NIAB

Fruit

Annual Review 2023

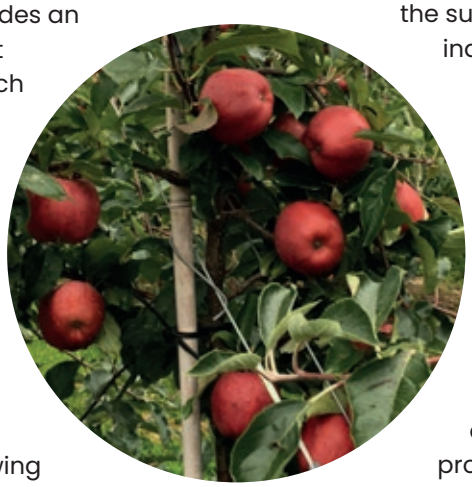
Mario Caccamo, Chief Executive, NIAB

Welcome to the NIAB Fruit Annual Review 2023

Fruit research began at the East Malling site in 1913 and since then, scientists working at the research station have communicated and disseminated results in various ways.

The East Malling Research Association fulfilled this function for some time and more recently, the Agriculture and Horticulture Development Board (AHDB) provided annual summaries of the grower levy funded fruit research that was undertaken by NIAB scientists. With the winding down of AHDB funded activities, we have set up 'NIAB Fruit' as a new means of communicating with the industry through this Review, together with electronic factsheets, international research up-dates, fruit dedicated web pages on the NIAB website, annual technical days and NIAB events at East Malling.

This Review provides an overview of the vast array of fruit research that is currently being carried out by NIAB scientists at East Malling. In it, you can learn more about the crop protection work we are doing to improve management and control of spotted wing drosophila, apple sawfly, forest bug and apple canker, along with the development of new technology to assess spray coverage and create precision dosing in orchard crops. We also report on research we are doing on the re-use of coir in strawberry production.

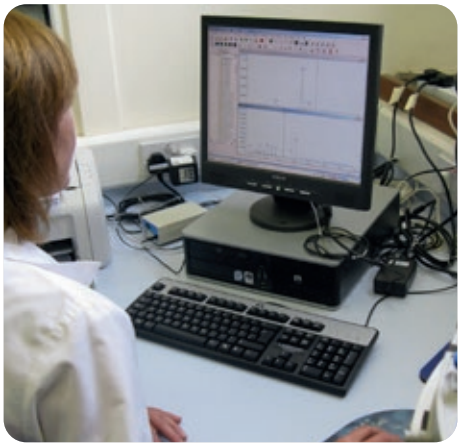


You can find out more about the crop science and physiology work to improve precision irrigation and fertigation in soft fruit and to improve yield predictions in strawberry, whilst we provide progress reports on the development of our three demonstration centres (WET Centre, Plum Demonstration Centre and Research Vineyard). These are particularly valuable resources as they allow us to put our research results into practice, whilst also offering facilities for our scientists to work on practical solutions for the problems facing today's commercial growers. I am particularly pleased that these three centres are receiving the support of the industry and I am excited about the potential to develop these further with direct input from growers.

We provide overviews of our NIAB genetics and breeding programmes which continue to develop new fruit varieties that meet the needs of growers. All of our programmes are funded by growers and industry stakeholders who set the objectives of our programmes, ensuring that we not only aim to improve yields and fruit quality, but also develop improved plant architecture to reduce management costs and incorporate genes or sequences of genes that offer insect pest or disease control.

You will also be able to read about the post-graduate training scheme for fruit crop research which is helping us to develop new scientists to work in the fruit sector and we provide an overview of the Growing Kent & Medway activities that are doing so much to support the horticultural, food and drink industry in the South East of England.

At NIAB we believe that a reliable supply of home-grown food is essential to maintain a stable and prosperous economy. The impact of the current energy prices and the inevitable consequences of a 30-year high inflation rate, however, is disproportionally affecting the horticulture sector. In these challenging times the continuation of the research and innovation work is essential to ensure we can support the UK's fruit growers. We look forward to working with you in 2023 and welcoming visitors to our site at various events throughout the year.



NIAB Trial services and glasshouse services at East Malling

NIAB's work at East Malling has gained recognition around the world through its employment of enthusiastic scientists from a wide range of disciplines who have become experts in their field. Together, they have engaged directly with fruit growers to develop solutions to their problems and help to increase yields and fruit quality, allowing local growers to remain profitable and compete on the world stage. In addition to our traditional fruit research, we now provide a range of trials services and glasshouse services to support the fruit industry.

Adrian Harris, Horticultural Trials Co-ordinator • adrian.harris@niab.com

Trials services

We offer a range of technical support through bespoke trials services, technical innovation, independent evaluation and commercial demonstration, all of which is accredited by ORETO, ISO and GEP. Specifically, we offer help in crop protection, crop production systems, vines and wine production, variety and novel crop trialling, true-to-type DNA fingerprinting and growing media trials. Crucially, the work we do is independent, authoritative, comprehensive and impartial.

Emma Easton, Head of Glasshouse Services • emma.easton@niab.com

Glasshouse services

Newly constructed and opened in 2022, with funding from Growing Kent & Medway, Kent County Council and The East Malling Trust, we offer both glasshouse and growth room facilities for research purposes to the fruit industry.

The glasshouses cover a total area of just under 2,000m^2 with compartments ranging from 24 to 352m^2. All compartments have concrete floors, allowing them to be fully cleaned between crops, ensuring that pests and pathogens are not carried from one crop to another. Each glasshouse compartment has insect proof netting on the vents, along with lockable zones for high-risk pest and pathogen research. The glass is built to reflect modern glasshouse facilities so that experiments or trials can mimic commercial practice.

A full range of irrigation facilities are on offer including mist, drip and hand watering. For small container grown plants, moveable benches with ebb and flow tops are available. Both high pressure sodium and LED lighting is available for use, depending on the research required and screens are also available for night break lighting or sun-shading. There are nine climate-controlled compartments with heating and cooling facilities and fitted with black out blinds. Coupled with LED lighting, scientists are able to set up experiments in these compartments to control light and temperature.

We have seven growth rooms in total, all of which have independently controlled environmental conditions that range in size from 10-20m^2. These growth rooms are controlled by a cloud based 'Trend' Building Management System (BMS). Temperatures can be controlled between 15-38°C, but there is also one vernalisation chamber where plants can be held in cooler conditions ranging from 6-21°C where there is also supplementary lighting available. Broad spectrum LED lighting is available to control plant growth, allowing for deep light penetration. High-tech humidity control is also available to provide uniform growing environments. The growth rooms facility is 'Containment Level 2' which allows for licenced pathogen work. This facility also has a laboratory.

New Projects 2022/23

CROP SCIENCE AND PRODUCTION SYSTEMS

Eleftheria Stavridou, Senior Specialist in Plant Nutrition

Title: Increasing ascorbic acid and iron levels in tomatoes to enhance human nutrition and plant abiotic stress tolerance

Funder: Growing Kent & Medway

Industry partner: Thanet Earth

Term: May 2022 to October 2024

Hotter drier summers can adversely affect the growth and yield of tomato plants, which have a narrow range of optimal growing temperatures. Heat stress not only limits yield, but has an adverse effect on fruit development and nutritional content. Increased levels of ascorbic acid (vitamin C) and iron levels help tomato to withstand heat stress (pictured). This project seeks to develop ways of enhancing the production of nutrient dense tomatoes, increasing the levels of both vitamin C and iron, providing improved cropping and a higher value product to enhance human health.

Increasing levels of vitamin c and iron can help tomato withstand heat stress

CROP SCIENCE AND PRODUCTION SYSTEMS

Flora O'Brien, Root and Soil Biologist

Title: Increasing productivity and sustainability in UK viticulture: investigating the potential impact of groundcover management practices on soil health, yields and juice quality, and emissions

Funder: Defra Farming Innovation Programme

Industry partners: Chapel Down, English Wines PLC, Gusbourne Estate Ltd, T. Denne & Sons Ltd, University of Greenwich, Vinescapes Ltd

Term: May 2022 to April 2024

NIAB's soil scientists are increasingly aware that poor soil health can give rise to inconsistent yields and juice quality in vine growing, which can lead to costly interventions in the vineyard and winery. This project is investigating the potential impact of groundcover management practices on soil health, yields, juice quality and emissions (pictured). It will also lead to grower guidance on bespoke cover crop mixes to alleviate soil compaction, improve soil nutrition and control nematodes. Guidelines to support transition towards net-zero carbon emissions will be drawn up alongside this.

Can groundcover management influence soil health and vineyard yields

GENETICS, GENOMICS AND BREEDING

Amanda Karlstrom, Plant Breeder and Geneticist

Title: Enabling marker-based breeding methods for apple crispness

Funder: Horticultural quality and food loss network

Industry partners: University of Greenwich (Natural Resources Institute), WORLDWIDE Fruit Ltd

Term: April 2022 to December 2022

Flavour and fruit texture are the most important fruit characteristics affecting consumer's liking of apple varieties. Fruit texture is composed of both firmness and crispness and successful post-harvest storage of apples depends on reducing the decline in firmness and crispness to a minimum. In breeding new varieties, apple breeders would benefit from identifying genetic markers which confer high levels of firmness and crispness and this project will help to validate these markers and identify potential breeding parents which can be deployed to improve these quality traits.

PEST AND PATHOGEN ECOLOGY

Michelle Fountain, Head of Pest and Pathogen Ecology

Title: Screening for 'resistance' to spotted wing drosophila (*Drosophila suzukii*) in strawberry and raspberry accessions

Funder: Growing Kent & Medway

Industry partner: Asplins Producer Organisation

Term: May 2022 to October 2024

Spotted wing drosophila (SWD – pictured) is an invasive pest of soft and stone fruit that originated in Japan and spread across the world, arriving in the UK in 2012. Since then NIAB entomologists have been engaged on a series of AHDB, government, research council and charity funded projects aimed at reducing the chemical inputs to control SWD. This project is investigating fruit characteristics in strawberry and raspberry that may be associated with 'resistance' to SWD and aims to identify germplasm for use in future strawberry and raspberry breeding programmes.

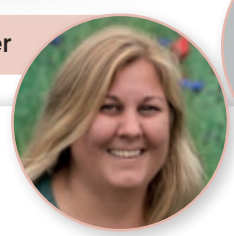
Adult female SWD

Photo: Nicolas Gompel

PEST AND PATHOGEN ECOLOGY

Matevz Papp-Rupar, Plant Pathology Research Leader

Louisa Robinson-Boyer, Plant Microbial Interactions Research Leader



Title: Enhancing orchard ecology for improved resilience to climate change and apple canker disease

Funder: Growing Kent & Medway

Industry partner: Avalon Fresh

Term: May 2022 to October 2024

Apple canker is the highest research priority for UK apple growers, particularly as it can result in up to 10% annual tree losses occurring in young orchards in the early years after establishment. It is particularly damaging in high density planting of highly susceptible varieties. Its impact is also increasing due to climate change. NIAB has benefited from AHDB and BBSRC funding to work on apple canker but control options continue to be expensive, time consuming and can have limited impact. This project will explore novel approaches such as biocontrol, alternative spray programmes and soil amendments for improved tree health and resilience with the hope of improving canker management practices.

PEST AND PATHOGEN ECOLOGY

Matevz Papp-Rupar, Plant Pathology Research Leader

Title: Testing field efficacy of spray programmes against apple canker pathogen *Neonectria ditissima* using novel plant protection products

Funder: AHDB

Term: May 2022 to June 2023

With limited effective fungicides available for apple canker and the recent loss of copper products for suppressing infection at bud burst and leaf fall, AHDB funded a project to assess novel products as standalone treatments. In its final operating year, the AHDB Horticulture crop protection team has funded NIAB to test combinations of the best performing products from the previous trials, and also include any new products that have become available including new fungicides, biocontrol agents, biostimulants and alternative chemicals (pictured).

Assessing novel products for apple canker control

PEST AND PATHOGEN ECOLOGY

Francis Wamonje, Entomology Research Leader

Title: Development of pheromones for innovative management of forest bug, an emerging pest of orchards in England

Funder: Defra Farming Innovation Programme

Partners: Agrovista UK Ltd, Avalon Fresh, Russell IPM, University of Greenwich

Term: May 2022 to April 2024

The forest bug (*Pentatoma rufipes*) is a new pest of apple and pear in the UK, which has been causing increasing levels of damage since the withdrawal of several broad-spectrum spray products. The bug, which feeds on developing fruitlets causes fruit distortion and can give rise to up to 40% crop losses. Monitoring by tap sampling is time consuming and unpractical. This project aims to identify and synthesise a pheromone for forest bug (pictured), which can then be used as a lure in traps which will allow growers to monitor for the presence of the pest and allow the industry to work towards novel approaches to control.

We aim to identify a sex pheromone for forest bug

Francis Wamonje, Entomology Research Leader

Title: Brown marmorated stink bug (*Halyomorpha halys*) surveillance in the UK

Funder: Defra

Term: March 2022 to February 2024

Brown marmorated stink bug (BMSB, *Halyomorpha halys*) is an invasive pest established in many European countries, causing significant crop damage in apples and pears in countries such as Italy, where temperatures favour two generations per year. NIAB has been monitoring since 2018 and has observed adults, more recently females, free in the environment within England. In this project we will continue to monitor for adults in the environment (pictured), search for immature stages to determine if populations are establishing in the UK, intercept BMSB emerging from overwintering sites and collate expert confirmed public findings.

Surveillance for populations of brown marmorated stink bug

PEST AND PATHOGEN ECOLOGY

Francis Wamonje, Entomology Research Leader

Title: Apple Sawfly: Developing extraction methods to acquire adult insects for pheromone identification

Funder: The Worshipful Company of Fruiterers

Term: February 2023 to December 2023

Apple sawfly larvae can cause serious damage (pictured) if left uncontrolled in apple orchards. With the loss of several broad-spectrum spray products and a period of activity that coincides with blossom when conservation of pollinating insects is vital, alternative control measures are needed. Previous attempts to identify the sex pheromone have been hampered by an inability to rear sufficient numbers, so this project will focus on methods of collecting and rearing sufficient apple sawfly adults to allow pheromone identification, which might lead to future development of novel monitoring and control tools.

Typical ribbon scar caused by apple sawfly larva

PEST AND PATHOGEN ECOLOGY

Michelle Fountain, Head of Pest and Pathogen Ecology

Title: Agrobioconnect: Connections in the landscape. Role of landscape complexity in agroecosystem sustainability

Funder: Defra SusCrop ERA-Net

Partners: Berry Gardens Growers and Avalon Fresh

Term: February 2023 to January 2026

Intensive horticultural practices can lead to unsustainable activities which exacerbate damage to the environment. Increased biodiversity can lead to more resilient ecosystems, but requires a holistic understanding of the ecological mechanisms at work. Working within a European science partnership, NIAB will study the landscape complexity across 18 commercial UK fruit farms, attempting to assess the impact on arthropod abundance including beneficials like predators, parasitoids and pollinators. The findings will guide policy and actions on fruit farms to adapt to climate change.

PEST AND PATHOGEN ECOLOGY

Xiangming Xu, Director of Research

Title: Advanced optical tomography tools for non-destructive detection of latent fungal infection in produce

Funder: Biotechnology and Biological Sciences Research Council

Partners: University of Kent

Term: April 2023 to June 2024

Two thirds of food waste occurs after harvest, much of it being lost through latent infections which can only be detected using destructive techniques which are expensive and time consuming. A non-destructive method would allow the industry to detect latent infections before fruit is loaded into store, where infection spreads rapidly. Fruit with latent infection could be marketed early, while fruit without infection could be stored with confidence for longer durations. This project aims to develop a new non-destructive imaging tool that will detect latent infections of brown rot on cherry before it is loaded into store (pictured).

Can we develop a non-destructive tool for identifying latent brown rot in harvested cherry?

PEST AND PATHOGEN ECOLOGY

Matevz Papp-Rupar, Plant Pathology Research Leader

Title: Assessing the biocontrol effect of coir adapted beneficial microbes on Phytophthora root diseases in berry production

Funder: The Worshipful Company of Fruiterers

Term: January 2023 to September 2023

Phytophthora pathogens can be highly destructive in strawberry and raspberry crops. The soft fruit industry now has very limited chemical control options available and biocontrol options have had mixed success, in part because they do not always establish well in coir substrate. NIAB scientists have isolated strains of Bacillus, Pseudomonas and Streptomyces species from commercially grown healthy strawberry and raspberry crops which could offer beneficial effects. In this project, they will be assessed for their biocontrol potential both in vitro and in semi-commercial trials.

PEST AND PATHOGEN ECOLOGY

Xiangming Xu, Director of Research

Title: Predicting the emergence of host-adapted bacterial phytopathogens

Funder: Biotechnology and Biological Sciences Research Council, Defra, NERC and the Scottish Government

Partners: University of Birmingham and Imperial College

Term: July 2020 to March 2024

Bacterial pathogens can cause significant commercial damage and in the case of cherry, *Pseudomonas syringae* (*pathovars syringae* and *morsprunorum*) can cause up to 70% tree loss. Cherry growers have recently lost the use of copper based control sprays, so new forms of management are required. This project aims to provide fundamental insights into how new strains of pathogens emerge and evolve on potential hosts using *Pseudomonas syringae* as an example. It will lead to improved design of disease management methods and new precision tools for assessing risks.

PEST AND PATHOGEN ECOLOGY

Xiangming Xu, Director of Research

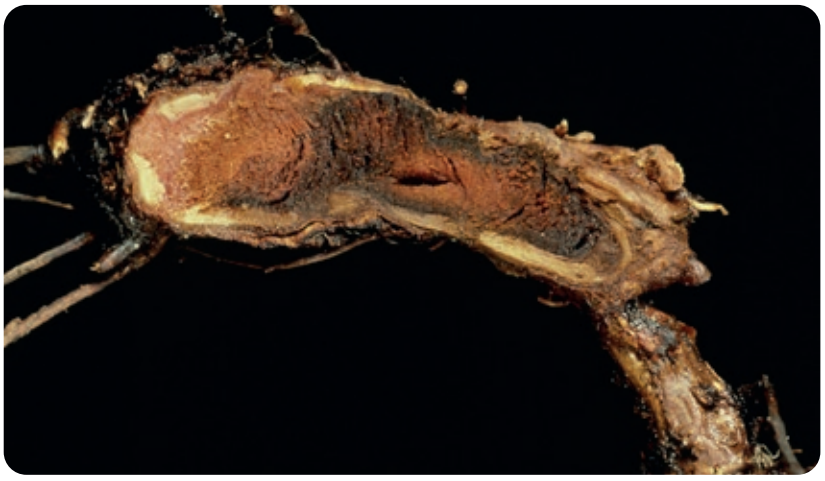
Title: Using end of season biocontrol to reduce crown rot in reused coir bags

Funder: Defra

Term: October 2022 to March 2023

Phytophthora cactorum (pictured) can contribute to reduced yields in strawberry plants established in reused coir bags. With few effective conventional fungicides available, growers may resort to biofungicides, but we need more information about their efficacy. NIAB scientists are infecting pots of both virgin and spent coir with *Phytophthora cactorum*, then applying five commercially available biofungicides at the end of the growing season, incubating them for 1 month, then planting the pots with clean strawberry plants. To assess the efficacy of each, the plants will be assessed both visually and using molecular analysis 12 weeks after planting.

Can biogungicides effectively control strawberry crown rot?



PEST AND PATHOGEN ECOLOGY

Xiangming Xu, Director of Research

Title: Biocontrol of horticultural diseases in apple and strawberry using cover crops and biopesticides

Funder: EU ERA-NET (Defra)

Term: April 2021 to March 2024

One part of this project is investigating the use of biological control agents (BCAs) to improve their efficacy for disease control in strawberry. Commercial use of BCAs in strawberry has mixed results and is often less reliable than conventional fungicides. However, understanding their population dynamics relative to climatic conditions can be crucial to their efficacy. NIAB is working on three BCAs commonly used in strawberry to obtain ecological knowledge and to develop models to predict their fate in the environment following their application, so that we can optimise the timing of their use.

Project summaries

CROP SCIENCE AND PRODUCTION SYSTEMS

Mark Else, Head of Crop Science & Production Systems

Developing a new strawberry crop forecasting tool

Title: BerryPredictor: Improving harvest forecasts, yield predictions and crop productivity by monitoring and optimising zonal phytoclimates in covered strawberry production

Funder: Innovate UK

Industry partners: Berry Gardens Growers Ltd, Cropdesk Technologies Ltd, Environmental Monitoring Solutions Ltd, SAGA Robotics Ltd, University of Reading, Weatherquest Ltd

Term: December 2019 to November 2022

For several decades, strawberry growers and their marketing groups have been aspiring to develop an improved and accurate method of estimating and forecasting the volume of fruit likely to be available for harvesting over a period of one to two weeks. A better understanding of how much fruit will be available to sell in the coming days will provide a smoother supply chain, reduce waste and reliance on imports, and improve the management of fruit retailing (Figure 1).

The project

This Innovate UK project has brought together a multidisciplinary team of scientists, technologists, meteorologists, and growers to pool their knowledge and skills to develop a new tool which will ultimately be available to strawberry growers. They have been tapping into the recent knowledge gained at NIAB's WET Centre at East Malling. The project has shown how higher levels of photosynthetic active radiation (PAR) can give rise to higher yields, not only in years like 2020 and 2022 where light levels were unusually high, but also in certain zones of polythene clad tunnel crops, where higher yielding middle rows receive higher levels of PAR compared to lower yielding leg rows.

Temperature also has an impact on yields through berry number and berry size. Leg rows are, on average, half a degree cooler than middle rows and this can give rise to higher fruit fresh weight. In contrast, the centre rows produce more fruit which overall leads to higher yields than in the leg rows. Different phytoclimates within tunnels also affect the rate of ripening and so in the development of a crop forecasting tool, the effects of different phytoclimates in tunnels needs to be accounted for in the total predicted yield for a given area.

Figure 1. Growers need to be able to predict harvest dates and yields to improve continuity of supply to customers

Results

BerryPredictor is a science-led forecasting tool based on plant, climate, and data science. Partner scientists at the University of Reading have produced variety specific temporal ripening models, which take into account the effects of temperature on fruit development rate and fruit size. When combined with a 5-day polytunnel "weather forecast" developed by Weatherquest, these models are capable of estimating the ideal ripening/harvest time to within one day for several commercial varieties. The models are currently being incorporated into the forecasting tool, which also takes account of estimates of fresh weight and fruit number.

Industry partner Cropdesk Technologies Ltd has developed a grower interface for the forecasting tool. They are now extending its capability to take account of intra-annual and inter-annual climate variability, the effect of different zonal tunnel phytoclimates and incorporating the impact of events that reduce yield such as heatwaves, variable plant quality, and pest/pathogen outbreaks.

The work will continue in 2023 at the WET Centre and Cropdesk Technologies Ltd is hoping to launch the new BerryPredictor tool in 2024.

Mark Else, Head of Crop Science & Production Systems

Matching nitrogen supply with demand in raspberry fertigation

Title: SMARTFert: Integrating nutrient demand models in AI-based sensors with precision-dosing rigs to improve resource use and productivity, and reduce waste and emissions in commercial raspberry production

Funder: Innovate UK

Industry partners: Netafim UK Ltd (Lead), Berry Gardens Growers Ltd, EDT DirectION

Term: August 2020 to February 2022

With the move to protected cropping of raspberry in container-grown soil-less substrates (Figure 1), where historical nitrogen fertiliser application rates are used, it is not unusual to find crops producing excessive vegetative growth. This not only leads to increased cane management costs, but also increased picking costs, as more time is taken searching and reaching for ripe fruits. Exceeding the plant's nitrogen requirements also increases the risk of fungal disease and could also elevate the production of nitrous oxide (N_2O), a potent greenhouse gas.

The project

In this project led by Netafim UK, NIAB aimed to develop a system to match the nitrogen supply to demand in a commercially-grown raspberry crop of Malling™ Bella at NIAB's Water Efficient Technologies (WET) Centre at East Malling. The project also aimed to measure how much nitrogen application could be reduced compared to commercially grown crops with no detrimental effect on yield or fruit quality.

Results

In the early stages of the project, variety-specific mathematical models were developed for commercial raspberry varieties to try to match the nutrient supply with the demand. In 2021, a model for Malling™ Bella was calibrated using a crop of three-year-old container-grown plants in coir substrate. It was found that, as the season progressed and the plants developed and started cropping, the nitrogen (N) content of the plants steadily increased in both the leaf tissue and the developing fruits. This data was then used to calibrate an N-demand model for Malling™ Bella, allowing an estimate to be made of how much nitrogen to apply over the growing season, and when it was required. The model was validated in the 2022 growing season.

The low-N treatment was compared to a commercial control in which Malling™ Bella received standard commercial fertigation regimes over the season. Apparent differences started to appear in July and excess vegetative growth in the control required labour to de-leaf the crop to improve access to the fruit. In contrast, no such work was required in the low N treatment. Low-N treated plants were also more resilient to the 2022 heatwaves due to the reduced canopy volume, and hence, transpirational water demand under high vapour pressure deficits. Both cane management and picking costs appeared to be reduced in the low N treatment, although a full financial comparison has not yet been carried out.

However, the low N plants started to display yellow leaf colour and by August and September, the canes were smaller and the canopies more sparse, and this resulted in the low N treatment crops producing an average of 3.5 kg per plant compared to 4.1 kg in the commercial control. Although the former yield was still higher than those for Malling™ Bella in previous years, the aim is to lower N inputs and emissions *without* reducing marketable yields. During the vegetative stage, the applied volume of N was lower than the scientists had anticipated, and they subsequently identified that the generic crop coefficients embedded in the model and used to predict water and subsequent N uptake in 2022 were not accurate enough for UK raspberry production. These were developed overseas for different glasshouse-grown crops in different climatic conditions and new variety-specific crop coefficients will now be developed for UK raspberry production.

Figure 1. Raspberry production has moved into container-grown soilless substrates

In other projects, the team has successfully employed N-demand models in raspberry and strawberry varieties and has achieved greater than 50% reduction in water use and ten times less N use, without seeing any impact on Class 1 yield or berry quality. In 2023, further experiments are planned to tweak the N demand model specifically for Malling™ Bella so that significant water and N savings can be made without adversely affecting yields.

Mark Else, Head of Crop Science & Production Systems

NIAB Viticulture: the science of quality

The rapid expansion of vine growing in the UK over the past decade reflects the burgeoning English apple and pear industry over a century ago. Indeed, it was the growth of fruit production in Kent and the South East that led to the founding of East Malling Research Station in 1913, an establishment that developed into the world renowned centre of excellence that we know today under the NIAB name.

Much of NIAB's success at East Malling has been built on the employment of scientists from a wide range of disciplines who have become experts in their field. Together, they have engaged directly with fruit growers to research and develop solutions to their problems and help to increase yields and fruit quality, allowing local growers to remain profitable and compete on the world stage. NIAB's famous series of apple rootstocks at East Malling, its pioneering work on apple storage technology and development of modern high-yielding strawberry varieties, has been achieved by multi-disciplinary teams collaborating closely with the industry.

Fast forward to 2022 and NIAB finds itself engaging with a new viticulture industry, drawing on a team of experts who can help to research the production of grapes in our UK climate (Figure 1), and the quality of wines made from these grapes.

With climate change occurring at swift pace, an increasing number of fruit growers spotted the opportunity of growing high quality grapes for wine production in England and Wales. Alongside this new opportunity however, climate change brings major challenges, including more variability in terms of temperatures, light, rain, and more extreme weather events such as hail, late frost, heatwaves, rainfall, and drought.

Figure 1. NIAB has a team of experts who can help to research the production of grapes in our climate

These variables do not necessarily have a negative impact on wine quality, but always influence plant physiology and therefore the wine produced (vintages, sugar/acid, varieties). As a result, some leading vine producers have sought the help of NIAB's expert scientists at East Malling.

This led to the first planting and establishment of a research and development vineyard at East Malling in 2015 (Figure 2). The vineyard was set up both for research purposes and to demonstrate best practice in vine growing, and it has been designed to reflect NIAB's successful WET (Water Efficient Technologies) Centre which was established to demonstrate "science into practice" for the soft fruit industry. Above all, it is a unique, randomised, replicated facility, enabling robust R&D investigations.

The aim of our applied research programme is to improve berry yields and juice quality, whilst using resources responsibly and sustainably in ways that can be implemented in the UK's cool-climate commercial vineyards. To this end, the vineyard has been planted and laid out in a way that ensures that our research is directly applicable to commercial practice and provides an essential facility to test upstream innovative practices or novel ideas of research in viticulture.

The demonstration work and research programme is guided by the industry funders, currently comprising four major wine producers - Chapel Down, Gusbourne, MDCVUK, and Nyetimber - along with irrigation specialists Netafim UK Ltd. Two new associate members bring additional support including Hutchinsons (agronomy support) and Hampton Steel Ltd (canopy support and training systems).

Early plantings have demonstrated the performance of a range of varieties on different rootstocks and using different training systems (Lyre, Guyot Double and a Malling system). The scientists have also been able to stage machinery demonstrations including methods of mechanical weed control and this has been

Figure 2. NIAB's research vineyard was established in 2015

employed in a European funded research project (IWMPRAISE) to compare the efficacy of mechanical weed control with conventional herbicide treatments. Both of the mechanical weeding methods assessed were as effective as herbicide treatments in terms of vine vigour and yield and did not result in losses in berry yield or quality. Interestingly, the control vines (no weed control) were chlorotic, nutrient deficient and produced only one third of the yield recorded for the weeded vines. Optimising the availability and uptake of sometimes limited soil water and nutrients is key and new work in 2023 will focus on testing the effects of targeted interventions in the vineyard on consistency of yields, juice quality, and winemaking in our new Wine Innovation Centre.

NIAB's soil scientists are increasingly aware that poor soil health can give rise to inconsistent yields and juice quality in vine growing, which can lead to costly interventions in the vineyard and winery. Working with Chapel Down and Gusbourne and an industry consortium, earlier this year NIAB successfully secured grant funding from Defra's Farming Innovation Programme (FIP) to investigate the potential impact of groundcover management practices on soil health, yields, juice quality and emissions. Outcomes will include grower guidance on bespoke cover crop mixes to alleviate soil compaction, improve soil nutrition and control nematodes. Guidelines to support transition towards net-zero carbon emissions will be drawn up alongside this.

In 2022, NIAB also established an additional research vineyard as part of its 'trial services for horticultural crops'. Consisting of Pinot Noir and Chardonnay in 24 rows (60 vines per row), it offers the opportunity to undertake agrochemical trials, which require 'crop destruction' where new and emerging chemistry is being assessed. With no grapes being harvested for sale or for juice, it is thought to be the only vineyard of its kind in the UK. During its establishment, a root treatment trial was also instigated in this vineyard.

Figure 3. It is vital that we link production to wine quality

With so much science being channelled into grape growing, the funders of the research vineyard at NIAB recognised the importance of linking production to wine quality (Figure 3) and with this in mind, a small research winery was created at East Malling in 2018. This allows NIAB to directly assess the impact of the research and different growing practices on the final wine product. The wines produced are regularly tasted and assessed by the funding consortium which is chaired by Geoff Taylor, who has 35 years of experience both working in the wine industry and employed in food and drink research.

Having outgrown the small winery, the consortium and NIAB have benefited from recent capital investment from the East Malling Trust, Kent County Council, and 'Growing Kent & Medway', a research, innovation and enterprise cluster which is supported by UKRI's 'Strength in Places Fund'. As part of a complex of new research facilities at East Malling, a new Wine Innovation Centre (WIC) has been built. Covering an area of 260m^2, it includes a fermentation area, temperature-controlled cellar, pressing area and analytical laboratory. With this new infrastructure in place, the final piece in NIAB's viticulture research programme is to secure a world-leading oenologist to work with the UK viticulture industry and steer our research to meet the needs of our wine producers.

NIAB is pleased to announce the appointment of Dr Belinda Kemp to this new role (Figure 4). Belinda brings eighteen years of experience working in the wine industry in England, New Zealand and most recently heading up oenology research at the Cool Climate Oenology and Viticulture Institute (CCOVI) in Ontario, Canada. She is also an Adjunct Professor in the Department of Biological Science, Faculty of Maths and Science at Brock University. Her role has been split evenly between scientific research and industry outreach, working with the Ontario wineries and vineyards. She was educated in viticulture and oenology at Plumpton College in West Sussex and undertook a Ph.D. at Lincoln University in New Zealand, where she studied the effect of the timing of leaf removal on Pinot Noir berry ripening, flavour, and aroma. Belinda will be starting her new role for NIAB at East Malling in April 2023, but she joined her new colleagues at the NIAB stand at the 2022 Vineyard & Winery Show and looks forward to developing new relations with our UK industry.

Figure 4. Belinda Kemp brings a lifetime's experience of the wine making industry to her role

Mark Else, Head of Crop Science & Production Systems

WET Centre technology delivers a new level of precision to soft fruit growers

Now in its seventh operating year, The Water Efficient Technologies (WET) Centre at East Malling is seen by many as NIAB's beacon to lead growers to a new level of precision in their soft fruit production. Originally set up in 2017 to demonstrate NIAB's water use efficiency research into practice for commercial growers, the Centre has now evolved and developed into an important research facility that investigates ways of optimising key resources and lowering emissions using novel approaches and, to increase precision, yields, fruit quality, and yield/harvest profiling.

Central to this pioneering work are the Centre's funders, whose contributions enable the researchers at East Malling to use the very latest science and technology to find answers to questions that many would not have believed possible just a few years ago. Berry Gardens Growers Ltd, Cocogreen, Delta-T Devices and Netafim have been an integral part of the Centre since its inception, but more recently they have been joined by Stoller and Yara, along with two associate members, H L Hutchinson and Weatherquest, who all take an active role in shaping the work of the Centre and provide product knowledge and technical support each season. This industry support is, in turn, used to leverage funding from UKRI, particularly Innovate UK (IUK) funding.

With commercial growers typically irrigating their substrate-grown strawberry crops to 15–25% run-off, some early work at the Centre demonstrated how growers could reduce their total water use each season by up to 33%, whilst maintaining the same yields and producing equal or higher quality berries (Figure 1). Combined with precision irrigation approaches, rainwater harvesting and re-use resulted in 90% water self-sufficiency in 2018, despite the very dry June and July in that year. The Centre has since compared reducing the level of run-off to 5% and 10%, without seeing any significant difference in yields between these levels, or any compromise in fruit quality.

Other early work demonstrated a 5% yield increase from white plastic Cocogreen bags in comparison to black bags, and current research is investigating the causes of this difference. The Centre was also used to demonstrate how the use of the powdery mildew risk prediction model, developed originally by NIAB at East Malling, could lead to a significant reduction in overall fungicide use on an everbearer strawberry variety.

Figure 1. Measuring run-off has allowed us to demonstrate that levels can be reduced from 25% to 5%

A crucial feature of the WET Centre has been the division of the cropping into a 'commercial area', which mirrors typical commercial practice, and an 'advanced area' (Figure 2), which incorporates the latest technologies to more precisely control the phytoclimate. Not only can visitors to the site view this in action, but the scientists are able to make direct comparisons of fruit yield and quality between the two areas and report their results to the industry, allowing businesses to make informed decisions over whether to implement such technology on their own sites. The latest strawberry varieties being released by the East Malling Strawberry Breeding Club are also grown to demonstrate any advantages and shortcomings over existing industry standards.

Comparisons between the commercial and advanced areas in recent years have demonstrated significant differences in fruit yield using the everbearer Malling™ Champion. In 2020, Class 1 yield was found to be 5% higher in the commercial area, perhaps a result of the higher levels of shading in the advanced area, lowering the photosynthetically active radiation (PAR) at the canopy by 3-7%. It is thought that the increased steelwork associated with the roof vents in the advanced tunnels reduces light levels sufficiently to cause this yield difference, and this effect is probably exacerbated by the relatively large rainwater collection gutters. However, the more flexible venting control resulted in a 1°C reduction in temperature in June and July and up to 7°C in August 2020, and so the improved internal climate control from auto-venting could have significant benefits in hotter years.

Yield differences have also been recorded between seasons, with Class 1 yields of Malling™ Champion in 2021 being 22% lower than those recorded in 2020. The amount of accumulated light (photosynthetically active radiation – PAR) has been measured each season and the lower yields in 2021 could be attributed to lower light levels. The differing yields between the commercial and advanced areas, coupled with differing light levels, prompted the science team to start investigating whether differences in PAR were responsible for the variability in yields between individual rows in the advanced area. Our research so far has shown a strong correlation between light availability (PAR) and Class 1 yields, with the latter differing by as much as 12% in rows just 2 metres apart within one tunnel bay. This equates to a yield differential of over 11 tonnes per hectare.

There are six rows within each tunnel bay and further investigation revealed that the middle rows (2, 3, 4 and 5) were producing higher yields than the outer rows (1 and 6), with the highest yield being produced in Row 4. Using an array of precision environmental sensors manufactured by Delta-T Devices, a correlation was found between the highest yields per row and the amount of light reaching the canopy, so a comparison was made between Row 4 with Rows 1 and 6. Row 4 was found to receive 2 hours more PAR per day than Row 1, but strangely, despite both being outside "leg" rows, Row 1 produced higher yields than Row 6. We don't yet know what is causing this result.

Like other plants, strawberry has a light saturation point, when photosynthesis plateaus, even with further increases in light levels. We discovered that the efficiency of photosynthesis is highest in Row 4 and also higher in the morning than in the afternoon. We are now testing if the higher-than-expected Class 1 yields in Row 1 could result from the peak in early morning PAR coinciding with the peak in photosynthetic efficiency. The results will inform our next steps to optimise the available light to each row at key times during the day using different techniques and technologies.

Figure 2. The Advanced area demonstrates the latest technology

Work in 2020 also investigated the effects of a UV-blocking film, originally developed as a non-chemical way of reducing pest numbers, on leaf physiology, Class 1 yields, and berry quality. When compared to Malling™ Champion plants cropping under a clear film, Class 1 yields were reduced by 15% under the UV-blocking film; this was due to a reduction in fruit number as individual berry fresh weight was increased slightly, presumably due to the slightly cooler (1°C) air temperatures under the UV-blocking film. Again, the loss of yield was strongly correlated with a reduction in the cumulated PAR reaching the canopy. Leaf physiology was also changed, with stomatal conductance and photosynthesis being lowered, and while the former response reduced plant transpirational water loss, the latter resulted in a 0.5% fall in the average berry soluble solids content (° BRIX) over the season.

The knowledge gained by the WET Centre team on zonal phytoclimates within the tunnel also has enabled NIAB scientists at East Malling to work with one of our funders, Berry Gardens Growers Ltd, and colleagues at the University of Reading in an IUK project called 'BerryPredictor' to improve harvest forecasts, yield predictions and crop productivity, through the development of thermal time and PAR models.

Most recently, the Centre has expanded to include raspberry tunnels where we are currently growing Malling™ Bella for a Netafim-led IUK-funded project ('SmartFert') on reducing fertiliser inputs and greenhouse gas emissions, using a combination of nitrogen-demand modelling, real-time NPK sensing and precision fertigation. We have also started to test new irrigation technology from Netafim to see if water and fertilisers can be distributed more evenly through the rootzone in a crop where Class 1 yield losses from inadequate fertigation scheduling are common.

The addition of Yara and Stoller to our funding consortium has enabled us to investigate the effects of some novel nutritional and biostimulant products in our commercial area. In 2022, we tested YaraVita's 'Actisil™' and 'BioNue' products to assess the effect on yield, fruit quality and shelf-life in Malling™ Champion, along with an iron product's effect on fruit quality. We also quantified the effects of Stoller's products 'Flower Power' and 'Green Forge' in improving tolerance to, and recovery from, heat stress (a good year to do this!) along with their potential to improve yields, fruit quality and shelf-life. Another Stoller product (N Less Advanced Solution) was used to understand if it allows us to lower nitrogen application rates without incurring any yield penalty.

Anyone wishing to learn more about The WET Centre or potential involvement in the work carried out there should contact wetcentre@niab.com.

Mark Else, Head of Crop Science & Production Systems

An exciting new beginning for NIAB's plum demonstration centre

The Plum Demonstration Centre (PDC) at East Malling has been evolving since the first tree was planted in 2016. Originally created to showcase best practice in plum production (Figure 1) in an Innovate UK project to reinvigorate the UK industry, the Centre was funded by the AHDB between 2019 and 2022, but with the demise of the horticultural levy body, a new funding mechanism had to be found.

Early in 2022, the team at East Malling convened a meeting with plum growers and marketing groups, who collectively offered to fund the day-to-day management of the Centre, whilst allowing NIAB to seek additional research funding on topics of most interest to the plum industry.

Until 2022, the focus had centred on a comparison of rootstocks and rootstock/training system combinations. To date, the Oblique spindle, Super spindle and Narrow A frame systems on VVA1 and Wavit rootstocks have produced the highest yields, although firm conclusions can't be drawn on the optimum combinations until more data is collected. Other work has included a comparison of yield and quality from tunnel-covered areas of plums with an uncovered area, a demonstration of the effect of mechanical weed control, as well as incorporating the results from AHDB funded and other tree fruit research projects.

The new funding consortium consists of eleven plum growing businesses and three marketing groups, who have taken a 'hands-on' approach to the management of the Centre, providing help and support with some of the husbandry tasks undertaken there. They are particularly interested to improve their knowledge and understanding of precision irrigation and fertigation in plums and to optimise nitrogen inputs, topics which are becoming increasingly important as the availability of water becomes ever scarcer, and the cost of fertiliser products continues to increase.

Figure 1. Plum Demonstration Centre showcasing best practice in plum production

In 2022, scientists at East Malling installed soil matric potential sensors at 15 cm, 30 cm and 45 cm depth and a volumetric moisture content sensor at 45 cm under representative trees. Irrigation (and fertigation) was initially triggered at an average soil matric potential value of -60 kPa across the rooting zone. This irrigation threshold was then lowered gradually throughout the season to a value of -100 KPa. Prior to harvest, some trees were allowed to dry down to below -400 kPa and were then rapidly returned to field capacity to try to simulate the effects of a heavy rain event on fruit splitting before harvest. This work will help us to better understand the demand for water and fertilisers by plums at different stages during crop development, and to identify the optimum soil moisture deficit at which to irrigate – work that has already been done at East Malling on other tree and soft fruit crops.

The science team managing the Centre has also been comparing water availability in trees managed with mown grass alleys versus those with freely growing wildflower strips. We have been trying to understand if wildflower strips, which are used to host the natural control predators of insect pests, have any adverse effects on soil resource acquisition, tree growth, and fruit yield and quality. Growth control is also of great interest and both the timing of tree pruning and use of root pruning are included in the ongoing investigations.

2022 not only brought a new approach to the funding and management of the Plum Demonstration Centre, it also saw the naming and release of 'Malling™ Elizabeth', which was heralded on the NIAB stand at Fruit Focus. This new plum variety offers growers and consumers a high quality Victoria-like plum, which produces attractive large, firm red/purple fruits, with excellent flavour and, perhaps most importantly, a very early season, cropping before Opal and some 6-7 weeks earlier than Victoria. We have high hopes for the commercial success of Malling™ Elizabeth.

Feli Fernandez, Senior Plant Breeder

Tree fruit rootstock breeding

Title: East Malling Rootstock Club

Funders of previous programme: AHDB, International New Varieties Network (INN)

Term: Completed 2020 – pipeline still under evaluation

Some of the earliest research done by scientists at East Malling was the collecting and typing of apple rootstocks, and the propagation and release of selections with defined effects on precocity and vigour of tree growth. This led to the Malling series of rootstocks and following further collaborative research with the John Innes Institute in Merton, Norfolk, the MM series of rootstocks was bred. These rootstocks are now used in virtually every part of the world where apples are grown commercially. In pear, our early scientists selected 'Quince A' and 'Quince C' rootstocks, which have been widely used by the industry ever since.

The latest rootstock breeding programme (Figure 1) funded by a consortium including AHDB and International New Varieties Network (INN) finished in 2020, and a new programme is currently being set up.

The project

Current breeding objectives for apple rootstocks are to match or exceed productivity achieved by 'M9', produce vigour between 'M9' and 'MM106', develop resistance to fireblight, *Phytophthora cactorum* (crown rot) and woolly apple aphid, and develop rootstocks that are easy to propagate. In pears (Figure 2), we aim to achieve productivity that matches or exceeds 'Quince A' and 'Quince C', produce vigour between 'Quince A' and 'Quince C', develop resistance to fireblight and develop rootstocks that are easy to propagate.

Results

The most recent apple rootstock to be released is '**M200**', which was bred from a cross between 'Robusta 5' and 'Ottawa 3'. It is between 'M9' and 'M26' in vigour and is similar in precocity to 'M9', but is on average, 35% more productive than 'M9'. It exhibits tolerance to fireblight and some tolerance to *Phytophthora cactorum*. Crucially, it is easily propagated in stoolbeds and Dalival Nursery in France has trial quantities available.

Figure 1. Apple rootstock plots

Figure 2. Pears being assessed on quince rootstocks

Feli Fernandez, Senior Plant Breeder

Raspberry and blackberry breeding

Title: The East Malling Rubus Breeding Consortium

Funders: Berry Gardens Growers Ltd, Blaise Plants, East Malling Services, Lubera, Onubafruit, Perfection Fresh, The Greenery, Tobi, WB Chambers

Term: April 2015 to present

Raspberry breeding began at East Malling over 100 years ago and 36 varieties have been released to UK and overseas growers since then. Notable introductions include the late summer fruiting raspberry 'Octavia' which straddles the summer and autumn fruiting seasons, and 'Autumn Bliss' which was released in 1984, the first primocane raspberry to be bred for UK conditions. Funding was received from government for many years and more recently from the Horticultural Development Council until 2009. Since then, the programme has been funded by private companies, many of whom have first refusal on selections and named varieties that are released to the industry. The East Malling Rubus Breeding Consortium was set up in 2015 to capitalise on long-term raspberry breeding on the site and work funded by East Malling Services and Lubera in a partnership to develop varieties suited to the amateur market. Following the release of 'Malling™ Bella' and 'Malling™ Charm' in 2017, the consortium was expanded in 2019 and is led by NIAB plant breeder Feli Fernandez.

The project

The breeding programme budget is split between raspberry (65-70%) and blackberry (30-35%), although blackberry breeding is still in its infancy. Of the raspberry budget, one quarter is spent on floricane fruiting varieties, one quarter on primocane fruiting varieties and half on double cropping varieties. The blackberry budget is split half and half on floricane and primocane varieties. Key breeding objectives for raspberry include high fruit quality and shelf-life, high yield and fruit size, simple cane architecture with ease of picking, pest and disease resistance and environmental adaptation.

Results

The most recent and successful primocane varieties to be released are 'Malling™ Bella' and 'Malling™ Charm'.

Malling™ Bella is a mid-season primocane variety, which is well adapted to UK and southern European conditions. It is suited for double cropping and long-cane production. Berries are attractive (Figure 1), mid-red in colour with excellent flavour and shelf-life. Mean berry weight is 7g and the fruit maintains good size throughout the season. Growth habit is upright, with well displayed fruits (Figure 2), allowing for rapid picking. To date, no disease issues have been reported for the variety. 'Malling™ Bella' is proving very popular with Spanish growers and in the UK, is increasingly being employed for long-cane production. In total, 3.5 million plants were produced in 2022.

Figure 1. Malling Bella has attractive berries

Figure 2. Malling Bella displays its fruit well to pickers

Malling™ Charm is an early primocane-fruiting variety, which is suited to cool climates and is not suitable for double cropping. The berries are attractive, bright and pale red in colour (Figure 3), with excellent sweet, juicy flavour. Berries are large, with average weight of 6.7g. Growth habit is upright (Figure 4) with well displayed fruit, allowing fast picking. No disease issues have been reported for Malling™ Charm so far.

Figure 3. Malling Charm has bright berries which are pale red in colour

Figure 4. Malling Charm produces upright canes

Adam Whitehouse, Senior Plant Breeder

Strawberry breeding

Title: The East Malling Strawberry Breeding Club

Funders: AHDB, Asplins PO, Berry Gardens Growers Ltd, BerryWorld Varieties, DPS, The Greenery, FFPO, Meiosis Ltd, Mack, NIAB

Term: April 2013 to May 2023

Strawberry breeding began at the East Malling site in the early 1980's and since 1988, a total of 48 varieties have been released to the industry. These include both main-season Junebearer and everbearer varieties which are suited to the fresh retail, Pick-your-Own and amateur garden markets. Funding originally came from government, the Horticultural Development Council (later AHDB) and Meiosis Ltd. In 2008, with the loss of government support, a new East Malling Strawberry Breeding Club was set up which was funded directly by industry partners. The inclusion of AHDB ensured that varieties released were available to all growers. The Club's second tranche of funding comes to an end in 2023 and a future funding model is currently under development.

The project

The breeding team led by Adam Whitehouse has more than 25 targets and objectives, but principally aims at breeding high-chill varieties seeking high fruit quality (appearance and flavour), high yields and fruit size, well displayed fruit, season extension, and disease resistance (powdery mildew, crown rot, Verticillium wilt). The current breeding process takes between 8-10 years from crossing to release to the industry. After crossing, around 1% of elite offspring are selected for trialling and resistance screening, and then the best performing selections progress to commercialisation via Malling™ Fruits, the commercial arm of our breeding programmes. We also work with partners and sponsors to trial and assess the optimum growing systems, so that guidance can be produced to ensure growers fulfil the yield and quality potential of each variety.

Results

At present, the split between short-day (mainseason) and day neutral (everbearer) varieties is 60%:40%, although everbearers may increase in future as the industry relies more heavily on these. The most recent and successful short-day varieties to be released include 'Malling™ Centenary', 'Malling™ Vitality' and 'Malling™ Allure'.

Figure 1. Malling Centenary has sold around 390 million plants

Malling™ Centenary has been the most successful release from the programme, having sold around 390 million plants (Figure 1) and currently around 68 million per annum. It has replaced the industry standard variety 'Elsanta' in the UK due to its higher Class 1 percentage of fruit and lower picking costs.

Malling™ Vitality has an early/mid harvest season, before 'Malling™ Centenary' under glass. It has attractive glossy berries and a very high percentage of Class 1 fruit. Plants have good fruit display, are moderately resistant to crown rot and powdery mildew, with intermediate resistance to *Verticillium wilt*.

Malling™ Allure is a late season selection, picking 10 days later than 'Malling™ Centenary', but similar in fruit quality with high sweetness. The plant has an upright habit, good fruit display and offers easy picking. It has intermediate resistance to powdery mildew but moderate susceptibility to crown rot and *Verticillium wilt*.

The most recent and successful day-neutral varieties to be released include Malling™ Champion, Malling™ Supreme and Malling™ Ace.

Malling™ Champion is an early season everbearer, with harvest peaking in July and picking steadily through August, with an average yield of 1kg per plant. It produces regular conical berries on compact plants with well displayed fruit. Size can decrease in hot conditions. It shows resistance to crown rot and *Verticillium wilt*, and moderate resistance to powdery mildew.

Malling™ Supreme starts producing fruit at the end of May from spring-initiated flowers and peaks at the end of July and beginning of August. It has glossy attractive berries which are consistently sweet and well-presented. It has good resistance to powdery mildew, moderate resistance to crown rot, but has a slightly lower yield than other leading everbearer varieties such as 'Malling Ace™' and 'Malling Champion™'.

Malling™ Ace starts producing fruit in May from spring-initiated flowers, with peak production in August. It is a very high yielding variety with yields up to 1.5kg per plant of Class 1 fruit. It has a sweet juicy flavour, and the plants are compact, with excellent fruit display. It has some resistance to crown rot but some susceptibility to powdery mildew.

Michelle Fountain, Head of Pest and Pathogen Ecology

Novel approaches to insect pest control in soft fruit

Title: SF 174: Improving integrated pest management in soft fruit crops

Funder: AHDB

Partners: ADAS, Russell IPM, University of Greenwich (Natural Resources Institute), University of Keele, The James Hutton Institute

Term: April 2020 to March 2023

With the continuing loss of authorised products to control insect pests in soft fruit crops, AHDB has been funding a series of research projects to identify and develop novel approaches to control which do not rely on traditional chemical spray application. Despite the winding down of AHDB Horticultural operations in 2021, the funding for this project continued until its contractual end date of March 2023. It has focussed on finding controls for capsids, aphids and thrips, all pests that have been ranked as a high research priority by the industry.

The project

Both in this and previous AHDB funded research projects, work has developed a 'push-pull' approach to **capsid** control. A semiochemical 'push' using hexyl butyrate was deployed in the crop (Figure 1) in combination with a semiochemical 'pull' in green cross vane funnel traps (strawberry only) at regular intervals around the crop perimeter. This approach has significantly reduced numbers of capsids in both strawberry and raspberry in both this project and in previous projects. Further work has been ongoing with Russell IPM, who are commercialising the hexyl butyrate 'push' component. Work has also been done in this project to assess the efficacy of biological control of capsids using the predatory bug Orius.

Figure 1. The semiochemical push component deployed in a strawberry crop

Figure 2. Hoverflies are effective natural enemies of aphids

Controlling **aphids** early in the season has become increasingly difficult as populations multiply relatively quickly at low temperatures. Many contact-acting biopesticides work less effectively at low temperatures and it can be difficult to hit aphids when they are hidden in the centre of plant crowns or in unfurled leaves. Hoverflies are effective natural enemies of aphids (Figure 2) with adult females laying lots of eggs in aphid colonies, but they tend to migrate into crops later in the season, once aphid populations have reached damaging thresholds. The purpose of this trial was to release hoverflies into the crop earlier in the season and to use volatiles to retain them in the crop.

Further work was done to understand how we can get more effective control of aphids using parasitoids. Working with scientists at the James Hutton Institute, research is ongoing to understand if parasitoids are overwintering in aphid colonies, to find out how much parasitoid releases help to boost existing levels of parasitism and identify any impact they are having on aphid numbers after their release.

A great deal of **thrips** research on strawberry has been done over the past decade and growers are generally successfully controlling western flower thrips (WFT - *Frankliniella occidentalis* – Figure 3) with IPM techniques employing both *Neoseiulus cucumeris* and Orius

Figure 3. Western flower thrips in strawberry flower

predators to gain control. However, several other species that fly into strawberry crops during the growing season are being found and trapped in crops, some of which cause damage and lead to crop losses. Many of them are not breeding in the crop, so are not always being controlled by methods employed for WFT. Previous AHDB funded work by ADAS has regularly recorded rubus thrips (*Thrips major*), onion thrips (*Thrips tabaci*), rose thrips (*Thrips fuscipennis*) and flower thrips (*Frankliniella intonsa*) as being present and causing damage. Recent work in this project has been assessing the use of sticky traps along with commercial lures both to monitor and control these non-WFT species.

Results

Capsid control: As a result of this project, Russell IPM has developed a commercial product incorporating hexyl butyrate as a capsid repellent. It is delivered as a tablet which lasts for 3 months at 24°C and is spaced in the crop every 5 metres, either between bags/containers or alongside. For controlling European tarnished plant bug (Figure 4), in organic crops, it should be introduced to the crop in Spring and in conventional crops in June.

Growers have reported fewer European tarnished plant bug (*Lygus rugulipennis*) where *Orius laevigatus* has been introduced to control other pests. In laboratory experiments, significantly fewer Lygus nymphs emerged from eggs where Orius was present. However, in field trials in 2022, Orius did not significantly reduce either the numbers of *L. rugulipennis* or the damage caused by the pest, so it was concluded that Orius may be contributing to Lygus control, but not in any significant way and it should not be relied upon solely for control.

Figure 4. European tarnished plant bug

Aphid control: In several trials to assess the use of early hoverfly release with volatiles to retain them, initial attempts to establish hoverflies with one volatile was inconclusive, but subsequent trials using Magipal™ and other volatiles to attract naturally occurring hoverflies showed significantly more promise, although there were no significant differences between treatments. The volatiles were tested on a larger commercial scale trial in 2022 to attract naturally occurring hoverflies. Where substantial aphid colonies were present (Figure 5), higher numbers of hoverfly were attracted into the crop, but not where only low aphid colonies were present. This suggests that hoverflies should only be released when aphid numbers begin to build up. Further work needs to be done on which commercially available hoverfly species predate which aphids and the best timing for release.

Parasitoids were found to overwinter in the crop in aphid colonies and increased in number once aphids were available to parasitise. However, further parasitoid releases in spring did not significantly increase levels of parasitism and there was no impact on aphid numbers following their release in this one year study. Work is ongoing to identify the species that overwintered and whether parasitoid releases changed the species assemblage. It is important that growers know if there are parasitoids in the crop going into the winter, as this can inform the decision to release parasitoids or apply plant protection products the following spring.

Thrips control: Most growers currently hang blue sticky monitoring traps beneath strawberry tabletop support systems. Initial work to identify which species are being caught have shown that WFT numbers are very low where growers have successfully controlled this species with IPM programmes. When the lures Lurem-TR (containing methyl isonicotinate) and Thripnok (containing a semiochemical) were used in combination with the traps, they didn't significantly increase catches of non-WFT species. However, when ADAS scientists compared the positioning of blue sticky traps beneath the crop canopy with positioning them directly above, significantly more non-WFT thrips species were caught in traps above (Figure 6), and when Lurem-TR and Thripnok were added to traps above the crop, they further increased trap catches. In addition, more non-damaging species like cereal thrips were caught on traps hung below the canopy, which could lead growers and agronomists to misidentify thrips problems in the crop. This compelling evidence should encourage growers to position their traps above the canopy in future.

Figure 5. Substantial potato aphid colonies attracted hoverflies into the crop

Figure 6. Significantly more thrips species were caught in traps above the crop than those below

Michelle Fountain, Head of Pest and Pathogen Ecology

Developing non-chemical control strategies for SWD

Since the arrival of spotted wing drosophila (SWD - *Drosophila suzukii* – Figure 1) in the UK in 2012, NIAB scientists have collaborated with others to lead two major AHDB funded projects to improve our knowledge and understanding of how to manage SWD in UK conditions, and more recently, to develop novel control strategies that don't rely on conventional chemical spray control. Most recently, they have been engaged in projects focussing on the use of bait sprays for control, the identification of oviposition deterrents (BBSRC funded) and the development of the sterile insect technique (SIT) for control (Innovate UK funded).

Figure 1. Adult Male SWD with characteristic spots on its wings

Title: Assessing the impact of bait sprays targeted to control spotted wing drosophila on beneficial and non-target insects

Funder: The Worshipful Company of Fruiterers

Industry partners: Microbiotech Ltd (Lead), Russell IPM, Berry Gardens Growers Ltd

Term: February 2022 to January 2024

In AHDB project SF/TF 145a, NIAB and Microbiotech Ltd scientists identified that the adjuvant Combi-Protec and a form of sugar (now commercially available as Probandz) acted as attractants to SWD adults. The baits were then used in combination with low rates of plant protection products (PPPs) and applied as a band spray to a reduced area of the crop canopy, where they attracted adult SWD to feed on the treated area of crop and ingest the PPP, which led to their death. Such an approach to control has financial benefits through the reduction of product being applied and reduced time taken to make the application. It also offers environmental benefits through a controlled application to a small area of crop. However, questions have been raised over the impact such a technique may have on beneficial and non-target insects, which may also be attracted to these bait sprays. This project aims to provide some answers.

The project

In laboratory conditions, NIAB has begun to assess the impact of spinosad alone, spinosad in combination with Combi-Protec, Combi-Protec alone, Probandz alone and a water control to non-target predators, pollinators and closely related Drosophila species. Insects being tested include ladybird larvae, hoverfly adults, lacewing larvae, earwigs, *Drosophila melanogaster* (common fruit fly) and the predatory bug, Orius.

Results

For earwigs and hoverflies, Combi-Protec and Probandz on their own had no impact on mortality, suggesting that these adjuvants/baits are not increasing the likelihood of mortality when used as bait sprays. Lacewing (Figure 2) and ladybird larval numbers were also unaffected using the adjuvants as baits, either with reduced rate plant protection product or on their own, confirming that the adjuvants/baits are not attractive to these species. Work is continuing to determine the impact on Orius.

Figure 2. Lacewing larva

Michelle Fountain, Head of Pest and Pathogen Ecology

Title: Bait sprays to control *Drosophila suzukii* in commercial raspberry
Funder: AHDB
Industry partners: Russell IPM (Lead), Berry Gardens Growers Ltd, Microbiotech Ltd
Term: May 2022 to December 2022

Previous bait spray research funded by AHDB has been very successful in strawberry, raspberry and cherry. A coded product (now named 'Probandz') and a commercially available adjuvant Combi-Protec are both very attractive to SWD adults. When added to reduced rates of Benevia on strawberry or Tracer and Exirel on raspberry (Figure 3) and cherry, and sprayed to a reduced area of the crop canopy, they attracted SWD adults to feed on the sprayed leaves, allowing them to ingest the control chemical causing death. To support future applications for authorisations, which can employ such adjuvants as bait sprays, residues data needs to be generated to demonstrate the safety of the application method.

The project

The aim of this project was to progress testing of bait sprays in a commercial raspberry crop, and compare efficacy to a full rate, grower standard plant protection product spray regime. Note there was no untreated control in this project and all bait sprays were compared to the industry standard of full foliar applications without bait. Treatment efficacy has been measured by the number of SWD larvae detected in weekly fruit samples over 6 weeks. Plant protection product residue levels have also been quantified to determine if treatments are likely to exceed maximum levels. In addition, we have measured the impact of bait sprays on non-target organisms in the crop, e.g. numbers of pollinators visiting flowers and natural enemies in the crop canopy.

Results

At the time of writing, residues data was still being obtained and analysed. Information on the impact of bait sprays has been collected. The entomology team at NIAB noted the number of visits from various non-target insects such as pollinators, beneficial insects and predators. There were no significant differences in bumblebee or honeybee numbers visiting raspberry flowers or leaves, suggesting that bait sprays had no effect in attracting beneficials to these plots. They also conducted tap sampling and assessed numbers of insects found. Orius, parasitic wasps and spiders were recorded but there were no significant differences in numbers between different treatments. Similarly, there were no significant differences in numbers of pest species or ants, although there were higher numbers of some fly species in the Probandz plus 4% plant protection product treatment.

Figure 3. Bait spray applied as a band of large droplets to raspberry

Figure 4. Bait spray being applied to a reduced area of the crop canopy in cherry

Michelle Fountain, Head of Pest and Pathogen Ecology

Developing non-chemical control strategies for SWD *continued*

Title: Exploitation of interspecific signals to deter oviposition by spotted wing drosophila

Funder: Biotechnology and Biological Sciences Research Council

Industry partners: University of Greenwich (Lead), Berry Gardens Growers Ltd, University of Southampton

Term: January 2019 to June 2022

Previous research by NIAB scientists has discovered that SWD lays fewer eggs on media previously visited by *Drosophila melanogaster*, the common fruit fly, which only tends to lay its eggs on ripe and overripe fruits, unlike *Drosophila suzukii* (SWD), which also lays eggs on under-ripe fruits. The project hypothesis was to try and identify what exactly is deterring SWD from laying eggs after *D. melanogaster* has visited, so that this compound might be able to be employed as a control strategy in commercial crops.

The project

The aim of this project was to understand SWD egg laying behaviour and to investigate how interactions with other *Drosophila* species impact SWD egg laying (oviposition). The work was carried out in the laboratory by a researcher, Trisna Tungadi, at East Malling. Trisna exposed *D. melanogaster* adults (male and female) to egg laying media before exposing the same media to SWD adults alongside a fresh media plate for comparison.

Results

The first experiment confirmed previous research, with fewer eggs laid by SWD on the plate that had previously been exposed to *D. melanogaster* (Figure 5). The next question was to find out which life stage and what *D. melanogaster* had left on those plates to deter SWD from laying its eggs. Further work discovered that the presence of live *D. melanogaster* larvae always resulted in fewer eggs being laid by SWD, rather than the presence of adult *D. melanogaster*.

Biochemical research was done to assess cuticular hydrocarbons found in the larvae of both *D. melanogaster* and SWD. Both species shared some compounds but also species specific cuticular hydrocarbons were identified. A synthetic blend of the *D. melanogaster* cuticular hydrocarbons was made and spread on egg laying media, but unfortunately this did not deter SWD laying eggs. Further work is now investigating whether other compounds left by *D. melanogaster* larvae deter SWD from laying eggs.

Figure 5. SWD Adults exposed to media previously exposed to D. melanogaster

Michelle Fountain, Head of Pest and Pathogen Ecology

Title: New sustainable solution to save healthy fruit from spotted wing drosophila: STOP-SPOT
Funder: Innovate UK
Industry partners: Big Sis (Lead), Berry Gardens Growers Ltd
Term: October 2021 to March 2023

Since the arrival of SWD in the UK in 2012, commercial soft and stone fruit growers have been heavily dependent on the use of conventional plant protection products to control the pest. Early research helped us to understand how best to monitor for the pest and manage its control but more recently, NIAB scientists have been engaged in developing novel management and control techniques that rely less on conventional chemical control. In this project, NIAB scientists have been collaborating with BigSis, a start-up company, and Berry Gardens Growers Ltd, to exploit a new approach called the Sterile Insect Technique (SIT). Sterile males are produced and introduced regularly by BigSis staff, to the semi-natural areas surrounding crops and within the crops themselves. These sterile males compete with wild males to mate with wild female SWD, which subsequently fail to produce any offspring. Such an approach is sustainable, non-toxic as the sterile males can't establish in the environment, and is species specific, so has no effect on beneficial insects or other fauna. As native wild SWD are used to create the sterile males, there are no barriers to introducing the control system in the UK once the technique has been proven to be effective.

The project

Early trials on strawberry, now published, showed very encouraging results with SWD levels remaining very low throughout the season compared to the SWD populations in adjacent crops with no SIT release which received plant protection products only (Figure 6). The most recent studies in 2022 have been assessing the SIT technique in the laboratory, in further field trials, and in 'semi-field' trials. The laboratory work has been testing, for example, how well the sterile males compete with wild female SWD and what ratios of sterile males to wild females are required for effective control.

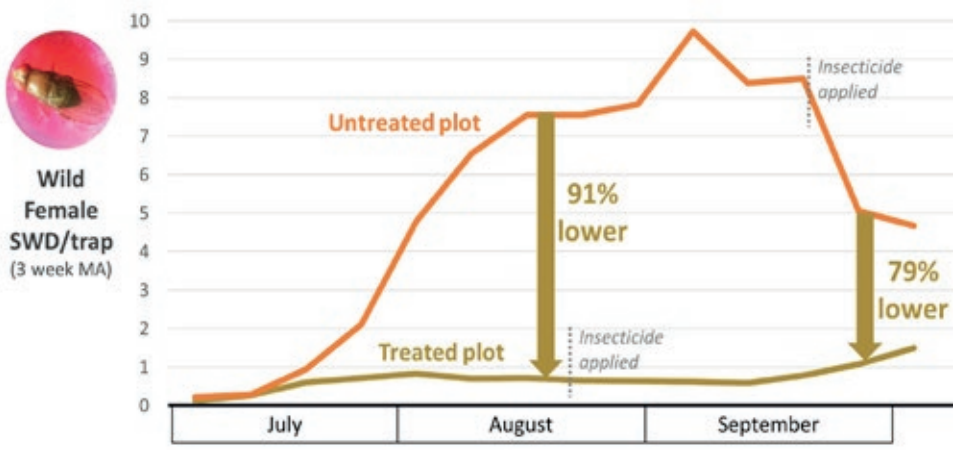
Results

The latest research has found that small plot experiments are vulnerable to border effects, where wild males can migrate across adjacent fields, so future commercial experiments will be done on a minimum field size of 7 ha. Work on blackberry provided season-long suppression compared to an untreated control. However, different crops have different dynamics and this has implications for release rates and tactics to control wild populations. It has also been found that if no or low releases are made for one to two weeks or more, wild populations increase rapidly and it is impossible to regain control using SIT.

In small scale cage studies to assess the optimum ratio of sterile males to wild males, a ratio of 5:1 was efficacious; however, in commercial practice, BigSis is aiming for a ratio of 10:1. To date, BigSis have been rearing sterile males by hand, but this is time consuming and cannot produce sufficient numbers to provide a commercially reliable service to growers. BigSis is, therefore, now developing a fully automated system for rearing larger numbers of SWD males using several micro-production units. The target for 2023 is to produce millions of sterile males per week, which will be released in commercial soft fruit crops over more than 100 hectares. Producing such high numbers will avoid the problem of having insufficient numbers to release for a week or two in the middle of the season, which can lead to loss of control.

The service will be fully commercial in 2023 and initially offered exclusively to Berry Gardens Growers Ltd, in return for the support they have given to the research in the past few years.

Figure 6. BigSis 2021 Trial showing how the SIT technique maintains low populations of SWD compared to the use of crop protection sprays



Matevz Papp-Rupar, Plant Pathology Research Leader

Developing methods to recycle coir substrate

Title: To evaluate the extent of biological, chemical and physical changes between virgin, re-used and recycled coir

Funder: Overland Ltd

Term: April 2022 to March 2023

The majority of fresh-market strawberry, raspberry and blueberry crops produced in the UK are now grown in coir substrate, which is more sustainable than peat as it is a by-product of the coconut industry. It offers lower plant disease risk compared to soil-grown crops, but the cost of virgin coir is increasing along with transport and shipping costs, which has an environmental impact. Supplies are also limited and there is a cost attached to its disposal, so the soft fruit industry is interested in re-using existing stocks (Figure 1), but this is known to lead to increased disease, pest and weed problems, and chemical and physical degradation can lead to reduced yields. EU funded research at NIAB (HORTI Blue C) with Berry Gardens Growers Ltd showed successful re-planting of coir bags with June-bearer strawberry, but significant yield penalty resulted when everbearers were re-planted year on year.

The project

Overland Ltd, a company offering agricultural waste removal and recycling services in Kent funded this project and worked with NIAB to find ways of mitigating the biological, chemical and physical risks before re-using spent coir. They tested factors that might be responsible for yield decline and compared strawberry plant growth in virgin coir, directly re-used coir, composted coir and coir that has been recycled using a system that Overland is developing. They measured physical and chemical changes, presence of pathogens and yield/production data for two different coir mixes and compared the results.

Results

The number of air spaces or air filled porosity (AFP) in directly reused coir from both types was lower than virgin coir, and this resulted in a high increase in water holding capacity in both types of reused and recycled coir. The degradation of AFP and increase of water holding capacity, was far greater in one of the coir mixes compared to the other. This was caused by reduction in the number of large particles (5-20mm) in the reused coir compared to virgin material. Composted coir also saw a reduction in AFP, although interestingly one type had a much larger reduction in large particles than the other. The initial quality of coir mix has a major influence on its long term physical properties and potential for re-use.

Differences in the chemical properties were also influenced by coir mix type, with one showing a marked increase in pH after re-use and composting, while the other showed a slight decrease. The EC of both types of coir mixes increased after composting and recycling, while K and Ca levels varied depending on the coir type. The levels of such nutrients can affect the feed recipe required when using coir for a second time.

Work to assess the levels of *Phytophthora cactorum* (the cause of crown rot) showed that the incidence of the pathogen increased in composted coir, but where the coir was recycled using the system Overland has been developing, the incidence of the pathogen was no different to virgin coir. Further work needs to be done to assess the impact on other pathogens.

When yield and productivity were assessed, directly re-used coir recorded a 10% reduction in yield, composted coir recorded a 16% reduction, but recycled coir recorded a 4% reduction. Although this figure is still significant, it suggests that if the recycling system can be improved further, yield reductions may be reduced. It is worth noting that all coir types were irrigated with the feed amount and composition optimised for virgin coir. Plants in recycled coir may have received too much water and imbalanced feed resulting in decreased yield.

Figure 1. There is great interest in re-using spent coir substrate

Further work is proposed to refine and improve the recycling procedure used by Overland, where they are seeking to improve the physical properties, mitigate chemical imbalances, inactivate a wide range of pathogens and measure risks of pests and weeds. They also plan to provide agronomy/fertigation guidance on how to maximise the potential of recycled media, and produce an economic and environmental assessment of recycled media.

Charles Whitfield, Crop Protection Scientist

Selecting blackberries at the optimum stage of maturity

Title: Augmented berry vision
Funder: Innovate UK
Partners: Opposable Games (Lead), Berry Gardens Growers Ltd, University of the West of England
Term: September 2020 to September 2022

Selecting dessert blackberries at the optimum stage of maturity is key to ensuring that the final product purchased by the consumer is of high quality, looks good and, most importantly, tastes good. Consumer satisfaction is essential for repeat purchasing, but so much depends on the harvest team selecting the right berries at the right time, every time! Selection of perfect berries is challenging due to subtle colour changes that occur during ripening. Blackberry can be a particularly difficult crop, for although many berries might have turned black, they are not all at the same stage of maturity in terms of flavour development. Removing every berry that is black can lead to considerable variation in taste and flavour, and consequently consumer satisfaction. For pickers to select ripe fruit, fast, consistently and accurately, requires considerable skill, which takes time to acquire (Figure 1). Pickers, therefore, need a more reliable method of selecting uniformly ripe berries.

The project

This feasibility project set out to develop technology that can be used by harvesting teams to help them differentiate between blackberries which are fully ripe and those that are black but haven't yet developed optimum flavour. With the help of Berry Gardens Growers, over 500 blackberries of varying ripeness were collected from member farms. Hyperspectral imaging of the fruit was conducted alongside laboratory assessments to determine berry ripeness and other metrics. From the analysis of the spectral images, key electromagnetic wavelengths were identified to provide significant differentiation between ripe and unripe fruit.

Figure 1. Pickers can find it difficult to know when a blackberry is fully ripe

Results

Using the results of these analyses, a berry detection algorithm has been developed to detect and assess berries within a video feed. As berries are detected, their images are analysed to determine their ripeness. Machine learning was used to create the berry ripeness detection system. A convolutional neural network (CNN) was trained with multi-spectral images of blackberries of known maturity. The resulting algorithm showed a 95% accuracy in ripeness detection. During the project prototype hardware and software were developed. The hardware was tested in the field by experienced pickers (Figure 2) providing valuable insight to improve future versions. The system employs augmented reality (AR) glasses, which are worn by the pickers. Augmented Reality is the overlaying of visual digital information onto the real world through the lenses. Bespoke multispectral imaging cameras and the machine vision algorithm determine the ripeness of each berry, which is relayed to the picker via the AR glasses. This allows the pickers to pick berries that are uniformly ripe and to leave any berries, which have not developed optimum flavour, still on the cane to be harvested on another occasion.

The concept was successfully demonstrated, and the partners are looking for routes to further develop the system into a product suitable for commercial use.

Figure 2. Augmented reality glasses being tested by pickers

Xiangming Xu, Director of Research

Novel approaches to apple canker control using endophytes

Title: Systemic infection and symptom expression of *Neonectria ditissima* in relation to endophytes conditioned by environmental stresses

Funder: AHDB (TF 226), Avalon Fresh, Adrian Scripps Ltd, Biotechnology and Biological Sciences Research Council, Frank P Matthews, WORLDWIDE Fruit Ltd

Term: October 2017 to March 2022

Novel approaches are urgently needed to control *Neonectria ditissima*, the cause of apple canker. Endophytes could be exploited to manage the disease, reducing the level of infection and subsequent symptom development. Endophytes are microbes that live within a plant for at least part of their lives, without causing apparent disease. Some endophytes can help plants to tolerate biotic stress (e.g. caused by plant pathogens) and abiotic stress (e.g. caused by drought or high temperatures). NIAB has previously found that antagonistic fungal endophytes (Figure 1) from the genus *Epicoccum* (particularly *Epicoccum purpurascens*) are much more abundant in apple varieties that are relatively canker tolerant.

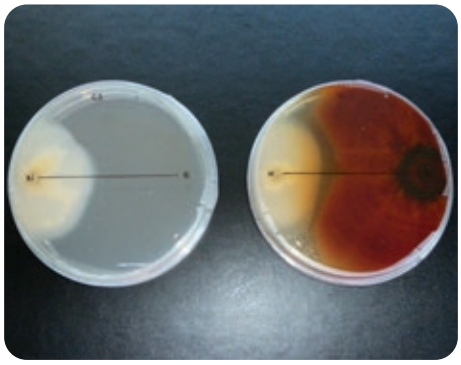
The project

The objective of this project has been to understand more about this relationship and learn exactly which species of endophytes might be exploited for controlling apple canker. We have been trying to find out if the tree's recruitment of these endophytes is genetically controlled by apple hosts and if it is influenced by site-specific characteristics and apple varieties. We have been studying whether canker symptom expression is related to planting times, or the abundance of specific endophytes across several orchards. We have also investigated the extent to which endophyte profiles of a specific apple genotype can be influenced by management practices, such as irrigation and soil amendments.

Results

When examining the abundance of endophytes on leaf scars, the main entry point of the pathogen, several fungal and bacterial groups differed in their relative abundance between canker resistant and susceptible varieties, but interestingly, the bacterial endophytes were more consistent over two seasons, suggesting that beneficial bacterial strains (biocontrol and/or general plant growth promoting) may be more effective than fungal ones.

Figure 1. Effect of endophyte antagonism towards N. ditissima on plated media in the laboratory



Co-inoculating both the fungal endophyte biocontrol agent *Epicoccum* and canker inoculum on leaf scars, reduced canker incidence at the leaf scars by 50%, but this strategy had limited effect on pruning wounds. There was only limited survival of the *Epicoccum* strain used in the leaf scars over winter.

Genetic studies showed that abundance of several endophytes is correlated with canker development and that abundance of specific endophytes is partially genetically controlled by the host genotype. Genetic mapping showed that gene sequences associated with endophytes are positioned close to those sequences associated with canker resistance hinting on potential interplay of microbiome and plant defences.

Amending soils with plant growth-promoting rhizobacteria (PGPR) or arbuscular mycorrhizal fungi (AMF) at planting time had negligible effects on canker development in polytunnel experiments.

Post-planting drought led to reduced tree development but did not affect canker development.

In work to test management practices on seven scion varieties across three commercial orchards, we found that longer periods of cold storage prior to tree planting led to increased canker incidence immediately after planting, but two years later, the effect on canker severity was negligible. Planting soon after tree lifting led to reduced peripheral canker development, but this reduction was only small. Variety susceptibility to the canker pathogen was consistent across the three commercial orchards studied. There was also some indication that symptom development of main stem cankers was affected by site specific factors which will be evaluated in the future.

Xiangming Xu, Director of Research

The impact of soil amendments on apple replant disease

Title: Exploiting the multifunctional potential of belowground biodiversity in horticultural farming

Funder: EU H2020

Partners: 16 Partners from eight European countries; CREA (an Italian research organisation) is the project co-ordinator

Term: June 2019 to December 2024

With the recent increase in apple fruit wall production systems on old orchard ground, there has been a corresponding increase in apple replant disease which has significantly reduced the financial returns in the early years after establishment (Figure 1). Apple replant disease causes a reduction in root growth which results in poor scion growth and cropping. Soil fumigation was used in the past on some sites before planting new orchards, but the availability of fumigants is much reduced and the industry needs more environmentally friendly and sustainable alternatives.

The project

This pan-European project known as EXCALIBUR aims to develop microbial solutions to improve management of key soilborne diseases in apple, strawberry and tomato. Within this project, NIAB focuses on evaluating the effects of individual and combined soil amendments at planting time on apple establishment and subsequent growth and fruit production. In April 2020, we planted a new apple trial on an old apple orchard site, designed to induce the development of apple replant disease. Gala was used on an M9 rootstock. The trial compared a NIAB arbuscular mycorrhizal fungal (AMF) species (*Diverspora*), a mix of biocontrol species (*Trichoderma* and *Bacillus subtilis*), a mix of plant growth promoting rhizobacteria (PGPR) species, a combination of these, Biofence granules and a mix of AMF species. These treatments were applied either pre-planting (Biofence) or during the planting process.

Results to date

In the Spring of 2021 and 2022, the tree girth and temporal flowering pattern of individual trees were measured, then the number of fruit and fruit weight was recorded at harvest for two classes of fruit (> 60 mm and ≤ 60 mm).

In 2021, there were significant effects of applying biocontrol species at the planting time for both fruit weight and fruit number, which were both higher than the untreated control. The AMF treatment also gave an increase in fruit number. The biocontrol species and AMF treatment also provided a significant increase in girth expansion, although the combination of AMF and PGPR led to a reduction in girth expansion.

In 2022, a season of extreme weather conditions, there were no significant differences in fruit weight and fruit number between treatments, but amendment with AMF or biocontrol species came close to providing a significant increase in tree girth.

Further data will be collected in 2023, but it is promising that specific amendments appear to be leading to some positive effects.

Figure 1. Establishing fruit wall systems on old orchard ground predisposes trees to apple replant disease

Charles Whitfield, Crop Protection Scientist

Accuracy of spray deposition

Title: Optimisation of imaging fluorometer and food safe tracer for crop spray deposit quantification

Funder: Innovate UK

Partners: Chelsea Technologies Group (Lead), Avalon Produce, Berry Gardens Growers Ltd, G's Fresh, Household Sprayers

Term: October 2014 to January 2020

Growers often question why they don't achieve effective pest or disease control when they have employed expensive crop protection products that have worked effectively under trial conditions. A common reason for ineffective control is poor spray deposition throughout the crop canopy, sometimes as a result of poor sprayer setup or use of incorrect sprayer type or nozzles for application. Assessing spray deposition can be difficult to achieve. A range of fluorescent dyes have been used in the past, but growers find these difficult to use themselves and it can be a time-consuming task. A more effective system is needed.

The project

The aim of this project was to develop new technology, which is safe and easy to use and can rapidly assess whether deposition is sufficiently good to control the target pests or diseases. It is essential that the spray deposition is accurately assessed to identify whether spray machine setup needs to be adjusted.

Results

NIAB scientists have been working with industrial partners in this project to develop a new instrument called a Handheld Imaging Fluorometer (Figure 1), which is a device that employs fluorescence imaging, and a novel food-safe fluorescent dye that can be applied to crops to provide an accurate assessment of spray deposition.

The combination of novel dye and fluorometer has many advantages over previous methods of assessing spray deposition, including being fast, more accurate, providing quantified results and provision of results in the field without the need to use additional kit, and direct measurements of the spray on plant surfaces. In addition, data and results can be downloaded for record keeping or further analysis.

Growers using the technology are able to compare the setup of their spraying machine, make adjustments, and optimise the application to ensure that the plant protection products applied are being most effective. Growers can also compare the performance of different adjuvants and visualise how much spray is reaching the target area.

Figure 1. NIAB's Charles Whitfield demonstrating a fluorometer to industry agronomists

Charles Whitfield, Crop Protection Scientist

Improving spray precision in orchards

Title: Precision fruit tree dosing to optimise yield and quality

Funder: Innovate UK

Partners: Hutchinsons, The Acclaimed Software Company, N.P. Seymour, Outfield Technology, WORLDWIDE Fruit Ltd, Plumford Farm

Term: January 2020 to March 2023

Commercial orchards may appear uniform, however, there is substantial variation between trees in terms of vegetative growth and size, and even greater variation in yield. Despite being the same variety and age, every tree in an orchard is different depending on its health, soil conditions, root growth, nutrient uptake, location in the orchard, light interception, and past tree management. Current orchard sprayers do not take account of this variation and spray at a fixed rate irrespective of individual tree size, vigour, and requirements. This can result in inefficient use of sprayed products, under/over dosing, and drift.

The project

NIAB has been working with industrial partners in an Innovate UK funded project to develop a precision orchard spray application system that varies the volume of spray applied to each tree based on tree size and shape, and other measurements (e.g. blossoms or fruit).

Results

The system applies tailored doses to individual trees throughout the orchard (Figure 1), employing LIDAR scanning, UAV aerial surveying, data analysis and machine learning, RTK-GPS positioning, and the use of pulse width modulation (PWM) nozzles to adjust the output of an air-assisted sprayer. The software can handle a variety of data types, so in the future as more variables can be mapped (e.g. disease), dose prescription maps could be created for other sprayable products. Initially, the system will be able to control and reduce bienniality, control crop load per tree, and maximise the percentage of class 1 fruit per tree.

The system provides many benefits to growers, including increased orchard uniformity, increased productivity and yield of Class 1 fruit, improved efficiency of resource use contributing to sustainability, reduced use of plant protection products, reduced environmental impact, and avoidance of unintended repeat application.

Figure 1. Precision dosing sprayer applying tailored doses to individual trees

Michelle Fountain, Head of Pest and Pathogen Ecology

Increasing the number of pollinators across the North Sea Region

Title: BEESPOKE

Funder: European Regional Development Fund

Industry partners: Policy makers, research institutes and agronomists from seven different north sea region countries including UK, Belgium, Netherlands, Germany, Denmark, Norway and Sweden

Term: April 2019 to March 2023

Insect pollination is worth €15 billion annually across Europe and it can affect crop yield, quality and farm incomes. It is therefore important to conserve insect pollinators and identify their value. Important pollinators such a bumble bees, solitary bees and hoverflies have declined in number in recent decades and although various schemes have been set up to encourage planting of wildflowers, they haven't always been targeted at the types of bees needed by each crop.

The project

The objective of BEESPOKE has been to increase the number of pollinators and crop pollination on a local and landscape scale by providing expertise, tools and financial knowledge to support growers. To achieve this, the project has been developing a range of seed mixes for planting on farms to help reverse the decline in pollinators. These have been targeted at the types of pollinators needed by each crop type. They have been sown at demonstration centres such as NIAB's East Malling site (Figure 1), to evaluate how effective they are by increasing not only the levels and types of pollinators visiting the strips but also whether they increase numbers in the crops, and whether this has a subsequent impact on crop yield and quality.

Results

NIAB entomologist Celine Silva has been actively assessing and recording the impact of wildflower strips at East Malling over the life of the BEESPOKE project. Her preliminary data suggested that wildflowers outside tunnels did not compete with flowering crops for visits by commercially installed bumblebees inside the tunnels. Indeed the fluorescent tracer marked bumblebees visit the crop flowers far more than the adjacent wildflowers (Figure 2). In raspberry crops, adjacent wildflowers enhanced the number of insect pollinator visits to the crop. This would dispel any concerns commercial growers might have about wildflowers competing with their crop for pollinators.

Figure 1. A range of seed mixes have been planted at demonstration centres such as NIAB's East Malling site

Figure 2. Bumblebees were found to visit strawberry crops in tunnels more often than the adjacent wildflowers

Research in apple orchards demonstrated how over three seasons, with alleyway sowings of knapweed, yarrow, oxeye daisy, bird's foot trefoil, self-heal, red campion and red clover, tree populations of predatory spiders, hoverflies, anthocorids and lacewings increased, while numbers of codling moth decreased. Early season aphids, such as rosy apple aphid, decreased in some years but not others, while rust mite increased in one season. Celine also identified adult thrips in wildflowers and found that species and numbers fluctuated between years but the majority of thrips recorded were not species damaging to strawberry. Further work is required in soft fruit crops to understand more about this relationship.

Celine is also of the view that there will be a greater impact of natural enemies if the wildflowers are positioned within the crop rather than around the field margin. She also recorded an increased diversity of invertebrates in soils where wildflowers were sown, compared to single species mixes, potentially having a positive impact on soil health.

NIAB organised a dedicated BEESPOKE event at East Malling in October 2022 and more information can be found on the NIAB website at: https://www.niab.com/event-hub/fruit-crops. Further guidance, publications and resources are available on the BEESPOKE website at: https://northsearegion.eu/beespoke/.

Dr Nicola Harrison, Programme Director, Growing Kent & Medway

Growing Kent & Medway

NIAB is the lead research partner in Growing Kent & Medway, a world-class research, innovation and enterprise cluster that is supported by UKRI's 'Strength in Places' fund. Working with our partners at the University of Greenwich, the University of Kent and Locate in Kent, our mission is to invest in sustainable innovation and technologies to help the horticultural and plant-based food and drink industry in the Kent and Medway region to continue to thrive.

Led by NIAB's Dr Nicola Harrison, we support businesses of any size; from a 'Kitchen Table' startup, to a large multinational. We bring together industry, scientists, technologists and entrepreneurs to stimulate innovation. We invest in new research facilities and technical expertise, business support, and grant funding to help businesses to grow.

Our programme of work, which began in 2021 is also supported by a number of Kent based businesses including APS Group, Berry Gardens Growers Ltd, Chapel Down, Geku Automation, Gusbourne, RH Group, Smurfit Kappa, Thanet Earth, WORLDWIDE Fruit Ltd and The Kent and Medway Economic Partnership.

We are managing our investment through several activities which include the development of new research facilities, research funding grants and business enterprise support. This support includes business mentoring and food accelerator programmes along with bringing together the regions expertise in areas such as 'Alternative Proteins', 'Growing Green,' 'Sustainable Packaging' and 'Skills'.

Research Facilities

A key priority at the inception of Growing Kent & Medway was to provide high quality, state-of-the-art research facilities for the horticultural, food and drink sector.

NIAB has utilised funds from Growing Kent & Medway, Kent County Council and The East Malling Trust, to build our 'GreenTech Hub for Advanced Horticulture' (Figure 1) providing brand new glasshouse, polytunnel and growth room facilities which allow horticultural businesses to collaborate with our NIAB scientists to undertake cutting-edge research, ensuring that we emulate the very best commercial systems employed by leading horticultural producers. This investment includes the development of a new research winery which will support new research for the UK's rapidly expanding viticulture and wine industry. Our expert horticultural scientists at NIAB are on hand to help with horticultural agronomy and research needs and a world-renowned oenologist has been appointed to lead our viticulture and wine-making research.

Our research partners also have new facilities to support businesses in the region. The University of Kent has a Biotechnology Hub to provide businesses with new research possibilities; from alternative ways to manage crop diseases to environmentally-friendly packaging options. It specialises in sustainable food and drink research and is run by some of the leading experts in plant biology, post-harvest and packaging. With new cutting-edge equipment, the research team based at the Hub are able to support horticultural and plant-based food and drink businesses to solve a wide range of industry challenges.

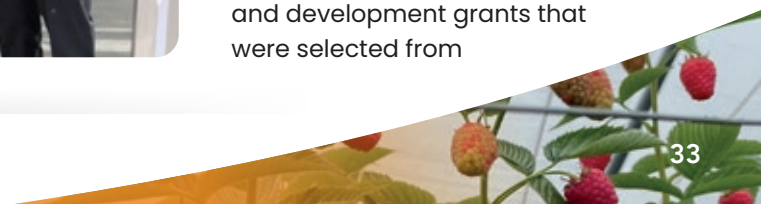
The University of Greenwich has developed its Medway Food Innovation Centre which offers state-of-the-art facilities, to provide the food industry with technical support and R&D capabilities. Through its technical expertise in food processing, plant and algal protein-based new product development, flavour and texture analysis, food safety, packaging and fresh produce storage, it will help to deliver step-changing food innovation. Support is also available for proof-of-concept research and development work to de-risk investment, such as scoping new product opportunities and reformulating existing products.

Figure 1. The opening of NIAB's GreenTech Hub for Advanced Horticulture

Research Funding Grants

Through Growing Kent & Medway, we are investing £5 million in research and development grants ranging from £5,000 to £350,000 for innovative projects that aim to solve problems in horticultural, plant-based food or drink production.

In the first round of research and development grants that were selected from



applicants in 2022, five projects were of particular interest to fruit growers. The University of Greenwich has partnered with fruit marketing business 'Norton Folgate' to investigate methods for improving longer term storage of UK cherries to help us to extend the marketing season. The University of Kent is working with Kent-based company 'Re-generation Earth' to assess the impact on soil carbon from incorporating biochar into soils, and the effect it has on soil fertility.

At NIAB, we have successfully partnered with 'Thanet Earth', 'Avalon Produce' and 'Asplins PO' to investigate further fruit related issues. Working with Thanet Earth, we are researching ways of increasing the concentration of iron and Vitamin C in tomatoes, not only to enhance their nutritional value, but also to increase the plant's ability to withstand the higher temperatures being brought about through global warming. With Avalon Produce, we are seeking to develop novel approaches to controlling apple canker (Figure 2), by enhancing the ecology of apple orchards, and with Asplins PO, our plant breeders and entomologists are working to identify differences between strawberry and raspberry varieties in their susceptibility to the invasive pest spotted wing drosophila.

A second round of funding grants was launched in the Autumn of 2022 and successful applicants and projects are due to be announced in the Spring of 2023. In addition to research grants, Growing Kent & Medway offers Business Innovation Vouchers. These can be used by businesses to gain access to technical research support. The business can gain 75% of funding towards research projects worth up to £20,000. The voucher is designed to help businesses with challenges in crop production, food processing, packaging, producing high-value compounds from plants, and agri-tech solutions. It could be used for projects to test products and prototypes, trialling new technology, validating data or proof of concept studies. Successful applicants from the first round of funding are due to be announced early in 2023.

Figure 2. A Growing Kent & Medway grant funded project is seeking to develop novel approaches to apple canker control

Figure 3. Group networking sessions help businesses to share ideas

Business Enterprise Support

Growing Kent & Medway provides free mentoring support for the self-employed or small and medium sized enterprises to help businesses to grow. Up to 12 hours of free one-on-one mentoring is offered, along with group networking sessions (Figure 3), support in applying for grants and access to research facilities and experts. Help is offered in areas including market research, sales, people management, finance and legal, through to supply chain development or marketing strategies.

Allied to our mentoring is the 'Food Accelerator' programme. To date, two separate cohorts of 17 businesses have enrolled on this programme, which lasts for four months and includes four main stages. We initially work with businesses to establish a proof of concept for a new food or drink product which will be of value to a consumer. We then provide support to develop a clear business model, and then help to develop prototypes using facilities at the Medway Food Innovation Centre. Finally, we work with the businesses to develop an innovation and funding strategy, get them 'pitch-ready' and introduce them to potential investors and commercial partners. Businesses are also eligible for free advice from technical experts and benefit from a series of networking events to share experiences.

In addition to these mentoring programmes, Growing Kent & Medway has been leading other programmes of work to support horticultural, food and drinks businesses in the region. These include 'Growing Green', an alternative proteins network and an agrifood skills strategy.

Growing Green

In 2022, Growing Kent & Medway led the Growing Green programme, a government-funded pilot training scheme that sought to provide the knowledge, tools and funding to reduce carbon emissions, helping businesses on their journey towards 'net-zero'. This was a pilot programme which aimed to work with businesses to learn and understand what aspects of reaching 'net-zero' they needed help and support with, allowing Growing Kent & Medway to put further support programmes together to ensure that they reach their ultimate targets.

A total of 37 horticultural and plant-based food and drink companies participated, including several fruit growing operations. Trained practitioners were allocated to each business and they worked together to quantify the principal inputs they require in their activities, including energy and water, along with the outputs in terms of waste products. They were encouraged to consider how they might reduce both inputs and outputs, and what help they needed to achieve this. The practitioners then helped the businesses to develop a decarbonisation plan, identifying several target goals they wished to achieve. A series of eight interactive training workshops were also provided to help the businesses with this process. As part of the project, a grant was available to each business to help them to implement one or more of their goals. For the participating horticultural and fruit businesses, the most commonly occurring decarbonisation goals included renewable energy, energy efficiency (Figure 4), water (Figure 5) and alternative fuels, with several novel approaches being identified.

The Growing Kent & Medway team now has an improved understanding of the decarbonisation challenges facing this sector and aims to deliver further resources and events, whilst seeking new funding opportunities.

Alternative Proteins Network

In 2021, the Good Food Institute reported a record investment in capital in the alternative protein sector. Alternative proteins offer an ideal way to reduce the impact of agriculture on the environment, as animal derived proteins can generate between 2 and 200 times more emissions than protein crops such as grains, pulses and nuts (Poore, J. and Nemecek, T. (2018) and additional calculations by World in Data. FoodClimate Res. Network, University of Oxford). In the National Food Strategy plan, it was suggested that an investment of £1 billion was needed into alternative protein research in order to meet health, climate and nature commitments.

Figure 4. Improving energy efficiency for fruit stores was a high priority for fruit growers in the Growing Green programme

The Alternative Proteins Network is bringing new investment and skills to the Kent and Medway region to meet the huge opportunity for innovation and growth in plant and fungal-based alternative proteins. Investment in our new research facilities at the GreenTech Hub along with the University of Kent's Biotechnology Hub and University of Greenwich's Medway Food Innovation Centre, coupled with the existing capabilities in crop science, fermentation and food innovation, allows Growing Kent & Medway to facilitate new research. We are connecting networks of funders, businesses, researchers and non-profit organisations to identify opportunities for collaboration and partnerships to develop new alternative proteins and new food products.

Working with UK Research and Innovation, Growing Kent & Medway has published an Alternative Proteins Roadmap (https://www.growingkentandmedway.com/alternative-proteins/) that outlines the potential for the growth of meat and dairy alternatives in the UK food industry. The report provides insight into how UK stakeholders can collaborate and innovate to tackle current challenges faced in meeting the rising demand of alternative proteins.

Agrifood Skills Strategy

In recent years, it has become increasingly difficult to attract and retain skilled staff to work in the horticultural, food and drink sector. Working with industry and further education providers, 'Locate in Kent' and Growing Kent & Medway have produced a new strategy to help address the skills challenges facing horticulture, viticulture and the food and drink sector. Entitled 'Workforce 2030', it sets out practical recommendations and objectives to train and attract the right talent to the sector.

Find out more about Growing Kent & Medway

For comprehensive information about how Growing Kent & Medway operates and the help it provides to the horticultural, food and drink businesses in the region, visit https://www.growingkentandmedway.com/.

Figure 5. Fruit growers are keen to develop new ways of capturing and storing water for irrigation

New research talent emerging from the Collaborative Training Partnership for Fruit Crop Research programme

The Collaborative Training Partnership for Fruit Crop Research (CTPfFCR) was instigated by lead partner Berry Gardens Growers Ltd in collaboration with NIAB at East Malling, to help to develop a new generation of fruit crop researchers, to fill the ever-expanding void of young talent coming into the horticulture industry. Funded by the Biotechnology and Biological Sciences Research Council (BBSRC) along with industry partners AHDB, Berry Gardens Growers Ltd, Marks and Spencer, the National Association of Cider Makers, WORLDWIDE Fruit Ltd and the Worshipful Company of Fruiterers, the programme aims to deliver a high-quality training programme for doctoral students, delivering independent, highly-employable scientists in strategically important research and development areas.

The first cohort of students commenced the programme in 2017 and consecutive intakes continued annually each autumn until 2021, so that 40 researchers will have been trained when the final project is completed in September 2025. The majority of students are working with NIAB at East Malling, with others based at the Universities of Cranfield, Essex, Harper Adams, Lincoln, Nottingham and Reading. Each one is researching a topic of interest selected by the industry partners and, within their four-year training period, the students also have the opportunity to experience the sector first hand by spending time with the CTP's industry partners in their businesses in order to widen their knowledge of the industry.

Many of the CTP's research topics are complementing research that is already in progress and the results will be adopted by existing NIAB researchers at East Malling and elsewhere. The projects currently in progress are grouped into the following categories:

• Artificial intelligence and robotics • Crop science and production systems • Genetics • Pest and pathogen ecology

Artificial intelligence and robotics

Three students at the University of Lincoln have been working on projects to inform robotic research and yield forecasting. Justin Le Louedec, who recently completed his doctorate, has been using novel machine learning techniques to teach cameras installed on robotic pickers to identify the correct colour and shape of fruits to pick. Katherine James is creating images of model strawberry plants, which will be able to be used by plant breeders to improve the phenotypic traits of new varieties so that they are, for example, more suited to robotic strawberry harvesters. Finally, George Onoufriou is using yield profile data collected from previous year's harvests, alongside the recorded temperatures and light levels, to build yield forecasting models. The combination of data sources in a neural network will allow growers to improve their prediction of yield forecasts for up to three weeks ahead.

Crop science and production systems

As you might expect with industry selected research projects, there are quite a few underway investigating aspects of plant physiology and improving crop production and fruit quality. Sophie Read at the University of Reading has been experimenting with the impact of additional lighting and night-break lighting to extend the UK strawberry production season between November and February under glass (Figure 1). In 2023, she plans to employ vertical growing systems

Figure 1. Sophie Read has been experimenting with additional lighting to extend the strawberry production season

Figure 2. Ece Moustafa is researching water relations in raspberry and their impact on fruit yield and quality

Figure 3. Camila Gonzalez is trying to understand what controls flowering in strawberry

using different light levels identified from her previous research. Nicholas Doddrell, another recent graduate from the programme, has worked at NIAB's Water Efficient Technologies Centre to understand the effect of increasing photosynthesis efficiency on strawberry yields. Measuring photosynthetic active radiation (PAR), he has found that the middle rows in tunnels have a higher rate of photosynthesis and subsequent yield than the outside rows. He is now considering if plant genetics might be manipulated to increase strawberry photosynthesis.

At the universities of Essex and Reading respectively, Menjie Fan and Winnie Swann are working with Dr Mark Else at East Malling to optimise light recipes to maximise photosynthesis and yields in strawberry. Mengjie is investigating the use of blue light with the intention of boosting yields late in the season whilst Winnie has been using supplementary LED lighting and added CO_2 to refine a system for improving yield and fruit quality.

Back at NIAB at East Malling, in a project seeking to improve CO_2 uptake by stomata in strawberry crops and increase their yields, William Atkinson is experimenting with light and other environmental cues both to increase stomatal density and stomatal opening. Emily Johnstone at the University of Reading is investigating ways to maximise optimum strawberry fruit size for sale to multiple retailers, by manipulating nitrogen input and strawberry growth.

In raspberry, Ece Moustafa is trying to understand the legacy effect of short-term water stress and its impact on fruit size and quality (Figure 2). Importantly, Ece is also determining how quickly raspberry plants recover from water stress events, which will be very useful information for growers in the future as our climate becomes warmer.

In tree fruit at East Malling, Haidee Tang is using climatic and imaging data to predict apple fruit ripeness, while Catherine Chapman is investigating the potential of apple trees to sequester carbon below ground. Magdalena Cobo-Medina has been researching apple root architecture, root function and soil management. She has identified zones on the genetic map conferring different traits in the rootstock.

Genetics

Creating new varieties and improving their genetic traits is another important aspect of the programme. Camila Gonzalez at NIAB at East Malling is working with the genetics and breeding teams, using a combination of genetic mapping and gene editing to understand the control of flowering in strawberries, specifically the Junebearer Malling™ Centenary and the everbearer Calypso (Figure 3). By improving our understanding of what controls flowering, we hope to be able to find ways of creating continuous flower and fruit production through the season.

Also at East Malling, Matteo Luberti has recently completed his studies having successfully identified genetic markers that confer resistance to *Phytophthora cactorum* (the cause of crown rot) in apple and these markers are now available for use in the apple breeding programme. At Reading University, Adam Gregg has been studying the genetics behind natural resistance in cherries to bacterial canker and aims to identify genetic loci that will aid resistance.

Pest and pathogen ecology

With the decline in plant protection products, the CTP has sponsored a large number of projects to find improved controls and provide growers with better understanding of how

to manage some of the major pests and diseases affecting fruit crops.

Laura Martinez at Harper Adams University is studying why the potato aphid, a common pest of strawberry, is not reliably controlled by aphid parasitoids. So far, she has discovered that there is genetic variability in the populations of the pest, but this does not appear to influence the susceptibility of the aphids to parasitoids. On a related theme, Stuart Edwards at the University of Reading is finishing his research into the influence of climate warming on aphid parasitoid/prey interactions. Hayden Tempest at East Malling has been investigating the predation of woolly apple aphid by earwigs using radio tagging whilst Cindayniah Godfrey has been investigating the interactions between woolly apple aphid and apple crops, learning about resistance mechanisms and the pest's reproductive ability.

Four soft fruit pathology projects are currently in progress. At East Malling, Lauren Farwell (Figure 4) is in the final stages of studying the management and control of *Cladosporium*, a green/black mould that develops on ripening raspberries. She has found that it only grows on

Figure 4. Lauren Farwell investigating the biology and control of Cladosporium mould on raspberry

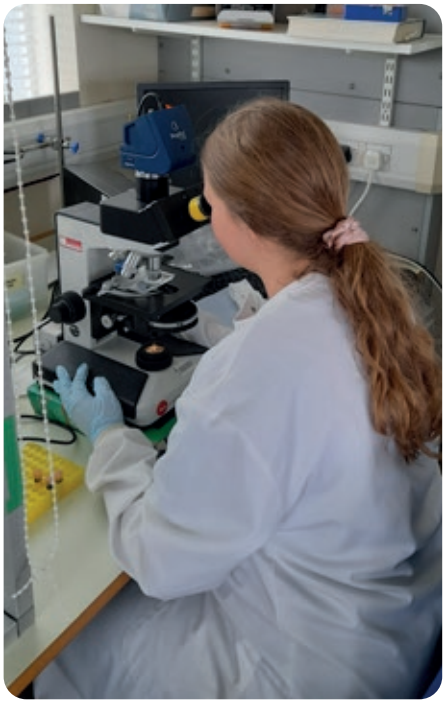


Figure 5. Hamish McLean is investigating biological control methods for apple canker

the surface of ripe fruits and not green fruits, that good hygiene is important to reduce infection, and she is now investigating biological control options on the surface of the fruit. The range of pathogenic *Phytophthora* species causing raspberry root rot appears to be increasing and Eithne Browne has been working at Harper Adams University and East Malling to find out which species are prevalent, and which are the most pathogenic. Samantha Lynn has been identifying strawberry genes that confer resistance to powdery mildew, and it is hoped to adopt these findings in the East Malling Strawberry Breeding Club programme. Finlay Bourquin at NIAB Cambridge is investigating both the resistance and susceptibility of strawberries to *Botrytis cinerea*, whilst also understanding the virulence of different pathogenic strains.

On tree fruit at East Malling, Chris Cook has recently been awarded his PhD after studying beneficial soil inhabiting organisms, some of which are antagonistic to the fungal organisms causing apple replant disease, while Hamish McLean is investigating potential biological control methods for apple canker (Figure 5). Thomas Heaven has been trying to understand why some populations of *Venturia inaequalis* (the fungus causing apple scab) have developed resistance to commonly used fungicides and at Cranfield University, Katie Stewart is working on novel methods for controlling apple scab.

Student progress into industry

The success of the CTP programme is not just measured by the output of the scientific results, but also by the employment secured by the students at the end of their studies. Three students, from the first intake in 2017, are already working in fruit research roles spanning academia and industry. Carlota Gonzalez Noguer is now a Quantitative Crop Physiologist with NIAB at East Malling and Raymond Kirk is the Chief Technology Officer of a start-up business, FruitCast, who plan to be offering a crop forecasting service to strawberry growers in the next few years. Lastly, Christina Conroy is employed as a Technical Account Manager at Berry Gardens Growers. The next generation of fruit research scientists has already landed!

Berry Gardens Growers Ltd and NIAB at East Malling are extremely grateful to the Biotechnology and Biological Sciences Research Council (BBSRC), AHDB and partner universities, for providing grant funding for the CTPfFCR programme as well as the industry funding sponsors.

Finding out more about NIAB fruit research

NIAB's fruit research is predominantly managed at our East Malling site, where our staff are divided into three teams:

PEST AND PATHOGEN ECOLOGY (PPE)

led by Michelle Fountain

CROP SCIENCE AND PRODUCTION SYSTEMS (CSPS)

led by Mark Else

GENETICS, GENOMICS AND BREEDING (GGB)

led by Dan Sargent

We also have two commercial teams; **Horticultural trials services** at East Malling, led by Adrian Harris, and **Malling Fruits**, led by Will Roberts. Malling Fruits works closely with our genetics, genomics and breeding team and deals with the commercialisation of the new fruit varieties that NIAB breeds at East Malling. It also produces helpful guidance to growers on how to optimise the yield and quality of newly released varieties.

To keep the industry informed about our research and the results that we produce, 'NIAB Fruit' has been set up to disseminate our latest news and information. NIAB Fruit's outreach programme will provide:

- **Annual Review** – digital and printed versions
- **Electronic Factsheets** – providing guidance to the industry on crop management and crop protection issues
- **International research updates** – offering summaries of overseas research visits and international conferences and symposia
- **Web archive of information** – including the Apple Best Practice Guide, SWD and relevant research information on the NIAB website
- **Technical webinars** – providing presentations on the latest research results
- **On-site events** – short events to appraise the industry of our research and demonstration work
- **Malling Fruits updates** – the latest information about new fruit varieties and grower guidance related to these
- **Growing Kent & Medway information** – updates and events from the Growing Kent & Medway Innovation Cluster

Anyone wishing to receive information from NIAB Fruit should register at: horticulture@niab.com

For further information, contact Scott Raffle, NIAB Knowledge Exchange manager:
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NIAB

Fruit

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