

Soft Fruit REVIEW

AHDB



2018

Improving
yield **stability**
in **blueberry**



SWD - Progress so far



Preserving earwigs



Delivering the next Malling Centenary

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Foreword



Louise Sutherland
Soft Fruit Panel Chairman

Welcome to the 2018 Soft Fruit Review, which summarises the current research AHDB is funding on behalf of soft fruit growers. This review should give you a flavour of the excellent results our research is achieving across the sector, and if you'd like to delve further into a project you can access the full reports on our horticulture website: horticulture.ahdb.org.uk/sector/soft-fruit

Spotted wing drosophila (SWD) continues to be one of our principal research priorities. The industry-funded SWD project SF 145, of which AHDB was a major funder, came to an end in March 2017 and I am pleased to report that it provided us with a vast amount of new knowledge which we have continually disseminated to you since the project began in 2013. Most growers are following the guidance that was formulated from the results, but there is no single measure available to control SWD, so it's essential our research continues. At AHDB we've therefore worked very closely with the industry to develop a new project, SF/TF 145a, to continue the work on your behalf. We're also funding a number of related SWD research projects through our PhD Studentship scheme. All the details can be found in this publication.

In parallel, we continue to fund other crop protection research, primarily through our five-year programmes on strawberry pests (SF 156), strawberry diseases (SF 157) and cane fruit pests and diseases (SF 158). These provide a structure to allow us to continue researching solutions to problems such as western flower thrips, aphids, powdery mildew, strawberry crown rot, Verticillium wilt and raspberry root rot, while the new AHDB SCEPTREplus project offers a mechanism of researching new and emerging crop protection products for controlling some of these problems.

Our funding of the East Malling Strawberry Breeding Club and UK Raspberry Breeding Programme

continues. I passionately believe that this funding is essential to developing new and improved genetic resistance to pest and disease problems, while also offering growers opportunities to further increase yields and reduce labour costs by improving fruit presentation to pickers. Some exciting new varieties are emerging from both programmes. Our involvement with a number of Innovate UK projects, which are using genetic techniques to develop ways of overcoming pest and disease problems and improving fruit quality and yield stability, will significantly contribute to the success of both breeding programmes in the long term.

We continue to develop new ways of disseminating the results of our research to you each year, while also continuing to organise the soft fruit technical day at East Malling and a dedicated day for fruit agronomists to learn about our research and discuss your research needs. If you haven't had the chance to read it yet, I recommend the AHDB Crop Protection Review 2017, which provides a comprehensive summary of the breadth and depth of work AHDB is carrying out on your behalf on all crop protection matters.

If you'd like notification of our latest events and publications, or want to know more about our results, contact Knowledge Exchange Manager Scott Raffle at scott.raffle@ahdb.org.uk or on 01732 876 671.

I am particularly grateful for the support I get from all the members of the AHDB soft fruit sector panel who help me to ensure that our research meets the needs of soft fruit growers. If you've any suggestions to make please contact our Research Manager Rachel McGauley at rachel.mcgale@ahdb.org.uk or on 02476 478 768. Alternatively, contact me or any of our panel members (contact details can be found on page 4).

I wish you a successful production season in 2018.

“There is no single measure available to control SWD, so it's essential our research continues”

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Contacting AHDB Horticulture

Soft fruit growers are currently served by Research Manager Rachel McGauley, Knowledge Exchange Manager Scott Raffle, and Crop Protection Manager Vivian Powell.

Rachel works with the industry to develop the correct research projects for your needs and to liaise with scientific contractors who undertake the work on your behalf.

Scott's task is to co-ordinate the dissemination of the information. They are supported by an administration team.

Vivian works on AHDB's minor use programme and is responsible for applying for and securing EAMUs to help growers protect their crops.

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How AHDB Horticulture operates for soft fruit growers

The levy form that you complete for AHDB Horticulture each year provides us with information, including annual turnover, from which your actual levy is calculated. The form also asks which crops you currently produce and which sector you would like your levy allocated to. From this we make a budget for soft

fruit R&D, which the soft fruit sector panel manages on behalf of the industry.

The panel is composed of elected grower members and technical specialists. The elected members decide each year how the sector's budget should be spent. Research Manager Rachel McGauley

and panel members continually liaise with growers and with technologists in the industry to keep abreast of the latest and likely problems. This allows the panel to maintain a research strategy, which ensures that new projects focus on the highest research priorities.

Helping support you through the next growing season

AHDB produce a range of materials and resources to help growers tackle the major issues facing the soft fruit industry



Crop protection

Access to plant protection products

The AHDB minor use programme aims to minimise the impact of losses of plant protection products and to provide alternative solutions for UK growers.

As well as collaborating with agrochemical and biopesticide companies to identify novel products for screening trials, the programme also makes applications to extend the authorisation for minor use (EAMU) of existing products.

Growers will continue to receive EAMU notifications as they become authorised and we have introduced a new monthly crop protection email newsletter, sharing industry developments.



SCEPTREplus

SCEPTREplus is a four-year crop protection programme to deliver applied research on high priority disease, pest and weed problems. The first trials for soft fruit will look at egg-laying deterrents to help control SWD and weed control in rhubarb crops.

To keep up-to-date with the trial's, visit horticulture.ahdb.org.uk/sceptreplus

We also want your input to shape future trials. Please contact joe.martin@ahdb.org.uk to let us know if SCEPTREplus could help address your pest, weed and disease challenges.

Spotted wing drosophila

Regularly updated with new information and research results, our dedicated SWD webpage also contains factsheets, identification guidance and training videos about pest monitoring, assembling traps, and methods for testing the presence of SWD in fruit. Visit www.horticulture.ahdb.org.uk/swd.

Biopesticides and biocontrol

The AMBER project, run by University of Warwick to help growers improve the performance of biopesticides, will be running a series of free workshops in 2018. More information and useful introduction guides to biopesticides can be found at bit.ly/AMBERproject

Videos on how to manage biocontrol predators when they arrive on the farm and how to introduce and manage them in the crop are also available at horticulture.ahdb.org.uk/biocontrol-videos

Labour

Lean

The high cost of labour and the uncertainty over the future supply of workers is causing significant concern for growers, particularly in the soft fruit industry.

To address this challenge, AHDB has launched a knowledge exchange programme to encourage the adoption of Lean principles into horticulture businesses to help improve labour efficiencies.

A series of events will be held for growers as part of the programme. The next workshops will be held in March 2018 in Lincolnshire and Lancashire. To find out more and to book a place, visit change to horticulture.ahdb.org.uk/labour

Horizon reports

AHDB has released a series of publications looking at the potential implications for the industry of the UK's decision to leave the EU. The analysis in the new 'Horizon' series examines trading relationships between the UK and the EU post-Brexit, the impact on workforce, alongside examining the implications of World Trade Organization (WTO) rules. Visit www.ahdb.org.uk/brexit

Nutrition

The Nutrient Management Guide (RB209) was revised by AHDB in 2017. It helps you make the most of organic materials and balance the benefits of fertiliser use against the costs, both economic and environmental. It explains the value of nutrients, soil and why good nutrient management is about more than just the fertilisers you buy; it can save you money as well as help protect the environment.

Download from the Apple Store or Google Play store, or visit ahdb.org.uk/projects/RB209

To request publications or for queries about access to AHDB resources, please contact comms@ahdb.org.uk



Latest crop protection news



Fruit agronomists briefed on latest AHDB research at NIAB EMR

Over fifty industry agronomists had the opportunity to view the current AHDB-funded fruit projects and discuss future research requirements at an event at NIAB EMR, Kent in September.

Michelle Fountain, researcher at NIAB EMR informed delegates about a new weevil pest found in pear orchards and the suggested control options based on its lifecycle.

Other tree fruit projects presented included maximising dry matter content of apples to improve storage life post-harvest, control

options for canker and powdery mildew in apples and fruit pollination by solitary bees.

Soft fruit agronomists were updated on current spotted wing drosophila research, strawberry powdery mildew control, new approaches to spider mite control in raspberry and a new monitoring device for western flower thrips and their predators.

There was also the opportunity to visit the new NIAB EMR WET (Water Efficient Technologies) Centre which offers a demonstration site for nutrient and irrigation management.

Richard Harnden, Berry Gardens Growers, who attended the event said: "There is

no substitute for getting out into the field to view the research in progress, rather than hear about the work in a PowerPoint presentation. I congratulate the AHDB in changing the arrangements for this year's event. Our own agronomists, who also attended, welcomed the opportunity to discuss current problems in the field with NIAB EMR's scientists and identified a number of practical issues and factors, which the scientists can incorporate in their projects as they continue into next year".

The latest research was also presented to growers at the AHDB / EMR Soft Fruit Day in Kent on 21 November and presentations are available on the event page, horticulture.ahdb.org.uk/events.

AHDB Bush Fruit Crop Walkers' Guide now available as an app

Accurately identify and diagnose pests and diseases while out in the field

Take photos and create reports of affected crops

Log the GPS location of where pest and disease symptoms are spotted

Download now from the Apple Store and Google Play Store



New AHDB projects

Five new research and development (R&D) projects with relevance to the soft fruit industry have recently begun. These were approved by the elected soft fruit panel members and all of them meet the needs of the latest R&D strategy developed by the panel. In addition, a new Collaborative Training Partnership (CTP) programme of research has begun in the past year, which AHDB part funds. Three new projects have relevance to soft fruit.

SCEPTREplus

SCEPTREPLUS

Term: April 2017 to March 2021

Project leader for fruit: Jerry Cross, NIAB EMR

Industry representative for soft fruit: Roger Vogels, S&A Produce

SCEPTREplus is an AHDB programme of research designed to assess the efficacy of new or emerging crop protection products at controlling pests, diseases or weeds in the full range of horticultural crops. It is a four year programme which will link with other crop protection projects already underway and, in particular, it dovetails closely with the AMBER project on biopesticides. Specifically on soft fruit, it will link closely with the existing crop protection projects on spotted wing drosophila (SF 145a), strawberry pests (SF 156), strawberry diseases (SF 157) and cane fruit pests and diseases (SF 158), providing a forum to examine the efficacy of products for controlling some of the pests and diseases being researched in these other projects. In the first year of SCEPTREplus (2017), soft fruit sector related problems being worked on are spotted wing drosophila, broadleaf weed and grass control in blackcurrant, and annual and perennial weeds in rhubarb.



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

Industry representative:

Marion Regan, Hugh Lowe Farms

Location: NIAB EMR and the James Hutton Institute

This project is a continuation of the work done in project SF 145 which ended in March 2017. This was the industry-funded SWD project which has already greatly enhanced our knowledge and understanding of how

spotted wing drosophila behaves in UK growing conditions and the best management and control options available to growers. This new project aims to further develop our knowledge of the pest's distribution across the UK and its preferred habitats. It will develop a 'push/pull' system using repellents and 'attract and kill' strategies which will be refined to provide guidance for growers. Bait sprays will also be investigated, using them in combination with control products to see if they will enhance their efficacy. The opportunity to prolong spray intervals to maximise the effect of control products, while reducing the number of applications, will be assessed. Later in the project, work will be done to integrate the use of exclusion netting with other control options. The results of all of these lines of research will be compiled into a year-round SWD control strategy for growers.



CP 171 – The use of highly attractive yeast strains for controlling *Drosophila suzukii* (spotted wing drosophila)

AHDBSTUDENTSHIP

Term: October 2017 to September 2020

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

PhD student: Rory Jones

Industry representatives: Harriet Duncalfe, H&H Duncalfe, and Oliver Doubleday, G H Dean

Location: University of Lincoln

AHDB has been funding research into spotted wing drosophila (SWD) since 2013 through the industry funded project SF 145. The work has identified that SWD populations reach a peak during the autumn and early winter months. It has also shown that ripening fruits tend to be more attractive to SWD adults than the baits currently used in commercial monitoring traps. In this project, a PhD student at the University of Lincoln, which has identified yeast attractant strains to other *Drosophila* species, will test and identify different species and strains of yeast as feeding attractants to *Drosophila suzukii*. Working in collaboration with the entomology team at NIAB EMR, the student aims to use the best attractant strain of yeast in 'attract and kill' systems to reduce the reservoirs of overwintering adult flies after the main cropping period when populations are highest and when no fruits are present to compete with the yeast bait.



CP 170 – Bioinspired vision systems for automated harvesting

AHDBSTUDENTSHIP

Term: August 2017 to July 2020

Project leader: Michael Mangan, University of Lincoln

Industry representative:

Harriet Duncalfe, H&H Duncalfe

Location: University of Lincoln and commercial strawberry production sites

Robotic harvesting of strawberries is an aspiration which is still some way from becoming a commercial reality for the strawberry industry. However, this PhD studentship project aims to develop

the vision systems required by a robot when it decides which strawberry fruits are ready to be picked. The work will take inspiration from insects such as bees and fruit flies which use visual cues invisible to humans and which tend to be overlooked by engineers. The student will work closely with industry partners to collect a novel image database of fruits and flowers at various stages of development and in different weather, lighting and protected conditions. This will be done using a specially developed camera which mimics the vision system of insects. Subsequent analysis will allow the fundamental methods employed by these insects to be revealed. The results will provide a vision system which could be used to drive a robotic strawberry harvester.

CP 173 – Towards a better understanding of the biology and genetics of *Phytophthora rubi* and *Phytophthora fragariae*

AHDBSTUDENTSHIP

Term: October 2017 to March 2021

Project leader: Eleanor Gilroy, the James Hutton Institute

PhD student: Aurélia Bézanger

Industry representative:

Richard Harnden, Berry Gardens Growers

Location: the James Hutton Institute

The control of raspberry root rot and other *Phytophthora* diseases in soft fruit continues to be a major research priority for the UK soft fruit

industry. Plant-based resistance is the only way forward but this requires knowledge of the effector arsenal by which pathogens will be recognised by the plant. This project aims to study in detail the unusual lifecycle and disease progression of *P. rubi* (the cause of raspberry root rot) and other closely related fruit crop-infecting *Phytophthoras*. The PhD student will develop *P. rubi* transformation protocols generating transgenic strains that will allow the infection process to be closely monitored in real time as well as improving upon infection methods on raspberry to allow better study of the roots during infection in resistant and susceptible cultivars. Using computational analysis, sequences of interest from genomic DNA of *P. rubi* will be identified and assessed to allow us to better understand the current diversity and population structure of *P. rubi* in the UK's fields/nurseries.



Collaborative Training Partnership for fruit crop research

The Collaborative Training Partnership (CTP) is a new research programme for UK Horticulture which is jointly funded by the Biotechnology and Biological Sciences Research Council (BBSRC), the AHDB and innovative international businesses. The specific programme for fruit crop research is led by Berry Gardens Growers Ltd. on behalf of an industry consortium which collaborates with its principal academic partner NIAB EMR. The programme aims to deliver high quality research projects while concurrently training the next generation of researchers to support the horticultural industry in the UK. In 2017, three CTP projects began which have direct relevance to the soft fruit industry.

This project relates to Project SF/TF 145a and will build upon a number of ongoing research projects at NIAB EMR and NRI investigating novel control methods for spotted wing drosophila (SWD). It will provide the basis for an IPM control strategy targeting *D. suzukii*, suitable for commercial growers of stone and soft fruit. The research will optimise attractants and repellents and their deployment in order to provide the control. The integration of several control methods to form a push-pull system is a novel idea for this pest and will lead to a significant reduction in the use of traditional crop protection products. Improved understanding of the insect's olfactory sense and searching behaviour will provide the scientific basis for the development of the push-pull system.

CTP FCR 2017 7 - Optimising the light recipe for maximum photosynthesis, yield and quality in strawberry

Term: October 2017 to September 2021

Project leaders: Gerard Bishop, NIAB EMR, Simon Pearson, University of Lincoln, and Paul Hadley, University of Reading

PhD student: Ben Chester

Industry representative: Richard Harnden, Berry Gardens Growers

Location: University of Lincoln

The strawberry market within the UK continues to grow but we are importing an increasing volume of fruit during the winter months. The UK has an opportunity to produce greater volumes of fruit during the winter but this requires glasshouse technology combined with modern supplementary lighting systems. There is an ongoing interest in the application of LED lighting systems in modern glasshouses as these provide an energy efficiency gain of circa 30% over conventional high-pressure sodium systems. They also offer opportunities to provide highly defined spectral outputs to maximise productivity. However, these opportunities have yet to be realised. We do not currently understand the optimal spectral qualities for strawberry or any other crop, how these change through production and how they affect the key agents (photosynthesis/radiation capture/partitioning etc.) of yield and quality. This PhD will examine these issues and develop optimal strategies for the use of LED lighting in soft fruit production.

CTP FCR 2017 8 - Application of novel machine learning techniques and high speed 3D vision algorithms for real time detection of fruit

Term: October 2017 to September 2021

Project leaders: Bo Li, NIAB EMR, and Tom Duckett, University of Lincoln

PhD student: Jake Bird

Industry representative: Richard Harnden, Berry Gardens Growers

Location: University of Lincoln

This project relates to project CP 170 in that the research will aid the development of a robotic strawberry harvester. The main objective is to deploy novel machine learning technologies to detect, locate and measure (size and colour) fruit. Researchers from the University of Lincoln have previously developed similar systems for broccoli. This earlier work showed that 3D cameras could be deployed in field environments, but the algorithms were highly complex with relatively slow processing speed. The new challenge for this PhD project will be to minimise processing requirements to identify fruit while maximising processing speed and recognition fidelity.



Latest crop protection news

Growers often refer to crop protection as the 'bread and butter' work for AHDB. Soft fruit marketing and producer organisations have many 'in-house' capabilities to deal with technical challenges and set up their own breeding programmes and quality control/assurance schemes to address these. However crop protection research and development requires wide-ranging skills, expertise and experience which is often beyond the budget or capability of individual grower groups.

AHDB has been set up with a structure which allows us to commission such expertise and experience to cater for the needs of the whole industry and we currently employ Crop Protection Research Managers Vivian Powell, Bolette Pallesen, Spencer Collins and Joe Martin to manage the vast portfolio of work we fund on crop protection for all of the horticultural sectors.

This portfolio of work has been comprehensively reported in the 2017 AHDB Horticulture Crop Protection Review magazine which was published and distributed in August 2017. Extra copies can be procured by contacting hort.info@ahdb.org.uk. The particular activities of greatest interest to soft fruit growers are our Gap Analysis, Basic Substances, SCEPTREplus, AMBER project and EAMU programme.

Our latest Gap Analysis was conducted in 2016 when we conducted a comprehensive survey of the pests, diseases and weeds that growers are trying to contain. This enabled us to pinpoint the gaps in the measures available for controlling them and hence where we should be focussing our research and development or knowledge exchange work.

Basic substances are defined as 'active substances, not predominantly used as a plant protection product but which may be of value for plant protection and for which the economic interest of applying for a full approval may be limited'. Our crop protection managers continually work with scientists, industry bodies and growers to keep abreast of substances which offer potential in crop protection so that we can submit applications for authorisations.

Our projects

SCEPTREplus is an AHDB programme of research designed to assess the efficacy of new or emerging crop protection products at controlling pests, diseases or weeds in the full range of horticultural crops. It is a four year programme which will link with other crop protection projects already underway and in particular, it dovetails closely with the AMBER project on biopesticides.

AMBER (Application and management of biopesticides for efficacy and reliability – CP 158) is a five year project being led by Dave Chandler, a Microbiologist and Entomologist at Warwick Crop Centre. In essence, it aims to find out what's causing some products not to work as well as they should and what growers can do to improve that. The focus is on certain commercially available biopesticides and on a select number of pests and diseases on crops representing a variety of types. The early results will be turned into a set of general principles that can then be transferred and tested on other crops later in the project. Visit bit.ly/AMBERproject

EAMUs

Perhaps best well known to growers is the continual energy we expend in our quest to secure new approvals, EAMUs and emergency authorisations for crop protection products to fill the gaps, where no alternative products or control measures

are currently available to prevent a pest, disease or weed from causing significant economic damage to a crop. To achieve this, we have developed very good links and working relationships with the Chemicals Regulation Directorate (CRD), agrochemical manufacturers, the EU Minor Uses Co-ordination Facility, overseas regulatory bodies and other foreign minor use facilities such as the USA's IR-4 programme.

In the past year, AHDB Crop Protection Manager Vivian Powell and Knowledge Exchange Manager Scott Raffle have worked tirelessly with the soft 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 and who helped us to secure products at a time in the season when growers were most in need. Important examples of products secured in 2017 include the emergency 120-day authorisations for Benevia on outdoor and protected strawberry, Tracer on outdoor strawberry, Exirel on outdoor and protected blueberry and Exirel on outdoor and protected raspberry and blackberry – all for the control of SWD.

"We are greatly indebted to staff at CRD for the help and co-operation we received in securing emergency authorisations for SWD control in 2017," commented Vivian Powell, AHDB Horticulture.

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

EAMUs secured in 2017

A list of the key products which have been delivered through AHDB activity in 2017 are found in the table below. (Please note that some of these approvals will have lapsed by the time of printing this publication.)

Product	Active ingredient	EAMU No.	Crops	Target pest/disease
Trianium P	Trichoderma harzianum strain T22	3431/16	Permanently protected bush fruit	Fusarium Pythium, Rhizoctonia
Trianium P	Trichoderma harzianum strain T22	3433/16	Permanently protected cane fruit	Fusarium Pythium, Rhizoctonia
Trianium P	Trichoderma harzianum strain T22	3434/16	Permanently protected strawberry	Fusarium Pythium, Rhizoctonia
Talius (12752)	proquinazid	0210/17	Protected strawberry	Powdery mildew
Shark	carfentrazone-ethyl	0378/17	Outdoor and protected strawberry	Polygonum weeds
Amistar	azoxystrobin	0895/17	Outdoor and protected cane fruit	Powdery mildew
Amistar Top	azoxystrobin + difenoconazole	Full approval	Outdoor and protected strawberry	Strawberry blackspot
Tracer	spinosad	1238/17*	Outdoor strawberry	SWD
K&S Chlorofume	chloropicrin	1316/17	Outdoor strawberry, raspberry and blackberry	Verticillium wilt, Pythium, free living nematodes
K&S Custo-Fume	chloropicrin	1318/17	Outdoor strawberry, raspberry and blackberry	Verticillium wilt, Pythium, free living nematodes
Exirel 10SE	cyantraniliprole	1488/17*	Outdoor blueberry	SWD
Exirel 10SE	cyantraniliprole	1508/17*	Outdoor raspberry and blackberry	SWD
Decis	deltamethrin	1516/17	Outdoor rhubarb	Aphid, capsid, caterpillar, cutworm
Benevia 10 OD	cyantraniliprole	1559/17*	Outdoor and protected strawberry	SWD, blossom weevil
Luna Sensation	fluopyram + trifloxystrobin	Full approval	Protected strawberry	Botrytis
Envidor	spirodiclofen	1600/17	Outdoor and protected strawberry	Two-spotted spider mite
Exirel 10SE	cyantraniliprole	1655/17*	Protected blueberry	SWD
Exirel 10SE	cyantraniliprole	1656/17*	Protected raspberry and blackberry	SWD

*denotes article 53 authorisation for 120 days



AHDB and CRD staff attend a liaison meeting to discuss EAMUs.



SF 145 - Understanding and developing methods for managing spotted wing drosophila (SWD) in the UK: Vital research to maintain the viability of the UK fruit industry

Term: April 2013 to March 2017

Project leader: Michelle Fountain, NIAB EMR

SWD Research – The progress so far

Shortly after spotted wing drosophila (SWD) was first identified in the UK in 2012, SWD Working Group Chair Harriet Duncalfe collaborated with AHDB, Defra, East Malling Trust, British Summer Fruits and The Worshipful Company of Fruiterers to set up AHDB Project SF 145. The four year project was led by Michelle Fountain of NIAB EMR in conjunction with Alison Dolan of the James Hutton Institute and David Hall of the Natural Resources Institute at the University of Greenwich.

The project

The research had five main objectives, which were: to understand the distribution and seasonal population dynamics of SWD in and around UK soft fruit farms; to develop treatment and disposal strategies for affected waste fruit; to develop ways of sampling fruit for the presence of SWD; to develop a synthetic lure and attract and kill technology for SWD to use within

IPM programmes; and to assess the effectiveness of a range of control products.

Results

The industry has learned a great deal about SWD through this project, but we have highlighted that effective control requires the integration of a range of management techniques. Further research is necessary and AHDB has commissioned project SF/TF 145a which began in April 2017, full details of which can be found in the 'New Projects' section of this publication.

As a result of project SF 145, the scientists working on the project drew up the following basic guidance for all soft and stone fruit growers to help them effectively manage the pest:

- Start monitoring regularly from March using Droso traps, particularly in woodland and hedgerows. The denser the wild habitat, the more likely it is

that SWD will have survived there over the winter. The trap contents should be monitored weekly and the bait replaced on each occasion

- Consider the use of smaller disposable traps for precision monitoring around the outside of crops all year round to reduce the winter population and to delay the movement of SWD adults into the crop in the Spring/Summer period. For maximum efficacy, change these every four weeks
- In cherry and other stone fruit crops, two Droso traps per hectare should also be positioned within the crop about 10 metres inside the perimeter from early leaf stage. Checking the numbers of SWD caught in the traps will help to monitor for their presence and gain an understanding of how well control tactics are working
- For soft fruit crops, the two traps per hectare should be erected at the stage when fruits start to swell



- As the fruit begins to ripen, all growers should use the flotation test every week to check for presence of larvae in developing fruits
- As soon as picking commences, the test should be carried out at every pick on a representative sample of fruits
- From early fruit ripening, if SWD populations are present in the crop, use recommended control products ensuring that harvest intervals are met and products/chemistry is rotated. Be mindful of the maximum number of applications permitted for a product and do not exhaust these before populations of the pest reaches a peak
- Always be guided by a BASIS qualified advisor before applying crop protection products
- During harvest, maintain strict hygiene measures ensuring the removal of every fruit from the crop, including all damaged, diseased or overripe fruits and any that have dropped to the ground
- All wasted fruit and any affected by SWD should be completely enclosed for at least 48 hours at 14°C in a sealed plastic pallet bin to kill immature stages of the pest. Longer times may be necessary at lower temperatures
- The fruit waste is still likely to be attractive to SWD adults, so it should be spread and incorporated into the soil or mixed with other organic waste (at least 90% w/w)

For more comprehensive information about monitoring traps, how to set them up, where to locate them, how to monitor them and how to test for the presence of larvae in the fruit, Visit horticulture.ahdb.org.uk/swd

SF 153 – Selection of strains of predatory mites that can survive applications of insecticides required for SWD control

Term: April 2014 to March 2017

Project leader: Jean Fitzgerald, NIAB EMR

Surviving with all your mite

Over the past 20 years, soft fruit growers have increasingly relied on introduced predatory mites to control pests, such as two-spotted spider mite, western flower thrips and tarsonemid mite. Integrated pest management (IPM) programmes have been refined and less reliance has been placed upon traditional crop protection products for these pests. However with the arrival of SWD, growers have had to increase their reliance upon traditional control products given the lack of effective biocontrol measures for SWD. Products used to control SWD have the potential to disrupt IPM and biocontrol programmes for mite and thrips pests, so if predatory mites could be found with resistance to products being used to control SWD, then IPM programmes would be unaffected.

The project

The work concentrated on the predatory mites *Amblyseius andersoni* and *Neoseiulus cucumeris* as they are commercially available for control

of a range of important pests and are considered 'native' species for authorisation for any subsequent use on non-glasshouse crops.

Results

Early work exposing *A. andersoni* and *N. cucumeris* to fresh residues of field rates of spinosad (Tracer) showed that this was only moderately harmful to both predators but exposure to fresh residues of 0.1 times field rate of lambda-cyhalothrin (Hallmark) was highly damaging to both species. It was therefore hoped to develop strains of mites with greater tolerance to spinosad, but it wasn't possible to rear sufficient numbers of *A. andersoni* or *N. cucumeris* under laboratory conditions to achieve this.

The work programme was therefore amended to provide growers with more information on the effects of topical applications of lambda-cyhalothrin (Hallmark), cyantraniliprole (Exirel) and spinosad (Tracer) on the survival of *A. andersoni* and *N. cucumeris*. For *A. andersoni*, the LD50 (dose required to

kill 50% of tested individuals) for lambda-cyhalothrin after 48 hours was 0.17 field rate, for cyantraniliprole it was 2.2 times field rate and for spinosad it was 3.6 times field rate.

For *N. cucumeris*, it wasn't possible to derive an LD50 for lambda-cyhalothrin, but the LD50 after 48 hours for cyantraniliprole was 0.5 times field rate and for spinosad was around field rate.

These results suggest that for both species some predatory mites are likely to survive field rate applications of spinosad and cyantraniliprole. However, growers should guard against relying solely on these products for SWD control as this will significantly increase the risk of the pest developing resistance to them over time.

"Although this project did not succeed in developing predatory mites resistant to SWD control sprays, we've increased our knowledge of the survival rates of certain predators to the most commonly used products," said industry representative Marion Regan, Hugh Lowe Farms.



CP 122 - The identification of viral pathogens suitable for the control of *Drosophila suzukii* in the UK

AHDBSTUDENTSHIP

Term: September 2014 to August 2017

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

CP 142 – Enhancing the control of the soft- and stone-fruit pest *Drosophila suzukii* (spotted wing drosophila) by exploiting its activity patterns in the field

AHDBSTUDENTSHIP

Term: October 2015 to September 2018

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

“Female *D. suzukii* display a preference for egg laying in the warmest part of the day”

Exploiting SWD activity for control

AHDB-funded research into spotted wing drosophila (SWD) has been extensive since the pest arrived in the UK in 2012 and many of the results have been presented in this publication over the years. In addition to the industry funded project SF 145, two PhD studentships have been supported by AHDB, investigating alternative and novel topics.

The projects

Bethan Shaw, who had previously worked with Michelle Fountain's entomology group at NIAB EMR focussing on SWD research, is studying a PhD under the joint leadership of University of Southampton and NIAB EMR. The research project is examining the behavioural and physiological rhythms of *Drosophila suzukii*, as determined by its internal circadian clock and environmental cues. It is hoped that this will reveal the times of day when SWD is most active in the crop, allowing growers to time control sprays to coincide with this.

Nathan Medd is working under the supervision of Edinburgh University and NIAB EMR to investigate viruses specific to SWD which might be used for the development of microbe-based biopesticides which would be compatible with all the other IPM programmes already used by soft fruit growers.

“The industry needs SWD research to follow up every line of enquiry to find a combination of control measures to contain this pest and both of these projects are usefully complementing the industry funded project SF/TF 145a,” explained Marion Regan, Hugh Lowe Farms.

Results

The circadian rhythm work has already identified 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, female *D. suzukii* 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. Bethan Shaw has also been investigating the optimum laboratory parameters such as social housing and environmental conditions with the aim of producing a standard laboratory practice.

In the virus work, Nathan Medd has so far discovered seven new RNA viruses unique to SWD along with a host of other viruses which, although described first in other fly species, regularly infest UK SWD. Techniques have been developed to isolate new viruses, to test their pathogenicity and applicability as biological control agents.

“We have discovered a host of viruses infecting *D. suzukii* in the wild. This is exciting because many of them are new to science and may potentially contain untapped potential as biological control agents. Isolation and production of viruses as viable crop protection products is difficult but, unlike 40 years ago when the first viral control agents were developed, we now have biotechnology on our side,” said Nathan Medd, student researcher on project CP 122.

SF 146 – New predators as bio-control agents of western flower thrips on protected strawberry

Term: April 2014 to March 2017

Project leader: Chantelle Jay, NIAB EMR



Supplementing *Neoseiulus cucumeris* for western flower thrips control

Western flower thrips (WFT), *Frankliniella occidentalis*, is a devastating pest of protected strawberries and recent experiences have suggested that existing biocontrol agents sometimes provide inadequate control in hot conditions. WFT feeding on the flowers and developing berries leads to bronzing of the fruit, which can cause downgrading and – in severe cases – to crop losses.

The project

This project aimed to identify alternative predators not currently being exploited for WFT control which could be incorporated into a biocontrol programme to replace or supplement *Neoseiulus cucumeris* for control of WFT on protected strawberry.

Results

Initial results from the first year's work demonstrated that the predatory mites *Amblyseius montdorensis*, *Amyloseius swirskii*, *Amblydromalus limonicus* and the current commercial standard *Neoseiulus cucumeris* are all effective predators of WFT. However these additional species are not currently registered for use in

polytunnels in the UK and are unlikely to be registered soon. Work switched to evaluating *Neoseiulus cucumeris*, *Neoseiulus californicus* and the predatory substrate dwelling mites *Stratiolaelaps scimitus* (formerly *Hypoaspis miles*) and *Macrocheles robustulus*.

N. californicus was shown to offer similar control of WFT to *N. cucumeris* and there was found to be no interspecific competition between the adult mites. However, *N. californicus* is known to prey on two-spotted spider mite in glasshouse crops, and if such alternative prey is present, control of WFT may be compromised. Growers need to find out which *Neoseiulus* predator they have in their crops; the two species can only be differentiated by trained entomologists.

The substrate predatory mites *S. scimitus* and *M. robustulus* were found to prey on WFT pupae in soilless substrates and when combined with the use of predatory nematodes (*Steinernema feltiae*), the level of control was improved, but control was not twice the level of that achieved by the predatory mite alone.

Predicting fruit damage from western flower thrips

Western flower thrips (WFT) continues to pose difficulties for strawberry growers and serious damage is still found in some crops. Following AHDB and Defra funded Horticulture LINK projects it was felt that growers needed more guidance on WFT population control.

The project

The work in project SF 156 has initially focussed on developing a reliable system for assessing the numbers of thrips and predatory mites present in the crop so that damage thresholds for various predator/prey ratios can be developed. Additional work is being done to assess the potential of using entomopathogenic fungi (EPF) for controlling the western flower thrips adults.

Results

Young button fruit were found to be the most appropriate part of the plant on which to assess numbers of *N. cucumeris*, while mid-aged and old flowers are best for assessing numbers of adult thrips. A

data analysis of the occurrence of both in commercial crops has been used to develop a prototype model to estimate the maximum mean number of WFT in a sample of a given size to ensure the probability of low levels of fruit damage. The model is currently being refined. A prototype extraction device using methyl isobutyl ketone for extracting *N. cucumeris* and thrips adults and larvae from plant material has also been developed and is now being assessed commercially.

Early experiments have been done using the new EPF formulation of Met 52 in a laboratory test against adult female WFT. Results show some promise for its use within an IPM system, if application and spore retention are good. This product is now commercially available to growers as a foliar spray against WFT in strawberry.

The work is continuing within this larger five year programme of research on strawberry pests, part of project SF 156.



SF 156 – Improving integrated pest management in strawberry

Term: April 2015 to March 2020

Project leader: Michelle Fountain, NIAB EMR



SF 157 - Improving integrated disease management in strawberry
Term: April 2015 to March 2020
Project leader: Xiangming Xu, EMR

Detecting hidden Phytophthora infection in strawberry plants

The principal Phytophthora diseases of strawberry cause crown rot and red core. Previous AHDB funded research has identified fungicide and biocontrol products which offer varying levels of control. However, frequent applications of control products may only delay the onset of symptom development, which can often occur after transplanting young plants into their final fruiting position.

The project

The aim of the work in project SF 157 is to quantify the extent of hidden Phytophthora infection in initial planting material and identify treatments to reduce plant losses due to this.

Results

Survey work in the first year suggested that the incidence of contamination by *P. fragariae* (causing red core) in runners is very low, but the level of contamination by *P. cactorum* can reach 25-30%. Further sampling and screening in year two therefore focussed on *P. cactorum* and the results agreed with those of year one. The level of infection in runners varied greatly between samples and could be as high as 20%, detected mostly in asymptomatic crowns. The level or incidence did not appear to correlate with particular varieties.

Work has also been done to assess the effect of AMF (*arbuscular mycorrhizal*

fungi) and PGPR (plant growth promoting bacteria) on Phytophthora development. Results suggested that amendment of compost with both AMF and PGPR together could reduce severity of red core development. However, these treatments failed to achieve significant reduction in the development of *P. cactorum* in inoculated crowns; further experiments are needed to confirm this result.

“Crown rot has been causing significant financial losses in strawberry production for many years and it’s vital that this work is continued to enhance our understanding of how best to manage it,” said Lindsay Hulme, E Oldroyd & Sons.



SF 157 - Improving integrated disease management in strawberry
Term: April 2015 to March 2020
Project leader: Xiangming Xu, EMR

Assessing biocontrol agents for strawberry powdery mildew control

Strawberry powdery mildew continues to cause growers a major problem, particularly under protection where conditions are often conducive to infection. Previous AHDB-funded research has helped to develop a model which can predict periods of infection risk, allowing growers to time their control programmes to coincide with these. More recent AHDB work on other edible crops has highlighted the efficacy of at least three biological plant protection products against powdery mildew.

The project

This project aims to optimise and integrate non-fungicide alternatives with conventional fungicides in the control of strawberry powdery mildew.

Results

Two trials were carried out under protective polythene tunnels, one in a field soil crop at NIAB EMR and one in a bag grown crop at ADAS Boxworth. They used biocontrol agents (BCA) and elicitors, with and without fungicides, at 14-day intervals and compared their effects to a seven or 14-day interval standard fungicide programme and untreated plots. The conditions at NIAB EMR were extremely favourable for powdery mildew and significant treatment effects were detected there, but not at the ADAS site.

At NIAB EMR, all the treatments assessed reduced incidence of powdery mildew on both leaves and flowers/fruit.

The lowest incidence was found on the standard seven-day fungicide programme. However, *Ampelomyces quisqualis* (AQ10 – currently approved on protected strawberry) and a biocontrol agent from Bayer Cropsience (not currently approved as a plant protection product) when applied in admixture with Silwet were as effective as the standard seven-day fungicide programme.

When applied alone, these BCAs provided better control. There were differences in plant vigour between the treated plots, but only those plots receiving the seven-day fungicide programme were significantly better, despite the similar incidence of foliar mildew symptoms in plots receiving biocontrol products.



Improving diagnostic capability for Verticillium wilt

SF 158 - The advancement and optimisation of integrated pest and disease management in cane fruit production systems

Term: April 2015 to March 2020

Project leader:
Aoife O'Driscoll, ADAS

Verticillium wilt has long been known to kill strawberry crops in the UK. Summer fruiting raspberry varieties have been less affected by this disease, but since the adoption of certain American bred primocane raspberry and blackberry varieties which are far more sensitive to Verticillium pathogens, UK growers have seen considerable losses to the disease. At present, little is known about which species is causing the problem in the UK (*V. dahliae* or *V. albo-atrum*) and which strains of these are most pathogenic.

The project

In this work, new molecular tools which have been developed for strawberry will be used to determine which strains are present in UK cane fruit crops and work towards determining the threshold for causing disease in raspberry and blackberry.

Results

Initial work examined raspberry and blackberry plants from commercial fields and from young plant material from three propagators. *Verticillium dahliae* was detected in plant material from the field but was not detected in young plants from three propagators. A range of other fungi were isolated from the plants including *Fusarium*, *Alternaria* and *Pythium*. *Ilyonectria* species were isolated from two plants and this was confirmed by DNA sequencing. *Ilyonectria* is a known pathogen of raspberry and may also be causing plant death. Further work will attempt to characterise these isolates further.

Additional work is in progress to develop new scientific assays which can be used to detect the different *Verticillium* species to an acceptable level both in plant material and in soils.

"It's essential that this basic research into *Verticillium* wilt in cane fruit crops is carried out in order to develop our understanding of the strains present and to find a way of determining the likely risk of infection of susceptible cultivars," observed Richard Harnden, Berry Gardens Growers.

Seeking alternative solutions to Phytophthora root rot

SF 158 - The advancement and optimisation of integrated pest and disease management in cane fruit production systems

Term: April 2015 to March 2020

Project leader:
Aoife O'Driscoll, ADAS

***Phytophthora rubi* is the most serious disease of raspberry causing root death and die-back of canes. It is a soil/substrate borne fungal pathogen which attacks the roots and spreads rapidly through soil water. Many growers reduce the risk of infection by planting in coir substrate which is sterile and devoid of *Phytophthora* spores. Control still relies on the application of a soil/substrate applied drench in spring and autumn.**

The project

The work in this project focuses on understanding the activity of non-conventional products that may improve root health and the production of propagation material that is more resistant to the disease.

Results

In the first year of the project, Tulameen plants were treated in growing media with biostimulants and growth promoters following propagation. In year two, these were potted up at a commercial site in Oxfordshire and ADAS Boxworth where the plants received various treatments including Prestop (*Gliocladium catenulatum*) and products approved for use in growing media in cane fruit. They were compared to a single drench of Paraat (dimethomorph).

At the Oxfordshire site, the ability of the products to improve crop performance and vigour was investigated, but no differences were found between any of the treatments or the untreated control. At the Boxworth site, plants were treated with preventive applications before inoculation with *P. rubi* and in some cases curative applications were also made. No primocane death occurred as a result of inoculation and destructive assessments of the roots are due to be made. Interestingly however, Prestop and three coded products had statistically significantly increased the number of primocanes compared with the untreated control and Paraat treated plants. The trial will continue for a further cropping year.

“Interestingly, Prestop and three coded products had statistically significantly increased the number of primocanes compared with the untreated control”





“Sprays being applied for SWD control were having a detrimental effect on spider mite control”

SF 158 - The advancement and optimisation of integrated pest and disease management in cane fruit production systems

Term: April 2015 to March 2020

Project leader:

Aoife O'Driscoll, ADAS

Project collaborators: NIAB EMR, Fera, University of Worcester

Compatibility between SWD and spider mite control in raspberry

Over the past decade, raspberry growers have increasingly developed biocontrol programmes to control two-spotted spider mite. They have achieved this by relying on naturally occurring predatory mites such as *Amblyseius andersoni* and *Neoseiulus californicus*, while also making introductions of *Phytoseiulus persimilis*. For many growers, such biocontrol programmes are more successful than using acaricide sprays as the acaricide products are limited in number, and achieving thorough coverage of the undersides of leaves can prove to be difficult. However, with a recent increase in the use of spotted wing drosophila (SWD) sprays, which may be harmful to our predators, spider mite control could be compromised.

The project

The project is aiming to address the problem by first investigating the effects of SWD control strategies on two-spotted spider mite populations on commercial farms which are dealing with the pest and

then developing compatibility strategies for controlling both pests together.

Results

In the first year's work, both canopy applications and overhead misting of a programme of sprays including deltamethrin (Decis), spinosad (Tracer) and chlorpyrifos (Equity) were applied to raspberries and their effects on two-spotted spider mite and naturally occurring predatory mites were compared. The effect of both date and treatment were significant. By early August, the numbers of both SWD and predatory mites were lower in both types of spray application and there was a corresponding increase in two-spotted spider mite populations from mid-August onwards. This result confirmed that the sprays being applied for SWD control were having a detrimental effect on spider mite control.

In the second year, a programme of sprays of Decis and Tracer were applied to tunnel grown raspberries using overall canopy sprays and comparing these

to overhead application. The effects on two-spotted spider mite, naturally occurring predators and *Phytoseiulus persimilis* (which had been introduced on two occasions) were assessed. Nozzles were used which gave a larger droplet size than in the first year, with the hope of creating less spray coverage on the undersides of the leaves and providing refuges for the predatory mites. Both treatments reduced SWD numbers compared to the untreated control. Less spray coverage was found on the undersides of the leaves treated with overhead sprays. Two-spotted spider mite numbers were higher in the sprayed treatments, but less so when sprayed from above. Introduced *P. persimilis* were less affected by the sprays than anticipated.

“We have been interested in the results of this work so far and are considering our spray application techniques to try to lend a hand to predatory mites,” said Salih Hodzhov, Farm Manager at W B Chambers & Son.

The work is continuing for another year.



SF 158 - The advancement and optimisation of integrated pest and disease management in cane fruit production systems

Term: April 2015 to March 2020

Project leader:

Aoife O'Driscoll, ADAS

Testing nematodes against blackberry leaf midge

Blackberry leaf midge has become an increasing problem in primocane raspberry and blackberry crops, particularly in protected crops where there can be up to four generations per year. The midge larvae feed in young leaves and shoot tips of primocanes, leading to distorted growth and branching of developing canes. This not only weakens the canes, but can lead to a reduction in subsequent yield. Double-cropped primocane raspberry varieties are particularly susceptible. Control in the past has relied on the use of crop protection products, but they are not fully effective and are incompatible with IPM programmes.

A sex pheromone trap to monitor the pest was developed by previous AHDB-funded research (project SF 117). Another project (SF 102) made some useful progress on cultural and biocontrol measures, but growers have continued to rely on broad-spectrum crop protection products. An effective and reliable biocontrol solution would reduce the use of traditional crop protection products and enhance integrated pest management programmes already being implemented in raspberry and blackberry crops.

The project

This work set out to assess the use of the insect-pathogenic nematode *Steinernema kraussei* as a soil or compost drench to determine its ability to control the midge larvae after they drop to the ground to pupate.

Results

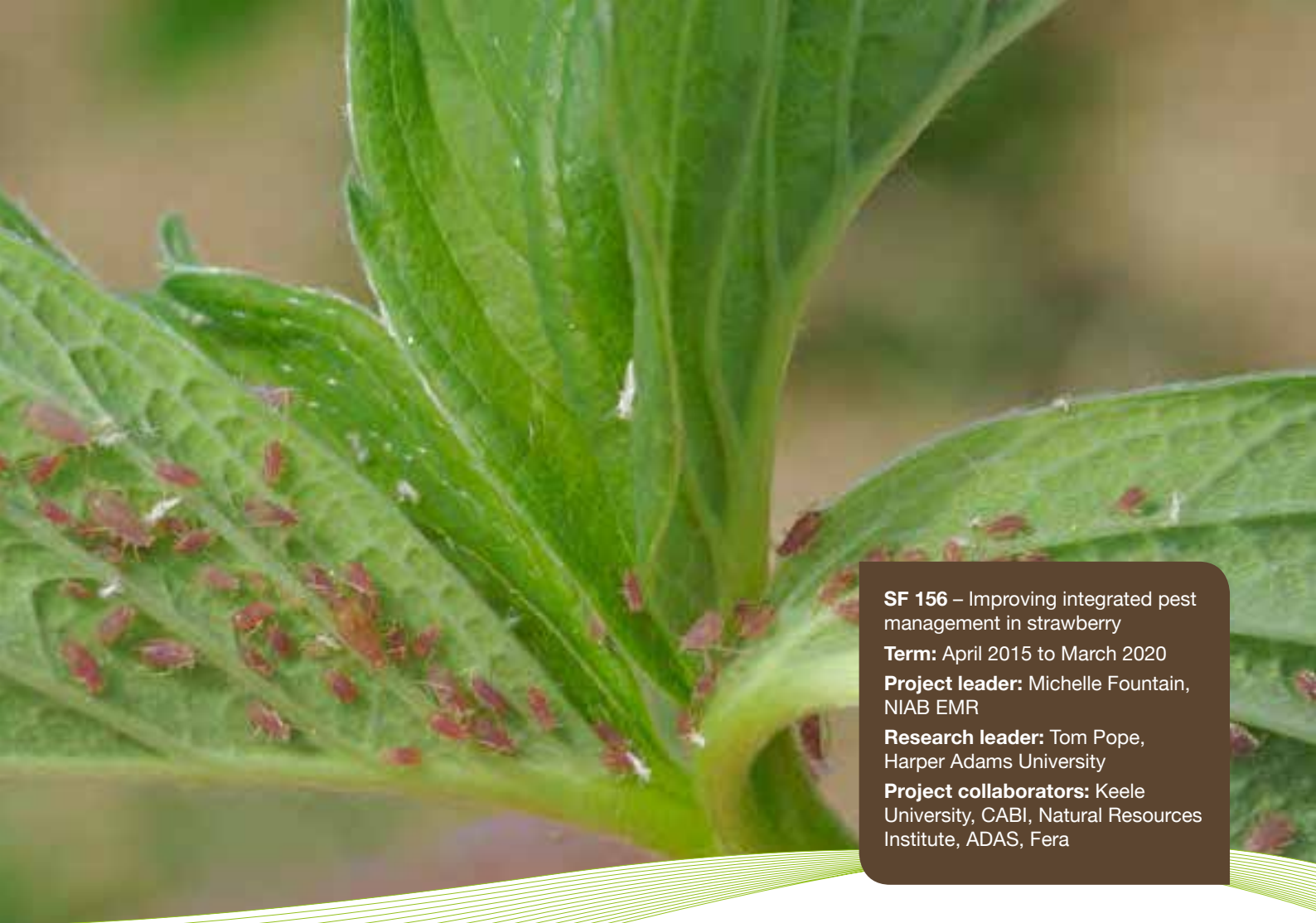
In the first year's work, drenches of *Steinernema kraussei* (*Nemasys* L) were applied to coir substrate in pots to which mature blackberry leaf midge larvae were added. The nematodes significantly reduced the numbers of adult blackberry leaf midges emerging compared to water controls.

In the second year, the nematodes were applied to the soil beneath the crop canopy of a soil grown raspberry crop with a history of blackberry leaf midge. The drenches were made on two occasions, the first one around seven days after midge larvae were first recorded in the shoot tips, so it was hoped application would coincide with the larvae dropping to the soil to pupate. Assessments were made of the numbers of affected leaf tips every two weeks after application for a period of two months. Unfortunately there were

no significant differences in the numbers of twisted or infested leaf tips between the treated and untreated plots. It is possible that insufficient moisture was present in the soil to aid the movement and survival of the nematodes and this could have restricted the success of such a treatment in the commercial crop. Another factor could have been that timing of the drenches may have been too late for the nematodes to reach the larvae before they formed a protective cocoon in which to pupate.

"This piece of work has not resolved the problem of blackberry cane midge, but we have gained some useful information from the results delivered," said Salih Hodzhov, WB Chambers & Son.

“Nematodes significantly reduced the numbers of adult blackberry leaf midges emerging compared to water controls in pot-grown trials”



SF 156 – Improving integrated pest management in strawberry

Term: April 2015 to March 2020

Project leader: Michelle Fountain, NIAB EMR

Research leader: Tom Pope, Harper Adams University

Project collaborators: Keele University, CABI, Natural Resources Institute, ADAS, Fera

“Hallmark, both with and without Silwet, gave 100% control”

New research into potato aphid control

Some commercial strawberry growers have been finding it extremely difficult to control aphids in recent years and in particular the potato aphid (*Macrosiphum euphorbiae*). Work in Defra Horticulture LINK Project HL0191 (SF 94) demonstrated that gaining control in the autumn helps to reduce populations the following spring, but conditions and timing are not always optimum and further spring applications can still be required. Project SF 140 showed that even spray coverage is essential for control, but this is not always easy to achieve in the spring when plants are compact.

The project

This project aimed to identify which products would be more effective under cooler spring temperatures before crop growth begins and the leaf canopy has extended and opened up. Two experiments were done, one under a ventilated polythene tunnel on plants infested with potato aphids and different

products applied by knapsack with or without the wetting agent Silwet L-77. The second was done in controlled environment rooms using fully expanded strawberry leaves sprayed with the same products to run-off on both leaf surfaces. This was done either after infesting the leaves with potato aphids or sprayed first followed by infesting the leaves later.

Results

In the polythene tunnel experiment, Hallmark (lambda-cyhalothrin), both with and without Silwet, gave 100% control, while Calypso (thiacloprid) gave moderate control initially, but aphid numbers started increasing again eight days after application. Chess (pymetrozine) with or without Silwet showed no significant difference to the water control. Where complete control was not achieved, the greatest proportion of surviving aphids were found in the crown of the plant.

In the leaf experiments in controlled atmosphere, the Hallmark and Calypso

treatments (both with and without Silwet) killed all aphids (whether leaves were already infested or infested later). The Chess + Silwet and the Silwet applied on its own killed all aphids, but only on leaves already infested with aphids which were directly sprayed.

“The results of this work still suggest that we need to seek ways of improving our leaf and crown spray coverage if we are to improve our spring control of aphid colonies,” explained Lindsay Hulme, E Oldroyd & Sons.

The scientists still suggest that growers should monitor aphids and their natural enemies before choosing to spray. If spraying is necessary, growers should ensure good coverage on the undersides of leaves and in the plant crown. Consider the use of water sensitive papers to visualise how effectively spray applications achieve this. Consider also the choice of product and its compatibility with biological control programmes.

Understanding the side effects of crop spraying on predatory mites

SF 156 – Improving integrated pest management in strawberry

Term: April 2015 to March 2020

Project leader: Michelle Fountain, NIAB EMR

Project collaborators: Keele University, CABI, Natural Resources Institute, Harper Adams University, ADAS, Fera



A number of crop protection products are known to be harmful to the predatory mite *Neoseiulus cucumeris* which can disrupt IPM programmes. In particular, products used for thrips and capsid control can pose problems and it has been suggested that repeated applications of fungicide mixes may also have an adverse effect on this predator. In the first year of this project, the effect of several tank mixes on *N. cucumeris* were assessed, with Nimrod/Teldor, Signum/Sythane and Aphox/Rovral all found to reduce *N. cucumeris* in strawberry. The adverse effects only appeared however after the third sequential application.

The project

In the second year, Calypso (thiacloprid) and potassium bicarbonate + Activator 90 were tested for their effect on *N. cucumeris* over multiple applications or in tank mixes. Both products are considered by industry agronomists as being potentially harmful. They were compared to the Nimrod/Teldor mix. A reintroduction of *N. cucumeris* was also tested to see if it could mitigate any effects of these spray treatments.

Results

The results were slightly surprising in that there was no evidence that Calypso, potassium bicarbonate + Activator 90 or

the Nimrod/Teldor mix had a detrimental effect on *N. cucumeris* populations in these experiments. The additional release of *N. cucumeris* after the second spray treatment led to an increase in adult *N. cucumeris* in the crop.

“We work closely with our agronomists to develop optimum IPM programmes in our strawberry crops and research of this nature helps to guide our crop protection programmes,” commented Sandy Booth from New Forest Fruits.

“ There was no evidence that Calypso had a detrimental effect on *N. cucumeris* populations ”

SF 162 – Development of a pheromone trap for monitoring blackcurrant sawfly

Term: March 2015 to March 2018

Project leaders: Michelle Fountain and Maddie Cannon, NIAB EMR and David Hall, NRI

Developing traps and thresholds for blackcurrant sawfly

Blackcurrant sawfly is a serious but sporadic pest of blackcurrant. After laying eggs on the undersides of leaves in May, they hatch into larvae which can rapidly devour the leaves, in May or June, and a second generation can occur in July/August. The chemical components of the adult female sex pheromone were identified in Defra Horticulture LINK Project HL01105 so that a monitoring trap could be developed to identify the need to implement control measures.

The project

This project is refining the pheromone blend, dispenser and trap that will be most effective and correlating catches of sawflies in the traps with field

populations. The scientists hope to find out more about the factors affecting this relationship, such as the presence of predators and use of crop protection products.

Results

In the first year the pheromone blend was refined to become more attractive to adult male sawflies and it was found that a red delta trap caught most sawfly using this blend. The pheromone blend and trap are now commercially available to blackcurrant growers.

In year two the traps were used in a commercial plantation to assess if natural enemies may be having an effect on sawfly populations. Despite finding

sawfly eggs and early stage larvae, only very low levels of foliar damage were detected, suggesting that predation could be occurring before significant damage could take place.

Further work is being done at a site with higher sawfly numbers to establish control thresholds and optimal trap placement.

“The delivery of a new monitoring trap for blackcurrant sawfly has been a huge step forward and, combined with a better understanding of the role of predators in regulating populations, will considerably improve growers’ ability to control the pest at the optimum time,” enthused Rob Saunders, Hutchinsons.



“Little is known about the impact of insecticide applications on earwig populations in blackcurrant plantations”

Preserving earwigs in blackcurrants

SF 168 – Distribution of earwigs in blackcurrant plantations

Term: March 2016 to March 2017

Project leaders: Michelle Fountain and Maddie Cannon, NIAB EMR

Following the loss of chlorpyrifos and pirimicarb for use on blackcurrant crops, the reliance on natural enemies is becoming increasingly important. Earwigs have long been recognised as effective predators of insect pests in apple and pear orchards including suckers, scale insects, aphids and codling moth. It is quite possible that they have the potential to offer pest control in blackcurrants also and may offer control of soft bodied pests such as aphids, sawfly eggs and larvae, midge larvae and caterpillars. If earwigs are found to be sufficient at controlling pests then fewer insecticides will need to be applied, reducing residue levels in the fruit and reducing the cost of insecticide inputs.

Earwig populations are known to vary greatly in orchards and there is evidence that certain crop protection products may adversely affect earwig populations. Little is known about the impact of insecticide applications on earwig populations in blackcurrant plantations.

The project

This project set out to assess the typical populations of earwigs in blackcurrant and ascertain if typical crop protection products used in blackcurrants may be having an adverse effect.

Results

Fifty blackcurrant plantations were surveyed across all the five main UK blackcurrant growing regions to determine earwig abundance. Ten plantations were surveyed in each region. Special earwig refuges were deployed at the edge and centre of each plantation for at least 45 days. In parallel, the spray programmes for each plantation were assessed and scored for their known level of toxicity to earwigs (based on previous AHDB funded research in tree fruit).

Earwig numbers varied greatly between blackcurrant plantations within and between farms (mean scores of 0-10 earwigs per refuge).

Although no significant correlation occurred between earwig abundance and the toxicity score of the spray programmes, trends did appear. Plantations with an overall toxicity score greater than 14 had fewer earwigs (<20 earwigs per refuge) and those with a score greater than 25 had no earwigs.

Earwig numbers varied between plantations where spray programmes were similar, suggesting that other abiotic and biotic factors may have influenced earwig abundance in blackcurrant plantations in addition to spray programmes. Further studies are needed to determine what other factors influence earwig populations in blackcurrants.

“This project has identified some interesting trends in earwig numbers in blackcurrants but further work is needed to increase our understanding of their survival and benefits to blackcurrant pest control,” said Harriet Prosser, LRS.

On the back of this research, growers are advised to foster and encourage populations of earwigs by considering the choice and timing (females in canopy April, nymphs in canopy May - September) of insecticide products applied, and to monitor pest incidence alongside general natural enemy numbers.



SF 152 – Improving the consistency of fruit quality in substrate-grown June-bearer strawberry varieties

Term: April 2014 to March 2017

Project leaders: Mark Else and Eleftheria Stavridou, EMR

Counteracting high EC in bag grown strawberries

AHDB has funded previous research into irrigation and nutrition of bag-grown strawberry crops at NIAB EMR, which has demonstrated that irrigation run-off can be eliminated while maintaining or improving marketable yields and consistency of fruit quality. However, perceived concern over a corresponding increase in electrical conductivity (EC) of the substrate has discouraged some growers from adopting the results of this research.

The project

This project was set up to identify the critical coir pore EC values and the contributory ions that limit fruit size and quality in the modern varieties Sonata and Vibrant. These values can then be used with the automated flushing technologies being developed in an IUK project to control coir pore EC more precisely, thereby offering growers more control and peace of mind when eliminating irrigation run-off. Previous research has shown that manipulating the ratio of NH_4 (Ammonium) to NO_3 (Nitrate) nitrogen can improve tolerance to high EC, so additional work was done to study this further.

Results

In the work to identify critical EC values in Sonata and Vibrant in 60-day crops, three different EC treatments were imposed.

One was kept below 2.5 mS/cm; the second was raised gradually to 3.5 then maintained between 3.5 and 4.0 mS/cm; the third was raised gradually to 4.5 then maintained between 4.5 and 5.0 mS/cm. The rate of photosynthesis and degree of stomatal opening were measured as an indication of the plant's stress response. Sonata was unaffected by the EC values reached, but Vibrant showed signs of stress after prolonged exposure to EC levels of 3.5 mS/cm and higher, compared to plants where EC was kept below 2.5 mS/cm.

In the work to manipulate the ratio of NH_4 to NO_3 nitrogen, both Sonata and Vibrant were subjected to four treatments; 1) a commercial control held at EC of 2.5 mS/cm with NH_4 to NO_3 ratio of 10:90; 2) a high salinity of 3.5 mS/cm with NH_4 to NO_3 ratio of 10:90; 3) a high salinity of 3.5 mS/cm with NH_4 to NO_3 ratio of 50:50; 4) a high salinity of 3.5 mS/cm with NH_4 to NO_3 ratio of 75:25. These feed ratios were not applied until the fruiting phase of crop growth.

The plants held at high EC were found to be experiencing water stress and this resulted in significantly poorer plant growth. In Sonata, the plants were better able to cope with high EC if they received higher NH_4 (75:25) and performed as well as those experiencing

low EC (commercial control). The 50:50 ratio reduced the adverse impact of high EC on total marketable yield per plant. However, plants grown at high salinity at 10:90 and 75:25 regimes had significantly lower marketable yield than plants grown under the commercial control.

In Vibrant, plants in high salinity at the 50:50 and 75:25 regime had the same class 1 yields as the commercial control. In both Sonata and Vibrant, plants grown in high EC or high NH_4 ratios did not result in softer fruit.

In summary

For Sonata and Vibrant 60-day crops, irrigation flushing can be triggered at coir pore EC values of 3-3.5 mS/cm without reducing marketable yields or fruit quality.

The 50:50 NH_4 to NO_3 ratio can reduce the adverse impact of high EC on total marketable yield per plant in Sonata.

The 50:50 and 75:25 NH_4 to NO_3 ratios can reduce the adverse impact of high EC on total marketable yield per plant in Vibrant.

Laurie Adams, Haygrove Fruit, explained, "These results have been extremely useful to guide growers as the EC control points to follow for Sonata and Vibrant and they offer a management feeding technique to counteract high EC."



Imaging sensor solutions for soft fruit

SF 155 – Imaging sensor solutions in the soft fruit industry for high throughput phenotyping and monitoring of abiotic and biotic stresses for premium variety production and maximised yields (Innovate UK Project 101819)

Term: November 2014 to October 2017

Project leader: Julie Graham, James Hutton Institute

Great progress has been made in the past decade to develop new tools for plant breeders to identify genetic traits of progeny. Marker assisted selection is one such tool and allows breeders

to find progeny with pest or disease resistance or other desirable traits such as flavour, firmness or shelf-life. A new technique called hyperspectral imaging can also now be used as a means of recording plant stress early before visible symptoms of stress develop.

The Project

This work is assessing the potential of hyperspectral imaging as a way of detecting plants which have useful stress tolerance traits. If the imaging proves viable, it could have a valuable role as an automated crop monitoring tool for growers as well as in breeding.

Results

Glasshouse experiments and a range of field trials have been carried out

with individual water stress regimes and pest and disease burdens, as well as combinations of the stresses. Automated image analysis techniques have been developed to analyse the images and pull out relevant spectral data for each plant. Early analysis has shown ability to distinguish varieties using spectral signals. Genetic variation has been quantified in the field trial and some associations of imaging data with particular parts of the chromosomes have been identified. The next phase of the project will be to link imaging signatures to the plant abiotic and biotic stresses with a view to providing an on-farm monitoring tool as well as a research platform to enable identification of stress-resilient germplasm.

Early stress detection via thermal imaging

SF 144 – Early detection of stress in strawberry plants using novel image analysis techniques

AHDB STUDENTSHIP

Term: April 2014 to March 2017

Project leaders: Andrew French, University of Nottingham and Nicola Harrison, AHDB

PhD student: Amy Lowe, University of Nottingham and NIAB EMR

Precision agriculture is increasingly in demand with new technologies becoming affordable, offering insight into crop performance and management during growth. Hyperspectral imaging is a technology able to capture wavelengths of light invisible to the human eye. Scientific studies have found that plants can reflect different wavelengths of light in response to plant stresses, such as pest attack, onset of disease or drought.

The project

Work in wheat and cereal crops has already used this type of technology to detect specific plant responses. In this project the aim was to examine if stress responses could be detected in soft fruit plants and if so, how early on? The work focussed solely on strawberry plants.

Results

The project began by determining that there is a difference in the spectral signatures from healthy and diseased plants. However, due to the plants being imaged in situ, the leaves lie at different angles which affects the reliability of the data captured. Ideally for hyperspectral imaging, the leaf would be removed, pinned and then scanned flat, but this is time consuming and would not be feasible when applied to large-scale commercial crops. Therefore, computer algorithms were developed to locate the leaves in the hyperspectral image that are facing the camera in order to select the best data for further analysis.

Initial results indicated a potential yet subtle difference in the reflectance curves of plants affected by early stages of drought. The future aim is that hyperspectral imaging can be used to detect certain diseases early before visible signs appear.

“I hope this technology can be developed further to allow growers to take remedial action before yield and quality are adversely affected,” said Marion Regan, Hugh Lowe Farms Ltd.



SF 154a – Blackcurrants: refining herbicide screen for use in recently planted cuttings

Term: October 2015 to October 2016

Project leader: Mike Hutchinson, Hutchinsons



The search for new blackcurrant herbicides

The residual herbicide Ronstar (oxadiazon) was widely used in newly planted blackcurrants until its approval lapsed, and since then growers have been lacking a reliable herbicide for this use. A previous project (SF 154) screened a range of potential replacement products on newly planted blackcurrant cuttings and they displayed both variable levels of safety to the cuttings and variable weed control. Some of the most efficacious herbicides also showed the greatest levels of crop damage.

The project

In this project, the aim was to refine the rates of the most promising treatments from the original trial and design tank-mixes with broad spectrum weed control activity.

Results

The predominant weeds in the trial were annual meadow grass, mayweeds, cleavers and thistle species, but overall weed numbers were too low to provide the most robust herbicide efficacy data. However, some trends in the results were apparent.


Nirvana (imazamox/pendimethalin) was previously found to be too phytotoxic in blackcurrants but a band spray between plant rows, in combination with Flexidor (isoxaben) sprayed over the plants, provided a safer option with good levels of weed control.

A range of other Nirvana containing tank-mixes showed only marginal crop safety and variable weed control levels.

Artist (flufenacet/metribuzin) plus Kerb (propyzamide) also provided good control of most of the weed species with a good level of crop safety.

Of these products, at present, only Flexidor and Artist (EAMU) are recommended for use on newly planted crops. Nirvana (EAMU) must not be used for 365 days before harvest. Kerb is only recommended for use on crops established for one year.

“This project allowed us to further investigate some better performing products from SF 154, although the absence of sufficient weed growth means results should be treated with caution,” warned James Wright, Whittern Farms.



“ Initial assessments indicate that EMR564 shows resistance to crown rot and Verticillium wilt ”

SF 096a – Membership of the East Malling Strawberry Breeding Club

Term: June 2013 to May 2018

Project leader: Adam Whitehouse, NIAB-EMR

Delivering the next Malling Centenary

AHDB has been part-funding the East Malling Strawberry Breeding Club since its inception in 2008 and the Club is now in its second tranche of funding. AHDB participation ensures that all varieties released from the programme will be made available to all UK strawberry growers and not an exclusive group, as can happen with privately funded programmes. The most notable success from the programme to date has been Malling Centenary which has been more widely adopted by UK growers than any other mainseason strawberry variety since Elsanta became the industry standard in the 1980s.

Malling Centenary, which has provided an alternative mid-season June-bearer to Elsanta, produces a significantly higher percentage of high quality, Class 1 fruit with a greater proportion of large berries that are very well-presented and have led to faster picking speeds and lower harvesting costs. Its fruit quality is also outstanding, offering growers a berry which consistently provides better flavour and shelf-life than Elsanta.

The East Malling Strawberry Breeding Club

The main objective of the Club is to develop improved strawberry varieties, both June-bearing and everbearing, with increased yield, larger fruit size, an extended season of production and greater resistance to fungal diseases. Each year, the most promising selections being assessed in preliminary trials at East Malling and offsite growers'

trials are highlighted and considered for further evaluation or release for commercialisation.

Advanced selections from growers' trials

Two new selections, one June-bearer and one everbearer, have been chosen for commercialisation and release to the industry.

The June-bearer is EM2157, a late Malling Centenary-type selection which has a similar season to Florence, but with better fruit size, Brix scores, appearance and plant habit. It is being fast-tracked towards commercialisation with first sales to industry expected in 2018/19.

The everbearer is EMR564, which has an early season of production with a high Class 1 yield and large fruit size. Fruit is glossy and attractive with uniform colour, firm skin and very firm flesh. Flavour has been judged to be pleasant with an average Brix score of 7.9. Fruit is displayed on long trusses. Initial assessments indicate that EMR564 shows resistance to crown rot and Verticillium wilt, with moderate resistance to powdery mildew. First commercial sales to the industry are expected in 2018/19.

One advanced everbearer EMR635 will progress to further large scale grower trials. This is a higher yielding everbearer with excellent fruit size and a high percentage of Class 1 fruit. The fruit is well displayed, with an attractive appearance and slightly aromatic flavour.

Initial assessments indicate that EMR635 shows resistance to powdery mildew and crown rot.


Promising selections

From the earlier trials at East Malling, four June-bearer selections have performed well in main crop trials and have been recommended for assessment in growers' trials in 2018/19. These include EM2448 (very early), EM2464 (early), EM2483 (early-mid) and EM2494 (mid-late). All of these have produced higher percentage Class 1 fruit than Elsanta, with the latter two producing higher yields.

Two June-bearers have shown particular promise in 60-day trials. EM2199 (early-mid) and EM2421 (mid-late) have both produced higher yield per plant than Elsanta and higher marketable yield. Both will be assessed further in grower trials.

Two everbearer selections have shown enough promise to go forward to growers' trials in 2018. Both EMR722 and EMR721 have exceptionally high quality fruit in terms of size, flavour, and appearance, and have also produced a high percentage of Class 1 fruit (> 80%). EMR721 also displayed resistance to powdery mildew.

"AHDB's continual funding of the East Malling Strawberry Breeding Club ensures that all growers have access to new varieties and I look forward to making use of the latest exciting selections being released in 2018/19," said Harriet Duncalfe, H & H Duncalfe.



“ In the breeding programme, several numbered florican selections are showing particular promise ”

SF 035c – UK raspberry breeding programme

Term: April 2014 to March 2024

Project leader: Nikki Jennings, James Hutton Institute

SF 041d – Raspberry: summer fruiting raspberry variety trial

Term: March 2013 to March 2017

Project leader: Janet Allen, ADAS

On the trail to an improved raspberry

The soft fruit panel has been funding two projects to breed and develop new and improved raspberry varieties for growers. The UK raspberry breeding programme (SF 035c) was set up in 2009 at the James Hutton Institute to breed new summer fruiting and primocane varieties suitable for either machine harvesting for processing or to extend the season of fresh-market fruit grown under protection. The summer fruiting selections with most promise have been assessed in a second project (SF 041d) to compare the performance of these with commercially grown varieties and new selections and varieties from other breeding programmes from around the world.

In its first five-year tranche of funding for the UK raspberry breeding programme, three new summer fruiting varieties have been produced which performed well in previous AHDB funded raspberry variety trials. Glen Fyne offers a suitable replacement for Glen Ample and Tulameen, producing higher yields and presenting its fruit well to pickers. It breaks its buds evenly down the length of the canes which lends itself to early production under tunnels and is also suited to machine harvesting, but is susceptible to *Phytophthora rubi*. Glen Ericht is an early/mid-season variety well suited to machine harvesting and the processing/freezing market. It regularly out-yields Glen Ample and exhibits strong field resistance to *Phytophthora*

rubi. Glen Dee is a late season variety, similar to Octavia, which consistently produces higher yields than Glen Ample, Tulameen and Octavia. The fruit quality is excellent and the size is consistently larger than Glen Ample, making it very suitable for the fresh market. Spawn growth is good too and, although it has no resistance to *Phytophthora rubi*, its root vigour is high.

Current programmes

The current tranche of funding for the breeding programme runs until 2019 and Head Breeder Nikki Jennings is now employing technology developed by three research projects part-funded by growers through AHDB and also through the Defra Horticulture LINK scheme and Innovate UK. The first, SF 063, identified molecular markers and genes on the raspberry genetic map which are linked to resistance to *Phytophthora rubi*. The second, SF 076, achieved the same, but for quality traits such as colour and flavour. A recent Innovate UK project (SF 138) developed this further to find markers for combinations of traits controlled by more complex genetic relationships to help breeding for fruit flavour and pest and disease resistance at the same time.

The recently completed summer fruiting variety trial (SF 041d) was located at Rectory Farm, Stanton St. John, near Oxford, by kind permission of Richard Stanley. Four of the breeding programme

selections, 0447C-5 (Glen Dee), 0435D-3, 0485K-1 and 0019E-2 were included in the main replicated trial and were compared to Octavia, Tulameen, the Canadian varieties AAC Eden and Squamish, along with four numbered selections from NIAB EMR.

Recent results

In the breeding programme, several numbered florican selections are showing particular promise at present and are being trialled on commercial sites around the UK and Europe. Since 2015 a number of new summer fruiting selections have been identified with root rot marker genes in the marker assisted selection process to breed varieties resistant to *Phytophthora*. Selection RBC16F6, in particular, has displayed robust resistance with high productivity and significant fruit size over five seasons and plants were distributed to grower trials in 2017.

Breeding for primocane varieties is focussing on early autumn season with high fruit quality and significant improvements could be seen in the JHI primocane germplasm in 2015. Eleven first stage selections were planted in glasshouse trials in England in 2015 to assess seasonality and yield. Two of these selections, RBC16P4 and RBC16P5, stood out with superior fruit quality and are currently in propagation for trials in 2018.

“Squamish produces unusually high yields for an early variety”



In the summer fruiting raspberry variety trial in Oxfordshire, twelve varieties and numbered selections, including the control varieties Tulameen and Octavia, were chosen for assessment in the main replicated trial. An additional 21 varieties/selections were planted in the trial as single guard plots. These included three 'Pearl' clones of Tulameen from Canada to compare them to the Naktuinbouw clone. The entries to both replicated and guard plots were planted in a field soil of loamy sand texture in 2013, established in 2014, and cropped and recorded in 2015 and 2016. During the harvest period, they were protected by a Spanish multi-bay tunnel.

After two years of assessment and collection of yield and quality data, five varieties/selections from the main replicated trial showed considerable promise for commercial production in the UK. Two selections from the guard plots were also outstanding.

Replicated trial

Squamish is an early variety from the PARC research centre in Canada which produces unusually high yields for an early variety. It appears to have a low chilling requirement compared to Tulameen with buds breaking evenly down the length of the cane, lending itself for early and forced production under

glass and polythene tunnel structures. Fruit quality is high with Brix levels consistently higher than Tulameen.

0485K-1 is an early/mid-season variety from the James Hutton Institute, with 50% pick date three to four days earlier than Tulameen. It stood out for its outstanding fruit quality and flavour. It has a high chilling requirement which does not lend itself to protected production or forcing, but sequential plantings of cold stored long canes offer an alternative use.

EM6805/142 is a late variety from NIAB EMR, with 50% pick date between seven and 10 days later than Tulameen and similar to or slightly later than Octavia. It produced higher yields of equal quality fruit to Tulameen and Octavia. It is seen as a good replacement for Octavia.

EM6804/81 is also a late variety from NIAB EMR, with 50% pick date seven to 10 days later than Tulameen and similar to Octavia. It looks extremely good in the punnet but did not score as highly for flavour as some of the other selections included in the replicated trial.

Glen Dee is a mid-late variety from the James Hutton Institute, with 50% pick date seven to 10 days later than Tulameen and similar to Octavia. It produced the largest berries of all the replicated trial varieties in 2015 and

2016 and had excellent shelf life and fruit quality. It offers growers the chance to pick through July and into early or even mid-August.

EM6805/142, EM6804/81 and Glen Dee are all seen as replacements for Octavia.

Guard pots

WSU 1607 is a mid-season variety from Washington State University with a 50% pick date identical to Tulameen and a similar long production season. Fruit size was larger than any other variety or selection in either replicated or guard plots and fruit quality was excellent.

WSU 1605 is a mid/late variety from Washington State University, slightly later than Tulameen. Like WSU 1607, it has extremely large fruit, although not larger than WSU 1607.

Both WSU 1605 and WSU 1607 offer a potential replacement to Tulameen.

As both the Washington State University selections were only assessed as single plots, growers would be advised to test their performance on a small scale before deciding to plant larger quantities.

Resisting root rot in raspberry

Plant based resistance is one of the few long-term solutions to *Phytophthora rubi* control. The development of genomic tools offers an opportunity to identify genes that have a significant role in this plant-pathogen interaction to determine the mechanisms of resistance and develop novel strategies of protection, including breeding.

The Project

This project investigated how both resistant and susceptible varieties respond at the level of gene expression. How the pathogen responds to the differing phenotypes will identify gene markers and allow strategies for control to be developed.

Results

The project sequenced the genome of the cultivar Latham which is known to be resistant to root rot (*Phytophthora rubi*). This allowed us to compare Latham with the previously sequenced genome of Glen Moy, which is known to be highly susceptible to root rot. To determine important genes relevant to pathogen resistance/susceptibility, we firstly looked at specific QTL regions which were known to be associated with resistance, to identify candidate genes. Secondly, in



SF 164 – Using genomics technologies to determine the mechanism of resistance to *Phytophthora* root rot in raspberry for future breeding applications to raspberry and other crops (Innovate UK Project 131890)

Term: July 2015 to December 2016

Project leader: Julie Graham, James Hutton Institute

order to understand how the two cultivars behave upon pathogen infection; we carried out root infections of both Latham and Glen Moy with *P. rubi* to examine differences in gene expression in the two varieties. This identified raspberry root genes that respond significantly to the initial infection phase of the pathogen. We also identified sets of genes known to be involved in pathogen responses

and found a group of genes with an unexpected response to the pathogen, which gives a new resistance mechanism to investigate. This project also successfully produced a draft genome for *P. rubi*. The infection experiment identified pathogen induced effectors that manipulate the plant cell physiology and development to allow disease to occur.

Understanding the causes of crumbly fruit in raspberry

SF 167 – Understanding the causes of crumbly fruit in red raspberry

AHDB STUDENTSHIP

Term: October 2016 to September 2019

Project leader: Julie Graham, James Hutton Institute

A condition known as crumbly fruit occurs to differing degrees in different raspberry varieties and is an indication of partial failure in the physiological processes in fruit development. Raspberry fruits are formed from an aggregation of multiple fertilised ovaries, each of which are known as a drupelet as they become fleshy. In the condition known as crumbly fruit, which has been linked with pollen abortion and embryo sac degeneration, drupelets may be greatly enlarged if their number is greatly reduced or, in the case of small reductions, cohere imperfectly so fruit readily crumbles when picked.

The project

This project aims to understand what the triggers for the condition are and how the crumbly phenotype arises, leading

to an improved test in the production of nuclear stock plants for entry into the UK certification scheme and knowledge for breeding less crumbly varieties.

Results

Crumbly fruit is a description of a symptom that seems to be caused by an event interfering with the fertilisation of the ovules. Two possible scenarios can be hypothesised: the ovule does not get fertilised due to a physical obstacle that impedes the process, or the ovule fertilisation occurs but something hinders the ovary developments into a drupelet. A set of experiments have been set up in an attempt to produce the crumbly phenotype under controlled conditions. To date it has been possible to induce crumbly fruit by mechanical damaging, removal of style and stigma, and by damage to the receptacle. Material has been collected and the control of the crumbly phenotype will be examined at the gene and hormone level.

It has also become clear that there is varying opinion on what constitutes the crumbly fruit condition, so a clear and universally accepted definition will be proposed as part of this PhD thesis. This will be based on a survey carried out by PhD student Luca Scolari.



“Each £1 invested in soft fruit breeding at JHL has generated £343 for the UK economy”



SF 163 – Developing genetic resources in blueberries (Innovate UK Project 131889)

Term: July 2015 to December 2016

Project leader: Julie Graham, James Hutton Institute

Developing genetic resources in blueberries

Lack of blueberry varieties with high fruit and nutritional quality combined with early and late ripening is a problem facing UK blueberry growers. UK growers are currently planting mixtures of existing varieties, mainly from the USA, but the long-term performance, fruit quality, yield and consumer acceptance of these varieties in the UK varies considerably. There has been increased demand for blueberries in recent years, fuelled in part because of their many recognised health benefits. With the availability of more genomic resources, marker-assisted breeding could be used in variety development to more efficiently combine traits for fruit and nutritional quality specific to UK climatic adaptation.

The project

This project will therefore develop pre-breeding populations and a high resolution Genotyping by Sequencing (GbS) linkage map to allow the UK to develop adapted blueberry varieties efficiently, cost effectively and in a shorter


time frame than would be feasible by traditional breeding means. This would allow the UK to produce more home-grown fruit for consumption to increase from the 5% UK fruit currently available.

Results

This project represents a significant advance in both fundamental and applied science with tangible outputs in terms of suitable UK adapted populations for breeding and high resolution linkage maps for marker assisted selection. This project developed tools for blueberry genomics and breeding by developing a range of novel populations and constructing a high resolution GbS linkage map in this tetraploid crop. These resources will allow the UK to breed blueberries in a shortened timeframe specific to UK conditions, allowing the production of more home-grown fruit for consumption to increase the 5-10% UK fruit currently available. The blueberry industry has been reliant on imports for around 90-95% of fruit consumed in

the UK for the last 10 years. Agriculture faces increasing challenges associated with declining yields in high yielding environments, reduction in arable and climate change and will need to access genetic resources efficiently to breed new varieties that can cope with the many pressures. Products, in terms of genomic resources generated as a result of this project, can now be utilised in the commercially funded JHL blueberry breeding programme valued at around £375,000 over five years. In terms of previous JHL funded breeding programmes, each £1 invested in soft fruit breeding at JHL has generated £343 for the UK economy.

“The demand for UK grown blueberries is increasing and the production industry needs to find new and improved varieties to meet this. Work of this nature will provide the breeding tools required to speed this process up,” explained Lindrea Latham, Total Worldfresh.



“ Even if interspersed with strong sunshine, too many heavily overcast days are likely to have a negative impact on yield ”

SF 160 – Improving yield stability in UK blueberry production (Innovate UK Project 102130)

Term: October 2015 to September 2020

Project leader: Julie Graham, James Hutton Institute

Improving yield stability in blueberry

Lack of yield stability is a major problem for UK soft fruit growers, preventing accurate profit prediction and maximisation, and causing volatility of UK supply. However, the causes of significant season-to-season yield variation are unknown.

The project

This project aims to identify the physiological, biochemical and genetic processes underlying yield limitations, thereby identifying causes of the yield volatility phenotype. An examination of the impact of the growing environment and management on yield will be undertaken, to allow development of predictive yield maps and models, which provide frameworks for yield optimisation in the short- to medium-term. This underpinning knowledge will be transferred to growers and also used to develop molecular markers for yield stability allowing long-term solutions to the problem, thereby future proofing the UK soft fruit industry, particularly blueberry crops.

“Yield stability is a very complicated subject and one that was almost impossible to study in the past. The modern scientific techniques employed in this project could offer a major breakthrough in improving our understanding and maybe even lead to new commercial guidance for blueberry growers,” enthused Ross Mitchell, Castleton Fruit Ltd.

Results

Work has been conducted across two complete growing seasons to identify the mechanisms underlying the yield instability trait. Data gathered indicates that fruit is lost progressively across the entire developmental period and is not associated with catastrophic environmental events, such as frost damage to flowers. This indicates that more subtle environmental variation must be associated with yield instability and highlights the need for the development of predictive yield maps and models that can support crop management.

A detailed examination of other potential mechanisms underlying the yield instability trait has consistently indicated that at moderate light levels, equivalent to a mildly overcast day, photosynthetic activity of blueberry bushes becomes saturated. Furthermore, the rate of photosynthesis at saturation is highly temperature dependent within the range of temperatures encountered during the UK growing season. For example, saturated photosynthetic rates were approximately 25% lower at 15°C than they were at 25°C. On heavily overcast or cooler days the plant is not able to achieve its full photosynthetic potential, however it is also unable to compensate by photosynthesising more on sunny days. This means that even if interspersed with strong sunshine, too many heavily overcast days are likely to have a negative impact on yield.

This problem is exacerbated by the observation that, unlike some other berry crops, blueberries do not accumulate a starch reserve that can be utilised to provide sugars and energy for fruit growth and maturation if the later part of the season is not ideal. These findings are being used to build a model which can be used by growers to aid yield prediction. The model is being further refined by collating a range of historic yield data to confirm the correlations between light intensity and temperature during fruit development and final fruit yield. New data is also being collected regarding the timing of critical developmental transitions (leaf out, bud burst, first flower, full flower, fruit set, fruit ripening, fruit run-off, leaf drop) to integrate with meteorological data to define heat-unit based models to allow growers to not only estimate their crop yields but also to accurately schedule their crops allowing them to provide their customers with crucial information to maintain UK blueberry supply.

The mechanistic understanding has additionally informed potential management solutions to prevent yield instability and experiments are presently being conducted to determine whether techniques to direct more light into the crop canopy can improve yields in an economically viable way.

Furthermore, the work is guiding breeding programmes providing insights into appropriate phenotypes and hints for candidate gene markers.

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Rhubarb downy mildew

This factsheet describes the symptoms of downy mildew (Figure 1) and how it spreads in rhubarb plantations. It provides guidance on disease avoidance and summarises both cultural and chemical control measures.



Figure 1. Early downy mildew symptoms displaying irregular yellow lesions on rhubarb leaf

Action points

- Prickle-gate from symptom-free plants
- Maintain weed control and manage irrigation to reduce humidity within the crop
- Consider targeting preventative fungicide applications by monitoring weather conditions favourable for downy mildew
- Be vigilant for early symptoms
- Be aware symptoms can be mistaken for other leaf pathogens and so microscope confirmation of diagnosis may be beneficial to ensure correct treatment
- Remove infected debris from the field where possible.