HORTICULTURE

Grower Summary

SF 156

Improving integrated pest management in strawberry

Annual 2017

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 number:	SF 156
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Report:	Annual report, March 2017
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GROWER SUMMARY

This project addresses the main pest problems reported by the UK strawberry industry, except for spotted wing drosophila (SWD), which is covered in other projects. Within this project, it is planned to work on four objectives over the five year duration:

1. Develop effective biological methods for managing western flower thrips, *Frankliniella occidentalis* (WFT), compatible with pesticide use against SWD, improve the reliability of biocontrol of WFT with predatory mites, and develop effective approaches to the use of entomopathogenic fungi (EPF) for control of WFT.
2. Refine pest control programmes on strawberry, integrating pesticides with phytoseiid mites.
3. Develop IPM compatible controls for European tarnished plant bug (*Lygus rugulipennis*), common green capsid (*Lygocoris pabulinus*), and strawberry blossom weevil (*Anthonomus rubi*).
4. Improve insecticide control of the potato aphid, *Macrosiphum euphorbiae,* so as to be more compatible with IPM programmes.

   For ease of reading, this Grower Summary report is split into sections for each of the objectives being worked upon. In Year 2 of the project, Objectives 1, 2 and 4 were worked on and are reported here.

Western flower thrips

Objective 1 - Develop effective biological methods for managing western flower thrips, *Frankliniella occidentalis* (WFT), compatible with pesticide use against SWD, improve the reliability of biocontrol of WFT with predatory mites, and develop effective approaches to the use of entomopathogenic fungi (EPF) for control of WFT.

Headline

- Advances in monitoring western flower thrips and *Neoseiulus cucumeris* in strawberry crops have been made.

Background and expected deliverables

At present, growers rely on introductions of the predatory mite *Neoseiulus cucumeris* (formerly called *Amblyseius cucumeris*) to control WFT. It is relatively inexpensive to release and can be introduced in large numbers. However, *N. cucumeris* only predates first-instar WFT larvae. Biocontrol with *Neoseiulus cucumeris* sometimes fails. The reasons for failure are not well understood but are thought to be caused by insufficiently early or frequent introductions, poor predator viability and/or adverse effects of crop protection programmes. For effective biocontrol, a high proportion of flowers must contain *N. cucumeris*. It is difficult to assess whether *N. cucumeris* populations have established adequately and whether they are in balance with their prey and so developing grower-friendly methods for estimating WFT and *N. cucumeris* predator-prey ratio thresholds in relation to fruit damage would be very useful.

In the first year of the project, different flower and fruit stages were assessed to determine which plant parts should be used to improve sampling strategies. Fruit consistently had higher numbers of *N. cucumeris* than any flower stages, so button fruit were chosen as the stage to be used for assessing numbers of *N. cucumeris*. Methyl isobutyl ketone was shown to be effective as a fumigant to extract arthropods from button fruit, with higher numbers recorded by extraction compared to 'by eye' assessments of flowers or fruits. A prototype monitoring device making use of this fumigant extraction method was constructed and initial experiments showed promise, but further testing is necessary.

Data were collected from commercial crops where *N. cucumeris* had been released by the growers. Results of the occurrence of *N. cucumeris* and WFT in individual flowers and button fruit indicated aggregation for both species. Results from this analysis have been used to develop a prototype model to estimate the maximum mean number of WFT in a sample of a given size to ensure the probability of low levels of fruit damage. However, these data did not cover a sufficiently large range of WFT and *N. cucumeris* densities and more data (with a wider range of thrips and predatory mite numbers) are needed to develop a more reliable model.

Strawberry crops need a second line of defence against WFT, such as curative spray treatments of entomopathogenic fungi (EPF). For effective control of a target pest, spores of an EPF strain have to adhere to the pest's cuticle, then germinate and penetrate the cuticle to cause mycosis. Efficacy requires an adequate number of spores to adhere in vulnerable parts of the body, then adequate high humidity and temperature for a sufficient period for spore germination and infection. Mortality occurs after a few days, but insects stop feeding, moving and reproducing well before death. Unfortunately, grower experience with spraying EPFs for controlling thrips in strawberries has been disappointing. In the first year, results from bioassays showed some promise for the use of EPF for WFT control within an IPM system, if application and spore retention are good. In the first year experiments to determine if the efficacy of entomopathogenic fungi to control WFT can be improved, three adjuvants were tested in conjunction with the EPF Naturalis L in laboratory bioassays and replicated field experiments. Effects on WFT mortality and on spore deposition, both on the treated surface and on treated thrips, were assessed. WFT mortality was low in these experiments. However improvements to bioassay techniques have been made during 2016 which were used in future assays. No significant difference in deposition/retention of spores could be identified between adjuvants following spraying. However, significantly higher deposition/retention was observed on flowers compared to leaves in all treatments.

Summary of the project and main conclusions

Extraction device for determining predator-prey ratios

An experiment was set up to derive predator and prey data for inclusion in the model to predict likely damage scenarios with particular ratios of *N. cucumeris* to WFT. However, despite three releases of 100 *N. cucumeris* per plant very few mites were found on the plants after release. The very low numbers of *N. cucumeris* recorded after high rates of application were unexpected and this requires further investigation to understand the dispersion of predators on plants after predator release. Since very few *N. cucumeris* were recorded on the button fruit or flowers, it was not possible to develop the modelling aspect of the project further in 2016.

However, the use of methyl isobutyl ketone in a prototype extraction device was effective at removing *N. cucumeris* and thrips adults and larvae from plant material. Field assessment of the device is now needed.

Control of WFT using entomopathogenic fungi

The new EPF formulation of Met52 OD (Fargro), which is recommended for use as a foliar spray, was tested in a laboratory bioassay against adult female WFT using a direct dosing method. The concentration 1.25L in 300L water equates to the aim of depositing 250 spores per mm^2 in the field for an effective dose to be applied. Results from bioassays show some promise for the use of EPF for WFT control within an IPM system, if application and spore retention are good. There were two experiments, similar in their methodology: in the first experiment there was 44% higher WFT mortality after 6 days at the highest label dose compared to the untreated control. In the second experiment there was over 40% WFT mortality after 6 days and nearly 70% mortality after 8 days, at the highest label dose, compared to the untreated control. However, it should be noted that there was around 40% WFT mortality in a blank oil control.

Financial benefits

Western flower thrips, *Frankliniella occidentalis* (WFT), causes bronzing of fruit and has become difficult to control because of resistance to crop protection products and lack of effective alternative biological controls. Financial losses can be high, exceeding £15m to the UK industry alone in 2013. This project is testing new approaches to monitoring and control of

WFT whilst maintaining control of other pests, particularly by conserving and improving efficacy of introduced arthropod biocontrol agents and entomopathogenic fungi in the crop.

Action points for growers

- Sample button fruit to determine establishment of *N. cucumeris* in the crop.
- Sample mid-aged flowers to determine thrips numbers in the crop.
- The new EPF formulation, Met52 OD (Fargro) is available in 2017 for use as a foliar spray against WFT in strawberry.
- Consider reducing the number of repeated applications of tank mixes of plant protection products as these may be harmful to introduced *N. cucumeris*.

Integrating pesticides with phytoseiid mites

Objective 2 - Refine pest control programmes on strawberry, integrating pesticides with phytoseiid mites.

Headline

- Repeated applications of some fungicides can cause reductions of *N. cucumeris* numbers in the crop. This can be alleviated by further applications of *N. cucumeris.*

Background and expected deliverables

Predatory mites such as *Neoseiulus cucumeris* can form a very successful part of Integrated Pest Management (IPM). However, they can be vulnerable to plant protection products, including, potentially, fungicides. Also, increased use of plant protection products against other pests, such as SWD, can potentially interfere with IPM. In addition, although some plant protection products have been shown to be safe or only slightly harmful to *N. cucumeris* in single applications, in the field, products are applied multiple times, and in tank mixes. In year 1 we demonstrated that tank mixes of Nimrod/Teldor and Signum/Systhane and Aphox/Rovral had a detrimental effect on *N. cucumeris* numbers in strawberry. However, adverse effects were only statistically significant after the third spray application, suggesting that previous studies in the literature might have underestimated the toxicity of these products to *N. cucumeris* under normal commercial usage.

Summary of the project and main conclusions

For effective biocontrol of WFT with *N. cucumeris*, crop protection products safe to the predator need to be integrated into the overall management programme. Some compounds that are regarded as relatively safe for predatory mites, may be applied multiple times, and combined in tank mixes, where they may act additively or synergistically against the predator. In Year 2 we tested Calypso (thiacloprid) and potassium bicarbonate+Activator90, products that the industry had suggested could be harmful to *N. cucumeris* over multiple applications or in tank mixes. These were compared to Nimrod+Teldor applications, a treatment tested in the previous year. We also tested whether a secondary addition of *N. cucumeris* could mitigate any effects of these spray treatments.

N. cucumeris were released onto strawberry plants before the trial began and three applications of plant protection products were applied, with assessment of adult and immature *N. cucumeris* numbers on button fruit made after each application. No evidence was found that Calypso, potassium bicarbonate+Activator90 or Nimrod+Teldor had a detrimental effect on *N. cucumeris* populations. An additional release of *N. cucumeris* after the second spray treatment led to an increase in adult *N. cucumeris* in the crop.

Neither Calypso nor the secondary addition of *N. cucumeris* had a significant effect on thrips numbers. However, there were significantly lower numbers of thrips in the potassium bicarbonate+Activator90 treated plots compared to the water controls. The reason for this is not clear.

Financial benefits

From a pest like western flower thrips (WFT), strawberry growers can typically lose 20% or more of their fruit. For a crop yielding 30 tonnes/ha, this equates to 6 tonnes/ha and at a value of £2,400 per tonne, losses of £14,400 per hectare.

Frequent introductions of high numbers of predatory mites such as *Neoseiulus cucumeris* are not only expensive to purchase, but costly to introduce by hand. Potential damage or disruption to the mites caused by the use of harmful fungicide mixes or other crop protection products will lead to reduced efficacy of control and hasten the onset of WFT induced damage, resulting in further financial losses.

It is therefore vital that growers are better informed of those fungicide mixes or other products which may have an adverse effect on the expensive predatory mites which have been introduced.

Action points for growers

- Consider reducing the number of repeated applications of tank mixes of plant protection products as these may be harmful to introduced *N. cucumeris*.
- Careful thought needs to be given to the tank mixes used, ensuring that thrips and tarsonemid control is achieved early before SWD enters the crop and requires insecticide treatments.

Potato aphid

Objective 4 - Improve aphicide control of the potato aphid, *Macrosiphum euphorbiae,* so as to be more compatible with IPM programmes.

Headline

- Good spray coverage of strawberry crops is required in order to achieve effective control of potato aphid, *Macrosiphum euphorbiae*, in spring when plants are relatively compact.

Background and expected deliverables

Several species of aphid are regularly found affecting strawberry crops. Five of the most frequently found and most damaging are the strawberry aphid (*Chaetosiphon fragaefolii*), the melon and cotton aphid (*Aphis gossypii*), the shallot aphid (*Myzus ascalonicus*), the glasshouse-potato aphid (*Aulacorthum solani*) and the potato aphid (*Macrosiphum euphorbiae*). Damage is caused by direct feeding which may distort plants, contaminate fruits with honeydew and sooty moulds (e.g. *Aphis gossypii* and *Macrosiphum euphorbiae*) and vector viruses, such as mottle virus (e.g. *C. fragaefolii* and *A. gossypii*). Aphicide resistance further complicates management of these pests. Populations of the melon and cotton aphid are, for example, known to be resistant to pyrethroid and carbamate products.

The Defra HortLINK project HL0191 (SF 94) demonstrated that product applications in the autumn may effectively reduce numbers of potato aphid on the crop the following spring. It is, however, not always possible to time applications in the autumn and so product applications in the spring may be required. There is a need to identify which products would be more effective under cooler spring temperatures before crops have begun to grow and when the canopy is still relatively compact.

In recent years growers have reported increasing problems in controlling the potato aphid, *M. euphorbiae*. Difficulty in controlling this aphid pest appears to be linked to the need for good spray coverage (AHDB Horticulture project SF 140). This problem is being exacerbated by the strawberry growing season being bought forward and extended by protected cropping with crops under fleece and tunnels and a reducing range of products available, with recent withdrawals of chlorpyrifos and pirimicarb.

Summary of the project and main conclusions

Two experiments to investigate the improvement of potato aphid control were completed; Experiment 1 was done in a ventilated research polytunnel. The experiment was a randomised block design with 5 replicates of each treatment (Table 1) including an adjuvant only and an untreated control. Each replicate consisted of a single potted strawberry (*Fragaria* x *ananassa*) plant (cv. Driscolls Diamond). All plants used were infested with potato aphids. Products were applied using an air assisted knapsack sprayer using a water volume of 1,000 l/ha.

Table 1. Treatments

Treat No.	Product	Active ingredient	Product dose (/ha)	HI	EAMU Approval
1	Hallmark with zeon technology 100g/l CS	lambda-cyhalothrin	0.075 l	3 d	1705/11
2	Hallmark with zeon technology 100g/l CS + Silwet L-77	lambda-cyhalothrin + trisiloxane ethoxylate	0.075 l 0.25 l		*
3	Calypso	thiaclorprid	0.250 l	3 d	2132/14
4	Calypso + Silwet L-77	thiacloprid + trisiloxane ethoxylate	0.250 l 0.25 ml		*
5	Chess 50% w/w WG	pymetrozine	0.400 kg	3 d	0504/07
6	Chess 50% w/w WG + Silwet L-77	pymetrozine + trisiloxane ethoxylate	0.400 kg 0.25 ml		*
7	Silwet L-77	trisiloxane ethoxylate	0.25 ml	-	-
8	Water control	-		-	-

*Note that strawberry crops are not permitted to be sprayed at full label rates when applied together with Silwet L-77 and should instead be sprayed at 50% of the full label rate.

Analysis of data for all assessments and additional comparisons between the separate treatments indicated that the treatments could be separated into three groups based on product efficacy. ‘Group A’ gave 100% control (Hallmark and Hallmark + Silwet), ‘Group B’ (Calypso and Calypso + Silwet) gave moderate control initially (approx. 75% reduction in aphids numbers three days after spray application) but aphid numbers started to increase again eight days after spray application and 'Group C' (Chess, Chess + Silwet, Silwet and the water control) gave no control . No significant difference was found between Chess and Chess + Silwet when compared with Silwet or the water control. Where complete control was not achieved there was evidence that a greater proportion of aphids in the crown of the plant survived the spray application than aphids on other parts of the plant.

Experiment 2 was done in controlled environment rooms and was a fully randomized experiment with 5 replicates of each treatment (Table 1) including a Silwet applied on its own, a water control and an untreated control. Each replicate consisted of a single aphid infested strawberry leaf (cv. Elsanta). In order to validate results from Experiment 1 and to determine the importance of spray coverage this experiment was divided into two bioassays. In the first bioassay, uninfested fully expanded strawberry leaves were sprayed on both surfaces to run-off and allowed to dry by placing the leaves on several layers of tissue paper before infesting each leaf with 20 potato aphid nymphs (1-3 instar). The second bioassay was prepared in the same way; however, leaves were infested with 20 potato aphid nymphs before spraying to run-off and allowing to dry. After spraying, the petioles of the leaves were wrapped in damp tissue paper and leaves were placed separately in filter paper lined Petri dishes (90 mm diameter). Each leaf was maintained in a Petri dish in a controlled environment room set to 20ºC and 60% RH.

The treatments Calypso, Calypso + Silwet, Hallmark and Hallmark + Silwet killed all aphids regardless of whether the aphids were directly sprayed or placed onto a leaf that had already been sprayed. Hallmark and Hallmark + Silwet gave 100% kill within 24 hours in both cases whereas Calypso and Calypso + Silwet gave 100% kill within 24 hours only when aphids were directly sprayed. Chess + Silwet and Silwet applied on its own killed all aphids but only when aphids were directly sprayed. Chess applied without Silwet did not kill all aphids when aphids were directly sprayed or placed onto a leaf that had already been sprayed. Aphid mortality on leaves sprayed with water or left untreated was low.

Financial benefits

Potentially, if not controlled, aphid infestations can lead to complete crop loss. No quantitative data on industry average losses resulting from aphid infestation is available but conservatively assuming that 1% of the crop is lost, this is equivalent to 507 tonnes of strawberries; worth £2.1 million p.a.. Improved control as a result of this work would reduce the scale of these losses considerably.

Action points for growers

- Consider autumn applications (post-harvest) of aphicides for aphid control as these have been shown to reduce populations of aphids found in crops the following year.
- Carefully monitor both aphid numbers and their associated natural enemies within crops to determine the need for aphicide sprays.
- Where spring applications are considered necessary, growers should ensure that there is good spray coverage, in particular the undersides of leaves and the crown of the plant. Consider the use of water sensitive papers to visualise how effectively spray applications achieve this.
- Some populations of aphid pests such as the melon and cotton aphid (*Aphis gossypii*) have developed aphicide resistance. Growers should ensure that they follow resistance management guidelines on the product label and rotate between products with different modes of action.
- It is important to carefully consider the compatibility of the available product options with aphid natural enemies as well as the biological control programmes used to control other pests of strawberry crops.