Grower Summary

SF 156

Improving integrated pest management in strawberry

Annual 2016

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Date project completed (or expected completion date):	31 March 2020

GROWER SUMMARY

Headline

The overall aim of this project is to increase the efficacy of existing IPM measures and explore new and emerging controls for the most damaging strawberry pests whilst maintaining control of spotted wing drosophila, *Drosophila suzukii* (SWD), thus enhancing the growth and profitability of the UK strawberry industry.

Within this project, it is planned to work on four differing 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.
    - 1.1. Improve the reliability of biocontrol of WFT with predatory mites, particularly *Neoseiulus cucumeris.*
    - 1.2. Develop effective approaches to the use of entomopathogenic fungi (EPF) for control of WFT.
    - 1.3. Investigate more effective predators for 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. The first year's work concentrated solely on Objectives 1 and 2, so only these are reported on in this first annual report.

Objective 1 - Develop effective biological methods for managing western flower thrips, Frankliniella occidentalis (WFT), compatible with pesticide use against SWD

Headline

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

Background and expected deliverables

In the first year of the project the major target was western flower thrips (WFT). Except for SWD, WFT is currently the most serious pest of UK strawberry and financial losses can be high. WFT is difficult to control because it is resistant to all crop protection products currently available to UK strawberry growers.

At present, growers rely on introductions of the predatory mite *Neoseiulus cucumeris* (formerly called *Amblyseius cucumeris*) to control WFT. It is relatively inexpensive to mass produce and can be introduced in large numbers but only predates first-instar WFT larvae. However, biocontrol with *Neoseiulus cucumeris* sometimes fails. This is usually due to 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*. Growers find it difficult to assess whether *N. cucumeris* populations have established adequately and whether they are in balance with their prey. It is crucial to develop grower-friendly methods for estimating WFT and *N. cucumeris* populations in relation to fruit damage and to develop attendant predator-prey ratio thresholds for interpreting relative populations.

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. There are three existing EPF products currently available in the UK:

1) Naturalis L (Belchim): sprayable formulation containing *Beauveria bassiana* approved for control of aphids, beetles and whitefly in protected edibles and ornamentals.

2) Met52 granular biopesticide (Fargro); granular formulation containing *Metarhizium anisopliae* incorporated into growing media for control of a wide range of pests including thrips and vine weevil in a wide range of crops, including strawberries. A liquid (sprayable) formulation of this product is under development by the parent company, Novozymes.

3) Mycotal (Koppert); sprayable formulation containing *Lecanicillium lecanii* approved for control of whitefly in a wide range of protected crops, including strawberries.

Unfortunately, grower experience with spraying these products for controlling thrips in strawberries has been disappointing. Another approach for exploiting EPFs is to apply them to the growing media.

Expected deliverables in Year 1:

- Development of a rapid and easy method of assessing populations of western flower thrips and *N. cucumeris* and their distribution on flowers and fruits suitable for use by agronomists.
- Determine whether the addition of adjuvants significantly improves spore distribution, adhesion and biological efficacy of EPFs against WFT.

Summary

To gain the background information needed to develop effective sampling strategies and treatment thresholds for WFT, samples of individual flowers and 'button' fruit were collected from two commercial crops, where *N. cucumeris* were being released, every two weeks from April to September. In addition, replicate samples of different plant parts, from unopened flowers to ripe fruit, were collected twice from each of two plantings to determine the distribution of pest and predator over the plant. One-off collections of flowers and fruit were also made from 12 crops that had different levels of WFT on the plants. Numbers of WFT and *N. cucumeris* were extracted and recorded in the lab and the data used to determine the most effective sampling strategy for *N. cucumeris* and to model the interaction between pest and predator.

In experiments to develop a field-based extraction/monitoring system, three fumigants were tested in replicated experiments for their efficacy in extracting

WFT and *N. cucumeris* from flowers and fruit. The most effective fumigant was used successfully in a prototype extraction/monitoring device in the field. Further development of this system will be done in 2016.

To determine if a method could be developed to enable *N. cucumeris* to be more easily visualised on plants, lab experiments were undertaken to assess the efficacy of staining the mites with CalcoRed, but this proved to be ineffective.

In 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 Q1 2016 and will be 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. Samples were also collected for testing by a molecular technique (QPCR); this method requires further development to give reliable results and CFU counts should be used for future assessments. Results from these experiments have been used to refine protocols for use in laboratory and field experiments in 2016.

The main findings of the research from year 1 are:

- Potentially the most appropriate plant part to sample to assess numbers of *N. cucumeris* in strawberry crops is young button fruit.
- Mid aged/old flowers are the most appropriate stages to sample to assess numbers of adult WFT present.
- There was no consistent pattern of distribution for thrips larvae, with larvae being found in flowers and on fruit
- Thrips and *N. cucumeris* were extracted easily from plant samples in the field using the fumigant methyl isobutyl ketone (MIK).
- A prototype monitoring device making use of the MIK fumigant extraction method was constructed and will be field tested in 2016.
- A preliminary analysis of distribution of *N. cucumeris* and WFT was completed. The maximum mean number of WFT in a sample of a given size to ensure the probability of less than 5% fruit damage with different damage thresholds has been calculated.

- Improved bioassay protocols have been developed for assessing the efficacy of entomopathogenic fungi against WFT in 2016.

Financial benefits

Western flower thrips, *Frankliniella occidentalis* (WFT), causes bronzing of the 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

- Inspect 'button' fruit to determine if *N. cucumeris* have established and assess numbers of thrips larvae in the crop.
- Continue to monitor thrips adults in mid-aged flowers.
- Monitor and make repeated releases of *N. cucumeris* as necessary.

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

Headline

- Growers should be aware that repeated applications of some fungicides can cause significant reductions in predatory mite populations

Background and expected deliverables

The efficient and successful use of predatory mites relies on careful coordination of crop protection product spray strategies to maintain predators in the crop. This coordination forms part of Integrated Pest Management (IPM) and can work very successfully. However, strawberries are vulnerable to attack by other pests, including SWD, leading to an increase in use of crop protection products which are not always compatible with IPM programmes. Information is needed on how control products used for SWD and other pests and diseases can be used without disrupting interactions between WFT and *N. cucumeris*. Studies also suggest that tank mixtures of fungicides and insecticides can have synergistic effects on mite toxicity whilst spray timing in relation to mite release may also be crucial.

Expected deliverables in year 1:

- Demonstration of which tank mixes are harmful to *N. cucumeris* on strawberry.

Summary

To determine if the reduction in *N. cucumeris* numbers often seen in commercial crops is due in part to applications of various crop protection products, the effect of repeated applications of three commonly used tank mixes of fungicides that are classed as harmless to predatory mites were compared to spinosad and assessed in a replicated field experiment. The fungicide mixes included Amistar (azoxystrobin) & Rovral (iprodione), Nimrod (bupirimate) & Teldor (fenhexamid) and Signum (boscalid + pyraclostrobin) & Systhane (myclobutanil). The aphicide/fungicide mix of Aphox (pirimicarb) & Rovral (iprodione) was also included. These mixes were chosen in consultation with growers and assessed in a replicated field experiment. It should be noted that products already known to be toxic to predatory mites were excluded. *N. cucumeris* was released onto the plants before the trial began and three applications of the fungicide mixes were applied, with assessment of predator numbers made after each application.

No significant treatment effects were found for the pre-assessment and first two assessments when analysed separately. However the third assessment showed a significant reduction in *N. cucumeris* numbers exposed to repeated applications of Nimrod/Teldor and Signum/Systhane. Tracer and Aphox/Rovral did not affect numbers of *N. cucumeris* on the strawberry leaves. A repeated measures analysis of the entire sample set showed a reduction in phytoseiid mite numbers through the course of the trial for Nimrod/Teldor and Signum/Systhane, as well as Aphox/ Rovral.

A widely used website associated with a biocontrol company defines Nimrod (bupirimate) and Signum (boscalid + pyraclostrobin) as safe to *N. cucumeris* and Teldor (fenhexamid) as only slightly harmful. Systhane (myclobutanil), was described as safe to the related species *Amblyseius californicus*. Growers could therefore assume that application of these compounds would be fully compliant with an IPM programme, when in fact these results suggest that this might not be the case where repeated applications are made.

Aphox was already reported as harmful to *N. cucumeris* (Koppert side effects guide, 2016). Although Aphox use on strawberries will be restricted from 2016, applications of Aphox could explain past biological control failures.

Each treatment was applied three times and it was only after the third application that significant differences in phytoseiid mite numbers were found. Hence, small cumulative impacts on *N. cucumeris* populations might be significant over time. A similar pattern has been reported for the use of phosalone on apple trees, where a single application had no effect on predatory mite numbers, but two applications reduced the population (Raudonis et al, 2004).

It is also possible that the compounds in tank mixes combine additively or even synergistically, so that the effect is greater than that of each individually, but this needs to be confirmed.

In summary, these results suggest that repeated applications of fungicides can have a detrimental effect on predatory mite populations.

Financial benefits

The two most damaging pests to strawberry at present are the spotted wing drosophila and western flower thrips. If left uncontrolled, both can cause total loss of crop.

If certain crop protection products are used to control spotted wing drosophila, they can disrupt the biological control programme employed for western flower thrips and other pests of strawberry, thereby resulting in serious or total crop loss caused by WFT and other pests. For this reason, it is important to research and develop improved integrated pest management programmes which avoid such an imbalance in the pest/predator ratio.

Similarly, if the typical crop protection spray programme used for other pests or fungal diseases is not sympathetic to the predatory mites being employed to control WFT and other strawberry pests, then IPM programmes will break down and lead to major crop losses.

Assuming a typical return for strawberries of £2.30/kg to growers (Defra Basic Horticultural Statistics 2014) and a yield of 20 tonnes/ha, then total crop loss would lead to a financial loss of £46,000/ha. The development of a reliable integrated pest management programme which does not fail, can therefore save growers from making such heavy losses.

Action points for growers

- Consider reducing the application of tank mixes of fungicides as these may be harmful to introduced predatory mites.