Grower Summary

HNS 195

Improving vine weevil control in Hardy Nursery Stock

Final Report

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[The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.]

AUTHENTICATION

We declare that this work was done under our 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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GROWER SUMMARY

Headline

- Vine weevil activity can start in spring when temperatures rise above the threshold of 6°C and continue until temperatures drop below this in autumn/winter. Egg laying can start after weevils have fed for at least five weeks.
- Of the commercially available traps tested, the ChemTica vine weevil trap is the most effective and practical for use in vine weevil monitoring. Other vine weevil traps that are not yet commercially available are, however, at least as effective as the ChemTica vine weevil trap design.
- Catches of vine weevil adults in a range of traps can be increased by placing yew or *Euonymus fortunei* foliage inside but weevil responses to plant volatiles may be influenced by previous feeding experience. A commercial lure for use with traps developed in the Netherlands should be available in 2020 but this was not available for testing in this project.

Background

Vine weevil is currently the most serious pest of UK hardy nursery stock (HNS). With the imminent withdrawal of thiacloprid (Exemptor) growers will have no chemical plant protection products for use in growing media for control of vine weevil larvae. There is now more grower interest in controlling of weevil adults as well as larvae, and growers need more information on the efficacy and timing of treatments that are compatible with Integrated Pest Management (IPM) programmes, linked with further knowledge on weevil activity and egg laying behaviour. Growers are under increasing pressures to reduce the use of chemical plant protection products, not only to meet retail demands but also to meet the requirements of the EC Sustainable Use Directive (SUD) which states that all growers must use IPM where practical and effective. Many growers of HNS are now adopting biological pest control methods within IPM programmes. Available biological methods for vine weevil control include the entomopathogenic fungus (Met52 Granular Bioinsecticide) for incorporation in growing media and entomopathogenic nematodes. However, Met52 needs warm temperatures to be effective and although in soft fruit production, nematodes for vine weevil control are applied quickly and easily through drip irrigation, most growers of HNS need to apply nematodes using high volume drenches which is labour-intensive and thus expensive. This project addresses grower needs by filling knowledge gaps in how to optimise best-practice use of available vine weevil control methods within IPM and to develop novel approaches to both monitoring and control.

Summary Years 1-4

Objective 1. Improve understanding of the impact of environmental conditions on vine weevil biology and behaviour in order to optimise application of plant protection products (Harper Adams University)

A minimum temperature of 12°C has been suggested for vine weevil egg laying to occur but some other researchers report egg laying at lower temperatures. The aim of this objective was to investigate the minimum temperature for both egg laying and feeding to occur. Work in the first two years of the project showed that vine weevil adults are active and feed at 6°C and above. Overwintered vine weevil adults (rather than those that overwinter as larvae) are likely to become active and start feeding, even outside, as early as March, although egg laying may not start until they have fed intensively for at least five weeks. For further details see first and second annual reports, 2016 and 2017.

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

2.1 Relative effectiveness of monitoring tools with and without use of lures. (Harper Adams University and NRI)

Trapping of vine weevil adults reduces the amount of time required to monitor crops and can be done at a convenient time of day. Several techniques have been developed with which to monitor for the presence of vine weevil adults, such as use of grooved boards and corrugated cardboard. A commercial vine weevil trap produced by ChemTica has also been developed and this is available from ChemTica in Costa Rica or from Sentomol Ltd. in the UK.

In Year 1, a comparative study tested the efficacy of different vine weevil monitoring tools without the use of lures under semi-field conditions with known vine weevil populations and potted strawberry plants that simulated a crop. Significantly more vine weevil adults were recovered from the commercial vine weevil trap produced by ChemTica than any of the other monitoring tool designs tested, including corrugated cardboard roll, upturned plastic tray, grooved board, pitfall trap, Roguard cockroach trap and modified palm weevil trap. The ChemTica trap was also the most reliable in terms of indicating the presence of a vine weevil population when there were weevils present in the simulated crops. For other monitoring tool designs, such as the grooved boards or corrugated card, few weevils were recovered and the presence of a weevil population was only confirmed in between 20 and 30% of cases.

In semi-field conditions in Year 4, however, other insect traps supplied by the UK company Sentomol Ltd. such as a different cockroach trap and a banana weevil trap were found to be at least as effective as the ChemTica vine weevil trap design for use in monitoring for the presence of vine weevil adults. In addition, two novel vine weevil trap designs produced by Russell IPM Ltd in the UK were also found to be at least as effective as the ChemTica vine weevil trap design for use in monitoring for the presence of vine weevil adults. These results indicate that, while the ChemTica trap is an effective monitoring tool, alternative designs that are at least as effective as this may be developed and made available in the UK. By contrast, the WeevilGrip, a fabric vine weevil refuge, produced by Agri Gripping, The Netherlands, was found to be less effective than the ChemTica vine weevil trap design under the semi-field conditions used in this study. It is expected, however, that the WeevilGrip vine weevil refuge will be sold together with a 'Weevil Lure', which was not available to test in this project.

The potential to increase the effectiveness of vine weevil monitoring tools through the use of a plant lure was investigated in this project. *Euonymus fortunei* and yew (*Taxus baccata*) foliage are particularly attractive to vine weevils, and, in Year 3 it was shown in the tent cages that addition of *Euonymus* or yew foliage to the ChemTica traps significantly increased catches of vine weevils, regardless of their previous feeding experience. However, the relative attractiveness of the two baits depended upon the prior experience of the weevils with a preference shown for the plant species on which the weevil had previously been feeding. In Year 4 the addition of plant material similarly increased numbers of vine weevil adults found in both the cockroach trap supplied by Sentomol Ltd. and the novel Russell IPM Ltd. design tested.

Also in Year 4, the four most promising trap designs were tested in containerised HNS crops on two commercial nurseries by ADAS with assistance from the host growers. Designs tested were the ChemTica trap, cockroach trap, Russell IPM novel trap and the WeevilGrip trap. No weevils were caught, probably due to very low populations, but useful insights into the practical use of such traps were obtained.

For further details on work investigating monitoring tools used with or without use of lures to detect the presence of vine weevil adults see first, second and third annual reports, 2017, 2018 and 2019.

2.2. Potential of lures to improve monitoring of vine weevil adults (Harper Adams and NRI)

Research on attractants for vine weevil adults has to date focussed on the volatile compounds produced by live weevils, those in weevil frass and volatiles produced by host plants. Recently a vine weevil attractant, marketed as Weevil Lure and based on the plant volatile (Z)-2-pentenol, has been developed by Agri Gripping (see https://agri-gripping.com/).

In Year 2 of this project, a series of laboratory experiments using a glass Y-tube olfactometer confirmed positive behavioural responses to live weevils, weevil frass, host plant odours as well as individual plant volatiles. A key finding was that behavioural responses of adult weevils to physiologically active host plant volatiles are affected by the concentration of the volatile(s) and the combination of volatiles that the vine weevil detects. Although the individual components were variously attractive or repellent at different doses, blends of (Z)-2-pentenol + methyl eugenol or of (*Z*)-2-pentenol + methyl salicylate + 1-octenol + (*E*)-2-hexenol + (*Z*)-3-hexenol + 1-hexanol + (*E*)-2-pentenol were very attractive. However, in a preliminary test in Year 2 addition of the former blend to ChemTica traps gave no increase in numbers of vine weevils caught. Catches were very low, but development of an effective lure will thus probably require careful formulation to be effective.

In laboratory work, volatiles were collected from various sources and analysed by gas chromatography (GC) coupled to electroantennographic (EAG) recording from receptors on vine weevil antennae to determine and identify which compounds are detected by the weevils and are hence candidate attractants. In Year 2, no consistent EAG responses were shown to volatiles collected from unstarved weevils. In Year 3, at least 23 compounds produced by *Euonymus fortunei* were shown to elicit EAG responses from vine weevils. Similar work in Year 4 showed that 20 compounds in volatiles from yew elicited EAG responses, with 10 compounds in common. Identified plant volatiles were mostly fairly ubiquitous plant volatiles and are strong candidates for use as attractants for vine weevil adults. Both (*E*)- and (*Z*)-2-pentenol and methyl eugenol have been reported by other workers to be produced by *Euonymus fortunei* but could not be detected in this work. Other EAG-active plant volatiles, such as cis-jasmone, 1.2-dimethoxybenzene, eugenol and myrtenol were, however, detected and may also be useful as part of a vine weevil lure.

In Year 2, cuticular hydrocarbons from *Otiorhynchus sulcatus* and a new species, *O. lavandus,* were collected and analysed. Analyses showed that their compositions were quite consistent but different from each other, providing evidence that they are species-specific and could be used for species recognition. These have potential to increase colonisation of refuges, but experiments in Year 3 showed no evidence that they could elicit trail following in vine weevils.

Various controlled-release dispensing systems for candidate attractants were investigated under laboratory conditions, including pipette tips, polyethylene vials and sealed polyethylene disposable pipettes.

For further details see first, second and third annual reports, 2017, 2018 and 2019.

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

3.1. Little and often application of nematodes (ADAS)

A 'little and often' system for applying reduced rates of entomopathogenic nematodes through the overhead irrigation was tested in a research polytunnel in Year 1 and validated on a commercial nursery in Year 2. Application of nematodes at 40% rate five times between June and October was equally as effective in reducing mean numbers of vine weevil larvae per plant as two conventional full rate drench applications in September and October. Using 40% rates five times between June and October offers up to 52% cost savings compared with using standard high volume drenches due to reduced labour time without compromising on efficacy. For further details see first and second annual reports, 2016 and 2017.

3.2. Lethal and sub-lethal effects of IPM-compatible products against adult weevils (ADAS)

Control of adult vine weevil 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. Chess WG is no longer available and the EAMU for Steward and other indoxacarb products allows application at the rate shown to be effective against vine weevil on outdoor ornamentals but only at a lower rate for protected ornamentals. Laboratory experiments in Year 3 tested the lethal and sub-lethal effects of candidate IPM-compatible treatments against adult vine weevils. None of the treatments gave effective weevil kill. Pymetrozine (Tafari) significantly reduced egg hatch but only to 65% compared with 78% in the water control. A spray of *Steinernema carpocapsae* (Nemasys C) and the coded insecticide AHDB 9933 led to short-term abnormal behaviour after which the weevils recovered. The botanical biopesticide azadirachtin (Azatin) acts on ingestion and has antifeedant effects on some insects but neither damp nor dry residues led to reduced weevil feeding on treated Euonymus leaves. No new IPM-compatible controls for adult weevils were identified. For further details see third annual report, 2018.

3.3 Effects of temperature on entomopathogenic fungi (Warwick University)

Experiments in Years 1 and 2 tested the effect of temperature (12.5-30°C) on the infectivity of Met52 to vine weevil larvae. Mortality increased with temperature. A predictive day degree model was developed to predict Met52 infection and this estimated that no kill will occur below 11.6°C and that for 75% kill 256 cumulative day degrees are needed, which could be reached between June and August in some years and locations. A cold-tolerant fungal strain would be useful. Experiments were done on 17 cold-tolerant isolates of fungi. Only two isolates germinated below 10°C and only four isolates grew at 4°C. The two most promising strains were tested against vine weevil larvae. A predictive model indicated that although these fungi could develop at lower temperatures than Met52 they were less virulent to vine weevil larvae so did not offer opportunities for further development. For further details see second and third year annual reports, 2017 and 2018.

Objective 4. Develop novel approaches to control vine weevil (Harper Adams University)

A wooden trap with grooves filled with a gel containing *Steinernema carpocapsae* is available from e-nema for control of adult vine weevils that seek refuge under the traps during the day, become infected and subsequently die. The traps were tested in another AHDB project (see 2013 report of CP 89) and led to 92% weevil kill within four weeks. The traps are currently sold for home garden use but are too expensive for commercial use. An alternative cost-effective lure and kill approach could potentially be developed. In experiments where a gel formulation of *S. carpocapsae* was either applied to the base of plant pots or placed inside Roguard crawling insect traps, adult vine weevil mortality was not statistically significantly increased. For further details see second year annual report, 2017.

Objective 5. Disseminate new knowledge and updated best-practice control methods to growers and other industry members (all partners)

Throughout the project the results of the project have been disseminated extensively to growers, other industry members, the scientific community and the general public. Communication methods ranged from presentations at industry events and scientific conferences, a video on the AHDB website, radio and TV presentations and scientific papers. For further details see first, second and third year annual reports, 2016, 2017 and 2018.

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. 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. 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 6°C and continue until the autumn/winter when temperatures decline below this threshold once more. Traps are available which may help with monitoring. The Chemtica trap is commercially available from Costa Rica http://www.chemtica.com/ at an approximate price of $7 plus shipping from Sentomol Ltd. in the UK http://sentomol.com at an approximate price of £15. The WeevilGrip trap and Weevil Lure may be available during 2020 https://agri-gripping.com/

- Overwintered adult vine weevils need a 5-week period of intense feeding before they recommence laying eggs. 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 application 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

- Do not rely on Met52 as the sole method for controlling vine weevil larvae, use as part of an IPM programme for vine weevil management (see AHDB factsheet 24/16).
- Be aware that garlic (Pitcher GR) now has an EAMU for use on both protected and outdoor ornamentals for control of vine weevil and leaf and bud nematodes. This product was not tested in this project.