

Integrated slug control



Always read product labels, consider your local conditions and consult a professional BASIS-qualified agronomist, if necessary.

Latest information

- The approval for methiocarb slug pellets expired on 19 September 2015.
- Metaldehyde can be detected in raw (untreated) water above the drinking water standard and was widely detected above the standard in autumn 2012.
- A ban on the outdoor use of metaldehyde slug pellets is to be introduced across Great Britain from spring 2020. For details, see the statement published at ahdb.org.uk/knowledge-library/integrated-slug-control

Action

- An integrated approach to slug control using several different techniques is more successful than relying solely on molluscicide pellets.
- Put slug traps out before cultivation to assess slug risk.
- Monitor slug activity throughout the susceptible crop growth stages.
- Find out if you are in a Drinking Water Protected Area or Safeguard Zone using the new tool at www.wiyby.co.uk
- Refer to the metaldehyde stewardship guidelines at www.getpelletwise.co.uk

Importance

Oilseed rape

Slugs are most damaging to seedlings because the growing point of a germinating oilseed rape shoot is, unlike cereals, above ground. Serious damage occurs up to the four true leaf stage.



Slug-damaged oilseed rape



Slug-damaged Brussels sprouts

Cereals

Slugs are most damaging to cereal crops when they cause seed hollowing. Each slug can kill up to 50 seeds in the first week after sowing, indicating the need for immediate control. Weight-for-weight, smaller slugs destroy more seeds than larger slugs.

Feeding on shoots and leaf shredding is also important and cereals are most vulnerable up to GS14 (four leaves unfolded) but remain vulnerable up to GS21 (one main shoot and one tiller).

Potatoes

Slugs are most damaging at the early stages of tuber bulking. They enter through small holes in the skin, causing irregular-shaped holes on the tuber surface extending into large cavities in the tuber (below).



Courtesy of The Food and Environment Research Agency (Fera), ©Crown Copyright

Slug-damaged potato

Horticulture

Slugs can attack and cause damage to vegetable crops at varying stages of their development. Attack in the early stages can result in plant loss by direct feeding on seedlings. At later stages, feeding can lead to cosmetic problems. Slug damage can cause contorted growth of the growing tip, eg in asparagus, also causing rejection.

The tolerance to feeding damage varies from zero in salad crops to small permitted tolerances in other crops like Brussels sprouts. Faecal and slime contamination to mature crops make them unmarketable and the presence of live or dead slugs in harvested produce will lead to rejections.

Celery, carrots, asparagus, long season Brassicas (such as Brussels sprouts, winter and spring cabbage), lettuce and spinach tend to be the most susceptible vegetable crops. Early planted crops like lettuce and salad crops are known to be very vulnerable. Horticultural crops covered by nets and covers may be more susceptible to slugs, as the humidity within the crop is increased.

Key slug species



The grey field slug (*Deroceras reticulatum*) and other *Deroceras* spp.

The grey field slug is the most widespread and troublesome species. It is usually light grey or brown, grows to 5 cm in length and produces milky white mucus.

Populations tend to have a mixed age structure, so damage occurs whenever conditions are favourable for activity. It continues to be active in damp weather and even when temperatures are close to freezing.

Breeding is generally at a peak in April and May and then again from September to October. However, in favourable conditions, it will breed throughout the year. In optimum conditions it can start to lay eggs within 16 weeks of hatching.



The garden slug (*Arion hortensis* and *Arion distinctus*)

The garden slug is usually smaller than the grey field slug, growing to 3 cm in length. The body is dark and the foot (underside) ranges from yellow to orange. It produces orange or yellow mucus. Egg hatching reaches its peak in late spring/early summer. Young slugs can develop rapidly to produce a further generation within the year. *Arion* species are only active at temperatures above 5°C and are less active on the soil surface than the grey field slug.



The keeled slug (*Milax*, *Tandonia* and *Boettgerilla* spp.)

Keeled slugs are more localised in arable crops than field or garden slugs but they can be important. They vary in size and generally produce a colourless mucus. Keeled slugs have annual life cycles, with eggs hatching from autumn to spring. All keeled species are generally subterranean but can be seen on the surface, especially during the breeding season.



The Spanish slug (*Arion vulgaris*)

Spanish slugs can be brown, black, fawn or mustard coloured and can grow up to 15 cm long. Unlike other slug species, the Spanish slug is omnivorous, eating dead animals, excrement and plant material. They produce twice as many eggs as native slug species.

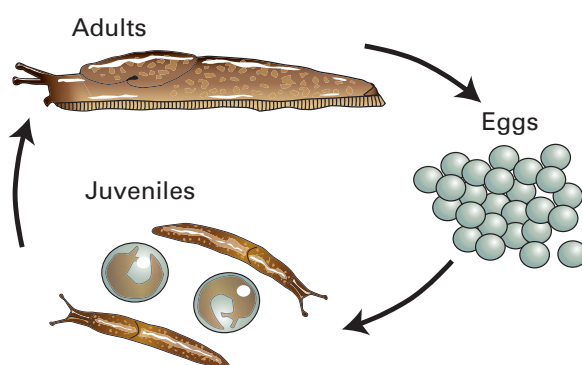
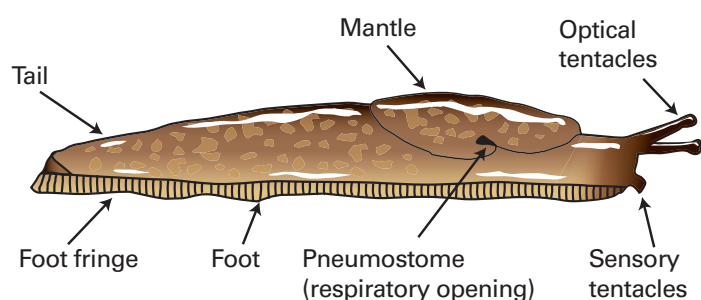
Life cycle

All slug species are hermaphrodite (each individual is both male and female). While some species are self-fertile, most mate before laying eggs in batches of 10 to 50 in soil cavities, between clods, under stones or at the base of plants.

Up to 500 eggs per slug may be laid over several weeks. Eggs develop slowly in the winter but will hatch within a few weeks when the temperature starts to rise.

The number of active slugs found at any one time and place is dictated by both the slug population density and the suitability of the weather for activity (activity-density). Rapid reproduction and growth is enhanced by mild, moist weather conditions, sufficient food supply and ample shelter. Such conditions prevail in the spring and early autumn, making crops like lettuce and Brassicas more vulnerable at these times of year.

Slug movement occurs most frequently at night but they will return to their resting site by dawn if weather conditions are unfavourable. They do not travel far from where they were hatched, often taking only a circular route of a few metres in search of food.



Risk factors

Moisture and temperature

Activity, survival and reproduction are dependent on temperature, moisture, light and soil structure. The optimum temperature for slugs is 17°C but they are active between 5°C and 20°C. The grey field slug is active even when temperatures are close to freezing.

Crops grown under fleece or polythene covers provide warm, damp and occasionally weedy conditions favourable for slugs. Irrigating crops after planting results in a conducive environment for slug activity.

Soil type

Slugs are more abundant in heavy soils with high clay or silt content.

Previous cropping

Slug damage is much greater after leafy crops which create moist soil conditions. New plantings that follow crops that have a long growing period are more susceptible.

Crop residues, organic matter and weeds

Crop residues or applications of manure, especially in the autumn, as well as weeds and volunteers, provide slugs with a source of food and shelter.

Slugs prefer soft, nutritious tissue provided by young ground plants rather than more fibrous material. A damp environment combined with succulent food is essential for their survival, so leafier crops that offer ground cover are often preferred.

Cultivation

Direct drilling, as well as delayed drilling, increases the risk of slug damage.

Open, damp and cloddy seedbeds allow slugs easy movement and provide more shelter than friable, frequently cultivated soils.

Crop type

Autumn crops are slow growing and so are more at risk than spring-sown crops. Barley and oat seeds have an extra seed coat, so are less vulnerable to attack than wheat. There is variation in susceptibility to slug damage between potato varieties but there are no independent variety resistance ratings available.

Small fields surrounded by ditches, wasteland, hedgerows or green fallow

In the field, slugs tend to be evenly distributed depending on soil moisture. The risk of damage can be increased on the perimeters of fields. Headlands are close to field boundary vegetation and are often compacted, with poor drainage. This can create a moist refuge for slugs.

Other agronomic conditions

Lack of nutrients, poor drainage and weed competition can all result in slow growth, prolonging the vulnerable period of establishment.

Cultural control

Cultivation

Seedbed preparation and quality are potentially more important than chemical control of slugs, particularly in combinable crops. Ploughing is a good way of reducing slug populations but even minimum tillage gives a considerable reduction in slug damage compared to direct drilling.

Seedbed cultivations will increase mortality depending on machine action, soil type, timing of cultivation, depth and intensity. Firm seedbeds reduce slug activity by making it harder for them to move around and reducing the availability of safe resting places.

A fine, consolidated seedbed is important and will protect seeds and prevent slugs accessing seedlings before emergence. A consolidated seedbed is important in providing good seed to soil contact, enabling seeds to germinate quickly and grow rapidly through the vulnerable establishment stage.

Increase sowing depth of wheat to 4–5 cm if the seedbed is cloddy.

Minimise weeds

Minimising weed growth in preceding crops and seedbeds will reduce sources of food and shelter.

Beetle banks

The establishment and management of beetle banks in field margins as habitats for carabid beetles has been shown to reduce slug numbers by predation, mainly from June to September.



Carabid beetles

©Roger Umpelby

Monitoring for slugs

To assess the risk of crop damage, it is important to estimate the size of slug populations present. Sampling in the field is best done using refuge traps. Put slug traps out before cultivation, when the soil surface is visibly moist and the weather is mild (5–25°C). When soil conditions are dry and slugs are not actively seeking food, trapping will have little value in determining the threat to the crop.

Traps consist of a cover about 25 cm across, such as a plant pot saucer, with a small heap of bait underneath. A suitable bait would be two heaped spoonfuls of chicken layers' mash or a cereal grain-based food (NOT slug pellets). Leave a small gap between the trap and the soil to allow slugs to enter. It may be necessary to put a weight on the trap in windy conditions.

In each field, nine traps (13 in fields larger than 20 ha) should be set out in a 'W' pattern spread over the entire area of the field. Also, concentrate on areas known to suffer damage. In standing crops, place the

traps just to the side of tramlines and mark with canes to allow them to be located.

Leave traps overnight and examine early the following morning while the soil surface is still moist, counting the number of slugs present and noting any slime trails. On warm days, it is important to check the traps early while the temperature is still cool, as slugs will leave the trap as it gets warmer.

If no slugs are found, continue to trap until crops have passed their vulnerable stage.

The following thresholds indicate a possible risk when soil and weather conditions favour slug activity.



Refuge trap using chicken layers' mash bait

Crop	Threshold (average number of slugs/trap)
Winter cereal	4
Oilseed rape (standing cereals)	4
Oilseed rape (cereal stubble)	1
Potatoes	1
Field vegetables	1

Monitoring slug damage

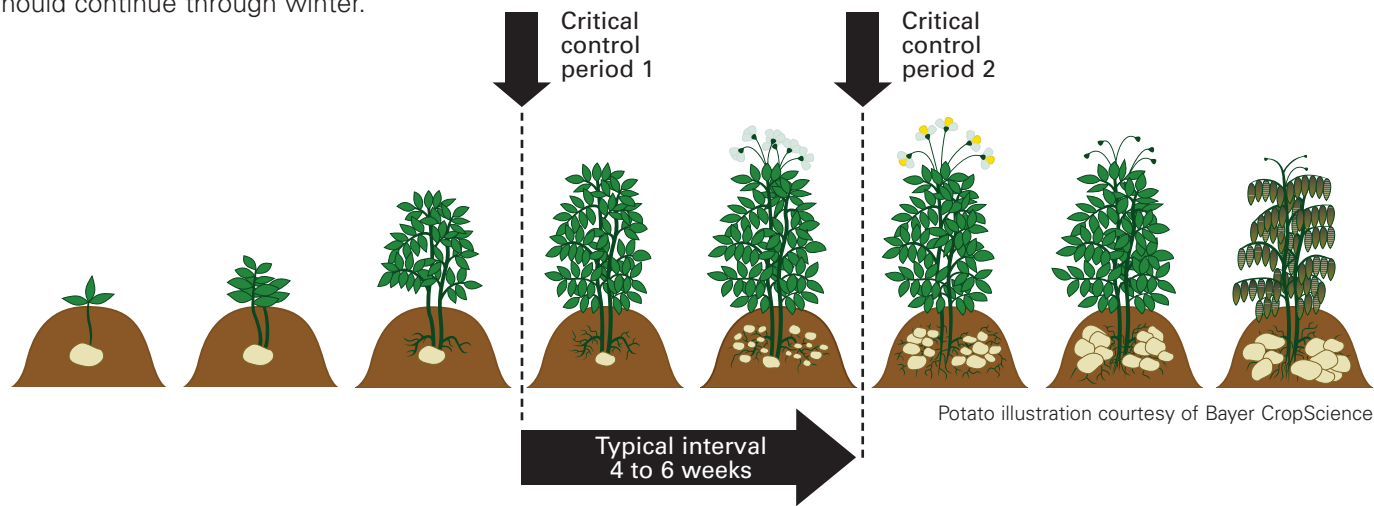
Oilseed rape crops should be monitored regularly for slug damage from sowing to the four true leaf stage when the crop is vulnerable.

Winter cereal crops should be regularly monitored from sowing to first tillering (GS21). Damage after this stage is less likely to result in further plant loss but monitoring should continue through winter.

Potatoes have two critical control periods (below), at 50% to 75% canopy closure and at the early stages of tuber bulking.

Closely monitor slug activity during these periods to determine if control is necessary. Continue to monitor the crop until burn down.

Lettuce crops should be monitored in January/February and **Brussels sprout** crops in March/April.



Biological control

Biological control of slugs is particularly suited to organic systems. *Phasmarhabditis hermaphrodita* is a nematode parasite of slugs that is commercially available as a biological molluscicide. Unlike pellets, nematodes can target soil-dwelling slugs, as well as surface-active slugs, although slugs may avoid feeding or resting on substrates treated with nematodes.

The nematodes enter the slug's shell sack (mantle), where bacteria from the nematode's gut are released and start to multiply. The nematodes feed on the bacteria and the bacteria cause the slug's mantle to swell and burst. It usually takes between 7 and 21 days for an infected slug to die but its feeding stops soon after the nematode enters the body, protecting plants from damage. When the slug dies, the nematodes will continue to feed on it until the food source is depleted, before leaving in search of more slugs.

P. hermaphrodita will kill most slugs. The grey field slug is highly vulnerable but larger species are only susceptible when they are young and small. Therefore, when

larger species are likely to cause damage, it is important to apply nematodes in spring when juvenile slugs are present.

Nematodes are best applied in dull weather, in the evening and before rain. They can be applied in advance of expected damage, at sowing or any time during the crop's lifetime; however, success is dependent on wet conditions after application. In ideal conditions, nematodes will

provide a reduction in damage for about six weeks after application. To get the best out of the product, it may need to be used soon after purchase: always follow the instructions carefully.

The use of nematodes is most viable for high-value crops. They are also extremely useful in situations where it can be difficult to target the slugs effectively with molluscicide pellets, such as mature lettuce crops.



©ADAS

Slug infected with *Phasmarhabditis hermaphrodita*

Chemical control

Applications of slug pellets should be integrated with cultural control measures. The effectiveness of pellets is dependent on their chemical content, constituents which affect their attractiveness to slugs and their durability under field conditions. Large slugs need to ingest more of the active substance than smaller ones to cause death so it is critical that the pellet is palatable to slugs to ensure enough bait is eaten. If there is too much active substance in a pellet, slugs may detect it and stop feeding before a lethal dose is consumed.

Ferric phosphate

Ferric phosphate is suitable for organic systems. It causes slugs to quickly stop feeding; they then become less mobile and die within 3–6 days. As slugs often die underground, effectiveness of the treatment should be measured by the decrease of feeding damage in the crop.

Metaldehyde

Metaldehyde is a selective molluscicide and principally acts on slugs by inducing excessive

secretion of mucus, leading to subsequent dehydration and death. At high temperatures of around 20° C, the activity of metaldehyde is optimised; at low temperatures its toxic effect may be diminished. Metaldehyde does not harm predatory ground beetles, which can help to restrict slug populations.

A ban on the outdoor use of metaldehyde slug pellets is to be introduced across Great Britain from spring 2020. For details, see the statement published at:

ahdb.org.uk/knowledge-library/integrated-slug-control



Application method and timing

Application in cereals and oilseed rape: Broadcasting pellets is the best method of application. Broadcasting kills slugs more quickly than pellets drilled with seeds and can facilitate stewardship. It gives more consistent slug control, particularly in combination with fine, firm seedbeds that help protect seeds and seedlings.

Broadcast slug pellets as soon as possible after drilling. Application is most effective up until the four true leaf stage in oilseed rape and GS14 in wheat.

Admixed slug pellets (pellets mixed with seed at drilling) are ineffective in fine seedbeds because both seeds and pellets are unavailable to slugs, which survive to attack emerging seedlings.

Pellet admixtures with wheat seeds when direct drilling or in open cloddy seedbeds can be effective.

The best time to apply pellets is just before the susceptible crop stage, when optimum weather conditions prevail. It can be beneficial to repeat treatment when new feeding damage is observed, when traps indicate an increase in activity or if pellets disintegrate or go mouldy. It is important to note that pellets can be rendered ineffective after prolonged heavy rain.

Critical control periods for potatoes:

- 50% to 75% canopy closure, usually in late June to early July. The canopy is sufficiently open to allow pellet penetration.

- Early stages of tuber bulking before slugs go underground to find developing tubers. August is the pivotal month for follow-up applications and when damage usually begins to appear.

Sensitive phases for field vegetables

The sensitive phase for lettuce and celery lasts for the whole of the growing period. Pellet application before a crop is planted may be justified.

Brussels sprouts are most sensitive at the seedling stage and when harvestable buttons start to develop. Application of slug pellets should be limited to the sensitive phases only.

Metaldehyde slug pellet stewardship

KILL SLUGS NOT METALDEHYDE

Metaldehyde is often detected in raw water above the drinking water standard, with peaks following rainfall. While levels detected pose no danger to health or the environment, the UK's environment agencies and Defra are responsible for the implementation of the Water Framework Directive (WFD). Unless action is taken, regulatory restrictions, or even withdrawal, may be enforced.

What's in Your Backyard?

Find out if you are in a Drinking Water Protected Area (DrWPA) or Safeguard Zone by entering your postcode into the Environment Agency's online tool 'What's in Your Backyard' www.wiyby.co.uk

Use WIYBY to create a targeted slug control programme that is up to date and tailored to your individual situation.



Application guidelines

- Use minimum active per hectare to avoid drainage and run-off losses.
- Maximum application rate: 210g metaldehyde a.s./ha*. For additional protection of water, BASIS-qualified suppliers or advisors may recommend rates reduced to 160g a.s./ha or less*.
- Maximum total dose from 1 August to 31 December: 210g metaldehyde a.s./ha*. For additional protection of water, BASIS-qualified suppliers or advisors may recommend rates reduced to 160g a.s./ha or less*.
- Maximum total dose rate: 700g metaldehyde a.s./ha/calendar year*.
- No pellets to be allowed to fall within a minimum of 10 metres of any field boundary or watercourse.
- Do not apply when heavy rain is forecast.
- If drains are flowing, do not apply metaldehyde-based slug pellets.

**from any combination of metaldehyde products. 700g is also the statutory limit. a.s. = active substance (or active ingredient)*

Further information

www.ahdb.org.uk/integrated-slug-control

The Metaldehyde Stewardship Group www.getpelletwise.com

What's in Your Backyard? www.wiyby.co.uk

Project Report 393: Integrated slug control in arable crops: Risk assessment, trapping, agronomy and chemical control (AHDB, 2006)

Research Review 79: Implications of not controlling slugs in oilseed rape and wheat in the UK (AHDB, 2014)

FV 379: Leafy salads & Brassicas: slugs – a review (AHDB, 2010)

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