Grower Summary

SF174

Improving integrated pest management in soft fruit crops.

Annual report Year 1 2021

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Location of project:	NIAB EMR, growers' holdings
Industry Representative:	**Chairman:** Stephen McGuffie **Industry representatives:** Andrey Ivanov, Steve Greenaway, Cristian Marmandiu, Richard Harnden
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[The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.]

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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GROWER SUMMARY

The UK soft fruit industry is experiencing a period of change which offers opportunities for new and novel pest control options. Brexit, coupled with uncertain crop protection product approvals, losses of actives (and associated product resistance), emerging and invasive pests, and climate change offer the industry an opportunity to explore and exploit novel control methods. These will span cultural to bio-control products for integration into pest management strategies for long lasting control, building up resilience through conservation biology and augmented applications of natural enemies.

The project covers a range of strategies targeted at key pests of soft fruit crops identified by AHDB soft fruit panel including capsids, thrips, early-season aphids and midges. We aim to test and integrate solutions that are often applicable across the range of soft fruit crops, including cane fruits, strawberries and blueberries whilst considering control measures being applied for spotted wing drosophila (SWD).

In the first three years of this project we will: 1) research and report on new and emerging pests which pose a future threat to UK soft fruit production, informing the industry ahead of potential pest outbreaks, allowing better preparation for prevention and control options; 2) test the efficacy of the repellent successfully used in strawberry to control capsid in cane fruit and optimise the dispensing method for the repellent compound; 3) investigate the ability of Orius to predate the capsid juvenile stages for use under warmer, summer, temperatures; 4) determine whether early season aphids can be kept in check with a novel biocontrol strategy utilising mass releases of hoverflies with semiochemical attractants for retention in the crop; 5) determine winter survival of parasitoids in aphids in strawberry crops and how insecticide use in the autumn and spring can be adjusted to protect these key natural enemies; 6) gain scientific data on efficacy of floral margins on soft fruit crop protection and potential to harbour pest species to inform growers on sowings; 7) pilot test a ‘push-pull’ method to prevent non-western flower thrips entering strawberry crops and causing fruit damage; 8) develop a culturing method for thrips so that cost effective experiments can be done to understand the biology, damage and control strategies for future use and, finally; 9) field test a semiochemical push pull strategy for control of midges in cane fruit.

For ease of reading, this Grower Summary report is split into sections for each of the work packages listed above.

WP1. Identify and report new and emerging pests which pose a future threat to UK soft fruit production (Year 1-2, Lead; NIAB EMR, Contributors; ADAS, JHI, NRI)

Headline

- A range of future potential pest threats to the soft fruit industry have been identified.

Background and expected deliverables

Whilst there continues to be successes in pest control strategies, changing climate (Sharma 2016; Taylor et al. 2018), the introduction of invasive pests into new territories (Early et al. 2016) and resistance to a declining selection of Plant Protection Products (PPPs) (Lamichhane et al. 2016) raises new challenges for food production. It is estimated that arthropod pests destroy up to 20% of annual crop production worldwide, at a value of more than US$470 billion (Fried et al. 2017; Sharma et al. 2017). In the last decade, in the UK, growers of soft fruit crops have been required to shift from the use of broad-spectrum PPPs to fewer selective PPPs combined with biopesticides, augmented and conservation biocontrol, cultural practices and novel semiochemical manipulation of insect pest populations to reduce the incidence and damage caused by pests. However, the removal of some broad-spectrum PPPs in combination with a warmer and more unpredictable climate can result in higher populations and unpredictable outbreaks of familiar, native and non-native species (Hulme 2016). Increased movement of plant material around the globe (Chapman et al. 2017) also leaves UK fruit production vulnerable to new pests, which often thrive in the extended season and warmer temperatures created by protected cropping. Hence, new monitoring tools for both arthropod pests and their natural enemies are needed in combination with new, less environmentally damaging approaches that can be integrated, but not at the detriment of other pest outbreaks. The reduced range of PPPs inevitably results in the same products being applied to crops sequentially, hence other control measures are needed which can be interspersed with remaining conventional PPPs, but which have different modes of action to reduce the occurrence of resistance to remaining products.

Summary of the project and main conclusions

The team of scientists working on this project attended national and international meetings to report back potential new and invasive pests of soft fruit crops. This has been summarised in the tables listed in the Science Section of this report, along with selected references and web links. There has been liaison with AHDB, Fera, Defra’s Animal and Plant Health Agency (APHA) and the Royal Horticultural Society (RHS). EPPO and CABI databases have also been searched to identify and alert growers and agronomists to potential new pest problems.

Future potential pest threats to the UK soft fruit industry are summarised in tables in the Science Section of this report, including their Species / Common name, Geographic distribution, Hosts / Crops, Symptoms, Description, Control used in other parts of world, Monitoring and potential Risk for soft fruit.

Current threats include:

- two species of thrips; Japanese flower thrips and flower thrips
- a true bug; Brown Marmorated Stink Bug
- a whitefly; honeysuckle whitefly
- a scale insect; white peach scale
- two beetles; Japanese flower beetle and whitefringed weevil
- several tortix moths; strawberry tortrix, Blastobasis, lesser apple leaf-folder, *Acleris nishidai*, *Acleris fimbriana*, yellow tortrix moth and snowy-shouldered acleris moth

In addition, a spider mite threatens to cause damage in glasshouse crops; *Tetranychus mexicanus*. Details of useful literature including links to keys are also included in the Science Section. Another beetle species has been raised as a potential concern, but little information has been found on this to date (*Anthonomus bisnignifer*).

Financial benefits

Native and non-native pests are increasing as a result of increased transport of goods around the world and fewer approved broad-spectrum products. These are likely to have a financial impact on fruit growers. Spotted wing drosophila is a good example of an invasive pest which has arrived in the UK in recent years, resulting in significantly increased management and control costs for soft fruit growers.

Action points for growers

- Growers and their agronomists should remain vigilant to new pests in the UK.
- All imported plant material should be isolated and rigorously checked before planting.
- Non-native species should be reported to Defra's Animal and Plant Health Agency: https://www.gov.uk/government/organisations/animal-and-plant-health-agency/about/access-and-opening
- Note that information in this report was correct at the time of writing.
- All control options employed by growers should be checked with a BASIS qualified adviser.

Task 2.1. To investigate the efficacy of the *Lygus rugulipennis* repellent compound for control of capsid species in cane fruits

Headline

- The synthetic semiochemical push (previously tested as part of a push-pull system in commercial strawberry) also reduces numbers of capsid nymphs (common green capsid, *Lygocoris pabulinus*) and capsid damage to fruit and leaves in commercial raspberry.

Background and expected deliverables

Recently, during two years of replicated field trials, successful control of the European tarnished plant bug *Lygus rugulipennis* was achieved in strawberry, using a synthetic semiochemical push-pull approach. A semiochemical 'push' was deployed in the crop in combination with a semiochemical 'pull' in green cross vane funnel traps at regular intervals around the crop perimeter (AHDB Project SF 156). The approach significantly reduced numbers of *L. rugulipennis* (adults and nymphs) in the crop and reduced fruit damage by up to 90% in organic strawberry. Cane fruits are also damaged by *L. rugulipennis*, along with the common green capsid, *Lygocoris pabulinus.*

Capsid control usually requires routine spray control treatments. However, the current plant protection products (PPP) employed to control capsids can disrupt biological control agents and increase product residues in fruits. Moreover, there are continuing restrictions on chemical PPP use (pan-europe.info. 2008) and a trend to promote the use of non-chemical alternatives (eur-lex.europa.eu. 2009). A semiochemical push-pull approach could therefore offer a useful alternative to growers.

The main aim of this trial was to find out whether the semiochemical push can reduce capsid numbers in the crop and damage to fruit in cane fruits. In summer 2020 a trial was set up in a commercial raspberry crop. The trial also studied whether distributing the semiochemical at alternating heights throughout the crop canopy improved efficacy.

Summary of the project and main conclusions

Between June and September 2020, a field trial was done in a raspberry plantation in Kent with a known history of capsid damage to fruits and foliage. The objective was to generate data to demonstrate that the semiochemical push could control capsids in cane fruits. The push was the standard formulation used in push-pull trials in commercial strawberry in 2017 and 2019. The raspberry plantation was divided into six replicates, each divided into the following three equal sized plots to test two methods of deploying the semiochemical push;

- Capsid repellent sachets deployed every 2 m along the row at 1 m height
- Capsid repellent sachets deployed every 2 m along the row, but at alternating staggered heights 0.5, 1.0 and 1.5 m
- An untreated control

We also tested whether the semiochemical push had side effects on numbers of beneficials or caused phytotoxicity to raspberry plants.

Fortnightly assessments were made in all plots. Assessments per plot consisted of:

1. Tap samples of 100 young lateral stems, counting capsids and beneficials
2. Damage assessments of approximately 100 raspberries
3. Damage assessments of approximately 100 young leaves
4. A phytotoxicity assessment after 1 month attachment of the repellent to young lateral stems

Both push treatments significantly reduced numbers of capsids in the crop as well as damage to fruit and young leaves. Treatments had no clear adverse effect on numbers of beneficials counted in the crop, due to low numbers sampled, so this may need further investigation. However, previously in strawberry, push-pull treatments had no adverse effect on numbers of beneficials counted in the crop. The repellent did not cause any detectable phytotoxic effects to the raspberry plants.

Financial benefits

L. rugulipennis causes damage in raspberry and *L. pabulinus* terminates fruiting laterals in this crop (Cross 2004). Up to 100% of fruit can become downgraded because of capsid damage to raspberry. Capsid bugs can also taint the fruit with their odour. During the trial in 2020, we observed an 8% increase in undamaged fruit where the push was applied compared to untreated plots. *L. pabulinus* is also a damaging pest of blackcurrant, apple, pear and cherry. Recent changes to PPP approvals have seen registration withdrawal for key capsid controlling products in the EU, including the broad-spectrum organophosphate chlorpyrifos, and more recently, the neonicotinoid thiacloprid. This repellent strategy offers a comparable alternative to PPPs and is IPM compatible.

Action points for growers

- Monitor for capsids around the crop from spring:

    - For *L. rugulipennis* use a standard green bucket trap (Unitrap) with green cross-vanes (no bee excluder grid) baited with synthetic attractants and water, with a drop of detergent as a drowning solution.
    - For *L. pabulinus* use a blue sticky trap baited with synthetic attractants.
- *L. rugulipennis* overwinter as adults in weeds surrounding soft fruit crops, breeding in spring and then adult offspring migrate into crops late June/early July.
- *L. pabulinus* overwinter as eggs in young shoots of various shrubs and trees. Nymphs of the first generation emerge in April or May.
- The semiochemical repellent used in these studies is not currently approved for pest control by CRD and this should be a focus for the AHDB, working with the industry to secure some form of registration and approval.
- Management of weeds that host capsids in and around the crop is recommended. Weed hosts include groundsel, mayweed, fat-hen, nettle, dock and common mugwort.
- Weedy areas could be replaced with perennial wildflowers which host a range of natural enemies and pollinators important to fruit crops as these can outcompete undesirable weeds.

Task 2.2. Dose and method of deployment of capsid repellent in strawberry and cane fruit (Year 1-2, Lead; NIAB EMR, Contributors; NRI, Russell IPM)

Headline

- A commercial product to repel capsids from crops is under development.

Background and expected deliverables

In previous work under AHDB Project SF156, successful control of *Lygus rugulipennis* was achieved in strawberry in two years of replicated field trials using a push-pull approach based on synthetic semiochemicals (Fountain et al. 2021). The repellent "push" component, hexyl butyrate, will require registration with CRD before it can be used by commercial growers. It is a component of the sex pheromone of several *Lygus* species, is registered as a food additive and is a GRAS compound (Generally Regarded as Safe), although it does not fall into the straight-chain Lepidopteran pheromone (SCLP) category given fast-track registration by the EU. To date, monitoring of crops containing the repellent has not revealed any adverse effects on natural enemies but this will continue to be monitored in all future experiments. Thus, there is a good prospect that registration will be relatively straightforward and the requirements for this are being explored by Russell IPM and CRD.

The objective of this work package is to develop commercial formulations of the capsid repellent and to evaluate them in the field. As well as formulations of hexyl butyrate alone, blends with methyl salicylate are being evaluated. Formulations are being optimised through laboratory release rate measurements during 2020 with the aim of developing a suitable formulation(s) for evaluation in field trials during 2021.

Summary of the project and main conclusions

Following discussion and feedback between NRI and Russell IPM, candidate commercial formulations of hexyl butyrate with and without methyl salicylate were prepared by Russell IPM using blister-pack technology. Release rates from these were compared with rates from low density polyethylene (LDPE) sachet formulations prepared at NRI and used in the previous trials to date. The "standard" sachet was 5 cm x 5 cm x 120 µm sachet containing hexyl butyrate (1 ml) impregnated onto a cotton dental roll. The "long-life" dispenser was the same sachet containing 5 ml hexyl butyrate impregnated on two dental rolls. Samples were tested for longevity under laboratory conditions.

Initial studies compared release rates from two blister pack formulations of hexyl butyrate (HB) alone with those from NRI standard and long-life sachets at 22°C. Release rates were unexpectedly higher than those originally measured (21 mg/d), with the two Russell IPM formulations releasing at half the rate of the standard NRI formulation. Although the laboratory temperature during these 2020 measurements was nominally 22°C, the very hot weather meant that this was very variable, occasionally reaching 34°C. Thus, all further experiments were carried out in a temperature-controlled room at a more reliable 27°C.

In the next series of experiments, release rates were measured from the standard Russell IPM blister pack formulation of hexyl butyrate and two new formulations designed to increase the release rate to match that from the standard NRI sachet. Also provided were blister pack formulations containing blends of hexyl butyrate with methyl salicylate at 50:50, 95:5, and 0:100, respectively. The standard formulation of HB, the increased release rate (HET 1) and the formulations with methyl salicylate all released at a similar rate (80-100 mg/d) to that of the NRI standard sachet (107 mg/d). The fast release rate formulation released at over three times the rate, but all these formulations lasted less than 10 days under the wind tunnel conditions. Blending the hexyl butyrate with ethanol apparently gave a more sustained release.

As the blister pack containing hexyl butyrate in ethanol seemed to give a more persistent formulation, in the third series of experiments two formulations of hexyl butyrate in ethanol were compared with a blister pack containing ethanol only. The 4:1 blend of hexyl butyrate and ethanol released hexyl butyrate rapidly (520 mg/h) and lasted less than 10 d. The 1:4 blend of hexyl butyrate and ethanol was more persistent and was still releasing hexyl butyrate after 15 d at approximately 50 mg/d allowing for the concomitant release of ethanol.

The Russell IPM blister packs provide a convenient, commercially available formulation of HB for use in control of capsids by a push-pull approach. The studies show that the standard blister pack formulation containing 1 g HB in 4 g paraffin oil releases the HB at a rate (approx. 80 mg/d) comparable to that from the standard NRI polyethylene sachets (approx. 100 mg/d) used in all previous push-pull field trials. Furthermore, the HB could be combined with methyl salicylate (hoverfly attractant), in a single formulation with release rate proportional to the proportion of compound in the blend.

However, both the blister pack and polyethylene sachet formulations had an unexpectedly short lifetime at 27ºC and 8 km/h windspeed. Preliminary studies suggest this can be extended by mixing the hexyl butyrate with ethanol which is released simultaneously.

Financial benefits

The capsid repellent is being formulated with and without hoverfly attractant into a commercially affordable product. The 2021 trials will test increasing the spacing of the devices to further reduce cost.

Action points for growers

Whilst a commercial repellent product for capsids is being developed, there are no specific action points for growers.

Task 3.5. Ability of floral margins to support natural enemies and pests in proximity to soft fruit crops (Year 1-2, Lead; NIAB EMR)

Headline

- Wildflower margins are a source of natural enemies and pollinators and should be considered for sowing adjacent to soft fruit crops to hasten the influx of beneficials to the neighbouring crop.

Background and expected deliverables

A literature review has recently been prepared for the AHDB on the impact of organic treatments and floral margins for pest and disease control in orchards. In addition, an Interreg project (BEESPOKE) is aiming at designing bespoke floral margins to encourage pollinating insects into flowerings crops. In 2019, a replicated experiment of floral margins was sown around the WET Centre at NIAB EMR not only to reduce run-off from polytunnel structures but provide secondary benefits of boosting natural enemies and pollinators in the vicinity of the tunnel (Holistic Water for Horticulture, HWH).

Several research studies, and growers themselves, have implemented floral margins which are thought to benefit strawberry crops but with very little evidence of the species or phenology of natural enemies in the crop or which flora might be attractive to crop pests.

Crops themselves do not provide the diversity that most natural enemies need to establish a stable and growing population throughout the year (Ramsden et al. 2017). A properly managed floral resource could provide a food source for natural enemies in the form of alternative prey, pollen and nectar, and as a shelter and overwintering habitat.

In the first year of this study, we aimed to;

1. Compare three floral treatments to an unsown control.
2. Monitor the establishment and floral resource in the margins.
3. Identify key natural enemies utilising floral margins.
4. Identify pest species inhabiting specific flora.
5. Establishing floral margins in commercial farms in the vicinity of soft fruit crops for 2021 trial.

Summary of the project and main conclusions

NIAB EMR WET Centre

In the first year the replicated plots (unsown, sainfoin, chicory, perennial meadow mix (EM1)) that had established around the WET Centre (strawberry crop) at NIAB EMR in 2019, were surveyed for soft fruit natural enemies and pest species in May, June, July, and August of 2020. Records of vegetation cover were also made in July. Floral units were identified, and invertebrates extracted using the extraction device, developed in AHDB Project SF 156, along with ethanol extraction to monitor for thrips species that may be attracted to floral margins. Thrips adults, relevant to strawberry production, were identified to species.

Floral margins

All sown plots established successfully. Single species plots had more than 90% coverage of the sown species, sainfoin and chicory. The EM1 meadow seed mix covered 72% of the plots with wild carrot and common knapweed being the better-established flowering species. Single species plots like sainfoin and chicory had shorter flowering periods than unsown and EM1 plots. Longer flowering periods provided a better food and habitat resource for natural enemies and pollinators.

Arthropods in floral margins

There was a higher abundance of beneficial arthropods in the margins of the strawberry crop in May and June. Floral resources were also adequate in July, but some arthropod groups like beetles, ladybirds and moths declined. This may be related to life cycle and/or dispersal away from the plots. The meadow mixture (EM1) had a higher floral resource in June. Arthropod group diversity was highest with approximately 1 specimen of each group recorded per 1.5 m^2. Chicory plots had fewer arthropods when compared with all other treatments. In August, unsown and EM1 plots were dominated by predatory spiders, and groundbugs thought to be from genus *Nysius* (not a soft fruit pest).

Herbivores in floral margins

Most arthropod herbivores or potential soft fruit pests found during this trial were capsids and aphids. No strawberry pest aphids were found in the floral resources. Aphids were only present in May and June and were particularly widespread in sainfoin plots. Capsid were thought to be breeding in sainfoin as higher numbers of nymphs were recorded in sainfoin in June. Most of the nymphs were common green capsid. Numbers of herbivores declined in

July. No aphids or capsid nymphs were found in July and August. Three capsid species were identified using the floral margins: Common green capsid, European tarnished plant bug and potato capsid. Common green capsid was found in high numbers in all treatments except in chicory. The meadow mix (EM1) was less attractive to capsids than the unsown treatment.

Thrips on flower heads

Unsown species like dandelion, bindweed, hawkbit, white clover and yarrow had, on-average, greater numbers of thrips (two per flower head) than sown species (Park et al. 2007). In June, yarrow contained on average 5.2 ±1.0 *Thrips tabaci* per flower, known to affect soft fruit crops. White clover had 5.1 ±4.1 *Frankliniella intonsa* per flower, also found on strawberry crops. Other unsown plant species had fewer than two thrips per flower or had thrips species not found on soft fruit.

In sown plots chicory, sainfoin, oxeye daisy, common knapweed and wild carrot were the flowering species with more than two thrips per flower (Park et al. 2007) on at least one sampling occasion. Wild carrot had higher numbers of *Thrips tabaci* per flower head in June and July (respectively, 6.7 ±2.3 and 4.4 ±1.4). Common knapweed attracted (2.0 ±0.3) *Frankliniella occidentalis* (WFT), a known pest of strawberry crops, and 2.2 ±0.6 'other' thrips not found in soft fruit crops. Overall thrips numbers declined in August.

The extraction device developed in AHDB Project SF 156 provided very good recovery of adult thrips (at least 90%) but was less efficient at extracting larval thrips (around 50%) from flower heads.

Beneficials on flower heads

Predatory thrips (*Aeolothrips*), parasitoids, ground beetles and *Orius* nymphs and adults were present in flower heads. No significant numbers were recorded on any plant species. There was a more diverse and abundant community of pollinators in May than September, probably a reflection of floral resource. Bumblebees were frequent visitors to sainfoin flowers, including many wild species, but more research is needed to see if commercial bumblebees are distracted by wildflower margins. Some bumblebee species with long tongues prefer flowers with longer corolla flowers (Plowright et al. 1997) than those typical of strawberry flowers.

Commercial Farms

In 2020, floral margins were successfully established in two commercial farms. A third farm was sourced from a previous project where floral margins were implemented in 2017. All sites will be monitored for beneficials and pests in 2021.

Financial benefits

At this stage in the work, no financial benefits from sowing wildflower strips in the vicinity of soft fruit crops have been identified or calculated. However, it is hoped that if the use of wildflower sowings is demonstrated to enhance pest control in soft fruit crops, then the exact financial benefits may be better understood in future.

Action points for growers

- There are currently no action points arising for growers from this work, but growers might consider implementing wildflower strips around soft fruit farms to encourage the biodiversity of pollinating insects and natural enemies in the landscape.
- Once established, wildflower margins may be able to help to outcompete less desirable weeds and require minimum maintenance after the second year.