatory ability of the crop is compromised by stress (particularly moisture stress), and aphid impact on flowering or pod set/fill may be significant.

Pulse aphids

- Cowpea aphid *Aphis craccivora*
- Blue green aphid *Acyrthosiphon kondoi*
- Green peach aphid *Myzus persica*
- Pea aphid *Acyrthosiphon pisum*

27 Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

Table 7: *Susceptibility of pulse crops to aphids according to growth stage.*

Pre-Plant/Plant	Seedling	Vegetative	Budding/ Flowering
Aphids can transmit viruses.	**Cowpea aphid:** colonies start in growing points. **Blue green aphid:** infest growing tips first then move down stems to the crown as numbers build up. Risk of large infestations is higher if weather conditions are mild and hosts abundant.	In lupins direct feeding during flowering can cause flower abortion and poor pod set. Heavily infested crops may show signs of wilting—more severe in water stressed crops. Early colonisation by virus-infected aphids may result in yield losses from virus infections; bean yellow mosaic virus infection (BYMV) or cucumber mosaic virus (CMV). Look for aphids on stems and lower leaves.	Most sensitive crop stage to damage**:** reduce flowering reduce or prevent pod-set and pod-fill Look for aphids on stems, lower leaves, buds and flowering heads.

Source: IPM Guidelines

Cowpea aphids are black, or dark grey-green, sometimes with a white 'dust' over them (Figure 14). Dense colonies can develop on individual plants, or in well-defined patches. Infestations start in the growing tip and spread down the stem, causing leaf bunching and stem twisting. Cowpea aphids tolerate warm dry weather, and can be severe on water-stressed plants. Water stress and warm weather before flowering can result in heavy, extensive infestations.

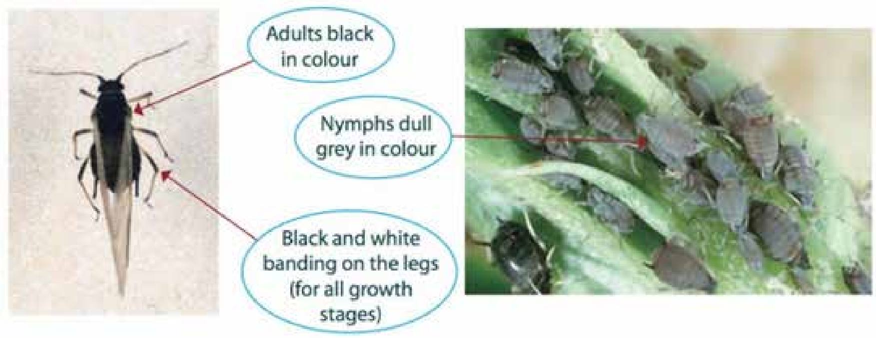


Figure 14: *Distinguishing characteristics/description of cowpea aphids*

Source: Bellati *et al.* 2012 in Cesar

Green peach aphids are waxy green (except the winged adults, which are almost black) (Figure 15). Occasionally, colours of individual wingless green peach aphids can range from a pale yellow-green to an orange-red. They usually feed in buds and flowers, and do not often form large dense colonies. Generally they are widespread, in low numbers, rather than in well-defined patches. They tolerate cool/ moist and warm/dry conditions. Green Peach Aphids are often resistant to synthetic pyrethroids, Organophosphateas and carbamates. Check with your local agronomist or entomologist for the correct insecticide group choice.

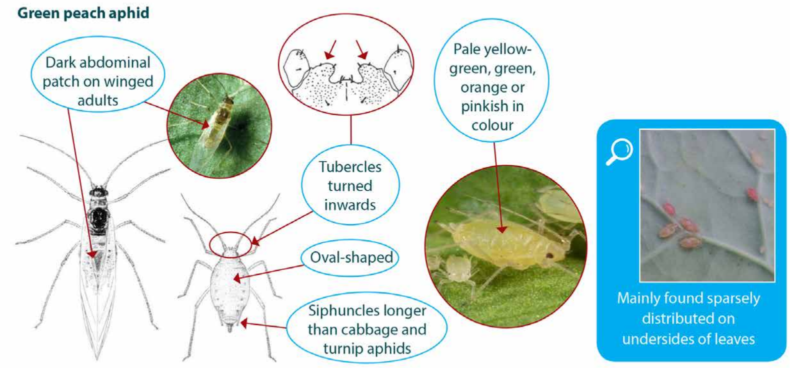


Figure 15: *Distinguishing characteristics/description of green peach aphid*

Source: Bellati et al. 2012, in Cesar

Life cycle

Winged aphids fly into lupin crops from surrounding vegetation and pastures. Spring population size depends on autumn and winter conditions. Long autumn growing periods allow early build-up and spread of aphids. Mild (not cold) winters allow further development and spread of winged aphids, which can establish many small colonies of wingless aphids throughout a crop. Reproduction is rapid if plant growth and spring weather is favourable, until the colonies are large, and winged aphids redevelop. All aphids are female and give birth to live young without mating. Viruses carried by flying aphids are transmitted to plants as they feed and establish colonies. Wingless aphids feeding on infected plants can also crawl to healthy plants (through the canopy or after falling to the ground) and spread disease. Viruses can be brought into crops from outside paddocks, or spread within a crop from infected plants.

Damage

Aphids feeding on lupins can cause yield loss before plant symptoms become obvious. Large colonies, with more than 40 aphids per stem, cause distortion of leaves, stems and flowers. By the time such symptoms are evident, there will have been yield loss that cannot be recovered by spraying to control the aphids. The crop should be treated before aphid numbers increase markedly. The economic loss over a paddock depends on the area infested, and on the numbers of aphids in each growing tip or bud. Yield losses are greater if virus transmission also occurs.

Virus infection causes additional plant symptoms. Aphid feeding slows growth, distorts flowers, and reduces pod set and fill. Viruses transmitted by the aphids cause a range of symptoms, including 'shepherds crook', stunting, and leaf yellowing. Low numbers of aphids can spread viruses, whereas larger widespread populations are needed to cause direct feeding loss. Virus diseases can cause significant yield loss in lupins. Aphids can carry and spread these diseases, at population levels that cause little damage from direct feeding.

WATCH: Green peach aphids and beet western yellows virus.

Control

Aphid numbers can rise and fall rapidly—mainly in response to weather conditions—so they are virtually impossible to predict beyond a few days. The potential for grain yield loss is high if five or more aphids are found in 30% of buds on the main stem or first branches of a plant, and 15% or more of the crop is affected at this level. Waiting until colonies are large, and plant damage symptoms are obvious, is too late; yield loss has occurred and cannot be recovered.

The type of aphid does not matter. Green peach aphid is more difficult to kill than the other aphids, and higher rates of aphicide should be used. An aphicide that does not kill beneficial insects (wasps, ladybeetles, lacewings, hoverflies) is preferred. It may be necessary to apply aphicide twice in a season, as each set of buds and flowers develop. Spot spraying may be effective.

Cucumber Mosaic Virus (CMV) is carried over in seed from infected plants, and can also be transmitted by aphids. Within a crop, aphids spread CMV from plants growing from infected seed. Usually the disease is localised and patchy, but yield losses due to the virus can exceed 50% if the infection spreads throughout a paddock early on. Recommended management strategies include early seeding, high seeding rates to generate dense stands, use of uninfected seed, and strategic application of aphicides to kill aphids in late winter/early spring.

Bean Yellow Mosaic Virus (BYMV) spreads into paddocks from neighbouring pastures. It is usually restricted to paddock edges, but occasionally widespread infections occur, resulting in severe yield loss. Sparse crops (low seeding rate, seedling loss) are especially vulnerable. Management strategies include high seeding rates to generate dense stands, cereal barriers around the crop, heavy grazing of adjoining pasture paddocks to reduce aphid numbers, and strategic aphicide sprays. [28]

7.5.1 Bluegreen aphid

Bluegreen aphids (BGA) are relatively large (up to 3 mm), matt blue-green, with a pair of slender tubes like exhaust pipes (cornicles) projecting from the back to beyond the tip of the abdomen (Figure 16). Winged aphids fly into pastures or crops and start colonies, which cause damage. Overcrowding or plant deterioration triggers the development of new winged aphids which migrate to establish new colonies. Winged aphids can spread viruses.

28 DAFWA. Lupin Aphids. http://agspsrv34.agric.wa.gov.au/ento/pestweb/Query1_1.idc?ID=1923328529

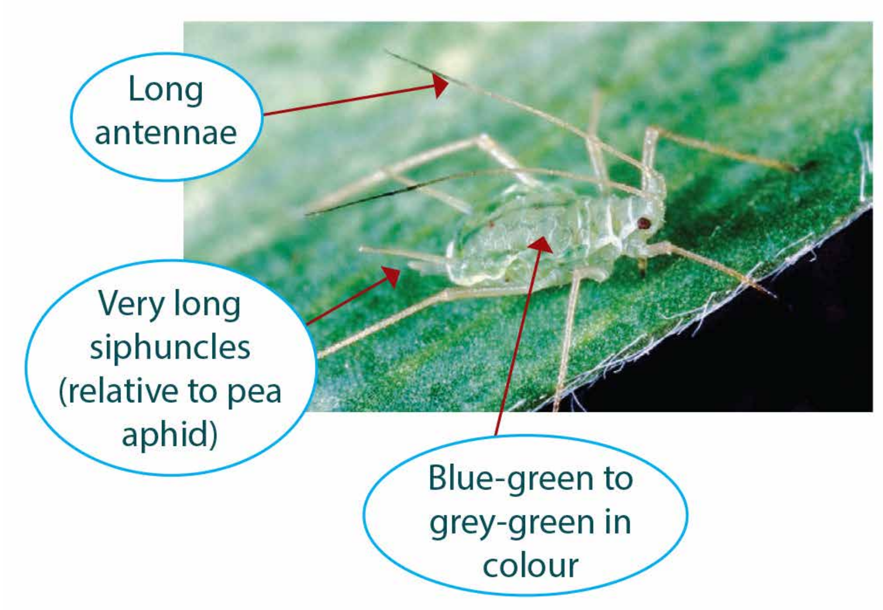


Figure 16: *Distinguishing characteristics/description of bluegreen aphid*

Source: Bellati *et al.* 2012 in Cesar

Life cycle

Like other aphids, all BGA are females and give birth to live young without having to mate. Reproduction rates are very high so numbers increase rapidly when conditions are favourable. BGA survive hot dry summers in low numbers on sheltered host plants, usually as winged aphids. Migration into germinating annual legumes or lucerne occurs in autumn, and large colonies can develop if it is warm and mild. Winter cold slows reproduction until spring, when populations grow rapidly on favourable plants. During heavy infestations, plants can be covered with white speckles, which are cast-off aphid skins. The number of winged aphids flying between paddocks also increases throughout spring; these can be caught with 'sticky' traps.

Damage

Annual medics, lucerne, subterranean clover and lupins are susceptible to bluegreen aphid. In lucerne and medics, heavy infestations cause stunted growth, leaf curling and leaf drop. Dry matter production can be reduced. In subterranean clover, leaves wilt before turning grey-brown and dying, becoming dry and 'crisp'. Pastures take on a patchy, burnt appearance. Seed yield of annual species can be reduced by 20–80%. The higher the legume content and the lighter the grazing pressure from flowering onwards, the greater the risk of aphid damage. Ungrazed swards with more than 50% legume dominance are at greatest risk in spring. BGA favour growing tips of medic or lucerne, while in subterranean clover they are widely dispersed under the canopy, particularly on flower/burr peduncles.

Control

For lucerne, sow resistant or tolerant cultivars. Parasitic wasps (Figure 17), ladybeetles, lacewings, hoverflies and fungal diseases exert useful biological control. Aphid-resistant annual medics and subterranean clover are not common, so insecticides may be needed in lightly or ungrazed spring pastures, if maximum seedset and spring drymatter production is wanted. Redlegged earthmite can cause similar spring losses, and may also be present. If BGA is the predominant pest, use insecticides that do not kill aphid parasites and predators; for mixed infestations, systemic chemicals that control aphids and mites should be used.

Figure 17: *Bluegreen aphid and parasitoid wasp*

Source: Cesar

7.5.2 Management of aphids

Monitoring

Monitor terminals/growing tips:

- Check at least 5 points in the field and sample 20 plants at each point.
- Check regularly at different locations across a field as populations are often patchy.
- Aphids are often first observed along the edges of crops. Inspect crops from crop edge to centre of paddock. Infestations may be patchy or in 'hot spots'.
- Infestations can be reduced by heavy rain. If rain occurs when spray decision is made but not carried out, monitor again to determine is spray still required.
- Record the number of large and small aphids (adults and juveniles), the number of beneficials as well as parasitised aphids (mummies), and the impact of infestation on crop.

Repeat sampling provides information on whether the population is increasing (lots of juveniles), stable or declining (lots of adults and winged adults). [29]

Table 8 summarises control strategies against aphids.

29 GRDC. IPM Guidelines. Aphids in pulses. http://ipmguidelinesforgrains.com.au/pests/aphids/aphids-in-pulses/

Table 8: *Best Bet IPM strategies for controlling aphids in winter pulses in the southern growing region.*

	Post Harvest, pre-sowing	Establishment – vegetative	Flowering - maturity
Aphid vectors and virus source	Control green bridge (in fallows) Sow virus – free seed Sowing into standing stubble may reduce aphid landing	Asses risk of aphid outbreak High risk when: Warm, mild conditions Abundant weed hosts Nearby food sources eg. Clover/medic Aim to close canopy and minimise gaps to outcompete infected plants	Conserve and monitor beneficials that suppress aphids. Use of broad spectrum pesticides may flare aphids. Check post-application for signs of flaring
Aphids – direct damage (not virus) Cowpea Green peach Blue-green Pea aphid	Remove green bridge (aphid hosts) to minimise build up during autumn and spring. Sowing into standing stubble may reduce aphid landing and delay aphid build up in crops.	Control in-crop weeds to minimse sources of aphids Beneficials suppress low population and reduce the chance of outbreaks. High nitrogen may make the crop more attractive to aphids	Monitoring: Conserve and monitor beneficials that suppress aphids. If not control is required, use soft options (eg. Pirimicarb). Use of broad spectrum pesticides may flare aphids. Check post-application for signs of flaring. Note: knowledge of damaging levels is limited.

Source: IPM Guidelines

Chemical control

- Systemic insecticides are the preferred chemical control (aphids often shelter in spray-inaccessible areas of the plant). However in very dry conditions translocation of chemicals may be impaired, and insecticide will be less effective.
- If chemical control is required, consider aphid specific products (e.g. pirimicarb) to preserve beneficials. Refer to the beneficial impact table.
- If heavy rain and cool temperature are forecast, consider delaying spray decisions until after rain and monitor again.
- Seed treatments and border spraying (autumn/early winter) when aphids begin to colonise crop edges may provide sufficient control.
- Controlling aphids to prevent virus is not an economic proposition, as a small number of aphids can transmit virus and these populations could establish without being detected.
- Rotate chemicals to prevent resistance. GPA is known to have resistance to pirimicarb in WA, and potentially to SPs and OPs nationally. [30]

30 GRDC. IPM Guidelines. Aphids in pulses. http://ipmguidelinesforgrains.com.au/pests/aphids/aphids-in-pulses/

Biological control

Beneficials

- Beneficials will suppress low to moderate aphid populations but will not control heavy infestations. Look for parasitoids (wasps, aphid mummies) and predators (ladybirds, hover flies and lacewings).
- The presence of bloated aphids with a pale gold/bronze sheen indicates parasitoid activity in the crop.
- Reviewing aphid and beneficial densities over time may provide information on the impact that natural enemies are making on the growth, or decline, of the aphid populations.
- Broad spectrum insecticides that target aphids will also kill beneficials.

Beneficials may not arrive early enough in the crop to prevent the build-up of aphids to above threshold. They are important to suppress populations after control, so determine impact of insecticides on beneficials before spraying. [31]

Cultural control

- Control alternative hosts (wet autumn and spring promotes the growth of weed hosts—when weed hosts dry off aphids move into crops). Legume pasture species are also hosts.
- Sow crops early where possible to enable plants to flower before aphid numbers peak.
- Sow clean seed tested for cucumber mosaic virus (CMV) in lupins or pea seed-borne mosaic virus (PsbMV) in field peas.
- Cover of bare ground through rapid canopy development assists in deterring aphids, e.g. narrow rows with high seeding rates.
- High intensity rain during crop growth can suppress aphids.
- Research in WA shows that high levels of reflective stubble may deter aphids, especially in crops with wide row spacing. [32]

7.5.3 Aphids and virus incidence

Aphids can damage crops by spreading viruses, or they can cause direct damage when feeding on plants. Feeding damage generally requires large populations, but virus transmission can occur before aphids are noticed. Pre-emptive management is required to minimise the risk of aphids and their transmission of viruses. Aphids are the principal, but not sole, vectors of viruses in pulses; some viruses are also transmitted in seed.

An integrated approach to aphid and virus management is required to reduce the risk of yield or quality loss.

Different aphid species transmit different viruses to particular crop types. Viruses are already transmitted before detection, but aphid species identification is important because management strategies can vary. Pulses are annual crops, whereas aphids and the viruses they spread have alternative hosts between seasons. Aphid population development is strongly influenced by local conditions. Early breaks and summer rainfall favour early increases in aphids and volunteers that host viruses, resulting in a higher level of virus risk.

Integrated management practices that aim to control aphid populations early in the season are important in minimising virus spread. Aphids can spread viruses persistently or non-persistently. Once an aphid has picked up a persistently transmitted virus, e.g. BWYV, it carries the virus for life, infecting every plant where it feeds on the phloem. Aphids carrying non-persistently transmitted viruses, e.g. CMV, carry the virus temporarily and only infect new plants in the first one or two probes.

31 GRDC. IPM Guidelines. Aphids in pulses. http://ipmguidelinesforgrains.com.au/pests/aphids/aphids-in-pulses/

32 GRDC. IPM Guidelines. Aphids in pulses. http://ipmguidelinesforgrains.com.au/pests/aphids/aphids-in-pulses/

Important vectors for non-persistent viruses in pulse crops include green peach aphid, pea aphid, cowpea aphid and blue-green aphid, which will colonise pulse crops (Table 9). Turnip aphid, maize aphid and oat aphid—which are non-colonising species in pulses—may also move through pulse crops, probing as they go, and potentially spreading pulse viruses. Green peach aphid and pea aphid are also important in spreading persistently transmitted viruses, depending on the virus involved. [33]

Table 9: *Differences in transmission of one persistent and two non-persistent viruses by four aphid species.*

Aphid species	Cucumber mosaic virus (non-persistent)	Pea seed-borne mosaic virus (non-persistent)	Beat western yellows virus (persistent)
Green peach aphid	Yes	Yes	Yes
Pea aphid	Yes	Yes	–
Cowpea aphid	Yes	Yes	Yes
Blue-green aphid	Yes	–	–

Source: GRDC

7.5.4 Integrated pest management and viruses

An integrated approach with crop, virus and insect management is required to control aphids and viruses in pulse crops.

Minimise the pool of potentially virus-infected plant material near crops by controlling the 'green bridge' of weeds, pastures and volunteer pulses that can harbour viruses and aphids over summer or between crops. This includes weeds around dams, tracks and the margins of crops.

Source clean seed and test retained seed for viruses including CMV, BYMV, *Alfalfa mosaic virus* (AMV) and *Pea seed-borne mosaic virus* (PSbMV). Sow tested seed with less than 0.1% virus infection to reduce the pool of virus-infected material. Field pea seed should have less than 0.5% PSbMV. Where possible, choose a pulse variety that has virus resistance.

Resistance to CMV seed transmission has been bred into many new lupin varieties, including Jenabillup. Yarrum field pea has resistance to BLRV and PSbMV. Pulse Breeding Australia is increasing its emphasis on developing pulse crop lines with increased virus resistance. Faba bean lines with resistance to BLRV and field pea with resistance to BLRV and PSbMV have been identified and should be commercially available in the future.

Some species of aphids are attracted to areas of bare earth. Use minimal tillage and sow into retained stubble, ideally inter-row to discourage aphid landings. This applies especially to minimising CMV spread in lupins and chickpea.

Seed dressings are probably the best aphid protection strategy compatible with an IPM approach, for example, Gaucho® 350SD insecticide seed dressing on other pulses to prevent aphids attacking emerging seedlings and spreading viruses (e.g. CMV, BLRV and BWYV). However, Gaucho® 350SD is not registered for use in chickpea.

Alternatively, a foliar insecticide can be applied early based on forecast reports of the degree of risk. Preferably use a 'soft' insecticide that targets the aphids and leaves beneficial insects unharmed. There is debate over the use of synthetic pyrethroids as a foliar application; they are recommended to prevent BLRV transmission because of so called 'anti-feed' properties that prevent early colonising of crops by pea aphids. However, discouraging colonisation may increase the spread of aphids and, potentially, virus through a crop.

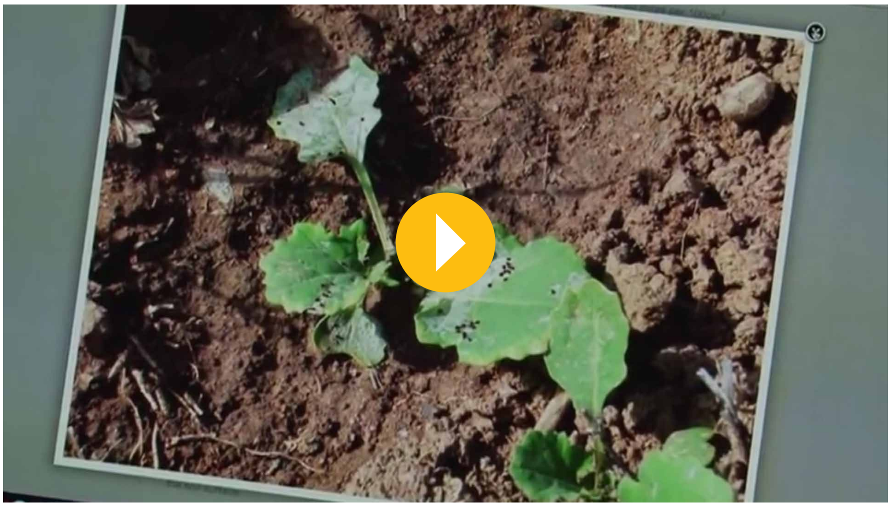
33 GRDC (2010) Aphids and viruses in Pulse Crops—Factsheet. Western and Southern Region.

Synthetic pyrethroid insecticides should not be used to control green peach aphid, an important vector of BWYV, as most populations of green peach aphid are resistant. Monitor crops and neighbouring areas regularly. Identify the species of aphid present and their numbers. [34]

7.6 Red legged earth mite (RLEM)

The redlegged earth mite (RLEM) (*Halotydeus destructor*) is a major pest of pastures, crops and vegetables in regions of Australia with cool wet winters and hot dry summers. The RLEM was accidentally introduced into Australia from the Cape region of South Africa in the early 1900s. These mites are commonly controlled using pesticides, however, non-chemical options are becoming increasingly important due to evidence of resistance and concern about long-term sustainability. RLEM is a sap-sucking pest of crops and pastures. They often co-exist with blue oat mites. The mites are often gregarious and are found clumped together in large numbers. They disperse quickly when disturbed. [35]

WATCH: GCTV9: Redlegged earth mites.



7.6.1 Symptoms

What to look for

Insect Adult

- Adults are 1 mm long with a black body and eight red-orange legs (Figure 18).
- Newly hatched mites are 0.2 mm long with a pinkish-orange body and 6 legs.

34 Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

35 Agriculture Victoria. Redlegged Earth Mite. http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/redlegged-earth-mite

Figure 18: *Leathery cotyledons with adult RLEM.*

Source: DAFWA, 2013

Plant

- Feeding causes a silver or white discolouration of leaves and distortion. If damage is severe, plants shrivel and die (Figure 19).
- Damage is more severe when seedlings are stressed (e.g. cold waterlogged or very dry conditions).

Figure 19: *Silver leaf discolouration.*

Source: DAFWA, 2013

7.6.2 Damage caused by RLEM

Large numbers of RLEM are commonly found in annual pastures at the break of the season and may cause heavy loss of subterranean clover and annual medic seedlings. These species are susceptible throughout the growing season, and can suffer losses in dry matter (10–80%) and seed yield (20–80%) in spring. The greater the legume content of pastures and the lighter the grazing pressure, the higher the risk of loss from mites. They also attack lupins, rape, field peas, serradella (cotyledons only) and vegetables.

Mites rupture cells on the surface of leaves and feed on exuding sap; affected leaves look silvered, but do not have holes as with lucerne flea attack. Mite damage to seedlings is more severe if plant growth is slowed. This could be caused by cold and/or waterlogging, low seedling density after a false break, low seed banks after a crop, or if pastures or stubble are being reseeded. Capeweed increases their reproductive potential, and legumes in paddocks with a lot of capeweed may be severely damaged, especially where mites can attack smaller clover and medic seedlings from the shelter of large capeweed plants. [36]

RLEM effects:

- Will damage all field crops and pastures.
- Reduces production and quality of older plants during the growing season.
- Reduces seed yield of legumes in spring.
- Silvering of leaves, distortion of leaf shape in broadleaf crops.

36 DAFWA, Pest Web. Redlegged earth mite. http://agspsrv34.agric.wa.gov.au/Ento/pestweb/Query1_1.idc?ID=247419235

- Affected seedlings can die.
- Seedlings can be killed below ground before they emerge.

7.6.3 Conditions favouring development

Earth mites are active in the cool, wet part of the year, usually between April and November. During this winter-spring period, RLEM may pass through three (sometimes only two) generations, with each generation surviving six to eight weeks.

RLEM eggs hatch in autumn following exposure to cooler temperatures and adequate rainfall. It takes approximately two weeks of exposure to favourable conditions for over-summering eggs to hatch. This releases swarms of mites, which attack delicate crop seedlings and emerging pasture plants.

RLEM eggs laid during the winter-spring period are orange in colour and about 0.1 mm in length. They are laid singly on the underside of leaves, the bases of host plants (particularly stems) and on nearby debris. They are often found in large numbers clustered together. Female RLEM can produce up to 100 winter eggs, which usually hatch in eight to ten days, depending on conditions.

Towards the end of spring, physiological changes in the plant, the hot dry weather and changes in light conditions combine to induce the production of over-summering or 'diapause eggs'. These are stress resistant eggs that are retained in the dead female bodies. Diapause eggs can successfully withstand the heat and desiccation of summer and give rise to the autumn generation the following year. Autumn conditions trigger egg hatching. [37]

7.6.4 Management of RLEM

Key points:

- Spray only if you need to. RLEM have been detected that have resistance to synthetic pyrethroids. Rotate chemical groups in and between seasons, as this will help to reduce resistance occurring.
- Use insecticide seed treatments for crops and new pastures with moderate pest pressure rather than spraying whole paddocks. This allows for smaller quantities of pesticide to be used that will directly target plant feeding pests.
- Control weeds before seeding, particularly in late autumn or winter sown crops where RLEM are likely to hatch before seeding. At least one week of bare soil can ‘starve out’ most of the mite population before crops are sown.
- Control weeds in the crop and along fencelines that provide habitat for mites. A weed-free crop will have few mites and over-summering eggs to carry through to the following season.
- Controlled grazing of pasture paddocks that will be cropped the next year will reduce mite numbers to levels that are almost as effective as chemical sprays. Sustained grazing of pastures throughout spring to maintain them at levels below 2 tonnes per hectare. Feed On Offer (FOO) (dry weight) will restrict mite numbers to low levels.
- Apply insecticides to paddocks that are to be cropped during spring to prevent RLEM populations producing over-summering eggs. This will minimise the pest population for the following autumn. TIMERITE® is a free package that provides a date in spring for a spray application to stop female RLEM from producing over-summering eggs.
- Look at your cropping rotations to decrease reliance on pesticides. The risk is generally highest if paddocks have been in long- term pasture (with high levels of broadleafed plants) where mite populations have been uncontrolled. Lower risk paddocks that generally do not require mite control are often those which follow a weed-free chickpea or cereal crop. [38]

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37 P Umina (2007) Redlegged earth mite. Agriculture Victoria, Ag Note AG0414 January 2007, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/redlegged-earth-mite

38 DAFWA (2015) Diagnosing redlegged earth mite. https://www.agric.wa.gov.au/mycrop/diagnosing-redlegged-earth-mite

Monitoring

Carefully inspect susceptible pastures and crops from autumn to spring for the presence of mites and evidence of damage. It is especially important to inspect crops regularly in the first 3–5 weeks after sowing. Mites are best detected feeding on the leaves in the morning or on overcast days. In the warmer part of the day RLEM tend to gather at the base of plants, sheltering in leaf sheaths and under debris. They will crawl into cracks in the ground to avoid heat and cold. When disturbed during feeding they will drop to the ground and seek shelter.

RLEM compete with other pasture pests, such as blue oat mites, for food and resources. Competition within and between mite species has been demonstrated in pastures and on a variety of crop types. This means control strategies that only target RLEM may not entirely remove pest pressure because other pests can fill the gap. This can be particularly evident after chemical applications, which are generally more effective against RLEM than other mite pests.

Chemical control

Chemicals are the most commonly used control option against earth mites. While a number of chemicals are registered for control of active RLEM in pastures and crops, there are no currently registered pesticides that are effective against RLEM eggs.

Autumn sprays

Controlling first generation mites before they have a chance to lay eggs is the only effective way to avoid the need for a second spray. Hence, pesticides used at or after sowing should be applied within three weeks of the first appearance of mites, before adults begin to lay eggs. Timing of chemical application is critical.

1. Pesticides with persistent residual activity can be used as bare earth treatments, either pre-sowing or at sowing to kill emerging mites. This will protect seedlings which are most vulnerable to damage.
2. Foliage sprays are applied once the crop has emerged and are generally an effective method of control.
3. Systemic pesticides are often applied as seed dressings. Seed dressings act by maintaining the pesticide at toxic levels within the growing plant, which then affects mites as they feed. This strategy aims to minimise damage to plants during the sensitive establishment phase. However, if mite numbers are high, plants may suffer significant damage before the pesticide has much effect.

Spring sprays

Research has shown that one accurately timed spring spray of an appropriate chemical can significantly reduce populations of RLEM the following autumn. This approach works by killing mites before they start producing diapause eggs in mid-late spring. The optimum date can be predicted using climatic variables, and tools such as TIMERITE® can help farmers identify the optimum date for spraying. Spring RLEM sprays will generally not be effective against other pest mites.

Repeated successive use of the 'spring spray' technique is not recommended as this could lead to populations evolving resistance to the strategy. To prevent the development of resistance, the selective rotation of products with different Modes of Action is advised.

Biological control

There is evidence of natural RLEM populations showing resistance to some chemicals, therefore, alternative management strategies are needed to complement current control methods.

At least 19 predators and one pathogen are known to attack earth mites in Australia. The most important predators of RLEM appear to be other mites, although small beetles, spiders and ants also play a role in reducing populations. A predatory mite (*Anystis wallacei*) has been introduced as a means of biological control, however, it has slow dispersal and establishment rates. Although locally successful, the benefits of this mite are yet to be demonstrated.

Preserving natural enemies may prevent RLEM population explosions in established pastures but this is often difficult to achieve. This is mainly because the pesticides generally used to control RLEM are broad-spectrum and kill beneficial species as well as the pests. The chemical impact on predator species can be minimised by choosing a spray that has least impact and by reducing the number of chemical applications. Although there are few registered alternatives for RLEM, there are groups that have low-moderate impacts on many natural enemies such as cyclodienes.

Natural enemies residing in windbreaks and roadside vegetation have been demonstrated to suppress RLEM in adjacent pasture paddocks. When pesticides with residual activity are applied as border sprays to prevent mites moving into a crop or pasture, beneficial insect numbers may be inadvertently reduced, thereby protecting RLEM populations.

Cultural control

Using cultural control methods can decrease the need for chemical control. Rotating crops or pastures with non-host crops can reduce pest colonisation, reproduction and survival. For example, prior to planting a susceptible crop like canola, a paddock may be sown to cereals or lentils to help reduce the risk of RLEM population build up. Cultivation can also help reduce RLEM populations by significantly decreasing the number of over-summering eggs. Hot stubble burns can provide a similar effect.

Clean fallowing and controlling weeds around crop and pasture perimeters can also act to reduce mite numbers. Control of weeds, especially thistles and capeweed, is important, as they provide important breeding sites for RLEM. Where paddocks have a history of damaging, high density RLEM populations, it is recommended that sowing pastures with a high clover content be avoided.

Appropriate grazing management can reduce RLEM populations to below damaging thresholds, possibly because shorter pasture results in lower relative humidity, which increases mite mortality and limits food resources.

Other cultural techniques including modification of tillage practices, trap or border crops, and mixed cropping can reduce overall infestation levels to below the economic control threshold, particularly when employed in conjunction with other measures. [39]

7.6.5 RLEM insecticide resistance in WA

Western Australia is the only state to have RLEM that are resistant to commonly applied insecticides, including synthetic pyrethroids (Group 2A) (SPs) and the organophosphates (Group 1B) omethoate and chlorpyrifos. Resistant RLEM populations are likely to be present in more localities in WA and elsewhere in southern Australia, especially in paddocks that have a history of repeated insecticide applications.

How does resistance occur?

Repeated use of synthetic pyrethroids (SP) insecticides, within seasons and between seasons, can encourage RLEM to develop resistance to this chemical group. All SPs have the same molecular mode of action. Once RLEM develop resistance to one insecticide, they are then resistant to all insecticides in this chemical group (Group 3A).

The repeated cumulative exposure of RLEM to SPs is the main factor behind resistance developing. Even if a SP insecticide is used against pests such as weevils or aphids and is not targeting RLEM, they will also receive a dose of the chemical.

39 Agriculture Victoria. Redlegged Earth Mite. http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/redlegged-earth-mite

Chemical control options

Farmers with resistant RLEM have been able to control these mites by using insecticides from the organophosphate (OP) group (Group 1B), e.g. dimethoate or omethoate. However, residual populations of SP-resistant RLEM were found on weeds along fencelines and re-infested paddocks.

How long does resistance last?

Resistance in RLEM is heritable and mechanisms to switch it off have not been found. RLEM from one site have been tested each year for four years and are still resistant to SPs, even without further SP application. This indicates that resistance, once established, is likely to persist in RLEM populations over many years. Growers need to prevent further development of resistance by decreasing overall use of SPs.

Spread of resistance

Locations of resistance within southern WA are geographically quite distinct, suggesting that the resistance develops in isolated RLEM populations within each property. Resistant RLEM have been found on properties near Esperance, Cranbrook, South Stirlings, Tenterden and Boyup Brook, making it unlikely that resistant RLEM have spread between locations. However, resistant RLEM can move into adjacent paddocks from weeds on fencelines.

Managing resistance

Identify your mites

RLEM are often found with other mites, such as blue oat mite (BOM), bryobia (clover) mite or balaustium mite, but resistance has only been found in RLEM. In situations where spray failures have occurred, it is important to correctly identify the mite. Blue oat mites are controlled by all chemicals registered for RLEM control, whereas chemical controls for bryobia mite and balaustium mites differ.

Plan ahead to reduce mite numbers

If you prepare paddocks in the preceding season, there will be lower numbers of pests on your crops. Consider the following to reduce pest numbers:

- Control weeds in the crop and along fencelines. Weeds provide habitat for mites. Controlling weeds with herbicides, cultivation or heavy grazing will decrease mite numbers. A weed-free crop will have few mites and over-summering eggs to carry through to the following season.
- Controlled grazing of pasture paddocks in the year prior to a cropping year will reduce RLEM numbers to levels similar to chemical sprays. Sustained grazing of pastures throughout spring to maintain Feed On Offer (FOO) levels below two tonnes per hectare (t/ha) (dry weight) will restrict mite numbers to low levels. Control RLEM in spring.
- Applying insecticides to some paddocks during spring to prevent RLEM populations producing over-summering eggs will decrease the pest population in the following autumn. Only specific paddocks should be selected for spring spraying based on FOO levels, future grazing management options, seed production requirements and intended paddock use next season.
- Use cropping rotations to decrease reliance on pesticides. Some paddocks will have a higher or lower risk of RLEM damage depending on previous crop rotations. The risk is generally highest if paddocks have been in long term pasture (with high levels of broadleafed plants) where mite populations have been uncontrolled. Lower risk paddocks that generally do not require mite control are often those that follow a cereal or canola weed-free crop, where conditions are less favourable for mite increase.

What you can do this season

Spray only if you need to

Farmers that currently have populations of resistant RLEM have mostly used repeated applications of SP chemicals as 'insurance' sprays to minimise anticipated pest risks. To decrease the likelihood of resistance developing on your property apply insecticides only on paddocks that have damaging numbers of pests.

Where spraying is needed, rotate chemical groups

For example, rotate between Synthetic Pyrethoids (SP, Group 3A) and Organophosphate (OP, group (Group 1B), e.g. dimethoate or omethoate), in and between seasons, as this will help to reduce resistance build-up. If spraying other pests, such as aphids, try not to use SPs. Consider other chemical options such as pirimicarb.

Predict hatchings of RLEM on your property to target your control strategy

Knowing approximately when the first autumn hatchings of RLEM is occurring on your property will help to determine if they will coincide with seedling crops. RLEM hatch in autumn from their over-summering egg stage, after adequate rainfall and at least seven days of average temperatures below 20°C. Crops sown in seasons with 'early breaks' with maximum temperatures well above 20°C (for example, canola sown in April) will not be damaged by RLEM.

Use insecticide seed treatments

Use insecticide seed treatments for crops and sown pastures with moderate pest pressure rather than spraying whole paddocks. Seed treatments allow smaller quantities of pesticide to be used that directly target plant feeding pests, allowing any predatory insects to continue their important beneficial role.

Do you suspect you have resistant RLEM?

If you have RLEM that survive registered rates of insecticide treatments or suspect that you have mites resistant to chemicals, please contact the DAFWA's broadacre entomologists. Arrangements can be made to have mites sampled and tested for their level of resistance. [40]

7.7 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-type 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 which attack animals and humans.

The adult lucerne flea is approximately 3 mm long with light green-yellow colouring and an irregular pattern of darker patches over the body (Figure 20). Lucerne fleas are wingless, have globular abdomens and can jump large distances relative to their size. Their mottled colouration, small size and elusive habits can often make detection difficult.

40 DAFWA (2016) Prevent redlegged earth mite resistance. https://www.agric.wa.gov.au/mites-spiders/prevent-redlegged-earth-mite-resistance?page=0%2C2

Figure 20: *Yellow-green wingless and globular adults, sometimes with dark markings.*

Source: DAFWA, 2013

Eggs, which are laid in batches, are covered in a soil layer making them almost impossible to detect in the field. The eggs are yellow-cream in colour and about 0.3 mm in diameter. The newly hatched nymphs are approximately 0.75 mm long and are pale yellow in colour. Young nymphs resemble adults except that they are much smaller in size and will moult several times before reaching maturity.

Lucerne fleas have a characteristic ability to 'spring' off vegetation when disturbed. This is due to a stiff appendage folded under their abdomen called a furcula, which is unfolded with such speed and force that it launches the lucerne flea into the air. Lucerne fleas are commonly observed on loam-clay soils.

7.7.1 Symptoms

What to look for

Paddock

- Small jumping bugs that appear early in the season and chew young leaves on heavier textured soils.

Plant

- Cereals, canola and pasture legumes have chewed leaves with transparent 'windows' (Figure 21).
- Green material completely removed in severe infestations.

Figure 21: *Chewed leaves have transparent 'windows'.*

Source: DAFWA, 2013

Insect Adult

- Adults (3 mm) yellow-green, wingless and globular in shape sometimes with dark markings.
- Insects 'spring' off foliage when disturbed. [41]

7.7.2 Damage caused by Lucerne flea

- Lucerne flea can kill seedling crops and pastures and re-growth of lucerne.
- Yield loss varies with the growth stage of the plant.
- Broadleaf seedlings are most susceptible.
- Young nymphs feed on the soft tissue on the underside of leaves leaving transparent 'windows'.
- Adults and older nymphs chew irregular holes in leaves and can completely defoliate plants. [42]

7.7.3 Thresholds for control

The key to preventing yield loss from pest infestation is early control.

- Establishing pasture: 15 per 100 cm^2 (sampling method not established, but could use that proposed by Taverner et al. 1996).
- A suggested threshold for other crops—treat if 50% of leaf area is likely to be damaged. [43]

7.7.4 Conditions favouring development

The lucerne flea has a similar seasonal biology to other important pests of establishing crops, such as the redlegged earth mite (RLEM). Lucerne fleas generally hatch from over-summering eggs in March-April following soaking autumn rains. They reproduce sexually and, depending on favourable temperatures and moisture availability, may go through as many as 3–5 generations between autumn and spring. Each generation takes three to five weeks, with each female capable of laying up to three batches of eggs during this time.

41 DAFWA. Diagnosing Lucerne flea. https://www.agric.wa.gov.au/mycrop/diagnosing-lucerne-flea

42 GRDC, IPM Guidelines. Lucerne Flea. http://ipmguidelinesforgrains.com.au/pests/lucerne-flea-in-winter-seedling-crops/

43 GRDC, IPM Guidelines. Lucerne Flea. http://ipmguidelinesforgrains.com.au/pests/lucerne-flea-in-winter-seedling-crops/

Winter eggs are laid in moist crevices on the soil surface in batches of about 20–60, usually under vegetation and debris. Females then excrete a fluid substance containing ingested soil and glandular secretions over the eggs. This acts to both camouflage and protect the eggs.

At the onset of warmer and drier conditions, over-summering eggs are produced which are protected from desiccation by a clay cement layer excreted by females. Consequently, lucerne fleas are more common on heavier loam/clay soils and are rarely found on sandy soils. The protective coating also prevents eggs from hatching when rain is insufficient for lucerne flea development or for the establishment of host plants.

7.7.5 Management of Lucerne flea

Monitoring

Monitoring is the key to reducing the impact of lucerne flea. Crops and pastures grown in areas where lucerne flea has previously been a problem should be regularly monitored for damage from autumn through to spring. Susceptible crops and pastures should also be carefully inspected for the presence of lucerne fleas and evidence of damage.

It is important to frequently inspect winter crops, particularly canola and pulses, in the first 3–5 weeks after sowing. Crops are most susceptible to damage immediately following seedling emergence. Pastures should be monitored at least fortnightly from autumn to spring, with weekly monitoring preferred where there have been problems in previous years.

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

Some sprays require application 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 RLEM and blue oat mites. This means control strategies that only target 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.

Chemical control

Lucerne fleas are commonly controlled post-emergence, usually after damage is first detected. Control is generally achieved with an organophosphate insecticide (eg. omethoate). 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 hatch of over-summering eggs but will be 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 hatches, 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 suffer damage where they follow a weedy crop or a pasture in which lucerne flea has not been controlled. As such, lucerne flea control in the season prior to the sowing of susceptible crops is recommended.

Caution is advised when selecting an insecticide. Several chemicals registered for RLEM (i.e. synthetic pyrethroids such as cypermethrin) are known to be ineffective against lucerne flea. When both lucerne fleas and RLEM are present, it is recommended that control strategies consider both pests, and a product registered for both is used at the highest directed rate between 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 DPI Chemical Standards Branch, chemical resellers, APVMA and the pesticide manufacturer. Always consult the label and MSDS before using any insecticide.

Biological control

Several predatory mites, various ground beetles and spiders prey upon lucerne fleas. Snout mites (which have orange bodies and legs) are particularly effective predators of this pest (Figure 22). The pasture snout mite (Bdellodes lapidaria) and the spiny snout mite (Neomulgus capillatus), have been the main focus of biological control efforts against lucerne flea.

Figure 22: *Predatory adult snout mite.*

Photo: A. Weeks (CESAR). Source from AgVic

The pasture snout mite was originally found in Western Australia and there are some examples of this mite successfully reducing lucerne flea numbers. Although more rare, the spiny snout mite can also drastically reduce lucerne flea populations, particularly in autumn.

Three species of predatory mites feed on lucerne flea. They include:

- pasture snout mite (*Bdellodes lapidaria*);
- spiny snout mite (*Neomulgus capillatus*);
- French anystis mite *Anystis wallacei* can provide effective suppression of lucerne flea.

Some field experiments indicate a 70–90% control of lucerne fleas by predatory mites. Other reports suggest that predatory mite activity is rarely effective to reduce lucerne flea impact on seedling crops. Predatory mites are slow to spread and can only do so by crawling. Redistribution of predatory mites is possible using suction machines to collect and transfer mites from established to new sites.

Other beneficials include ground beetles and spiders. [44]

44 GRDC, IPM Guidelines. Lucerne Flea. http://ipmguidelinesforgrains.com.au/pests/lucerne-flea-in-winter-seedling-crops/

7.8 Cutworms

Cutworms are plump, smooth caterpillars of several moth species. They feed on all crop and pasture plants, damaging them near the ground. The caterpillars hide under the soil or litter by day. When mature, they pupate in the soil. Cutworm caterpillars grow to about 40 mm long, but they usually cannot be seen as they hide under soil or litter by day. Often they can be located by scratching the surface near damaged plants, where they can be seen curled up in a defensive position.

Caterpillars with a pink tinge belong to the pink cutworm, *Agrotis munda*, which has caused widespread damage in agricultural areas north of Perth. The dark grey caterpillars of the bogong moth, *Agrotis infusa*, have been extremely damaging in most parts of the agricultural areas from time to time. Large numbers of patterned caterpillars belonging to different genera, *Rictonis* and *Omphaletis*, have also been found attacking cereals in agricultural areas.

Adult cutworms are stout-bodied moths with patterned wings. They fly very well and may be seen on window panes at night as they are attracted to lights. [45]

7.8.1 Symptoms

What to look for

Insect Adult

Adult cutworms are stout-bodied moths with patterned wings (Figure 23).

Figure 23: *Cutworm moths.*

Source: DAFWA, 2013

Insect Larvae

- Caterpillars are up to 50 mm long, hairless with a dark head.
- They vary in colour and can have:
- a dark grey to green body often with lines and/or dark spots running along length;
- a pale grey-green body with a pinkish tinge, often with lines and/or dark spots running along length; or

45 DAFWA (2016) Cutworm: pests of crops and pastures. https://www.agric.wa.gov.au/pest-insects/cutworm-pests-crops-and-pastures

- an orange-brown body with diagonal markings (Figure 24).

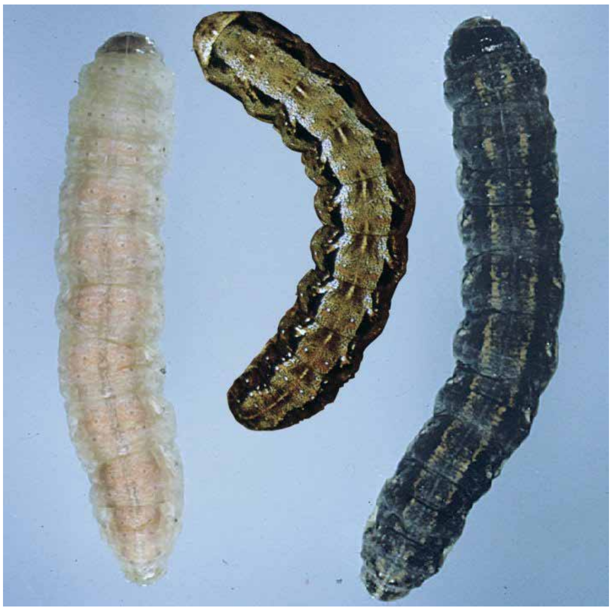

Figure 24: *Larvae of the three main species of cutworm.*

Source: DAFWA, 2013

Paddock

Often patches will have plants with leaves lopped or cut off at the base (Figure 25).

Figure 25: *Damage often occurs in patches.*

Source: DAFWA, 2013

Plant

- Damage is worst at the seedling stage but can persist for several weeks.
- Larvae hide in the soil during the day, often at the base of lopped plants (Figure 26). [46]

46 DAFWA (2015) Diagnosing Cutworm in Canola and Pulses. https://www.agric.wa.gov.au/mycrop/diagnosing-cutworm-canola-and-pulses

Figure 26: *Lopped lupin and wheat (insert) plants.*

Source: DAFWA, 2013

7.8.2 Damaged caused by cutworms

- Small larvae cause skeletonised or scalloped leaves (damage may be confused with that of lucerne flea or pasture web worm).
- Large larvae sever seedling stems near ground level.
- Large larvae (40–50 mm) are the damaging stage. These larvae may remain below the soil surface feeding on the stem at or below ground level.
- Whilst generally a pest of seedlings (1 to 5 leaf stage), cutworms can occasionally cause damage at tillering and early stem elongation in winter cereals. [47]

Economic and financial considerations

To assist in assessing the economic risk and financial costs associated with various treatment strategies go to MyEconomicTool.

There may be other economic and financial implications that need to be considered when choosing a management option. These may include:

Pre-crop

- Understand the potential yield losses associated with cutworm feeding damage.
- Assess the costs and benefits of taking preventative action.
- Assess the cost and benefits of controlling summer weeds (green bridge) to reduce potential feed source.

47 GRDC, IPM Guidelines. Cutworms. http://ipmguidelinesforgrains.com.au/pests/soil-insects/cutworms/

In-crop

- Compare the costs, benefits and risk of each management option against doing nothing or delaying treatment.
- Ignore all previous treatment costs in assessing current management options.
- Undertake a 'what if' scenario analysis to see what impact changing variables, such as grain price and season, have on the net income.

Post-crop

- Consider using an integrated pest management system and include a resistance management strategy in your spray program to reduce the chance of cutworm and other non-target insects becoming resistant. [48]

View these economic considerations in more detail.

7.8.3 Conditions favouring development

Cutworm moths can fly large distances and favour bare or lightly vegetated areas for egg laying. Moths emerge in late spring or early summer and are often observed entering houses and buildings for shelter over summer. They have one generation per year.

They are most damaging in autumn when large caterpillars (>20 mm) transfer from summer and autumn weeds onto newly emerged crop seedlings.

7.8.4 Thresholds for control

Control is warranted when two larvae per 0.5 m of crop row is present under visual inspection.

7.8.5 Control

Cutworms are easily controlled by insecticides. They are most damaging in autumn when large caterpillars (>20 mm) transfer from summer and autumn weeds onto newly emerged seedlings.

Monitoring:

- Inspect crops regularly from emergence to establishment. Larvae are active from late afternoon through the night.
- Look for signs of feeding on leaves. If detected, search the soil and stubble in the areas that are damaged, or where the plant stand is thinned.
- Larvae may move into a crop from a neighbouring weedy fallow, particularly as the weeds start to dry off, or are sprayed. Be alert to sources of larvae from outside the field.

Chemical control

- Treat the crop when seedling loss is nearing minimal plant density crop requirements.
- Treat older plants if more than 50% of plants have 75% or more leaf tissue loss.
- Chemical control is most effective when applied late in the day to maximise likelihood of larvae contacting/ingesting insecticide when they emerge at night to feed.
- Ground rig applications may provide flexibility to treat just affected areas, or to apply a border spray where larvae are moving into the crop from neighbouring weeds.

Cultural control

- Control weeds in and around fields prior to planting to reduce potential cutworm infestations.

48 DAFWA (2015) Diagnosing Cutworm in Canola and Pulses. https://www.agric.wa.gov.au/mycrop/diagnosing-cutworm-canola-and-pulses

- Be aware of cutworm movement from sprayed weedy fallow into neighbouring crops.
- Prolonged green feed in autumn allows larvae to develop to a large size by the time crops emerge.
- Aim to control potential hosts at least two weeks prior to planting to ensure larvae do not survive to infest crops.

Biological control

Biological control agents, or beneficials, include fly and wasp parasites, predatory beetles and diseases, continually reduce cutworm numbers but cannot be relied on to give adequate control. Orange and two-toned caterpillar parasites and orchid dupe are key parasitoids. These beneficials may suppress cutworm populations, but are unlikely to prevent crop loss in the event of an outbreak. [49]

7.9 Locusts

Locusts and grasshoppers will cause damage to chickpeas in the same way that they will cause damage to any green material when in plague numbers. Chickpea may be less vulnerable in the seedling stages than lupins and lentils. However, sheer weight of numbers can lead to significant damage (Figure 27).

Figure 27: *Locust swarms can travel long distances on the wind. Landholders are required to report locust activity.*

Source: Pulse Australia

Though locusts plagues are infrequent, they can be unpredictable and cause serious damaged if not managed. Plagues are traditionally thought to occur once every decade, however, locust hatchings arrived in 2012, just five years after the previous plague in WA in 2007. There could be a number of reasons for the increased frequency of locust hatchings—changing weather patterns, low summer rainfall and widespread uptake of minimum-till cropping, resulting in less disturbance of beds. Whatever the cause, growers are urged to be vigilant over spring-summer period in monitoring and controlling locusts. [50]

7.9.1 Effect on growing crops

While it is well known that cereals are particularly vulnerable to locusts, the susceptibility of the various pulses is uncertain, but growers must assume that they could be attacked while they remain green. It is important to note that:

- Established green crops are susceptible to damage by adult locusts but tend to be avoided by hoppers (immature locusts), although crop edges can be damaged and may warrant a perimeter spray.

49 IPM Guidelines (2016) Cutworms. GRDC, http://ipmguidelinesforgrains.com.au/pests/soil-insects/cutworms/

50 GRDC (2012) Early return for locusts in WA. https://grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-101/Early-return-for-locusts-in-WA

- Locusts cause little damage to crops that have dried off, but crops that are beginning to dry down when locusts begin to fly are still susceptible to attack.
- Even slight damage to pulse crops that have a high grain value or are destined for specific export markets could justify the cost of control (Figure 28).
- As a general rule, hopper and adult numbers should be closely monitored, and if any damage is seen, spraying should be commenced immediately.
- Comply with label directions for the chosen insecticide and pay particular attention to withholding periods (WHP) for harvest/windrowing or swathing, and for grazing/fodder. [51]

Figure 28: *Locust hatchlings cause the most damage when they form feeding bands that move across the land, eating anything that is green.*

Source: Pulse Australia

7.9.2 Locusts can impact on pulse deliveries

Key points:

- Locusts pose more than just a physical threat to pulse crop yields and quality.
- Controlling locusts before harvest is imperative to ensure marketable quality grain and to ensure successful delivery.
- Pulse growers need to make contact with their receival agent well in advance of harvest to discuss probable industry attitudes to high locust inclusion in the grain sample.
- Both receival agents and marketers may reject grain with high locust inclusion despite the sample technically meeting the receival standard for field insects.
- Grain staining, slimes and objectionable odours may arise from squashing live locusts during harvest. This material is difficult, if not impossible to remove.
- Objectionable material and odours in the sample will result in the product being rejected at the receival point.
- Only permitted chemicals are to be used for control of locusts.
- Maximum residue limits apply and grain samples may be collected and analysed for compliance with regulatory and market requirements.

7.9.3 Management of locusts

The decision on how locusts in crops are best managed is affected by a range of factors including:

- Growth stage of the crop, i.e. is there any green plant material or has the crop completely dried off?
- Ability to harvest early—desiccation may be an option to advance harvest.

MORE INFORMATION

Pulse Australia: Locusts can impact on pulse deliveries.

51 Pulse Australia. Australian pulse bulletin: Impact of locusts on pulse crops and grain quality. http://pulseaus.com.au/growing-pulses/publications/locust-control

- Delivery standards required for the specific pulse—discuss requirements with potential buyers.
- Risk to market from pesticide residues—WHP for windrowing/swathing is the same as harvest.
- Ability to clean physical locust contamination from harvested grain.

Control

The easiest and most effective way for landholders to control locusts is by ground spraying the hoppers when they have formed into dense aggregations called bands. This normally occurs from 1–2 weeks after hatching. The time available for controlling an outbreak is short with hoppers taking about five weeks to develop into swarming adults. Hoppers are most likely to hatch in pasture paddocks and along roadsides, fencelines and non-cultivated ground around the crop perimeter, but some hoppers may hatch from egg beds laid within crops particularly bare areas such as wheel tracks where tram lining is practiced.

It is critical in these situations that the correct insecticide is used to avoid residue issues. Australian grain produce must meet minimum residue levels (MRLs). Individual deliveries of grain will be tested for chemical residues, to detect the use of unapproved pesticides and to ensure that withholding periods have been followed.

- Only use an insecticide that is registered or has a permit for locust control in the specific pulse crop.
- Users must obtain, read and adhere to the conditions of APVMA permits prior to use.
- Follow label directions and pay attention to the WHP (withholding period). Following pesticide application, the relevant withholding period MUST expire BEFORE cutting for hay, windrowing, harvest or undertaking of any similar operation.
- Plan well ahead in choosing the most appropriate product(s) to suit your situation as availability may become an issue as the season progresses.
- Be aware of the receival standards that apply to insect contamination (alive or dead) and grain damage from locust feeding.
- Be aware of nil tolerance for odour and taints that could arise from crushing locusts during harvest, handling or while in storage.
- Avoid inadvertent contamination of grain with other chemicals not used in pulses. [52]

MORE INFORMATION

Impact of locusts on pulse crops and grain quality.

Spur-throated locust: insecticide spraying guide—WA

Spur-throated locusts are an infrequent but important pest of agriculture in parts of Western Australia (Figure 29). Damage to winter crops tends to occur in the autumn just after sowing when the locusts are fledging and at the late ripening stage in spring when the locusts are beginning to mature.

52 Pulse Australia. Australian pulse bulletin: Impact of locusts on pulse crops and grain quality. http://pulseaus.com.au/growing-pulses/publications/locust-control

Figure 29: *Spur throated locust.*

Source: DAFWA

Chemicals registered or permitted in Western Australia

There are many products with different trade names that contain the same active ingredient:

- Emulsifiable concentrate (EC), ultra low volume (ULV), suspension concentrate (SC).
- Withholding period (WHP): number of days are given for: Harvest withholding period (H) and export withholding periods (Export Slaughter Interval (ESI), Export Grazing Interval (EGI) and Export Animal Feed Interval (EAFI). For grazing WHP's refer to chemical label.
- Avoid overspraying stock. Refer to labels for withholding grazing periods for domestic markets. For animals destined for export: if overspraying does occur, withhold stock for slaughter until the ESI on clean feed is met. Or the EGI on treated crops/pasture.
- Many products are dangerous to fish and crustaceans. Do not contaminate ponds, rivers or waterways and do not spray flowering crops when bees are foraging.

MORE INFORMATION

DAFWA Spur throated locust: insecticide spraying guide.

7.10 Slugs and snails

7.10.1 Increase in WA

Numbers of slugs and snails have increased in broadacre cropping in Western Australia with the use of minimum tillage and stubble-retention practices (Figure 30). These systems increase the organic content of paddocks and the soil moisture content, leading to higher survival levels of slugs and snails.

Slug and snail pests in Australia have come from other countries, mainly the Mediterranean region. They damage plant seeds (mainly legumes), recently germinated seeds, seedlings and leaves and can be a contaminant of grain at harvest.

Figure 30: *Snails and slugs have increased in WA.*

Source: DAFWA

MORE INFORMATION

Identification and control of pest slugs and snails for broadacre crops in WA.

Distribution of slugs and snails

Slugs are pests of crops, especially emerging canola, in the higher rainfall regions of Western Australia. Slugs tend to be restricted to soils with a clay content.

Snails are found on all soil types. White Italian and vineyard snails prefer alkaline sandy soils, the small pointed snail is able to survive on all soil types, even acidic soils. Liming areas where there are snails will aid snail survival.

The small pointed snails are only known to cause economic crop damage in high rainfall areas, whereas the vineyard and white Italian snails are known to cause crop damage in the Greenough flats (which is the region between Dongara and Geraldton) and the Geraldton region. [53]

7.10.2 Damage caused by slugs and snails

Slug and snail pests damage plant seeds (mainly legumes), recently germinated seeds, seedlings and leaves and can be a contaminant of grain at harvest.

Snails are not known to damage seeds, but may damage germinated seeds close to the soil surface. However, slugs, especially black keeled slugs, will feed in the furrows on seeds of legumes. These slugs are not known to feed on ungerminated seeds.

Irregular pieces chewed from leaves and shredded leaf edges are typical of snail and slug presence. Damage to legume crops can be difficult to detect if seedlings are chewed down to the ground during emergence. Different species of slugs cause differing amounts of damage. [54]

7.10.3 Thresholds for control

Table 10: *Suggested thresholds for control of slugs and snails in broadacre crops.*

Species	Oilseeds	Cereals	Pulses	Pastures
Black keeled slug	1-2/m^2	1-2/m^2	1-2/m^2	5/m^2
Reticulated slug	1-2/m^2	5/m^2	1-2/m^2	5/m^2
Small pointed snail	20/m^2	40/m^2	5 per seedling	100/m^2
Vineyard snail	5/m^2	20/m^2	5/m^2	80/m^2
White Italian snail	5/m^2	20/m^2	5/m^2	80/m^2

Please note: the above thresholds are from limited data. It is essential to carefully monitor crops as distributions of snails and slugs are patchy.

Source: DAFWA

7.10.4 Management of slugs and snails

From a management point of view, slugs and snails have similar lifecycles. This means similar management techniques can be employed to control them in broadacre crops. Effective management requires applying controls that coincide with different phases of the pest's lifecycle (Figure 31).

53 DAFWA. Identification and control of pest slugs and snails for broadacre crops in WA. https://www.agric.wa.gov.au/grains/identification-and-control-pest-slugs-and-snails-broadacre-crops-western-australia?page=0%2C0

54 Micic S. (2016). Identification and control of pest slugs and snails for broadacre crops in Western Australia. DAFWA. https://www.agric.wa.gov.au/grains/identification-and-control-pest-slugs-and-snails-broadacre-crops-western-australia?page=0%2C0

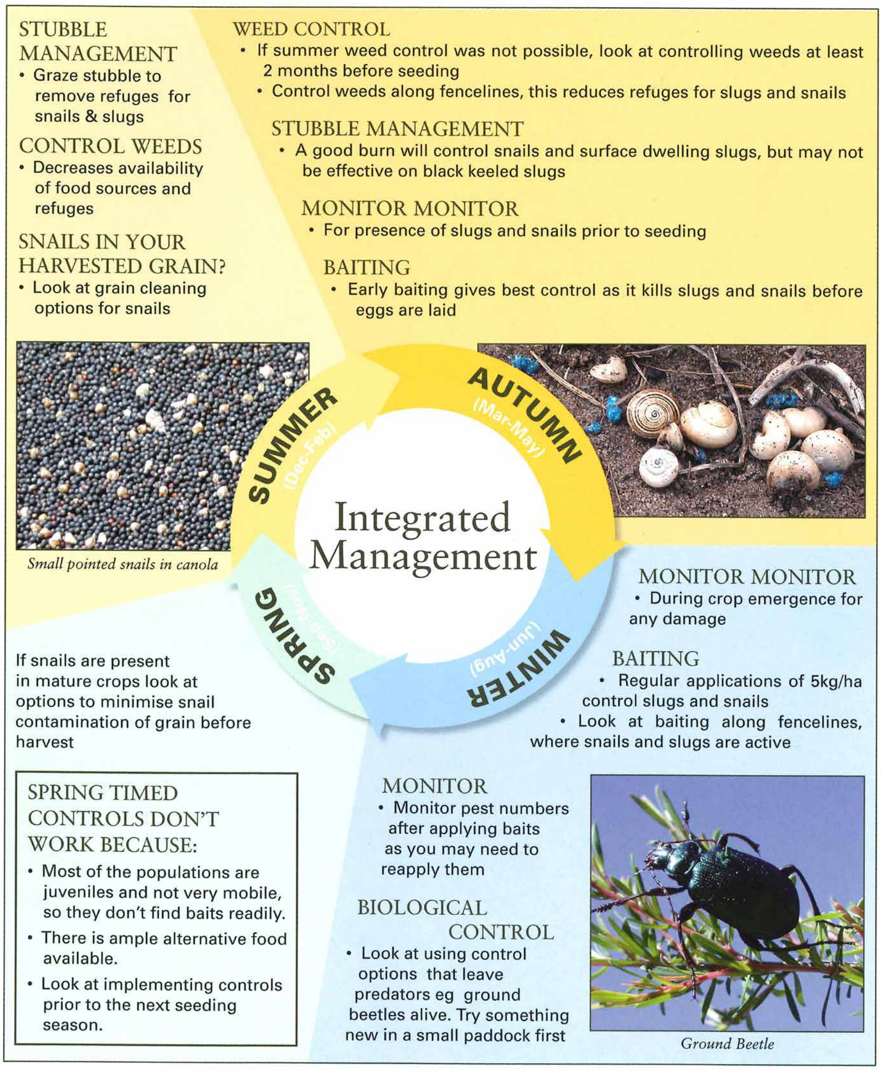

Figure 31: *Integrated control options that align with slug and snail lifecycles, breaking the cycle of reinfestation.*

Source: DAFWA

MORE INFORMATION

Snails: Bash'em Burn'em Bait'em

Chemical control

There are no sprays registered for snail and slug control in broadacre cropping. Be aware that insecticides commonly used to control insect pests of broadacre crops are not effective against slugs and snails.

Baits

Slugs and snails can only be controlled by baits if they are mobile and looking for food. Note that young snails; i.e. those less than 7 mm in diameter for round snails and 7 mm in height for conical snails are not likely to be controlled by baits. Young snails feed on decaying plant matter and are not likely to be attracted to baits.

Snail and slug numbers should be monitored to determine if there is a need to bait especially during crop emergence. Baiting will generally only kill 50% of a slug population at any one time and then mainly the larger ones. Younger slugs may emerge in successive waves. Monitoring numbers (refer to Table 10) will determine if there is a need for multiple bait applications. Based on this, baiting can be confined to areas of high snail/slug density.

All baiting must be stopped at least two months prior to harvest to ensure baits are broken down and do not become a contaminant of grain.

Biological control

There are a range of native ground beetles (family Carabidae: carabids) that are generalist predators, which attack slugs. These beetles would normally eat other prey, but some have been found to have a significant impact on slug populations. They can be important factor in controlling slugs, in combination with baiting.

The only biological control developed for snails (by the South Australian Research and Development Institute) is a parasitic fly, *Sarcophaga penicillata.* Its effectiveness has been limited.

Cultural control

Burning

Burning prior to seeding, is one of the most effective methods for pre-breeding snail control and provides some slug control. The burning itself kills snails but does not kill slugs. The lack of food and shelter following a burn makes it more likely that slugs will move elsewhere.

Before deciding to burn, soil type and weather conditions need to be taken into consideration. Also, summer weeds should be desiccated and browned off. Rocks also provide hiding places and these, if possible, should be turned by cabling or fire harrowing just prior to burning.

It is important to ensure that an even burn is applied across the paddock, as unburnt patches will provide habitats (refuges) especially for snails. An even burn causes 80-100% kill, patchy burn 50-80% kill. Burning on a warm day with little wind in a paddock that has a reasonable fuel load should achieve good control, can be less effective on small pointed snails if rocks are not turned.

When snail populations are large, a strategic burn every three or four years will assist in controlling snail numbers.

Grazing

Grazing animals will knock snails from stubble and may also trample them. Grazing will also decrease the stubble load into a paddock about to be seeded. Decreasing stubble ground cover will decrease refuges for slugs and snails.

Tillage

The most effective form of tillage to reduce numbers of snails and slugs is wide points or full-cut discs that are used in conventional tillage methods. Ploughing the soil to a depth of 5 cm or more will bury surface snails and slugs. Burying snails, especially small pointed snails, can reduce surface numbers of snails by around 40-60%.

Conventional tillage may have limited impact on black keeled slugs. Tillage will disrupt burrows made by these slugs and may cause some mortality. However, it is unlikely that tillage alone will decrease the number of black keeled slugs sufficiently to protect crops.

If tillage coincides with egg laying by slugs and snails, it may expose buried eggs to the environment. This may cause eggs to dry out and die, thereby decreasing slug and snail populations.

Cultivation of the soil does bury surface trash, disturbing potential shelters for slugs and snails. Ploughing trash residues after harvest has been found to remove over-summering habitat for slugs and snails. [55]

55 Micic S. (2016). Identification and control of pest slugs and snails for broadacre crops in Western Australia. DAFWA. https://www.agric.wa.gov.au/grains/identification-and-control-pest-slugs-and-snails-broadacre-crops-western-australia?page=0%2C0

7.10.5 Monitoring

Monitoring regularly, means pests can be detected early, ideally before seeding as there are more control options available at this time. Once the crop has been seeded and germination is commencing, control options are limited to baiting. At this time crops should be examined at night for slug and snail activity.

It is best to look for slugs and snails on moist, warm and still nights. Fresh trails of white and clear slime (mucus) visible in the morning also indicate the presence of slugs or snails. However, prior to and after applying control measures, it is necessary to estimate how many slugs and snails are present.

It is a good idea to monitor in:

- January/February to assess stubble management options for slug and snail management
- March/April to assess options for burning and/or baiting
- May to August to assess options for baiting especially along fencelines
- For snails 3-4 weeks before harvest to assess risk of snail contamination of grain and if required, implement options to minimise the risk.

How to find slugs

A useful method to detect areas infested with slugs, prior to seeding or crop emergence, is to lay lines of slug pellets with a rabbit baiter. In infested areas, slugs are attracted to the freshly turned soil and pellets placed in the furrow. Very large numbers can be found dead or dying in the furrows or nearby. On sloping ground, furrows should be run along contours to reduce the risk of soil erosion in the event of heavy rain.

An alternative method to gain an indication of the numbers of slugs present in a paddock is to place wet carpet squares, hessian sacks or tiles on the soil surface. They should at least be 32x32 cm (10% of a square metre). Place pellets under them. After a few days, count the number of slugs under and around each square. Multiplying by 10 will give an estimate of slugs per square metre (/m^2).

How to find snails

Snails are usually found on stumps, fence lines and under stubbles. A good way to determine snail numbers on open ground is to use a 32x32 cm square quadrant and count all of the live snails in it. This is an area of 10% of a square metre so multiplying by 10 will give an estimate of snails/m^2. [56]

MORE INFORMATION

Snails – economic considerations for management

Slugs – economic considerations

56 Micic S. (2016). Identification and control of pest slugs and snails for broadacre crops in Western Australia. DAFWA. https://www.agric.wa.gov.au/grains/identification-and-control-pest-slugs-and-snails-broadacre-crops-western-australia?page=0%2C0