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GRAINS RESEARCH & DEVELOPMENT CORPORATION

LENTIL

SECTION 9

PEST MANAGEMENT

Pest management

Key points

- **The key pests of lentil in southern Australia are Helicoverpa punctigera (native budworm), etiella, snails, slugs, aphids, redlegged earth mite and lucerne flea.**
- **Damage from pests such as budworm and etiella have marketability implications, as does contamination of the grain samples with snails.**
- **Integrated pest management (IPM) is an ecological approach aimed at significantly reducing use of pesticides while managing pest populations at an acceptable level.**
- **IPM involves planning, monitoring and recording, identification, assessing options, controlling/managing and reassessing.**
- **Monitoring for beneficial species is important.**
- **Exotic bruchids and leaf miners pose a biosecurity threat.**

9.1 Integrated pest management (IPM)

9.1.1 IPM definition

Integrated pest management (IPM) is an integrated approach to crop management to reduce chemical inputs and solve ecological problems. Although originally developed for agricultural insect pest management, IPM programs are now developed to encompass diseases, weeds and other pests that interfere with the management objectives of sites.

IPM is an ecological approach aimed at significantly reducing use of pesticides while managing pest populations at an acceptable level. IPM uses an array of complementary methods including mechanical and physical devices, as well as genetic, biological, cultural management and chemical management.[1] It uses strategies of prevention, observation and intervention. Benefits include the reduction in cost, contamination, residues and resistance to the pesticide.

9.1.2 Problems with pesticides

IPM does not mean abandoning pesticides – they are still the basis for pest control – but the impact on natural enemies is considered when selecting a pesticide. Regular monitoring needs to observe the pest and beneficial species dynamics. Beneficial species can provide control of most pests if they are present. By reducing the use of non-selective pesticides, the aim is to foster predators and parasites to stabilise pest populations and reduce the need to spray.

Overuse of pesticides can hasten pesticide resistance developing. It can also lead to a resurgence of pests, create new pests, potentially increase pesticide residues in grain and lead to off-target contamination including of wildlife reserves and waterways.

MORE INFORMATION

Please see the GRDC Integrated Pest Management Fact Sheet for more details, https://grdc.com.au/resources-and-publications/all-publications/bookshop/2009/12/integrated-pest-management-fact-sheet-national

9.1.3 IPM, organics and biological control

IPM is not the same as organic pest management, although many organic options are compatible with IPM.

IPM is sometimes confused with classic biological control. While they are not the same, IPM plays an important role in maximising the success of biological control by reducing the use of non-selective sprays and boosting the survival of biological control agents.[2]

Native remnant vegetation can support beneficial predatory insects. Pest-suppressive landscapes are those that have the right mix of habitats that support beneficial insects and allow them to move into crop fields, while discouraging the build-up of pest insect species.[3]

1 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

2 H Brier (2008) Break crop IPM short course manual. Southern Region IPM Workshop Training Manual: Soybeans and Winter Pulses, 11 March 2008, Griffith and Coleambally, NSW, 82pp.

3 GRDC (2014) Pest suppressive landscapes: Pest management using native vegetation Fact Sheet, 4 pp., Grains Research and Development Corporation, www.grdc.com.au/GRDC-FS-PestSuppressiveLandscapes

FEEDBACK

MORE INFORMATION

A Fact Sheet on pest-suppressive landscapes can be found at www.grdc.com.au/GRDC-FS-PestSuppressiveLandscapes

9.1.4 Soft *v.* hard pesticides

The terms 'soft' and 'selective' are terms used to describe pesticides that kill target pests but have minimal impact on parasites and predators attacking these pests. Parasites and predators are often called 'beneficials'.

Pesticides that impact on beneficial species are termed 'hard', 'non-selective' or 'broad-spectrum'.

In practice, there are varying degrees of softness and many products may be hard on one group of beneficial species but relatively soft on another. (See Section 9.7)

Insecticides that are less toxic to beneficial insects should be used where possible.[4]

Synthetic pesticides are generally only used as required and often only at specific times in a pest's life cycle.

Many newer pesticide groups are derived from plants or naturally occurring substances.[5] Examples are nicotine, pyrethrum and insect juvenile hormone analogues. Further 'biology-based' or 'ecological' techniques are being evaluated.

9.1.5 IPM process

The process in managing insect pests to reduce damage in a profitable manner is:

1. Planning.
2. Monitoring and recording.
3. Identification.
4. Assessing options.
5. Controlling/managing.
6. Reassessing.[6]

Regular monitoring, with accurate pest identification, is the key to IPM. For insects, monitoring for beneficial organisms and predators is important too. Record-keeping is essential, as is knowledge of the behaviour and reproductive cycles of target pests. For more information on monitoring, see Section 9.1.7.

Use the information gathered from monitoring to decide what sort of control action (if any) is required. Make spray decisions based on a combination of economic threshold information and your experience. Insecticide resistance and area-wide management strategies may also affect spray recommendations.

If a control operation is required, ensure 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.

Assess crops after spraying and record data. Post-spray inspections are important in assessing whether the spray has been effective.[7]

4 H Brier (2008) Break crop IPM short course manual. Southern Region IPM Workshop Training Manual: Soybeans and Winter Pulses, 11 March 2008, Griffith and Coleambally, NSW, 82pp.

5 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

6 H Brier (2008) Break crop IPM short course manual. Southern Region IPM Workshop Training Manual: Soybeans and Winter Pulses, 11 March 2008, Griffith and Coleambally, NSW, 82pp.

7 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

9.1.6 IPM system

An IPM system is designed around some basic components:

1. Acceptable pest levels.
2. Preventative cultural practices.
3. Monitoring the crop.
4. Biological and environmental control.
5. Responsible chemical use.

Acceptable pest levels

Emphasis is on control, not eradication. IPM programs work to establish acceptable pest levels (action thresholds) and then apply controls if those thresholds are exceeded.

The most common threshold used is an economic threshold, which involves control at a density that will prevent the pest numbers from reaching an economically damaging population. The aim of pest management is to keep pest populations below the economic threshold.

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

Preventative cultural practices

Use varieties best suited to local growing conditions and maintain healthy crops. Mechanical methods may be possible under some circumstances.

If lentil is the first crop in the rotation after a pasture phase, there can be a range of pests that occur naturally in pastures that can attack lentil seedlings. These include blue oat mite, wireworm and pasture cockchafer, which will often be present in the pasture phase. A long fallow (September–April) with clean cultivation and good weed control before the lentil crop can prevent these pests. Weedy fallows can provide resources and shelter for these pests as well as taking soil moisture that could be used by the crop later in the season.

Monitoring lentil crops

Regular observation is the key to IPM. Observation is broken into inspection and then identification. For insects, monitoring for beneficial organisms and predators is important too. Record-keeping is essential, as is a thorough knowledge of the behaviour and reproductive cycles of target pests.

Before sowing lentil, the paddocks should be checked for signs of insect presence. When stubble mulch covers soil in autumn there are several pests that are capable of feeding on organic matter and then transferring to emerging seedlings. Earwigs, slaters and Rutherglen bugs can all be present in stubble residues waiting to attack crops as they emerge.

Monitoring should start as the crop emerges, to check plant populations and for gaps from attack by insects such as earwigs, weevils or by slugs. These can leave large bare patches which may need resowing. As the crop grows there can be a range of herbivores and sucking pests that can feed on lentil, but as many varieties of lentil are capable of vigorous growth, the main threat is transfer of viruses.

Monitoring during the vegetative stages can be limited to weekly visual inspections looking for evidence of caterpillar or aphids in the crop. Beneficial species such as lady beetles, hoverflies and wasps are often seen during this phase and can be a good indicator to check for pest species.

As the canopy closes, monitor weekly to check for presence of pests, particularly aphids. Aphids will target stressed crops. They will move quickly from weeds or other crops and can build up overnight. Monitoring needs to occur several times a week if aphids are noticed. Many beneficial species such as lady beetles, hoverflies and wasps will follow the aphid colonies.

Once the crop is flowering, use of a beat-sheet or sweep net and a standardised protocol for each sample can be useful to give counts that can be compared with previous counts.

Recording results in a diary or on a spreadsheet will enable decisions to be made objectively rather than in an ad-hoc manner.

Monitor the degree days of an environment to determine when is the optimal time for a specific insect outbreak, particularly etiella.

Biological and environmental control

A range of organisms and environmental processes can provide control, with minimal crop damage, often at low cost. The main focus is on promoting beneficial organisms that target pests. (See Section 9.7)

There is a lag period between when a pest is present and when the beneficial species affect the pest population. Predators destroy their prey and leave little evidence of their actions, so these effects are often underestimated. Some biological control agents are very prolific, relatively predictable and able to keep the pests at low levels so they do not impact on crop production.

In broadacre crops the best strategy is to preserve and encourage these beneficial organisms that are naturally occurring. Grow a diverse range of plant species around the farm, preserving native habitat near crop paddocks and reduce the use of broad-spectrum insecticides.

Use biological insecticides, derived from naturally occurring microorganisms (*Bt*, Viva Gold®, entomopathogenic fungi and nematodes) and chemicals specific to pest species where possible.

Responsible chemical use

Synthetic pesticides are generally only used as required and often only at specific times in a pest's life cycle. Many newer pesticide groups are derived from plants or naturally occurring substances.

Insecticides that are less toxic to beneficial insects should be used where possible. For example, pirimicarb for aphid control, in seasons where permitted, may mean less repeat applications compared with the use of synthetic pyrethroids because beneficial insects are preserved.

(Pirimicarb is not currently registered for use in lentil. However, emergency permits have previously existed.)

9.1.7 Monitoring methods

Scout crops thoroughly and regularly during 'at risk' periods using the most appropriate sampling method. Record insect counts and other relevant information using a consistent method to allow comparisons over time. Also monitor any nearby crops that may be harbouring aphids that could rapidly build up to then take flight into a neighbouring lentil crop.

Pest numbers alone may not always give an accurate assessment of damage being caused. Observing and monitoring crop damage may also assist in assessing any accumulating yield loss.[8]

Pest monitoring needs to be based on a realistic but effective system suited to individual needs.

8 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

Sweep net monitoring

The easiest and quickest way to determine the number of grubs in a crop is to ‘sweep’ the crop with an insect sweep net. It is impossible to accurately determine numbers by simply looking in the crop. However, sweep-net sampling can underestimate the abundance of pest insects present in the crop.

Sweep netting works best for small pests found in the tops of small crops. It is less efficient in assessing larger pests such as pod-sucking bugs. Sweep netting can be used for flighty insects and is the easiest method for sampling crops with narrow row spacing. It is also useful in wet paddocks[9]

A standard sized net (380 mm in diameter) can be purchased from most chemical suppliers.

- Take 10 sweeps of the net through the crop canopy while walking slowly through the paddock. A standard sweep of the net needs to be about 2 m.
- Empty the contents into a tray or bucket and count the caterpillars of various sizes. It is important to look very carefully for small caterpillars as these have the most potential to cause damage.
- Repeat this process in at least 12 places throughout the paddock to obtain an average insect density.

Crop inspection

Sampling flowers and leaves in the crop can tell you much more than a sticky trap including:

- levels of non-flying juvenile stages (eggs, larvae, pupae);
- levels of non-flying adult pests (such as mites, snails); and
- early stages and extent of pest damage.

This information is much more powerful for assessing pest levels, accurately predicting trends and checking the effectiveness of control measures. It is essential for making decisions and following up on the results.

Depending on the pest, where it feeds, hides and breeds, you will need to check flowers, leaves, pods and stems. The pattern, frequency and level of sampling depend on the crop, pests of concern and beneficial insects of interest, and the time of year.

Weeds nearby will build up large numbers of pests in spring. Inspecting the weeds can keep you in touch with how the local pest pressure is building. Ideally, remove the weeds before the pest numbers build.[10]

9 DAF (2012) Insect monitoring techniques for field crops, Queensland Department of Agriculture and Fisheries, www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/help-pages/insect-monitoring

10 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

Yellow sticky traps or cards

Sticky traps are useful as a way of monitoring flying pests like thrips, whitefly and aphids. They attract these insects because of their colour. They are a useful way of sending samples away for identification of thrips species. However, they do not give a complete picture of pest dynamics in the crop. Adult insects may settle into the crop after flying in and juvenile non-flying stages may survive spray applications but will not show up on the traps.

Sticky traps should be changed or checked at least weekly. They need to be placed just above the growing tips of the plants to catch insects hovering above them and to avoid getting stuck and lost in the crop.[11]

Quadrats

Use quadrats to sample snails. (See Section 9.3.2)

Tiles, hessian bags and slug traps

Use either a tile, hessian bag or slug trap left in the paddock overnight to count snail or slug numbers. (See Section 9.3.2)

9.2 Identifying pests

9.2.1 Correct identification of insect species

It is important to be able to identify the various insects present in your crop, whether they are pest or beneficial species, and their growth stages.

Sending insect samples for diagnostics

SARDI Entomology Unit provides free insect diagnostic services for subscribers of PestFacts South Australia and western Victoria newsletter. For more details on how to package specimens, go to: www.pir.sa.gov.au/research/services/crop_diagnostics/insect_diagnostic_service

The NSW DPI will identify insects for a fee. Phone 1800 675 821 for more information.

Agriculture Victoria and cesar (University of Melbourne) do not offer a routine insect-identification service.[12]

11 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

12 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

FEEDBACK

> **MORE INFORMATION**
>
> For more information see: Insect ID: The Ute Guide app: https://grdc.com.au/resources-and-publications/app

9.2.2 Insect ID: The Ute Guide

While many resources are available, the primary insect-identification resource for grain growers is 'Insect ID: The Ute Guide', a digital guide for smart phones and tablets that is progressively updated as new information becomes available (Figure 1).

Insect ID is a comprehensive reference guide to insect pests commonly affecting broadacre crops and growers across Australia, and includes the beneficial insects that may help to control the pests.

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.[13]

Not all insects found in field crops are listed in this app, so further advice may be required before making management decisions.

Figure 1: *Screenshots from the iOS edition of 'Insect ID: The Ute Guide' app.*

> **MORE INFORMATION**
>
> GrowNotes™ Alerts
> https://grdc.com.au/grownotesalert

9.2.3 GrowNotes™ Alerts

GrowNotes™ Alerts is a free, early warning system that notifies you of any emerging disease, pest and weed threats specific to the user's chosen area. It provides real-time information from experts across Australia.

A GrowNotes™ Alert can be delivered via app, SMS, voice, email, social media or web portal (or a combination of preferred methods). The urgency with which they are delivered can help reduce the impact of weed, pest and disease costs. GrowNotes Alerts improve the relevance, reliability, speed and coverage of notifications on the incidence, prevalence and distribution of weed, pest and diseases.

13 GRDC (2014) Northern faba bean GrowNotes, Grains Research and Development Corporation, https://grdc.com.au/Resources/GrowNotes

9.3 Key pests of lentil

Lentil is most vulnerable to economic insect damage during establishment and between flowering and maturity.[14]

The key pests of lentil in southern Australia are *Helicoverpa punctigera* (native budworm), etiella, snails, slugs, aphids, redlegged earth mite (RLEM) and lucerne flea. Table 1 shows the timing of damaging effects of the key and other pests in lentil crops.

Table 1: Incidence of lentil crop pests.

Pest	Crop stage				
	Emergence/ seedling	Vegetative	Flowering	Podding	Grain-fill
RLEM	Damaging	Present			
Lucerne flea	Damaging	Present			
Cutworms	Damaging				
Slugs and snails*	Damaging	Damaging			
Aphids	Damaging	Present	Present		
Thrips	Present				
Loopers		Damaging			
Native budworm		Present	Damaging	Damaging	Damaging
Etiella			Damaging	Damaging	Present

*Snails may also cause grain contamination at harvest. Present = Present in crop but generally not damaging. Damaging = Crop susceptible to damage and loss.

Source: http://ipmguidelinesforgrains.com.au/crops/winter-pulses/lentils/

Lentil is useful as a rotation crop as it can suppress RLEM and blue oat mite populations if weeds are controlled. However, lentil crops will suffer if mite populations are high. RLEM populations have been found with high levels of resistance to two synthetic pyrethroids – bifenthrin and alpha-cypermethrin.

Lentil is tolerant of some foliar damage and can compensate by producing secondary shoots.[15]

9.3.1 *Helicoverpa* species: native budworm and corn earworm (*Helicoverpa punctigera* and *H. armigera*)

The larva of native budworm (*Helicoverpa punctigera*) is the main insect pest of lentil late in the season in southern Australia.

H. punctigera is not the same species *H. armigera*, which is commonly known as corn earworm or cotton bollworm.[16]

Helicoverpa spp. are commonly referred to as helicoverpa, heliothis, or 'helis'. It is technically more correct to refer to them as "*Helicoverpa* species" to distinguish them from true *Heliothis* spp.[17]

14 Queensland Government (2016) IPM Guidelines, website, http://ipmguidelinesforgrains.com.au/crops/winter-pulses/lentils/

15 http://ipmguidelinesforgrains.com.au/crops/winter-pulses/lentils/

16 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

17 H Brier (2008) Break crop IPM short course manual. Southern Region IPM Workshop Training Manual: Soybeans and Winter Pulses, 11 March 2008, Griffith and Coleambally, NSW, 82pp

Distribution of *Helicoverpa* spp.

Most *Helicoverpa* in southern Australia from September to early November will be *H. punctigera*.[18] *H. punctigera* is native to Australia. It is more common in inland regions and southern Australia.[19]

H. punctigera (native budworm) breeds over winter in the arid inland regions of Queensland, South Australia, Western Australia and New South Wales on desert plants before migrating into southern agricultural areas in late winter or spring. They can migrate as far south as Tasmania.[20]

H. armigera is more problematic in summer crop irrigation areas. It occasionally occurs in significant numbers in Victorian crops.[21] Although summer pulses are at greatest risk from *H. armigera*, spring outbreaks are possible.

H. armigera is present in Europe, Asia, Africa and Australasia. While it is present in all Australian states, it is more common in the tropics and subtropics.[22] It is a major pest of chickpea and other pulses in northern Australia.

Pest status of *Helicoverpa* spp.

Helicoverpa spp. are major pests and can severely damage all crop stages and all plant parts of all summer and winter pulses. Both species of *Helicoverpa* may be found in lentil.

While significant numbers of *H. armigera* are rare in Victoria, it is still an important pest when it does occur in large numbers, as it may be resistant to many of the commonly used insecticides.[23]

MORE INFORMATION

For more information on insect identification, see: Insect ID: The Ute Guide: https://grdc.com.au/Resources/Ute-Guides/Insects/Butterflies-moths-larvae/North/Heliothis

Identification of *Helicoverpa* spp. eggs and larvae

The adult moths lay round eggs singly on the host plant. Eggs are pale cream or white when laid, 0.6 mm diameter, ribbed and globular. Fertile eggs develop a red or brown ring after one to two days and become brown or black before hatching.[24 25] They hatch two to five days after being laid.[26]

18 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

19 H Brier (2008) Break crop IPM short course manual. Southern Region IPM Workshop Training Manual: Soybeans and Winter Pulses, 11 March 2008, Griffith and Coleambally, NSW, 82pp.

20 G McDonald (2015) Native budworm. 8 pp. Pest Notes Southern. CESAR and South Australian Research and Development Institute. http://www.pir.sa.gov.au/__data/assets/pdf_file/0005/274181/Native_Budworm.pdf

21 G McDonald (1995) Native budworm. Agnote Ag0417. Agriculture Victoria. June 1995. http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/native-budworm

22 H Brier (2008) Break crop IPM short course manual. Southern Region IPM Workshop Training Manual: Soybeans and Winter Pulses, 11 March 2008, Griffith and Coleambally, NSW, 82pp.

23 G McDonald (1995) Native budworm. Agnote Ag0417. Agriculture Victoria. June 1995. http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/native-budworm

24 H Brier (2008) Break crop IPM short course manual. Southern Region IPM Workshop Training Manual: Soybeans and Winter Pulses, 11 March 2008, Griffith and Coleambally, NSW, 82pp.

25 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited.

26 GRDC (2013) Insect ID: The Ute Guide, iOs app, Version 1.1, 14 October 2013. https://grdc.com.au/Resources-and-Publications/app

The two *Helicoverpa* species can be differentiated for eggs and small larvae with a Lepton™ test.[27]

Photo 1: *(From left) fresh white eggs of* Helicoverpa*, 1–2-day-old eggs showing brown ring and eggs close to hatching, showing black larval head.*

Photo: Northern Faba Bean GrowNotes™ (2014), Grains Research and Development Corporation, https://grdc.com.au/GrowNotes

Newly hatched larvae are pale with tiny dark spots and dark heads.

Medium larvae are usually brown and the darker spots become more obvious.

Medium larvae develop lines and bands running the length of the body in variable colours.[28]

Large larvae can reach 45 mm. Darker specimens are more common in high density populations. Large larvae vary from green, yellow, orange, pink and red-brown to black.[29] [30]

27 GRDC (2013) Insect ID: The Ute Guide, iOs app, Version 1.1, 14 October 2013. https://grdc.com.au/resources-and-publications/app

28 GRDC (2013) Insect ID: The Ute Guide, iOs app, Version 1.1, 14 October 2013. https://grdc.com.au/resources-and-publications/app

29 H Brier (2008) Break crop IPM short course manual. Southern Region IPM Workshop Training Manual: Soybeans and Winter Pulses, 11 March 2008, Griffith and Coleambally, NSW, 82pp.

30 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

Photo 2: *It is important to be able to identify the different larval instars of* Helicoverpa *spp.*[31] *The six larval instars and two eggs are shown.* Helicoverpa *spp. have four abdominal pro-legs.*[32] *Insecticides are more effective on smaller larvae.*[33]

Photo: Gabriella Caon, SARDI.

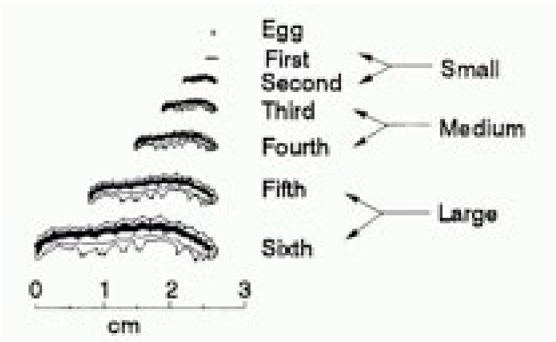

Figure 2: *Approximate sizes of the six instars of* Helicoverpa *spp.*

Source: Agriculture Victoria.

Sometimes the two *Helicoverpa* spp. can be identified by visually examining the larvae. Small *H. armigera* (third instar) have a saddle on the fourth segment but *H. punctigera* do not. While this method can be difficult in the field and is not completely reliable, it may provide a good guide.

In larger (fifth and sixth instar) larvae, hair colour in the segment immediately behind the head is a good species indicator. These hairs are white for *H. armigera* and black for *H. punctigera* (Photo 3).[34]

31 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

32 H Brier (2008) Break crop IPM short course manual. Southern Region IPM Workshop Training Manual: Soybeans and Winter Pulses, 11 March 2008, Griffith and Coleambally, NSW, 82pp.

33 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

34 GRDC (2014) Northern faba bean GrowNotes, Grains Research and Development Corporation, https://grdc.com.au/Resources/GrowNotes

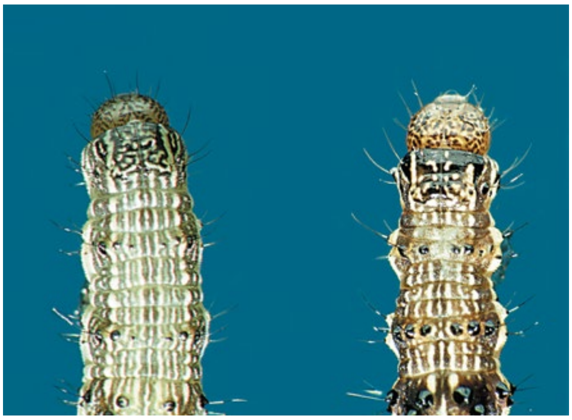

Photo 3: H. punctigera *with black hairs from head (left) and* H. armigera *with white hairs and 'saddle' on fourth abdominal segment (right).*

Photo: L Turton and M Cahill.

Distinguishing *Helicoverpa* spp. from other caterpillars

Helicoverpa spp. larvae can be easily identified, despite the colour variation, by a broad yellow stripe along the body. Young larvae (<10 mm) prefer to feed on foliage; older larvae prefer to feed on pods.

In southern Australia, other larvae which look like native budworm may be found in a pulse crop, for example, southern armyworm and pink cutworm. These are primarily grass feeders and rarely do any damage to pulses.[35]

H. punctigera larvae have black hairs around the head, no dark 'saddle' and light-coloured legs. In contrast, medium larvae of *H. armigera* have white hairs around the head, a dark 'saddle' on the fourth segment back from the head and dark-coloured legs. Pupae of *H. armigera* are readily separated from *H. punctigera* which have spines that are close together.

Medium and large larvae, pupae and adult of *Helicoverpa* spp. can be distinguished visually. Both species of *Helicoverpa* larvae have a group of four pairs of 'legs' in the back half of the body; loopers can have a group of two, three or four pairs of legs at the rear and loop when walking.[36] *Helicoverpa* spp. larvae do not taper noticeably towards the head, as do loopers.

Armyworm larvae can be distinguished by the lack of hairs and by bodies that taper at both ends.

Medium *H. armigera* larvae may also be confused with cluster caterpillar (*Spodoptera litura*) but are more hairy and lack the cluster caterpillar's distinctive spots and hump behind the head.

Helicoverpa eggs are paler than looper eggs, which have a green tinge and are squatter.[37]

35 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

36 GRDC (2014) Northern faba bean GrowNotes, Grains Research and Development Corporation, https://grdc.com.au/Resources/GrowNotes

37 H Brier (2008) Break crop IPM short course manual. Southern Region IPM Workshop Training Manual: Soybeans and Winter Pulses, 11 March 2008, Griffith and Coleambally, NSW, 82pp

Identification of *Helicoverpa* spp. moths

Helicoverpa spp. moths have a 30–45 mm wingspan with stout bodies.[38] Moths are a dull light brown with dark markings.

Adult moths of *H. punctigera* are usually active during the evening and night and are rarely seen during the day. For native budworm (*H. punctigera*), the fore-wings are buff-olive to red-brown with numerous dark spots and blotches.[39] The hind wings are pale grey with dark veins and a dark band along the lower edge. The hind wings have a dark, broad band on the outer margin.[40]

Photo 4: Helicoverpa punctigera *(native budworm) moths, showing female (left) and male (right).*

Photo: SARDI.

H. armigera has a small light or pale patch in the dark section of the hind-wing while the dark section is uniform in *H. punctigera*.

38 GRDC (2014) Northern faba bean GrowNotes, Grains Research and Development Corporation, https://grdc.com.au/Resources/GrowNotes

39 G McDonald (1995) Native budworm. Agnote Ag0417. Agriculture Victoria. June 1995. http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/native-budworm

40 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited.

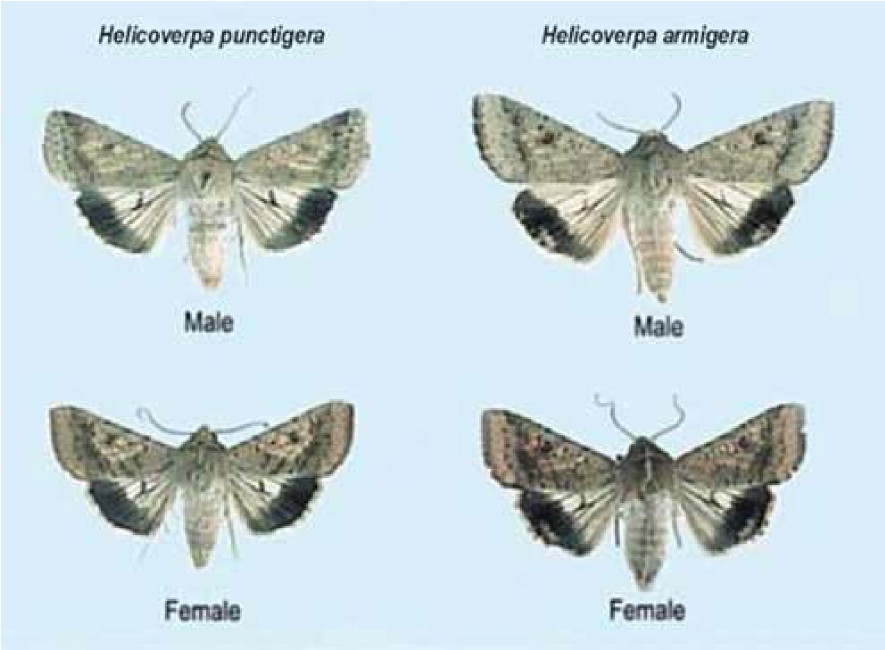

Photo 5: Helicoverpa punctigera *(native budworm) and* H. armigera *moths. The two species are distinguished by the presence of a pale patch in the margin of the hind-wing of* H. armigera*. Most helicoverpa in southern Australia from September to early November will be* H. punctigera*.*

Photo: Northern Faba Bean GrowNote (2014), Grains Research and Development Corporation,https://grdc.com.au/Resources/GrowNotes

Life cycle of *Helicoverpa* spp.

Each female helicoverpa can lay more than 1,000 eggs. In southern Australia, native budworm may produce up to five generations a year. The eggs hatch 1–2 weeks after laying in spring (or 2–6 days in summer) and the larvae feed in crops for 4–6 weeks.[41 42]

Once larvae are fully grown, they crawl to the base of the plant, tunnel into the soil and form a chamber in which they pupate. During spring, summer and early autumn, the pupae develop quickly and a new generation of moths emerges after about two weeks. As with all insect development, the duration of pupation is determined by temperature, taking longer in spring and autumn. Diapausing pupae take much longer to emerge.

The moth emerges, feeds, mates and is then ready to begin the cycle of egg laying and larval development.

Native budworm eggs and holes on soursob (oxalis) petals are signs of native budworm activity in the area.

The spring generation causes the most damage, especially to pulse crops.

During winter, native budworm enters a resting period as a pupa in the soil. Adult moths emerge from these overwintering pupae in August and September and live for about 2–4 weeks.[43]

41 H Brier (2008) Break crop IPM short course manual. Southern Region IPM Workshop Training Manual: Soybeans and Winter Pulses, 11 March 2008, Griffith and Coleambally, NSW, 82pp.

42 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

43 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

Diapause in *Helicoverpa* spp.

Both species of *Helicoverpa* survive winter as pupae in the soil, when host plants and thus food sources are scarce. *H. punctigera* are capable of overwintering in southern cropping regions, but only a few are ever found. By contrast, substantial numbers of overwintering *H. armigera* pupae can be found under late summer crops, particularly when helicoverpa activity has been high, late into March.

Not all pupae that form in late summer go into diapause; a proportion continues to develop, perhaps emerging during winter, or early in spring.

Overwintering pupae can be killed without use of chemicals. Pupae in the soil are susceptible to soil disturbance and disruption of the emergence tunnel. Cultivation is enough to create this disturbance.

Damage by *Helicoverpa* spp.

Helicoverpa spp. attack most major field crops as well as many horticultural crops. They attack all above-round plant parts. Once crops reach flowering, larvae focus on buds, flowers and pods.[44]

Native budworm (*H. punctigera*) larvae bore into lentil pods and usually destroy several seeds in each pod. A single larva may attack four to five pods before reaching maturity.

The amount of damage to each seed varies considerably, but the damaged area has jagged edges. In contrast, etiella leaves a 'pin-prick' hole.

Helicoverpa spp. cause most damage from podset to maturity, and can reduce grain yield and quality. Lentil grain affected by native budworm damage is classified as 'defective'.[45]

It is important to control larvae while they are still very small to small (<7 mm). Ninety per cent of all feeding (and therefore damage) by helicoverpa is done by larvae from the third instar (small to medium larva that are 8–13 mm long) onwards. Large helicoverpa larvae (>24 mm) are the most damaging stage, since larvae consume about 80% of their diet in the fifth and sixth instars.[46]

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44 H Brier (2008) Break crop IPM short course manual. Southern Region IPM Workshop Training Manual: Soybeans and Winter Pulses, 11 March 2008, Griffith and Coleambally, NSW, 82pp

45 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

46 GRDC (2014) Northern faba bean GrowNotes, Grains Research and Development Corporation, https://grdc.com.au/Resources/GrowNotes

Photo 6: *Native budworm.* Helicoverpa *spp. attack all above-ground parts of plants.*[47]

Photo: Wayne Hawthorne, formerly Pulse Australia.

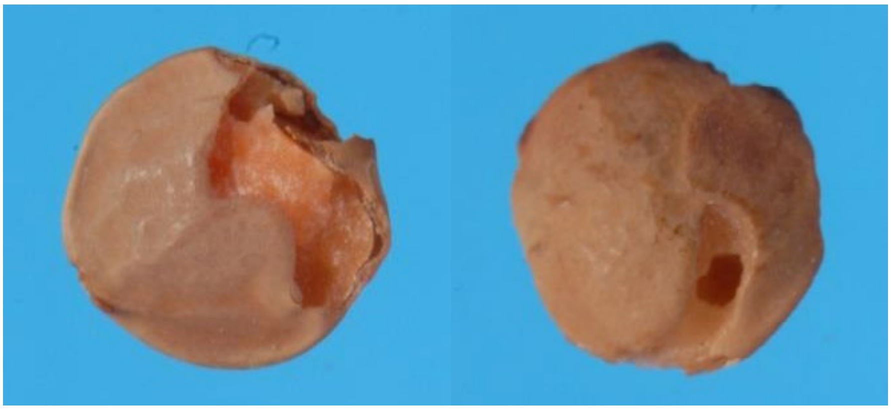

Photo 7: *Native budworm damage to lentil grain downgrades its quality. Affected grains are classified as defective.*[48]

Photo: Pulse Australia.

While the feeding behaviour of *H. armigera* and *H. punctigera* is expected to be the same, no research has been undertaken to assess this.

No studies have compared the behaviour of larvae in drought-stressed crops compared with crops with adequate moisture. Consequently there is no certainty about whether there is more, or earlier, flower and pod feeding when foliage appears to be less attractive.[49]

Monitoring *Helicoverpa* spp. larvae

Helicoverpa spp. cause most damage between podset and maturity.

Regularly monitor the lentil crop for insect pests and/or damage, to make timely decisions on control. It is important to target small larvae.[50]

Begin monitoring crops for helicoverpa larvae when crops start flowering and continue until late maturity.[51] One recommendation is to inspect crops weekly for before podset, then two or three times a week until late podding. Another recommendation is to monitor crops every three or four days from the beginning of flowering. Moth flight activity can provide an early warning for egg laying and

47 H Brier (2008) Break crop IPM short course manual. Southern Region IPM Workshop Training Manual: Soybeans and Winter Pulses, 11 March 2008, Griffith and Coleambally, NSW, 82pp.

48 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

49 GRDC (2014) Northern faba bean GrowNotes, Grains Research and Development Corporation, https://grdc.com.au/Resources/GrowNotes

50 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

51 D Lush (2013) Time to watch for native budworm. Grains Research and Development Corporation, https://grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-106-Sept-Oct-2013/Time-to-watch-for-native-budworm

potential future larval activity in the crop, and also signals the time to start monitoring crops for larvae.[52]

Growers also need to take into account beneficial species and populations in lentil crops.

Experienced agronomists suggest that helicoverpa numbers alone do not always give an accurate assessment of damage. In some situations (for example, if the crop is severely moisture stressed), monitoring crop damage will assist in assessing the accumulating yield loss.

The quickest and easiest method to sample most crops is to use a 38 cm diameter sweep net. Repeat the sweeping process of ten sweeps in at least 12 places throughout the paddock to obtain an average caterpillar density.[53] For more details, see: Section 9.1.7.

Beat-sheet sampling is the preferred sampling method for medium to large helicoverpa larvae. Scout for small larvae by opening vegetative terminals, buds and flowers.[54] Sample six widely spaced locations per paddock and take five 1-m-long samples at each site with a standard beat sheet. Convert larval counts per metre to larvae per square metre by dividing the counts by the row spacing, in metres.[55]

Helicoverpa eggs are difficult to see, so egg counts are an unreliable indicator of control thresholds. Egg survival to larvae can also be highly variable. If an egg count is taken, use it as an indication of an egg-laying event and determine the potential development rate of the helicoverpa.[56] Rates of native budworm (*H. punctigera*) development have been estimated for South Australia, based on meteorological data (Table 2); eggs laid on 20 August will take about three weeks to hatch, while eggs laid one month later will take 13 days. In some seasons, a second spray is needed.[57]

Table 2: Estimated developmental rate (number of days between stages) for native budworm in South Australia. Development is faster in spring than winter. In some years, a second spray is required. Based on former Victorian Department of Primary Industries estimates using DARABUG software using moth counts, larvae developmental stages and weather pattern information. These are a guide only.

Stage	Aug 20	Aug 30	Sep 10	Sep 20	Sep 30
Egg laying to egg hatch	21	18	16	13	13
Egg hatch to larvae 7–10 mm	32	30	28	27	24
Egg laying to larvae 7–10 mm	53	48	44	40	37

Source: Southern Lentil Best Management Practices Training Course Manual, (2016), Pulse Australia; Budworm Watch program – more than monitoring, (2003), Pacific Extension Network 2003 Forum, www.regional.org.au/au/apen/2003/abstracts/p-37.htm

It is difficult to estimate the number of very small larvae hatched in the previous 24 hours. Often they are low in the canopy. When using a beat sheet, they often remain on leaflets, making them very difficult to see and count. Very small larvae do no economic damage to the crop, their feeding confined to leaves. Early research on helicoverpa has shown high mortality of very small larvae; their value in monitoring is potential activity of larger larvae in a week or two.

In studies of helicoverpa larval feeding behaviour in soybean, large larvae were found to cause the majority of damage, in the order of 80%, with medium larvae contributing about 15% and other instars the remainder.

52 D Lush (2013) Time to watch for native budworm. Grains Research and Development Corporation, https://grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-106-Sept-Oct-2013/Time-to-watch-for-native-budworm

53 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

54 M Miles, P Grundy, A Quade and R Lloyd (2015) Insect management in fababeans and canola recent research. GRDC Update Paper. 25 February 2015. https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2015/02/insect-management-in-fababeans-and-canola-recent-research

55 H Brier (2008) Break crop IPM short course manual. Southern Region IPM Workshop Training Manual: Soybeans and Winter Pulses, 11 March 2008, Griffith and Coleambally, NSW, 82pp.

56 GRDC (2014) Northern faba bean GrowNotes, Grains Research and Development Corporation, https://grdc.com.au/Resources/GrowNotes

57 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

FEEDBACK

Monitoring *Helicoverpa punctigera* (native budworm) moth flights

Helicoverpa punctigera (native budworm) moths migrate to southern Australia from breeding grounds in the northern pastoral and desert areas after winter rainfall.

Large numbers of native budworm moths usually fly into cropping areas during late winter and spring, with infestations commencing in the northern cropping areas.

Moths are attracted to traps containing a chemical sex-attractant (pheromone), specific to the species so only the helicoverpa is caught.

Photo 8: *Pheromone traps can be used as a guide to identifying and monitoring moth numbers.*

Photo: Unknown

Take note of news of helicoverpa moth flights and inspect crops for the presence of caterpillars when crops are flowering and podding.

Growers should begin monitoring crops when moths are detected in their region. However, as there is no established relationship between the numbers of moths trapped and the resulting caterpillar population in nearby crops, growers cannot determine the need for sprays by the moth traps.

Control thresholds for *Helicoverpa* spp.

An economic control threshold is the number of caterpillars that will cause more financial loss than the cost of spraying.[58] Further research is needed into control thresholds for helicoverpa in lentil in southern Australia.

The thresholds used for helicoverpa are based on yield loss rather than quality; however, in pulses for human consumption, the quality threshold (defective grain) is probably reached before significant yield loss. Even in low numbers, helicoverpa can affect the marketability of grain while not economically affecting yield, meaning that control measures may be needed before economic thresholds are reached.

The control thresholds used in the southern region are those developed for Western Australia. This threshold is the only one used in Australia that may be derived from research, rather than 'best guesses', and assumes 60 kg/ha yield loss per larva in 10 sweeps (Table 3).[59 60]

58 P Mangano, S Micic (2016) Management and economic thresholds for native budworm control. Department of Agriculture and Food Western Australia, www.agric.wa.gov.au/grains/management-and-economic-thresholds-native-budworm

59 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

60 M Miles, P Grundy, A Quade and R Lloyd (2015) Insect management in fababeans and canola recent research. GRDC Update Paper. 25 February 2015. https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2015/02/insect-management-in-fababeans-and-canola-recent-research

Note that the Western Australian thresholds are only a guide for the Southern Region.[61] To calculate the threshold, use the formula:

Economic threshold (ET) for grubs in 10 sweeps = C ÷ (K x P)

Where:
C = control cost ($/ha), i.e. chemical plus application costs per hectare
K = 60 kg/ha lentil grain eaten for every one caterpillar netted in 10 sweeps or per square metre
P = price of grain per kg, i.e. price per tonne ÷ 1,000

For example, with lentil:
P = $420/t, (i.e. $0.42/kg)
C = $10/ha
K = 60 kg/ha

Therefore:
ET = 10 ÷ (60 x 0.42)
ET = 10 ÷ 25.2
ET = 0.4 grubs per 10 sweeps.

Table 3: Examples of economic thresholds for native budworm control in lentil.

	P	C	K	Economic thresholds	
Grain price per tonne ($)	**Grain price per kg ($)**	**Control costs including application ($/ha)**	**Loss per grub in each of 10 sweeps (kg/ha/grub)**	**Average grubs in 10 sweeps**	**Grubs in 5 lots of 10 sweeps (5x previous column)**
210	0.21	10	60	0.8	4
280	0.28	10	60	0.6	3
420	0.42	10	60	0.4	2
840	0.56	10	60	0.2	1

These thresholds were developed in Western Australia and are a guide only, as no thresholds have been developed for south-eastern Australia. They are based on yield loss only, not loss of quality.

Source: Southern Lentil: Best Management Practices Training Course (2016), Pulse Australia; P Mangano, S Micic (2016) Management and economic thresholds for native budworm control. Department of Agriculture and Food Western Australia, www.agric.wa.gov.au/grains/management-and-economic-thresholds-native-budworm

Helicoverpa punctigera (native budworm) control

Few control options are currently available other than the use of chemical insecticides or bio-pesticides for above-threshold populations of larvae in a crop.

Spray promptly once the threshold are exceeded. *Helicoverpa punctigera* (native budworm) larvae are easily killed by all registered products, including products to which *H. armigera* is resistant.[62 63]

Where insecticide has been used to control etiella, helicoverpa moths are often deterred from laying eggs in lentil crops.

Registered chemicals can be used at the same time as ascochyta fungicides, if necessary, as long as products are compatible.[64]

Because *H. punctigera* moths migrate annually into eastern Australian cropping regions, any resistance that might be selected for, because of exposure to insecticides in crops, is lost among the larger susceptible population. In other words,

61 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

62 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

63 GRDC (2014) Northern faba bean GrowNotes, Grains Research and Development Corporation, https://grdc.com.au/Resources/GrowNotes

64 R Rundell-Gordon (2016) Growing lentils: lessons learnt from growing lentils in central and north west Victoria, GRDC Update paper, 17 March 2016, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/03/Growing-lentils-lessons-learnt-from-growing-lentils-in-central-and-north-west-Victoria

as new *H. punctigera*, moths appear each year, insecticide resistance is unlikely to be a threat to pulse production in southern and western regions of Australia.

Commonly used insecticides registered for use on native budworm are shown in Table 7 with details in "Table 8: Green lentil disease traits." on page 23.

Aim to control larvae less than 10 mm long, because bigger larvae require higher rates of insecticides. The larvae must be sprayed before they burrow into the seed pods or they will be shielded from insecticides and will continue to damage seed.[65]

Helicoverpa armigera control

H. armigera has developed resistance to synthetic pyrethroids, organophosphates and carbamates. Unlike *H. punctigera*, populations tend to remain local, so their resistance to insecticides is maintained in the population from season to season.

If *H. armigera* is the dominant species, spray with carbamates or pyrethroids may fail because of resistance. The bio-pesticides *Helicoverpa* nucleopolyhedrovirus (NPV) and *Bacillus thuringiensis* (Bt) currently have no known resistance problems.[66]

Before flowering, bio-pesticides are recommended in preference to chemical insecticides in all pulses, particularly older, less selective products, for integrated pest management.

After flowering, control is recommended only for small larvae 5–7 mm long, depending on the product and if resistance levels are within acceptable limits for the region.

If using a product that is effective only against early instar larvae, another spray may be necessary during flowering to prevent large larvae damage at podset.

Where newer, more selective pesticides, are used for *H. armigera*, the number of spray applications per crop is restricted (usually to one) for resistance management. Because of this, and because they are often more expensive. New chemical pesticides are best reserved for 'at risk' flowering and podding stages.

For best results, all 'ingestion' products (including bio-pesticides) require thorough plant coverage. The addition of Amino Feed® or equivalent is strongly recommended for bio-pesticides.[67]

Spray applications

Correct timing and coverage are critical to achieving good control of helicoverpa larvae, whether using a chemical insecticide or a biopesticide (such as NPV or *Bt*).

Inappropriate timing risks crop loss and the costs of re-treating. It also increases the likelihood of insecticide resistance by exposing larvae to sub-lethal doses (for *H. armigera*). Regular crop scouting enables assessment of the number of helicoverpa larvae and the age structure of the population.

Early detection is critical to ensure effective timing of sprays. Larvae in the open are more easily contacted by spray. Target larvae before they move into flowers and pods.

Very small (1–3 mm) to small (4–7 mm) larvae are the most susceptible stages to insecticide and require a lower dose to kill. If a spray application is delayed more than two days, rechecked and reassessed.

Only spray if the value of the crop saved is more than the cost of spraying. Vegetative feeding generally does not equate to significant yield loss.

65 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

66 GRDC (2014) Northern faba bean GrowNotes, Grains Research and Development Corporation, https://grdc.com.au/Resources/GrowNotes

67 H Brier (2008) Break crop IPM short course manual. Southern Region IPM Workshop Training Manual: Soybeans and Winter Pulses, 11 March 2008, Griffith and Coleambally, NSW, 82pp

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

Attract-and-kill products such as Magnet® consist of a liquid moth lure based on floral volatiles mixed with an insecticide. Only a relatively small area needs to be treated (less than 2% of the total crop), minimising impact on natural enemies. Reducing the pest moth population decreases the number of eggs laid into a crop, which can lower subsequent pest pressure and delay the need for foliar insecticides.

9.3.2 Etiella (*Etiella behrii*)

Etiella, also known as lucerne seed web moth, attacks lentil, lupin and field pea crops. Lentil is its favourite winter pulse crop, of which etiella is a sporadic but major pest.[68]

Etiella is found over the whole of Australia, including Tasmania.

Etiella identification

Adult moths are grey, 10–15mm long, with a prominent beak or 'snout'. Their wing span varies between 20–25 mm. The are grey-brown with a distinctive white stripe running along the full length of the fore-wing.[69] Moths have an orange band on each fore-wing.

At rest, the wings are folded over the body, making the moth appear long and narrow. The moths will fly one to two metres if disturbed by walking through a crop.

Moths are sometimes confused with those of other non-pest *Etiella* spp. Other snout nosed moths similar to etiella may be found in lentil crops, but only etiella has the prominent white stripes running along the wing.

Adult females lay approximately 200 eggs, which are about 0.5–0.6 mm in diameter and difficult to see with the naked eye.[70] They are initially cream-coloured, and flattened but turn pink-orange just before hatching.[71] In lentil crops, eggs are commonly laid under the calyx and hatch in 4–7 days.[72]

Etiella larvae leave frass (excrement) inside pods and may web pods together.

Etiella has five larval stages (instars). Newly hatched larvae are very small, approximately 1mm,and are light orange with a dark head. As they develop, small larvae may be cream or green, lacking stripes, with a dark head.

Mid-sized larvae may be pale green or cream, with pale brown, pink or red stripes running along their length.[73]

Mature larvae are 10–12mm long. They are characteristically green with pink or red stripes and a brown head or pink-red. Larvae in the pre-pupal stage can be aqua blue or dark pink with no stripes.

Mature larvae exit pods to pupate in the soil. Pupae are smooth, light to dark brown in colour, and 9–12 mm long.

68 C Krawec (2006). Etiella management in lentils, brochure, 10 pp., South Australian Research and Development Institute, http://www.pulseaus.com.au/storage/app/media/crops/2008_Lentil-Etiella-management.pdf

69 C Krawec (2006). Etiella management in lentils, brochure, 10 pp., South Australian Research and Development Institute, http://www.pulseaus.com.au/storage/app/media/crops/2008_Lentil-Etiella-management.pdf

70 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

71 H Brier (2008) Break crop IPM short course manual. Southern Region IPM Workshop Training Manual: Soybeans and Winter Pulses, 11 March 2008, Griffith and Coleambally, NSW, 82pp.

72 C Krawec (2006). Etiella management in lentils, brochure, 10 pp., South Australian Research and Development Institute, http://www.pulseaus.com.au/storage/app/media/crops/2008_Lentil-Etiella-management.pdf

73 C Krawec (2006). Etiella management in lentils, brochure, 10 pp., South Australian Research and Development Institute, http://www.pulseaus.com.au/storage/app/media/crops/2008_Lentil-Etiella-management.pdf

Etiella damage

Etiella larvae feed on seeds within pods. Pods are susceptible to damage while they are green.[74] Etiella larvae consume far less than large caterpillars like helicoverpa; seeds are usually only partially eaten, often with characteristic pin-hole damage. While damaged seeds have jagged edges similar to native budworm damage, they are distinguished by the presence of silken webbing associated with large larvae.[75]

Etiella damage is difficult to grade out and its unattractive appearance reduces seed quality.

Larval frass (excrement) adhering to damaged seeds is frequently mistaken for bruchid eggs. However, unlike bruchids, etiella are unable to re-infect stored seed.[76]

Etiella damage results in inferior quality lentil and yield losses due to a reduction in grain weight and grain breakage. Insect damaged grain is often unsaleable. Australian lentil producers face significant cleaning costs to meet receival standards, which allow for no more than 1% insect damaged grain.

Typically, only the first generation of etiella moths is a concern for lentil growers. However, in seasons that finish late, the second generation may also cause significant seed damage.

First instar etiella larvae bore into pods shortly after hatching and begin feeding on the developing grain. Usually each larva damages more than a single pod, and often webs several pods together to continue feeding.

74 M Raynes (2015) Etiella moths active in southern lentil crops, Pulse Industry Update, 22 September 2015, Pulse Australia, http://pulseausblog.tumblr.com/post/129634859040/etiella-moths-active-in-southern-lentil-crops

75 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

76 H Brier (2008) Break crop IPM short course manual. Southern Region IPM Workshop Training Manual: Soybeans and Winter Pulses, 11 March 2008, Griffith and Coleambally, NSW, 82pp.

Etiella life cycle

Etiella flights can often occur in mid to late September, coinciding with early pod development in most districts, however, the first moth flights are usually in late September to early October.

Female moths lay their eggs under the calyx or on the pod surface, and these hatch in 4–7 days depending on temperature.

Newly hatched larvae bore into green pods within 24 hours to begin feeding on developing grain. This can make etiella more difficult to manage than native budworm.

Etiella has two to three generations per year, from spring to autumn. Larvae over-winter in the soil and emerge as adults the following spring. Researchers do not know if etiella moths colonising lentil crops emerge locally, or whether they migrate from further distances. Etiella moths may live from 1–3 weeks.[77 78]

Etiella monitoring methods

Etiella is considered a high priority pest and successful control relies on thorough crop monitoring in order to properly time insecticide applications to target adult moths before egg laying. Also monitor lentil crops during peak flight for the larvae of etiella, as the larvae damage plants.

Lentil is susceptible to etiella damage from late flowering onwards, as soon as the first pods appear. Monitor every 4–5 days and recommence monitoring within one week of spraying.

Etiella flights commonly occur in mid to late September and frequently coincide with early pod development in lentil.

A number of monitoring methods are available and should be implemented from the beginning of pod formation. These include:

- degree-day model;
- pheromone traps;
- light traps; and
- sweep netting.

77 C Krawec (2006). Etiella management in lentils, brochure, 10 pp., South Australian Research and Development Institute, http://www.pulseaus.com.au/storage/app/media/crops/2008_Lentil-Etiella-management.pdf

78 M Raynes (2015) Etiella moths active in southern lentil crops, Pulse Industry Update, 22 September 2015, Pulse Australia, http://pulseausblog.tumblr.com/post/129634859040/etiella-moths-active-in-southern-lentil-crops

FEEDBACK

IN FOCUS

Day degree model for monitoring etiella

The SARDI etiella degree-day model is a proxy for estimating rates of insect development. It uses maximum and minimum daily temperature data to forecast the timing of peak etiella flight activity for the various lentil-growing districts. The model identifies the date to commence in-crop monitoring for etiella moths.

Peak etiella moth activity in lentil crops (for most areas) is estimated as the date when the model reaches 351 degree-days.

Begin monitoring lentil crops at least two weeks before 351 degree-days accumulate, or at about 300 degree-days, to ensure detection of early etiella. The degree-day accumulation cut-off is 341 in the Streaky Bay area, South Australia. SARDI will refine guidelines in 2017 based on a network of field observations in different districts in 2016.

Download the model at: SARDI etiella degree-day model.

www.pir.sa.gov.au/__data/assets/file/0003/45759/etiella_degree_day_model.xls

Temperature data for your local region can be obtained from the Bureau of Meteorology website (http://www.bom.gov.au) and must be entered into the model from 21 June onwards.

Detailed instructions for running the model can be obtained by emailing Bill Kimber (bill.kimber@sa.gov.au).

MORE INFORMATION

The Pest Facts newsletter provides updated model predictions to growers in South Australia. To subscribe, click on Pest Facts.

www.pir.sa.gov.au/research/services/reports_and_newsletters/pestfacts_newsletter

Pheromone traps for etiella

Pheromone traps are useful to indicate the presence and timing of moth flight activity. These are sticky traps baited with a specific sex attractant. They have the advantage over light trapping of being specifically attractive to etiella.

Pheromone traps provide a crude measurement of etiella abundance; trap catches depend on moth movement, as well as numbers.

A minimum of two to three traps should be placed within a crop, positioned approximately 25 cm above the crop canopy. Traps may be effective for up to one month.

Sweep nets for etiella

Sweep netting is a common method for monitoring etiella moths. Lentil crops should be sampled at least weekly during podding for evidence of etiella activity.

Randomly take a minimum of three groups of 20 sweeps in each lentil paddock. The control threshold for etiella is 1–2 moths per 20 sweeps. This is an average count from a minimum of three sets of 20 sweeps in a lentil paddock.

Begin sweep netting when the degree-day figure is close to 300 degree-days.[79, 80, 81]

Light traps for etiella

Light traps are another means of monitoring etiella moths. However, they catch a wide range of insects. Checking outdoor lights around buildings during the evening is a simple means of detecting etiella flight activity in spring.

Chemical control of etiella

Effective management of the etiella moth relies on controlling the adults with well-timed insecticide treatments, if required, before they lay eggs on lentil pods; understanding the timing of moth flights is critical.[82]

Growers need to be ready to control the first generation of etiella as soon as the control threshold of sweeps is reached. Insecticide should be applied immediately after peak flights of etiella, targeting adult moths before they lay eggs.[83]

Esfenvalerate and deltamethrin are registered for the control of etiella moths in lentil. The short withholding periods (14 days and 7 days, respectively) of these insecticides allow them to be used late in the season.

Both products provide excellent and rapid control of adult moths and small larvae before they burrow into pods. Once inside the pods, larvae are protected from insecticide sprays and damage is usually only identified at harvest.[84, 85]

Etiella damage can be controlled within the acceptable industry threshold if insecticide is applied at the correct time.

An indication of damage and the inability to fully control etiella with the wrong insecticide timing, is given in Table 4. Note that timing of the insecticides used in the trial is now considered too late. Although the levels of damage caused to pods were consistently lower in the insecticide-treated plots, the percentage of *E. behrii* damaged grain was commercially unacceptable (>1% damaged).

Table 4: Mean percentage of insect-damaged pods, insect-damaged grain and yield of Nugget lentils in an early evaluation trial of three insecticides at Netherby, Victoria, November 2003.[86] Treatments were applied seven days after peak moth flights, which is now known to be too late.

Treatment	Pre-treatment assessment (% damaged pods)	5 days post-treatment (% damaged pods)	19 days post-treatment (% damaged pods)	Grain quality (% damaged grains)	Grain yield (t/ha)
Untreated	4.1 a**	12.6 a	4.8 a	2.16 a	2.83 a
Deltamethrin	1.8 a	4.2 a	1.5 b	1.14 a	2.87 a
Methomyl*	2.9 a	3.3 a	2.8 ab	1.82 a	2.79 a
Esfenvalerate	2.8 a	4.3 a	1.2 b	2.07 a	2.82 a

**Different letters within columns indicate significant differences among treatments at the $p < 0.05$ level using the Tukey's HSD comparisons of means test.

* Methomyl is not registered for control of etiella in lentil.

Source: Agriculture Victoria

79 C Krawec (2006). Etiella management in lentils, brochure, 10 pp., South Australian Research and Development Institute, http://www.pulseaus.com.au/storage/app/media/crops/2008_Lentil-Etiella-management.pdf

80 SARDI (2016) The etiella degree-day model, Pestfacts newsletter, Issue 11, 15 September 2016, www.pir.sa.gov.au/research/services/reports_and_newsletters/pestfacts_newsletter/pestfacts_issue_11_2016/etiella_degree-day_model

81 M Raynes (2015) Etiella moths active in southern lentil crops, Pulse Industry Update, 22 September 2015, Pulse Australia, http://pulseausblog.tumblr.com/post/129634859040/etiella-moths-active-in-southern-lentil-crops

82 SARDI (2016) The etiella degree-day model, Pestfacts newsletter, Issue 11, 15 September 2016, http://www.pir.sa.gov.au/research/services/reports_and_newsletters/pestfacts_newsletter/pestfacts_issue_11_2016/etiella_degree-day_model

83 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

84 C Krawec (2006). Etiella management in lentils, brochure, 10 pp., South Australian Research and Development Institute, http://www.pulseaus.com.au/storage/app/media/crops/2008_Lentil-Etiella-management.pdf

85 M Raynes (2015) Etiella moths active in southern lentil crops, Pulse Industry Update, 22 September 2015, Pulse Australia, http://pulseausblog.tumblr.com/post/129634859040/etiella-moths-active-in-southern-lentil-crops

86 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited.

Helicoverpa (native budworm) moths may be deterred from laying eggs in lentil crops where insecticide has been used for etiella.[87] Conversely, sprays applied to control native budworm in early podding may offer some control of etiella. Importantly, note monitoring for etiella should recommence no longer than one week after spraying.[88, 89]

The glossy shield bug can attack etiella moth, while parasitic wasps and flies have been recorded from larvae and pupae.[90]

MORE INFORMATION

For more details on snail management, please see the GRDC Snail Management Fact Sheet: www.grdc.com.au/GRDC-FS-SnailManagement

9.3.3 Snails

Snail populations can build up readily in lentil crops and can become a major problem if not controlled. They can enter the grain sample at harvest, even when they have not climbed onto the lentil plant.[91] Snail numbers can explode in seasons with wet springs, summers and autumns.[92] Particular attention must be paid to snails under no-till and stubble retention. [93]

Comprehensive information on snail management is available in the publications:

- Snail Bait Application Factsheet;[94] www.grdc.com.au/Resources/Factsheets/2015/01/Snail-Bait-Application
- *Bash 'Em, Burn 'Em, Bait 'Em: Integrated snail management in crops and pastures*.[95] www.grdc.com.au/GRDC-Snails-BashBurnBait
- *Snail Identification and Control: The Back Pocket Guide*. www.grdc.com.au/BPG-SnailIdentificationAndControl

White snails or round snails (*Cernuella virgata* and *Theba pisana*)

Two species of white (or round) snails exist: the vineyard or common white snail (*Cernuella virgata*) and the white Italian snail (*Theba pisana*). They are found throughout the agricultural districts of South Australia, the Victorian Mallee and Wimmera. They also occur in Western Australia, New South Wales and Tasmania.

Both species have similar shapes: white coiled shells up to 20 mm diameter, which may have brown bands around the spiral. The common white snail has an open umbilicus whereas the umbilicus of the Italian snail is partly closed. The umbilicus of a white snail is the hollow space on the underside of the shell.[96 97]

87 R Rundell-Gordon (2016) Growing lentils: lessons learnt from growing lentils in central and north west Victoria, GRDC Update paper, 17 March 2016, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/03/Growing-lentils-lessons-learnt-from-growing-lentils-in-central-and-north-west-Victoria

88 C Krawec (2006). Etiella management in lentils, brochure, 10 pp., South Australian Research and Development Institute, http://www.pulseaus.com.au/storage/app/media/crops/2008_Lentil-Etiella-management.pdf

89 M Raynes (2015) Etiella moths active in southern lentil crops, Pulse Industry Update, 22 September 2015, Pulse Australia, http://pulseausblog.tumblr.com/post/129634859040/etiella-moths-active-in-southern-lentil-crops

90 http://ipmguidelinesforgrains.com.au/pests/etiella/

91 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

92 GRDC (2012) Snail Management: All-year-round attack on snails required. Southern and Western Region Factsheet. 6 pp. Grains Research and Development Corporation, www.grdc.com.au/GRDC-FS-SnailManagement

93 J Kirkegaard (2017) Opportunities and challenges for continuous cropping systems, GRDC Update Paper, https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2017/02/opportunities-and-challenges-for-continuous-cropping-systems

94 GRDC (2015) Snail Bait Application: Lessons from the Yorke Peninsula to improve snail baiting effectiveness. Factsheet. 4pp. Grains Research and Development Corporation, https://grdc.com.au/Resources/Factsheets/2015/01/Snail-Bait-Application

95 D Hopkins, E Leonard, G Baker (2003) "Bash 'Em, Burn 'Em, Bait 'Em: Integrated snail management in crops and pastures". 40 pp. South Australian Research and Development Institute, www.grdc.com.au/GRDC-Snails-BashBurnBait

96 Pulse Australia (2016) Agronomy. Southern Faba Bean Best Management Practices Training Course Manual 2016, Pulse Australia Limited

97 GRDC (2011) Snail Identification and Control: The Back Pocket Guide, www.grdc.com.au/BPG-SnailIdentificationAndControl

Photo 9: *Vineyard or common white snail. Note the umbilicus (hollow space) is open.*
Photos: SARDI

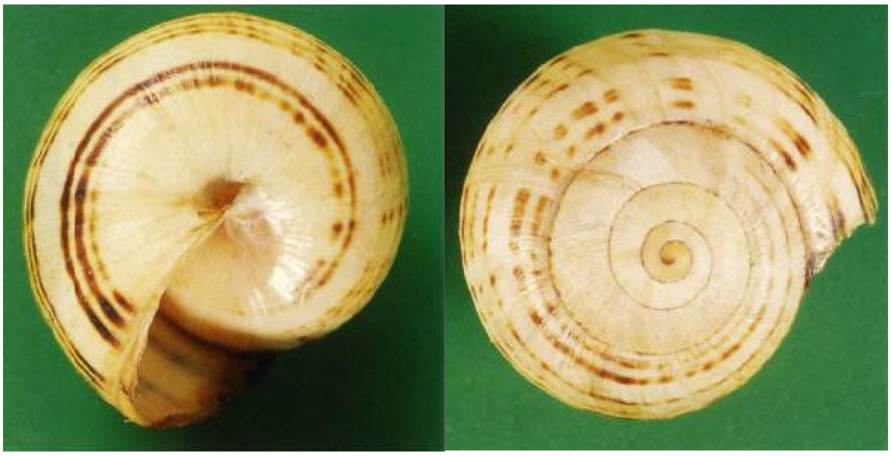

Photo 10: *White Italian snail. Note the umbilicus (hollow space) is partly closed.*
Photos: SARDI.

Conical snails or pointed snails or (*Prietocella acuta* and *Prietocella barbara*)

Two species of conical snails exist: conical snails (*Prietocella acuta*) and small conical snails (*P. barbara*).

Conical snails are also known as pointed snails. They have fawn, grey or brown shells. Mature conical snails have shells 12–18 mm long whereas the shells on the small conical snails are 8–10 mm long.

Highest numbers of conical snails (*P. acuta*) are found on the Yorke Peninsula in South Australia. Isolated populations are also present in other parts of South Australia, Victoria, New South Wales and Western Australia.

The small conical snail, *P. barbara*, occurs throughout South Australia, but is most abundant in the higher rainfall areas (>500 mm). It is also widely spread in Victoria, New South Wales and Western Australia.[98 99]

98 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

99 GRDC (2015) Snail Bait Application: Lessons from the Yorke Peninsula to improve snail baiting effectiveness. Factsheet. 4pp. Grains Research and Development Corporation, https://grdc.com.au/Resources/Factsheets/2015/01/Snail-Bait-Application

The ratio of shell length to base diameter is always >2 for conical snails and <2 for small conical snails.

Photo 11: *Conical snail, also known as pointed snail. The shell length is always more than double the base diameter. Mature conical snail shells are 12–18 mm long.*

Photo: SARDI.

Photo 12: *Small conical snail, also known as small pointed snail. The shell length is always less than double the base diameter. Mature small conical snail shells are 8–10 mm long.*

Photo: SARDI.

MORE INFORMATION

For more information on managing snails at harvest, refer to: Section 12.5 Snails.

Damage by snails

White snails mainly damage crops during establishment and harvest. Both common white and Italian snails may feed on young crops and destroy substantial areas which then need re-sowing. In late spring, snails climb plants. The juveniles, in particular, contaminate the grain at harvest.

Conical snails, *Prietocella acuta*, contaminate grain at harvest, especially cereals and canola. They feed mostly on decaying plant material but can damage cereal and canola seedlings.[100]

The small conical snail *P. barbara* feeds on growing plants and can contaminate grain. Lucerne is a favoured plant.

The contaminated grain may be downgraded or rejected and live snails in grain pose a threat to exports. Grain will be rejected if more than half a dead or one live snail is found in a 200 g pulse sample.[101] Check with your buyers for specific regulations.

Crushed snails clog up machinery causing delays during harvest. Modify headers and clean grain to eliminate snail contamination of grain.

Life cycle of snails

Snails appear to build up most rapidly in canola, field pea and faba bean. However, they can feed and multiply in all crops and pastures. White snails are dormant in summer. Young snails hatch about two weeks after eggs are laid. They feed and grow through the winter and spring before climbing fence posts or plants in late spring or summer, where they enter summer dormancy. Snails live for 1–2 years, and move only short distances. They are spread in hay, grain, machinery, or vehicles.[102]

Conical snails have a similar life cycle to white snails. Conical snails may over-summer under stones and on posts and plants.

Small conical snails over-summer on the ground in the leaf litter and under stones and stumps.[103]

Monitoring snails

Monitor snails regularly to establish their numbers, types and activity as well as success of controls. Monitoring and early baiting before eggs are laid is critical.[104] [105] [106]

Look for snails in the early morning or evening when conditions are cooler and snails are more active.

The key times to monitor snail populations are:

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

100 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

101 Pulse Australia (2016) Australian pulse standards 2016/2017, 68 pp., www.graintrade.org.au/sites/default/files/Pulse_Standards_2016-2017_01Aug16.pdf

102 GRDC (2012) Snail Management: All-year-round attack on snails required. Southern and Western Region Factsheet. 6 pp. Grains Research and Development Corporation, www.grdc.com.au/GRDC-FS-SnailManagement

103 GRDC (2015) Snail Bait Application: Lessons from the Yorke Peninsula to improve snail baiting effectiveness. Factsheet. 4pp. Grains Research and Development Corporation, https://grdc.com.au/Resources/Factsheets/2015/01/Snail-Bait-Application

104 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

105 GRDC (2012) Snail Management: All-year-round attack on snails required. Southern and Western Region Factsheet. 6 pp. Grains Research and Development Corporation, www.grdc.com.au/GRDC-FS-SnailManagement

106 http://ipmguidelinesforgrains.com.au/pests/slugs-and-snails/snails-in-seedling-crops/

A wide range of snail sizes in an area indicates that snails are breeding there; if most snails are the same size, snails are moving in from other areas. The size range of snails is important as juveniles do not take baits.

Various monitoring techniques are recommended for snails. Methods include:

- sampling with 10 x 10 cm quadrats at 50 locations across the paddock. Take samples from the perimeter to the interior of the paddock and note density in different areas;
- sampling with a 0.1 m^2 (32 x 32 cm) quadrat. Place the quadrat on the ground and count all live snails within it. Take five counts along the fence at approximately 10 m apart, then five counts into the paddock every 10m.
- sampling with a 30 x 30 cm quadrat at 50 locations across the paddock.

When sampling at 50 locations, take five sampling transects in each paddock. One transect is taken at 90 degrees to each fence line whilst the fifth transect runs across the centre of the paddock. Take five samples (counts), 10 m apart along each transect. Record the size and number of the snails in each sample. Average the counts for each transect and multiple this figure by 10 to calculate the number of snails per square metre in that area of the paddock.

If both round and conical snails are present, record the number of each group separately.

Place the snails in a simple sieve box and shake gently to separate into larger snails and those <7 mm. Round snails and small conical snails (<7 mm) are unlikely to be controlled by bait. Record two size groups (juveniles <7 mm and adults >7 mm). Sieve boxes can be constructed from two stackable containers, such as sandwich boxes. Remove the bottom from one and replace by a punch hole screen. The suggested screen size is 7 mm round or hexagonal.[107]

When looking for snails, check under weeds, and shake and thresh samples of mature crops onto a small tarp or sack, to see if snails are in the portion of crop that will enter the harvester.[108]

Record live snails before and seven days after baiting or the paddock operation and calculate the reduction in numbers.[109]

107 http://ipmguidelinesforgrains.com.au/pests/slugs-and-snails/snails-in-seedling-crops/

108 GRDC (2012) Snail Management: All-year-round attack on snails required. Southern and Western Region Factsheet. 6 pp. Grains Research and Development Corporation, www.grdc.com.au/GRDC-FS-SnailManagement

109 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

Snail control

To control snails, you will need to apply a combination of treatments throughout the year.

The keys to snail management and control are:

- Stubble management:
  - cabling or rolling in summer;
  - slashing in summer; and
  - burning in autumn.
- Summer weed control.
- Baiting in autumn.
- Harvest and delivery:
  - reducing snail intake during harvest (windrowing, brushes, bars);
  - header settings; and
  - cleaning after harvest.

Cultural management for snail control

Snail control starts in the summer before sowing.

While control measures for conical snails are the same as those used on white snails, they are generally less effective, as conical snails can shelter in cracks in the ground or under stones. Dragging harrows or a cable before burning improves the control of conical snails by exposing more snails to burning.

The best control is achieved by stubble management on hot days or burning, followed by baiting in autumn before egg laying.

Rolling, harrowing or dragging a cable over stubble on hot days reduces snail numbers by knocking snails to the ground to die in the heat (air temperature >35°C). Some snails may also be crushed by rollers.

Burning in autumn can reduce snail numbers by up to 95%, provided there is sufficient stubble for a hot and even burn. Note that wind or water erosion become a risk on burnt stubble.

Windrowing can reduce white snail numbers harvested. Snails are knocked from the crops during windrowing, and most re-climb the stalks between the windrows rather than in the windrow.

Grain can be cleaned on-farm where snail contamination is so high that grain will be downgraded or rejected.

Baiting snails

If lentil crops have more than 5 snails/m^2, growers are likely have grain contamination at harvest.

Bait in autumn when snails have commenced activity following rain. This must be done before egg laying.[110] Baiting may be necessary to reduce damage to young crops. Juvenile snails (less than seven mm) cannot be controlled after sowing. Fence line baiting can also be vital to prevent re-infestation of the paddock. Do not bait within two months of harvest to avoid bait contamination in grain.

Timing and choice of controls will depend on the season.[111] Three bait types are available for snail control: methiocarb, metaldehyde and iron chelates, which are similar in efficacy. (However, methiocarb and iron chelates are not registered for use in lentil). The metaldehyde rate used depends on the product.

110 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

111 GRDC (2012) Snail Management: All-year-round attack on snails required. Southern and Western Region Factsheet. 6 pp. Grains Research and Development Corporation, www.grdc.com.au/GRDC-FS-SnailManagement

Most spreaders are designed for fertiliser; a South Australian trial has shown that snail and slug bait is not spread as widely as expected and can become fragmented. Ute spreaders give uneven coverage.[112] For optimal coverage, calibrate spreaders for snail bait. For details, see the snail bait application factsheet. https://grdc.com.au/Resources/Factsheets/2015/01/Snail-Bait-Application.

Photo 13: *Growers must calibrate spreaders especially for snail bait for optimal bait coverage. Baits come in different shapes and sizes, which affects the evenness of spread.* Photo: Felicity Pritchard.

Biological control of snails

Biological controls are not yet available for white snails.[113] Native nematode species have shown promise against the four pest snail species but commercially trialled with limited success.[114]

112 GRDC (2015) Snail Bait Application: Lessons from the Yorke Peninsula to improve snail baiting effectiveness. Factsheet. 4pp. Grains Research and Development Corporation, https://grdc.com.au/Resources/Factsheets/2015/01/Snail-Bait-Application

113 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

114 M Nash (2013) Slug control – new insight. GRDC Update paper. https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/07/Slug-control-new-insights

FEEDBACK

MORE INFORMATION

For more information see *Slugs in Crops: the Back Pocket Guide*: www.grdc.com.au/GRDC-BPG-Slug

MORE INFORMATION

For details on a GRDC project that explored a range of management strategies to effectively reduce damage caused by slug species in the High Rainfall Zone, please see 'Slugging Slugs': www.grdc.com.au/Media-Centre/Hot-Topics/Slugging-slugs/Details

9.3.4 Slugs (*Deroceras reticulatum*, *Milax gagates* and others)

Slugs are a growing problem in the high rainfall zones with zero-till and stubble retention.

No single control method will provide complete protection; an integrated approach is best.

Slug populations are regulated by moisture. Cool, wet summers and heavy stubble provide ideal conditions for slugs as they need moisture and shelter to thrive.

Slug species identification

The two main pest species are the grey field or reticulated slug (*Deroceras reticulatum*), and the black keeled slug (*Milax gagates*). The grey field slug is the most common slug species in southern Australia. Brown field slugs, *D. invadens* or *D. laeve*, can also pose a serious threat.

Details of other species can be found in the *Slug in Crops: The Back Pocket Guide*. www.grdc.com.au/GRDC-BPG-Slug[115]

Adult grey field slugs are usually grey and about 2–5 cm long. They may have dark brown mottling and range from light grey to fawn. The black keeled slug is uniform black to grey, with a ridge down its back, and 4–6 cm long. The brown field slug is 25–35 mm, and usually brown all over with no distinct markings.[116]

The brown field slug is mainly surface active but can burrow to shallow depths.[117]

Grey field slugs are mainly active on the surface while the black keeled slug can burrow up to 20 cm underground to escape the heat. For this reason, black keeled slugs may become active in emerging crops later than grey field slugs, as the autumn break develops. This means the optimal timing of control will differ for the two species.[118]

As black keeled slugs are a burrowing species, they are considered better suited to drier environments.

115 P Horne, J Page (2006) Slugs in Crops: The Back Pocket Guide, 2 pp., Grains Research and Development Corporation, www.grdc.com.au/GRDC-BPG-Slug

116 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

117 M Nash, H Brier, P Horne, J Page, S Micic, G Ash, A Wang (2013) Slug control: Slug identification and management factsheet. 4pp. Grains Research and Development Corporation, www.grdc.com.au/GRDC-FS-SlugControl

118 GRDC (2014) Slugging Slugs: findings from recent GRDC High Rainfall Zone (HRZ) trials, 2 pp. Grains Research and Development Corporation, https://grdc.com.au/Media-Centre/Hot-Topics/Slugging-slugs/Details

Photo 14: *The two main slug species in Southern Australia, grey field slug (*Deroceras reticulatum*) (top) and the black keeled slug (*Milax gagates*).*

Photo: Peter Mangano, DAFWA.

Damage by slugs

Slugs will attack all plant parts. Seedlings are the most vulnerable and can suffer major economic damage.

Slugs can be underestimated as pests because they are nocturnal and shelter during dry conditions.

Although slugs can cause major damage to emerging pulse, canola and wheat crops in high rainfall areas, they have also caused damage in lower rainfall areas in wetter years. Damage is usually greater in cracking clay soils.

Life cycle of slugs

Slugs are hermaphrodites, that is, individuals are both male and female. Slugs will breed whenever moisture and temperature conditions are suitable – generally from mid-autumn to late spring. Both individuals of a mating pair lay eggs in batches. Each individual can lay about 100 eggs; some species can produce about 1,000 eggs per year.[119] [120]

Eggs are laid in moist soils and will hatch within 3–6 weeks, depending on temperature. Juveniles look like smaller versions of the adult.

Moisture is essential for slug survival. Some species, such as the black keeled slug, may move down the soil to depths of 20 cm or more in dry periods and reappear when conditions improve.

119 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

120 M Nash, H Brier, P Horne, J Page, S Micic, G Ash, A Wang (2013) Slug control: Slug identification and management factsheet. 4pp. Grains Research and Development Corporation, www.grdc.com.au/GRDC-FS-SlugControl

Photo 15: *Slug eggs hatch within 3–6 weeks of laying. Some species can produce up to 1,000 eggs per year.*

Photo: Michael Nash

Monitoring of slugs

Research suggests that monitoring slugs is unreliable because populations vary so much. Growers need to know the hot spots for slugs in each paddock and use baits at crop establishment when the risk is high.

If monitoring, use surface refuges, such as 30 x 30cm pavers, to monitor slugs. This represents approximately 1 m^2 for slugs. Ideally use a minimum of 10 tiles per 10 ha placed evenly across the entire paddock.

Growers can also use either a tile, hessian bag or slug trap left in the paddock over night to count snail or slug numbers. Use surface traps baited with layers' mash and check them early in the morning, as slugs move out of the traps as the day starts to warm up.

Slug control

When slugs are actively breeding, no current control measure will reduce populations below established thresholds.[121] Particular attention must be paid to slugs under no-till and stubble retention[122].

Cultivation and rolling, and burning stubble after weed control will reduce slug populations. Rolling the soil immediately after sowing can markedly reduce slug damage. Shallow discing may reduce populations of grey field slugs by 40–50%. While burning may help control surface-active species, it will not control the burrowing black keeled slugs.[123 124]

If anticipating crop damage from slugs, bait after sowing, before crop emergence. Differences in biology between species can affect control options and chemical efficacy.

Always use the highest possible label rates or adjust the rate to the perceived size of the slug population.[125] Bait is commonly applied at 4–5 kg/ha, but be aware that the density of bait points needs to be at about 25–30 bait points/m^2 for a paddock population of 20 slugs/m^2, giving 80% chance of slugs encountering the baits. Spreading bait with fertiliser spreaders can lead to poor distribution of bait.[126 127 128]

MORE INFORMATION

For details on identifying slugs, please see the GRDC Fact Sheet on slug identification and management www.grdc.com.au/GRDC-FS-SlugControl

121 M Nash, M Richards, H De Graff, G Baker (2016) New insights into slug and snail control. 7 pp. GRDC Update Paper. https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/New-insights-into-slug-and-snail-control

122 J Kirkegaard (2017) Opportunities and challenges for continuous cropping systems, GRDC Update Paper, https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2017/02/opportunities-and-challenges-for-continuous-cropping-systems

123 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

124 GRDC (2014) Slugging Slugs: findings from recent GRDC High Rainfall Zone (HRZ) trials, 2 pp. Grains Research and Development Corporation, https://grdc.com.au/Media-Centre/Hot-Topics/Slugging-slugs/Details

125 M Nash, H Brier, P Horne, J Page, S Micic, G Ash, A Wang (2013) Slug control: Slug identification and management factsheet. 4pp. Grains Research and Development Corporation, www.grdc.com.au/GRDC-FS-SlugControl

126 GRDC (2015) Snail Bait Application: Lessons from the Yorke Peninsula to improve snail baiting effectiveness. Factsheet. 4pp. Grains Research and Development Corporation, https://grdc.com.au/Resources/Factsheets/2015/01/Snail-Bait-Application

127 M Nash (2013) Slug control – new insight. GRDC Update paper. https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/07/Slug-control-new-insights

128 GRDC (2010) Aphids and viruses in pulse crops, Factsheet, 4 pp. Grains Research and Development Corporation, www.grdc.com.au/GRDC-FS-AphidsandVirusesinPulses

Preliminary trials found the effective bait life is between 2–3 weeks. More than one bait application may be necessary, particularly with wet winters. Cheaper options give similar results if baiting occurs monthly.

Buried bait is less effective than bait on the soil surface.

Similar to snails, three bait types are available for slug control: methiocarb, metaldehyde and iron chelates, which are similar in efficacy.[129] (However, methiocarb and iron chelates are not registered for use in lentil.)

Baiting will generally only kill half of the slug population at any one time.

Consider placing baits with the seed when sowing, when black keeled slugs are present.

For grey field slugs, broadcasting baits is more effective.[130]

Predators may provide some regulation of slug populations. The carabid or ground beetle, *Notonomus gravis*, reduces grey field slug numbers but not below damage thresholds.[131]

9.3.5 Aphids

MORE INFORMATION

For more details on aphids and viruses, please see the GRDC fact sheet: www.grdc.com.au/GRDC-FS-AphidsandVirusesinPulses

Aphids are a pest of lentil chiefly because they spread viruses during feeding which can reduce crop yields, especially when infection is extensive in early crop stages. A few aphids can cause substantial damage if they are spreading viruses, especially early in the season.

It takes large numbers of aphids to damage crops by direct feeding.[132] Insecticides aimed at controlling damage from aphid feeding are normally too late to control virus spread and damage.

Aphids and virus transmission

Virus transmission typically occurs well before aphid colonies are evident. A pre-emptive and integrated management approach (taking into account the risk factors) is required to minimise the impact of virus.[133]

Prolonged, high levels of aphids arriving early in the season are associated with unique cases of viruses causing major yield losses in lentil crops. Combinations of Cucumber mosaic virus (CMV), Alfalfa mosaic virus (AMV) and Turnip yellows virus (TuYV), (also known as Beet western yellows virus, BWYV) are often present.[134]

Lentil crops are also susceptible to Bean leaf roll virus (BLRV), Bean yellow mosaic virus (BYMV) and Pea seedborne mosaic virus (PsbMV), Subterranean clover red leaf virus (SCRLV) and Subterranean clover stunt virus (SCSV).[135] [136] [137]

Most lentil crops surveyed in South Australia and Victoria have CMV, which occasionally becomes a major problem.

129 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

130 M Nash, H Brier, P Horne, J Page, S Micic, G Ash, A Wang (2013) Slug control: Slug identification and management factsheet. 4pp. Grains Research and Development Corporation, www.grdc.com.au/GRDC-FS-SlugControl

131 M Nash (2013) Slug control – new insight. GRDC Update paper. https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/07/Slug-control-new-insights

132 GRDC (2010) Aphids and viruses in pulse crops, Factsheet, 4 pp. Grains Research and Development Corporation, www.grdc.com.au/GRDC-FS-AphidsandVirusesinPulses

133 http://ipmguidelinesforgrains.com.au/crops/winter-pulses/lentils/

134 W Hawthorne, M Materne, J Davidson, K Lindbeck, L McMurray, J Brand (2015) Lentil: integrated disease management, Australian Pulse Bulletin, 20 November 2015, Pulse Australia, http://www.pulseaus.com.au/growing-pulses/bmp/lentil/idm-strategies

135 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

136 M Aftab, A Freeman, F Henry (2013) Temperate Pulse Viruses: Pea-seedborne Mosaic Virus (AMV), Agnote AG1267, Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/temperate-pulse-viruses-pea-seed-borne-mosaic-virus-psbmv

137 M Aftab, A Freeman, F Henry (2013) Temperate Pulse Viruses: Bean yellow Mosaic Virus (BYMV), Agnote AG1266, Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/temperate-pulse-viruses-bean-yellow-mosaic-virus-bymv

MORE INFORMATION

For more information on viruses, refer to Section 10 Diseases

The most important factors that predispose lentil crops to severe virus infection are:

- close proximity to a large virus reservoir (such as lucerne and summer weeds);
- high summer and autumn rainfall, followed by uncontrolled multiplication of aphids on host plants; and
- early aphid flights to newly emerged crops causing early infection. Infected plants act as a reservoir for the disease to spread even further.

Aphids can spread viruses persistently or non-persistently (Table 5). Once an aphid has picked up a persistently transmitted virus, it carries the virus for life, infecting every plant where it feeds. Aphids carrying non-persistently transmitted viruses carry the virus temporarily and only infect new plants in the first one or two probes.

Table 5: Examples of transmission of some persistent and non-persistent viruses by four aphid species affecting pulse crops, including lentil. Non-persistently transmitted viruses may be seedborne but require aphid vectors to spread during the season.

Aphid	Cucumber mosaic virus (CMV)	Pea seedborne mosaic virus (PSbMV)	Turnip yellows virus (TuYV)*
	Non-persistent	**Non-persistent**	**Persistent**
Green peach aphid	Yes	Yes	Yes
Pea aphid	Yes	Yes	No
Cowpea aphid	Yes	Yes	Yes
Bluegreen aphid	Yes	No	No

*Formerly known as Beet western yellows virus, BWYV

Source: Aphids and viruses in pulse crops Fact Sheet (2010), Grains Research and Development Corporation, www.grdc.com.au/GRDC-FS-AphidsandVirusesinPulses

Different aphid species transmit different viruses to particular crop types, so species identification is important because management strategies can vary.

MORE INFORMATION

Information on this widespread and common pulse crop pest can be found at PestNotes Southern: http://pir.sa.gov.au/__data/assets/pdf_file/0003/275826/Cowpea_Aphid.pdf

Cowpea aphid (*Aphis craccivora*)

The cowpea aphid is a widespread and common pest of pulse crops, including lentil. It has a wide range of host plants and can tolerate warm, dry weather that causes many other aphid species to suffer.

Cowpea aphid is the only black aphid. All stages have black and white legs.[138] Adults are shiny black, up to 2.5 mm long and may have wings. Nymphs are slate grey. Superficially, nymphs of the brown smudge bug look like cowpea aphid nymphs.

Photo 16: *Cowpea aphids can transmit a number of viruses. Note the different aphid ages. The older aphids are shiny black. The white cast is a skin, shed as the aphid grows.*

Photo: SARDI

Before they colonise a lentil crop, cowpea aphids can transmit viruses (Table 6).

Table 6: Some persistent and non-persistent viruses spread by cowpea aphid that affect lentil. This list is not exhaustive and the viruses may be spread by other aphid species[139]

Persistent	Non-persistent
Bean leaf roll virus (BLRV)	Pea seedborne Mosaic Virus (PSbMV)
Subclover red leaf virus (SCRLV)	Bean yellow mosaic virus (BYMV)
Subclover stunt virus (SCSV)	Cucumber mosaic virus (CMV)
Turnip yellows virus (TuYV)*	Alfalfa mosaic virus (AMV)

*Also known as beet western yellows virus, BWYV

Sources: Southern Lentil Best Management Practices Training Course Manual, (2016), Pulse Australia Limited and Cowpea aphid, Pest Notes Southern, (2015), cesar and the South Australian Research and Development Institute, www.pir.sa.gov.au/__data/assets/pdf_file/0003/275826/Cowpea_Aphid.pdf

A cowpea aphid infestation is generally patchy at first but will spread through the crop if the weather is fine and warm.

Infestations start when winged females colonise a few plants in a crop and give birth to wingless nymphs that live in colonies. This may occur from early winter onwards. As the plant deteriorates, the aphids move to neighbouring plants, increasing the area of infested patches within the crop.[140]

138 T Yeatman, W Hawthorne, J Paull, J Bellati, J Egan, K Henry, R Kimber, M Seymour, J van Leur, K Lindbeck, P Matthews, I Rose (2009) Faba beans: The Ute Guide. 127 pp. Primary Industries and Resources South Australia, https://grdc.com.au/resources-and-publications/all-publications/publications/2009/11/faba-beans-the-ute-guide

139 P Umina, S Hangartner (2015) Cowpea aphid, Pest Notes Southern, 6 pp. cesar and the South Australian Research and Development Institute, www.pir.sa.gov.au/__data/assets/pdf_file/0003/275826/Cowpea_Aphid.pdf

140 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

FEEDBACK

MORE INFORMATION

More information on Bluegreen aphids can be found in the information sheets developed between cesar and the South Australian Research and Development Institute (SARDI).

See PestNotes Southern: http://www.pir.sa.gov.au/__data/assets/pdf_file/0011/275492/Bluegreen_Aphid.pdf

Bluegreen aphid (*Acyrthosiphon kondoi*)

Adult bluegreen aphids grow up to 3 mm, may have wings and vary from matte blue-green to grey-green. They are oval, with long legs and antennae. They have two large cornicles (tubes) that extend beyond the base of the abdomen. Nymphs are similar to adults but smaller.[141]

Photo 17: *Bluegreen aphid.*

Photo: Grain Legume Handbook (2008) Grain Legume Handbook for the Pulse Industry. Grain Legume Hand Book Committee, https://grdc.com.au/grainlegumehandbook.

Photo 18: *Bluegreen aphids of various ages. The brown insects are dead bluegreen aphids which have been parasitised by wasps.*

Photo: Grain Legume Handbook (2008) Grain Legume Handbook for the Pulse Industry. Grain Legume Hand Book Committee, https://grdc.com.au/grainlegumehandbook

Bluegreen aphids can colonise lentil plants and transmit important viruses including the non-persistent viruses Cucumber mosaic virus (CMV) and Bean yellow mosaic virus (BYMV).[142] Bluegreen aphids do not transmit Pea seedborne mosaic virus (PSbMV).

Bluegreen aphids cause feeding damage to upper leaves, stems and terminal buds of host plants. Heavy infestations can cause damage to plants by direct removal of nutrients. In general, aphids have the greatest impact on crops when soil moisture is limited.[143]

Bluegreen aphids prefer cooler weather (10–18°C) for breeding. Females produce up to 100 young at a rate of approximately seven young per day. Winged aphids develop

141 T Yeatman, W Hawthorne, J Paull, J Bellati, J Egan, K Henry, R Kimber, M Seymour, J van Leur, K Lindbeck, P Matthews, I Rose (2009) Faba beans: The Ute Guide. 127 pp. Primary Industries and Resources South Australia, https://grdc.com.au/resources-and-publications/all-publications/publications/2009/11/faba-beans-the-ute-guide

142 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

143 P Umina, W Kimber (2015) Bluegreen aphid, Pest Notes Southern, 6 pp. cesar and the South Australian Research and Development Institute, http://www.pir.sa.gov.au/__data/assets/pdf_file/0011/275492/Bluegreen_Aphid.pdf

when infestations become crowded; they fly or are blown by wind to start new infestations elsewhere.

Monitoring aphids

Frequent monitoring is necessary to detect rapid increases of aphid populations.

Aphids invade lentil crops from adjacent crops, pastures and roadsides. Monitor all crop stages. In particular, regularly monitor lentil crops in the seedling and establishment stages and between bud formation to late flowering.

Aphids will target stressed plants and often progress into crops from the edges. Monitoring adjacent paddocks and fence lines before crop emergence can help, as aphids will transmit the viruses as soon as they reach crops; knowing if aphids are present in the area will help avoid virus problems.

Note with early monitoring of aphids in lentil crops for virus control, non-colonising aphids may be found. Even when colonising aphids are found, the virus may have already spread by the time they are observed.

Aphid distribution may be patchy, so monitoring should include at least five sampling points across the paddock. Inspect at least 20 plants at each sampling point. Search for aphids looking at the youngest flowers of each plant. Look for clusters of aphids or symptoms of leaf-curling.[144] Stem samples give useful estimates of aphid density.

Sticky traps might assist in identifying early aphid activity, as well as the presence of beneficial insects including hoverflies, lacewings, lady beetles and parasitic wasps. These species will attack aphids.

While beneficial insects can help reduce virus spread and spring feeding damage, some virus spread will have occurred before aphid numbers subside.

Aphid control for viruses

Use an integrated management approach to reduce the risk of virus transmission by aphids.[145] Particular attention must be paid to pests that develop resistance to available pesticides, such as green peach aphid.[146]

The best protection against aphid infestation and virus spread in lentil is to prevent aphids landing in the crop. Use imidocloprid seed dressing. A prophylactic insecticide spray in lentil to prevent aphid incursion is not desirable.

When crops are damaged, control may be necessary. Beneficial insects always arrive later than the pest. Although beneficial species may help reduce virus spread (and spring feeding damage), some virus spread will have already occurred before aphid numbers subside.

Control the aphids if virus spread and direct feeding damage is of concern. Lentil suffers some mechanical damage from aphids.[147 148]

Thresholds for managing aphids in lentil crops have not been established. Any threshold to prevent the incursion of aphid-vectored virus will be much lower than any threshold to prevent yield loss via direct feeding.

Aphid infestations can be reduced by heavy rain or sustained frosts. If heavy rain occurs after deciding to spray, check the crop again to see if treatment is still needed.[149]

144 P Umina, W Kimber (2015) Bluegreen aphid, Pest Notes Southern, 6 pp. cesar and the South Australian Research and Development Institute, http://www.pir.sa.gov.au/__data/assets/pdf_file/0011/275492/Bluegreen_Aphid.pdf

145 GRDC (2010) Aphids and viruses in pulse crops, Factsheet, 4 pp. Grains Research and Development Corporation, www.grdc.com.au/GRDC-FS-AphidsandVirusesinPulses

146 J Kirkegaard (2017) Opportunities and challenges for continuous cropping systems, GRDC Update Paper, https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2017/02/opportunities-and-challenges-for-continuous-cropping-systems

147 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

148 GRDC (2010) Aphids and viruses in pulse crops, Factsheet, 4 pp. Grains Research and Development Corporation, www.grdc.com.au/GRDC-FS-AphidsandVirusesinPulses

149 W Kimber (2015) Bluegreen aphid, Pest Notes Southern, 6 pp. cesar and the South Australian Research and Development Institute, http://www.pir.sa.gov.au/__data/assets/pdf_file/0011/275492/Bluegreen_Aphid.pdf

Use integrated management practices to control aphid populations early in the season. Virus risks can be managed by:

- sowing seed with <0.1% infection;
- considering seed dressings (see below);
- controlling volunteer weeds during summer and autumn where lentil is to be sown, as aphids (and the viruses they spread) have alternative hosts between growing seasons;
- rotating pulse crops with cereals to reduce virus and vector sources;
- where possible, avoiding close proximity to perennial pastures (such as lucerne) or other crops that host viruses and aphid vectors;
- monitoring in nearby crops and pastures early in the season;
- reducing aphid landing rates with retained stubble, as bare soil is more attractive to some aphid species. While higher sowing rates and narrow row spacing can also help, this can create difficulties with fungal disease management. Minimum-tillage with standing stubble and inter-row sowing is ideal to discourage aphid landings; and
- applying insecticide for virus control, but only if crops are at high risk.[150] Spray if cowpea aphid is easily found and only where damage to growing points is obvious.[151]

Pirimicarb is registered for field pea, lupin and broad bean but not lentil. However, an emergency use permit is usually in place when needed.

Insecticide seed treatments can delay aphid colonisation and reduce early infestation and aphid feeding.[152] Gaucho® 600 SD Red Flowable (imidacloprid) is registered. When applied as a seed treatment, it will help protect lentil seedlings from early season aphid attack and reduce spread of the persistently transmitted viruses early in the season.[153] [154] These include Bean leaf roll virus (BLRV), Turnip yellows virus (TuYV, synonym BWYV), Subterranean clover red leaf virus (SCRLV) and Subterranean clover stunt virus (SCSV).

Several insecticides for aphid control are highly toxic to bees and should not be applied while bees or native insects are foraging or pollinating lentil. Avoid broad-spectrum insecticides to conserve beneficial species. If blue green aphid 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. Refer to Table 7 “Registered insecticides commonly used”.

Natural enemies of aphids are hoverfly larvae, aphid parasites, green lacewing larvae, brown lacewing and lady beetles.[155]

‘Soft’ insecticides used soon after emergence help control persistently transmitted viruses only.

150 Hawthorne, M Materne, J Davidson, K Lindbeck, L McMurray, J Brand (2015) Lentil: integrated disease management, Australian Pulse Bulletin, 20 November 2015, Pulse Australia, http://www.pulseaus.com.au/growing-pulses/bmp/lentil/idm-strategies

151 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

152 P Umina, W Kimber (2015) Bluegreen aphid, Pest Notes Southern, 6 pp. cesar and the South Australian Research and Development Institute, http://www.pir.sa.gov.au/__data/assets/pdf_file/0011/275492/Bluegreen_Aphid.pdf

153 GRDC (2010) Aphids and viruses in pulse crops, Factsheet, 4 pp. Grains Research and Development Corporation, www.grdc.com.au/GRDC-FS-AphidsandVirusesinPulses

154 Pulse Australia (2015) Managing viruses in pulses, Australian Pulse Bulletin, 20 November 2015, Pulse Australia, www.pulseaus.com.au/growing-pulses/publications/manage-viruses

155 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

MORE INFORMATION

For more information of insecticide resistance and management of green peach aphid and TuYV (formerly BWYV), watch:
https://youtu.be/1MlRtsfydkc

Only use a synthetic pyrethroid (SP) if aphids are present. Use of an SP is controversial; while it prevents early colonisation due to 'anti feed' properties, it can also agitate uncontrolled aphids to increase virus spread. Impact on beneficial insects can also lead to higher aphid numbers.

Synthetic pyrethroid insecticides should not be used to control green peach aphid, an important vector of TuYV (formerly known as BWYV) as most populations are resistant to SPs.[156 157] Commonly used insecticides registered for use on bluegreen aphid are shown in Table 7 with details in Table 8.

Aphid control for direct feeding damage

No thresholds have been developed for aphids in lentil crops. However, bluegreen aphid control is recommended when damage becomes evident.[158]

In general, stressed crops will attract insect pests. Crops that are not moisture stressed have a greater ability to compensate for aphid damage and will generally be able to tolerate far higher infestations than moisture stressed plants before a yield loss occurs.[159]

156 GRDC (2010) Aphids and viruses in pulse crops, Factsheet, 4 pp. Grains Research and Development Corporation, www.grdc.com.au/GRDC-FS-AphidsandVirusesinPulses

157 Pulse Australia (2015) Managing viruses in pulses, Australian Pulse Bulletin, 20 November 2015, Pulse Australia, www.pulseaus.com.au/growing-pulses/publications/manage-viruses

158 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

159 P Umina, W Kimber (2015) Bluegreen aphid, Pest Notes Southern, 6 pp. cesar and the South Australian Research and Development Institute, http://www.pir.sa.gov.au/__data/assets/pdf_file/0011/275492/Bluegreen_Aphid.pdf

MORE INFORMATION

More information on redlegged earthmites can be found in the Agriculture Victoria Agnote: agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/redlegged-earth-mite

Or watch GroundCover™ TV: GCTV9: Redlegged earthmites, https://www.youtube.com/watch?v=tMnUVGOUXu8

GCTV16: IPM beatsheet demo. Mung bean, https://www.youtube.com/watch?v=MwtqG6lC49E

9.3.6 Redlegged earth mite (*Halotydeus destructor*)

RLEM identification

Redlegged earth mites (RLEM) are active from autumn to late spring and are found in southern Australia.

Adults and nymphs of RLEM have a 'velvety' black body. Adult RLEM are 1 mm long with eight red-orange legs. Newly hatched mites are only 0.2 mm, pinkish-orange with only six legs.[160 161]

Photo 19: *Redlegged earth mite (RLEM) close up.*

Photo: Grain Legume Handbook (2008) Grain Legume Handbook for the Pulse Industry. Grain Legume Hand Book Committee, https://grdc.com.au/grainlegumehandbook.

Photo 20: *RLEM feeding causes leaves to first turn silvery, then brown and shrivelled, so that the plants look scorched.*

Photo: Grain Legume Handbook (2008) Grain Legume Handbook for the Pulse Industry. Grain Legume Hand Book Committee, https://grdc.com.au/grainlegumehandbook.

RLEM damage

RLEM feed on the foliage for short periods and then move around. Other mites are attracted to compounds released from damaged leaves.

Typical RLEM damage appears as 'silvering' or 'whitening' of the attacked foliage. RLEM are most damaging to emerging crops, greatly reducing seedling survival and development.

160 GRDC (2013) Insect ID: The Ute Guide, iOs app, Version 1.1, 14 October 2013. https://grdc.com.au/resources-and-publications/app

161 T Yeatman, W Hawthorne, J Paull, J Bellati, J Egan, K Henry, R Kimber, M Seymour, J van Leur, K Lindbeck, P Matthews, I Rose (2009) Faba beans; The Ute Guide. 127 pp. Primary Industries and Resources South Australia, https://grdc.com.au/resources-and-publications/all-publications/publications/2009/11/faba-beans-the-ute-guide

In severe cases, entire crops may need re-sowing following RLEM attack. RLEM feed on a wide range of plant species.[162]

RLEM life cycle

RLEM are usually active between April and November. During this period, RLEM may pass through 2–3 generations, with each generation surviving 6–8 weeks. Long, wet springs favour the production of over-summering eggs. When this occurs, subsequent crops can be at risk.

Autumn rains trigger hatching in 3–9 days. False autumn breaks can cause large losses in mite numbers. Mites take 20–25 days from hatching to mature and start laying eggs.

RLEM monitoring

Inspect lentil crops from autumn to spring for mites and their damage, particularly in the first few weeks after sowing.

Mites feed 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 crawl into cracks in the soil to avoid heat and cold. When disturbed during feeding they will drop to the ground and seek shelter.

MORE INFORMATION

For details on a resistance management strategy for the redlegged earth mite, please see the GRDC Fact Sheet www.grdc.com.au/FS-RLEM-Resistance-strategy-South

RLEM control and insecticide resistance management

Control strategies that only target RLEM may not entirely remove pest pressure. Other pests can fill the gap, and this is particularly evident after chemical applications which are generally more effective against RLEM than other mite pests.

Non-chemical options are becoming increasingly important due to evidence of resistance in RLEM populations and concern about long-term sustainability. If using a chemical spray, choose one that has least environmental impact and aim to reduce the number of chemical applications. Pesticide groups exist with low to moderate impacts on many natural enemies, such as cyclodienes.[163]

Insecticide resistance in RLEM is presently confined to Western Australia. High levels of resistance to pyrethroids exist within Western Australian populations. Resistance to organophosphates has also evolved. A strategy to manage insecticide resistance in RLEM populations is available for use by grain growers and their advisers.

Chemical control of RLEM

While insecticides are registered for control of active RLEM, no registered insecticides are effective against RLEM eggs. Commonly used insecticides registered for use on RLEM are shown in Table 7 with details in Table 8.

Four chemical sub-groups are registered to control RLEM in grain crops: organophosphates (Group 1B); synthetic pyrethroids (Group 3A); phenylpyrazole (Group 2B); and neonicotinoids (Group 4A). The latter two are registered only for use as seed treatments.[164] Fipronyl is the only Group 2B pesticide but it is not registered for lentil.

If spraying in autumn, control the first generation of mites before they lay eggs. Pesticides used at or after sowing should be applied within three weeks of the first appearance of mites, before adults begin to lay eggs. Rotate products with different modes of action to reduce the risk of insecticide resistance.

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

163 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

164 GRDC (2016) Resistance management strategy for the redlegged earth mite in Australian grains and pastures in New South Wales, South Australia, Tasmania and Victoria, factsheet. 4pp. Grains Research and Development Corporation, https://grdc.com.au/FS-RLEM-Resistance-strategy-South

MORE INFORMATION

For details on climatic variables, and tools such as TIMERITE® please go to www.wool.com/globalassets/start/woolgrower-tools/timerite/timeriteinformationpackage.pdf

Autumn insecticide application includes:

- pesticides with persistent residual activity used as bare-earth treatments to protect seedlings;
- foliage sprays applied after crop emergence, which are generally an effective control; and
- systemic pesticides applied as seed dressings, which act by maintaining the pesticide at toxic levels within the seedling. Note, if mite numbers are high, plants may suffer significant damage before the pesticide has much effect.

Bare-earth insecticides and seed dressings for RLEM are not registered in lentil but can be used in other parts of the rotation.

A correctly timed spray in spring can reduce populations of RLEM the following autumn. Use climatic variables, and tools such as TIMERITE® to determine the optimum date for spraying. While TIMERITE® has less relevance in pulse cropping, it has an important role in pastures and RLEM population management. Research in southern Australia has shown the use of a TIMERITE® spring spray is effective in reducing RLEM populations by 93%.[165]

Users need to be mindful of its limitations and the issues around repeated insecticide applications according to this approach. Spring RLEM sprays will generally not be effective against other pest mites.

Biological control of RLEM

At least 19 predators and one pathogen are known to attack earth mites in eastern Australia, particularly other mites, although small beetles, spiders and ants also play a role. None of these natural enemies can be relied on to provide control if there has been a favourable spring for RLEM prior to sowing the new crop. The benefits of a predatory mite (*Anystis wallacei*), which has been released, are yet to be demonstrated.[166]

Natural enemies of RLEM residing in windbreaks and roadside vegetation need to be protected as well, so avoid pesticides with residual activity applied as border sprays to prevent mites moving into a crop or pasture.

Cultural control of RLEM

Cultural control measures include:

- rotating crops or pastures with non-host crops, such as cereals;
- cultivating, which can also help reduce RLEM populations;
- clean fallowing and controlling weeds around crop and pasture perimeters and
- controlling weeds, especially thistles and capeweed, to remove breeding sites for RLEM.[167]

165 TJ Ridsdill-Smith, C Pavri (2015) Controlling redlegged earth mite, Halotydeus destructor (Acari: Penthaleidae), with a spring spray in legume pastures. Crop and Pasture Sci., 66: 938–946

166 T Yeatman, W Hawthorne, J Paull, J Bellati, J Egan, K Henry, R Kimber, M Seymour, J van Leur, K Lindbeck, P Matthews, I Rose (2009) Faba beans: The Ute Guide. 127 pp. Primary Industries and Resources South Australia, https://grdc.com.au/resources-and-publications/all-publications/publications/2009/11/faba-beans-the-ute-guide

167 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

MORE INFORMATION

For details on lucerne flea please visit PestNotes Southern www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Lucerne-flea

9.3.7 Lucerne flea (*Sminthurus viridis*)

Lucerne flea is mostly found on loam or clay soils and can damage a wide range of crops. It is commonly found in all southern states of Australia.

High numbers of lucerne flea are often found in the winter rainfall areas of southern Australia, or in irrigation areas where moisture is plentiful. Lucerne flea is often patchily distributed within paddocks and across a region.[168]

Lucerne flea identification

Lucerne flea springs off plants when disturbed. It is yellow-green and may have dark markings. Adults are plump and wingless and approximately 2–3 mm long.

Photo 21: *Lucerne flea with eggs. Adults are yellow-green and may have black or brown markings.*

Photo: Grain Legume Handbook (2008) Grain Legume Handbook for the Pulse Industry. Grain Legume Hand Book Committee, https://grdc.com.au/grainlegumehandbook.

Lucerne flea damage

Lentil is susceptible to lucerne flea, in contrast to chickpea. In addition to pulses, the insect can damage pastures, lucerne, oilseeds and cereals.[169]

Lucerne flea is present in autumn to spring. Crops are most susceptible to damage immediately following seedling emergence. Numbers tend to peak in spring.[170]

Although a serious pest of young crops, lucerne flea can also damage older crops. They move up plants from the soil level, leaving a distinctive transparent 'window' on leaves. A severe infestation may remove all green material.[171]

168 P Umina, S Hangartner, G McDonald (2015) Lucerne flea, Pest Notes Southern, cesar and the South Australian Research and Development Institute, www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Lucerne-flea

169 D Hopkins, M Miles (1998) Insect ID: The Ute Guide, Southern Region. 98 pp. Primary Industries and Resources SA

170 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

171 T Yeatman, W Hawthorne, J Paull, J Bellati, J Egan, K Henry, R Kimber, M Seymour, J van Leur, K Lindbeck, P Matthews, I Rose (2009) Faba beans: The Ute Guide. 127 pp. Primary Industries and Resources South Australia

Photo 22: *Leaf damage caused by lucerne flea feeding, causing a distinctive transparent 'window' appearance.*

Photo: Grain Legume Handbook (2008) Grain Legume Handbook for the Pulse Industry. Grain Legume Hand Book Committee, https://grdc.com.au/grainlegumehandbook.

Lucerne flea life cycle

High humidity and moisture and a mild auumn and winter favour growth.[172]

Long wet springs favour lucerne flea, often causing more serious outbreaks in the following autumn. It requires cool, moist conditions.

Lucerne flea will produce up to five generations in most years. Activity stops in late spring when dry conditions lead to the production of over-summering eggs by the final generation of females.

Over-summering eggs hatch the following autumn, usually soon after opening rains in southern Australia, when the right combination of temperature and moisture occurs.

Monitoring lucerne flea

Regularly monitor for damage from autumn to spring. Lentil crops are most susceptible to damage immediately following seedling emergence.[173]

Lucerne flea is 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 the characteristic damage and check the soil surface, where insects may be sheltering. Monitoring usually involves working on hands and knees.

Monitoring lucerne flea populations for growth stage as well as numbers can also be important for accurate timing of some sprays.

Chemical control of lucerne flea

There are no formal spray thresholds for lucerne flea damage in crops. However, the key is early control because of the impact of seedling vigour on crop performance. Damage levels can be used to determine whether or not spraying is necessary.[174]

Avoid 'insurance sprays' which select for insecticide resistance and rotate insecticide groups to avoid resistance developing.[175]

172 T Yeatman, W Hawthorne, J Paull, J Bellati, J Egan, K Henry, R Kimber, M Seymour, J van Leur, K Lindbeck, P Matthews, I Rose (2009) Faba beans: The Ute Guide. 127 pp. Primary Industries and Resources South Australia, https://grdc.com.au/resources-and-publications/all-publications/publications/2009/11/faba-beans-the-ute-guide

173 T Yeatman, W Hawthorne, J Paull, J Bellati, J Egan, K Henry, R Kimber, M Seymour, J van Leur, K Lindbeck, P Matthews, I Rose (2009) Faba beans: The Ute Guide. 127 pp. Primary Industries and Resources South Australia, https://grdc.com.au/resources-and-publications/all-publications/publications/2009/11/faba-beans-the-ute-guide

174 G Jennings (2002) Knowledge, timing, key to lucerne flea control, 2 pp. Grains Research Advice, November 2002, Grains Research and Development Corporation

175 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

Assess the complex of pests present before deciding on the most appropriate control strategy. Lucerne flea competes for food and resources with other pests such as redlegged earth mite and blue oat mite. When both lucerne flea and redlegged earth mite are present, control strategies should consider both pests, as control strategies that only target one species may not necessarily reduce the overall pest pressure because other pests can fill any gaps.

Control lucerne flea in the paddock the season before sowing susceptible crops like lentil. Spring spraying can reduce the number of insects in the following autumn by preventing the laying of over-summering eggs.

If lucerne flea requires control, treat the infested area with an insecticide three weeks after the pest first emerges in autumn in the newly sown crop. While this will allow for the further hatching of over-summering eggs, it will be before lucerne flea has a chance to lay winter eggs.

Insecticides provide the most effective means of control.[176] However, lucerne flea should not be treated with synthetic pyrethroids (SPs) as it has a high natural tolerance. Most SPs are also ineffective on bryobia or balaustium mites.

To avoid developing multiple pesticide resistance, rotate chemical classes across generations rather than within a generation of a pest.

A border spray may be enough to prevent lucerne flea moving in from neighbouring paddocks. Spot spraying may also be sufficient as lucerne flea is often distributed patchily in crops. Do not blanket spray unless necessary.

Biological and cultural control of lucerne flea

Several predatory mites, for example, snout mites, various ground beetles and spiders, prey on lucerne flea.[177]

Clean fallows and control of weeds within crops and around pasture perimeters, especially capeweed, helps reduce lucerne flea numbers.

Cultivation, using traps, border crops and mixed cropping can help reduce the overall infestation levels, particularly when used in conjunction with other measures. Grasses and cereals can be useful for crop borders as they are less favourable to lucerne flea.[178]

176 G Jennings (2002) Knowledge, timing, key to lucerne flea control, 2 pp. Grains Research Advice, November 2002, Grains Research and Development Corporation

177 P Umina, S Hangartner, G McDonald (2015) Lucerne flea, Pest Notes Southern, cesar and the South Australian Research and Development Institute, www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Lucerne-flea

178 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

FEEDBACK

9.4 Other pests of lentil

A range of other species are potentially major pests in some pulses, including lentil. These should not be ignored in the monitoring and management of lentil crops.

MORE INFORMATION

For more details on blue oat mite, please see Pest Notes Southern http://www.pir.sa.gov.au/__data/assets/pdf_file/0004/274090/Blue_oat_mite.pdf

9.4.1 Blue oat mite (*Penthaleus* spp.)

Blue oat mite identification

Adult blue oat mites (BOM) are 1 mm, with eight red-orange legs. They have a dark blue-black body with an oval red or orange spot on their back, which distinguishes them from redlegged earth mite (RLEM). Mites generally feed singularly. They share similar life cycles with RLEM.[179, 180] (See section 9.3.6)

Three pest species of BOM exist in Australia, which complicates identification and control. These are *Penthaleus major*, *P. falcatus* and *P. tectus*.

Photo 23: *Blue oat mite has a blue-black or deep purple body with a distinct red to orange spot on its back, which distinguishes it from redlegged earth mite.*

Photo: Gordon Cumming, Pulse Australia.

Blue oat mite damage

The BOM species *P. major* and *P. tectus* occasionally attack lentil crops, while *P. falcatus* is rarely a problem in lentil.

Blue oat mites attack most crops and pastures, but cereals, canola and lucerne are most susceptible.

Blue oat mite life cycle

BOM is active from April to late October, and over-summer as eggs. Autumn rains trigger hatching within 3–9 days. False breaks in the season can cause large losses in mite numbers. Mites take 20–25 days from hatching to mature and start laying eggs.[181]

179 D Hopkins, M Miles (1998) Insects: the Ute Guide, Southern Region. 98 pp. Primary Industries and Resources SA

180 T Yeatman, W Hawthorne, J Paull, J Bellati, J Egan, K Henry, R Kimber, M Seymour, J van Leur, K Lindbeck, P Matthews, I Rose (2009) Faba beans: The Ute Guide. 127 pp. Primary Industries and Resources South Australia, https://grdc.com.au/resources-and-publications/all-publications/publications/2009/11/faba-beans-the-ute-guide

181 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

Blue oat mite monitoring

It is important to monitor germinating pulse crops. Check paddocks before sowing in autumn and throughout winter.

Examine plants for damage and search for mites on leaves and the soil, especially in late-sown crops.

BOM spend most of their time on the soil surface, rather than on the foliage. They are most active during the cooler parts of the day, feeding in the mornings and in cloudy weather. They seek protection during the warmer part of the day on moist soil surfaces or under foliage, and may even dig into the soil under extreme conditions.

Chemical control

Each species differs in its distribution, pesticide tolerance and crop plant preferences.

BOM is often misidentified as RLEM but some BOM species are more tolerant than RLEM to a range of synthetic pyrethroid and organophosphate insecticides.[182]

All current pesticides are only effective against the active stages of mites, and do not kill mite eggs. Commonly used insecticides registered for use on BOM are shown in Table 7 with details in Table 8.

While seed dressings are registered for blue oat mite in other crops, none are registered for this pest in lentil.

P. falcatus has a high natural tolerance to a range of pesticides registered for use against earth mites. The other BOM species, which are more likely to affect lentil, have a lower level of tolerance to pesticides and are generally easier to control with chemicals.

Control first generation mites before they can lay eggs to avoid a second spray. Pesticides used at or after sowing should be applied within three weeks of the first appearance of mites, as adults will then begin laying eggs.

Spraying in spring is usually ineffective and not recommended for BOM.[183]

Pesticides with persistent residual effects can be used as bare-earth treatments. If applied by sowing, these treatments can protect the plants throughout their seedling stage.[184]

Systemic pesticides applied as seed dressings can help minimise crop damage during establishment but if mite numbers are high, significant damage may still occur before the pesticide has much effect. However, there are no seed dressing products registered for use with lentil for BOM.

182 T Yeatman, W Hawthorne, J Paull, J Bellati, J Egan, K Henry, R Kimber, M Seymour, J van Leur, K Lindbeck, P Matthews, I Rose (2009) Faba beans: The Ute Guide. 127 pp. Primary Industries and Resources South Australia, https://grdc.com.au/resources-and-publications/all-publications/publications/2009/11/faba-beans-the-ute-guide

183 P Umina, S Hangartner (2015) Blue oat mite, Pest Notes Southern, 6 pp. cesar and the South Australian Research and Development Institute, http://www.pir.sa.gov.au/__data/assets/pdf_file/0004/274090/Blue_oat_mite.pdf

184 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

Biological and cultural control

A number of predator species are known to attack earth mites in Australia. Leaving shelter belts or refuges between paddocks will help maintain natural enemy populations.

Preserving natural enemies when using chemicals is often difficult for growers because the pesticides generally used are broad-spectrum and kill beneficial species with the pests.

Cultural controls such as rotating crops or pastures with non-host crops can reduce pest colonisation, reproduction and survival, decreasing the need for chemical control. Non-preferred crops are:

- *P. major* – canola;
- *P. tectus* – chickpea; and
- *P. falcatus* – wheat and barley.[185]

Lentil is considered vulnerable, and not a useful rotational crop to help control BOM species.

Pre and post-sowing weed management (particularly of broadleaf weeds) is important.

MORE INFORMATION

Information on plague locust control can be found in this GRDC Fact Sheet www.grdc.com.au/Resources/Factsheets/2010/08/Plague-Locust-Control-Factsheet

9.4.2 Australian plague locust (*Chortoicetes terminifera*)

Australian plague locust identification

Adults of the Australian plague locust have a characteristic black spot on the tip of the hind wing. Nymphs or hoppers are more difficult to identify. If swarming in a large band, it is likely to be the Australian plague locust.

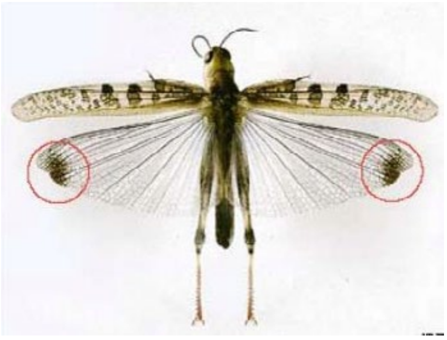

Photo 24: *Australian plague locust. Note the black spot at the tip of the hind wing.*

Photo: APLC via PIRSA.

Australian plague locust damage

Locusts and grasshoppers will cause damage to lentil in the same way that they cause damage to any green material when in plague numbers.[186]

Pulses are susceptible to attack while they remain green. The susceptibility of drying pulse crops is not known.[187] Grain can be rejected at delivery if adult locust, or parts of them, are present in the sample, or if objectionable stains and odours exist.

185 P Umina, S Hangartner (2015) Blue oat mite, Pest Notes Southern, 6 pp. cesar and the South Australian Research and Development Institute, http://www.pir.sa.gov.au/__data/assets/pdf_file/0004/274090/Blue_oat_mite.pdf

186 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

187 GRDC (2010) Plague locust control: a coordinated approach to control plague locusts. Factsheet. 8 pp. September 2010, Grains Research and Development Corporation and Australian Plague Locust Commission, https://grdc.com.au/Resources/Factsheets/2010/08/Plague-Locust-Control-Factsheet

MORE INFORMATION

Comprehensive details and government responses to plague locust threats can be found on state government websites and at:

Australian Plague Locust Commission: http://www.agriculture.gov.au/pests-diseases-weeds/locusts/about/australia

Australian plague locust life cycle

Most locust plagues originate in south-west Queensland and adjacent areas of South Australia, New South Wales and the Northern Territory. Populations develop following rainfall in this area.

With suitable conditions, autumn swarms may migrate 200–500 km into pastoral and adjacent agricultural areas. On arrival, they lay millions of eggs in bare ground which can produce the spring outbreak.

Control

The Australian Plague Commission (APLC) undertakes surveillance threat assessments, forecasting and control measures when locust populations in outbreak areas have the potential to cross into agricultural locations.

In the event of a plague, local government may undertake some spraying operations within their own area. Where significant problems are expected, government agencies may undertake large-scale control in pastoral and adjacent agricultural areas.

Effective locust suppression can only be achieved by landowners, local government and government agencies working cooperatively, together with ongoing APLC activities.

Cultivating egg beds will destroy the eggs. Use approved insecticides to target the bands of nymphs before they take flight. Advice on timings and chemicals can be obtained from state government departments or local chemical resellers. Often APVMA permits are required for chemical use.[188]

9.5 Occasional pests of lentil

The pests listed below are seldom seen in lentil crops, but have been known to occur and under ideal conditions may occasionally represent an economic threat. See more specific publications for full details.

Helicoverpa armigera is an occasional pest of lentil in the southern region and is detailed in "9.3.1 Helicoverpa species: native budworm and corn earworm (Helicoverpa punctigera and H. armigera)".

Cutworms

Cutworms include the common cutworm or Bogong moth (*Agrotis infusa*), black cutworm (*Agrotis ipsilon*), brown or pink cutworm (*Agrotis munda*), herringbone cutworm and other *Agrotis* species.

MORE INFORMATION

For more details on identification, see: Insect ID: The Ute Guide: https://grdc.com.au/Resources/Ute-Guides/Insects/Moths-butterflies-caterpillars/South/Cutworms

Cutworm identification and life cycle

Cutworm larvae are hairless with dark heads and usually dark bodies. They live in the soil and grow to 50 mm. They curl up and remain still if disturbed.[189]

Female moths lay eggs in soil in lightly vegetated or bare areas. Larvae have six growth stages (instars).

Cutworm monitoring, damage and control

Cutworm is a sporadic emergence pest. It attacks all crops and pastures including lentil.

Large larvae (20–40 mm) ringbark or cut off seedlings at ground level; the final sixth-stage larvae eat 86% of food.

188 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

189 T Yeatman, W Hawthorne, J Paull, J Bellati, J Egan, K Henry, R Kimber, M Seymour, J van Leur, K Lindbeck, P Matthews, I Rose (2009) Faba beans: The Ute Guide. 127 pp. Primary Industries and Resources South Australia, https://grdc.com.au/resources-and-publications/all-publications/publications/2009/11/faba-beans-the-ute-guide

Check crops from emergence to establishment. Look for patchy or thin parts of the crop. Scratch the soil to reveal hidden larvae near the base of recently damaged plants.

Larvae feed at ground level, chewing through leaves and stems. Stems are often cut off at the base. Damage mostly occurs at night. When larva numbers are high, crops can be severely thinned.

Treat affected patches with a registered insecticide. Spraying in the evening can be more effective.[190] Commonly used insecticides registered for use on cutworm are shown in Table 7 with details in Table 8.

Biological controls include a number of parasites, disease and spiders.

MORE INFORMATION

For more details on identification, see: Insect ID: The Ute Guide: https://grdc.com.au/Resources/Ute-Guides/Insects/Mites/South/Balaustium-Mite

9.5.1 Balaustium mite (*Balaustium medicagoense*)

Balaustium mite identification and life cycle

Correct identification is critical for control.

Balaustium mite adults grow to 2 mm, with variable colours but are mainly dark red to brown.. They are slow-moving and have characteristic short hairs covering the body. They also have a 'pad'-like structure on the forelegs. Newly hatched nymphs have six bright orange legs, while adults have eight red legs.

Balaustium mite activity is from March to November in a Mediterranean climate. The mite requires autumn rainfall for over-summered eggs to hatch.[191]

Balaustium mite monitoring, damage and control

Recorded cases of balaustium mite damage have increased markedly in the past decade.

Balaustium mite probes leaves and sucks the sap. It usually causes little damage, except when numbers are high and plants are already stressed, when it can cause significant damage. Under high infestations, plants can wilt and die.

In lentil, balaustium mite causes irregular white spotting or bleaching of the leaves. With good conditions, crops often outgrow the damage.[192]

Check crops throughout the growing season, particularly in paddocks with a history of chemical treatments for redlegged earth mite (RLEM).[193]

Aim to manage balaustium mite without relying on chemicals as no insecticides are registered in pulses and the mite has a high natural tolerance to many insecticides. It will generally survive applications aimed at other mite pests. Research in Victoria has shown balaustium mite to be much more tolerant of omethoate, bifenthrin, chlorpyrifos, methidathion and alpha-cypermethrin than redlegged earth mite.

Most synthetic pyrethroids are not effective on balaustium mite, lucerne flea or bryobia mite (and no insecticides are registered for balaustium or bryobia mites in lentil). Balaustium mite is also more tolerant of organophosphate insecticides than RLEM.[194]

190 S Hangartner, G McDonald, P Umina, R Kimber (2015) Cutworm, Pest Notes Southern, cesar and the South Australian Research and Development Institute, www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/cutworm

191 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

192 P Umina, S Hangartner, B Kimber, A Govender (2015) Balaustium Mite, Pest Notes Southern, cesar and the South Australian Research and Development Institute, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Balaustium-mite

193 T Yeatman, W Hawthorne, J Paull, J Bellati, J Egan, K Henry, R Kimber, M Seymour, J van Leur, K Lindbeck, P Matthews, I Rose (2009) Faba beans: The Ute guide. 127 pp. Primary Industries and Resources South Australia, https://grdc.com.au/resources-and-publications/all-publications/publications/2009/11/faba-beans-the-ute-guide

194 T Yeatman, W Hawthorne, J Paull, J Bellati, J Egan, K Henry, R Kimber, M Seymour, J van Leur, K Lindbeck, P Matthews, I Rose (2009) Faba beans: The Ute Guide. 127 pp. Primary Industries and Resources South Australia, https://grdc.com.au/resources-and-publications/all-publications/publications/2009/11/faba-beans-the-ute-guide

MORE INFORMATION

For more details on identification, see: Insect ID: The Ute Guide: https://grdc.com.au/Resources/Ute-Guides/Insects/Mites/South/Clover-Mite

9.5.2 Clover mite or bryobia mite (*Bryobia* spp.)

Bryobia mite identification and life cycle

Adults are 0.75–1 mm long with pale orange legs with a dark grey-brown to fawn-orange body, which is oval and flattened. Their front legs are 1.5 times body length. Bryobia mite leave distinct feeding trails.

Bryobia mite is highly active during warm conditions in autumn, spring and early summer. They are found in low numbers in winter when they are unlikely to cause problems. Summer rains followed by a warm autumn increases their survival.[195]

Bryobia mite monitoring, damage and control

Bryobia mite is becoming an increasing problem in lentil grown in stubble-retention systems.[196]

Bryobia mite causes most damage in autumn, attacking emerging crops, greatly reducing seedling survival and slowing development. It feeds on the upper surfaces of leaves and cotyledons by piercing and sucking, causing distinctive trails of white-grey spots. Extensive feeding damage can lead to cotyledons shrivelling.

Monitor paddocks during crop establishment and in early autumn and spring, during the warmer parts of the day in fine weather. Look for mites and evidence of feeding damage on newly established crops, as well as clovers and brassica weeds before sowing. Bryobia mite is mostly found on the lower and upper leaf surfaces. Mites can be sampled with a garden vacuum with a fine sieve or stocking placed over the end of the suction pipe to trap mites.

No control thresholds have been developed for bryobia mite.

Control summer weeds early in paddocks to be cropped, especially broadleaf weeds. Before sowing, look for damage and their presence on clover and cruciferous weeds.

No products are registered for control of bryobia mite in lentil. There are no known biological control agents for bryobia mite in Australia.[197]

195 Pulse Australia (2016) Agronomy. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

196 R Rundell-Gordon (2016) Growing lentils: lessons learnt from growing lentils in central and north west Victoria, GRDC Update paper, 17 March 2016, https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2016/03/growing-lentils-lessons-learnt-from-growing-lentils-in-central-and-north-west-victoria

197 P Umina, S Hangartner, G McDonald, A Govender, B Kimber (2015) Bryobia Mite, Pest Notes Southern, cesar and the South Australian Research and Development Institute, www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Bryobia-mite

9.5.3 Earwigs

Earwig species include the European earwig (*Forficulina auricularia*) and Native Earwig (*Labidura truncata*) plus other species.

For more details on identification, see: Insects the Ute Guide. https://grdc.com.au/Resources/Ute-Guides/Insects/Earwigs/South/European-Earwig-and-Native-Earwig

For information on management, see: European earwigs Fact Sheet, https://grdc.com.au/Resources/Factsheets/2013/11/European-Earwigs-Fact-Sheet

9.5.4 Mandalotus weevil (Mandalotus spp.)

Mandalotus weevil is becoming an increasing problem in lentil crops with stubble retention.[198]

For more details on identification, see: Insect ID: The Ute Guide. https://grdc.com.au/Resources/Ute-Guides/Insects/Beetles-larvae/South/Mandalotus-Weevil

There are no control thresholds, cultural control methods or registered insecticides for controlling mandalotus weevil.[199] For more information, see http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Mandalotus-weevil

9.5.5 Thrips

Thrip species include onion thrips (*Thrips tabaci),* plague thrips (*Thrips imaginis*) and western flower thrips (*Frankliniella occidenttalis*).

For more details on identification, see: Insect ID: The Ute Guide. https://grdc.com.au/Resources/Ute-Guides/Insects/Thrips/South/Onion-Thrips-Plague-Thrips-and-Western-Flower-Thrips

9.5.6 Brown pasture looper (Ciampa arietaria)

For more details on identification, see: Insect ID: The Ute Guide. https://grdc.com.au/Resources/Ute-Guides/Insects/Moths-butterflies-caterpillars/South/Brown-Pasture-Looper

9.5.7 Looper caterpillar (*Chrysodiexis* spp.)

For more details on identification, see: Insect ID: The Ute Guide. https://grdc.com.au/Resources/Ute-Guides/Insects/Moths-butterflies-caterpillars/South/Looper-Caterpillar

9.5.8 Bronze field beetle (Adelium brevicorne)

For more details on identification, see: Insect ID: The Ute Guide. https://grdc.com.au/Resources/Ute-Guides/Insects/Beetles-larvae/South/Bronzed-Field-Beetle

9.5.9 False wireworm (Gonocephalum misellum)

For more details on identification, see: Insect iD: The Ute Guide. https://grdc.com.au/Resources/Ute-Guides/Insects/Beetles-larvae/South/False-Wireworms

9.5.10 Onion seedling maggot (Delia platura)

For more details on identification, see: Insects the Ute Guide. https://grdc.com.au/Resources/Ute-Guides/Insects/Flies/South/Onion-Maggot

198 R Rundell-Gordon (2016) Growing lentils: lessons learnt from growing lentils in central and north west Victoria, GRDC Update paper, 17 March 2016, https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2016/03/growing-lentils-lessons-learnt-from-growing-lentils-in-central-and-north-west-victoria

199 K Perry, B Kimber (2015) Mandalotus weevil, Pest Notes Southern, cesar and the South Australian Research and Development Institute, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Mandalotus-weevil

9.6 Exotic lentil insects – biosecurity threats

9.6.1 Exotic seed beetles/bruchids

(Coleoptera; Family: Chrysomelidae, sub-family: Bruchinae)

Seed beetles, also known as bruchids, are a group of relatively small beetles that attack ripe or ripening seeds, especially legumes. More than 200 species of bruchids exist world-wide from several genera that are important primary pests with significant economic impact to pulses.

While several pest bruchid species occur in Australia, bruchid damage in lentil is rarely seen in Australia. The potential exists for other exotic lentil-attacking bruchids to be introduced and established in Australia. The host range for these may be quite specific, such as *Bruchus lentis* and *Bruchus ervi*, while other species can attack a wide range of pulse crops. Early detection of new bruchids in lentil may have consequences across a range of crops.

The presence of damaged seed (round holes) in stored grain is an indication of bruchids.

The general form of bruchids and their association with pulses make them unlikely to be confused with other beetle pests associated with stored product. Any bruchids found in lentil – in the field or in storage – should be sent away for further identification. Call the Exotic Plant Pest Hotline (1800 084 881) for more information.

MORE INFORMATION

Plant Health Australia has a Fact Sheet on exotic bruchids, Please see http://www.planthealthaustralia.com.au/wp-content/uploads/2014/02/Exotic-Bruchids-FS.pdf

9.6.2 Exotic leaf-miners (Diptera: family Agromyzidae)

The Agromyzidae are a group of small flies whose larvae feed internally on living plant tissue, often as leaf and stem miners. Key exotic Agromyzidae species for lentil include the American serpentine leafminer (*Liriomyza trifolii*) and pea leafminers (*Chromatomyia horticola, Liriomyza huidobrensis*).

Leaf-mining (tunnelling) is the most obvious symptom that can be seen and surveyed for in the field. Leaf-mining damage caused by exotic Agromyzidae species can be confused with native leaf-miner species and moth larvae. Any suspicious examples of mining should be sent in for identification. Call the Exotic Plant Pest Hotline (1800 084 881) for more information.

Control of *Liriomyza* is difficult. The economic impact could be highly significant in most crops and across most cropping regions if exotic *Liriomyza* enter Australia and is not eradicated.[200]

200 Pulse Australia (2016) Insect management. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

9.7 Beneficial species

All pest populations are regulated to some degree by the direct effects of other living organisms. Beneficial organisms include a range of wasps, flies, bugs, mites, lacewings, beetles and spiders that can reduce insect pest populations through predation and parasitisation. Viruses and fungal diseases also provide control.

A wide range of beneficial organisms can be grouped into three categories:

- Parasites: Organisms that feed on, or in the body, of another host. Most eventually kill their host and are free living as an adult (parasitoids) for example, aphid wasp parasites.
- Predators: Mainly free-living insects that consume a large number of prey during their lifetime, for example, shield bugs, lacewings, hoverflies, spiders, predatory mites and predatory beetles.
- Insect diseases: Including bacterial, fungal and viral infections of insects.

Inappropriate use of an insecticide that reduces the number of beneficial species can result in a more rapid build-up of insect populations and reliance on further use of insecticide.

Integrated pest management (IPM) in its simplest form is a management strategy in which a variety of biological, chemical and cultural control practices are combined to provide stable long-term pest control.[201] See Section 9.1 Integrated pest management.

Photo 25: *A pea aphid being consumed by the seven-spotted lady beetle (*Coccinella septempunctata*).* Photo: Brad Stokes, University of Idaho

A list of some beneficial organisms is provided below. For more details and photographs of beneficial organisms in insect management, see:

- CESAR website: http://www.cesaraustralia.com/sustainable-agriculture/identify-an-insect/[202]
- the GRDC booklet Insect ID: The Ute Guide.[203, 204]

201 Pulse Australia (2016) Insect management. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited

202 www.cesaraustralia.com/sustainable-agriculture/identify-an-insect/

203 D Hopkins, M Miles (1998) Insects: the Ute Guide, Southern Region. 98 pp. Primary Industries and Resources SA

204 GRDC (2013) Insect ID: The Ute Guide, iOs app, Version 1.1, 14 October 2013. https://grdc.com.au/resources-and-publications/app

9.7.1 Beetles

- Carabid beetle (*Notonomous gravis*); https://grdc.com.au/Resources/Ute-Guides/Insects/Predators/South/Carabid-Beetles
- Transverse ladybird and common ladybird; https://grdc.com.au/Resources/Ute-Guides/Insects/Predators/South/Predatory-Ladybird-Beetles-Transverse-Ladybird-Common-Spotted-Ladybird-Minute-TwoSpotted-Ladybird-And-Others

9.7.2 Bugs

- Damsel bug (Family Nabidae); https://grdc.com.au/Resources/Ute-Guides/Insects/Predators/South/Damsel-Bug
- Assassin bug; https://grdc.com.au/Resources/Ute-Guides/Insects/Predators/South/Assassin-Bugs
- Glossy shield bug; https://grdc.com.au/Resources/Ute-Guides/Insects/Predators/South/Glossy-Shield-Bug
- Spined predatory shield bug (*Oechalia schellenbergii*); https://grdc.com.au/Resources/Ute-Guides/Insects/Predators/South/Spined-Predatory-Shield-Bug

9.7.3 Flies

- Hoverfly (Family Syrphidae);
- Tachinid fly; https://grdc.com.au/Resources/Ute-Guides/Insects/Parasites/South/Tachinid-Calliphorid-and-Sarcophagid-Flies

9.7.4 Lacewings

- Green lacewing (Family Chrysopidae); https://grdc.com.au/Resources/Ute-Guides/Insects/Predators/South/Green-Lacewings
- Brown lacewing (Family Hemerobiidae); https://grdc.com.au/Resources/Ute-Guides/Insects/Predators/South/Brown-Lacewings

9.7.5 Mites

- Pasture snout mite (*Bdellodes lapidaria*); https://grdc.com.au/Resources/Ute-Guides/Insects/Predators/South/Snout-Mites-Pasture-Snout-Mite-And-Spiny-Snout-Mite
- French anystis mite; https://grdc.com.au/Resources/Ute-Guides/Insects/Predators/South/French-Anystis-Mite

9.7.6 Caterpillar wasps

- Orange caterpillar parasite wasp; https://grdc.com.au/Resources/Ute-Guides/Insects/Parasites/South/Orange-Caterpillar-Parasite
- Two-toned caterpillar wasp
- Banded caterpillar wasp; https://grdc.com.au/Resources/Ute-Guides/Insects/Parasites/North/Banded-Caterpillar-Parasite
- Telenomus wasp and Trichogramma wasp; https://grdc.com.au/Resources/Ute-Guides/Insects/Parasites/South/Caterpillar-Egg-Parasites
- Orchid dupe; https://grdc.com.au/Resources/Ute-Guides/Insects/Parasites/South/Orchid-Dupe
- Braconid wasp (*Microplitis demolitor*); https://grdc.com.au/Resources/Ute-Guides/Insects/Parasites/North/Microplitis-demolitor

9.7.7 Aphid wasps

Aphidius ervi and *Trioxys complanatus* wasp; https://grdc.com.au/Resources/Ute-Guides/Insects/Parasites/South/Aphid-Parasites

9.7.8 Spiders

Wolf spider (Family Lycosidae);

Jumping spider (Family Salticidae).

9.7.9 Insect diseases – viral & fungal

Bacillus thuringiensis (*Bt*);

Nuclear polyhedrosis virus (NPV).

9.8 Commonly used registered insecticides

Table 7: Registered insecticides commonly used in pulses in Australia. Adhere to registered rates and withholding periods.

Active ingredient Example trade name	Red legged earth mite (RLEM)	Blue oat mite (BOM)	Lucerne flea	Bluegreen aphid	Native budworm	Brown pasture looper	Cutworm	Locust	Withholding period (days)	
									Harvest	Grazing
alpha-cypermethrin DOMINEX® DUO	NSW ACT Vic TAS SA WA	NSW ACT Vic TAS SA WA			NSW, ACT, Vic, SA, WA		NSW ACT Vic TAS SA WA	P	21	35
chlorpyrifos LORSBAN® 500 EC	NSW	NSW								2
cypermethrin SCUD®					NSW Vic TAS SA WA			P	21	35
deltamethrin DECIS® OPTIONS				All states			NSW WA		7	
dimethoate Various	Vic Tas SA		WA							14
endosulfan* Various	All States	NSW WA							Nil	49
esfenvalerate SUMI-ALPHA FLEX®	All states	All states			All states				14	7
gamma-cyhalothrin TROJAN®	NSW Vic Tas SA WA				Sth NSW, WA, Vic, SA, ACT			P	7	7
lambda-cyhalothrin KARATE® ZEON	NSW Vic Tas SA WA				NSW Vic SA WA			P	7	7
Maldison FYFANON® ULV	NSW									1
omethoate LE-MAT®	NSW Vic Tas SA WA	Qld NSW								1
metarhizium anisopliae GREEN GUARD®								All states		

Registered for use in the indicated states. * Endosulfan not permitted post-emergence in pulses. P = Permit only so check if still applicable and which crops are listed on the permit.

Source: Southern Lentil Best Management Practices Training Course Manual (2016), Pulse Australia

FEEDBACK

9.8.1 Comments on insecticides

Registrations and use details may differ between states. Always read the label for specific details and information on registration status and insects controlled.[205] Check the APVMA website (http://apvma.gov.au) for labels.

Table 8: Comments on insecticides.

Insecticide & trade name	Remarks
alpha-cypermethrin DOMINEX® DUO	Best results if sprayed at egg hatching of native budworm. Apply when damaging numbers first appear in the crop. Use higher rate if native budworm larvae are longer than 10 mm. Use higher rate if native budworm are longer than 20 mm for Fastac®. Can be used post-emergence for redlegged earth mite control in field pea.
chlorpyrifos LORSBAN®	Active against a wide range of insect pests. Not systemic. Very highly toxic to fish.
dimethoate Various	Apply to the emerged crop. Has contact and systemic activity.
esfenvalerate SUMI-ALPHA FLEX®	Use 130 ml/ha for native budworm larvae less than 10 mm, 200 ml/ha if 10–20 mm long and 330 ml/ha for >20 mm long.
gamma-cyhalothrin TROJAN®	For native budworm use higher rate if larvae are longer than 10 mm or the crop is dense. Rainfast after 30 minutes. S5 poison schedule.
lambda-cyhalothrin KARATE® ZEON	For control of native budworm apply at hatching or soon after when the larvae are small. Use the higher rate if larvae are longer than 10 mm or if the crop is dense.
omethoate LE-MAT®	Spray crop 2–5 weeks after opening rains and before serious damage occurs. Rainfast in 1 hour. Application in spring will reduce redlegged earth mite the following year.
metarhizium anisopliae GREEN GUARD®	Biological control agent. Apply in 75–225 L/ha of water for best results when locusts and grasshoppers are at the nymph stage. Do not apply in gusty conditions with winds >8 m/sec or rainfall imminent in next 6 hours. Surfactant and oil supplied.

Source: Southern Lentil Best Management Practices Training Course Manual (2016), Pulse Australia Limited

205 Pulse Australia (2016) Insect management. Southern Lentil Best Management Practices Training Course Manual 2016, Pulse Australia Limited