AHDB
HORTICULTURE

# Grower Summary

## HNS 195

Improving vine weevil control in Hardy Nursery Stock

Annual report 2019

## Disclaimer



The results and conclusions in this report may be based on an investigation conducted over one year. Therefore, care must be taken with the interpretation of the results.

## Use of pesticides

Only officially approved pesticides may be used in the UK. Approvals are normally granted only in relation to individual products and for specified uses. It is an offence to use non-approved products or to use approved products in a manner that does not comply with the statutory conditions of use, except where the crop or situation is the subject of an off-label extension of use.
Before using all pesticides check the approval status and conditions of use.
Read the label before use: use pesticides safely.

## Further information

If you would like a copy of the full report, please email the AHDB Horticulture office (hort.info.@ahdb.org.uk), quoting your AHDB Horticulture number, alternatively contact AHDB Horticulture at the address below.

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| **Project title:** | Improving vine weevil control in Hardy Nursery Stock |
| **Project number:** | HNS 195 |
| **Project leader:** | Jude Bennison, ADAS |
| **Report:** | Third annual report, January 2019 |
| **Previous report:** | Second annual report, March 2018 |
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| **Date project commenced:** | 1 January 2016 |
| **Expected completion date:** | 31 December 2019 |

# GROWER SUMMARY

## Headline

- Catches of vine weevil adults in Chemtica traps can be increased by placing yew or *Euonymus fortunei* foliage inside traps.
- Spraying adult vine weevils with *Steinernema carpocapsae* (Nemasys C) and spraying both weevils and Euonymus leaves with AHDB 9933 led to temporary weevil abnormal behaviour but the weevils recovered and neither treatment led to effective kill or to reduced feeding or egg laying.
- Isolates of entomopathogenic fungi were identified with lower optimal temperatures for growth and germination than Met52. However, a predictive day degree model estimated that the cumulative day degrees needed for 50% mortality was similar or higher to that of Met52, suggesting that these fungi are less virulent to vine weevil larvae than Met52 which may offset the benefits of lower temperature development.

## Objective 2. Develop practical methods for monitoring adults in order to detect early infestations and inform control methods

## Background

The development of an effective vine weevil lure would improve the reliability and sensitivity of monitoring strategies and contribute to improved integrated pest management (IPM) of this pest. Several studies have shown that vine weevil adults detect plant-derived odours and these are used by weevils to locate suitable host plants for feeding and oviposition and may, therefore, also play a role in aggregation. Odours from yew (*Taxus baccata*) and *Euonymus fortunei*, for example, are known to be attractive to adult vine weevils. It is, however, not yet fully understood how vine weevil discriminate between the odours of potential host plants, although it is likely that the ratios of blends as well as concentrations of plant volatiles is important (see Year 2 annual report). Vine weevil adults also appear to be attracted by the odour of other vine weevils and specifically to the frass (droppings) produced by these weevils. Positive behavioural responses were also recorded in this study (see Year 2 annual report) to both other weevils and weevil frass. There is, however, conflicting evidence as to whether weevils use these cues to aggregate, and to date, weevil or plant odours have not been used to successfully increase catches of vine weevil adults in monitoring traps. Here we: (1) seek to understand whether host plant material can be used to increase catches of vine weevil adults and (2) to further investigate the presence of a volatile aggregation pheromone.


## Summary

*Baiting Chemtica traps with plant material* – using large tent cages set up within an unheated glasshouse at Harper Adams University, responses of vine weevil adults to traps containing a fine 'weevil proof' nylon mesh bag, which was either left empty or filled with 15 g of freshly cut *Euonymus fortunei* or yew foliage. Potted strawberry plants were placed into each of the cages to simulate a crop and to provide alternate refuges to the Chemtica traps. In this way vine weevil adults were presented with a choice between two Chemtica traps in each cage that differed only by the plant foliage inside each trap. Weevils entering a trap were not able to feed on the foliage inside the mesh bags. The cages were prepared as described and 15 weevils were released into each cage between 6pm and 8pm in the evening and traps assessed the following morning between 8am and 9am. Before being released into the tent cages, vine weevil adults were conditioned by providing either yew or *Euonymus fortunei* plant material as a food source for 10 days before the start of the experiment.

Results from this series of experiments indicated that the number of weevils found in Chemtica traps could be significantly increased by the addition of either type of plant material. This is the first time that plant volatiles have been used to increase catches of vine weevil adults in traps. When given a choice between traps containing different host-plant foliage, significantly more adult weevils were found in traps containing the host-plant foliage on which they had previously fed. These results indicate that previous feeding experience by vine weevil adults may have implications for designing effective monitoring strategies.

*Aggregation pheromone* – the volatile chemicals produced by 30 adult vine weevils were sampled (entrained) over a period of 30 minutes (before weevils had chance to start to produce frass) and then any volatile chemicals collected were washed off the filters using diethyl ether. This process was repeated both for weevils that had been fed on yew foliage or had first been starved for 72 hours before the sampling was started. Completed samples for fed and starved weevils were each analysed by gas chromatography-electroantennography (GC-EAG). For the EAG preparations, individual vine weevil adults were anaesthetised before excising their head and one antenna. The reference electrode was inserted into the back of the head and attached to a silver electrode held in micromanipulators on a portable EAG device. To complete the circuit, the tip of the one remaining antenna was excised and the recording glass electrode attached to the EAG device inserted. To confirm that the EAG preparation method was suitable for recording electrophysiological responses from excised vine weevil heads, three individual preparations

were tested against ylang ylang (*Cananga odorata*) essential oil. This essential oil is known to elicit electrophysiological responses in vine weevil adults. Samples containing chromatographic peaks evoking electrophysiological responses were further analysed using gas chromatograph-mass spectrometry (GC-MS). The diethyl ether extract from the samples was analysed and peak identification completed using a mass spectra database.

No consistent EAG responses were recorded for samples from fed or starved vine weevil adults. These results are consistent with most previously published research but do not explain the results presented in Year 2 where vine weevil adults respond positively to the odour produced by fed weevils. It remains possible that high molecular weight compounds, not detected using the set-up employed here, may be important as aggregation pheromones. Analysis of the ylang ylang essential oil by GC-EAG resulted in good electrophysiological responses to 16 chemical compounds, which were then identified by GC-MS. This result confirms previous work that identified responses to linalool present in this essential oil. Responses to other compounds also present in ylang ylang essential oil were also detected for the first time. These compounds include caryophyllene and germacrene D.

Previous work on analysis of volatiles from *Euonymouos fortunei* using GC-EAG was revisited. Additional compounds were identified, in particular *cis*-jasmone which caused a strong EAG response at low levels.

The electrophysiologically active compounds identified here may be important in the development of a vine weevil lure.

## Objective 3. Improve best-practice IPM approaches including the use of entomopathogenic nematodes, fungi and IPM-compatible insecticides

### Background

*Lethal and sub-lethal effects on adult weevils in response to direct application and to residues of IPM-compatible insecticides, entomopathogenic nematodes and a botanical pesticide*

Many growers use entomopathogenic nematodes for the control of vine weevil larvae. However, control of adults is currently reliant on foliar sprays of insecticides. AHDB project SF HNS 112 showed that the IPM-compatible pesticides pymetrozine (Chess WG) and indoxacarb (Steward) gave useful control of adults. However, pymetrozine approval will expire on 31 January 2020 and Steward currently only has an EAMU for use on outdoor ornamentals so cannot be used on protected HNS. Thus alternative IPM-compatible treatments are needed for adult control. Adult sprays are usually applied late in the day with the aim of direct contact with the nocturnal adults but it is not known whether spraying during the day could be as effective when adults pick up dried spray residues. As well as killing adults, some insecticides and biopesticides could have sub-lethal effects e.g. antifeedant activity, abnormal behaviour or egg laying or egg hatch inhibition. These sub-lethal effects could make an important contribution to vine weevil management.

*Cold active entomopathogenic fungi*

Laboratory experiments to quantify the effect of temperature on the virulence of Met52 to vine weevil larvae indicated strongly that this fungus has an optimum of about 27°C and has a low rate of infection at temperatures below 15°C. This is likely to be a problem when using the product on outdoor plants, as the soil temperatures in the autumn and spring when larvae are active and damaging plants are likely to be below 15°C. Fungal biopesticides can work very well against vine weevil larvae when the temperature is favourable, and they fit in well with IPM programmes. Hence there would be potential for a fungal strain that works well at the lower temperatures that typically occur in soil in the autumn and spring in the UK and other northern temperate countries where vine weevil is a problem. The aim of this new piece of work was to investigate the potential of 'cold active' EPF strains against vine weevil larvae, with the target temperatures for fungal activity being between 5 - 15°C.

**Summary**

*Lethal and sub-lethal effects on adult weevils*

Laboratory experiments were done to test the direct contact and leaf residue lethal and sub-lethal effects of candidate treatments against adult vine weevils. In the direct contact experiment, vine weevils were sprayed with each treatment then added to Euonymus leaves. In the leaf residue experiment, Euonymus plants were sprayed and vine weevils were added to detached sprayed leaves either when the spray deposit was still damp or when the leaves had dried one day later. Water was used as the control in both experiments. None of the treatments tested in the three experiments led to effective kill of vine weevil adults. One weevil died due to natural infection with the entomopathogenic fungus *Beauveria bassiana* and the other few deaths are likely to have been due to natural causes. A direct contact spray of pymetrozine (Tafari) significantly reduced egg hatch but only to 65% compared with 78% in the water control. A direct contact spray of *S. carpocapsae* (Nemasys C) applied in 0.1 L water/ha as recommended for caterpillar control led to strong aversion behaviour by

adult vine weevils, but only on the day of application. Treated weevils also laid significantly fewer eggs than those treated with *S. kraussei* (Nemasys L) or Nemasys C applied in 4 L water/ha as recommended as a drench for control of vine weevil larvae, but not fewer than in the water controls. Spraying leaves, or weevils and leaves with the coded insecticide AHDB 9933 led to abnormal behaviour of vine weevil adults (lying on their backs or hiding under leaves) for 2-3 days, after which the weevils recovered and behaved normally. The botanical biopesticide azadirachtin (Azatin) acts on ingestion and has antifeedant (reduced feeding) effects on some insects but neither damp nor dry residues of Azatin led to reduced feeding on treated Euonymus leaves.

*Cold active entomopathogenic fungi*

An analysis of the scientific literature on the thermal tolerance of entomopathogenic fungi was done. It identified a number of EPF strains which were able to germinate and grow adequately between 5 - 15°C and hence could have potential against vine weevil larvae at these temperatures. To date, 17 candidate isolates of fungi have been acquired for experiments from a variety of sources, and these have been catalogued and cryopreserved in the Warwick Crop Centre collection of entomopathogens. Laboratory experiments were done to measure the rate of spore germination and the rate of fungal colony extension on agar-based media at a range of temperatures between 4 - 30°C. Optimum temperatures for spore germination ranged from 20 - 28°C and for fungal colony extension ranged from 17.5 - 24.8°C. Only two isolates were able to germinate at temperatures below 10°C and only four isolates were able to grow at 4°C. The two most promising strains were screened in a laboratory bioassay (determines the concentration or potency of a substance) over 28 days, at temperatures ranging from 12.5 - 25°C and mortality fitted to a predictive model. The cumulative day degrees needed for 50% mortality was similar or higher to that of Met52, suggesting that they had a lower inherent virulence to vine weevil larvae than Met52 which offset the benefits obtained from these fungi being able to develop at lower temperatures than Met52.

**Financial Benefits**

- The value of the UK HNS industry is estimated at £933 million per year (Defra Horticultural Statistics 2017). Crop damage and crop rejections due to the presence of vine weevil larvae can cause up to 100% losses if control measures give inadequate control. Most of the growers of HNS interviewed in project CP 111 (Review of vine weevil knowledge in order to design best-practice IPM protocols suitable for implementation in UK horticulture) reported that vine weevil caused significant crop losses, although only one grower estimated the losses, at 3-5%. Even at a conservative estimate of 3% losses due to vine weevil leading to crop damage or crop rejections, if improved control of vine weevil were achieved, this could be worth an extra £28 million per year to the industry.

- Various entomopathogenic nematode species and products are available for vine weevil control (see AHDB Horticulture Factsheet 24/16). Many growers choose to use *Heterorhabditis bacteriophora* when growing media temperatures are suitable (minimum 12-14°C depending on product) and *Steinernema kraussei* at lower temperatures (minimum 5°C). It is estimated that it takes five hours labour to apply a high volume drench of nematodes to an area of 1000m$^2$ with 3L pots but only one hour to apply them through the overhead irrigation. Taking into account the costs of two consecutive drenches of nematodes at recommended rates (one of *H. bacteriophora* and one of *S. kraussei),* it is estimated that applying 40% rates of the same products five times through the overhead irrigation (four applications of *H. bacteriophora* and one application of *S. kraussei*) would save 31% of the cost, and using three applications of *H. bacteriophora* and two applications of *S. kraussei* (in a cold autumn) would save 26% of the cost. Cost savings of applying reduced rates of nematodes five times through the overhead irrigation would be even greater if growers currently apply three consecutive drenches of nematodes at recommended rates (two of *H. bacteriophora* and one of *S. kraussei*) i.e. a saving of 52% if using four applications of *H. bacteriophora* and one of *S. kraussei* and a saving of 49% if using three applications of *H. bacteriophora* and two of *S. kraussei*. Cost savings would be even greater if using 20% rates of nematodes but using 40% rates is considered a safer option.

**Action Points**

- Monitoring for vine weevil adults should begin in spring when temperatures rise above the threshold of 6°C and continue until the autumn/winter when temperatures decline below this threshold once more. Keep up to date with results of this project as further work on monitoring will be done during 2019 using prototype new traps which may become available in the UK.
- Overwintered adult vine weevils need a 5-week period of intense feeding before they recommence laying eggs. Growers should monitor for adults and check for feeding damage from March onwards and consider applying a plant protection product for adult

control before egg laying starts. No new effective products were identified in this project. In project SF/HNS 112, indoxacarb gave promising control of adults when used at 250 g/ha and three products (Explicit, Rumo and Steward) currently have EAMUs for use on both outdoor and protected ornamentals. However, the 250 g/ha application rate may only be used on outdoor ornamentals. For protected ornamentals the EAMU specifies that spray concentrations should not exceed 12.5g/100L and the efficacy of this rate was not tested in SF/HNS 112.

- Use entomopathogenic nematodes for control of larvae (see AHDB Horticulture factsheet 24/16 'Vine weevil control in hardy nursery stock' for more details). Consider using the 'little and often' system of applying entomopathogenic nematodes through the overhead irrigation between June and October, which is as effective as using two high volume drenches in September and October and is more cost-effective. If using this system it is very important to remove any internal or external filters from the dosing unit to avoid nematode blockages. See https://horticulture.ahdb.org.uk/video/vine-weevil-control-%E2%80%93-overhead-nematode-application