Grower Summary

TF 223

Improving integrated pest and disease management in tree fruit

Annual 2019

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Project number:	TF 223
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Report:	Annual report, March 2019 (Year 4)
Previous report:	Annual report, March 2018 (Year 3)
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Date project commenced:	01/04/2015

GROWER SUMMARY

Background

Project TF 223 is a five year project which commenced in April 2015. The project is investigating solutions to the key tree fruit diseases and pests, namely: European apple canker, scab, powdery mildew, *Monilinia* species and bacterial canker affecting stone fruit, codling and tortrix moths including Blastobasis, pear sucker, apple fruit rhynchites weevil, apple sawfly, pear weevils and phytophagous mites. In the first year, work focused on European apple canker, powdery mildew, codling and tortrix moths and apple fruit rhynchites weevil. In the second year research focused on European apple canker, apple foliar diseases, bacterial canker of stone fruit, codling moth, tortirx moths, weevil affecting pear buds, pear sucker and associated natural enemies. In the third year, work continued on European apple canker and apple powdery mildew and we began trials for control of Monilinia diseases on stone fruit. Entomology work focused on blastobasis, a weevil affecting pear buds, pear sucker and their associated natural enemies (NE) and establishing trial sites to enhance NEs in newly established orchards. For ease of reading, this grower summary report is split into sections for each of the diseases and pests worked on in the fourth year. Full details of each objective are presented in the Science Section of this report.

Objective 1. Surveillance

Headlines

- Vf (scab resistance gene) breaking strains of scab have been observed in the UK
- A new apple rot pathogen, *Neofabrae kienholzii,* has been reported for the first time in the UK
- A new pest of pear, *Anthonomus spilotus,* has been reported for the first time in the UK
- A new species of aphid, Green citrus aphid - *Aphis spiraecola*, has been reported in South East England apple orchards which is more resistant to insecticides

Background and expected deliverables

The surveillance objective provides the opportunity for ongoing activities to continue and be reported. Such activities include the monitoring of scab virulence on indicator trees, undertaking an apple rot survey and horizon scanning for emerging and future pest and disease threats to the UK tree fruit industry. This objective aims to keep the industry up to date

with the pest and disease threats which ultimately lead to yield losses and provides information for the industry to inform future research targets and priorities.

Summary of the project and main conclusions

Scab virulence: This task involves the monitoring of an indicator orchard, planted as part of a large pan-European project in which the same indicator cultivars are planted in 25 European countries. As in previous years the severity of the disease epidemic on the *Vf* (scab resistance gene) containing cultivars was comparable to the disease incidence on Gala. This confirms that the local scab population has broken the resistance conferred by *Vf*.

Apple rot survey: Of the 52 samples assessed from the 16/17 storage season, overall average loss was 1.5%, lower than recent past surveys. Nectria rot was the most prevalent rot with an overall incidence of 33%, Brown rot (*Monililnia*) was the next most prevalent rot (19.3%) followed by *Gloeosporium* (12.4%), *Penicillium* (11.2%) and Botrytis (9.2%). *Phytophthora* was only found in a single sample.

Neofabraea kienholzii, a pathogen closely related to those which cause Gloeosporium rot has been reported for the first time in the UK. Gloeosporium rots (caused by *Neofabraea*) have been increasing in prevalence in recent apple rot surveys. *N. Kienholzii* adds to the list of *Neofabraea* known to occur in the UK (*N. perrenans* and *N. vegabunda*).

In 2017/18 there were relatively low overall losses (1.6%) from the rot survey, similar to the previous year and partly due to a relatively dry harvest period in September. Neonectria continued to contribute to losses in susceptible varieties such as Gala, Jazz and Cameo, although the weather around blossom was only moderately favourable. Changes in rot incidence of brown rot and Botrytis rot may be more related to the change in varieties assessed. Botrytis tends to be more prevalent in Jazz, associated with missing stalks, whereas brown rot is more prevalent in Cox and Bramley. In 2017/18 only one Cox sample was assessed, compared to eight in each of the previous two years.

***Drosophila suzukii* (spotted wing drosophila – SWD)** numbers were delayed in 2018, compared to previous years, because of the cooler spring. However, by the end of the year, numbers were similar indicating that generations increased through the season and did not seem to be deterred by the hot, dry, weather.

Summer fruit tortrix was detected for the first time in the West Midlands during the 2015 growing season and it is recommended that growers now monitor for this pest in the region using pheromone traps alongside codling moth and fruit tree tortrix monitoring traps.

Brown Marmarated Stink Bug (BMSB): Monitoring traps in the South East and East of England did not detect any incursions of the pest. Monitoring will continue in 2019.

Anthonomus spilotus: A weevil found in pear orchards which has been damaging spring flower and leaf buds over the last two to three years, was identified as *Anthonomus spilotus* by the National History Museum and NIAB EMR in 2017, and is new to the UK. It has also been recently identified as an invasive pest in Belgium. Progress was made on the estimation of damage and the susceptibility to specific control products. More details are found in Objective 10.

Pear shoot sawfly: The RHS reported sightings of pear shoot sawfly (*Janus compressus*) in 2016. This has not been seen in commercial pear as far as we are aware.

Green citrus aphid: A new species of aphid, green citrus aphid (*Aphis spiraecola*), was reported in South East of England apple orchards. This species is difficult to distinguish and is more resistant to aphicides.

A table of additional pest and disease threats relevant to tree fruit growers is presented in the science section of this report with links to useful resources.

Financial benefits

Current, emerging and newly introduced pests and disease can have a devastating effect on yield and economic return to businesses. This objective enables the ongoing monitoring of these threats helping to inform future research priorities.

Action points for growers

- Continue to use the rot risk survey available in the Apple Best Practice Guide on the AHDB website, to limit loss of apples in store
- Monitor for summer fruit tortrix moth in the west of England
- Keep an eye on trade press for important announcements from the animal and plant health agency (APHA) about invasive pests and disease which will affect your business such as *Xylella fastidiosa*

Objective 2. Neonectria

Headlines

- Long term trials were established to determine the effects of rootstock/interstock choice and biological soil amendments on susceptibility/tolerance to European apple canker
- Experiments have identified rootstocks which have reduced susceptibility to canker

- A biological treatment which reduces canker infection, particularly in stoolbeds was identified
- Application of wound protectant treatments to pruning cuts using secateurs with a chemical dispenser can significantly decrease the incidence of apple canker (*Neonectria ditissima*) infection

Background and expected deliverables

European apple canker caused by *Neonectria ditissima*, is a devastating disease of apple which has been increasing in significance over the past 10-15 years as the industry has changed agronomic practices and cultivar choice. This objective looks at various factors such as rootstock/interstock choice and the use of biological amendments which, together with work from other projects, will contribute to the development of a systems approach for canker control from the nursery to the orchard.

Traditionally used wound paints to protect pruning wounds from *Neonectria ditissima* have been removed from the market in the past few years due to the high labour costs required in application, resulting in a lack of demand. Newly available application products, such as chemical dispensers attached to pruning secateurs, have the potential to reduce labour costs involved with protecting pruning wounds from canker infection by treating them at the same time as hand pruning. An initial trial looking at wound protectants in 2017 indicated that biological and chemical products may have a protective effect on the pruning wounds when used in conjunction with a polymer to seal the wound. The purpose of this trial is to evaluate efficacy of a selection of protectants that can be applied to wounds during tree pruning

Summary of the project and main conclusions

Long-term trials have been established on multiple sites to determine the effect of rootstock/interstock and biological soil amendments on canker incidence and severity. The rootstock trials are evaluating a panel of commonly used rootstocks alongside several advanced selections from the NIAB EMR and Geneva rootstock breeding programmes.

The amendment trials are evaluating the effect of arbuscular mycorrhizal fungi (AMF), plant growth promoting rhizobacteria (PGPR), Trichoderma and Biochar in both newly planted orchards and stoolbeds. Trichoderma significantly reduced the incidence of canker in the stoolbed at one trial site. This treatment also reduced total canker incidence at a second orchard, although this was not statistically significant.

The protectant treatments used in the wound trial included a biological (coded product BCP511B), chemical (tebuconazole) and physical (BlocCade) treatment. The wound treatments were applied in April 2018 to trees in the trial during pruning, using Felco 19

secateurs with a chemical dispenser. The marked cuts were then inoculated with canker spores 24 hours after application of the wound treatments to simulate an infection event. The trial was monitored and recorded for the presence of canker in the marked cuts as well as regrowth and any phytotoxic effects of the treatments.

Some degree of preventive effect was seen in all of the treatments, with the tebuconazole and tebuconazole + BlocCade treatments showing significant reduction of canker development. Although the biological treatment showed a reduction in canker development compared to the control, it was not significantly better. It is probable that this biological treatment did not have sufficient time to establish on the cuts before the wounds were inoculated resulting in reduced performance.

Regrowth was generally low for all treatments, although there was slightly higher regrowth in shoots treated with BCP511B, although the effect was not significant. No phytotoxic effects were seen on the trees. The branches treated with tebuconazole (Folicur) formed good callouses over the pruning wound.

Financial benefits

European apple canker is a devastating disease that has an economic impact from plants grown at nurseries, orchards, to fruit sold at stores. This project focuses on key areas within the supply chain to develop an integrated approach to canker control and reduce financial losses caused by the disease.

The use of preventive treatments on pruning wounds to reduce infection is a useful tool in developing an integrated approach to canker control. Application of treatments at the same time as hand pruning using secateurs with a chemical dispenser can reduce the labour cost of application to growers as it can be done in a single pass.

Action points for growers

- With the results generated to date, and those we will generate in the final year of the project, we will have a clearer idea of the rootstock/interstock varieties that are the most promising for reducing canker
- Application of Trichoderma appears to be promising for reducing canker particularly in stoolbeds. This experiment is being repeated this year
- It is still important to be vigilant with visual inspection, identifying trees which are showing canker symptoms and limiting abiotic stress as far as possible when planting out and establishing new orchards
- Treatment of pruning wounds with tubuconazole with or without a polymer can significantly reduce canker incidence even when high levels of inoculum are present

- The use of directed sprays of preventive treatments during hand pruning can be a useful tool to reduce canker development in an orchard

Objective 3 Foliar diseases

Task 3.1 Determine optimum timing of treatments to target the over-wintering phase of mildew to disrupt the lifecycle (NIAB EMR)

Headline

- A new approach to reducing over-wintering powdery mildew has been proposed.

Background and expected deliverables

The uptake of biological control agents (BCAs) has been limited for disease control in orchard crops despite their great potential to replace conventional control products as part of an integrated pest management programme. Barriers for the uptake of BCAs in orchard systems include the higher cost/ha and their reduced/variable efficacy relative to conventional products. If applied during the season when a pahtogen is developing rapidly, there is a delay before the BCA has time to establish and gain control. Crop damage therefore often occurs before control is achieved. This task aims to develop understanding of interactions between potential antagonists and the pathogen (or pathogen substrate) to inform strategies which can target the overwintering phase.

Powdery mildew (*Podosphaera leucotricha*) mainly overwinters as mycelium in floral and vegetative buds. *Ampelomyces quisqualis* (AQ) is a mycoparasite of powdery mildew. Commercial preparations of AQ such as AQ10, have been successfully used in greenhouse and field-grown vegetable crops to gain control, usually with reduced fungicide inputs. AQ10 was one of the best performing BCAs in the SCEPTRE project trials when applied throughout the season and in combination with fungicides in a managed programme. However the control achieved was not commercially acceptable. One of the disadvantages of using AQ10 is the slow growth rate of this parasite. This has led to the strategy proposed here; to target the overwintering phase of the disease offering a long interaction period between parasite and powdery mildew. Trials were set up over the summer of 2016 to test whether the BCA is incorporated into the bud, whether the parasite can survive over winter and whether the stratergy is effective at reducing inoculum. These trials were inconclusive. The objective of trials in 2018 was to re-evaluate the strategy with AQ10 and to include an alternative BCA – a bacterial-based product from Bayer – which has been very effective in controlling strawberry powdery mildew.

Summary of the project and main conclusions

The trial was located in a Gala orchard at NIAB EMR. The plan was to target overwintering mildew in vegetative buds by applying treatments starting towards the end of shoot growth at the end of summer. However, shoot growth stopped early in 2018 due to the hot dry conditions in July so treatments were not applied. There are plans to repeat the trial in a new project.

Financial benefits

The quantity of primary mildew overwintering in fruit and vegetative buds is key to the new season mildew epidemic. For effective mildew control, primary mildew must be minimised. The availability of methods to reduce overwintering mildew would enable improved mildew control in the growing season with reductions in fungicide use and consequent savings in costs.

Action points for growers

- There are no action points at present

Task 3.2 Efficacy of alternative chemical treatments to fungicides (NIAB EMR)

Headline

- Alternative products show promise to control powdery mildew when incorporated into fungicide spray programmes

Background and expected deliverables

Foliar diseases of apple require season-long control. For powdery mildew control, susceptible cultivars require season long programmes of fungicides (~10-15 sprays) to protect shoots and buds and prevent high levels of over-wintering inoculum. Routine sprays of fungicides cost around £700/ha/annum with a large proportion spent on scab and mildew control. Despite such stringent measures, scab and mildew control can break down during the growing season resulting in disease epidemics. Mildew epidemics, in extreme cases, can defoliate affected trees reducing yield and causing russeting of the fruit. With a reduction in the availability of effective products against powdery mildew, due to changing regulations and fungicide insensitivity, new approaches to disease control need to be developed which are less dependent on conventional fungicides. This project aims to assess alternative treatments based on physical and biological properties with the aim of reducing fungicide applications whilst maintaining acceptable disease control.

Summary of the project and main conclusions

The physical control products SB Invigorator and Wetcit have shown consistently good results as have the biostimulants Cultigrow CBL, Trident and Mantrac. In 2018, these were reassessed in combination with fungicides in programmes applied at 7- or 14-day intervals and compared with fungicide only programmes in a Gala orchard at NIAB EMR. The incidence of primary and subsequent secondary mildew in 2018 was high as a result of favourable weather conditions at the end of May. Over the ten weekly assessments, the lowest incidence of secondary mildew was found in the 7-day fungicide only programme and the highest in the 14-day fungicide only programme. Plots receiving the combined programme had significantly less mildew than those receiving the 14-day fungicide only programme, indicating some benefit from the alternative treatments. There were no phytotoxic effects of these treatments, but two of the treatments resulted in lower fruit set, so further evaluation of these products in programmes with fungicides is needed before recommendations are made to growers.

Financial benefits

A high incidence of powdery mildew in apple orchards reduces yield and fruit quality. Generally 10-15 sprays are required to control powdery mildew and to ensure buds are free of overwintering mildew. This is costly and with a limited number of effective fungicide products available control is not always ideal. Identifying effective alternative products reduces the dependence on fungicides and possibly also reduces costs.

Action points for growers

Some alternative products have been identified but further evaluation of these products in programmes with fungicides, particularly on their effects on fruit quality is needed before recommendations can be made to growers.

Objective 4. Stone fruit diseases

Headline

- Coded fungicide HDC F266 was effective in reducing brown rot and Botrytis rot on cherries

Background and expected deliverables

Losses resulting from Monilinia sp. in stone fruit are hard to quantify because infection occurs throughout the season (blossom and fruit pre- and post-harvest). Post-harvest development

of brown rot limits the storage potential of UK stone fruit and a few rotten fruit in one punnet can lead to food retailers rejecting whole consignments. Two *Monilinia* species are present in the UK; *Monilinia laxa* and *Monilinia fructigena*. Currently diseases associated with Monilinia are controlled by 1) inoculum removal and 2) fungicides. The former was seldom practiced due to the associated increase in cost. However in recent years with the advent of spotted wing drosophila (SWD), removal of rotted and ripe fruit at harvest has become a management necessity to control SWD but with obvious benefits in rot control for fungal diseases. Fungicides are applied at blossom and pre-harvest including Signum and Switch, but are not totally effective and pre-harvest applications present a residue risk. This project will evaluate newly available products including plant health promotors, biological control agents and fungicides, which in combination could provide a more effective programme for brown rot control.

Due to the late frosts during the 2017 growing season which coincided with blossom and early fruitlet development, the yield within the trial orchard was significantly affected. In addition to the frost, the trial was severely hit by SWD prior to harvest, despite the use of weekly control sprays. Together the frost and the SWD damage meant that very little fruit was available for picking by harvest and it was impossible to draw any meaningful conclusions on the products evaluated. Therefore the trial in 2018 was largely a repeat of the 2017 work.

Summary of the project and main conclusions

In a small plot trial on cv. Skeena the control of blossom wilt and brown rot achieved by a range of coded test products, including a biostimulant and an elicitor (HDC F266, HDC F267, HDC F268, HDC F 269, HDC F270, HDC F271) was compared with that achieved by the biofungicide Serenade, standard fungicide products (Signum and Switch) and an untreated control. Treatments were applied as two sprays at blossom and two pre-harvest, except for HDC F271 (biostimulant) which was applied at three week intervals from blossom. Plots were assessed for blossom wilt soon after petal fall and for rots at harvest and in post-harvest tests after storage for three days and incubation at ambient temperature for 7 days. Yield and fruit size were also recorded. The results obtained were as follows.

The incidence of blossom wilt (*M. laxa*) was negligible. The incidence of rots at harvest was low (5% in untreated plots). There were no significant effects of treatments on rot incidence, but the lowest incidence of rots was recorded in Treatments 3 (HDC F266) and 4 (HDC F267) and in the standard treatment 2 (Signum/Switch). The rot incidence increased in post-harvest tests to over 30% in untreated plots after 7 days' incubation. The lowest incidence after 3 days' incubation was recorded in Treatment 2 (Signum/Switch), Treatment 3 (HDC F266), Treatment 4 (HDC F267) and Treatment 8 (HDC F270). However, the differences were not

quite significant compared to the untreated control. At the final assessment after 7 days' incubation the lowest rot (accumulated rot) incidence was again recorded in Treatment 2 (Signum/Switch), Treatment 3 (HDC F266) and Treatment 8 (HDC F268). Only Treatment 3 had significantly less rot than the untreated control. The effects of the treatments on the incidence of *M. fructigena* was not significant, however, the lowest incidence of *M. fructigena* was recorded in fruit treated with HDC F266 or HDC F268. All treatments apart fromT6 and T7 significantly reduced the incidence of *M laxa* with the lowest incidence in fruit treated with Treatments 3 (HDC F266) or 4 (HDC F267). All treatments, apart from T6, significantly reduced the incidence of Botrytis compared to the untreated control. The lowest incidence was in fruit treated with T3 (HDC F266) which performed significantly better than most other treatments. Several of the fungicides evaluated in this trial were effective in reducing rotting, in particular HDC F266 (Treatment 3) which was the most consistently effective of the fungicides tested. Of the alternative products tested HDC F269 and Serenade were ineffective. The effect of HDC F271, a biostimulant was variable. It was not effective in boosting plant resistance to *M fructigena* which is a wound pathogen but more successful in improving resistance to *M laxa* and *Botrytis.* There were no significant effects of treatments on yield or fruit size. There were no phytotoxic effects of any of the treatments.

Financial benefits

Brown rot is an important disease of cherries causing significant losses both in the orchard and post-harvest and limiting the storage of cherries to extend the marketing period. The availability of a range of effective fungicides to control the disease is vital to the profitability of the industry.

Action points for growers

- Orchard sanitation is important for brown rot control, removing all mummies from the orchard is important
- Blossom and pre harvest application of fungicides are generally required in most seasons
- The effective products identified in 2018 in this trial are not currently approved for use on cherries.

Task 4.3 Bacteriophages against bacterial canker in cherry

Headlines

- Large collection of native bacteriophages isolated from UK orchards have been established and partly characterised
- The first year of efficacy trials on detached cherry leaves have identified some phages with biocontrol potential

Background and expected deliverables

Pseudomonas syringae pathovars; *syringae* (PSS), *morspronorum* race 1 (PSM1) and *morspronorum* race 2 (PSM2) cause a destructive disease called bacterial canker on prunus species. This disease reduces yields; cankers can girdle branches and trunks causing wilting and tree death. Until now growers have relied on copper treatments at leaf fall to reduce bacterial populations. However copper is no longer permitted to be used as a plant protection. Moreover, there have been reports of emerging bacterial resistance to chemical control. Bacteriophages (phages) are natural antimicrobial agents with enormous potential to treat bacterial diseases. Phages very effectively reduce very specific bacterial populations and have therefore minimal unintended consequences in terms of inhibiting non target and beneficial organisms. This objective is focused on i) finding and characterising native UK phages against prunus canker pathogen and ii) test their efficacy on plants to provide proof of concept for their use in disease management.

Summary of the project and main conclusions

Research team from University of Reading have isolated 70 potential biocontrol phages different cherry orchards in UK. All isolated phages were active against a PSS strain and 10 phages were active against PSM1 and PSM2 strains. Six phage isolates were found to have broader host range with activity against PSS, PSM1 and PSM2 and are therefore good candidates for further characterisation and efficacy testing. Importantly, none of the isolated phages showed any activity against *Pseudomonas fluorescens*, beneficial bacteria related to canker pathogen, which demonstrates specific action of phages against pathogen bacteria.

In parallel to phage collection we have established a phage efficacy testing method. We have optimised a detached leaf assay where cherry leaves from the orchard were inoculated with PSS, PSM1 and PSM2 in laboratory conditions. Leaves were then treated with phages and necrotic lesion symptoms observed to ascertain their ability to control disease. This year we have used five phage isolates collected from NIAB EMR and Brogdale Collection sites during preliminary study in 2015. The best success was observed when PSM1 inoculated leaves

were treated with the phages. Three out of five isolates significantly reduced PSM1 lesions incidence (from 100% to 60%) and lesion size compared to untreated control establishing the first line of evidence for phage efficacy against cherry canker pathogen. We have also sprayed the five phage blend on inoculated detached shoots which are currently incubating and canker incidence will be assessed in March 2019 to confirm their efficacy in woody part of the plants.

In the next year we plan to select the best phages from our collection based on their characteristics on in-vitro agar assays in the lab. The phages with best antimicrobial potential will be tested on detached leaf and to confirm their activity on the plants. Phages will be also tested in an orchard field trial if approved by CRD.

Financial benefits

This project endeavours to speed up the development of new integrated approach to canker control and reduce financial losses caused by this disease. These approaches are still being evaluated and will be reported in subsequent reports.

Action points for growers

No action points at this time.

Objective 6. Codling and Tortrix Moth

Headline

- Early attempts to identify a sex pheromone from Blastobasis for monitoring purposes have been unsuccessful

Background and expected deliverables

Larvae of the moth *Blastobasis lacticolella*, Rebel, 1940 (Synonym: *decolorella*) (Lepidoptera: Blastobasidae) feed on the surface of apple and pear fruits in mid- and late- summer, often where clusters are touching, causing large open scallop-shaped wounds in the flesh and making attacked apples un-saleable. Very severe damage can result if the pest is allowed to increase over a number of years unchecked, especially on short stalked varieties such as Bramley and Egremont Russet which are very susceptible. Growers currently have no means of identifying whether they have a problem other than the occurrence of damage the previous year, which is often confused with damage caused by other apple moth pests. It is also difficult to time sprays accurately against Blastobasis.

A recent increase in the use of mating disruption techniques such as RAK 3+4 for codling and tortrix moth control along with use of granulovirus, has resulted in a reduction in application of broad-spectrum control products. Occasional but severe outbreaks of Blastobasis have consequently occurred, requiring application of products which negated the benefit of using mating disruption or granulovirus. There is a clear commercial need to develop a pheromone monitoring trap for Blastobasis so that growers can determine whether they have a problem and time insecticide applications correctly.

Summary of the project and main conclusions

Field trapping experiments with three potential pheromone blends based on previous work were carried out in Northern Ireland, Hereford and Kent. A number of moths were caught, but analysis of sample moths by DNA barcoding of COI gene locus and comparison with NCBI Database indicated that probably none were *Blastobasis lacticollela*. The majority identified were *Rhigognostis incarnatella* and six out of eight were from traps baited with blend C, 1:10 Z11-16:Ac : Z11-16:Ald. This species is related to the diamondback moth, *Plutella xylostella*, the pheromone of which is a 1:1 blend of Z11-16:Ac and Z11-16:Ald. These results confirmed that the lures were working as intended and would have trapped *B. laticollela* if the pheromone blend was correct and this species was present.

Field trapping was repeated in 2018 and once again blends of (Z)-11-hexadecenal and (Z)-11-hexadecenyl acetate failed to attract *Blastobasis laticolella* moths in field trapping tests, even though this species was clearly present as indicated by catches in light traps. Rearing *B. laticolella* adult moths from larvae collected in the field proved a real challenge, but some were reared through to adult. Extracts of the pheromone glands of female moths were made both from moths collected in the field which were probably mated and from virgin female moths reared from larvae in the laboratory. In analyses of extracts by GC-MS, potential pheromone components including (Z)-11-hexadecenal, (Z)-11-hexadecenyl acetate, (Z)-5-decenyl acetate and (Z)-5-decenol could not be detected. (Z,Z,Z)-3,6,9-Nonadecatriene was identified as a potential component of the female sex pheromone. However, it was subsequently shown to be present in extracts from both female and male moths and did not attract male *B. laticolella* moths in the field. Further work is required and growers who belived they have populations of Blastobasis in their orchards are encouraged to make contact with Michelle Fountain and her team at NIAB EMR.

Financial benefits

- No financial benefits have been identified at this stage of the project

Action points for growers

- No action points have been identified at this stage of the project

Objective 7. Natural predation of pests

Objective 7.1. Improving the reliability of natural predation of pests

Headline

- Six trial orchards have been set up to monitor the benefits of hastening the influx of natural predators into newly planted orchards to reduce pest damage.

Background and expected deliverables

Establishing new orchard crops requires substantial investment (~£35k/ha for apple) and growers need confidence that their orchards will crop reliably and that their fruit will find a profitable market. Ecological succession is the observed process of change in the species structure of an ecological community over time. The community begins with relatively few pioneering plants and animals and develops through increasing complexity until it becomes stable or self-perpetuating, as a climax community. Newly planted orchards have an un-established ecosystem. The recently tilled ground in newly planted orchards often has minimal, simplified or absent vegetation cover with a low diversity of plant species resulting in low pollen and nectar provision and low refugia and structure. The tree bark and canopy are simple compared to older established trees affording little availability for predatory arthropods to gain refuge. Hence, local, natural predators and pollinators have not built up and established in new orchards leading to random, sporadic, attacks from a number of pest species which can then be difficult to control.

In this project, work has been instigated to hasten the influx of natural predators in new orchards. Six replicate commercial apple orchards were chosen in 2017 and secured for experimental purposes through help from Caroline Ashdown at Worldwide Fruit. In each orchard, 0.25 ha is being treated with ecological enhancement interventions.

In each treated area, interventions included the sowing of alleyway seed mixes (including yarrow, ox-eye daisy, bird's foot trefoil, self-heal, red campion and red clover), and the provision of earwig refuges and hoverfly attractants. Each treated area is being assessed and compared to an untreated area of the same orchard throughout 2018 and 2019.

Summary of the project and main conclusions

In 2018, four of the six alleyway seed mixes established very well with over 50% coverage of sown species. Fewer aphids were observed in the apple trees on treated plots in spring. Unlike

in the control plots, no apple leaf curling midge damage was found in the treated plots. Fewer fruit tree red spider mites and predatory mites were found in the treated plots than the control plots. However, in contrast, there were higher populations of rust mites and predatory mites in the treated plots than in the control plots. In the treated plots, there were fewer fruits with codling moth damage and also higher numbers of hoverfly adults. Given this is the first year of recording, the results should still be treated with caution.

Financial benefits

- No financial benefits have been identified at this stage of the project.

Action points for growers

- No action points have been identified at this stage of the project.

Objective 7.2. Dynamic pear sucker/ predator chart

Headline

- Threshold numbers of pear sucker eggs and natural enemies will enable growers to decide on the need to implement pear sucker control measures

Background and expected deliverables

Pear sucker, *Cacopsylla pyri*, is still the major pest on pear with sporadic population growth in relation to warm dry weather and in orchards where the numbers of earwigs and anthocorids is not sustained. Emerging evidence from other AHDB and Innovate UK projects is showing that earwigs are important control agents for aphids and pear sucker. Additional research in the USA also demonstrates predation of codling moth eggs. Earwigs, hoverfly larvae, lacewing larvae, spiders and ladybirds are able to penetrate the leaf rolls (galls) caused by the various apple aphid species.

There are large differences, between orchards, in earwig populations and Project TF 196 has demonstrated that plant protection product use and timing may be, at least partly, responsible. However, anecdotal evidence is showing that earwigs can be patchily distributed within an individual orchard.

The aim of this study is to enable more effective monitoring, control product use and natural enemy build-up in pear orchards. It is expected that the application of control product interventions will be better timed.

Summary of the project and main conclusions

Six farms were involved in the study in 2016, 2017 and 2018. All participants were trained in the monitoring technique at the start of the growing season. Each grower selected three orchards (high, medium and low pear sucker populations) on each farm and allowed time for a worker to systematically assess the chosen orchards each week. The results were collated at least fortnightly by NIAB EMR and then shared with all participants.

Records of pear sucker eggs, nymphs and adults, and ladybirds, earwigs and anthocorids in the perceived low, medium and high pear sucker pressure orchards were made from March to September. The records were scrutinised and it was concluded that in general, sprays could be avoided where there were <1,000 pear sucker eggs per 30 shoots per week and >10 natural enemies per 30 shoots per week. More work is needed to determine the threshold of nymphs.

Financial benefits

Close monitoring of pear sucker and natural enemies can help to avoid use of unnecessary sprays and conserve natural enemies which control pear sucker. This will reduce the need for applications of products needed to control honey dew on trees. The reduction of pear sucker in the crop prevents direct damage to fruits as well as damage to overwintering bud and tree health.

Action points for growers

- Monitor pear sucker stages in the crop to accurately time Envidor applications and avoid sprays where unnecessary
- Use the monitoring of natural enemies such as earwigs, anthocorids and ladybirds alongside pear sucker monitoring to track the likely future control by these predators in the absence of sprays
- Consider releases of anthocorids early on if natural enemies are low, but think about the surrounding habitat to encourage long term resilience in populations
- Be considered with the choice, numbers and timing of spray applications. Think about spray frequency and impact on natural enemies

Objective 8. Apple sawfly

Headline

- Attempts are being made to discover the sex pheromone of apple sawfly for future monitoring

Background and expected deliverables

Apple sawfly is a locally common and problem pest, particularly in organic orchards where products for effective control are not available. However, timing of application relies on knowing when the first flight is occurring and when females are laying eggs. This project aims to identify the sex pheromone of the apple sawfly for use in future monitoring and mating disruption studies.

Summary of the project and main conclusions

Apple sawfly larval infected apples were collected in spring 2015, 2016, 2017 and 2018 from an unsprayed orchard at NIAB EMR. The apples were placed onto compost in mesh covered bins. Larvae were allowed to crawl out from the fruits and enter the compost. As apple sawfly has only one generation per year these were maintained outside until spring 2016 and spring 2017. However, no apple sawfly adults emerged and pupae were found to be infected with either bacteria or fungus, even when in 2017 bins were maintained with lids to prevent over wetting from rain. The previous winter had been very wet and it was speculated that the soil may have become too wet outside.

In spring 2017and 2018 apple sawfly infected apples were collected again and kept in Bugdorm cages under cover. As the larvae emerged from the apples and began to 'wander' they were transferred into smaller plant pots of compost. Six were kept at ambient conditions in an outside area under cover and 2 were stored at 6^{o}C for 2 months in 2017 and 5 months in 2018 to attempt to simulate a cold period. To date no adults have emerged, but pots will be bought into room conditions in spring 2018 for emergence of adults and headspace volatile collection for pheromone identification.

Financial benefits

- No financial benefits have been identified at this stage of the project

Action points for growers

- No action points have been identified at this stage of the project

Objective 9. *Anthonomus spilotus* in pear

Headline

- New damaging weevil pest of pear blossom identified as *Anthonomus spilotus* and is new to the UK

Background and expected deliverables

A new weevil pest of pear has been identified. The weevil is from the *Anthonomus* family of weevils known to feed and develop in buds and fruits of plants. Unlike *Anthonomus piri*, *A. spilotus* feeds and lays eggs in spring blossom and leaf buds. In order to control the weevil it is likely to be necessary to target sprays in the spring, before the flower clusters open. This objective aimed to establish the activity period, lifecycle and toxicity of commonly used control products. More research is needed to establish thresholds and to target spray timing more precisely.

Summary of the project and main conclusions

Extensive field surveys and damage assessments were done on four affected orchards in Kent. *Anthonomus spilotus* adult activity, eggs in buds and adult feeding damage was recorded from 8 March until 6 June in 2018. Weevils fed on and laid eggs in flower and leaf buds depending on availability. The percentage of flower buds damaged by adult feeding was 22.6% and the percentage of flower buds damaged by larvae 0.7%. The percentage of leaf buds damaged by adult feeding was 42.3% and the percentage of leaf buds damaged by larvae was 0.7%. Hence most bud damage was the result of adult feeding.

Fewer than 10% of the flowers in a truss were damaged by adult feeding and fewer than 16 % were damaged by larvae. Greater flower and leaf damage was observed when eggs/larvae were present. Hence the damage to flowers at one weevil per 40 taps is not the main consideration as only one of the six flowers is normally destroyed and only three to four Conference fruits can set to harvest on a single truss. The main consideration is the damage to leaves and photosynthetic ability for future years.

Even at very low levels of weevils (~one per 40 tree taps) ~60% of new leaves were damaged later in the season. We have not been able to set a damage threshold for this because the resultant health to the tree could not be estimated in this study. The majority of buds usually had one to three damage holes although buds with more punctures could be found.

There were indications that population activity may be sensitive to significant temperature changes, but more data is needed to reach a more accurate conclusion.

In laboratory tests in 2016, Gazelle did not give effective control, but Calypso at full and half field rate gave 80-90% mortality. Calypso, Hallmark, Gazelle and Spruzit were the most effective products against *A. spilotus* in the laboratory. High mortality and fast negative behavioural effects were observed in these treatments. However note that in this experiment, weevils received a direct application of the product. In a pear crop this scenario is less likely and weevils may be more likely to come into contact with dried residues.

In 2018 we determined whether control product efficacy can be improved through stimulating ingestion of the actives, spinosad and indoxacarb. Calypso was the most effective product against *A. spilotus* in the laboratory trial where shoots had been sprayed with products and then weevils allowed to feed. 100% mortality in nine days after ingestion was observed compared to the control group (40%). In 2019 we will examine the best timing of control measures in growers' orchards.

Financial benefits

Larvae in flower buds feed on flowers, but then also feed on emerging leaf shoots. This could affect yield but also the health of trees over the long term. It is essential to calculate thresholds for spraying and spray timing. It is estimated that a female weevil in the *Anthonomus* family can lay around 25 eggs in her lifetime.

Action points for growers

- Monitor pear orchards weekly from February by inspecting for feeding holes in unopened flower buds and then later on in leaf buds
- Continue to monitor until May
- Make a careful decision over the need to use control measures and the choice of product so that natural enemies are not affected
- Continue to monitor for the pest after control methods have been used