

Worldwide search still on for new answers to slugs



Grey field slug, *Deroceras reticulatum*, on the soil surface

Mike Lole has been trawling international research reports looking for novel slug control products but finds current best practice remains the key for UK growers

All growers are having to review their approach to slug control in response to society's concerns about the use of chemical crop protection products. Given the huge economic impact of slug damage, that in turn is driving a new generation of research – not just in the UK but around the world – into molluscicides and anti-feedants based on naturally occurring molecules extracted from plants.

The list includes saponins, carvone, azadirachtin, caffeine and cinnamide, and extracts from plants as diverse as lichens, parsley, hemlock, coriander, garlic, yucca, myrrh and opoponax. However, none have been developed to the point where they are available for use by professional growers. Often a promising compound falls by the wayside at an early stage because of one critical piece of information researchers have to gather early into the development process – toxicity to plants, mammals and beneficial organisms. Caffeine, for instance, may

Project profile

FV 379 Review of slug control in salads and baby-leaf Cruciferae

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be as effective a molluscicide as metaldehyde, but it is less specific and, surprisingly, has a higher mammalian toxicity, both of which compromise its acceptability as a slug control.

The success of the parasitic nematode *Phasmarhabditis hermaphrodita* as a biocontrol agent for slugs and snails in Europe has prompted a continuing search for similar organisms that can be used as biopesticides, particularly outside Europe, where *P. hermaphrodita* does not occur naturally. Though other slug-parasitic nematodes, such as species of angiostrongylus, have been found, none of these have the same potential as *P. hermaphrodita* and none have been developed commercially.

Of course, there are a large number of other natural enemies of molluscs,

including bacterial, fungal and viral diseases; parasitic single-celled organisms such as protozoa and microsporidia; parasitic and predatory flies; predatory molluscs, flatworms and arthropods; and predatory vertebrates, including amphibians, reptiles, birds and mammals. None of these have yet been successfully exploited and so far there appears to be no new biopesticide for slug or snail control under development anywhere in the world.

Getting the best from current controls

All pellet baits are formulated on a cereal base, usually wheat bran or durum wheat – those based on durum wheat are more expensive but likely to be more palatable to slugs and may also be more durable. Pellets may be manufactured by variations on either a 'dry' or 'wet' process. The former is cheaper but tends to produce dusty pellets of varying size that don't last so well in the field. The most expensive 'wet' process, where the ingredients are mixed into a paste before forming and then drying, produces uniform, dust-free, more durable pellets. Uniformity of pellet size is important because it aids accurate distribution. And the more durable they are, the longer they are available to the slugs which makes them more effective and reduces the need for repeat applications.

The amount of active ingredient – currently either metaldehyde, methiocarb or ferric phosphate in the UK – included in a bait formulation is a balance between the toxic effect on the slug and the palatability of the bait. For



Simple slug trap using poultry layers' mash and a plant-pot saucer, used to monitor slug activity

Joined-up approach to new slug control chemistry

One project on slug control that's currently under way, and which could eventually generate information useful for horticulture, is funded by AHDB's cereals sector body, the Home Grown Cereals Authority (HGCA). Working with scientists at Fera and the University of Durham, it follows on from earlier work using 'fusion proteins' for the control of insect pests.

A fusion protein consists of two combined elements. The first is a molecule (in this case a lectin extracted from snowdrops) which can pass harmlessly through the slug's gut wall. The second element is a peptide or protein – such as toxins from spider or scorpion venom – that is specifically toxic to the target if it is able to pass from its gut into its body cavity. These toxins have no effect if eaten on their own by the pest because they are broken down in the gut. In the HGCA project the combination of the lectin with the toxin produces the fusion protein, which is able to penetrate the gut wall and in doing so introduces the toxin directly into the slug's body cavity.

Some fusion proteins have been shown to have effects on the grey field slug *Deroceras reticulatum* in injection and feeding experiments, suggesting they do have potential for incorporating into slug control baits. The two key advantages over active ingredients used in commercial baits now is that there should be no palatability problems; and they will be more specific to molluscs than some conventional treatments, so avoiding potential impacts on beneficial organisms.

instance, levels of metaldehyde lower than 1.5% generally mean the slug will complete its meal before eating a lethal dose, while levels above about 6% makes the bait taste bad to the slug and it won't eat any.

Metaldehyde has come under close scrutiny since traces were found in raw water supplies intended for drinking, in late 2007, prompting an annual limit on the amount of metaldehyde that can be applied per hectare (700g), and there have been some recent developments in metaldehyde baits as a result.

Until recently, metaldehyde baits generally contained between 3 and 6% active ingredient but with current restrictions on the overall amount of metaldehyde that can be applied per year, several products containing only 1.5% active ingredient have been introduced. Managing the dose of metaldehyde by reducing the amount of ingredient in the pellet in this way is better than reducing the number of pellets applied because the number of

bait points has an influence on the effectiveness of treatments – 25 to 100 per sq m being the optimum range for controlling the grey field slug. Growers can make six applications per year using pellets containing 1.5% metaldehyde at 7.5kg/ha, giving 60 bait points per sq m – but only three applications would be possible using a 3% pellet at the same rate.

Methiocarb is a carbamate pesticide that acts on nerve tissues. The mode of action ensures that it works even, for example, at low temperature or high humidity and that is its main advantage as a slug bait ingredient. A disadvantage is that it is poisonous to other invertebrates and is more likely to have an impact on non-target organisms, such as ground beetles, than metaldehyde.

Ferric phosphate is a newer ingredient for slug baits, having been approved only since 2005. Three products are now available. Suppliers say the advantage of ferric phosphate over other molluscicides is that it is less toxic to mammals than either metaldehyde or methiocarb and is broken down by soil microbes to iron and phosphate, which are plant nutrients. Some organisations have approved the products for use in organic agriculture.

The parasitic nematode *Phasmarhabditis hermaphrodita* tracks down slugs and then infects them through the shell cavity at the back of the mantle. Once inside the slug the nematodes release bacteria, which initially stop the slug feeding and then quickly kill it. The nematodes develop and breed within the dead slug and a new generation of infective juveniles is produced which disperse in search of further prey. The ability to stop slugs feeding quickly and the absence of residues is particularly valuable in those horticultural crops, including ornamentals, where product quality is of primary importance.

In the UK vegetable industry, cost-effective slug control using parasitic nematodes has so far been confined to high-value crops such as Brussels sprouts and lettuce. The significant extra cost compared with molluscicide pellets is just one factor that counts against them for most broad-acre crops. Their lack of reliability in unfavourable conditions, limited shelf-life and the need to achieve correct timing of applications for optimum effectiveness will need to be addressed if they are to



Slug grazing of sprout buttons. Note damage to wrapper leaves and the crop debris that provides food and shelter



Severe interveinal leaf holing on hosta due to slugs

win a higher proportion of the slug control market in the UK.

So despite considerable and continuing research effort, poison baits will remain the most cost-effective method for controlling slugs and snails in most horticultural crops for the foreseeable future, with a niche role for nematodes in ornamentals and other high-value crops where quality is critical.

In terms of effectiveness there is little to choose between the three chemical molluscicides currently available in the UK. So the choice between bait pellets is likely to be made on other criteria, including cost, number of bait points that can be achieved in a given area, pellet palatability/durability, effects on non-target organisms, perceived environmental safety and the regulatory or voluntary restrictions on use.



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