

Tree Fruit Review 2019



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Meet the team

AHDB Horticulture contacts



Rachel McGauley
AHDB Research Manager
T: 02476 478768
E: rachel.mcgauley@ahdb.org.uk



Scott Raffle
Knowledge Exchange Manager
T: 01732 876671
E: scott.raffe@ahdb.org.uk



Spencer Collins
AHDB Crop Protection Manager
T: 02476 478755
E: spencer.collins@ahdb.org.uk

Elected members

- Rob Saunders (chair)**, H L Hutchinson, Kent
- Christopher Baker**, CC & JA Baker, Newent, Gloucestershire
- Alison Capper**, Stocks Farm, Suckley, Worcestershire
- Russell Graydon**, Adrian Scripps Ltd, Five Oak Green, Kent
- Tom Hulme**, A.C. Hulme & Sons, Hoaden Court, Ash, Kent
- Jeremy Linsell**, Chromesword Ltd, Eye, Suffolk
- Emily Cliff**, Lower Hope Fruit Ltd, Nr. Ullingswick, Herefordshire
- Paul Smith**, Bardsley (England), River Farm, Tonbridge, Kent
- Nigel Stewart**, AC Goatham & Son, Rochester, Kent
- Paul Ward**, Mole End Farms Ltd, Cranbrook, Kent





Foreword

Welcome to the 2019 Tree Fruit Review annual supplement to AHDB Grower, which summarises the current research AHDB is funding on behalf of tree fruit growers.

In this year's Review, you can read about the latest progress in our five-year project (TF 223) to develop integrated pest and disease management (IPM) in tree fruit crops. Growers will be keen to find out how our multi-pronged approach to controlling apple canker is developing, along with our work on novel approaches to powdery mildew control. You can also learn about a handful of projects aimed at controlling fungal and bacterial diseases of plums and cherries.

One aspiration of AHDB is to accelerate the uptake of new research and development that we fund, along with research funded by other sources both in the UK and overseas. We plan to do this by developing strategic centres of excellence and demonstration sites in all crop areas. To this end, as part of Project TF 223, we are already funding two forms of demonstration in commercial orchards. One of these is educating participating growers on how to monitor for pear sucker and manage predators to avoid the need to use traditional control methods. The other demonstrates ways of enhancing the rapid influx of beneficial insects into newly planted orchards to develop integrated pest control early in the life of an apple crop.

Furthermore, in 2019, a new opportunity arose with the planting of a plum demonstration centre at NIAB EMR as partial fulfilment of a four-year Innovate UK project to improve profitability in the UK plum industry. The orchard will demonstrate many of the results of this research, as well as a range of mechanical approaches to orchard management and weed control. The site will also offer us the chance to put our IPM research into practice, including the use of 'earwig-friendly spray programmes' and modern approaches to spotted wing drosophila (SWD) control.

I hope you have a successful harvest season in 2019.



Rob Saunders
Tree Fruit Panel Chairman

Pests and diseases

Finding alternative crop protection solutions

Highly valued by growers is our work to secure new and alternative crop protection products to maintain the industry's plant protection armoury. In tree fruit, we work closely with the AHDB tree fruit panel of growers and advisors to keep abreast of those pest, disease and weed problems that are of highest priority. We also undertake regular 'gap analyses' to highlight where extra measures need to be taken to find alternative products, and where we should be focussing our research and development or knowledge exchange work.

A list of pests, diseases and weeds is drawn up that is dependent on a diminishing number of products – and in some cases a single product – for control. Our crop protection team work closely with the Chemicals Regulation Directorate (CRD) and agrochemical manufacturers to keep track of those products that are at risk of losing their approval status. We then use this information to pinpoint likely trouble ahead. We also closely track the EU and UK approvals databases to monitor changes as they occur. By keeping a step ahead, we are able to implement measures to find alternative solutions before products are lost for good.

In some cases, new alternative chemistry or biological control agents become available to the industry. But, the arrival of new products does not keep pace with the loss of approvals so we tend to be firefighting for much of the time as we seek alternatives. We frequently submit EAMU and emergency authorisation applications to CRD to secure these alternatives. To achieve this, we have developed very good links and working relationships with the staff at CRD, agrochemical manufacturers, the EU Minor Uses Co-ordination Facility, overseas regulatory bodies and other foreign minor use facilities such as the USA's Inter-Regional Research No. 4 (IR-4) Project.

Over the years, many growers in the tree fruit industry have benefited from the hard work and efforts of Vivian Powell, who has secured a great many new approvals for us. Vivian retired from AHDB at the end of April 2019 and we wish her many happy and healthy years of retirement. Spencer Collins and Bolette Palle-Neve continue to work tirelessly for us and Spencer will be replacing Vivian as our lead on tree fruit crop protection.

In recent months, Spencer has worked to secure some important products for tree fruit, including Cuprolyt for scab control on organic apple and pear crops. In the autumn of 2018, the same product was secured for use on stone fruit for the control of bacterial canker, without which growers had no alternative control measures.

In the past year, Spencer and knowledge exchange (KE) manager Scott Raffle have worked tirelessly with the soft and stone fruit industry, and in particular SWD Working Group chair Harriet Duncalfe, to secure EAMUs and emergency approvals to help us gain control of spotted wing drosophila (SWD). They worked in close collaboration with CRD who have been particularly understanding of the difficulties facing the soft and stone fruit industry. They have also helped us to secure products at a time in the season when growers were most in need. Important examples of products secured for SWD control include the emergency 120-day authorisations for Tracer on plum, cherry and apricot, and Exirel on plum, damson and cherry.

A list of the key products that have been delivered through AHDB activity in 2018 and early 2019 are found in the table opposite. Note that some of these approvals will have lapsed by the time of printing this publication.

Growers and grower groups who have concerns about impending losses of crop protection products should contact the AHDB Horticulture crop protection team at EAMU@ahdb.org.uk or email spencer.collins@ahdb.org.uk.



Apple scab

Product	Active ingredient	EAMU No.	Crops	Target pest/disease
Capex	<i>Adoxophyes orana granulovirus</i>	0262/18	Plum	Summer fruit tortrix
Amylo X	<i>Bacillus amyloliquefaciens</i>	0469/18	Tree fruit	Bacterial canker, <i>Monilinia</i> , fireblight, <i>Botrytis</i> , Powdery mildew
Cuprokylt	copper oxychloride	0669/18*	Organic apple and pear	Scab
Custo-Fume	chloropicrin	1432/18	Apple, pear	Nematodes, soil-borne diseases
Serenade ASO	<i>Bacillus subtilis</i>	2354/18	Plum	<i>Botrytis</i>
Serenade ASO	<i>Bacillus subtilis</i>	2360/18	Apple, pear	<i>Botrytis</i>
Prestop	<i>Gliocladium catenulatum</i>	2843/18	Apple, pear, plum, cherry, apricot	<i>Phytophthora</i> , <i>Botrytis</i> , other diseases
Cuprokylt	copper oxychloride	3307/18*	Outdoor apricot, plum, cherry	Bacterial canker
Steward	indoxacarb	0590/19	Apricot	Capsids, peach fruit moth, winter moth
Explicit	indoxacarb	0759/19	Apricot	Capsids, peach fruit moth, winter moth
Explicit	indoxacarb	0760/19	Cherry	Summer fruit tortrix, light Brown apple moth
Batavia	spirotetramat	1055/19	Apricot	Aphids
GIBB 3	Gibberellic acid	2041/19	Cherry	Plant growth regulator
Kudos	prohexadione	2120/19	Cherry	Plant growth regulator
Exirel	cyantraniliprole	2387/19*	Cherry	Spotted wing drosophila
Tracer	spinosad	2589/19*	Cherry	Spotted wing drosophila
Exirel	cyantraniliprole	2610/19*	Plum, damson	Spotted wing drosophila
Tracer	spinosad	2645/19*	Plum	Spotted wing drosophila

*denotes article 53, authorisation for 120 days.



“Our crop protection team work closely with the Chemicals Regulation Directorate (CRD) and agrochemical manufacturers to keep track of those products that are at risk of losing their approval status. We then use this information to pinpoint likely trouble ahead”



Adult male SWD



Assessing attract and kill technology

Finding new control options for spotted wing drosophila (SWD)

AHDB Project Code: SF/TF 145a Development and implementation of season-long control strategies for *Drosophila suzukii* in soft and tree fruit

Term: April 2017 to March 2021

Project leader: Michelle Fountain, NIAB EMR

Since 2013, AHDB has been funding research into the management and control of spotted wing drosophila (SWD). During this time, we have greatly enhanced our knowledge and understanding of how SWD behaves in UK growing conditions, and the best management and control options available to growers. The work continues in this project to develop novel approaches that may reduce our reliance on traditional crop protection products.

National monitoring

The entomology teams at NIAB EMR and James Hutton Institute have continued to monitor populations of SWD across the UK with the help and collaboration of Berry Gardens. Fifty-seven traps have been deployed across nine farms in England and four farms in Scotland. The modified Biobest trap design and Cha-Landolt bait have been used. The cold spring in 2018 meant that the activity density of adult SWD was lower than in 2017. As a result of this, overall population numbers in 2018 were slightly lower than in 2017. The main flight and dispersal of adult SWD occurred again in 2018 between September and November, when winter-form adults develop, a depletion in egg-laying sites (fruits) occurs and defoliation of trees (SWD refuges) begins. Despite higher than average temperatures in Scotland during the summer months of 2018, the number/activity levels of SWD remained low.

Developing a push/pull system

The purpose of this project is to combine the use of repellents and attractants so that the pest can be pushed away from the crop using a repellent and attracted into a trap which would contain a distracting or fatal component. Research to identify repellent compounds have so far been inconclusive, but further work collaborating with a NIAB EMR CTP student is showing promising results for some potential repellents.

NIAB EMR entomologists have developed a prototype 'attract and kill' trap which has been comparable to a commercially available alternative, with both achieving up to 30% kill of SWD adults within 24 hours in semi-field cage trials. However, in the presence of ripe fruit, the efficacy of both devices decreased by half. This crucial result suggests that these traps/devices might be best deployed in early spring when there is no competition from ripening fruit and SWD populations are at their lowest.

Other work has focused on developing a dry formulation of the 'Cha-Landolt' lure which is contained within a sachet. This saves time on weekly changes of the liquid lures while also lasting up to six weeks.

Bait sprays

Using bait sprays in combination with spray control products should encourage SWD adults to feed on the spray product – improving the likelihood of control. When compared with a spray control product on its own, it offers the potential to gain the same level of control with a lower rate of product.

A yeast (*Hanseniaspora uvarum*) in sugar solution, fermented strawberry juice and Combi-protec, a proprietary mixture of protein, yeast and sugars, all showed promise as bait sprays. When tested in the laboratory with three control products, they all increased mortality of SWD summer forms compared with using

the products in water alone. The work will continue in 2019, testing the baits in semi-field tests using strawberry plants inoculated with SWD.

Prolonging spray intervals

This piece of work is endeavoring to determine the length of time that cherry extra-floral nectaries (the glands at the base of cherry leaves) are available to SWD in a cherry orchard. It is also investigating whether growers might prolong their spray intervals beyond seven to ten days.

In the floral nectary work in 2017, the first fertile females were found in early April and more than 50% were producing offspring within a week. This coincided with cherry flowering. As the season progressed, the time taken to locate extra-floral nectaries in the leaves tended to increase but demonstrated that there was a nectar food source available to SWD until after harvest.

In the spray interval work, the scientists compared the use of weekly versus fortnightly spray programmes to control SWD. Results demonstrated that fortnightly sprays gave comparable efficacy to weekly sprays in cherry crops. The work was repeated in 2018 and the results were similar. It was also noted that where mesh was employed to exclude SWD from the crop, there were fewer adult SWD in the crop. In 2019, a fully replicated spray trial will be done in a commercial raspberry crop to reveal if similar results can be achieved compared with the cherry work.

Further lines of investigation into spotted wing drosophila (SWD)

In addition to the significant progress made with the principal SWD project funded by AHDB, we have been funding both a series of PhD studentship studies and the SCEPTREplus project to investigate alternative control strategies.

AHDB Project Code: CP 122 The identification of viral pathogens suitable for the control of *Drosophila suzukii* in the UK (AHDB studentship project)

Term: September 2014 to August 2017

Project leader: Darren Obbard, University of Edinburgh, and Jerry Cross, NIAB EMR

Nathan Medd at the University of Edinburgh and NIAB EMR investigated viruses specific to SWD that might be used for the development of microbe-based biopesticides. The work identified 18 new viruses from SWD alone. One of the viruses that was identified is named the 'Eccles Virus' (from the reovirus group) and belongs to a family of viruses that has been advocated for biological control in China. It is a candidate for further investigation for its insecticidal activity. Nathan later explored SWD's susceptibility to two different viruses by exploring its immune response. He found that several SWD genes change expression significantly upon

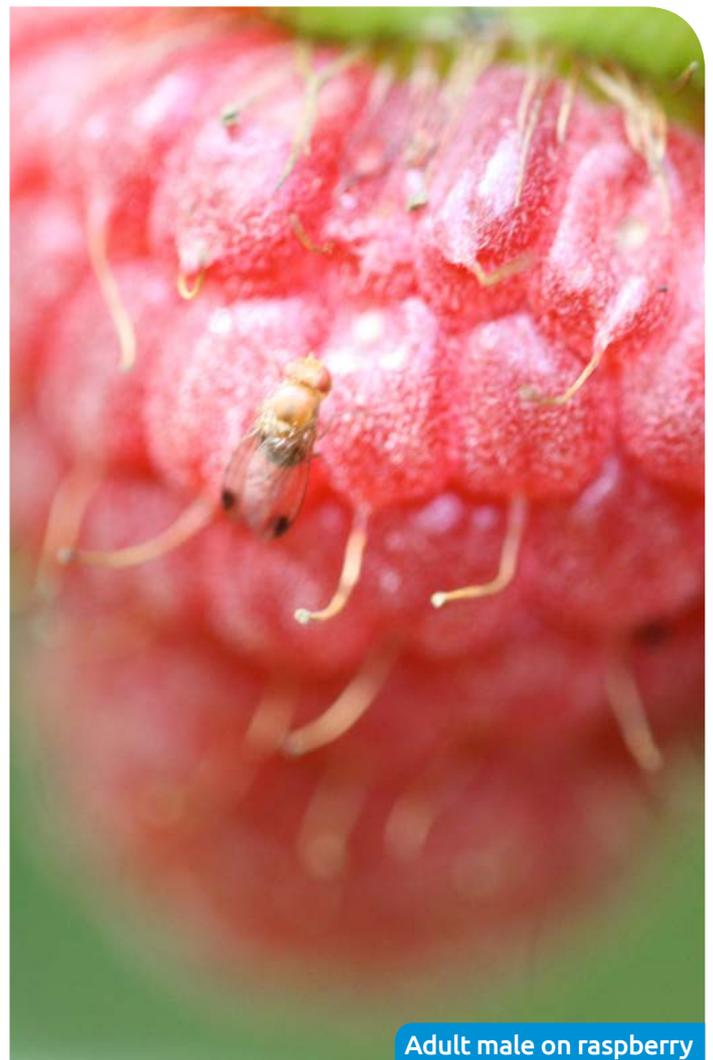
infection with the virus. Further work is required before viral pathogens become a realistic control opportunity.

AHDB Project Code: CP 142 Enhancing the control of the soft and stone fruit pest *D. suzukii* by exploiting its activity patterns in the field (AHDB studentship project)

Term: October 2015 to September 2018

Project leader: Herman Wijnen, University of Southampton, and Michelle Fountain, NIAB EMR

Bethan Shaw's project at the University of Southampton and NIAB EMR examined the behavioural and physiological rhythms of SWD, as determined by its internal circadian clock and environmental cues. Bethan discovered that the most active period for the female SWD to lay its eggs is during the daytime when the outside temperature reaches between 25–29.9°C. During the cropping months, the female insects display a preference for egg laying in the warmest part of the day, typically early afternoon. However, when temperatures exceed 30°C, egg laying is greatly reduced. Periods of activity appear to be in the morning and late afternoon, with very little movement or egg laying at night. Additional research demonstrated that SWD females choose to lay fewer eggs in fruits containing other species.



Adult male on raspberry

AHDB Project Code: CP 171 The use of highly attractive yeast strains for controlling *D. suzukii* (AHDB studentship project)

Term: October 2017 to September 2020

Project leaders: Matthew Goddard, University of Lincoln, and Michelle Fountain, NIAB EMR

PhD student: Rory Jones

In the first of three more recently commissioned SWD studentship projects, Rory Jones at the University of Lincoln and NIAB EMR is trying to identify different species and strains of yeast that attract *Drosophila* species. He also aims to use the best attractant strain, or blends of strains, of yeasts in 'attract and kill' systems to reduce the reservoirs of overwintering adult flies after the main cropping period.



Yeasts are known to attract SWD

AHDB Project Code: CTP FCR 2017 1
Developing a 'push-pull' strategy for the management of *D. suzukii*

Term: October 2017 to September 2021

Project leaders: Michelle Fountain, NIAB EMR, and Daniel Bray, NRI University of Greenwich

PhD student: Christina Conroy

Christina Conroy is further developing the 'push-pull' principle of control at NIAB EMR and the University of Greenwich. The aim is to optimise attractants and repellents and their deployment in control programmes, which will hopefully reduce reliance upon traditional crop protection products. Fourteen potential repellents have already been tested on both summer and winter morphs of adult SWD in the laboratory and all of these were found to cause some response in the creatures' antennae.

AHDB Project Code: CTP FCR 2018 4
Understanding and optimising entomopathogenic fungi for control of spotted wing drosophila

Term: October 2018 to September 2022

Project leader: Michelle Fountain, NIAB EMR

PhD student: Laurence Mason

Laurence Mason is investigating laboratory evidence that suggests that entomopathogenic fungi (particularly *Metarhizium anisopliae* and *Beauveria bassiana*) have shown promise in controlling adult SWD. The first aim of this NIAB EMR- and Harper Adams University-led project is to screen several strains of *Metarhizium anisopliae*.

The fungi are being screened for their efficacy in controlling SWD at various concentrations and fly life stages in comparison with currently available treatments. The second aim is improve our understanding of the genetics behind the pathogenicity of the fungal strains.

AHDB Project Code: SCEPTREplus 11
Egg-laying deterrents for the spotted wing drosophila

Term: January 2018 to March 2018

Project leader: Jerry Cross, NIAB EMR

The SCEPTREplus project aimed to identify new products that either deter SWD from laying eggs in developing fruits or reduce egg hatch. Various candidate products were tested by dipping blueberry and blackberry fruits in aqueous solutions of each product at the standard recommended rate. The adult SWD were then introduced to the fruits either 48 hours before, or 48 hours after, inoculation. One product (*Urtica*) significantly reduced numbers of emerging adults on blueberry. Another coded product (AHDB9931), when mixed with calcium hydroxide or another coded product (AHDB9919), reduced numbers

of SWD that emerged both before and after inoculation treatments, but only one result was significant. These results are promising and are worthy of further investigation.



SWD released into dipped blueberries



Assessing dipped blueberry



Assessing the attract and kill device

TF 223 project overview

AHDB Project Code: TF 223 Integrated pest management (IPM) of tree fruit pests and diseases

Term: April 2015 to March 2020

Project leader: Michelle Fountain, NIAB EMR

The five-year TF 223 project, set up in 2015, is focusing on the investigation of control measures for a range of key pests and diseases in tree fruit crops. It also has the flexibility to switch to other pressing problems as they arise during the course of the programme.

In the early years of the project, the research dealt with apple scab, powdery mildew, canker, codling moth, tortrix moth and apple fruit rhynchites weevil. The results have been reported in previous Tree Fruit Review magazines and in the annual reports, which can be viewed on the AHDB website.

Research has continued on powdery mildew and canker, and work has begun on *Monilinia* (brown rot) in cherry, *Blastobasis* moth, *Hoplocampa testudinea* (apple sawfly) and *Anthonomus spilotus* (pear blossom weevil). In addition, practical work in commercial orchards has been instigated to improve the reliability of natural predation of pests. A final objective of this project is to implement a surveillance programme for new and emerging pest and disease threats to the UK tree fruit industry. Each of these individual strands of the project are reported here.

Building up natural predator populations

AHDB Project Code: TF 223 Integrated pest management (IPM) of tree fruit pests and diseases – Objective 7 – Improving the reliability of natural predation of pests

Term: April 2015 to March 2020

Project leader: Michelle Fountain, NIAB EMR

Work has been instigated to increase 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 include 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 with an untreated area of the same orchard throughout 2018 and 2019.

In 2018, four of the six alleyway seed mixes established very well, with more than 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.

NIAB EMR entomologists are collaborating with five pear growers and their staff, training them to record pear sucker pest/predator numbers. This will help growers to make more informed decisions on whether and when to apply control measures and contribute to data for a potential model for predator/prey thresholds. The work so far has identified that where there are fewer than 1,000 pear sucker eggs, per 30 shoots, per week, and at least 10 anthocorids and/or earwigs, there is good control of pear sucker and control sprays can be avoided.

Often, earwigs were found where there were more anthocorids. This could be a consequence of crop management being more sympathetic to natural enemies on some sites. It was found to be important to continue monitoring after harvest, when there can be a resurgence in egg laying and nymph hatch, which subsequently damages overwintering buds.



Pear sucker nymphs



Brown marmorated stink bug

Keeping abreast of new pest and disease threats

AHDB Project Code: TF 223 Integrated pest management (IPM) of tree fruit pests and diseases – Objective 1 – Surveillance

Term: April 2015 to March 2020

Project leader: Michelle Fountain, NIAB EMR

The AHDB tree fruit panel members have emphasised the need for us to monitor new threats to our sector in the form of pests and diseases. Objective 1 of the tree fruit crop protection project TF 223 is monitoring the emergence of potential problems.

Insect pests

Spotted wing drosophila (SWD) (*Drosophila suzukii*) continues to be surveyed as part of a national monitoring scheme in Project SF/TF 145a.

Summer fruit tortrix moth (*Adoxophyes orana Fischer von Röslerstamm*) was detected for the first time in the West Midlands in 2015 and growers are encouraged to monitor for it in the region using pheromone traps alongside codling moth and fruit tree tortrix monitoring traps.

Pear blossom weevil (*Anthonomus spilotus*) is a new pest damaging spring flower and leaf buds that has been found in commercial pear orchards over the past few seasons. It was identified in 2017 by NIAB EMR and the Natural History Museum. Our factsheet '*Anthonomus spilotus* – a new pest of pears in the spring' summarises our current knowledge of its biology and control.

Brown marmorated stink bug (*Halyomorpha halys*) is an invasive pest which has been causing serious damage to horticulture crops in Italy and has the potential to cause

damage elsewhere. NIAB EMR is now deploying traps to monitor for its presence in Kent.

Pear shoot sawfly (*Janus compressus*) has been sighted by the Royal Horticultural Society. To our knowledge, this sawfly has not yet been found in any commercial pear orchards.

Green citrus aphid (*Aphis spiraecola*) was reported in apple orchards in south-east England in 2018. This species is difficult to distinguish from other species and is proving to be increasingly resistant to the current armoury of aphicides being employed by growers.

Diseases

Apple scab is being monitored in an indicator orchard by NIAB EMR as part of a large global project. The same indicator varieties have been planted at more than 30 sites in 24 different countries, each variety containing different known resistance genes to the scab pathogen. The survey work in this project has confirmed that the local UK scab population has broken the resistance conferred by the resistance gene *Rvi6*.

Apple rot surveys continue to be carried out by NIAB EMR. In 2017/18, *Neonectria* rot was particularly high in canker-susceptible varieties where inoculum was prevalent: Gala (64.2%), Cameo (57.9%) and Jazz (52.6%). *Botrytis* was the next most prevalent rot followed by *Neofabraea* (formerly called *Gloeosporium*), *Penicillium* and brown rot (*Monilinia*).

Neofabraea kienholzii is a species of *Neofabraea* (formerly called *Gloeosporium*) which causes an apple rot in store and has been reported in the UK by NIAB EMR pathologists.

Pear blossom weevil – a new, springtime pest of pears

AHDB Project Code: TF 223 Integrated pest management (IPM) of tree fruit pests and diseases – Objective 9 – *Anthonomus spilotus* in pear

Term: April 2015 to March 2020

Project leader: Michelle Fountain, NIAB EMR

Over the past few seasons, entomologists at NIAB EMR have been made aware of a weevil pest that has become increasingly prevalent in pear orchards in south-east England. The weevil was initially thought to be the pear bud weevil (*Anthonomus pyri*) – an uncommon species that is known to cause damage to pear – but experience of the damage being found was not consistent with pear bud weevil.

In 2017, the weevil was confirmed as being *Anthonomus spilotus*, which has one generation per year and which is commonly known as pear blossom weevil. Adults overwinter until early March and then begin to feed on developing flower and leaf buds of pear trees and, less frequently, on medlar or hawthorn. Our factsheet '*Anthonomus spilotus* – a new pest of pears in the spring' has been published to offer comprehensive guidance to growers.

The project

Both field and laboratory trials were carried out in 2017 to identify the best control products to employ. Further research in 2018 surveyed the damage caused by the differing life stages of the pest and the nature of the damage.

Results

Calypso (thiacloprid) was shown to provide effective control in field studies. Laboratory studies demonstrated that Calypso and Spruzit (pyrethrins) gave almost 90% kill, while Hallmark (lambda-cyhalothrin), Gazelle (acetamiprid) and Exirel (cyantraniliprole) offered around 50% control of adults. It should be noted that Exirel is not currently approved for use on pear crops. In research to determine whether product efficacy could be improved through stimulating ingestion, Calypso was found to be most effective in laboratory studies where shoots had been sprayed with products and then weevils allowed to feed.

In the studies to investigate damage caused in spring 2018, it was found that most flower and leaf bud damage was caused by adult *A. spilotus* feeding, with very little damage caused by the larvae. Damage to individual flowers by adults and larvae is very low, with only one out of a cluster of six typically damaged. As only three to four Conference fruits set on a single truss, this level of damage is not of significant commercial consequence. However, it was found that even at low levels of weevil population (around one per 40 tree taps), around 60% of new leaves could be damaged later in the season – post petal fall. This could have an adverse effect on photosynthetic ability. Long-term effects on tree health remain uncertain.

The optimum timing of control measures in growers' orchards will be determined in scheduled work in 2019.



Damage to pear buds caused by *Anthonomus spilotus*



Apple powdery mildew

New approaches to apple powdery mildew control

AHDB Project Code: TF 223 Integrated pest management (IPM) of tree fruit pests and diseases – Objective 3 – Foliar diseases

Term: April 2015 to March 2020

Project leader: Michelle Fountain, NIAB EMR

With the continuing pressure to reduce reliance upon traditional crop protection products, the industry needs to develop novel and alternative control measures for apple powdery mildew, which is caused by the pathogen *Podosphaera leucotricha*. A range of elicitors, biostimulants, biocontrol and physical control products are available to growers, but their success has shown great variation depending on seasonal weather conditions and disease pressure. Work on this project has aimed to find methods of reducing levels of overwintering mildew and develop ways of improving the reliability and use of alternative control products.

The project

During the past two to three years of this project, efforts have been made to investigate the use of fungal and bacterial parasites, which are applied to apple trees in late summer as a means of antagonising the pathogen over the winter and reducing levels of overwintering inoculum. During the growing season, work has also been directed at complementing standard routine 7- or 14-day spray programmes with novel products to improve the level of control being achieved, while reducing reliance upon traditional fungicides.

Results

Trials to incorporate the mycoparasite *Ampelomyces quisqualis* (AQ10) in overwintering buds to reduce mildew inoculum were inconclusive. Plans to repeat the trials in 2018, applying both AQ10 and a novel bacterial parasite towards the end of shoot growth in late summer, were hampered by early termination of growth due to the hot, dry conditions. It is therefore planned to reassess this approach in a different project.

Work carried out over the past two years that has sought to find ways of complementing fungicides with novel alternative control has found that 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 10 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 routine, 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. Further investigations are therefore needed.



Developing moth detection methods

AHDB Project Code: TF 223 Integrated pest management (IPM) of tree fruit pests and diseases – Objective 6 – Codling and tortrix moths

Term: April 2015 to March 2020

Project leader: Michelle Fountain, NIAB EMR

Growers are increasingly using pheromone mating disruption and granulovirus for moth control in orchards. Their use, coupled with a loss of approvals with broad-spectrum activity, has inadvertently resulted in the rise in populations of *Blastobasis* moth (*Blastobasis lacticolella*). Growers are often unaware that they have a problem and would therefore benefit from the development of a pheromone monitoring trap to detect the presence of this insect. Three potential pheromone

blends were identified in 2017 but failed to attract *Blastobasis* in trials, so the work continued in 2018.

Despite *Blastobasis* being present, as indicated by catches in light traps, the blends tested in 2018 failed to attract the pest. A new approach was adopted with adult *Blastobasis* moths being reared in the laboratory from larvae collected in the field, but the pheromones collected are unlikely to be sex pheromones. Further work is required and any growers who believe that they have populations of *Blastobasis* in their orchards are encouraged to make contact with Michelle Fountain and her team at NIAB EMR.

“The recent reappearance of *Blastobasis* following the use of mating disruption is a warning to growers that this pest could become a bigger problem in future, so I am pleased that NIAB EMR scientists are working to develop improved monitoring techniques.” Nigel Kitney, Herridges Orchard.

Multi-pronged attack for long-term solutions to European apple canker

AHDB Project Code: TF 223 Integrated pest management (IPM) of tree fruit pests and diseases – Objective 2 – Canker

Term: April 2015 to March 2020

Project leader: Michelle Fountain, NIAB EMR

AHDB Project Code: TF 226 The role of endophytes in affecting symptom development of European apple canker caused by *Neonectria ditissima*

Term: October 2017 to December 2020

Project leader: Xiangming Xu, NIAB EMR

AHDB Project Code: CP 161 Understanding endophytes to improve tree health

Term: October 2016 to September 2019

Main supervisor: Xiangming Xu, NIAB EMR

PhD student: Leone Olivieri

AHDB Project Code: CP 141 The molecular basis of pathogenicity of *Neonectria ditissima*

Term: October 2015 to October 2018

Project leaders: Richard Harrison, NIAB EMR, and Robert Jackson, University of Reading

PhD student: Antonio Gomez Cortecero

European apple canker, caused by *Neonectria ditissima*, continues to challenge apple growers as it can give rise to significant levels of tree death, reduce fruiting wood and cause fruit rot in stores, leading to serious yield reductions. Perhaps unsurprisingly, growers continually cite the disease as being the single most important problem they need AHDB research to address.

Canker can be particularly prevalent in newly established orchards and it is not uncommon to lose up to 10% of trees per year in the first three years after planting. This incurs additional costs in replacing and replanting trees and reduces yields in the early stages of a new plantation. These extra expenses come at a time when growers need quick returns to repay the significant outlay required to establish a new orchard.





Biological soil amendments

The projects

We are funding four projects at NIAB EMR to tackle this costly problem:

Within the five-year crop protection project (TF 223), we have been developing a tool to detect latent infection that isn't yet showing symptoms, assessing a number of rootstock/interstock combinations to measure any effects on canker, determining any effect of biological soil amendments on canker, examining novel methods to reduce canker such as trunk injection, and treatment of pruning wounds.

Project TF 226 is investigating the role that endophytes (organisms such as fungi and bacteria that live between living plant cells) may play in the suppression of canker and how we may use them to reduce the disease. Two PhD studentship projects are also included in the mix.

In Project CP 161, we are trying to learn if the canker fungus establishes itself in the tree as an endophyte before it changes to a pathogenic phase while also learning more about how it spreads once within the tree.

In Project CP 141, we are investigating the genetics of the pathogen to improve our understanding of potential resistance.

Results

Early work has successfully developed a diagnostic tool that is now being used within Project CP 161 with the intention of developing a sampling strategy to deploy the diagnostic tool in the nursery. The rootstock trials are evaluating a panel of rootstocks commonly used today, alongside several advanced selections from NIAB EMR and Geneva rootstock breeding programmes. By the end of the project, we may have a clearer understanding of the rootstock/interstock varieties associated with reduced canker of the scion. To date, across all sites, the rootstock EMR006 is looking the most promising. In the artificial inoculation experiment, in addition to EMR006, the rootstocks EMR002, M26 and MM106 also had reduced canker on the scion.

In the work testing biological soil amendments, we evaluated arbuscular mycorrhizal fungi (AMF), plant growth promoting rhizobacteria (PGPR), *Trichoderma* and biochar in both newly planted orchards and stoolbeds. *Trichoderma* significantly reduced the canker incidence in stoolbeds at one trial site, compared with PGPR, but not the untreated control. *Trichoderma* also significantly reduced mainstem canker incidence at a newly planted orchard.

Growers are likely to be particularly interested in the results of those trials that have assessed novel methods of treating canker. A tree injection system (Fertinyect) was assessed in the hope of eradicating systemic infection within the tree using a range of products, but none of these have provided sufficient efficacy to recommend to growers. More success has been achieved using Felco 19 secateurs with a chemical dispenser which treats pruning wounds at the time the cut is made. The fungicide tebuconazole, a coded biological control product and the physical barrier BlocCade were all compared with an untreated control. The marked cuts were inoculated with spores 24 hours after application of the treatments to simulate infection. All treatments offered some level of prevention, with the tebuconazole and tebuconazole + BlocCade treatments showing a significant reduction in canker.

Endophytes are microorganisms (bacteria and fungi) that live within plant tissues and can have a pathogenic or symbiotic relationship within it. Recent research has shown a link between antagonist fungal endophytes and cultivar tolerance to *Neonectria ditissima*. One fungal endophyte group belonging to the genus *Epicoccum* is much more abundant in two canker-tolerant cultivars than in two canker-susceptible ones. In Project TF 226, laboratory work has confirmed that a strain of *Epicoccum purpurascens* (isolated from an apple tree in the UK) can significantly reduce colony expansion of the canker pathogen. Work is now underway to find out if inoculating trees in the field with this strain can affect canker development. Related work is investigating whether soil amendments with AMF or PGPR can affect endophyte composition in trees and, similarly, whether soil physical and biological properties, cultivars and planting dates affect endophyte populations and canker expression.



Investigating the virulence of *Neonectria ditissima*

In project CP 161, artificial inoculation and reisolation experiments have demonstrated that *N. ditissima* can be isolated from apparently healthy woody tissue. This tissue lies underneath the cambium at 1 cm from the inoculated pruning wounds, both prior to and after the first canker lesions appear. The fungus was never isolated 4 cm away from the inoculation point. The work also showed that when infection occurs at pruning wounds, the pathogen is localised in the internal woody tissues of the branch within (at least) the four months following the onset of infection. Growers are therefore advised to completely remove infected areas of branches as soon as the first canker symptoms appear. The pruning cut should be made at least 5 cm from the edge of canker lesions. Other work in this project revealed that four different

apple cultivars are characterised by different endophyte profiles. Further research for this study will analyse the correlation between the endophyte profiles of eight apple cultivars representative of different levels of field resistance and their respective resistance level.

Project CP 141 has been investigating the ability of *N. ditissima* to cause disease, with the hope of identifying the specific genes that control hosts' ability to stand up to this problematic fungus. The PhD scientist has sequenced the genome of the pathogen and the next stage is to identify specific candidate genes that control pathogen virulence to allow a better understanding of the mechanism of infection.



Leone Olivier demonstrating his work to fruit agronomists as part of CP 161



Brown rot in plum

Developing novel measures for brown rot control on stone fruit

AHDB Project Code: TF 223 Integrated pest management (IPM) of tree fruit pests and diseases – Objective 4 – Stone fruit diseases

Term: April 2015 to March 2020

Project leader: Michelle Fountain, NIAB EMR

AHDB Project Code: CTP FCR 2017 7 Biocontrol as a key component to manage brown rot diseases on stone fruit

Term: October 2017 to September 2021

Project leaders: Xiangming Xu, NIAB EMR, and Michael Shaw, University of Reading

PhD student: Sophia Bellamy

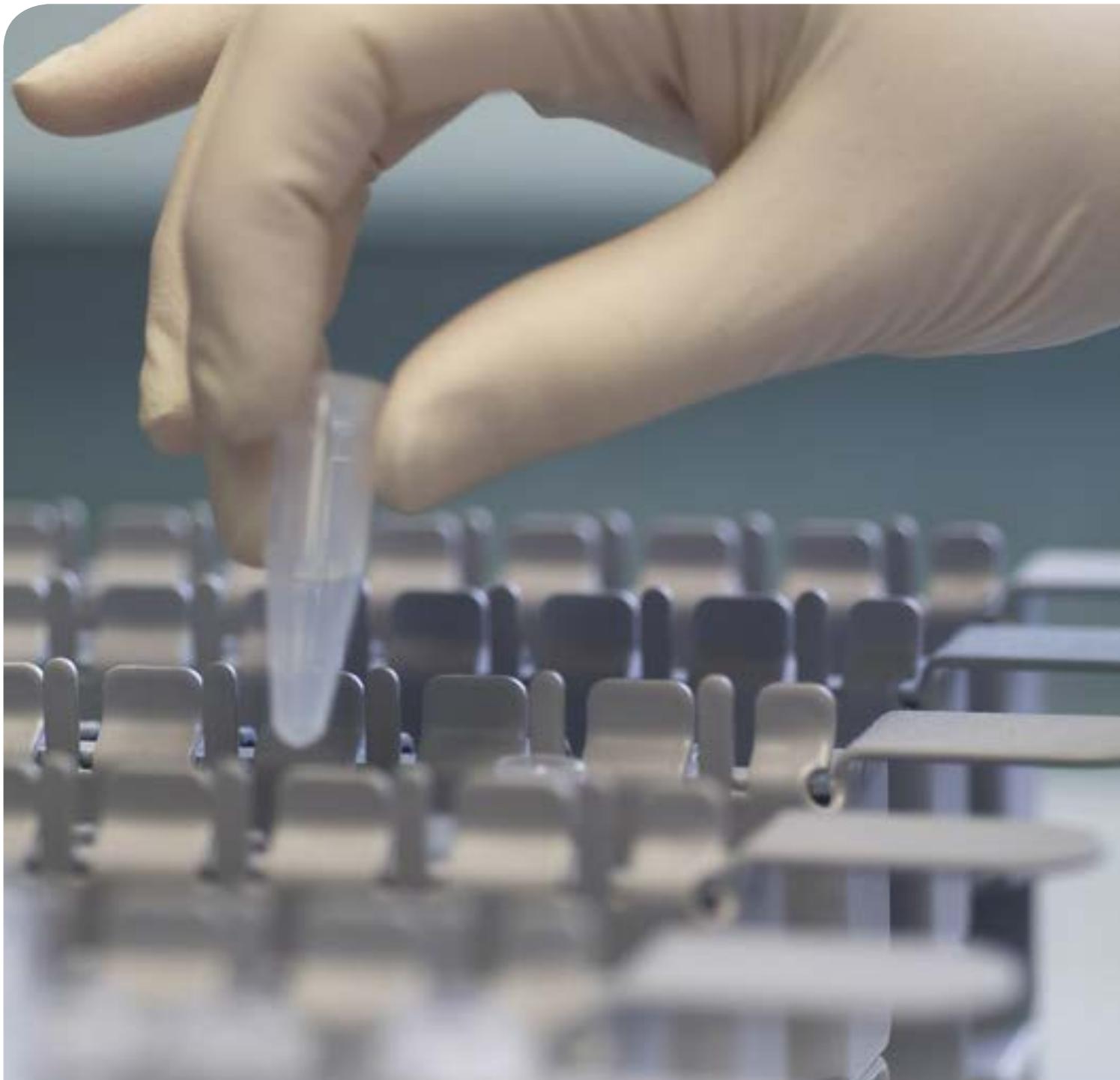
Brown rot caused by *Monilinia* species leads to serious losses in stone fruit crops through blossom blight, twig cankers and fruit rot. Latent infection (when the species lies dormant until the conditions for it to expand are right) on fruits is particularly prevalent as the pathogen can grow at temperatures of between 5–10°C. This means that *Monilinia* is capable of spreading during the cool chain and reducing the shelf life of fruit. Control generally relies on the use of traditional fungicide products, but as their availability diminishes and the pressure to reduce reliance on traditional products increases, the industry needs to find novel and alternative management and control measures. AHDB is therefore currently funding two projects to address the problem.

The projects

The first project falls within the five-year crop protection programme, TF 223. It has seen a range of products screened for their efficacy. They were applied as two sprays at blossom and two pre-harvest – with the exception of one coded, biostimulant product that 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 shelf-life tests. The incidence of blossom wilt was negligible in the trial, so no conclusions could be drawn. The incidence of brown rot at harvest was only 5% and there were no significant differences between treatments, although the standard fungicide treatment (Signum/Switch) and two coded products had the lowest incidence of rotting.

The second piece of work is a CTP studentship project, which is building on previous work carried out in the Defra Horticulture LINK project HL0189 (TF 194). This earlier project identified two microbial biocontrol agents that consistently suppressed brown rot development on cherry and plum in laboratory experiments at NIAB EMR. One was a bacterial species (*Bacillus subtilis*) and the other a yeast (*Aureobasidium pullulans*). In this work, further research with these biocontrol agents is being undertaken in the field to help the industry get the most out of these treatments.

A laboratory study to identify the optimum concentration of the biocontrol agents to successfully reduce brown rot on cherry has also been conducted. The work continues in 2019 and beyond.



The future of bacterial canker control in cherry and plum crops

AHDB Project Code: SCEPTREplus Laboratory and greenhouse evaluation of alternative products for control of bacterial canker

Term: March 2018 to September 2018

SCEPTREPLUS

Project leader: Matevz Papp-Rupar, NIAB EMR

AHDB Project Code: BBSRC IPA TF 227 An evolutionary approach to develop durable disease resistance to bacterial canker of cherry

Term: April 2017 to March 2021

Project leader: Michelle Hulin, NIAB EMR

The UK cherry market has greatly expanded in recent years, but bacterial canker remains a challenge for stone fruit growers. The disease is caused by the bacterial pathogen *Pseudomonas syringae* (*pathovars syringae* and *morsprunorum*). It affects all economically important *Prunus* species, including both ornamentals and tree fruits, such as cherries, plums and apricots. The disease affects all parts of the tree and symptoms include leaf spots, fruit necrosis, blossom blight and cankers on woody tissues. In severe cases, it has been reported to cause up to 70% tree loss in young cherry orchards. The disease was traditionally reduced to economically acceptable levels through the use of post-harvest applications of copper-based products prior to leaf fall, but this approval has been lost to growers.

The projects

Two projects are researching bacterial canker. In the first of these, a breeding project, work is focusing on the strains of the bacterial pathogens, and the proteins they produce, to suppress the host plant's immune system. It is known that host plants can also detect some of these proteins to induce resistance to them. The research is therefore trying to identify these host proteins so that they can be utilised in breeding host resistance. Work is also trying to improve our understanding of the genetic make-up of the bacterial pathogen, which will help in developing novel control methods. A final strand is the screening of cherry germplasm (commercial, wild and other *Prunus* species) for possible resistance towards the main bacterial canker pathogens.

The screening for resistance so far suggests that certain commercial cultivars such as Colney are more tolerant of all strain groups causing the disease, while wild cherry and ornamental species may possess a stronger resistance that could eventually be bred into commercial cherry crops. The longer-term objective is to identify the regions of the cherry genome (which is its complete set of genes) that control tolerance/resistance. Molecular markers (sections of DNA linked to a particular region of the genome) will then be developed to help the industry breed for resistance towards the main canker pathogens.

The second project is part of SCEPTREplus, in which NIAB EMR is screening the use of alternative products to copper for control of both pathogens (bacterial strains) in laboratory trials. A range of products were compared with the industry-standard copper product (Cuprokylt). A handful of them have shown promising results, with the food supplement N-acetyl-L-cysteine (NAC), AHDB9884 and hydrogen peroxide performing better or equivalent to the Cuprokylt industry standard across all three assays,

reducing bacterial population and disease severity. Serenade ASO and AHDB9885 also performed well, especially on leaf tests. Of the products tested, only Serenade ASO and Amylo X are currently approved for use on plum and cherry. Neither of the sterilants or NAC are approved as plant protection products. However, AHDB plans to investigate the prospect of getting NAC approved in future.

Reviewing control measures for plum rust

AHDB Project Code: SCEPTREplus A review of key current control measures for plum rust (*Tranzschelia discolor*) in the UK and overseas

Term: August 2018 to October 2018

SCEPTREPLUS

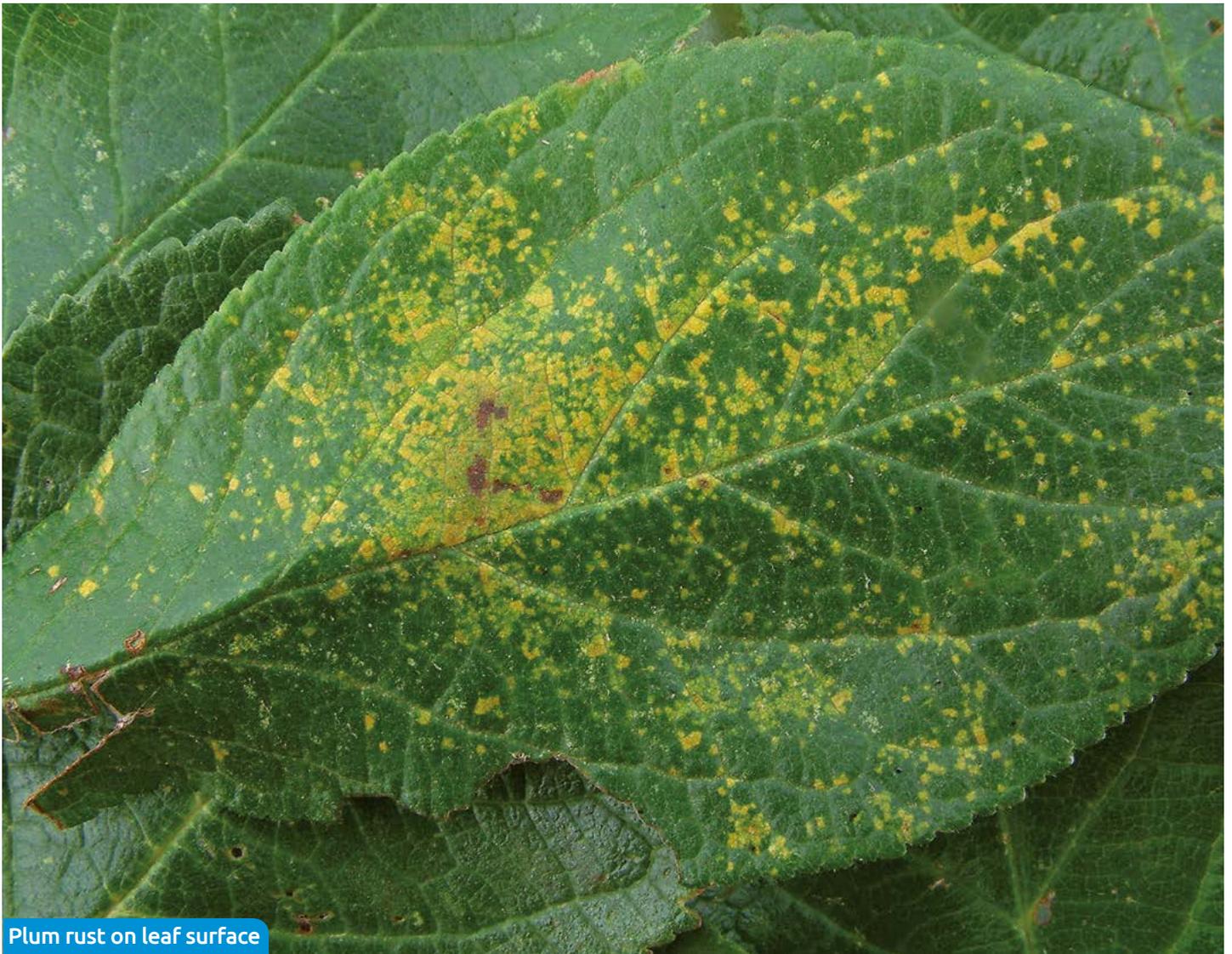
Project leader: Ruth D'urban Jackson, ADAS

The project

Control of plum rust caused by *Tranzschelia discolor* has always relied upon the use of a limited number of fungicides. Lately, growers have been depending on myclobutanil (Systhane 20EW), the only rust-specific product available. The recent loss of this active has, however, left a gap in plum growers' crop protection programmes. As part of the SCEPTREplus project, ADAS was commissioned to review potential management techniques and plant protection products that might offer control of plum rust. It included cultural practices to limit rust infection and management using conventional fungicides and biocontrol products.



SP19 Bacterial canker



Plum rust on leaf surface

Results

The review identified two particular areas that need to be addressed. The first is the need to better understand the disease conditions of plum rust, including the weather conditions that favour its appearance and when spore dispersal occurs. The second is to confirm whether infection is systemic (able to spread throughout the tree), as this knowledge will determine the choice and timing of spray control products.

Having done this, it would be prudent to test potential fungicides and biopesticides in efficacy trial work against *T. discolor* using products listed in the table below, which have potential to be registered for use on plum in the UK.

It would also be helpful to compare susceptible and tolerant plum rootstocks, such as St. Julian A and Wavit. The results could then inform growers of rootstocks that could be used in an integrated management programme.

Preliminary list of candidate products to control plum rust

Difenoconazole*	Pyraclostrobin + fluxapyroxad	Citronella oil**
Tebuconazole*	Pyraclostrobin + boscalid	Thyme oil
Azoxystrobin	Trifloxystrobin + fluopyram	Clove oil
Trifloxystrobin	Penthiopyrad	Orange oil
		Spearmint oil

* Actives are currently on the EC's list of candidates for substitution (as of December 2018). ** All oils listed are approved in the EU.

Breeding

Delivering new and improved rootstocks to the tree fruit industry

AHDB Project Code: TF 224, East Malling Rootstock Club

Term: June 2015 until May 2020

Project leader: Feli Fernández

The project

The AHDB tree fruit panel members believe that we should continue to fund the East Malling Rootstock Club to facilitate the delivery of new and improved rootstocks to the UK's tree fruit industry. AHDB has been co-funding the existing programme with the International New Varieties Network (INN) since 2008. The project aims to generate or identify new rootstocks in a vigour range, from dwarfing to semi-invigorating, that produce apples and pears with excellent yield efficiency and precocity. Nursery attributes (such as ease of propagation) and resistance to pests and diseases are also essential. Specifically, for apple growers, we aim to replace M9 and M26 with selections that have better anchorage and are resistant to replant and other soilborne diseases. In pear, a more dwarfing rootstock than Quince C is required, along with a dwarfing *Pyrus* rootstock that is easy to propagate. Interactions with other research projects at NIAB EMR, such as the BBSRC BB/P000851/1 on apple canker, and PhD studentships under the Collaborative Training Partnership for Fruit Crop Research (CTP FCR), will also benefit the breeding and selection processes. The CTP FCR research includes projects on root architecture and dwarfing, collar rot and woolly apple aphid resistance.

Recent progress

Second-stage trials are progressing well and LiDAR technology was tested for estimating plant vigour in 2018 with encouraging results. So far, some of the Canadian-bred entries look promising; for example, SJM127 produced trees of a similar size to M26 but with much higher yield efficiency. We would like to recommend that these genotypes are also characterised for pest and disease resistance prior to providing recommendations to industry.

The incorporation of the use of molecular markers (fragments of DNA linked to particular traits) for pre-selection and characterisation of apple breeding lines is steadily building up. The first markers to be incorporated into this pipeline of selection are those linked to the two main fireblight (*Erwinia amylovora*) resistance genes, followed by dwarfing-related genes.



Rootstock plots

The next tranche of the breeding programme is currently being renegotiated with the EMRC members for the period after 2020. The focus would be to prioritise early selection for pests and diseases, incorporate automated phenotyping and deploy marker selection as routine. Additional funding for marker characterisation for the pipeline of selection has been approved this year (TF224a) to assist the transition.

For this historical pipeline, a new dwarfing rootstock with excellent yield efficiency will be released from the programme in 2019–20 with the aim to replace M9.

Post-harvest

Strengthening storage regimes

AHDB Project Code: TF 225 Developing practical strategies to improve quality and storability of UK apples

Term: May 2016 to April 2021

Project leader: Richard Colgan, University of Greenwich

We have funded a great many post-harvest projects on apples and pears over the years – seeking ways to improve storage regimes to extend the long-term storage life of fruit and the subsequent quality being marketed. In recent times, world research has demonstrated that increased fruit dry matter (FDM) of apples at harvest is linked to improved eating quality and, in particular,

sweetness. It is also anticipated that higher FDM will maintain fruit quality for longer during storage. This project therefore set out to determine ways of manipulating FDM before harvest to improve the storage potential of fruit.

The project

The project has been focusing on four main objectives:

1. To carry out a meta-analysis (examination) of existing data sets to obtain a greater understanding of factors controlling both FDM and quality.
2. To assess whether improving light interception in the orchard can improve FDM at harvest.
3. To understand if the manipulation of crop load through fruit thinning can lead to increases in FDM.
4. To investigate the use of chlorophyll fluorescence to determine the optimum picking date for long-term storage of apples.



Use of white mulch to improve light interception



Mechanical thinning of flowers

Results

In the meta-analysis work, historical data for Gala identified 56 orchards where correlations between fruit dry matter and soil or leaf mineral analysis existed. It revealed a weak positive relationship between fruit potassium and magnesium concentrations and FDM, and also a negative relationship between zinc and FDM.

The effect of light interception on FDM has been investigated at NIAB EMR, where a trial area in an existing Gala orchard was set up to compare the existing tall spindle (TS) tree architecture with trees converted to a centrifugal system (CS). The use of white mulch reflective covers was also compared in both tree training systems. Light interception of the tree canopy in the CS was significantly higher than the TS system and the reflective covers increased yields in both systems. To date, yields of the CS have been lower than the TS, but this is in part due to the restructuring of TS trees into CS trees at the start of the trial and the yields are expected to equalise in time. The only difference in FDM in the trial so far was recorded in fruit in the upper canopy of the CS, where FDM was higher than fruit in the lower canopy. Recording is continuing in 2019.

The crop load work has been conducted in an orchard at Brogdale by FAST. A series of bud-, flower- and

fruitlet-thinning practices have been compared, including bud thinning, mechanical flower thinning, chemical thinning (including Exilis + Fixor and Brevis), standard hand thinning, hand thinning based on size and late hand thinning. The work has been done over two seasons so far and, to date, no significant differences in yield, proportion of Class 1 or FDM have been noted between the treatments.

Dessert apple growers currently choose to pick Gala apples based on starch/iodine testing – guidance is to pick when starch patterns clear to 75–80%. Little advance warning is provided using this method, so growers find it hard to mobilise picking staff quickly enough to harvest the fruit at the optimum time. In this project, staff at Landseer have experimented with a technique called chlorophyll fluorescence modelling (CF) – a non-destructive method of measuring fruit maturity. When compared with starch/iodine testing, it has repeatedly provided 7–10 days' advance warning of the optimum picking date. In commercial practice, this would allow forward planning to ensure sufficient pickers were available to start harvest at the optimum time and allow growers to put fruit in long-term storage in optimum condition.

Resource management

Plum Demonstration Centre – a new opportunity for growers

Four new plum demonstration orchards have now been planted in Kent following the completion of a four-year project on plums. Funded by Innovate UK and fruit industry partners, Sustainable Intensification of UK Plum Production was managed by NIAB EMR and FAST at Brogdale. It set out to study ways in which plum profitability in the UK could be improved. It therefore focused on enhancing yields, reliability of cropping,

extending the production season from July to October, and improving fruit value by raising the quality of the fruit being marketed and consumed. The results of the project are now available to the industry in a new Plum Best Practice Guide that can be found on NIAB EMR's website (emr.ac.uk/projects/best-practice-guide-to-uk-plum-production/). We are planning to make it available, and keep it up to date, on our website.



Plum demonstration Centre



Training systems on show at the Plum Demonstration Centre

Another outcome of Sustainable intensification of UK Plum Production has been the planting of four new demonstration orchards. Three of these are hosted by Kent growers – allowing a range of new varieties to be viewed by the industry. Early varieties are on show at Ash near Canterbury (A.C. Hulme & Sons), while late varieties can be seen at Pluckley (S W Highwood). A new plantation of varieties with high yield and quality potential, but which have been found to have unreliable cropping, has been planted near Sittingbourne (GH Dean).

The fourth orchard has been planted at NIAB EMR to demonstrate some of the outcomes from the research. Available for growers to view will be two new exciting varieties bred at NIAB EMR (P7-38 and P6-19). An adjoining area will showcase Victoria grown on Wavit and five other promising rootstocks, while another area is being planted with 23 new varieties, demonstrating how the season can be extended from July to October. Two additional areas of the orchard will demonstrate a range of tree architecture for Victoria and an area under protection to demonstrate the differences between outdoor and protected cropping.

AHDB has a long-term aspiration to develop more strategic and demonstration centres where research can be put into practice and help to speed up industry adoption of new technology. It is for this reason that we will be part-funding the maintenance and development of this plum demonstration orchard at NIAB EMR. It will not only allow growers to view the results of this particular plum project but will also enable the development and demonstration of other new technology. In the short term, it will be used to demonstrate weed control, use of organic mulches, optimum soil management practices and earwig-safe spray programmes, which were developed in AHDB Projects TF 196 and TF 220.

It is also planned to seek support from machinery manufacturers to demonstrate a wide range of cultural techniques, such as mechanised weed control and flower/fruitlet thinning. With further integrated pest management research projects currently being planned by the AHDB tree fruit panel, the orchard is well placed to demonstrate the results of these in future seasons.



Demonstration orchard at G.H. Dean near Sittingbourne

Production systems

Refining fruit wall growing in the UK

AHDB Project Code: TF 206 Comparison of different planting material for fruit wall orchard systems for apple

Term: December 2012 to March 2019

Project leader: Abi Dalton (FAST LLP)

The project

The use of fruit wall training systems is increasing within the UK's tree fruit industry, with a range of tree types being available to growers to help them establish such orchards. It is, however, unclear which tree type is best suited to the soils and growing conditions in England. This project determined the effect of tree type on tree development, yield and quality so that growers can make informed choices of which trees to buy for fruit wall growing.

Five distinctly different tree types (Gala clone Royal Beaut) were compared in a fruit wall orchard including: one-year 5 + branches, one-year unfeathered, two-year (grow-through), standard knip, twin stem. Tree height, spread and volume, yield, fruit weight and size and percentage class for each treatment were determined after harvest.

Results

The fruit wall trees at Brogdale were first mechanically pruned in 2014, timed when nine new leaves had emerged on the current season's growth. In the first

two years, trees from the two-year-old (grow-through) planting material yielded most fruit overall, while one-year unfeathered trees yielded the least fruit.

In 2016, the two-year-old (grow-through) trees produced the highest yields but were not statistically different from the standard knip or one-year 5 + branches, with all three of these tree types producing the expected 30 tonnes/ha of commercially grown three-year-old trees. One-year unfeathered trees remained the lowest yielding.

The following year (2017) showed that the two-year-old (grow-through) trees again had a significantly higher annual yield and also the highest cumulative yield. Twin stems had the lowest yield in 2017 and one-year unfeathered had the lowest cumulative yield.

In the final year of the trial (2018), standard knip trees had higher Class 1 yields than any other tree type, while twin stem and one-year unfeathered had the lowest. Two-year-old (grow-through) trees had the highest cumulative yields and twin stem and one-year unfeathered had the lowest.

Based on early yields in this trial compared with predicted returns, and considering tree costs, two-year-old, standard knip and one-year 5 + branches would be more profitable than one-year unfeathered and twin stem for growing in a fruit wall system at the same tree height and alley width as in the trial.

However, while twin stem and one-year unfeathered trees in this trial had statistically lower volumes and yields than the other tree types (and were also slower to establish and had higher incidences of disease), their higher yield efficiency suggests that they could be grown at reduced inter-row and alley widths and lower canopy height without yield reductions.



The Fruit Wall Trial at FAST's Brogdale site

Labour and logistics

Smart ideas to labour challenges

Our SmartHort campaign to help horticulture address the challenge of access to affordable labour continues to grow, with the launch of three new Strategic Centres and a challenge to help bring automated solutions into the production line.

While crop protection research remains at the heart of our activity at AHDB, we understand from talking to growers

that access to affordable labour has become one of the biggest concerns, particularly for the fruit industry.

Our SmartHort programme was launched in 2018 to support the industry resilience to labour challenges, from rising wage costs to difficulties in recruiting and retaining staff. More recent changes in language and dexterity skills of the staff now applying for work in the sector add to the challenges businesses face. The campaign has two clear strands: to look at improving management practices for the existing workforce and to identify new technologies and innovation, such as robotics and automation, which could play a role in providing longer-term solutions.



Smart labour management

We know that management techniques such as Lean, Champion and Continuous Improvement can make a difference to businesses of all shapes and sizes to improve labour efficiency and can apply throughout the production system, from picking to packing. Importantly, we want to help businesses to be confident that they are getting the best out of the workers that they have.

To help demonstrate the benefits of implementing 'LEAN' and efficiency techniques and to support growers bringing them into their own businesses, we are launching three new 'Strategic SmartHort Centres'.

The centres will be located around the UK in Cambridgeshire (Volmary), Herefordshire (Haygrove), and Perthshire (Thomas Thomson). Each business has offered to implement 'LEAN' to improve their labour management and demonstrate their progress with other growers as a live case study for productivity improvements. As the centres focus on labour management the type of production is of secondary importance and growers who want to get involved are recommended to come along to the centre nearest to them.

Businesses who attend the three annual workshops at their chosen centre will also be guided by specialists, Fedden USP, to develop their own labour efficiency plans. We expect all businesses who fully engage with these centres will see labour and productivity improvements of between 25–40%.

Neil Fedden, the productivity consultant, who will run the Strategic Centres, explains: "We will take the host centre, as well as the workshop attendees, through the LEAN process, which is really about identifying and then cutting out or reducing those activities that don't add value to the business. When you reduce waste and use your resources more efficiently you can add significant value to the business."

The workshops will cover:

- Process mapping and waste identification
- Practical problem solving using a technique called Plan, Do, Check, Act
- How to encourage continuous improvement across the whole organisation
- Visual management boards and metrics to check improvements have worked

Francis Mizuro, Operations Manager of Volmary Ltd, said: "We're delighted to have been chosen as one of the first SmartHort Centres. We're very excited to bring the investigative trial work to our site and to be a key part of the development of systems and technologies that will help both the industry as a whole and our own business.

"We feel, by investing some of our time and resources to this programme, we will help progress an industry that has lacked investment, focus and people."

For those not able to attend the events, progress and results will be shared to the whole industry through blogs, podcasts, articles and videos.

The Strategic SmartHort Centres build on the success of previous training and development workshops that have been offered as part of the SmartHort programme. A series of supervisor training courses ran around the UK in early 2019 as investment in management training for supervisors is often limited. And eight workshops that introduced the concept of Lean, Champion and Continuous Improvement proved so popular that further courses were developed to meet the increasing demand.

If you'd like to find out more about our skills and education programme and labour efficiency improvements, please contact grace.emeny@ahdb.org.uk





Smart technology

The ultimate solution to the shrinking pool of available labour is to automate, and our survey in 2017, which showed over 84% of businesses were planning to invest in automation or robotics to offset labour challenges, confirmed how progressive horticultural businesses are with their investment and future plans in this area. However, no growers yet have end-to-end automated processes. This could be due to a combination of a poor fit of 'off-the-shelf' solutions to the diverse production systems many growers work with, or an unfavourable cost/benefit ratio for the current trading climate.

To help accelerate automation in horticulture, we launched our pioneering SmartHort Automation Challenge. The challenge offered the opportunity for a UK horticulture business to work collaboratively with experts to deliver an applied automation prototype solution to their production system.

This new initiative will adapt and assemble off-the-shelf solutions to function effectively within live commercial systems. The experts managing the Automation Challenge from the WMG department of the University of Warwick have an excellent track record of delivering automation solutions to manufacturing industries and working with commercial companies to find solutions to specific problems.

In response to our call, we received great ideas from 22 different growers across horticulture, from which the Challenge project will be selected. These ideas ranged from correcting the position of pots on potting lines for

smoother operation, through to developing a smarter version of the irrigation boom for precision application of water and pesticides, to Autonomous Guided Vehicles (AGVs) in different nursery situations for moving product around a site. Solving all of these problems would reduce labour inputs and improve productivity for each business. Thanks to the 2,500-strong pool of postgraduate students at WMG, this initiative will additionally address several projects by feeding the challenges set by growers through to student projects.

At the time of writing, final decisions are being made, but the exciting news is that the current lead project, based around AGVs, has potential to work with the needs of three different businesses who posed similar challenges to the team. Furthermore, we expect the solution delivered will be suitably adaptable that it would meet the needs of a much large number of horticultural businesses. Please keep an eye on the SmartHort webpages for updates on how this project develops.

Our SmartHort 2019 conference back in March explored the future of automation and robotics with the aim of driving innovation into horticulture. Guest speakers from around the world shared some of the most impressive technological developments that could change the way you grow. If you missed the conference, you can watch again online.

To find out more about the SmartHort campaign and how it could help your business, visit ahdb.org.uk/smarthort or contact grace.emeny@ahdb.org.uk

Project round-ups

Cutting-edge, cross-sector research

Students are busily working on several AHDB-commissioned projects that are of particular interest to fruit growers. Two of these are PhD studentship projects that pertain to several horticulture sectors, while another four CTP studentship projects are of specific interest to fruit growers.

AHDB Project Code: CP 176 Selection and improvement of insect pathogenic fungi for the control of multi-resistant aphids

Term: October 2018 to September 2021

Project leader: Ben Raymond, University of Exeter

PhD student: Zoltan Erdos

Several aphid species, including the problematic peach-potato aphid (*Myzus persicae*), have developed resistance to traditional aphicides used by growers. However, entomopathogenic fungi (EPF) (which can act as a harmful parasite to these aphids) are largely unexplored for use in controlling these insects. This project will therefore assess whether the aphid clones displaying resistance to chemical aphicides are susceptible to fungal infection. Further work will employ novel selection techniques to develop more virulent strains of the pathogenic fungi so growers can improve the control achieved in the field. Ultimately, the aim is to produce clones of pathogenic fungi that have increased killing power in multi-resistant clones of aphids.



Aphid attacked by EPF B13

AHDB Project Code: CP 178 Population genetics to understand the mechanisms of *Xylella fastidiosa* pathogenesis to inform novel control measures

Term: October 2018 to September 2021

Project leader: Robert Jackson, University of Reading

PhD student: Luisse Paola Mirabueno

The bacterial plant pathogen *Xylella fastidiosa* has been identified in mainland Europe as being the cause of stunting, wilting and death in several horticulture crops, including fruit crops. Olives, citrus and grapevines have all been damaged in Southern Europe and *Prunus* species, such as plum and cherry, are at great risk. To date, *Xylella* has not been confirmed in the UK, but there is a very great threat of it arriving here on infected plant material that shows no symptoms. This project aims to understand the genetic mechanisms of infection in different hosts to help inform the development of specific control measures for the disease.

AHDB Project Code: CTP FCR 2017 3 Mechanisms of winter dormancy break and how to better influence in the context of climate change

Term: October 2017 to September 2021

Project leaders: Mark Else, NIAB EMR, and Paul Hadley, University of Reading

PhD student: Carlota Gonzalez Noguera

Dormancy in apple is regulated solely by temperature, so bud break is especially vulnerable to climatic changes and global warming. Insufficient winter chilling can reduce or delay bud break, result in non-uniform flowering and therefore smaller and abnormal fruit development. Earlier bud break advances flowering date and makes the crop more vulnerable to late spring frosts. To this end, this project will investigate existing chilling models and develop improved models that will help to inform cultivars' responses to warmer temperatures.



Uniform flowering in apple



Soil quality for tree health

AHDB Project Code: CTP FCR 2017 9 Combining root architecture, root function and soil management to improve production efficiency and quality of apples

Term: October 2017 to September 2021

Project leaders: Richard Harnden, Berry Gardens, Feli Fernandez, NIAB EMR, and Amanda Rasmussen, University of Nottingham

PhD student: Magdalena Cobo Medina

This project will use new advances in molecular marker development to understand how root system architecture (RSA) can be optimised for anchorage, vigour control and nutrient use efficiencies, and how these traits can then be deployed in breeding programmes to aid selection for new and improved rootstocks. The results will hugely benefit the work being done in the East Malling Rootstock Club.

AHDB Project Code: CTP FCR 2018 5 Investigating durable resistance to *Phytophthora cactorum* in strawberry and apple

Term: October 2018 to September 2022

Project leaders: Charlotte Nellist, NIAB EMR, and Jim Dunwell, University of Reading

PhD student: Matteo Luberti

The oomycete pathogen *Phytophthora cactorum* damages both strawberry and apple crops, causing crown rot and leather rot in strawberries and crown rot, collar rot and root disease in apples. Extensive work



Crown rot in apple

has been done at NIAB EMR to identify genetic markers conferring resistance in strawberry, while also sequencing the genes of 19 isolates of *P. cactorum* from both strawberry and apple. In this project, investigations will seek to understand why isolates from apple are unable to cause disease in strawberry and vice versa. Screening apple rootstock cells for resistance to the pathogen and mapping the genes behind any resistance will also be carried out.

AHDB Project Code: CTP FCR 2018 6 Understanding soil resilience to improve tree health

Term: October 2018 to September 2022

Project leaders: Louisa Robinson-Bowyer and Xiangming Xu, NIAB EMR, and Naresh Magan, University of Cranfield

PhD student: Chris Cook

Specific apple replant disease (SARD) has long been known to reduce the growth of newly planted trees in soils that have previously grown apples. The use of soil fumigation in the past has helped to alleviate the problem, but with the loss of such products, coupled with increased planting of high-density fruit wall production systems, the UK apple industry has seen an upturn in the problem. An AHDB-funded review of the problem highlighted a mix of likely contributing factors, including the presence of certain fungal and oomycete pathogens, the lack of specific beneficial microorganisms and the presence of certain nematode species. This project aims to improve our understanding of how various soil management practices affect SARD and canker development in apples.

Keeping you informed

AHDB Podcast

We have launched a podcast channel to keep you informed about the latest research, news, events and innovation to support UK horticulture. We cover topics from crop protection, labour and water, to Brexit. You can now subscribe and listen any time on iPhone and Android: bit.ly/AHDBpodcast

Best practice guide

The Apple Best Practice Guide is a one-stop shop for all your information. It provides comprehensive information about the agronomy of growing apples, pest and disease recognition, biology and control, harvesting information and post-harvest technology. apples.ahdb.org.uk

Publications

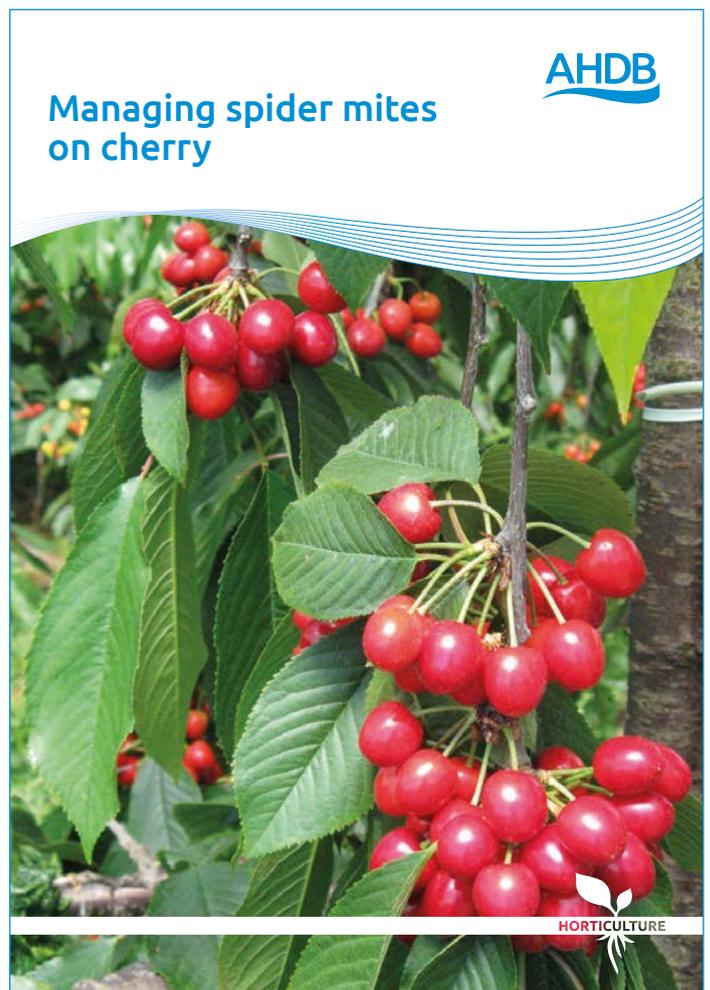
We have recently published two new guides, 'Earwig-friendly spray programmes in apple and pear crops' and 'Managing spider mites on cherry'. These, along with our rich back catalogue of factsheets, Crop Walkers Guides and posters, are all available online at ahdb.org.uk/knowledge-library or to order from comms@ahdb.org.uk

Brexit

Depending on the outcome of the Brexit negotiations, there may be a significant impact on the horticulture industry. We have compiled a wealth of information on the potential impact to your business, with tools, case studies, our Horizon reports and links to useful technical notices from government. ahdb.org.uk/Brexit

Become a panel member

Our crop sector panels play an important role in guiding us on how we tackle the critical issues that affect the industry. We rely on having progressive growers with new ideas to join our panels to make sure your levy is being invested in the most impactful and useful way. This year we are looking for growers to represent both culinary apples and East Anglia. If you would like to help steer the work we do for you, get in touch with katja.maurer@ahdb.org.uk to find out more.



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Produced for you by:

AHDB Horticulture

Stoneleigh Park
Kenilworth
Warwickshire
CV8 2TL

T 024 7669 2051
E comms@ahdb.org.uk
W horticulture.ahdb.org.uk
 [@AHDB_Hort](https://twitter.com/AHDB_Hort)

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