



Agri Services

Decoy Wetex

Deter

DRAZA
forte

Huron

Karan

REDIGO
Deter

Rivet



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Bayer Expert Guide Slug Control

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Introduction

Slugs pose significant risk to virtually all arable and horticultural crops grown in the UK. Given suitable soil and weather conditions, they can compromise the establishment of winter cereals and oilseed rape, dramatically reducing yield potential, and can downgrade the quality of potatoes and field vegetables, reducing market value and even causing rejection.

This Bayer Expert Guide brings together the current knowledge base on slugs and their control to support agronomists and growers in the continued struggle against these voracious pests.

It is structured to build understanding of the fundamentals first with chapters on slug biology, risk assessment and control tactics. This is then applied to the construction of crop specific control strategies based on critical control periods; a new concept for targeting of treatments to optimise control. It ends with a chapter dedicated to the increasingly important topic of best practice in the application of slug pellets.

It has been authored by a team of independent experts in conjunction with the technical development and stewardship managers at Bayer CropScience, a leader in crop protection. Together we hope you will find it a valuable guide in the continuing challenge of slug control to realise the full potential of your crops; in yield, quality and profit.

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1

Biology

Dr Gordon Port, Newcastle University

Although growers and advisers refer to slugs in general there are more than 30 species in the UK, which vary in their distribution and critically in the extent of the damage they can cause. The timing and nature of slug damage is also crop specific.

Most combinable crops and sugar beet are vulnerable during the establishment phase whereas with potatoes it is the harvestable parts, the tubers, that are at risk and increasingly so as they mature. Depending on the crop, field vegetables can suffer damage through the establishment phase and to harvestable parts.

Understanding the biology of slugs is fundamental to the planning and implementation of crop specific control strategies. This chapter introduces the main species encountered in the UK, explains their life cycles and behaviour and describes by crop the nature of the damage they cause.



1.1 Key species and life cycles

Slugs and snails are molluscs and are related to shellfish and squid. Most molluscs live in aquatic habitats and so terrestrial slugs and snails have special adaptations to enable them to survive on land. Whereas insects have their waterproof cuticle and snails can rely on their shells, slugs depend on their sophisticated behaviour. Molluscs have well-developed nervous systems and show a much greater ability to learn about their environment and food than insects.

Slugs have evolved from snails by losing their external protective shell. As a result slugs are more vulnerable to desiccation and very dependent on a moist environment for their survival. They thrive in the mild, moist climate of the British Isles, which is ideally suited to them. Their flexible, streamlined shape allows them to move through soil cracks and to survive in the disturbed soil of arable crops.

All slug pest species are hermaphrodite i.e. each individual is both male and female. Whilst some species are self-fertile, most normally mate and exchange sperm. They lay eggs in batches of 10 to 50 in soil cavities, under stones or similar cover when the soil is moist but not water-logged. Up to 500 eggs per slug may be laid in a season by some species. Slugs hatch from eggs after a period of a few weeks in summer or months in winter and grow steadily to maturity.

Unlike many insect pests slugs and snails have variable life-cycles. Some may hatch, grow, reproduce and die annually or more rapidly in protected environments but others show variable growth rates and can reproduce throughout the year. This means that slug and snail populations are often made up of individuals of different ages. However, the rate of slug growth is highly variable within and between species, so their size is not a very reliable guide to age or maturity. In outdoor crops reproduction is most likely when the soil is moist and temperatures are neither too hot nor too cold, usually in autumn and spring.

The grey field slug and other *Deroceras* spp.

The grey field slug is the most common and widespread slug pest in both arable and horticultural crops ①. It usually goes through one complete generation plus one partial generation each year. Breeding activity normally peaks in spring and in autumn but it can breed at any time of year when conditions are suitably mild and moist.

In outdoor horticultural crops at particular times and locations other species may be more significant. In protected crops the most frequently encountered slug pest is the chestnut slug (*Deroceras panormitanum*) ②. This and the marsh slug (*D. laeve*) are sometimes found in arable crops but they are more localised in their distribution.

Round-backed slugs (*Arion* spp.)

Several species of round-backed slugs are found in arable crops with the smaller species generally being more important than the larger ones. Garden slugs (*Arion hortensis* species aggregate) are common and also potential pests of horticultural crops ③.

One larger species, the dusky slug (*Arion subfuscus*) can be abundant in arable crops ④. All *Arion* species have annual life cycles and breed at a time of year that is characteristic of each species for example *A. hortensis* in spring to early summer, *A. subfuscus* in late summer to early autumn.



The grey field slug (*Deroceras reticulatum*)



The chestnut slug (*Deroceras panormitanum*)



The garden slug (*Arion hortensis* species aggregate)



The dusky slug (*Arion subfuscus*)

Keeled slugs (*Milax*, *Tandonia* and *Boettgerilla* spp.)

Keeled slugs are more localised in arable crops than field slugs or round-backed slugs but they can be important and are potential pests of horticultural crops.

They have annual life cycles with eggs hatching from autumn to spring.

Tandonia budapestensis 5 is probably the most common but *Milax gagates* 6 and *T. sowerbyi* can also be important. The worm-like slug *Boettgerilla pallens* is thought to have been introduced from the Caucasus and is now widespread.



Tandonia budapestensis



Milax gagates

Snails

Snails do not usually present a serious problem in arable crops or field vegetables but in salad and fruit crops the garden snail (*Helix aspersa*) and the banded snail (*Cepaea hortensis*) can be pests. In protected crops the small snail (*Oxyloma pfeifferi*) can occur at very high densities 7.

Most snails are unable to find refuge in soil and prefer vertical habitats such as tall vegetation, walls and fences. They may damage crops grown near such habitats.



The small snail (*Oxyloma pfeifferi*)

1.2 Damage to crops

Winter wheat

Slugs cause most damage to winter wheat at the early stage. Seeds become attractive to slugs within hours after sowing, as soon as they have imbibed water. Slugs feed on the embryo, killing the seed, and they often eat part or all of the endosperm resulting in the characteristic 'seed hollowing' 8.

Juvenile slugs are important in killing winter wheat seed, because they are often abundant in seedbeds and can move through small spaces in the soil to reach the seed. Weight-for-weight they also kill more seeds than larger individuals.

Slugs will also graze emerged leaves but this is less likely to affect yield.



Slug feeding on wheat seed

Oilseed rape

Seedlings of modern varieties of oilseed rape are highly susceptible to slug damage, compared to varieties grown 25 years ago, because of their lower concentrations of glucosinolates 9. Seedlings are at their most vulnerable soon after they begin to germinate and remain at risk until they reach the four true leaf stage.



Slug feeding on oilseed rape

Oats and barley

Seeds of oats and barley have an extra seed coat so are less vulnerable than wheat seeds. However, as soon as they germinate, shoots and roots are vulnerable to damage by slugs in the same way as winter wheat.

Spring cereals

Spring-sown cereals are at less risk of slug damage than autumn sowings, probably because slugs are generally less abundant and active in spring and crops grow quickly through the early vulnerable stages.

Sugar beet

Slug attacks on sugar beet are sporadic and tend to occur where agronomic and environmental conditions have favoured slug overwinter survival, for example where cover crops have been grown through the winter.

Seedling loss in precision sown crops, such as sugar beet and some field vegetables, is even more serious than for drilled crops such as cereals and oilseed rape.

Potatoes

Slugs do not attack young potato tubers to any significant extent but start to feed on them as they mature. They enter the tubers leaving small holes in the skin and hollow out feeding cavities in the tissue beneath ¹⁰. From the outside slugs' entrance holes look very similar to wireworm attack but their internal damage is quite different. They hollow out much larger cavities than the narrower tunnels made by wireworms.



Slug damage to potato tuber

Slug damage can also be confused with cutworm damage but slug damage is most prevalent on heavier soils in wet seasons whereas cutworm damage is most prevalent on lighter soils in dry seasons. Some potato varieties show partial resistance to slug damage whilst others such as Maris Piper are highly susceptible. Prompt harvesting reduces the period that tubers are exposed to slug attack.

Field vegetables

Like many other crops, field vegetables can be susceptible from sowing whilst transplanted vegetables can be susceptible immediately following planting out. Late slug attack close to harvest can also be serious for many vegetable crops by reducing the quality and hence value of the produce. Buttons of Brussels sprouts ¹¹ are particularly prone to slug damage and most retailers have a zero tolerance policy.



Brussels sprout buttons damaged by slugs

In broccoli, cabbage, cauliflower, lettuce and strawberry slug damage can also result in crop rejection following unacceptable contamination with slugs and their faeces ¹² ¹³. In asparagus slug attack can also cause distortion of the growing shoot that leads to rejection or downgrading of the produce.



Lettuce damaged and contaminated by slugs

In root crops such as carrots the cavities excavated in the roots by slugs not only reduce quality directly but can also lead to bacterial rotting. However, slugs do not survive well in sandy soils where carrots are grown, so attack is usually most severe at field edges where the slugs have moved in from field margins.



Strawberry damaged and contaminated by slugs

Peas for canning or freezing are particularly at risk from slug contamination at harvest. The harvesting operation is frequently carried out at night to meet the processors' precise requirements and this coincides with maximum slug activity in the crop canopy. As a consequence juvenile slugs may be harvested along with the crop.

In agricultural and horticultural environments slugs usually have less food choice and will feed on the crop. In weedy areas slugs may be diverted from the crop but weeds also provide food and shelter for slugs and may thus encourage an increase in numbers.

1.3 Behaviour

Dr Catherine Whaley, i2L Research Ltd

Slugs are normally active at night with peaks at dawn and dusk as they move to and from shelter. The grey field slug is the most surface-active species and can often be seen on the soil surface or in the crop canopy even during the day in overcast, humid weather. It has a greater preference for green plant material than other species. However, it is also active in feeding below ground on wheat seeds, potato tubers and other plant material.

Round-backed and keeled slugs are less likely to be seen on the soil surface. They also show less preference for green-leaf material and are considered to be more important as subterranean pests of wheat seeds, potato tubers and root crops.

When they become dehydrated, slugs take specific action to reduce further water loss. They move down in the soil to escape drying conditions and often huddle together. When moisture returns slugs will remain in contact with a damp surface absorbing water through the skin until the water content of their body returns to near normal.

As high temperatures increase water loss slugs often move deep into the soil during hot weather. At the other extreme slugs run the risk of freezing. Although their bodies will not freeze until temperatures drop below 0°C, they can continue to feed at temperatures close to this. Activity on the soil surface declines dramatically at air temperatures below 5°C. To escape freezing conditions slugs again move down into the soil.

To avoid hot, drying conditions slugs are usually nocturnal and in ideal weather the grey field slug will begin foraging on the soil surface 20 to 40 minutes after nightfall. If food is found, slugs go through two or three cycles of feeding and resting before returning to shelter. They have well-developed internal clocks and this pattern of activity continues even if they are kept in constant darkness.

In a natural environment slugs usually encounter several different types of food during foraging. They stay and feed for longer on the most preferred food. Once they have learned the location of food they come back each night to feed, returning by day to a nearby 'home'.

Whilst foraging, slugs that are sexually mature may encounter potential mates by following their slime trails. If courtship is successful they will mate. The slime trail also helps predators such as ground beetles to find slugs.

In their turn slugs that detect the odour of predatory beetles may leave an area. Slugs can also detect the presence of the nematode *Phasmarhabditis hermaphrodita* and will move off surfaces that have been treated with this biological control agent.

Sensory organs' structure and function

The most obvious organs involved in sensory functions in slugs and snails are the tentacles, which are arranged as two pairs (Diagram 1). The posterior pair are long and mobile and held out slightly above the horizontal whereas the anterior pair are shorter and normally point downwards, often making contact with the ground or whatever surface the slug is on. It has been generally recognised that the posterior tentacles deal with light detection and odour recognition (olfaction), whereas the anterior are involved with touch and taste (gustation). Although the posterior tentacles have 'eyes', these are primitive structures and only able to distinguish between light and dark.

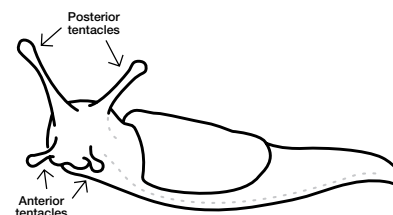


Diagram 1. The main slug sense organs involved in chemoreception.

However, also located on the tips of both pairs of tentacles are specialised sensory pads that are densely packed with receptors. These are able to detect and differentiate between chemical stimuli and relay this information via nerves to the cerebral ganglion or 'slug brain'. The pattern of nerve signals from the posterior tentacle varies according to the type of plant chemical it is exposed to, demonstrating that chemical sensing in slugs is a highly specialised response. Other regions of the molluscan anatomy thought to be sensitive to chemical stimuli are the lips and the buccal mass, a large muscular organ leading from the mouth to the rest of the gut.

i Further information on the biology of slug pest species can be found in:

- Barker G.M. (Ed.) (2001). The Biology of Terrestrial Molluscs. CABI Publishing, Wallingford.
- Barker G.M. (Ed.) (2002). Molluscs as Crop Pests. CABI Publishing, Wallingford.
- Godan D. (1983). Pest Slugs and Snails, Biology and Control. Springer-Verlag, Berlin.
- South A. (1992). Terrestrial Slugs Biology, Ecology and Control. Chapman & Hall: London.

Chemoreception

Since slugs have very limited 'vision' and are mainly active at night, they rely heavily on acute chemical sensing for their survival. The detection and response of slugs to chemical signals in the environment, known as chemoreception, has been demonstrated in all aspects of their behaviour.

Slugs have been shown to return to daytime resting sites by following chemical signals present in slime trails. They can also use these chemical signals not only to distinguish between slime trails laid by different slug species, but also to detect the direction in which the trail was laid. Escape response studies have shown slugs can detect and avoid areas releasing odours from slug predatory beetles.

However, perhaps one of the more important areas where slugs rely heavily on chemoreception is feeding behaviour. Terrestrial slugs are not only prolific feeders but are also capable of a high degree of selection in their feeding. This selection process is primarily due to the different chemical compositions of individual plant species. For instance, some plants contain secondary metabolites which act as repellents or anti-feedants thus deterring slug feeding. Conversely some plants may contain high concentrations of fatty acid metabolites and sugars which stimulate slug feeding (Diagram 2).

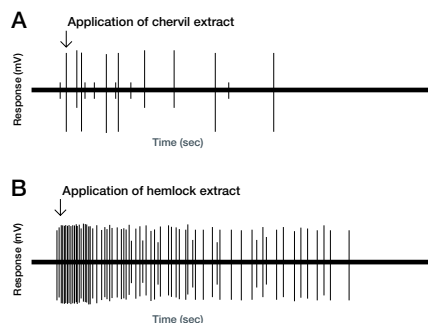


Diagram 2. Electrical responses to plant odours.

When the sensory pad of a large posterior tentacle is exposed to various plant odours an electrical response is generated and sent to the 'slug brain' via the main nerve. Such activity was recorded in laboratory studies and two typical results are shown.

Trace A illustrates the slug response to a general weed, whereas Trace B shows the slug response to an extract of hemlock containing a strong slug repellent. These traces demonstrate how different plant odours can induce unique responses and thus confirm that slug chemoreception is a highly specialised skill.

Different plant compounds are detected and recognised by the sensory organs of slugs and thus provide some extremely specialised associations between slugs and plants. Early studies have even suggested that the process of chemical sensing can induce some sort of learned response in slugs and that cumulative effects can produce learned associations which may persist for prolonged periods of time.

Chemoreception has been shown to play a central role in how slugs perceive and respond to their environment especially orientation, survival and food selection. Future research in this area could lead to novel forms of slug management.

2

Risk assessment

Professor David Glen, Styloma Research & Consulting

Risk assessment is an essential principle of Integrated Pest Management (IPM) and avoids unnecessary prophylactic applications of slug pellets.

The key risk factors are whether slugs and/or snails are present in the area of the crop and the size of the population. They do not usually travel more than one or two metres into the crop in any numbers so most damage is caused by pests already present in the soil.

This chapter summarises the risk factors conducive to slug activity, explains how to monitor populations by bait trapping and weigh up the results against established crop thresholds to decide whether or not a control strategy needs to be deployed.

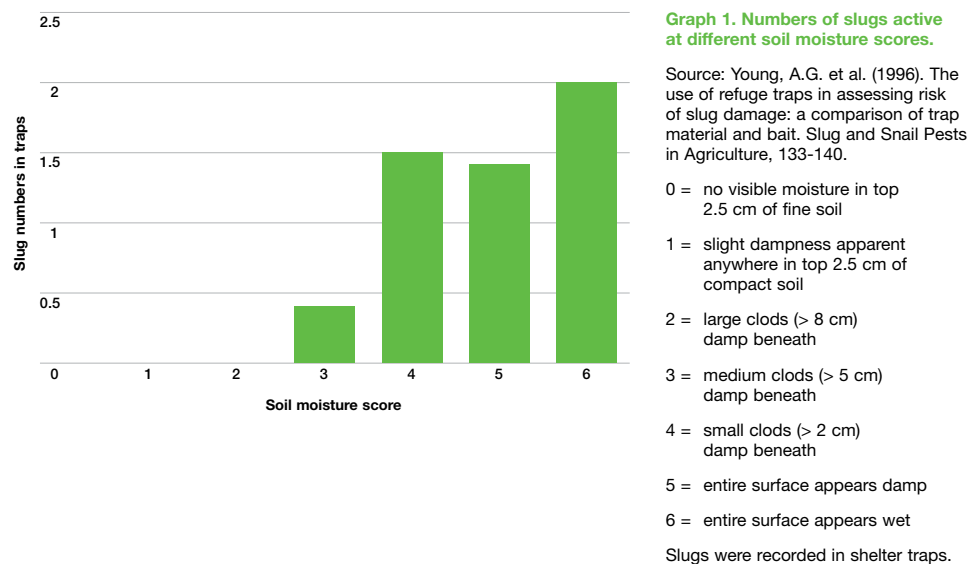


2.1 Risk factors

Moisture and temperature

Slugs are highly dependent on moisture for activity, survival and reproduction, so they are at their most damaging in wet weather and can cause problems in irrigated crops. Irrigation of potato crops late in the growing season when tubers are susceptible increases the risk of slug attack whereas irrigation early in the season does not. Slugs also prefer mild temperatures. The optimum temperature for the activity of the grey field slug is about 17°C but it remains active even close to freezing. Other species are active only above about 5°C.

Even if slugs and snails are present they will not cause feeding damage if weather is unsuitable. Slug activity is reduced when the soil surface is dry (Graph 1) or if the air temperature drops below 5°C.



Soil type

Heavy soils with high clay or silt contents are suitable for slugs as they retain moisture. Seedbeds on these soils also tend to be open and cloddy allowing slugs to attack seeds and newly germinated seedlings.

Previous cropping

The risk of slug damage to winter wheat is much greater after dense leafy crops, especially oilseed rape, than after crops such as potatoes and sugar beet that leave more bare ground between crop rows.

Cover crops grown over-winter to reduce the risk of nitrogen leaching or for other purposes provide slugs with a sheltered, moist habitat and plentiful food. As a result the risk of damage to a spring crop following a cover crop is increased.

Crop type

Varietal resistance has been found in some crops such as potatoes but for most horticultural crops it has not been studied. However, this is probably not a very important consideration in slug and snail management as they become less discriminating where there is little choice of food.

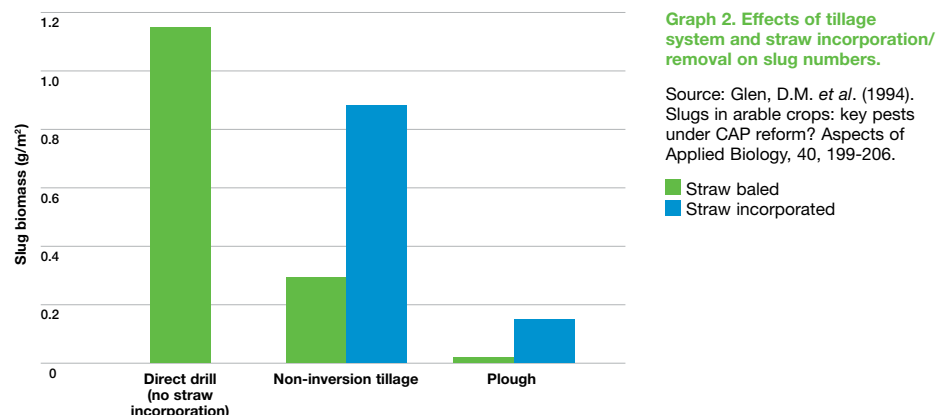
The biggest effect of crop type as a risk factor comes from the different thresholds for damage that are acceptable, lettuce and strawberry having very low thresholds. Adverse weather such as cool conditions may encourage slugs to take refuge in plants and thus exacerbate the problem of contamination.

Planting dates

Crops sown in autumn are generally at greater risk than spring crops because slug populations are high in autumn and the weather is generally more suitable for slug activity. However, spring sowings can also suffer especially in cold wet weather.

Crop residues and other organic matter

Crop residues incorporated into soil, or applications of manure, provide slugs with a source of food and shelter whilst also increasing the soil's moisture-holding capacity. As a consequence slug numbers tend to be greater where straw is incorporated than where it is baled and removed (Graph 2).



Cultivation and seedbed preparation

Slug populations can be greatly reduced by cultivation. In general, the greater the soil disturbance, the greater the impact on slug numbers. For this reason ploughing normally has a greater effect than reduced, non-inversion tillage (Graph 2). Direct drilled crops are at especially high risk of slug damage because there is no cultivation to reduce numbers. An equally important aspect of cultivation is its influence on seedbed tilth as described in section 3.1.

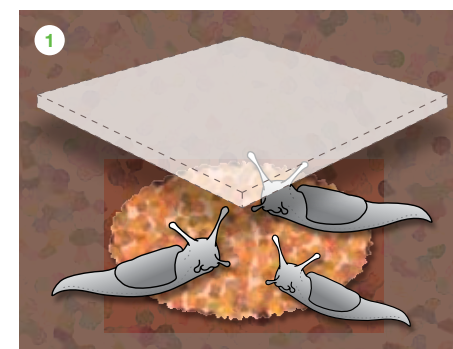
Other agronomic conditions

Lack of nutrients, cloddy seedbeds, poor drainage, diseases, other pests and weed competition can all slow crop growth and prolong the vulnerable period at establishment.

2.2 Monitoring slug populations

To assess the risk of crop damage it is important to assess the size of the populations present. Snails are difficult to sample but can often be assessed by searching the habitat.

Shelter traps provide valuable information on slug activity and should be used as the first step in assessing the risk of slug damage. If the risk is high it is important not to wait until damage is seen; by then it may already be too late. Traps are baited with food and are not really traps as slugs are free to enter and leave at will. However they are the most efficient way of monitoring slug population activity. Slugs active on the soil surface at night may enter these traps and a proportion of them stay to be counted the next day.



1
Slug trap

Traps consist of a cover such as a plant-pot saucer, tile or hardboard sheet about 25 to 30 cm diameter or square to provide shelter with a small quantity of bait beneath to attract slugs 1 2.

Chicken layers' mash is a suitable bait; about 20 ml per trap or two heaped teaspoonfuls is recommended. Slug pellets must not be used as bait because of the risk of accidental poisoning to wildlife, companion animals or beneficials resulting from the concentration of pellets beneath traps.



2
Very high slug population in a bait trap

Traps must be put out when the soil surface is visibly moist to ensure that slugs are sufficiently active to be recorded. With warm sunshine the next morning it is important to examine traps early because slugs leave as the sun heats them. If the weather is cloudy and damp, or cool, early examination is not so important as slugs stay in traps.

Traps should be spread out across the field in a 'W' formation with 9 traps per field up to 20 ha (Diagram 1) and 13 traps per field over 20 ha. Where certain parts of the field such as patches of clay soil are known to be at higher risk, traps should be concentrated in these areas.

Whilst traps are useful for identifying slug activity in crops monitoring should ideally commence in the previous crop or soon after harvest. Cultivations prior to drilling or planting often disrupt slug activity and can lead to an underestimate of numbers around the time of drilling. However, in the three to four weeks following cultivation foraging routes become re-established and slug fatalities are replaced by others from depth. Monitoring should continue until crops are past their vulnerable stage.



Diagram 1.
Sampling a 20 ha field.

2.3 Decision making

For sugar beet and many field vegetable crops any damage is undesirable so the presence of any slugs in traps indicates the need for control.

Prior to winter wheat an average of four or more slugs per trap represents a potential risk of damage.

For winter oilseed rape there is only a brief period between harvesting the previous cereal crop, especially if it is wheat, and drilling oilseed rape. The weather during this period may not be suitable for trapping so it may be valuable to put out traps in the standing cereal crop before harvest. A catch of four or more slugs per trap in standing cereals, or one or more slugs per trap in cereal stubbles indicates potential risk.

For winter wheat and oilseed rape, when in-crop trap catches reach the threshold, slug pellet treatment is strongly advised when one or more of the following criteria are also met, as this indicates a significant risk to seeds and seedlings:

- ▶ The field is drilled during a period of generally wet weather
- ▶ Wet weather delays sowing in a prepared seed bed
- ▶ The seedbed is coarse and cloddy and further consolidation is not possible following sowing
- ▶ The crop is slow to emerge or to grow through the early vulnerable stages and symptoms of slug damage are seen

Table 1. Slug trap thresholds.

Crop	Threshold (slugs/trap)
Winter wheat	4
Other cereals	
Oilseed rape (trap in preceding cereal crop)	
Oilseed rape (trap in preceding cereal stubble)	1
Sugar beet	
Potatoes	
Field vegetables	

3

Control tactics

Cultural practices can be at least and potentially more important than chemical control of slugs, particularly in combinable crops.

Fine, well-consolidated seedbeds restrict slug movement, making it difficult for them to find seeds and seedlings. Good seed to soil contact enables seeds to germinate quickly and then grow rapidly through the vulnerable establishment phase.

Modern insecticide treatments work hand-in-hand with quality seedbeds to deter slugs from hollowing seed prior to emergence. Since the first clothianidin-based treatment was introduced in 2006 many growers have found they bring significant improvements in establishment.

Post-emergence, and in crops for which insecticide seed treatments have not yet been developed, slug pellets remain the mainstay of control. However, recent research has shown the potential of biocontrol agents, which in the future may be well suited to organic horticulture.

This chapter profiles the main control tactics, discusses the attributes of the three main active substances and various formulations used in slug pellets today.



3.1 Cultural practices

Professor David Glen, Styloma Research & Consulting

Seedbed preparation and quality are at least and potentially more important than chemical control as they can reduce slug numbers and restrict their movement. Weeds should also be removed where they are sustaining slug and snail populations prior to sowing or planting a crop.

For cereals and oilseed rape minimal cultivations are popular. Seedbeds produced in this way often have the advantage of being firmer and restrict slug movement but may also leave more debris from the previous crop near the surface providing a refuge for slugs. Reducing cultivation also limits the physical destruction of slugs in the upper layers of the soil.

Rolling provides a firm seedbed with fewer clods. Not only is it easier for slugs to move through cloddy seedbeds but a large number of clods means the distance slugs have to travel between baiting points is much greater. Rolling in dry conditions may however be ineffective if clods are hard and do not break down. In wet conditions rolling may not be possible because it would smear the soil.

Fine, consolidated seedbeds have three main benefits:

- ▶ Slug numbers are reduced
- ▶ Seeds and seedlings are in close contact with soil enabling them to take up moisture and nutrients rapidly and grow quickly through the early vulnerable stages
- ▶ Surviving slugs are unable to feed below ground on seeds and germinating seedlings because the seedbed restricts their movement and the seeds are difficult to find due to their close soil covering

Shallow-sown wheat seeds in cloddy seedbeds (Diagram 1A) are readily killed by slugs which cannot reach seeds in fine, firm seedbeds (Diagram 1B). Deeper drilling of seeds in a cloddy seedbed (Diagram 1C) can prevent slugs from killing seeds but seedlings will be exposed to slug attack as they grow to the surface. Deeper sowing in a fine seedbed is unnecessary (Diagram 1D).

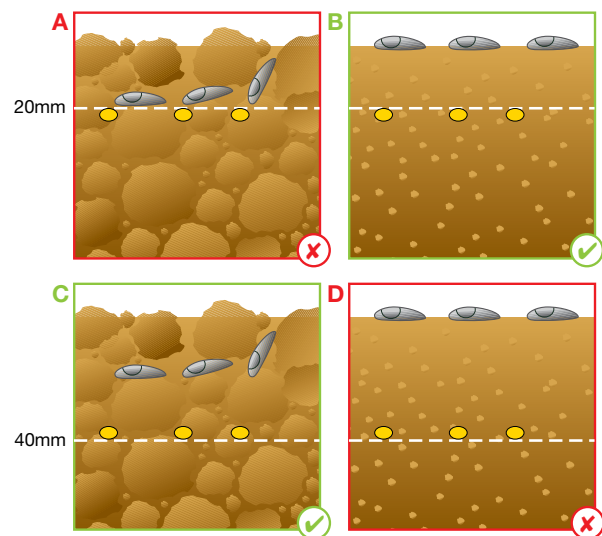


Diagram 1. Quality of seedbed and depth of drilling play an important role in slug management.

It is important to stress that, because of the importance of seedbed tilth, better control of slug damage may be achieved by using reduced methods of tillage if these produce finer seedbeds than ploughing, despite the fact that more slugs may survive.

If it is necessary to drill into a cloddy seedbed sowing at 4 to 5 cm depth may reduce damage. A reason for this is that fine soil falling through the gaps between larger clods forms a fine tilth around the seed protecting it from damage.

3.2 Seed treatments

Nigel Adam, Bayer CropScience

Insecticidal seed treatments from the neonicotinoid class of chemistry can be key in achieving establishment and compared with unprotected seed the visual effect is often dramatic ¹. Their mode of action is however fundamentally different from that of slug pellets although the final objective of protecting the emerging crop is the same.

Whilst slug pellets aim to attract the pest in order to give them a lethal dose of molluscicide, seed treatments aim to deter slugs from feeding as even one 'bite' could prove very damaging or even fatal to an emerging seedling.

Most arable crops are vulnerable to slug attack at establishment, particularly cereals and oilseed rape but also sugar beet and maize under moist, damp spring conditions. Neonicotinoid seed treatments are now available for use on all of these crops, principally to control a range of crop specific early soil and foliar pests, but only Redigo Deter is approved for improvement of establishment in winter cereals by reducing damage caused by slugs.

In unprotected cereals and maize slugs tend to attack the embryo of the germinating seed causing the typical grain-hollowing symptoms; the subterranean shoots are also particularly vulnerable. With oilseed rape and sugar beet hypocotyls and cotyledons are particularly subject to attack by slugs which often strike underground.

The neonicotinoid seed treatments imidacloprid and clothianidin are systemic so they move into emerging shoots to protect against foliar insect pests. However in the case of large soil-dwelling pests such as slugs, it is the zone of protection on and around the seed that is most significant. This has the effect of preventing damage through deterring rather than killing soil-active pests.



3.3 Slug pellets

Dr Richard Meredith, Bayer CropScience

The most effective method of targeting gastropod pests is to formulate a low dose (2 to 4% w/w) of the active substance in pellet baits made from a slug-palatable cereal base. Death occurs once sufficient active substance has been consumed, larger individuals needing more bait to die than smaller ones. The use of a quality base in pellets is therefore critical to encourage slugs to eat sufficient bait for a lethal dose to be ingested.

The effectiveness of pellets is not only governed by their chemical content but also by their make up, especially those constituents that affect their attractiveness to slugs and durability under field conditions. There are three main active substances used in slug pellets; ferric phosphate, metaldehyde and methiocarb.

Methiocarb acts on the nerve tissues of slugs and snails inhibiting acetylcholine esterase. Symptoms of poisoning are typically hyperactive, disorientated movement followed by a period of immobilisation before the toxin exerts its full lethal effect. Methiocarb's mode of action ensures its molluscicidal activity is independent of environmental conditions, working even when low temperatures and/or high humidity prevail.

Owing to the characteristic hyperactivity following ingestion of methiocarb, poisoned slugs and snails may move to shelter before dying; they may travel some distance. Slugs feeding on pellets containing metaldehyde become poisoned where they feed, secrete copious mucus and are found within a few centimetres of the pellet.

If there is too much active substance in a pellet slugs may detect it and cease feeding before consuming a lethal dose.

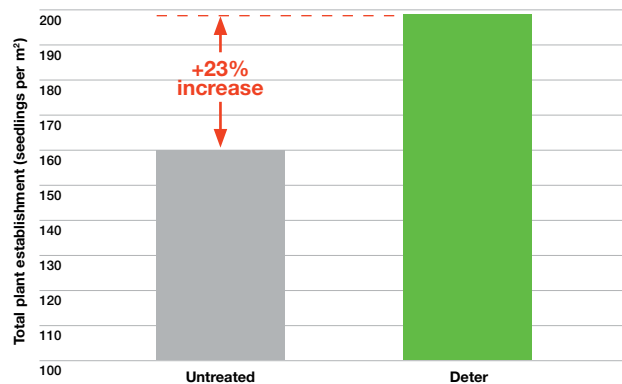
As Diagram 2 shows, the greatest protection zone is around the treated seed but this does not completely protect the plant below ground. Factors such as the depth of drilling, soil consolidation and soil moisture all influence the extent of protection by the seed treatment. Complementary protection measures such as slug pellets will be required under conditions of major slug activity.



Diagram 2: Seed protection zone from neonicotinoid seed treatment.

Trials conducted at the turn of the century demonstrated that the neonicotinoid seed treatment imidacloprid gave a similar level of protection during the establishment phase of a wheat crop as a surface application of methiocarb-based pellets at drilling. Under the significant slug pressure prevalent during these trials a combination of the seed treatment with methiocarb-based pellets at drilling was the most effective treatment.

In trials sown in the very dry autumn of 2003 conditions were not conducive for slug damage until late rain germinated the crops and brought up slugs from depth. In this extreme situation, slugs encountered the seed before foraging on the surface and the seed treatments proved particularly effective in comparison to slug baits.



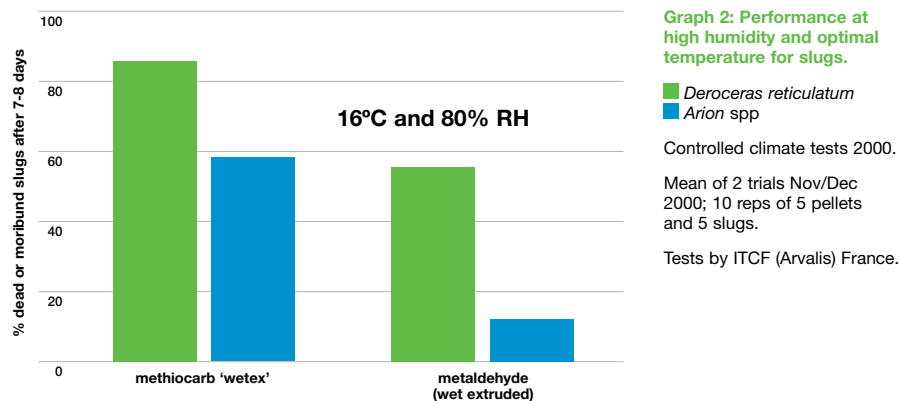
Graph 1. Establishment with and without seed treatment.
Mean of 10 trials in winter wheat 2005-09.

Since the introduction of the advanced seed treatment clothianidin, as in Redigo Deter, a large number of trials in slug pest situations have confirmed that the seed treatment is an effective method of reducing the grain-hollowing damage caused by slugs and thus improving establishment (Graph 1). In oilseed rape seed treatments the neonicotinoid components are not sufficient to give effective protection against subterranean feeding damage by slugs, so other measures should be used to protect this crop.

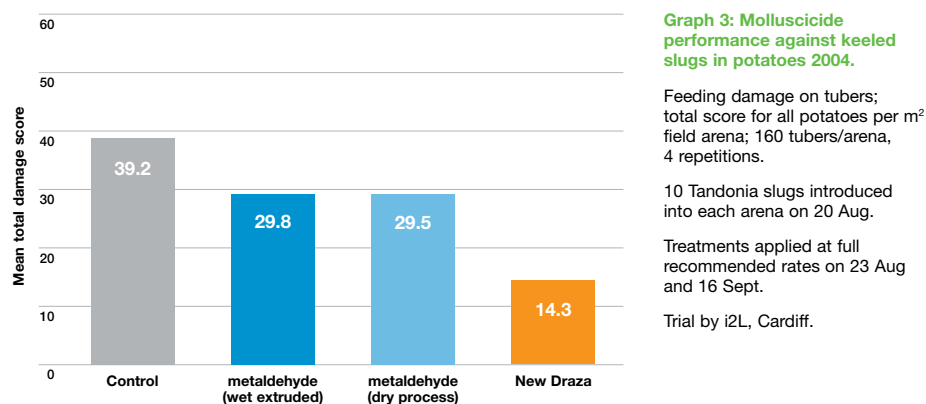
Species

Active substances vary in their effectiveness against the key species that damage crops so knowledge of the predominant species should influence product choice.

In trials and commercial practice methiocarb-based pellets have shown good control across all slug species, including round-backed slugs, which can be more of a challenge for other pellet types than grey field slugs (Graph 2).



Furthermore 'walled arena' trials have enabled performance against keeled slugs in potatoes to be assessed in relative isolation (Graph 3).

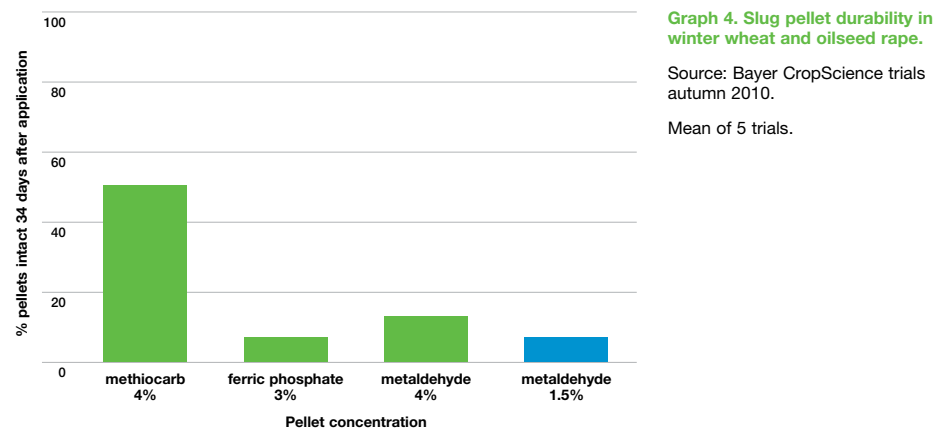


Methiocarb is unique in providing the most effective control of the three main species that damage crops.

Durability and persistence

Where only a short interval is anticipated between application, harvest and establishing the next crop pellet persistence is less important than quick activity. Should a prolonged gap be anticipated then a persistent pellet should be considered. If a large number of small juvenile slugs are found, choosing a product with a larger number of baiting points could also be advantageous.

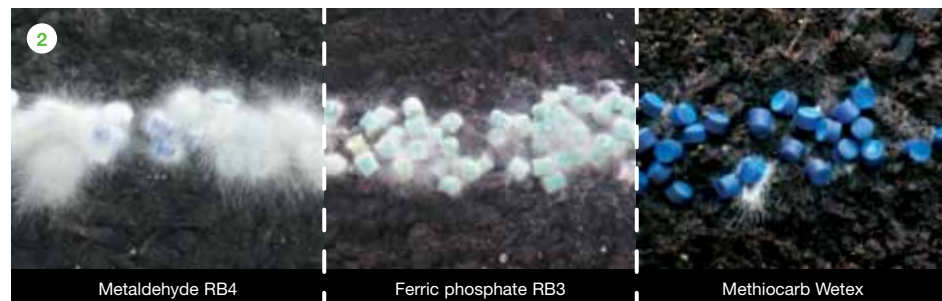
How long a pellet lasts depends on a range of factors including composition, manufacturing process and weather prevailing after application. Very wet weather generally accelerates degradation and warmth combined with wetness has the greatest effect on this. Field experience has shown methiocarb-based pellets typically last three to four weeks. All methiocarb-based pellets show excellent durability being at least equivalent and generally better than other commercial products including quality wet extruded formulations based on other active substances (Graph 4).



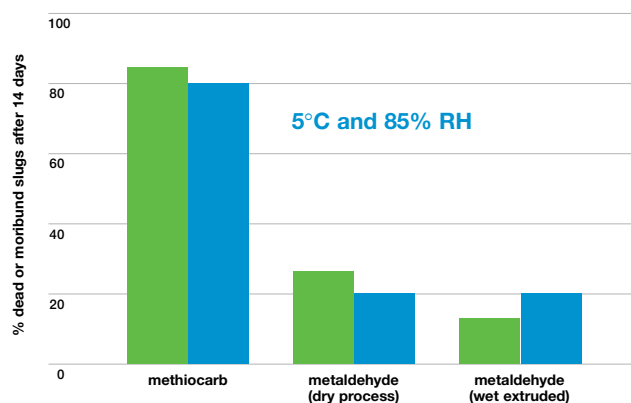
In these trials over 50% of methiocarb-based pellets remained intact 34 days after application whereas other pellet types had all but disappeared by then. In addition between 50 and 70% of metaldehyde-based pellets had degraded after 21 days.

The durability of methiocarb-based pellets is also readily observed in laboratory tests ②. These photographs show pellets after seven days exposure to conditions of 15°C and 95% relative humidity.

By this stage the methiocarb-based pellets were proving highly resistant to moulding whereas the metaldehyde-based pellets had almost disintegrated.



Weather can significantly affect the performance of some slug pellets with efficacy falling at low temperatures and/or under very wet or humid conditions. Methiocarb does not involve desiccation, as some active substances do, so it carries on working at high humidity and at the lowest temperatures at which slugs are active. Furthermore all methiocarb formulations have undergone extensive research to ensure that even under the most adverse conditions a minimum life of two weeks is achieved. Under such conditions slugs will also be very active so a rapid result from treatment is likely. These properties have long been recognised and, despite new formulations based on other active substances being introduced in recent years, methiocarb remains superior at high humidity and low temperature (Graph 5).



Graph 5: Molluscicide performance at low temperature and high humidity.

Controlled climate tests 2003/2004.

■ *Deroceas reticulatum*
■ *Arion hortensis*

Results from 2 trials of 5 replicates each; 5 slugs/terrarium.

Tests by i2L, Cardiff.

Slug baits applied at full recommended rate/ha.

Pellet attractiveness

Methiocarb-based pellets are manufactured by the patented wetex wet extrusion process from a high quality durum wheat base.

'Y-tube' tests of slug preferences (Diagram 3) demonstrate not only that methiocarb-based pellets can exert a significant attraction on slugs through the release of volatile compounds, but also that this continues even when they have been weathered under natural conditions for 11 days. Interestingly, in these studies an identically weathered commercial quality metaldehyde-based pellet did not significantly attract slugs. Tests (Graph 6) comparing the pellets with each other or with imbibed wheat grain produced remarkably consistent results with 60% of slugs moving towards methiocarb wetex pellets whether the alternative choice was wheat grain or the quality metaldehyde-based pellet; the effect of methiocarb was statistically significant in both comparisons.

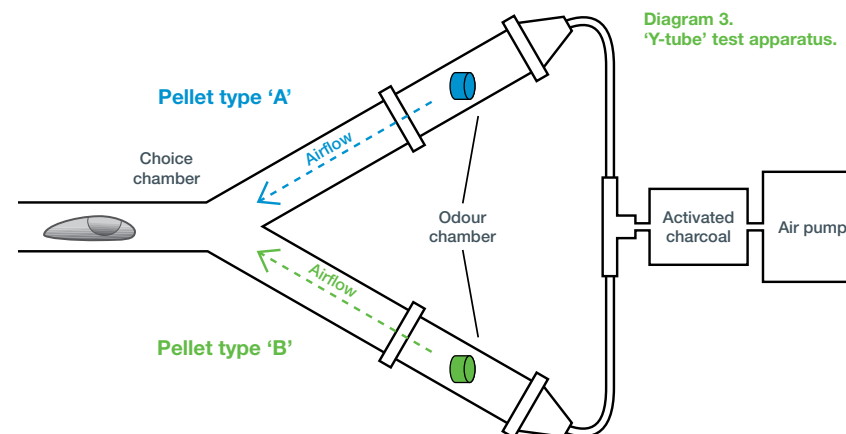
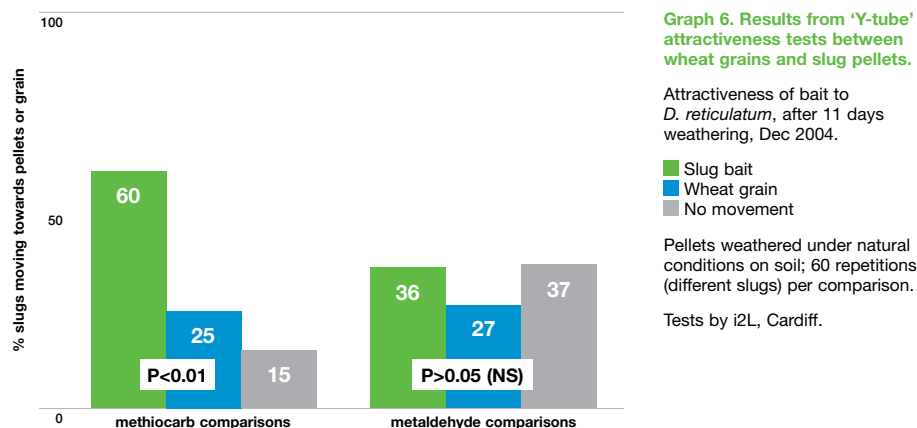


Diagram 3. 'Y-tube' test apparatus.



When slugs start their nocturnal foraging they move in a random search until they encounter food. When slug pellets have been applied to the soil surface slugs usually encounter a pellet within the first hour of activity and begin to feed.

Best use

If a site has been identified as at high risk it is important to apply pellets just after drilling and rolling because slugs start to feed on emerging shoots, especially if no seed treatment has been applied. This pellet application protects seeds and germinating seedlings.

If pellets are not applied until damage is noted at emergence many plants will already have been killed and the growth of the survivors set back by slug attack. They will therefore be less able to compensate for damage and will remain at risk for a longer period. These principles apply to winter wheat, oilseed rape, sugar beet and field vegetables that are all vulnerable at establishment.

Baiting points

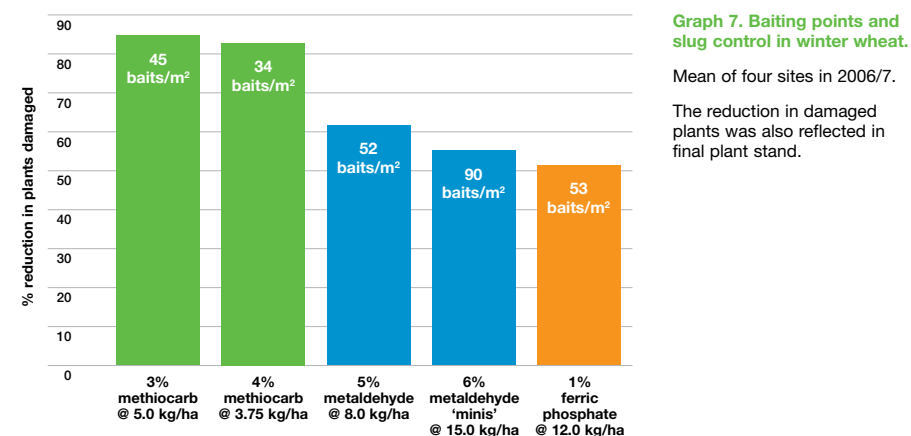
The optimum pellet density is between 25 and 100 per square metre. Products delivering a high number of baiting points are not necessarily more effective than those delivering a low number of baiting points. Pellet effectiveness depends on a number of factors including; attractiveness, palatability, the active substance, its concentration per pellet and the slug species present. However if there is a small number of baiting points and a high slug population, all of the pellets may be consumed leaving no protection from the remaining slugs.

With wetex products there is a choice of three concentrations of bait, providing a range of baiting point to pellet strength options (Table 1) for delivering the full recommended dose of 150 g active substance per hectare.

Table 1. Application rates for methiocarb-based pellets.

	Methiocarb product		
	Decoy wetex	Huron, Karan, Rivet	Draza forte
Concentration in pellet	2%	3%	4%
Dose for 150 g active substance/ha	7.5 kg/ha	5.0 kg/ha	3.75 kg/ha
Number of baiting points	68/m ²	45/m ²	34/m ²

The number of baiting points required can depend on the type of product applied. As slugs are attracted to methiocarb-based pellets the number of baiting points with this active substance can be less critical than for other products (Graph 7).



3.4 Biocontrol agents

Professor David Glen, Styloma Research & Consulting

Slugs have many natural biocontrol agents but only one, the nematode *Phasmarhabditis hermaphrodita*, has been developed as a commercial biocontrol agent marketed as Nemaslug. *P. hermaphrodita* is a bacterial-feeding nematode which is widely distributed in Europe and was discovered parasitising grey field slugs at Long Ashton Research Station near Bristol, England (Wilson *et al.*, 1993). It survives in the soil as non-feeding infective juveniles that penetrate the body of slugs.

If they enter into the shell sac containing the vestigial shell, just below the dorsal surface of the mantle, carrying suitable bacteria the nematodes can set up a bacterial infection. They grow and multiply causing the mantle to swell ^{3a} in a characteristic way which can result in the shell sac bursting open ^{3b}. When the slug dies the nematodes spread over its cadaver ^{3c} eventually producing more infective juveniles ready to infect further slugs. In the field, slugs die below ground level as a result of nematode infection so infected dead bodies are rarely seen.



Infection of the grey field slug by the nematode *P. hermaphrodita*

Photos © Becker Underwood

Slug in foreground has swollen mantle, characteristic of infection. Slug in background is unaffected.



The shell sac has burst open, showing the vestigial shell and nematodes.



Slug cadaver covered in large numbers of nematodes.

This biocontrol agent can have an especially valuable role in situations where slug pellets cannot be used. It is particularly suitable for organic horticulture where its use can be integrated with other methods of control such as mechanical barriers and hand-picking of slugs. The value of *P. hermaphrodita* as a biocontrol agent (Glen & Wilson, 1997; Rae *et al.*, 2006) is made possible by four main factors:

1. It can be reared on a large scale in artificial liquid cultures on selected bacteria that promote good population growth of high quality nematodes capable of infecting slugs. Infective juveniles can be harvested, formulated and stored at low temperatures ready to be applied by spraying or drenching
2. It can attack and kill slugs living in the soil
3. Slugs stop feeding soon after the nematode enters the body thus plants are quickly protected from damage
4. Slugs avoid feeding or resting on substrates treated with it

All the main species of slug and snail pests have been shown to be infected and killed by *P. hermaphrodita*. The grey field slug is highly vulnerable but larger species of slugs and snails are susceptible only when they are young and small. Thus where larger species such as *Arion ater* are likely to cause damage it is important to apply nematodes in springtime when young juveniles are present. Other soil fauna such as arthropods and earthworms are not affected.

The infective juveniles are applied at a rate of 300,000 per square metre at or just before the time when slug damage is expected. Mathematical modelling studies (Wilson *et al.*, 2004) suggest that the nematode dose should be adjusted in relation to slug density but this information is often not available. These infective juveniles need to have moisture and a temperature between 5°C and 22°C in order to be effective biocontrol agents. This is not a major constraint because slugs require similar conditions of temperature and moisture for survival, feeding and growth. If it is necessary to apply infective juveniles to relatively dry soil, their efficacy can be improved by shallow cultivation to incorporate them into the soil surface.

As with most biocontrol agents results can be variable even under apparently ideal conditions of moisture and temperature. One possible reason for this is that infective juveniles are readily eaten by a range of soil micro-arthropods, mainly Collembola and mites (Read *et al.*, 2006). The storage life of infective juveniles is limited and the formulated product containing them needs to be stored at low temperatures. However the main constraint on the use of *P. hermaphrodita* as a slug control agent is its high cost which restricts use to gardens and high-value crops such as lettuce and Brussels sprouts.

Although *P. hermaphrodita* is capable of killing a wide range of slug and snail species its use as a biocontrol agent does not pose a threat to molluscs of conservation interest, for example snails living in field margins, hedgerows or waterways because when infective juveniles are applied to soil, the vast majority move only 1 cm or less from the point of application. Thus provided that normal care is taken during application, snails living in field margins or water do not come into contact with sufficient numbers of infective juveniles to pose a threat to them.

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4

Crop strategies

Dr Richard Meredith, Bayer CropScience

In this chapter the themes of the previous three chapters – biology, risk assessment and control tactics – are brought together and applied to the construction of crop specific control strategies based on critical control periods. This new concept enables greater precision in targeting of treatments to optimise control.

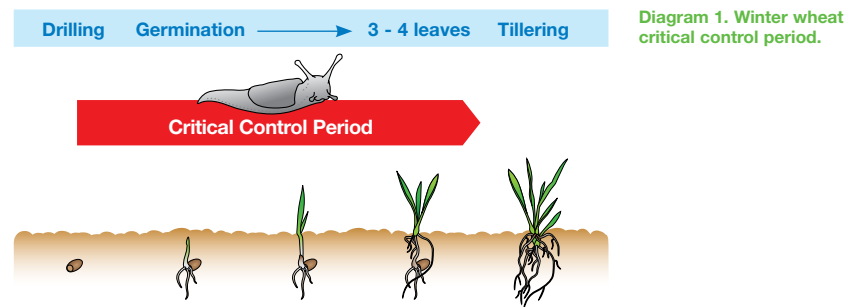
The critical control periods are those when slugs cause the greatest damage to crops and economic loss. Treatments are particularly warranted during these vulnerable stages but become less necessary at other times.

Crops vary as to when they are most susceptible to damage and even which plant parts are most vulnerable. Crops require close monitoring through their critical control periods and if risk assessment indicates a need for control, the most robust and effective treatments should be chosen for these applications.

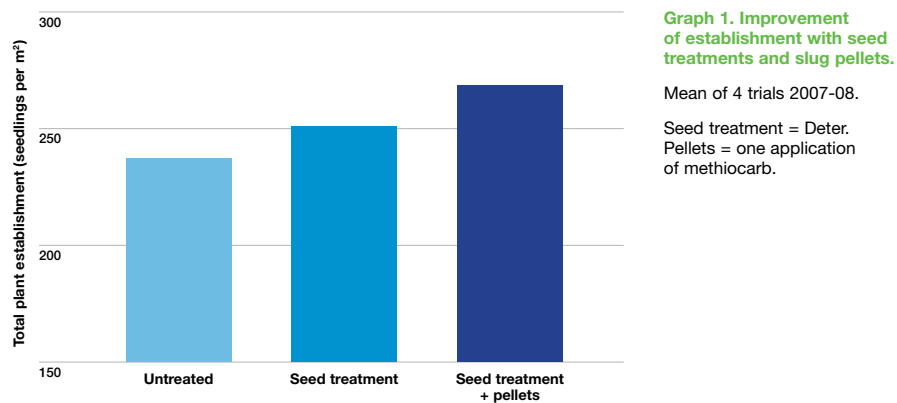


4.1 Winter wheat

Winter wheat is highly vulnerable to slug damage from the moment the seed starts to take up water. Therefore the critical control period for winter wheat stretches from drilling to the three to four leaf stage (Diagram 1).



Redigo Deter should be used as part of the control strategy to protect the seed and germinating shoots. The use of pellets should follow soon after drilling and certainly before the crop emerges. Graph 1 shows how the combination of seed treatments and pellets are particularly useful in winter wheat. In autumn workloads are high and the weather can be changeable, so methiocarb-based pellets should be used because of their high level of effectiveness and durability during this critical control period. There should also be less need for repeat applications.

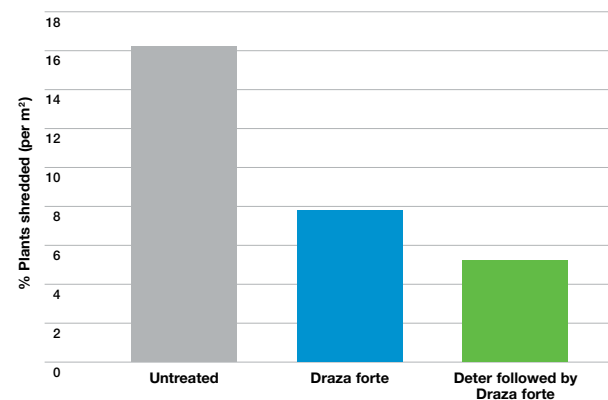


When the weather turns colder the grey field slug can remain active at temperatures close to freezing. Given that crop growth will be slow, later drilled crops will remain vulnerable for longer. Also in wet autumns slug populations can increase rapidly, even after molluscicide treatment. For these reasons it is important to monitor all crops carefully throughout establishment and be ready to apply or re-apply pellets, taking note of critical control periods and paying particular attention to durability and efficacy at low temperatures.

Slow-growing crops are normally vulnerable until the start of tillering. From then on damage is less likely to affect the crop. Whilst leaf grazing causing typical shredding ❶ needs to be tackled primarily by use of Draza forte at or just after crop emergence, Redigo Deter can also enhance this effect (Graph 2).



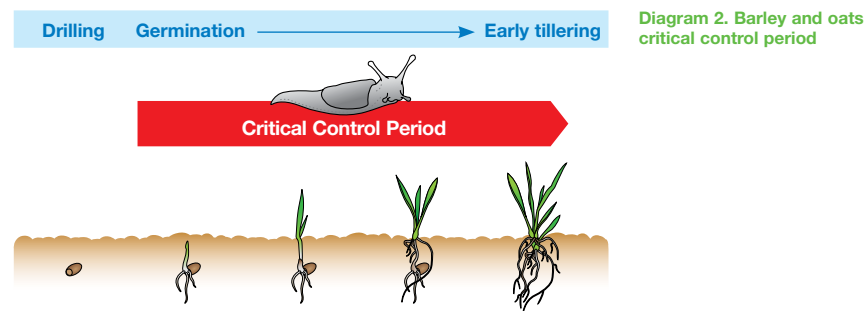
Wheat leaves shredded by slugs



Although cereal plants are not normally at risk from slug damage after the start of tillering, it is important to continue to monitor throughout the winter looking for evidence of fresh damage to young leaves and whether plants show signs of being set back by slug damage.

4.2 Other cereals

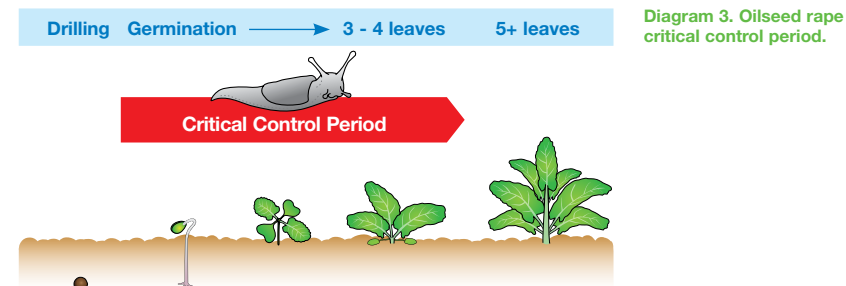
As barley and oat seeds have an extra seed coat and are less vulnerable to attack than wheat seeds the critical control period is later, from germination to early tillering (Diagram 2). However, slug pellets are still best applied just before crop emergence to protect the vulnerable newly emerging shoots.



Spring-sown cereals are at less risk of slug damage than autumn sowings as they can grow quickly through the early vulnerable stages. However, under slow-growing conditions crops may be vulnerable and should be monitored and treated if appropriate.

4.3 Oilseed rape

As seedlings of modern varieties of oilseed rape are highly susceptible to slug damage the critical control period is from germination to the four true leaf stage (Diagram 3).

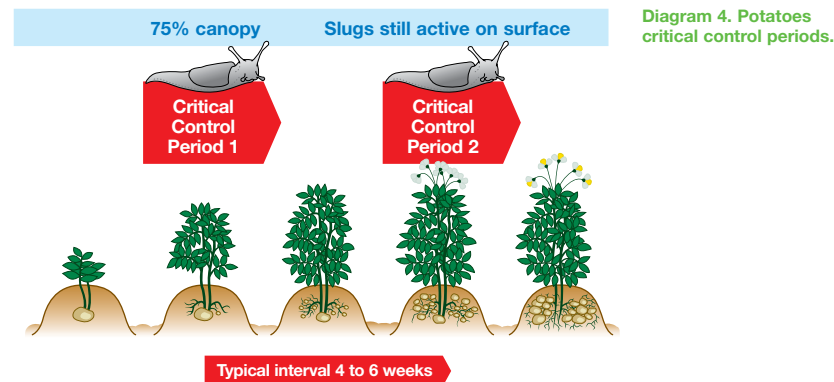


Oilseed rape is particularly vulnerable to slug damage and can require protection through the whole critical control period. To reduce the need for repeated applications it is essential to use an effective and durable product such as a methiocarb-based pellet for control ②. In addition, crops that are thin and/or backward coming into spring are vulnerable to slug damage and need careful monitoring until their growth accelerates.



4.4 Potatoes

Due to the high value of potato crops and the low market tolerance of slug damage to tubers – often 5% maximum for all defects including slug damage – particular care is needed to reduce the potential slug threat and optimise control measures. Finding just one slug per monitoring trap is enough to justify treatment.



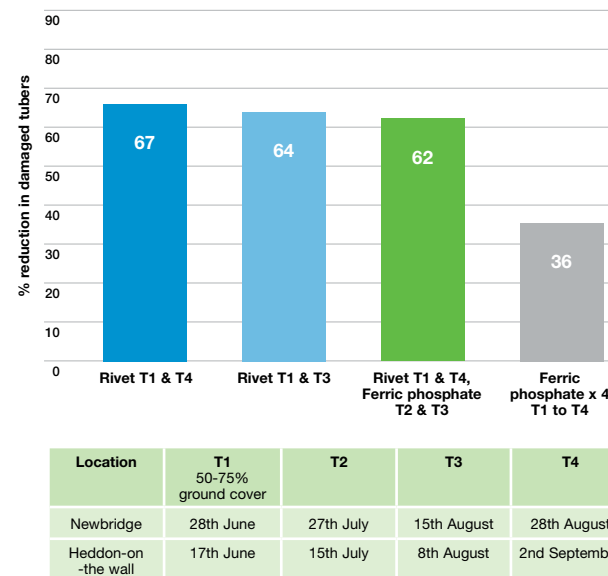
There are two critical control periods for potatoes;

- ▶ At 50% to 75% canopy closure, usually in late June to early July. In this period shade encourages surface activity but the canopy is sufficiently open to allow pellet penetration
- ▶ The early stages of tuber bulking before slugs go underground to find developing tubers. August is the pivotal month for this follow-up application because slugs are still likely to be active under the canopy and tubers become attractive to slugs from September.

Later applications of pellets during tuber bulking have less effect on slug numbers or tuber damage as they spend more of their time underground and less time on the surface where pellets would be. Applications other than those during the critical control periods can be made according to risk assessment based on varietal susceptibility, planned lifting date and results of activity monitoring.

As timing of control is critical, methiocarb-based pellets with their good durability should be used as the backbone treatment applied once at both critical control periods: this can often be sufficient. Timings should be based on monitoring and soil moisture.

Graph 3 presents the results of 2011 trials where Rivet pellets (3% methiocarb) were applied during the two critical control periods and illustrates the importance of using methiocarb as the backbone of control. Comparison programmes included addition of two applications of 3% ferric phosphate pellets between the two methiocarb applications and a full programme of ferric phosphate at all four timings.



Graph 3. Slug control in potatoes 2011.

Trials by i2L (Heddon-on-the-wall) and Scottish Agronomy (Newbridge).

Untreated control = 19% damaged.

Mean of 2 trials.

Two well-timed applications of methiocarb resulted in the greatest reduction of damage to tubers which was almost double the reduction achieved by four applications of ferric phosphate. Adding two applications of ferric phosphate in between the two applications of methiocarb did not improve control.

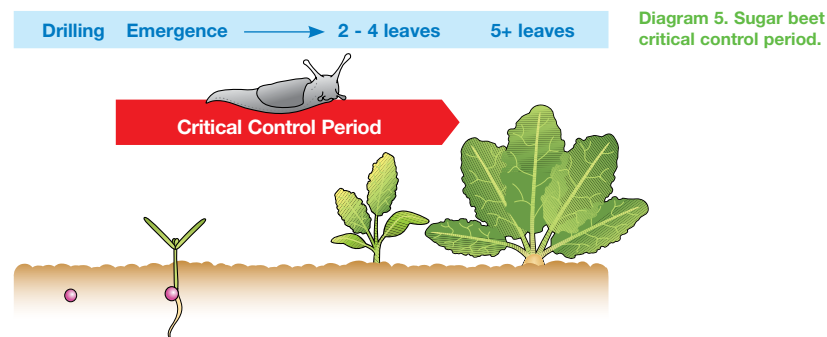
In the past metaldehyde mini pellets were commonly applied weekly with each blight spray. More recent trials have shown that slug control programmes with a methiocarb backbone are generally the simplest, most robust and cost-effective.

The keeled slug remains the most problematic slug to control in potatoes. Normally they will be reaching a size at which they can be effectively targeted at the first critical control period. The shade of the crop canopy at this stage also favours their surface activity.

The risk of slug damage to potatoes may also be reduced by pre-cultivation applications of slug pellets and by the use of haulm desiccants to bring harvest forward; most slug damage to tubers occurs in September and October so earlier lifting can help. Cultivar choice can reduce the risk of damage too, although the most popular varieties tend at best to be only moderately resistant to slug attack.

4.5 Sugar beet

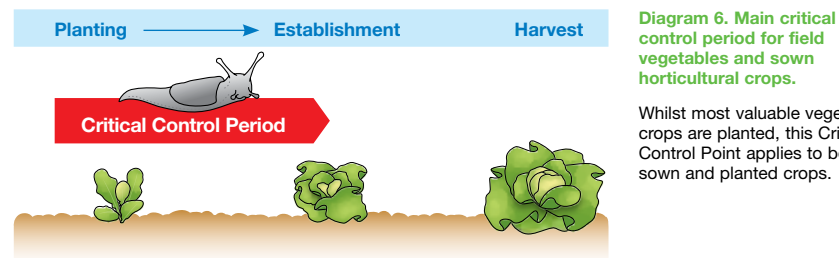
The critical control period for sugar beet is between germination and the two to four leaf stage (Diagram 5). However slug attacks on sugar beet are sporadic and tend to occur where agronomic and environmental conditions have favoured slug overwinter survival such as where preceeding cover crops have been grown through the winter.



4.6 Field vegetables and horticultural crops

A wide range of vegetable and horticultural crops is grown in the UK and their susceptibility to slug damage varies greatly. However the main critical control period for most crops is from germination to the early true leaf stage or in transplanted crops from planting out to establishment (Diagram 6).

Some crops will also suffer economic damage from later attack by slugs. Careful attention to these crops is needed to ensure that pellets are applied to the ground around plants and do not become lodged in the harvestable parts. Maximising the benefit from early applications around the time of planting will minimise the need for later applications which are most likely to cause this contamination. Cultivation and rotations should also be used to reduce the risk to high value crops.



Whilst most valuable vegetable crops are planted, this Critical Control Point applies to both sown and planted crops.

5

Application

Paul Goddard, Bayer CropScience

Accurate application and safe use of crop protection products have always been key principles of IPM. But since the issue of metaldehyde contamination of water arose there has been heightened awareness of the need to adhere to best practice.

This chapter summarises the best practice guidelines for application of slug pellets, which all users should follow and relate to all pellet types.



Photo © Peter Green

Training

It is now mandatory for those applying slug pellets to hold a PA4S certificate or have their previous PA4 certificate upgraded to comply with revised legislation. The training for this qualification covers all aspects of best practice and machinery use.

Application rates

Table 1 shows the rate of application and number of baiting points per square metre for Draza forte in each recommended crop. For other active substances consult the relevant manufacturer's labels.

Table 1. Draza forte application rates and latest times of application by crop (May 2012).

Crops	Maximum individual dose (kg product/ha)	Maximum total dose per season (kg product/ha/year)	Latest time of application
Brussels sprouts	3.75	7.5	14 days before harvest
Cabbage	3.0	3.0	14 days before harvest
Cauliflower	3.0	6.0	14 days before harvest
Barley Forage maize Oats Rye Triticale Wheat	3.75	2 applications per crop (see 'Other specific restrictions')	Growth stage 31 (before first node detectable)
Lettuce (outdoor)	3.0	3.0	14 days before harvest
Potato	3.75	11.25	18 days before harvest
Strawberry (outdoor)	3.75	3.75	7 days before harvest
Spinach (outdoor)	3.0	3.0	7 days before harvest
Sugar beet	3.75	3.75	6 months before harvest
Sunflower	3.75	7.5	Before growth stage 33 (3 visibly extended internodes)
Oilseed rape	3.75	7.5	Before growth stage 33 (3 visibly extended internodes)
All non-edible crops	3.75	–	–

Other specific restrictions: The maximum number of treatments for use on barley, forage maize, oats, rye, triticale and wheat must not exceed 2 per crop as a broadcast application or 1 per crop admixture and 1 per crop as a broadcast application.

Bout widths

For all bout widths it is important to check the applicator is set level and at the correct height so pellets reach the full width intended. If conditions are not suitable for spraying then pellets should also not be spread.

Bout widths of up to 24 metres have been successfully tested for all methiocarb-based pellets using equipment designed for this purpose. For other active substances refer to manufacturer's recommendations.

Equipment calibration and maintenance

Always maintain machinery according to the manufacturer's handbook. Note that an individual applicator's output will vary according to wear and tear so to ensure accurate application it is important to check calibration of the applicator under field conditions before use. Users should stop after a few metres and check for even distribution, correct spreading width and rate of application.

Always remove unused pellets from applicators after use and store in resealed original containers in the chemical store. Slug pellets are pesticides and must be used in line with current legislation. Clean the applicator in the field or on a designated spray pad where washings are collected for appropriate disposal.

Appropriate PPE must be worn when working with slug pellets (see product labels).

i For details of calibration methods refer to the relevant machinery manufacturer's handbook. For additional calibration information visit www.bayercropscience.co.uk

For specific enquiries contact Bayer Assist:
0845 6092266

Crop contamination

Particular care is needed with applications to crops where pellets may become lodged in the harvestable parts, especially open, leafy crops like lettuce and brassicas. Maximising the opportunities from early applications is particularly important in these crops to avoid such occurrences.

Storage

Keep in the original packaging tightly closed and store securely in the chemical store which should be a cool, dry place away from children, animals, feeding stuffs, fertilisers and water supplies.

Store application equipment under cover.

Responsible use

As with all crop protection materials it is essential to ensure appropriate use of slug pellets.

In vegetable crops it is frequently quality issues rather than crop establishment that are the key drivers for effective slug control. Monitoring slug activity and timely application of treatments are just as vital as in arable crops.

Probably the most difficult challenge for the vegetable grower is avoiding contamination of the crop with pellets, even when harvest intervals are adhered to. It can be difficult to direct applications very accurately so strategies like avoiding application to wet leaf surfaces when pellets tend to stick to the foliage can help. Reducing slug populations by cultivation and early applications in less sensitive crops can also be an advantage.

No single method of slug control is likely to be completely successful and a combination of both cultural and chemical techniques should be utilised to optimise control of slugs and snails.

Methiocarb-based pellets present little or no practical risk to most beneficial invertebrates. Many insects such as bees, lacewings and parasitic wasps will either not be attracted to the baits as a food source and/or will not be active in crops at the time of application.

Only insects such as carabids that actively feed on slug pellets are likely to be affected in the short term. Populations return to normal by the spring following autumn applications. Earthworms may be affected by contact with pellets as they travel across the surface of water-logged soils but the short term impact on populations is negligible.

To minimise such effects on non-target organisms always follow the label and avoid application within 6 m of field boundaries which are an important location for the breeding and overwintering of some beneficial species, such as carabid beetles.

Spillage

The main danger from any type of slug bait, regardless of the active substance, is when a spillage makes piles of pellets available to wildlife.

It is therefore most important to:

- ▶ Fill on level clear area
- ▶ Clean up any spillage immediately
- ▶ Not use slug pellets in monitoring traps
- ▶ Keep packs of pellets inaccessible to animals

Stewardship

As a result of the detection of metaldehyde in water, a Metaldehyde Stewardship Group (MSG) has been established with the aim of preventing this from occurring. As well as label instructions the general stewardship recommendations of the MSG should be followed when using all types of pellet.

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Best practice

- ▶ Make use of all available agronomic means of reducing slug damage
- ▶ Prepare good seedbeds
- ▶ Always read the label before applying pellets and ensure maximum permitted doses are not exceeded
- ▶ Ensure applicator operators are suitably trained (PA1 and PA4S)
- ▶ Wear correct PPE when working with slug pellets
- ▶ If conditions are not suitable for spraying then don't pellet
- ▶ Keep all slug pellets away from water
- ▶ Do not leave slug pellet containers unsupervised
- ▶ Maintain a 6 m no-spread zone next to field margins, hedges and ditches; these areas are important for slug predators
- ▶ Take care and clean up any spillage immediately, especially when filling or cleaning applicators
- ▶ Maintain and calibrate applicators
- ▶ Always remove pellets from applicators after use and store in resealed original containers in the chemical store
- ▶ Clean applicators in the field or on a designated spray pad where washings are collected for appropriate disposal
- ▶ Store applicators under cover

