Project Title:	Remedial and protectant treatments for vine weevil larvae in containerised HNS, as part of an overall IPM strategy
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AUTHENTICATION

I declare that this work was done under my supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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CONTENTS

Grower Summary

Background and expected deliverables

Vine weevil is the most serious pest of containerised nursery stock in the UK, and growers spend a significant amount of money and time in either preventing infestation, or controlling established infestations.

Many growers use compost incorporated granular insecticides as a routine preventive control measure against vine weevil. This is an effective insurance treatment, but the cost increases with the size of container. Some growers do not wish to use such products routinely. When larvae are found, growers can either use an insect pathogenic nematode product, or apply a drench treatment of chlorpyrifos, which has a label recommendation for vine weevil control in conifers that can be extrapolated under the long-term arrangements for use in containerised nursery stock. However, chlorpyrifos is an organophosphorous (OP) product. While chlorpyrifos is safe to use providing all label precautions are followed, some growers prefer not to use this product.

The aim of this project was to determine whether the pyrethroid insecticide Cypermethrin, as Toppel 10 EC, applied as a drench either preventatively, or to existing infestations of vine weevil, would give effective control, thus providing growers with an alternative to the use of chlorpyrifos. The product chosen (Toppel 10 EC) is inexpensive and widely available. In addition, the project tested a range of other treatments, including the new insect pathogenic nematode Nemasys L (based on the novel nematode species *Steinernema krausii)*, in order to provide independent data on its effectiveness.

The experiment was conducted in an open sided polythene tunnel at ADAS Rosemaund, in conditions that were as close as possible to those found on commercial holdings.

Summary of the project and main conclusions

The work was done on hardy fuchsias (variety Beacon) potted as rooted plugs (in April 2003) into 2 litre (14 cm diameter) pots using a proprietary Ego peat/coir based nursery stock compost.

When larval assessments were made (December 2003 and March 2004), the untreated pots had a mean of 8.8 larvae per pot (from 30 eggs applied per pot). Toppel 10 EC (cypermethrin) applied as a drench to pots two, four or six weeks before egg inoculation gave 95-100% control. Toppel 10 EC drenches made six weeks post-infestation were less effective (79% control), and those made 22 weeks post-inoculation were ineffective. This means that cypermethrin (Toppel 10 EC) products can be used as a preventative treatment, against young larvae, but would be less effective once an infestation has become well established and larvae are in the later stages of development. In comparison, Intercept 70 WG (imidacloprid) gave 100% control when applied six weeks before egg inoculation.

The insect pathogenic nematode products Larvanem (based on a species of Heterorhabditis) or Nemasys L (Steinernema krausii) did not give a statistically significant level of control, when applied either eight weeks (to young larvae) or about 30 weeks (to large larvae) after egg inoculation.

Financial benefits

- Toppel 10 EC (cypermethrin) could be used as a replacement treatment for those growers who do not wish to use chlorpyrifos.
- Toppel 10 EC is relatively inexpensive compared to chlorpyrifos, and so will result in a financial saving, if used on large number of pots, instead of chlorpyrifos or Intercept 70 WG.
- Toppel 10 EC also has shown excellent crop safety to a wide range of ornamental HNS species (when used a foliar spray) and so should be safe when used as a

drench application (although growers will need to test individual species or cultivars before treating on a large scale).

The approval status of Toppel 10 EC requires clarification. At present, the product only has a label recommendation for use as a foliar spray. However, based on the data from this experiment, it may be possible for HDC to apply for a SOLA for the use of Toppel 10 EC as a drench application to HNS. Discussions with HDC and the Pesticides Safety Directorate will be carried forward in the near future.

Action points for growers

- Applying the pyrethroid insecticide cypermethrin, as Toppel 10 EC, gives commercially acceptable vine weevil control (broadly similar to Intercept 70 WG) when applied as a preventative drench treatment, with a persistence of at least six weeks.
- When applied as a drench to young vine weevil larvae, control with cypermethrin (Toppel 10 EC) can also be good, but this treatment is not effective once an infestation of large larvae is established.

- Toppel 10 EC (cypermethrin) is inexpensive, widely available and could represent an alternative product to chlorpyrifos or imidacloprid, for growers to use against vine weevil.
- Insect pathogenic nematodes in the products Nemasys L and Larvanem were not effective at the rates used in this experiment.

Science Section

Introduction

The HDC and commercial companies have conducted extensive trials to develop the most effective methods of vine weevil control over the past 10 years. As a result, there are three granular insecticides now available to UK growers, for use as compost incorporated treatments. These products are widely used by the HNS industry as they generally provide reliable control over a period of two seasons. However, the cost of these products increases with increasing pot size. Growers of larger stock (5 litre pots and above) are sometimes reluctant to pay the extra cost of a granular insecticide product. In addition, stock plants may be retained for many years and can become infested by vine weevil once the granular product has lost its efficacy. Unprotected plants also commonly become infested, as vine weevil is a widespread pest and is found to some extent on almost all HNS nurseries. At times, therefore, growers may need a drench treatment to eradicate existing infestations of vine weevil larvae in the compost root ball. Although the organophosphorous (OP) insecticide, chlorpyrifos, can be used as a drench treatment, many growers would prefer not to have to use this type of product.

The aim of the project was to evaluate the efficacy against vine weevil in containerised HNS of a non-OP insecticide that could potentially be used as an alternative drench treatment to chlorpyrifos.

Materials and Methods

Site location

ADAS Rosemaund, Preston Wynne, Herefordshire.

General procedure

Hardy fuchsias (variety Beacon) were potted as rooted plugs into 2 litre (14 cm diameter) pots, using a proprietary Ego peat/coir based nursery stock compost, in April 2003. They were placed in an open sided polythene tunnel, standing on a gravel bed and watered overhead by hand as needed. Great care was taken not to over-water vine weevil infested plants, as they have damaged root systems and take up less water than might be expected. Very wet compost can, in itself, lead to high vine weevil larval mortality, which would mask the effects of treatment. Plants were grown on until mid-July, when the first drench treatments (see below) were applied.

Experiment design and treatments

The experiment was done according to the standard EPPO guideline PP1/111(2) revised in 1997 entitled 'Guidelines for the efficacy evaluation of insecticides, vine weevil control in containerised nursery stock'. Each of 25 replicate plants per treatment, were arranged on the gravel bed in a complete randomised block design. The insecticide treatments used are given in Table 1.

Application of drench treatments

Insecticides were made up to the rates shown in Table 1 and the solution agitated before application. The compost was just moist at the time of each drench application.

Drenches were applied at 20 % of pot volume, i.e. 400 ml per 2 litre pot. This volume of dilute insecticide was applied carefully to individual pots from the bulk solution, avoiding run off from the top of the pot. Little or no run off, from the bottom of the pot, was observed using this drench volume.

For insect pathogenic nematodes (Nemasys L and Larvanem), the label recommendations for each product were followed closely. Luke warm water (15^{o}C) was used to mix up the nematode solution and this was constantly agitated to ensure that the nematodes did not settle out. A stock solution was made up in a bucket to 10 litres, using a complete pack of nematodes (each pack contained 50 million nematodes).

100 ml of the stock solution, containing approximately 500,000 nematodes, was withdrawn using a clean measuring jug. This sample was then placed into another plastic bucket and made up to 10 litres using fresh lukewarm water. The whole solution was then agitated again, and a sub-sample of 250 ml was taken and applied to each pot using a measuring jug.

This, theoretically, applied 12,500 nematodes per pot. Application was made on a dull day, as nematodes can be inactivated by bright sunlight. One hour after the application, each pot received 150 ml of clean water, to ensure good movement of the nematodes into the compost.

Table 1. Insecticide treatments used in the experiment at ADAS Rosemaund.

Treatment	**Active ingredient**	**Formulation**	**Dose rate/100 litres water**	**Drench timing**	**Egg inoculation timing**	**Drench interval before/after egg inoculation**
Untreated	-		-	-	30th July	No drench applied
Toppel 10 EC	Cypermethrin	10% EC	70 ml	12thJuly 03	30th July	2 weeks before
Toppel 10 EC	Cypermethrin	10% EC	70 ml	12th July 03	15th August	4 weeks before
Toppel 10 EC	Cypermethrin	10% EC	70 ml	12th July 03	29th August	6 weeks before
Toppel 10 EC	Cypermethrin	10% EC	105 ml$^+$	12th July 03	29th August	6 weeks before
Intercept 70 WG	Imidacloprid	WG	20 g	12th July 03	29th August	6 weeks before
Nemasys L*	*Steinernema kraussei*	-	0.5 million/ m^2	30th Sept 03	30th July	8 weeks after
Toppel 10 EC	Cypermethrin	10% EC	70 ml	30th Sept 03	30th July	8 weeks after
Larvanem**	*Heterorhabditis* spp	-	0.5 million/ m^2	30th Sept 03	30th July	8 weeks after
Toppel 10 EC	Cypermethrin	10% EC	105 ml$^+$	19th January 04	15th August	22 weeks after
Nemasys L	*Steinernema kraussei*	-	0.5 million/ m^2	19th January 04	15th August	22 weeks after

$^+$ 1.5 times the label rate * Becker-Underwood product ** Koppert product

Inoculation of vine weevil eggs

Eggs were obtained from a laboratory colony of adult vine weevils, fed on evergreen *Taxus* and evergreen *Euonymus*. At the dates shown in Table 1, each pot was inoculated with 30 vine weevil eggs, using the following procedure. A shallow depression was made in the surface of the compost, across the pot radius and the eggs were gently washed into this from small tubes, into which the eggs had previously been dispensed. The eggs were then covered over and the pots shaded with green mesh, to keep compost temperatures down. Only brown, sclerotised eggs were used; any that were opaque white in colour were rejected. A total of 8,250 eggs were used in the experiment in the period late July to late August 2003.

Larval assessments

These were done from December 2003, (Treatments 1-9) to March 2004 (Treatments 10 and 11). Each pot was emptied out onto a plastic tray in the laboratory, the compost carefully sorted and vine weevil larvae counted individually. A record of the total numbers of larvae per pot was made.

Phytotoxicity

All the fuchsia plants were assessed visually for several weeks after application of Toppel 10 EC and Intercept 70 WG drenches, for signs of phytotoxicity.

Statistical analysis

The data on vine weevil counts from individual pots were $\log_{10}$ (n+1) transformed, to achieve a normal data distribution, and then subjected to an analysis of variance (ANOVA). Where a significant F test (variance ratio) was found, differences between means were assessed using Duncan's multiple range test.

Results

Vine weevil counts

The results of the experiment are given in Table 2. A significant effect of treatment on the mean number of live vine weevil larvae, recovered from the pots, was found.

Table 2. Mean no. and range of vine weevil larvae/pot found in each treatment. $Log_{10}(n+1)$ values in parentheses.

Treatment	**Mean no. Larvae/pot**		**Range per pot**
Untreated	8.8	(0.826 c)*	0 - 17
Toppel 10 EC (70 ml) 2 weeks pre-inoculation	0.4	(0.042 a)	0 - 10
Toppel 10 EC (70 ml) 4 weeks pre-inoculation	0.3	(0.079 a)	0 - 3
Toppel 10 EC (70 ml) 6 weeks pre-inoculation	0.0	(0.000 a)	-
Toppel 10 EC (105 ml) 6 weeks pre-inoculation	0.4	(0.070 a)	0 - 3
Intercept 6 weeks pre-inoculation	0.0	(0.000 a)	-
Nemasys L 8 weeks post inoculation	5.8	(0.752 c)	0 -14
Toppel 10 EC (70 ml) 8 weeks post inoculation	1.8	(0.334 b)	0 - 4
Larvanem 8 weeks post inoculation	5.6	(0.742 c)	0 - 13
Toppel 10 EC (105 ml) 22 weeks post inoculation	11.8	(1.083 d)	3 - 22
Nemasys L 22 weeks post inoculation	12.5	(1.112 d)	4 - 22
F ratio		0.001	
		(d.f.) 240	
P		0.05	
SED		0.07	

Means followed by the same letter are not significantly different at *P*=0.05, Duncan's multiple range test (d.f. = degree of freedom, SED = standard error of the difference between means).

When larval assessments were made (December 2003 and March 2004), the untreated pots had a mean of 8.8 larvae per pot (from 30 eggs applied per pot). In comparison, Toppel 10 EC (cypermethrin) applied as a drench to pots two, four or six weeks before egg inoculation gave excellent (95-100% control), with the normal label rate (70 ml/100 litres of water) as effective as the 1.5 x label rate (105 ml/100 litres of water) treatment. Similarly, Intercept 70 WG (imidacloprid) gave 100% control when applied six weeks before egg inoculation. As vine weevil eggs take between 10 and 14 days to hatch, the period of activity, of both the Intercept and Toppel 10 EC, treatments in the compost may actually be longer than the 6 weeks evaluated here.

When Toppel 10 EC was applied as a drench treatment to young vine weevil larvae (eggs inoculated eight weeks before treatment), good control was achieved (79%), but Toppel 10 EC, applied in January 2004 to large larvae that had overwintered (22 weeks after egg inoculation), was ineffective. This result concurs with what has been found in commercial practice and in previous work, both in the UK and abroad - that large larvae (5^{th} instar and older), are much more difficult to control with insecticide drenches.

The nematode treatments (Larvanem and Nemasys L) did not control vine weevil larvae in this experiment. The level of control from both these nematode products was much lower than expected. The reasons for this are unclear at present. Discussions with Becker Underwood staff, established that the rate applied per pot was correct.

When applied to overwintered larvae, Nemasys L was similarly ineffective. Again, this result was surprising because nematodes, providing they are applied correctly, can control large larvae as well as smaller ones. Nemasys L is active at temperatures down to 5^{o}C, and the minimum compost temperature in the tunnel, after application in January 2004, was 8^{o}C.

In general, these efficacy data should be treated with some caution, as they only represent one season at one site.

Phytotoxicity

No evidence of phytotoxicity, caused by any of the drench treatments, was observed at any time. When temperatures in the tunnel decreased in the autumn (from early November onwards) most plants dropped a proportion of their leaves and watering was reduced to a minimum. Temperatures in the tunnel were recorded, but never went below 8 ^{o}C, at any time during the winter period.

Conclusions

- The pyrethroid insecticide cypermethrin (Toppel 10 EC) gave excellent control (96-100%) of vine weevil, when used preventatively as a drench, showing persistence for up to 6 weeks after application.
- Toppel 10 EC was also effective (79% control) when applied as a drench to young vine weevil larvae, at the end of September. This approximates to the end of the egg laying period for vine weevil and so a drench applied at this time, should control the majority of larvae that establish over the summer.
- Toppel 10 EC is inexpensive and so growers could save money by switching to this product rather than using the OP product chlorpyrifos or the neonicotinoid product imidacloprid.
- Because Toppel 10 EC is based on an insecticide from a different chemical group to chlorpyrifos and imidacloprid, alternating between these products, may help reduce any build up of resistance in the UK vine weevil population.
- Toppel 10 EC is registered for use on protected ornamentals as a foliar spray and an application to PSD for a SOLA, to enable its use as a drench, would have to be made.
- Pyrethroid insecticides, although of low hazard to mammals, are highly toxic to fish and other aquatic life and so great care would have to be taken to avoid any drift onto, or near, watercourses or ditches. However, these restrictions also apply to their use as a foliar spray and a carefully timed and applied drench application, may be less hazardous than a high volume foliar spray.

- Pyrethroid insecticides are also incompatible with biological controls used against other insect or mite pests; however, a drench application in late September, or early October, would be unlikely to interfere with IPM, as the majority of biological control introductions, are discontinued after mid September on protected HNS crops. Moreover, a drench application is inherently safer to beneficial insects, on plant foliage, than an overall high volume spray.

Recommendations

- Ideally, any new vine weevil control recommendations should be made until these results have been replicated at several sites.
- A SOLA application for the use of Toppel 10 EC, as a drench, should be pursued by the HDC for the benefit of HNC growers.