Grower Summary

SF 165

Improving Integrated Pest Management in Strawberry

Annual 2019

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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 there will be work on five 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.
5. Improve the control of aphids through the growing season.

For ease of reading, this Grower Summary report is split into sections for each of the objectives being worked upon. In Year 4 of the project, Objectives 1, 2, 3 and 4 were worked on and are reported here.

Objective 1. Develop effective biological methods for managing western flower thrips, *Frankliniella occidentalis* (WFT), compatible with pesticide use for control of spotted wing drosophila, *Drosophila suzukii* (SWD)

Task 1.1 Develop and determine the efficacy and ease of use of the prototype extraction device for WFT and the predatory mite *N. cucumeris* in commercial strawberry crops, by agronomists and growers

Headline

- An extraction device has been developed for detecting *N. cucumeris,* thrips, *Orius,* and predatory thrips in strawberry button fruit samples and could be produced ready for growers and agronomists to use.

Background and expected deliverables

In 2015, the fumigant methyl isobutyl ketone (MIK), 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 (see 2016 Annual Report). Three prototype monitoring devices, making use of this fumigant extraction method, were constructed. Following grower/advisor feedback on the different designs and prototypes, a 'Tupperware' type device was chosen for further development based on its robustness, ease of use, and transparency.

Following initial laboratory studies in 2016 to assess the efficacy of the device in extracting thrips and mites from flowers and fruit, further laboratory and field experiments were carried out in the summer and autumn of 2017 to achieve a more thorough calibration of the device with *N. cucumeris*. Laboratory findings indicated that around 57% of the mites that were present on the button fruit were recovered. However, under field operation with more variable conditions and using a hand lens rather than a microscope, the recovery of mites from button fruit using the extraction device represented a much lower proportion (27%). In 2018, the objective was to finalise calibration of this device using the following four trials:

1. Improve MIK dispenser release
2. Determine the minimum time for maximum *N. cucumeris* extraction
3. Determine the maximum number of uses from the MIK dispenser
4. Confirm temperature effects on *N. cucumeris* extraction

Summary of the project and main conclusions

To improve release of MIK and improve operator handling, three different MIK dispensers were tested in the labroratory. After 10 minutes, the best dispenser for field testing from an operator perspective contained two ‘size 2’ dental rolls saturated in the fumigant. These fitted securely into the dispenser, preventing escape and lowering user contact exposure. They produced a higher MIK release than the dispenser used in 2017 (25 mg in 10 minutes as opposed to 14 mg). As a result, this dispenser was selected for field tests.

To determine the minimum time for maximum arthropod extraction, the extraction device was tested in the field at five different exposure times (1, 3, 5, 10 and 20 minutes) on samples of 20 strawberry button fruits. Subsequently, the percentage of arthropods extracted was compared for each exposure. Overall, for *N. cucumeris*, pale thrips and dark thrips, as duration of exposure to MIK increased, the percentage of extraction increased in the device up to 10 minutes. After this time there was no significant increase. The mean percentage of *N. cucumeris* extraction levelled off at 57% which is similar to laboratory findings in 2017 after 20 minutes of exposure (57.8% and 58.4%), although the percentage of *N. cucumeris* extraction in the field in 2017 was lower (27%). Mean numbers of *Orius* and aphids were too low for statistical analysis. As a result of these findings a 10 minute exposure period was selected for the remaining two field trials.

To determine the maximum number of uses from the MIK dispenser, arthropod extraction was assessed in the field using 30 dispensers, prepared with previous uses ranging from 0 to 57. The number of MIK uses, up to 57 times, resulted in no significant difference in the percentage of *N. cucumeris,* pale thrips or *Orius* extracted from strawberry button fruit. For predatory thrips, there was also no significant difference, but mean numbers were very low. For dark thrips there was a significant difference, but again mean numbers were low. Overall mean percentage of *N. cucumeris* extracted was 21.8%, less than half that found in the second trial (57%), but numbers in the crop were also low. Correspondence with the grower confirmed *N. cucumeris* had stopped being released nearly two weeks prior to this trial. Mean percentage *N. cucumeris* extraction appears more variable when the mean number of mites on button fruit samples is below ten, although this requires further testing for confirmation. Findings here indicate that the MIK dispenser developed in Trial 1 is suitable for at least 57 uses, though given the low numbers of *N. cucumeris* upon which this assumption is based, a repeated test would be advised.

To confirm the temperature effects on *N. cucumeris* extraction, five daily time points were selected (09.00; 12.00; 15.00; 18.00; 20.00) to achieve varying temperatures, then samples of 20 button fruits were exposed to MIK at each time point in the field. Subsequently, the percentage of arthropods extracted from the button fruits at each time point and corresponding temperature were analysed. Findings showed that the mean percentage of *N. cucumeris* extracted was not significantly linked to time of day, or average temperature, however mean percentage extraction did appear to follow a pattern, whereby it was lowest at the beginning and end of the day when average temperatures were coolest, and highest mid-afternoon when average temperature was warmest. During this experiment, the effect of temperature was not fully explored. Average temperatures ranged from 13.9 °C at 20:00 to 20.7 °C at 15:00. It may be that the percentage of extraction is significantly affected by temperature, but outside this range. To assess this possibility, further studies at more extreme temperatures are recommended. The highest mean percentage of *N. cucumeris* extracted was 44.5% at 15:00. Of the other arthropods extracted, mean numbers were low.

If using the device to estimate numbers of *N. cucumeris* in the crop, temperature should be taken into consideration. In 2017, it was found that a 1 °C increase in mean temperature could result in an approximate 2.5% reduction of numbers of *N. cucumeris* counted in sample units (e.g. strawberry button fruits).

Financial benefits

Western flower thrips (*F. occidentalis*) causes bronzing of fruit. It has become difficult to control because of resistance to crop protection products and a 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

- Test the practicality of the extraction device for detecting *N. cucumeris* and thrips compared to existing methods.
- Sample button fruit to determine establishment of *N. cucumeris* in the crop.
- Sample mid-aged flowers to determine thrips numbers in the crop.
- 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 *D. suzukii* enters the crop and requires treatment.
- Reduce use of crop protection products where possible to ensure that *N. cucumeris* gains control of WFT before *D. suzukii* control is needed.

Task 1.2. Testing *Metahzium brunneum* (strain F52) against biological control insects used in strawberry production

Headline

- Met52 is a commercially available biopesticide to control thrips, among other insects. Contact experiments concluded that Met52 has minimal effect on the viability of beneficial insects, even under ideal conditions for Met52 and hence Met52 EC is recommended for growers to use on their strawberries.

Background and expected deliverables

The Monsanto marketed product Met 52 EC, containing the active ingredient *Metarhizium brunneum* strain F52 in an emulsifiable oil for suspending in water, is sold through Fargro in the UK. It is anticipated that it will become available to UK growers in 2019 for the control of pests such as thrips, whitefly and mites on commercially grown crops including strawberries. At present, the label does not show natural enemy compatibility. However, Fargro say that under the IOBC Classification system for non-target effects on augmentative and native biological control insects (Hassan, 1992), Met52 is classified as harmless against *Amblyseius swirskii*, *Macrolophus caliginosus* and *Nesidiocoris tenuis*. It is compatible (EPA tox) with *Chrysopa* spp. and *Nasonia vitripennis* and it is anecdotally okay against *Orius* spp. and *Hypoaspsis miles*. Testing is underway for *Encarsia formosa*, *Eretmocerus eremicus* and *Phytoseiulus persimilis*. Its status is unknown for *Feltiella acarisuga* and *Aphidius* spp. Therefore, bioassays were carried out, testing Met52 (as product Met52 EC or the spores only F52) against three commercially produced natural enemy products (Chrysopa, Aphidalia and Ervipar), to fill a knowledge gap so that growers may best know how to utilise it within their growing systems.

To determine the effect of Met52 on beneficial insects regularly purchased and used in the UK strawberry growing system, two tasks were conducted:

1. A literature review on effects of *M. brunneum* strain F52 (the active ingredient of Met52) against western flower thrips and natural enemies.

2. The effect of *M. brunneum* strain F52 spores and Met52 EC was investigated on natural enemies used in UK strawberry growing systems.

Summary of the project and main conclusions

To establish which natural enemies had already been tested for effects of F52, a literature review was conducted prior to the commencement of work.

In the literature review, two abstracts referred to the effects of F52 on non-target organisms directly (Saito & Brownbridge, 2016 and EFSA, 2012). Saito and Brownbridge (2016) exposed soil-dwelling predators (a rove beetle, *Dalotia coriaria* (Kraatz); predatory mites, *Stratiolaelaps scimitus* (Womersley) and *Gaeolaelaps gillespiei* (Beaulieu) to filter papers treated with Met52 EC. They found only *D. coriaria* was significantly affected by exposure to the high dose of Met52. EFSA (2012) Annex IIM 8; HIM 10 shows that there is evidence that direct application of Met52 to *Orius majusculus* (insidious flower bug) (dripping onto the insect at a rate of 5.1 x 108 CFU /mL) causes 70% mortality after seven days. In addition, 37% mortality after 12 days has been noted for *Chrysoperla carnea* (common green lacewing), through dietary exposure of Met52 at 4.2 x 105 CFU/mL, and 31% mortality was observed after 22 days for *Hippodamia convergens* (convergent lady beetle) (Coccinellidae).

The literature review showed that some work on the effects of Met52 EC on beneficial insects has already been studied. However, there is little information available about the main natural enemies which are used in cropping systems in the UK. The experimental work in this study will therefore be focused on the main beneficials used in the UK strawberry system.

The experimental work was divided into two parts: firstly, the active ingredient of Met52 EC, *Metarhizium brunneum*, was tested on five natural enemy products: Aphiscout (*Aphidius colemani, Aphidius ervi, Aphelinus abdominalis, Praon volucre* and *Ephedrus cerasicola*), Chrysopa (*Chrysoperla carnea*), Thripor-L (*Orius laevigatus*), Aphidalia (*Adalia bipunctata*) and Ervipar (*Aphidius ervi*). First a ‘dipping assay’ method was employed and secondly ‘spray contact assays’ were performed on the three products which showed the highest mortality levels in the dipping assay (Chrysopa, Aphidalia and Ervipar). All experiments were carried out at the recommended field rate for Met52 EC.

The results for the dipping assay, where the insects were submerged in the recommended dose of *M. brunneum* spore suspension showed that Aphiscout and Chrysopa had mortality levels around 50%. For Thripor-L and Aphidalia there was around 65% mortality and 70% mortality in Ervipar three days after treatment. This was a worse-case scenario and is unlikely to happen in the field.

The spray contact assays consisted of a recommended rate tank mix of Met52 EC sprayed onto strawberry leaves using a Burkard Computer sprayer, allowed to dry, prior to insects being placed on the leaves for three days before removing the leaf. Three products; Chrysopa, Aphidalia and Ervipar, were tested. The results showed that there was around 20% death of the Chrysopa and Aphidalia treatments and less than 10% death of the Ervipar treatment after three days. The conditions used in the assays were the best for fungal growth and hence in the field it is likely that these effects will not be as high as in this experiment.

It was concluded that Met52 EC is likely to have little significant effect on survival of Thripor-L, Ervipar, Aphiscout, Aphidalia and Chrysopa products when applied to UK strawberry system.

Financial benefits

Western flower thrips (*F. occidentalis*) causes bronzing of fruit. It has become difficult to control because of resistance to crop protection products and a 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

- Use of Met52 EC is recommended for use by UK strawberry growers and is likely to have minimal impact on beneficial organisms.

Task 1.3. Investigate the potential of garlic grown in strawberry bags to reduce pests in the crop.

Headline

- Planting garlic in a strawberry crop may reduce the numbers of aphids in the crop.

Background and expected deliverables

In 2017, a strawberry grower reported that intercropping garlic and periodically breaking garlic leaves within the strawberry crop, could reduce the prevalence of thrips. This effect had not been quantified alongside an untreated crop. However, there is experimental evidence in other crops showing that garlic intercropping can reduce the prevalence of pests.

To investigate the pest control potential of garlic intercropping, during the summer of 2018, NIAB EMR conducted a garlic trial on a commercial everbearer strawberry plantation in Kent.

During the trial, a group of strawberry plots were intercropped with garlic and garlic leaves were broken fortnightly and laid on to the crop. Alongside these were another group of strawberry plots without garlic. Assessments were made fortnightly in both groups of plots to determine if the garlic treatment could deter the main strawberry pests, without adversely affecting beneficials. Here we aimed to determine if this method of intercropping garlic is a feasible pest control option for everbearer strawberry.

Summary of the project and main conclusions

The trial was set up in a commercial strawberry plantation in Kent in everbearer varieties. The plantation was divided into two sections according to strawberry plant age: 1st or 2nd year. Within each plant age, four plots were intercropped with garlic and four comparable plots were not intercropped. In the garlic plots, garlic cloves were planted in mid-May, then approximately a month later, a garlic leaf from every plant was snapped off and laid on to the strawberry plants. This continued fortnightly until the end of the trial on 23 August.

Assessments were divided into two phases: pre-assessments and full assessments. Pre-assessments occurred between the planting of garlic cloves and the snapping of garlic leaves. Full assessments occurred during the period that garlic leaves were being snapped. Assessments were made in all plots, with and without garlic, and involved:

- Examining 20 strawberry plants for the presence of aphids.
- Examining 20 strawberry button fruits for the presence of *N. cucumeris* and thrips.
- Tap sampling 20 strawberry plants for capsids and natural enemies.

Throughout the assessments the main aphid species recorded was the strawberry aphid (*Chaetosiphon fragaefolii*). Of the key findings, fewer *C. fragaefolii* occured in first year strawberry plantings than second year plantings. More mummified aphids, parasitoids and predatory spiders were also present in the older crop.

During most full assessments, the garlic treatment significantly reduced *C. fragaefolii* in strawberry compared to untreated strawberry. It is hypothesised that breaking garlic leaves may release compounds which repel aphids and is sustained by the continuous presence of garlic plants in the crop. However, this is yet to be confirmed. Also it is unclear whether the reduction in numbers of *C. fragaefolii* is significant enough to reduce damage to the crop.

More predatory spiders were counted in garlic treated strawberry than the untreated strawberry. Garlic possibly provides a structure on which to spin webbing, but this also remains to be confirmed.

Encouragingly garlic did not significantly affect numbers of the predatory phytoseiid mite, *Neoseiulus cucumeris*, indicating that garlic does not have a negative impact on this natural enemy. However, thrips (adults and larvae) were similarly unaffected. This is in contrast to the observations made by the grower who employs this approach. Differences between our approach and the grower's approach included climatic conditions, the variety of garlic planted and possibly the higher frequency in which the grower's staff break garlic leaves.

Financial benefits

The estimated cost of applying this garlic treatment was £263-395/ha per year. This includes purchase, splitting, planting, breaking-leaves, harvesting and labour. However this can be more expensive. Another grower with experience of intercropping garlic has informed us that it can cost up to £1,000/ha (personal contact). In our trial there was no loss to the grower in terms of spaces taken up in grow bags for garlic, because two spaces were free in each. However, this may also need to be taken into consideration.

Action points for growers

NOTE: during this trial although there is evidence of a reduction in aphid numbers, it is unclear whether this resulted in less aphid damage, so if adopting these proposed action points do so with caution. For growers wishing to trial the use of garlic, follow these action points:

- If planning to test garlic intercropping to control thrips, plant a hard neck variety such as 'Violet' in autumn for control the next year, although control of thrips using this method is still anecdotal.
- For maximum effect consider planting garlic every 1 metre along the crop row.
- When the garlic plants are established, snap leaves at least fortnightly and lay these on the strawberry crop.
- Continue to apply *N. cucumeris* and other pest control products at the usual rate in garlic treated strawberry.
- Renew strawberry plantings each year to reduce the chance of aphid numbers building up.

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

Headline

- A one-year study demonstrated that the persistence of Hallmark and Calypso in strawberry in early spring did not reduce numbers of the predatory mite *N. cucumeris.*

Background and expected deliverables

This field study looked at the effect that aphicides, commonly used to target spring aphids, have on the establishment of *N. cucumeris* and other predators. In order to make rational decisions on the release of this predator, during the spring time, it is important to determine whether *N. cucumeris* is affected by plant protection products applied for aphid control.

Summary of the project and main conclusions

The experiment was set up on a commercial table top of 2nd year June bearer strawberry. On 7 March plots were sprayed with either field rates of lambda-cyhalothrin (Hallmark) or thiacloprid (Calypso) and compared to an untreated control. The experiment was a randomised block design with six replicates of each treatment including an untreated control. *N. cucumeris* releases were made at a rate of 200 mites per plant.

On 23 February a pre-assessment was done followed by three post-spray assessments. At each assessment the numbers of *N. cucumeris* adults, nymphs and eggs on either, leaves, flowers or button fruits (depending on availability) were recorded by collecting 30 samples from each plot.

At the beginning of this trial the weather was unusually cold for the time of year. During the trial no thrips were recorded but tarsonemid mites were found in the young folded leaves over the duration of the trial, providing a source of food for *N. cucumeris*.

The establishment of *N. cucumeris* adults, immature forms and eggs were not affected by one application of either Hallmark or Calypso applied to target spring aphids. Indeed following three releases of *N. cucumeris* the population indiscriminately increased over the time in control and treated plots.

The newly emerging folded leaves and flowers where *N. cucumeris* was detected had very little or no target product residue, potentially enabling the predatory mites to establish and reproduce (evidenced by the presence of eggs and nymphs). Hallmark, which is suggested to have a persistence of activity against *N. cucumeris* of between 8 and 12 weeks, did not appear to have an adverse effect on mite releases in the field, in this trial.

Financial benefits

Growers invest substantial sums in the purchase and release of biocontrol agents. Knowledge that an early spring spray targeted against aphids is unlikely to affect subsequent releases of *N. cucumeris* is helpful to encourage biocontrol as soon as possible and before numbers of thrips and tarsonemid proliferate.

Action points for growers

- Release *Neoseiulus cucumeris* early in strawberry crops to control western flower thrips and tarsonemid mite.
- It is better to use products that are not sympathetic to IPM programmes early in the season to control aphid if needed, than to rely on introduced biological controls and wild natural enemies as the temperature increases.
- *N. cucumeris* should be introduced into the crop frequently through the growing season. Added to parasitoids for aphids and Orius for thrips control, these can mitigate the need for later insecticide applications which disrupt thrips control.
- Growers need to couple this with control of SWD and control of non western flower thrips species (see Objective 6)

Objective 3. Develop IPM compatible controls for European tarnished plant bug, *Lygus rugulipennis*, common green capsid, *Lygocoris pabulinus*, and strawberry blossom weevil, *Anthonomus rubi*.

Headline

- Although the push-pull of capsid bugs was successful in 2017, the low numbers of capsid in 2018 resulted in levels of strawberry damage which were too low to draw any conclusions this year.

Background and expected deliverables

Push-pull is a strategy with the potential to control capsidsi n strawberry. The strategy uses a stimulus to repel the capsids away from the crop (push), in combination with another stimulus (pull) which attracts them to a trap surrounding the crop where they are concentrated and eliminated. Besides pest control, additional benefits of the technique are likely to include a reduced need for chemical plant protection products (PPP) and an elevation of natural enemies in the crop.

In UK strawberry, the European tarnished plant bug (*Lygus rugulipennis*) and the common green capsid (*Lygocoris pabulinus*) are two potential targets for push-pull. *L. rugulipennis* can cause up to 80% crop loss due to misshapen fruits. In everbearers, it requires routine treatment with plant protection products, usually from June onwards. *L. pabulinus* may also be a damaging pest. Products currently used for control can disrupt biological control agents and increase residue levels in fruits.

In summer 2017, NIAB EMR generated promising data after trialing a push-pull strategy for capsids in four commercial everbearer strawberry crops in Kent. Findings showed significantly reduced numbers of capsids and damage to fruits in crops where the push was applied (either alone or in combination with a pull).

In 2018, the objective was to continue the development of this push-pull strategy. Field trials were performed in four everbearer strawberry plantations in Kent, to test: 1) whether a significantly improved push could be achieved when using the 2017 push in combination with a second one, 2) capsid damage (cat-facing of the fruit) could be reduced where treatments were applied and 3) if the additional push also attracts natural enemies into the crop.

Summary of the project and main conclusions

The experiment was conducted between July and September in four tunnel grown commercial strawberry plantations in Kent. To compare the different push-pull variations, each plantation was divided into the following four equal sized plots;

1) A push-pull plot, where the push was the same as 2017.
2) A push-pull plot, testing a new push.
3) A push-pull plot, testing the 2017 push with the new push and.
4) A control plot with no push or pull.

The pull was the same as 2017, consisting of traps holding a lure and a killing agent, positioned at regular intervals around the perimeter of the push-pull plots.

Fortnightly assessments were made in all four plots at each of the four plantations. Assessments consisted of tap samples of 50 strawberry plants for capsids and natural enemies within the plots, counts of capsids in traps around the perimeter of push-pull plots and damage assessments of approximately 100 strawberries within the plots, at each visit.

In 2018 results were inconclusive. Capsid numbers from both tap samples and trap counts were low (lower than 2017) and therefore unsuitable for statistical analysis. The same applied to natural enemy numbers. Results from the fruit damage assessment showed no significant difference between any of the push-pull variants and the control, unlike in 2017. Climatic conditions in 2018 were unusual in being very warm and dry. This is believed to have contributed to the low capsid counts.

Financial benefits

Lygus rugulipennis (European tarnished plant bug) and *Lygocoris pabulinus* (common green capsid) are serious pests on everbearer strawberries causing crop losses by feeding on developing fruits which become deformed and unmarketable. Over 50% of fruit may be downgraded as a result of capsid feeding in unsprayed crops. The development of improved trap and monitoring systems for capsids will help growers to identify the exact time of their appearance in the crop, allowing control measures to be implemented at the optimum time.

Should traditional spray control products be employed, the numbers required can be reduced by applying at the optimum time, saving money on unnecessary sprays. Novel control methods such as the 'push-pull system' will help to reduce reliance on traditional control products, which will further reduce crop protection costs for growers. Such a system will also enhance biological control methods employed for other pests, increasing their efficacy and reducing the need to introduce additional numbers of predatory mites, further reducing costs.

Action points for growers

- There are no grower actions points for growers at this stage of the research.

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

Headlines

- A single application of the approved product Batavia or the coded product AHDB9966 gave durable (up to three weeks) and effective control of the melon-cotton aphid.
- Applications of two other coded experimental spray treatments (AHDB9934 and AHDB9951) were also very effective at killing aphids and protecting strawberry plants.

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-cotton aphid (*Aphis gossypii*), the shallot aphid (*Myzus ascalonicus*), the glasshouse-potato aphid (*Aulacorthum solani*) and the potato aphid (*Macrosiphum euphorbiae*).

In recent years the control of early season aphids such as the potato aphid has become more problematic due to the withdrawal of commonly used aphicides. The remaining options often have limited efficacy (AHDB Projects SF 140 and 156) and there is little evidence that biological controls are effective at the low temperatures experienced in early spring. The **potato aphid** causes damage to the crop through the production of honeydew and cast skins which result in sooty moulds making the fruit unmarketable. Feeding action of these aphids can also result in distortion of the leaves and fruit. The species may breed all year round on strawberry crops if conditions allow and populations can build up rapidly in the spring.

Outbreaks of **melon-cotton aphid** are also a concern for strawberry growers, and like the potato aphid, it causes feeding damage and contaminates fruit with honeydew and cast skins. In addition, melon-cotton aphids are known to be resistant to multiple classes of plant protection products, so this species can be very difficult to control.

The aim of this work was to assess the potential of plant protection products (without current approvals for strawberries) to control melon-cotton aphid. Comparisons were made with untreated control plants and with plants treated with four approved products (Batavia, Flipper, Met52 OD and Majestik).

Summary of the project and main conclusions

- Single applications of the coded product AHDB9966 and the approved insecticide product Batavia gave effective control of melon-cotton aphid on strawberries.
- Effective aphid control was also achieved using two applications of two further coded products: AHDB9934 and AHDB9951.
- The other products tested were not associated with statistically significant reductions in aphid numbers. These included “softer” products such as Flipper, Majestik and Met52 OD. However, in practice, growers are likely to apply these treatments using shorter spray intervals than used in this experimental trial.

Financial benefits

Potentially, if not controlled, aphid infestations can lead to complete crop loss. No quantitative data on industry average losses from aphids is available but conservatively, assuming that 1% of the crop is lost, this is equivalent to 1,316 tonnes of strawberries; worth £2.7 million per annum (Defra Horticultural Statistics 2018). Improved control as a result of this work would reduce the scale of these losses considerably.

Action points for growers

- Batavia provides effective control of melon-cotton aphid and other aphid species which damage strawberries. However, application of this product to strawberry crops (both protected and unprotected) is restricted to the pre-flowering period. Two applications of Batavia are permitted each year, but it can only be applied up to 14 days before flowering and not during the flowering / cropping period.
- Carefully consider early season control sprays and wherever possible, choose benign products which are sympathetic to aphid parasitoids and any biocontrol agents being employed to control other pests.
- To help inform product selection, visit website: https://www.koppert.com/side-effects/ or http://www.biobestgroup.com/en/side-effect-manual

Objective 6. Fill key gaps in knowledge on Thrips fuscipennis biology in strawberry crops so that IPM strategies can be developed

Headline

- Adults of five thrips species that can damage strawberry fruit were confirmed at four sites during 2018 where rose thrips had been the predominant species in 2017.

Background and expected deliverables

Western flower thrips (WFT, *Frankliniella occidentalis*) is a serious pest of strawberry, feeding on flowers and developing fruits leading to damaged bronzed fruits, which are unmarketable. ADAS has recently identified the presence of rose thrips (*Thrips fuscipennis*) in strawberry flowers where fruit bronzing is occurring. Often rose thrips has been the predominant species in mixtures of species including the rubus thrips (*Thrips major*). At sites where fruit damage attributed to rose thrips has occurred, some growers have been using IPM programmes based on *Neoseiulus cucumeris* and good control of WFT has been achieved. However at the same sites, rose thrips have not been controlled and growers have needed to apply plant protection products including spinosad (Tracer) to prevent further fruit damage. There is concern that, like WFT, rose thrips could develop resistance to Tracer and other control products. In addition, the number of Tracer applications permitted on each crop is limited and growers may prefer to reserve these for control of spotted wing drosophila (SWD).
Adult female rose thrips and other *Thrips* species are darker than WFT and fruit damage often seems to occur soon after 'dark' thrips adults are noticed in the flowers, so it is possible that rose thrips and possibly other thrips species adults are migrating into the crop and damaging the fruit before they start reproducing. Adult thrips would not be controlled by *N. cucumeris*, which only feeds on first instar WFT larvae. The predatory bug *Orius laevigatus* will feed on thrips adults as well as larvae. However, *O. laevigatus* needs high temperatures to establish and they are sensitive to a number of crop protection products.

The aims of the project are to:

1. Determine when adult thrips species activity starts in strawberry crops and identify peaks in numbers between March and August inclusive.
2. Determine if larvae of species other than WFT develop in strawberry flowers.
3. Record fruit damage associated with *T. fuscipennis* and other thrips species in flowers.

Summary of the project and main conclusions

- Adults of five thrips species that can damage strawberry fruit were recorded at four sites in 2018 where fruit damage attributed to rose thrips had occurred during 2017.
- The earliest thrips species recorded during May in the June-bearer crops were the onion thrips (*Thrips tabaci*) and the rubus thrips (*Thrips major*). Mean numbers were less than one per flower and only slight fruit damage occurred.
- The rose thrips (*Thrips fuscipennis*) was recorded at all four sites and was the predominant species during June in the two outdoor everbearer crops in Essex and Buckinghamshire, with mean numbers peaking in late June and early July at 0.8 and 1.5 per flower. Rose thrips numbers peaked in early August in the tunnelled crops in Kent with means of three and 0.6 per flower.
- Numbers of the combined species peaked on 11 July in the two outdoor everbearer crops at around four adults per flower and these were mainly the flower thrips (*Frankliniella intonsa*), with means of 3.1 and 1.9 per flower. This species occurred in much higher numbers than usual in strawberry flowers in 2018, possibly due to the unusually hot summer. Severe fruit damage due to *F. intonsa* occurred in Denmark in 2018 where mean numbers exceeded 20 per flower.
- In the two tunnelled everbearer crops, numbers of thrips adults peaked on 3 August and 20 September at 46 and 13 adults per flower respectively and these were mainly western flower thrips (WFT).
- Low numbers of thrips larvae were found in flowers in the outdoor everbearer crops during July and August and these are likely to be species other than WFT. Thrips larvae were found in higher numbers in the two tunnelled everbearer crops between July and early October and these are likely to be mainly WFT. Thrips larvae at all sites will be identified during 2019.
- Fruit damage was only slight in the two outdoor and one of the tunnelled everbearer crops. The damage may have been caused by a mixture of *F. intonsa*, *T. fuscipennis*, *T. tabaci* and *T. major* adults in the two outdoor everbearer crops and is likely to have been caused by WFT in the tunnelled crop. More severe damage occurred in the second tunnelled everbearer crop where high numbers of WFT led to a mean of 7.3% fruit area bronzed. However, this is below the 10% fruit area bronzed that is considered to be the threshold at which fruit is downgraded.
- However, *F. intonsa*, *T. fuscipennis*, *T. tabaci* and *T. major* adults may also have contributed to the damage. More severe damage occurred in the second tunnelled everbearer crop where a maximum mean of 7.3% fruit area was bronzed. However, this

is below the 10% fruit area bronzed that is considered to be the threshold at which fruit is downgraded. WFT was the dominant species in this crop but *F. intonsa*, *T. fuscipennis*, *T. tabaci* and *T. major* adults may also have contributed to the damage.

- Numbers of thrips in the two outdoor everbearer crops are likely to have been kept below damaging levels by a combination of released predators (*N. cucumeris* and *Orius*) and naturally-occurring predators including the banded wing thrips and by plant protection products applied for the control of SWD.
- An effective IPM programme needs to be developed for control of a range of thrips species that can cause fruit damage, including components for control of both adults and larvae. The biology and behaviour of thrips species other than WFT on strawberry is currently largely unknown. *Orius* is likely to feed on both adults and larvae of all thrips species but it needs warm temperatures to establish and these do not occur every year. In addition *Orius* is very susceptible to some of the products applied for control of other pests such as SWD. Although most thrips species other than WFT still seem to be susceptible to plant protection products, there is a risk of resistance developing so reliance on control with such products is not sustainable.

Financial benefits

Western flower thrips can cause financial annual losses to the UK strawberry industry in excess of £15m if IPM techniques are not deployed. Financial loss due to other thrips species is still not known, but these species have the potential to cause severe losses if effective IPM strategies are not developed in future.

Action points for growers

Thrips control should be planned as part of an Integrated Pest Management (IPM) programme. Until effective strategies are developed for thrips species other than WFT, the IPM programme should be the same as that commonly used against WFT. Useful guidance is set ou in AHDB Factsheet 14/15. The salient points are summarised below:

- Release the predatory mite *Neoseiulus cucumeris* regularly throughout the season from first flower. The minimum release rate should be 25 per plant every week or fortnight, increasing to 50 per plant if numbers of thrips start to increase.
- Apply the ground-dwelling predatory mites *Statiolaelaps scimitus* (formerly known as *Hypoaspis miles*) once at about 10 per plant. It is not yet known how effective this species is against larvae of thrips species other than WFT that might drop to the ground to pupate, but as they are effective against WFT it is a sensible option.

- Release *Orius laevigatus* in addition to *N. cucumeris* once temperatures are suitable. This predator needs a minimum of 15 °C for egg laying and over 20 °C for good establishment. Commonly used release rates are a minimum of 0.25 to one *Orius* per plant, repeated after two weeks. *Orius laevigatus* are very sensitive to plant protection products so avoid using any that are harmful (consult your supplier or adviser).
- Some growers use blue roller traps in the leg rows to help control WFT adults in strawberry but there is no evidence yet that these also help to control adults of other thrips species. Colour preference in other thrips species is being investigated in this project during 2019.
- If fruit bronzing is seen, consider using an IPM-compatible plant protection product for control. Options include spinosad (Tracer) but growers may wish to reserve this for control of SWD. Do not use Tracer if only WFT are present as they are likely to be resistant to this product. Consult your agronomist to seek help in getting the thrips species identified and for choosing a plant protection product if required.