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SLUG CONTROL FACT SHEET

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NORTHERN, SOUTHERN AND WESTERN REGIONS

SLUG IDENTIFICATION AND MANAGEMENT

In the higher rainfall zones where zero till and stubble retention is practiced, slugs are an increasing problem. As no single control method will provide complete protection, an integrated approach is best.

KEY POINTS

- Slugs need moisture and shelter to thrive. Cool wet summers and an abundance of stubble provide ideal conditions.
- Moisture availability is a key regulator of slug populations.
- The grey field slug, or reticulated slug, and black keeled slug are the main pest species, but brown field slugs can also pose a serious threat.
- No single control method will be completely effective; an integrated approach is needed.

Slugs are a major pest of crops globally, and have emerged as a serious pest for Australian grain growers in recent decades.

Attacks on emerging crops can cause major economic losses, even when slug numbers are relatively low.

Slugs will eat all parts of a crop plant, however, seedlings are the most vulnerable and this is the time when major economic losses can occur.

A GRDC report, *The current and potential costs of invertebrate pests in grain crops*, (see Useful Resources) has found that in terms of economic loss, slugs are the sixth most damaging invertebrate pest for the Australian grains industry, costing on average $25.9 million in lost production across wheat, barley, oats and canola crops annually.

Slugs are present in all major grain growing regions of Australia. They pose the biggest threat to growers in the southern and western regions, but are also a significant problem for growers on Queensland's south eastern Darling Downs.

Australian growers spend an average $8.7 million annually on slug control.

The incidence of slugs has increased with changes to cropping practices. Cultivation and stubble-burning previously kept numbers down, but the widespread adoption of minimum till and stubble retention has provided slugs with more favourable habitat.

Surface-active slug species such as the grey and brown field slug find crevices in the soil during dry summer conditions to avoid heat and drying out. They emerge when conditions are moist to breed and feed. Grey field slugs are most active at temperatures between 4°C and 20°C.

Life cycle

Slugs are hermaphrodites, therefore, both individuals of a mating pair lay eggs.

They will breed whenever moisture and temperature conditions are suitable – generally from mid-autumn to late spring. Each pair will lay eggs in batches.

Eggs are laid in moist soils and will hatch within three to six weeks, dependent on temperature. Juveniles look like smaller versions of the adult.

PHOTO: MICHAEL NASH

The eggs of the black keeled slug, laid in a clod of moist soil. Slug eggs hatch within three to six weeks. A pair of black keeled slugs can lay up to 200 eggs per year, but some species are able to produce up to 1000 eggs per year.

Pest species

The main pest species in Australia are the grey field slug and the black keeled slug, but the brown field slug has also been recorded in high numbers. More than one species may be present within a single paddock.

Grey field slug or reticulated slug (*Deroceras reticulatum*)

The grey field or reticulated slug is 35 to 50 millimetres long and light grey to fawn in colour with dark brown mottling. There are up to three generations a year. It will generally breed in autumn and spring, however, if conditions are favourable this species will breed any time – a pair can produce up to 1000 eggs a year. It is mainly surface active and is a major pest of crops and pastures.

Black keeled slug (*Milax gagates*)

The black keeled slug is 40 to 60mm long and black or brown with a ridge down its back. This species can burrow up to 20 centimetres underground to escape the heat. It is more problematic in drier environments, such as South Australia, although it is widespread throughout south-eastern and Western Australia. A breeding pair can lay up to 200 eggs a year.

Brown field slug (*Deroceras panormitanum*)

The brown field slug is 25 to 35mm long, and usually brown all over with no distinct markings. It is mainly surface active but can burrow to shallow depths. It is more common when pasture is a frequent part of the crop rotation. A breeding pair can lay up to 500 eggs per year.

The grey field or reticulated slug is a major pest of Australian grain crops and pastures. It is 35 to 50mm long and ranges from light grey to fawn in colour with dark brown mottling. Under favourable conditions, this species will breed any time. A pair can produce up to 1000 eggs a year.

PHOTO:S MICHAEL NASH

The black keeled slug can burrow up to 20cm underground to escape the heat and so it survives well in drier environments. Its burrowing behaviour also allows it to attack germinating seedlings underground, making damage difficult to detect.

PHOTO: MICHAEL NASH

Hedgehog slug (*Arion intermedius*)

A significant pest species in Europe and New Zealand, the hedgehog slug has been recorded in a number of high-rainfall (more than 600mm) locations. It is up to 25mm long and grey in colour with a yellow foot. It is distinguished by its breathing pore at the front of the mantle (the section at the front of the slug that covers the internal organs).

Crop damage

Slugs can be underestimated as pests because they are nocturnal and shelter during dry conditions, and therefore are not generally visible during daylight hours.

They will attack all plant parts but seedlings are the most vulnerable crop stage and can suffer major economic damage.

Populations as low as one grey field slug per square metre can inflict severe damage on a canola crop at establishment.

Grey and brown field slugs are mainly surface active, requiring moist refuges at the soil surface such as volunteer crop plants and broadleaf weeds.

Black keeled slugs are a burrowing species, and can feed directly on germinating seed. This often makes damage more difficult to detect compared to the surface-feeding species.

Control approaches

No single method will provide complete control so an integrated pest management (IPM) approach is required.

By understanding the system's complexity and working on pest control year round, a reasonable level of control can be achieved.

In the summer months, remove refuges by controlling weeds and managing stubble through grazing.

If summer weed control is not possible, look to control weeds at least two months prior to seeding.

At the break of season, monitor for the presence of slugs. The most effective time to bait is at sowing, followed by rolling to consolidate the seedbed. However, this cultural practice may not fit with a zero-till operation, so assess the scale of the problem and make the management decision appropriate to your operation.

Baits are most effective when paddocks are bare, so if there is retained stubble, control may not be as good.

During the winter months, continue to monitor for any plant damage during crop emergence. Repeat baiting may be required during crop establishment. Baiting in spring is generally not effective because there are ample alternative food sources.

In Queensland, seedling canola, soybeans and sunflowers are the crops at greatest risk, particularly on creek flats where there is zero till and overhead irrigation.

Monitoring

The foundation of any IPM program is monitoring, but accurate estimation of slug numbers is difficult because slugs are hard to find, populations are often clumped and their activity is dependent on moisture availability.

One monitoring method is to create surface refuges in the form of terracotta paving tiles, carpet squares or similar. These can give an indication of slug activity and the relative number of slugs present. A 300mm by 300mm refuge represents approximately 1m^2 when soil moisture is favourable (more than 25 per cent). Concentrate monitoring on areas where slugs have been a problem in the previous autumn in order to assess population activity, especially after rainfall.

Check the refuges early in the morning, as slugs seek shelter in the soil as it gets warmer.

Keep in mind that monitoring does not provide an accurate guide to the total numbers of slugs present. To counter this, sample more than 10 refuges per 10 hectares.

Where unexpected crop damage is occurring, inspect the area after 10pm on a mild, calm night.

As well as looking for slugs, check for other pests such as European earwigs or beetles that could cause similar damage.

When monitoring is not practical from a time or resource perspective, an alternative option is to put out lines of bait to gauge populations, especially in areas where slugs occurred previously.

Control methods

Effective control involves a combination of measures: chemical, cultural, and biological.

Chemical control

Baiting is still the only chemical control option. Apply baits after sowing and before crop emergence to protect emerging seedlings.

Three types of baits are registered for the control of slugs.

1. Baits based on metaldehyde (there are many products available), some of which are registered for all slugs and some for grey field slugs only. Metaldehyde is a Schedule 5 poison and is highly toxic to birds and mammals. Spread evenly and avoid heaping to avoid attracting off-target animals.
2. Baits based on methiocarb (Mesurol®), which is registered for all slugs. Methiocarb is highly toxic to carabid beetles, one of the few predators of slugs in Australia and New Zealand, which it kills by secondary poisoning.
3. A bait based on iron EDTA complex (Multiguard®), which is registered for grey field slugs only. Multiguard® Iron EDTA complex bait is snail and slug-specific and has low toxicity to

The brown field slug has not been considered a major pest species but has nevertheless been recorded in high numbers and can inflict serious damage. It is mainly surface active but can burrow to shallow depths.

PHOTO: MICHAEL NASH

Slugs will attack all plant parts but seedlings are the most vulnerable. Damage to the cotyledons in canola seedlings can mean major economic losses.

PHOTO: MICHAEL NASH

Patchy emergence of this canola crop is evidence of extensive slug damage. Baiting can continue at this time, but it will only serve to minimise further damage; it will not be able to retrieve lost yield.

PHOTO: MICHAEL NASH

mammals and birds. It has no impact on predatory insects such as carabid beetles, iron complex baits and so is the recommended IPM option in Europe.

Different species have demonstrated different levels of tolerance to metaldehyde, so researchers are testing if black keeled and/or brown field slugs may be more tolerant to baits containing metaldehyde than grey field slugs.

The different responses to bait may also be due to behaviour. Consider placing baits with the seed when sowing, when black keeled slugs are present and easily move along drill rows. For grey field slugs, broadcasting baits is more effective.

The biggest issue with baits is the application rate. Don't underestimate the size of the slug population just because they are not visible. Always use the highest possible label rates or adjust the rate to the perceived size of the slug population.

The number of baits per hectare is more important than kilograms of bait per hectare. Higher bait densities may be required where high slug populations occur (more than approximately 20/m^2) . Current research is investigating this further, but preliminary results suggest that a minimum of 250,000 bait points per hectare may be required.

Bait failures are often associated with unfavourable weather conditions. More than one bait application may be necessary.

When slugs are actively breeding, no current control measure will reduce populations below established thresholds. For canola, this is as low as one slug per square metre.

Cultural control

Some crops, such as canola, soybeans and sunflowers, are more susceptible to slug damage than others.

If planting a susceptible crop, increase seeding rates in paddocks where slugs have been present and follow good agronomic practices to get the crop established.

Controlling weeds removes vegetation cover and thus food and shelter for slugs. Keep paddocks as weed-free as possible, especially if there is a wet summer.

Cultivation is effective in reducing slug numbers as it destroys their habitat, however, this is not an option in zero-till operations where the aim is to conserve soil moisture.

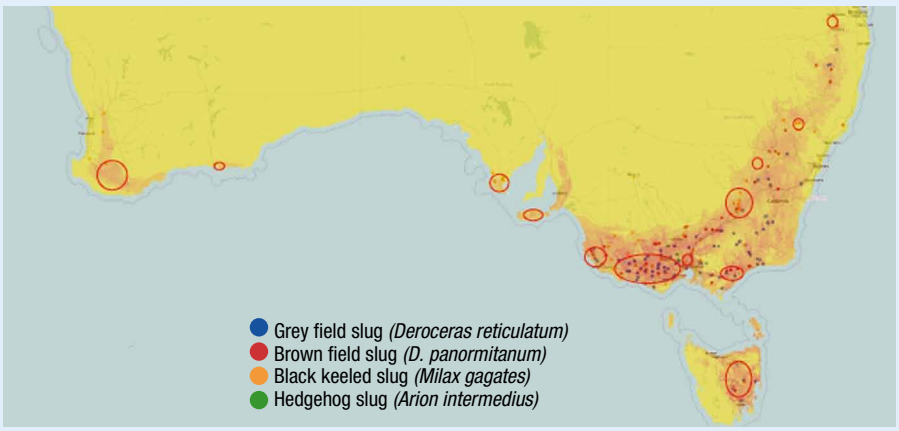
Stubble burning is another option but, again, is not always desirable nor failsafe, as a hot burn is required.

Rolling after sowing to consolidate the seed bed is an important component of an integrated slug control program. Rolling improves the establishment of many crops and reduces surface clods that provide habitat for slugs. Heavy rolling can reduce soybean emergence but lighter (selective) rolling can be carried out in well structured soils. Rolling is also at odds with a minimum till philosophy, so decide whether the size of the slug problem means the outcome justifies a change of approach.

The best approach is to incorporate appropriate cultural controls for your

Terracotta paving tiles can act as surface refuges for slugs and are useful for monitoring slug numbers. Check the tiles early in the morning when it is still cool, but bear in mind the clumping behaviour of slugs, and their dependence on moisture, may mean that samples are not always an accurate representation of the total number.

PHOTO: MICHAEL NASH



COURTESY: MICHAEAL NASH

FIGURE 1 Slug distribution in Australian grain-growing regions

These results are from an initial GRDC-funded SARDI survey of pest slug distributions throughout grain growing regions of Australia 2011 to 2012. WA was not sampled due to drought conditions; historical records from 2002 to 2007 indicate WA distribution.

Darker colours indicate more attractive areas for slug populations. Circles indicate areas where damage from slugs was reported.

operation into a broader IPM strategy, however, in some scenarios all controls are needed for successful crop establishment.

Biological control

Predatory insects and organisms play a role in limiting slug populations.

Carabid (or ground) beetles feed on both ground-dwelling pests and those that live on plants. Both larvae and adult carabids are predatory and they do well in the same conditions that favour slug populations.

As they are easily killed by some pesticides, reducing pesticide use or avoiding broad-spectrum insecticides is essential to make use of carabid beetles.

Research demonstrating the effectiveness of several species of nematodes as biological control for snails has been extended to slugs. The research is showing great promise in the laboratory.

MORE INFORMATION

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PHOTO: MICHAEL NASH

Carabid beetles can provide biological slug control. Because they are easily killed by some pesticides, reducing pesticide use or avoiding broad-spectrum insecticides can support their activity. Iron EDTA complex baits are slug and snail-specific and will not harm such beneficial predators.

The nematodes invade the animal and an associated bacterium kills it within five to six days. The dying slug acts as an incubator and, on the death of the animal, massive numbers of new nematodes are released to infest more slugs.

The nematode species capable of controlling slugs already occur naturally but not in sufficient numbers to provide adequate control.

Field trials will take place in Victoria this season to determine if applying nematodes to the soil and in-furrow prior to the season will be as effective as predicted.

USEFUL RESOURCES

Identification and control of pest slugs and snails for broadacre crops in Western Australia (1.7mb)
www.grdc.com.au/DAFWA-Bulletin4713-SlugSnail

Slugs in Crops Back Pocket Guide
www.grdc.com.au/GRDC-BPG-Slug

The current and potential costs of invertebrate pests in grain crops
www.grdc.com.au/GRDC-Report-InvertebratePestsCosts

IPM Technologies
www.ipmtechnologies.com.au

GRDC PROJECT CODE

DAS00127, CSE00046

Currently the research team has had encouraging kill rates on some species of snails in South Australia. They expect results to be even better in high rainfall zones. However, moisture at the site at the time of application and other factors will play an important role in determining whether or not these are an economic control measure.

Building a database for the future: reporting slugs

Submitting specimens to researchers can help build a picture of slug numbers and damage across the grain-growing regions of Australia, although this is dependent on local weather conditions and tillage systems used. Building such a database will benefit researchers into the future.

Place collected slugs in a jar with moist paper and some crop leaves, then post or courier the specimen to Michael Nash at the University of Melbourne. See Reporting Slugs for address details.

Provide the following information along with the specimen:

- your name and full address; telephone number and email address;
- the date and location of collection (where the specimen was found, preferably with GPS coordinates);
- soil type;
- paddock history (zero/minimum tillage or regular cultivation and cropping history);
- crop attacked; and
- description of the damage (photos are optional but useful).

REPORTING SLUGS

Send slug specimens (in a jar with moist paper and some crop leaves) to:

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CESAR
Bio21 Institute
Melbourne University
30 Flemington Road
Parkville VIC 3100
03 8344 2521 or 0417 992 097

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