Horticultural Fellowship Awards

Interim Report Form

Project title:	Maintaining the expertise for developing and communicating practical Integrated Pest Management (IPM) solutions for Horticulture
Project number:	CP 89
Project leader:	Jude Bennison, ADAS
Report:	Interim, 30 April 2013
Previous report:	Interim report 2012
Fellowship staff:	Jude Bennison, Senior Entomologist, ADAS Boxworth (lead Fellowship mentor)
	Mike Lole, Senior Entomologist, ADAS Rosemaund (mentor)
	Steve Ellis, Senior Entomologist, ADAS High Mowthorpe (mentor)
	The late John Buxton, Senior Entomologist (mentor)
	John Atwood, Senior Horticultural Consultant (mentor)
	Chris Dyer, Statistician, ADAS (mentor)
	Heather Maher, Senior Research Manager, ADAS Boxworth (mentor until August 2012)
	Kerry Maulden, Senior Research Manager, ADAS Boxworth (mentor)
	Shaun Buck, Senior Research Manager, ADAS High Mowthorpe (mentor)
("Trainees")	Gemma Hough, Entomologist, ADAS

	Boxworth (Fellowship trainee Entomologist and Project Manager from Dec 2012) Tom Pope, Entomologist, ADAS Boxworth (Fellowship trainee Entomologist and Project Manager until August 2012) Gemma Gillies, Graduate Entomologist, ADAS Boxworth (Fellowship trainee Entomologist until Dec 2012) Tracie Evans, Research Technician, ADAS Boxworth (Fellowship trainee scientific support staff until August 2012) Chloe Whiteside, Research Technician, ADAS Boxworth (Fellowship trainee scientific support staff) Robert Drummond, Technician, ADAS Boxworth (Fellowship trainee scientific support staff) Abby Wood, Technician, ADAS Boxworth (Fellowship trainee scientific support staff)
Location of project:	ADAS Boxworth and commercial farms and nurseries
Industry Representative:	-
Date project commenced:	01 April 2011
Date project completed (or expected completion date):	31 March 2016

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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.

Jude Bennison
Senior Research Entomologist
ADAS

Signature ..... Date .....

Report authorised by:

Dr Tim O'Neill
Horticulture Research Manager
ADAS

Signature ..... Date .....

Progress Against Objectives

Objectives

Objective	Original Completion Date	Actual Completion Date	Revised Completion Date
1. Provide mentoring of two next generation ADAS research entomologists to equip them with the knowledge, skills, competencies and flexibility required to develop IPM strategies on horticultural crops.	31/03/2016	ongoing	-
2. Deliver practical solutions to selected current and emerging pest management problems through specific applied research projects.	31/03/2016	ongoing	-
3. Transfer knowledge and new IPM developments to the industry through a range of communication media.	31/03/2016	ongoing	-

Summary of Progress

Objective 1: Mentor two 'next generation' IPM research Entomologists

Tom Pope was already in post at ADAS Boxworth at the start of the Fellowship. He joined ADAS in 2009 and worked with Jude Bennison and colleagues on a range of projects investigating the biology and control of various horticultural pests including aphids, cabbage root fly and vine weevil. As part of the Fellowship Tom led work on predatory mites in soft fruit, biological control of vine weevil, incidence of aphid hyperparasitoids and biological control of aphids on outdoor lettuce. In August 2012, Tom left ADAS to join Harper Adams University as a lecturer in entomology and applied pest management research, where he is now training future entomologists. Tom is now a valued research collaborator with ADAS, already working with Jude Bennison and her team in two Defra-funded IPM projects.

Gemma Gillies joined ADAS Boxworth in October 2011 and assisted on the Fellowship projects, taking over the work on biological control of vine weevil in August 2012. Gemma left ADAS to return to teaching in December 2012 and ADAS has now recruited to replace her in its pest management team. The new ADAS Entomologist will start at ADAS Boxworth on 7 May 2013.

Gemma Hough joined ADAS Boxworth as a research entomologist in December 2012 after completing a HDC-funded PhD studentship on the biology and control of currant lettuce

aphid at Warwick University. As part of the Fellowship during 2013 Gemma will be taking over work on biological control of vine weevil, biological control of aphids on lettuce and monitoring hyperparasitism in HNS. She is already involved in two HDC-funded projects, on improving biological control of aphids on protected herbs (PE 006a) and on reducing damage by *Scaptomyza flava* on baby-leaf salads (FV 408).

Mentoring activities during the second year of the Fellowship included:

Visits to commercial nurseries and farms

Visits were made by Gemma Gillies and Gemma Hough with Senior ADAS entomologists, Jude Bennison and the late John Buxton and with ADAS horticultural consultants, David Talbot and Angela Huckle. Nurseries and farms visited included:

Protected ornamentals: Gemma Gillies made consultancy visits to discuss IPM strategies with the late John Buxton.

Hardy nursery stock: Gemma Gillies made consultancy visits and specific monitoring of aphids and parasitoids with Jude Bennison and the late John Buxton. Gemma Hough visited growers with ADAS HNS consultant David Talbot to discuss leaf and bud nematode problems and potential control methods within IPM programmes.

Soft fruit: Gemma Gillies visited soft fruit nurseries with Jude Bennison to monitor for thrips, predatory mites, predatory bugs and aphid parasitoids and hyperparasitoids on protected strawberry.

Field vegetables: Gemma Gillies visited outdoor cucurbit growers with ADAS field vegetable consultant Angela Huckle to identify pests and take photographs for the HDC Crop Walkers Guide on outdoor cucurbits.

Protected herbs: Gemma Hough visited protected herbs growers with Jude Bennison to discuss aphid problems and biocontrol strategies.

Pest and biocontrol agent identification

Laboratory training on identification of key horticultural pests was completed by Gemma Gillies, Gemma Hough and Tom Pope as well as key members of the scientific support team at ADAS Boxworth. Training courses included:

- Aphid parasitoid and hyperparasitoid spp. identification (training given by Tom Pope and Tracie Evans)

- *Scaptomyza* spp. Identification (training given by Heather Maher)
- Thrips spp. identification (training given by Mike Lole and Jude Bennison)
- Predatory mite spp. identification (training given by Mike Lole)
- Free living nematode spp. identification (training given by Heather Maher and Shaun Buck)

Technical updates on biocontrol agents, biopesticides, pesticides and horticultural research

Technical meetings with suppliers of pesticides, biopesticides and biocontrol agents were attended throughout the year. These meetings provided updates on new products under development or those recently available for use by UK growers. Industry commodity group meetings and HDC research update meetings were also attended, where the trainees discussed key pest problems and research needs with growers. These included the BLSA (British Leafy Salads Association) conference, BHTA (British Herbs Trade Association) technical meeting and SPGA (Speciality Produce Growers Association) technical meeting. Scientific meetings attended included a Royal Entomological Society Meeting on 'Insects in a human-dominated world', the AAB (Association of Applied Biologists) conference on 'Advances in Biological Control'. Tom Pope and Gemma Gillies gave presentations at both these meetings.

Objective 2: Deliver practical solutions to selected current and emerging pest management problems through specific applied research projects

Efficacy of entomopathogenic nematodes against vine weevil

The efficacies of two commercially available nematode products for the control of vine weevil (VW) larvae in substrate-grown strawberry were compared: Nemasys® L (*Steinernema kraussei*) and the newly available patented product containing a mix of *Steinernema feltiae*, *Steinernema carpocapsae* and *Heterorhabditis megidis* (SuperNemos®).

The experiment was done in a poly tunnel at ADAS Boxworth. On 1 May 2012, ten bare-rooted everbearer strawberry plants were planted per standard one metre-long grow-bag (80% peat and 20% wood fibre). VW eggs were added on 1 August (15 eggs per plant) and curative applications of the nematode products were made on 6 September. In late October,

plants were destructively sampled and the numbers of live larvae in each grow-bag were recorded.

The highest numbers of larvae were recorded in the untreated grow-bags which had a mean of 61.5 larvae per bag (equivalent to 6.2 larvae per plant). Plants treated with Nemasys L and SuperNemos both reduced the mean number of larvae per bag to 3.7 and 6.2 respectively (equivalent to 0.4 and 0.6 per plant respectively), which were both significantly different to the untreated control. Nemasys L and SuperNemos were equally effective, giving 94% and 90% control of VW larvae compared with untreated plants.

Aphid hyperparasitoids on protected edibles, soft fruit and ornamentals

Aphid hyperparasitoids were collected from a hardy nursery stock (HNS) site in Norfolk where the grower used regular releases of the newly available aphid parasitoid mix, which included the six parasitoid species *Aphidius colemani*, *Aphidius* ervi, Aphelinus *abdominalis*, *Aphidius matricariae*, *Praon volucre* and *Ephedrus cerasicola*.

The site was sampled on two occasions and parasitised (mummified) aphids were collected. Where possible, the aphid species and primary parasitoid genus were identified from the appearance of the 'mummy'. Evidence of primary parasitoid adult emergence (indicated by a neat circular exit hole) or hyperparasitoid adult emergence (indicated by a ragged emergence hole) was also recorded. Where there was no emergence hole, the mummified aphids were kept in the laboratory until either a primary or a hyperparasitoid adult emerged.

On the first sampling date percentage hyperparasitism was 33-50% and only one hyperparasitoid species was present (*Asaphes* sp). On the second sampling date, percentage hyperparasitism was17-70%. Three species of hyperparasitoids emerged from mummies collected on this sampling date: *Dendrocerus* sp*. Asaphes* sp. and *Alloystra brevis*. The potato aphid, *Macrosiphum euphorbiae,* the violet aphid, *Myzus ornatus* and the peach-potato aphid, *Myzus persicae* were the only parasitised aphids recorded.

Biological control of aphids on lettuce

The population dynamics of aphids in response to the release of parasitoids in an organic lettuce crop were monitored. In addition, any hyperparasitism was recorded to determine whether it could affect the aphid control provided by primary parasitoids.

Fifty lettuce plants were assessed in a new planting on five weekly occasions during the summer. For each plant the number and species of aphids, the number of parasitised

'mummies' and any aphid predators or pathogens were recorded. Evidence of primary parasitoid emergence or hyperparasitoid emergence was also recorded. Where there was no emergence hole, the mummified aphids were kept in the laboratory until either a primary

or a hyperparasitoid adult emerged. Parasitoids were released into the field containing our monitoring planting by the grower on 20, 27 June and 4 July 2012 at 0.23, 0.35 and 0.47 parasitoids/m^2 respectively. After the conclusion of the weekly monitoring, the farm was visited again on 21 August where two additional lettuce crops where no parasitoids had been released were monitored.

All the aphids recorded during the weekly monitoring were *Myzus persicae.* Aphid populations peaked on 3 July at 10 aphids per plant which was followed by a population crash. The decline in aphids coincided with a significant number of the aphids being infected with naturally-occurring entomopathogenic fungi. During the monitoring period in June and July only five mummies were found and of these, 80% were hyperparasitised, 50% of which were identified as *Asaphes* spp. On the additional monitoring date in August natural parasitism of both *M. persicae* and *M. euphorbiae* was observed. Fifteen mummies were recorded and 63% of these were hyperparasitised. The species responsible were identified as *Asaphes*, *Alloxysta* and *Dendrocerus* spp.

Review of alternatives to Vydate for the control of leaf and bud nematodes

A review of the literature indicated that programmes of high crop hygiene remain the most effective cultural control measure against leaf and bud nematodes. Hot water treatments can also be effective but are not used as the requirements for and safety to all susceptible HNS species and cultivars are not available. Currently there are no effective alternative nematicides to oxamyl (Vydate 10G) for the control of this pest, but the review identified some potential alternative control measures that justify evaluation.

Objective 3: Transfer knowledge of new IPM developments to the industry

Knowledge transfer activities delivered by the trainees in year 2 of this project related both to this Fellowship project, and also to other horticultural projects, and included:

Publications (with input from experienced ADAS colleagues):

● HDC News articles on the Entomology Fellowship (CP 89) and the leaf miner *Scaptomyza flava* (FV 408), April 2013 (Gemma Hough)

● HDC Factsheet 10/12 Midge, mite and caterpillar pests of cane fruit crops (Tom Pope).

● Defra RADAR - Autumn 2012. Title: A new way of tackling an old problem (report on CRD-funded project evaluating the potential of using refuge traps as a means of disseminating entomopathogenic fungi for the control of adult vine weevil), Tom Pope.

● Bennison, J., Pope, T., Greetham, J., Evans, T. & Maher, H. (2012) Improved biological control of 'problem' aphids on protected herbs. IOBC/wprs Bulletin. 80:155-158

Industry Presentations:

● Summary of results on HDC-funded project FV 408: Baby-leaf Cruciferae and Watercress: Improved control of *Scaptomyza flava* at SPGA Technical Meeting (Gemma Hough and Jude Bennison)

● Summary of the Fellowship project CP 89 at ADAS Technical Skills Meeting (Gemma Hough)

● Summary of Entomology work at ADAS at Syngenta Horticultural meeting (Gemma Gillies)

Scientific Conference Presentations:

● Royal Entomological Society Meeting - Insects in a human dominated world- The Horticultural Fellowship explained - Summary of the Fellowship project CP 89 (Gemma Gillies).

● Royal Entomological Society Meeting - Insects in a human dominated world- Are adult vine weevils running out of places to hide? – results from CRD-funded project PS2134 (Tom Pope).

● AAB Advances in Biological Control meeting; Aphid parasitoids - new opportunities and challenges – results of HDC-funded projects on protected herbs, PE 006 and PE 006a (Tom Pope).

● AAB Advances in Biological Control meeting; The ADAS IPM Horticultural Fellowship (Gemma Gillies).

Milestones not being reached

None

Do remaining milestones look realistic?

Yes

Other achievements in the last year not originally in the objectives

Trainees have worked with experienced ADAS entomologists on a wide range of horticultural projects over the last year. These included:

- HDC-funded project PE 006a - Protected herbs: improved biological control of aphids.
- HDC-funded project FV407- Baby-leaf Cruciferae and Watercress: Improved control of *Scaptomyza flava*.
- HDC Crop Walkers Guide – pests and diseases of outdoor cucurbits.
- Updating the Best-Practice Guide to Integrated pest and disease management on protected herbs on the HDC website.
- CRD-funded project PS2134 - Use of refuge traps to disseminate entomopathogenic fungi for the control of adult vine weevil.
- HortLINK project HL001107 - Biological, semiochemical and selective chemical management methods for insecticide resistant western flower thrips on protected strawberry.
- Defra-funded project TH0102 – Improving control of oak processionary moth.
- Defra-funded project FFG 1146 – Tree health: review and analysis of control strategies for established pests and pathogens of trees to inform current and future management.
- Defra-funded project - Combating Resistance to Aphicides in UK Aphid Pests.
- CRD-funded report – Pest, weed and disease incidence report 2012

In addition to the technical skills learnt through involvement on these projects, this work has provided several knowledge transfer opportunities as previously discussed. These activities were delivered by Tom Pope, Gemma Hough and Gemma Gillies.

Changes to Project

Are the current objectives still appropriate for the Fellowship?

Indicate any changes to the ordinal objectives that you would like to make and provide any information that you can to support this decision.

None

GROWER SUMMARY

Headline

- The entomopathogenic nematode products Nemasys L and SuperNemos were equally effective and significantly reduced numbers of live vine weevil larvae in substrate-grown strawberry when compared with untreated controls.
- Aphid hyperparasitoids were identified on protected HNS and on outdoor organic lettuce where growers were releasing aphid parasitoids during 2012.
- A literature review to identify potential alternatives to oxamyl (Vydate 10G) for leaf and bud nematode control on HNS indicated that a high standard of nursery hygiene remains the most effective cultural control measure but potential alternative nematicides and cultural methods were identified.

Background

Efficacy of entomopathogenic nematodes against vine weevil

Vine weevil (VW, *Otiorhynchus sulcatus*) remains one of the most serious problems in both soft fruit and nursery stock industries. In order to reduce damage caused by this pest, controls can be targeted against both the larvae in the soil and the adult weevils within the crop. Biological control of VW is preferable to the use of insecticides in Integrated Pest Management (IPM) programmes. Current options for biological control of VW larvae are entomopathogenic nematodes (various species and products) and the entomopathogenic fungus *Metarhizium anisopliae* (Met52).

This experiment compared the efficacies of two commercially available nematode products for the control of VW larvae in substrate-grown strawberry: Nemasys® L (*Steinernema kraussei*) and the newly available patented product containing a mix of *Steinernema feltiae*, *Steinernema carpocapsae* and *Heterorhabditis megidis* (SuperNemos®).

Aphid hyperparasitoids on protected ornamentals

Aphid parasitoids are widely used for biological control of aphids within IPM programmes on many protected crops. Until recently, biological control of aphids on protected crops relied mainly on three aphid parasitoid species:

- *Aphidius colemani* for control of e.g. the peach-potato aphid, *Myzus persicae* and the melon-cotton aphid, *Aphis gossypii*.
- *Aphidius ervi* and *Aphelinus abdominalis* for control of e.g. the potato aphid, *Macrosiphum euphorbiae* and the glasshouse-potato aphid, *Aulacorthum solani*.

Use of aphid parasitoids on some crops has increased recently, due to the availability of a new mix of six parasitoid species. The new mix contains the above three parasitoid species plus an additional three species (*Aphidius matricariae*, *Ephedrus cerasicola* and *Praon volucre*) which has extended the range of aphid species that can be parasitised, and has thus led to further uptake of aphid parasitoids on a range of crops. In 2005, in a MAFF (now Defra)-funded project on developing IPM in outdoor Hardy Nursery Stock (HNS), ADAS confirmed that hyperparasitoids (secondary parasitoids which parasitise the primary aphid parasitoids) were a potential problem in naturally- parasitised aphids in outdoor HNS (Buxton *et al.* 2005). More recent investigations by Rob Jacobson in HDC-funded project PC 295, 295a and 295b have shown that breakdown in aphid control by parasitoids in mid-summer on some sweet pepper nurseries were predominantly due to the presence of hyperparasitoids (Jacobson 2010, 2011).

During 2011 in this Fellowship project, the presence of hyperparasitism was monitored and confirmed in sweet pepper, protected strawberry and HNS crops. A range of aphid species were parasitised by both *Aphidius* spp. and *Praon* spp. The hyperparasitoid species indentified were similar to those recorded in PC 295 and 295a and b, including *Asaphes suspensus*, *Asaphes vulgaris*, *Dendrocerus carpenteri*, *Dendrocerus laticeps* and *Pachyneuron* sp. On protected strawberry, HNS and sweet pepper hyperparasitism reached 5, 32 and 25% respectively. The aim during 2012 was to continue monitoring hyperparasitism at a HNS site.

Biological control of aphids on lettuce

Control of aphids on lettuce with pesticides is becoming increasingly difficult due to the limited number of pesticides available, pressures to reduce pesticide use and the increasing aphid resistance issues to both insecticides and to resistant cultivars which have been observed on lettuce for the peach-potato aphid, *Myzus persicae* and for currant-lettuce aphid, *Nasonovia ribisnigri* respectively. A major grower has reported achieving successful control of aphids in organic outdoor lettuce through the release of parasitoids. The use of biological control in field-grown lettuce, particularly for organic growers, could be an important component of an IPM programme.

Following discussion with the HDC and members of the British Leafy Salad Association, it was decided to evaluate the population dynamics of aphids in response to the release of parasitoids in an organic lettuce crop and to determine whether hyperparasitism occurred and if this could threaten the aphid control provided by primary parasitoids.

Review of the control of leaf and bud nematodes

Leaf and bud nematodes (LBN), *Aphelenchoides sp.,* are a significant foliar pest of the hardy nursery stock plants whose feeding results in angular-shaped dark blotches on the leaves which are delineated by the veins and often accompanied by leaf distortion. Subsequent damage from a LBN infestation can make a plant unmarketable causing significant economic losses for growers. Furthermore, once present on a nursery it is a challenging pest to eradicate due to its transmission being facilitated by overhead irrigation and its ability to survive for several years in infested dried leaf debris. Currently the only effective nematicide against this pest in the UK is oxamyl (Vydate 10G), which has an EAMU for use on protected HNS. Not all growers wish to use Vydate as it is not compatible with biological control agents used for other pests within IPM programmes and its use requires precautions for operator and environmental protection, a re-entry time to treated glasshouses and a harvest interval. Many growers prefer to use stringent nursery hygiene methods and sub-irrigation as key cultural control methods for the pest. This review aimed to summarise and collate potential alternative control measures available for LBN.

Summary

Efficacy of entomopathogenic nematodes against vine weevil

The efficacies of two commercially available nematode products for the control of vine weevil (VW) larvae in substrate-grown strawberry were compared: Nemasys® L (*Steinernema kraussei*) and the newly available patented product containing a mix of *Steinernema feltiae*, *Steinernema carpocapsae* and *Heterorhabditis megidis* (SuperNemos®).

The experiment was done in a poly tunnel at ADAS Boxworth. On 1 May 2012, ten bare-rooted everbearer strawberry plants were planted per standard one metre-long grow-bag (80% peat and 20% wood fibre). VW eggs were added on 1 August (15 eggs per plant) and curative applications of the nematode products were made on 6 September. In late October,

plants were destructively sampled and the numbers of live larvae in each grow-bag were recorded.

The highest numbers of larvae were recorded in the untreated grow-bags which had a mean of 61.5 larvae per bag (equivalent to 6.2 larvae per plant). Plants treated with Nemasys L and SuperNemos both reduced the mean number of larvae per bag to 3.7 and 6.2 respectively (equivalent of 0.4 and 0.6 per plant respectively), which were both significantly different to the untreated control. Nemasys L and SuperNemos were equally effective, giving 94% and 90% control respectively of VW larvae compared with untreated plants. There was no statistical difference between the control provided by Nemasys L and SuperNemos.

Aphid hyperparasitoids on protected ornamentals

Aphid hyperparasitoids were collected from a hardy nursery stock site in Norfolk where the grower used regular releases of a new aphid parasitoid mix, which included the six parasitoid species *Aphidius colemani*, *Aphidius ervi* and *Aphelinus abdominalis*, *Aphidius matricariae*, *Praon volucre* and *Ephedrus cerasicola*. The parasitoids were released weekly during the sampling period and the '6-pack' mix was supplemented with releases of single species as necessary e.g. with *Aphidius ervi* in 'hotspots' of the potato aphid, *Macrosiphum euphorbiae.*

The site was sampled on 18 May and 1 August and parasitised (mummified) aphids were collected. Where possible, the aphid species and primary parasitoid genus were identified from the appearance of the 'mummy'. Evidence of primary parasitoid adult emergence (indicated by a neat circular exit hole) or hyperparasitoid adult emergence (indicated by a ragged emergence hole) was also recorded. Where there was no emergence hole, the mummified aphids were kept in the laboratory until either a primary or a hyperparasitoid adult emerged.

On the first sampling date percentage hyperparasitism was 33-50% and only one hyperparasitoid species was present (*Asaphes* sp). On the second sampling date, percentage hyperparasitism was 17-70%. Three species of hyperparasitoids emerged from mummies collected on this sampling date: *Dendrocerus* sp. *Asaphes* sp. and *Alloystra brevis*. The potato aphid, *Macrosiphum euphorbiae,* the violet aphid, *Myzus ornatus* and the peach-potato aphid, *Myzus persicae* were the only parasitised aphids recorded.

Biological control of aphids on lettuce

Following discussions with a large lettuce grower who had been achieving successful control of aphids in organic outdoor lettuce through the release of parasitoids, it was decided to evaluate the population dynamics of aphids in response to the release of parasitoids in an organic lettuce crop and to determine whether hyperparasitism occurred and whether this could threaten the aphid control provided by primary parasitoids.

A new lettuce planting was monitored on five weekly occasions during the summer. Sampling started on 20 June, one week after the crop was planted. Fifty plants were assessed and for each plant the number and species of aphids, the number of mummies and any aphid predators or pathogens were recorded. Evidence of primary parasitoid emergence or hyperparasitoid emergence was also recorded. Where there was no emergence hole, the mummified aphids were kept in the laboratory until either a primary or a hyperparasitoid adult emerged. The grower released *Aphidius colemani* into the field containing the monitored planting on 20, 27 June and 4 July 2012 at 0.23, 0.35 and 0.47 parasitoids/m^2 respectively. After the conclusion of the weekly monitoring, the farm was visited again on 21 August where two additional lettuce crops where no parasitoids had been released were monitored.

All the aphids recorded during the weekly monitoring were *Myzus persicae.* Aphid populations peaked on 3 July at a mean of 10 aphids per plant which was followed by a population crash. The decline in aphids coincided with a significant number of the aphids being infected with naturally-occurring entomopathogenic fungi. During the monitoring period in June and July only five mummies were recorded, of which 80% were hyperparasitised, 50% of which were identified as *Asaphes* spp. On the additional monitoring date natural parasitism was observed of both *M. persicae* and *M. euphorbiae*. Fifteen mummies were recorded, of which 63% were hyperparasitised. The species responsible were identified as *Asaphes*, *Alloxysta* and *Dendrocerus* spp.

Review of the control of leaf and bud nematodes

Leaf and bud nematodes, *Aphelenchoides sp.,* are a significant foliar pest of hardy nursery stock plants whose feeding results in angular-shaped blotches on the leaves which are delineated by the veins and often accompanied by leaf distortion. Subsequent damage from a LBN infestation can make a plant unmarketable causing significant economic losses for growers. Furthermore, once present in a nursery it is a challenging pest to eradicate due to

its transmission being facilitated by overhead irrigation and its ability to survive for several years in infested dried leaf debris.

This review summarised and collated current and potential alternative control measures for LBN. The review showed that currently the only effective nematicide against this pest in the UK is oxamyl (Vydate 10G) and that stringent nursery hygiene methods and sub-irrigation are key cultural control methods. The potential use and further evaluation of hot water treatments, biological control (bacteria and entomopathogenic nematodes), natural plant extracts/biopesticides and host plant resistance were also discussed.

Financial Benefits

- Biocontrol of aphids usually requires regular releases of parasitoids. High proportions of aphid hyperparasitoids reduce the effectiveness of these parasitoids, resulting in increased losses caused by aphids. Growers will benefit from being aware of this risk on a range of horticultural crops so that they can adapt their IPM programmes if needed.
- Growers are not always confident of using entomopathogenic nematodes for control of vine weevil in strawberry, and are unsure of which product to buy. Growers will benefit from the results in this project that demonstrated that a new nematode product, SuperNemos was equally effective in controlling vine weevil in substrate-grown strawberry as one of the 'standard' products, Nemasys L. Further work will be done in this project during 2013 to compare control of vine weevil by all nematode products available in the UK and by the entomopathogenic fungus Met52.
- Not all growers wish to use oxamyl (Vydate 10G) for control of leaf and bud nematode on HNS, preferring to use high standards of nursery hygiene together with sub-irrigation as key cultural control methods. Growers will benefit from the literature review in this project which identified some potential alternative methods for control which justify consideration for future research.

Action Points

- When selecting nematode products for control of vine weevil, growers should consider their optimum temperature range and cost in addition to available information on comparative efficacy.

- Growers using aphid parasitoids in any crop should be aware that aphid hyperparasitism may occur. Look out for ragged emergence holes in aphid 'mummies' as an indicator that hyperparasitoids are present and monitor percentage parasitism and hyperparasitism.
- Seek advice from your biocontrol supplier or IPM consultant if percentage aphid hyperparasitism starts to increase. You may need to switch from using aphid parasitoids to aphid predators, and/or IPM-compatible pesticides.
- Vydate 10G is the only effective nematicide currently available for control of leaf and bud nematodes in HNS. This pesticide is not compatible with biological control agents used within IPM. Maintaining high standards of crop hygiene together with using sub-irrigation is currently the most effective cultural control measure for this pest.