NIAB

Fruit

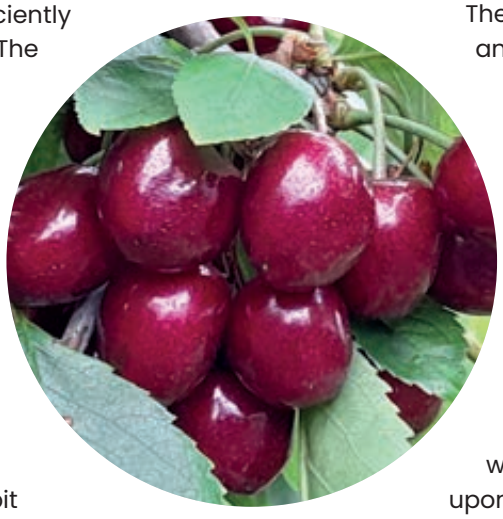
Annual Review 2025

Mario Caccamo, Chief Executive Officer, Niab

Welcome to the Niab Fruit Annual Review 2025

This Review magazine provides the industry with a snapshot of the range of fruit research projects that are being carried out by Niab at East Malling and other sites. The format has proved popular with our readers as the work is presented in short summary format which picks out the results that will be most relevant to commercial growers, agronomists and technologists.
I would like to acknowledge the successful partnership with The East Malling Trust, and their generous contribution to support Niab's research programme. This year, we are also particularly pleased to be reporting on work that is being funded by British Apples and Pears Ltd and British Berry Growers, as one of our principal objectives is to support UK fruit growers in their determination to maintain sustainability and profitability.

To this end, I draw your attention to the work of our crop science team. We report in this issue about the work of Niab's WET Centre in demonstrating the use of precision irrigation technology to produce soft fruit more efficiently with fewer inputs. The Centre's funding ended in 2024 but the legacy of the research supported by this facility will support future research in resource use efficiency.
In January 2025, we were pleased to be able to exhibit our findings at the Palace of Westminster to members of the All-Party Parliamentary Group on Science and Technology in Agriculture, of which Niab is proud to be a founding member. Our work is now focused on producing strawberry and raspberry plants in optimum growing conditions to maximise the yield potential of every plant and help growers to increase their yields significantly.



The work of our pest and pathogen ecology team continues to develop solutions to crop protection problems using novel and alternative control strategies which rely less upon conventional plant protection products.
You can read about some exciting new research we have carried out to identify new ways of controlling canker, scab and replant disease in apple, along with new research to tackle woolly apple aphid and spring pests in apple orchards. We have also been seeking IPM solutions to large raspberry aphid and earwigs in strawberry, and continuing our work to develop improved methods of managing spotted wing drosophila.

The work of the Growing Kent & Medway team is included in this Review and you can learn how the programme has been supporting fruit businesses not only through research and development, but through the Growing Green programme to support businesses in their journey towards net zero. Then find out how the programme is enabling the development of young start-up businesses through the business mentoring and food accelerator programmes.

Lastly, I would like to reflect on the opportunity that new genetics technologies such as precision breeding could offer to accelerate the breeding of new fruit varieties.

Niab presentation at the 2025 BAPL/Niab Apple and Pear Technical Day

As I write this, the government published the secondary legislation needed to implement the Genetic Technology (Precision Breeding) Act 2023. I believe this is a truly historic moment as this represents the first time in more than 30 years that new legislation has been brought forward in this country which seeks to enable, rather than to further restrict, the use of genetic innovation in agriculture. Exciting times ahead!

I look forward to welcoming visitors from the fruit industry to various events that are planned at East Malling over the coming months.

Niab vineyard tour at Fruit Focus

Oliver Doubleday, Chairman, East Malling Trust

The East Malling Trust: pioneering horticultural innovation with Niab

Since 1913, The East Malling Trust (EMT) has been at the forefront of innovation in the horticultural and fruit industries. Recently, EMT proudly unveiled its Science and Impact Strategy, focusing on three core objectives:

1. **Driving growth and resilience**: Empowering research and innovation in horticulture to boost the sector and positively impact the wider economy and society.
2. **Championing UK research**: Supporting cutting-edge horticultural research and innovation across the UK.
3. **Building strategic partnerships**: Collaborating with industry leaders, researchers, policymakers, and funders to foster impactful partnerships.

EMT continues to back high-quality fruit science research at Niab, not only by providing and maintaining infrastructure but also by funding a diverse range of high-quality projects. Highlights include:

- **£6.7 million co-funding**: Supporting the GreenTech Hub for Advanced Horticulture, featuring new research glasshouses and winery buildings.
- **Niab Wine Innovation Centre**: Equipping the centre to advance wine research.
- **£1 million Niab Director's Award for Horticulture**: Funding a variety of research projects, leveraging over £5.7 million in government-funded research, and investing in early career researchers.

By partnering with Niab and other key stakeholders, EMT aims to make a significant impact, especially in these crucial times for food security and sustainability. This includes such initiatives such as supporting Brogdale Collections, an organisation responsible for managing public access to the National Fruit Collections at Brogdale Farm. The Trust is dedicated to enhancing public understanding of horticulture, and views Brogdale as an exemplar in this field.

All our initiatives are driven by a dedicated and knowledgeable board of trustees, who are always eager to hear from industry and stakeholders about future innovation needs. Scan the QR code to learn more about the trustees:


Aerial view of the East Malling site

Niab trials services and glasshouse services at East Malling

Niab's work at East Malling has gained recognition around the world through its employment of enthusiastic researchers 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.l.harris@niab.com

Spray trials at Niab research vineyard

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, 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

Niab has a full range of glasshouse and growth room facilities that are used by staff and research partners at both our Park Farm (Cambridge) and East Malling (Kent) sites. The facilities at East Malling were constructed in 2021/22 with funding from Growing Kent & Medway, The East Malling Trust and Kent County Council. They include some state-of-the art glass, allowing researchers to replicate the very best glasshouses that are used by the industry, making our research relevant to current commercial practice.

Niab works collaboratively with industry partners to develop projects designed to find solutions to crop production problems commonly faced by the commercial fruit sector. The glass is equipped with a full range of irrigation facilities, lighting design and screens for night break lighting or sun-shading. We also have climate-controlled compartments with heating and cooling facilities, which are also fitted with black out blinds. The growth rooms have independently controlled environmental conditions and range in size.

We currently use some of the glasshouse units in research on tomatoes and peppers to utilise the latest diagnostic technology and agronomic knowledge to co-develop a crop scouting service, informed by spectral diagnostics (wearable and mounted diagnostic hardware) that can detect the early establishment of any event which adversely affects yield, and which can be integrated within crop management systems. The growth rooms allow research into Total Controlled Environment Agriculture (TCEA) systems enabling us to study the full yield potential of fruit plants under optimum growing conditions.

Glasshouse strawberry trials

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 (see right).

We also have our **horticultural trials services** team led by Adrian Harris.

To keep the industry informed about our research and the results that we produce, 'Niab Fruit' was set up to disseminate our latest news and information. Niab Fruit's outreach programme provides:

- **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 and relevant research information at niab.com
- **Technical webinars** – providing presentations on the latest research results
- **On-site events** – short events to appraise the industry of our research and demonstration work
- **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: scott.raffle@niab.com Tel: 07712 131769

PEST AND PATHOGEN ECOLOGY (PPE)

led by Michelle Fountain

CROP SCIENCE AND PRODUCTION SYSTEMS (CSPS)

led by Mark Else

PLANT GENETICS (PG)

led by Xiangming Xu

Niab presentation at the 2025 BAPL/Niab Apple and Pear Technical Day

Presentation at the East Kent Fruit Society visit to Niab

New projects 2024/25

Niab has begun work on a series of fruit research projects over the past year which all seek to make fruit production more sustainable. Whether developing more sustainable methods for improving crop health and crop protection, producing plants in a more sustainable way with reduced inputs, or improving the efficiency and speed of fruit plant breeding, all seek to increase efficiency of production in ways that are sympathetic to the environmental challenges growers face today.

CROP SCIENCE AND PRODUCTION SYSTEMS

Graham Dow, Ecophysiology Group Leader

Title: Arboricrop: Next generation agriculture using real-time information from tree crops

Funder: Innovate UK

Industry partners: Benchmark Control Ltd (Lead), Adrian Scripps Ltd and H. L. Hutchinson Ltd

Term: February 2024 to July 2026

Conventional fruit production relies upon growers employing costly interventions of water, nutrients and crop protection products to optimise plant health, yields and fruit quality. This project will design, test and produce a Next Generation Electrophysiological Sensor (NGES) that can detect plant stress before visual symptoms appear, allowing growers and agronomists to apply interventions earlier, thereby minimising yield losses and maximising efficiency. Such technology has demonstrated promise in protected crops, but this project will focus on woody crops such as apple and vines.

Next generation electrophysiological sensor being set up in an orchard

Belinda Kemp, Viticulture & Oenology Research Leader

Title: Vine AI: Artificial intelligence for fungal disease management

Funder: Growing Kent & Medway Prototype and Demonstrator fund

Industry partners: Deep Planet Ltd (Lead), English Wines plc, Gusbourne Estate Ltd, Nyetimber Ltd and Rathfinny Wine Estate Ltd

Term: May 2024 to April 2025

Early detection of fungal diseases in vineyards is crucial if growers are to prevent disease spread and reduce the number of crop protection products used to manage the problem. Conventional crop monitoring by agronomists and farm staff using human eyes does not always identify problems quickly enough. In this project, Deep Planet is working with Niab and UK vineyards to employ satellite imaging and machine learning artificial intelligence, to accurately detect and predict early infection by Botrytis, powdery and downy mildew to replace inefficient methods of monitoring.

Artificial intelligence will be used to identify very early symptoms of Botrytis on grape

CROP SCIENCE AND PRODUCTION SYSTEMS

Belinda Kemp, Viticulture & Oenology Research Leader

Title: Project PIP: Crafted in Kent – raising the bar for alcohol-free wine

Funder: Growing Kent & Medway Business Innovation Voucher

Industry partner: HWB Group

Term: June 2024 to May 2025

With increasing consumption of alcohol-free drinks, there is a significant market need for an alcohol-free wine. Niab is working with The HWB Group who have successfully introduced over 50 beverage brands over 20 years, to create the first UK-based alcohol-free wine. Together they are exploring innovative fermentation and de-alcoholisation techniques using locally sourced produce from Kent. The vision goes beyond tradition, incorporating cutting-edge technologies and know-how to deliver a refined de-alcoholisation process that preserves the intrinsic character of the fruit.

Exploring innovative fermentation and de-alcoholisation techniques to create alcohol-free wine

CROP SCIENCE AND PRODUCTION SYSTEMS

Flora O'Brien, Root and Soil Biologist

Title: Soil health: Developing a holistic biological soil health test
Funder: Innovate UK
Industry partner: Verdant Carbon Ltd
Term: August 2024 to January 2026

With fruit growers keen to maximise yield potential from every soil-grown tree or plant, it is important to employ land which is in optimum health, but it can be difficult to determine the relative health of a field soil. In this project, Niab and Verdant Carbon Ltd seek to develop a test that will reliably assess the abundance and functionality of soil microbial communities, and relay the information to the grower in a simple-to-understand metric. The work also aims to measure the health of soil nutrient (carbon and nitrogen) cycling functions, to further support environmentally positive farming.

Developing a test to determine the relative health of a field soil

PLANT GENETICS

Abi Johnson, Senior Plant Breeder

Title: Berry Fresh Initiative: Evaluating impact of decontamination on strawberry sensory properties
Funder: Growing Kent & Medway Business Innovation Voucher
Industry partner: Aridom Sanex
Term: May 2024 to May 2025

The shelf-life of harvested strawberries can be significantly reduced by fungal pathogens and food spoiling organisms, leading to loss of sales and food waste. This project will investigate a novel decontamination process using pre-harvest treatments of dry fogging technology and hypochlorous acid to assess if it maintains fruit quality and extends shelf life. The work will also refine application rates to maximise fruit flavour and texture, and identify the optimum frequency of application. If successful, the work will lead to improved fruit quality and reduce the level of food waste.

Investigating a decontamination process to maintain strawberry quality and extend shelf-life

PLANT GENETICS

Xiangming Xu, Director of Research

Title: Soft fruit genetic improvement network (GIN)
Funder: Defra
Industry partners: ADAS and the James Hutton Institute
Term: October 2024 to June 2029

There are increasing numbers of privately funded breeding programmes in the UK soft fruit industry which would all benefit from a co-ordinated research approach to pre-breeding genetics of key traits and new breeding tools. This project is being funded by Defra to link academia to industry and develop our understanding of the genetics influencing improved tolerance to pests and diseases, and increased water and nutrient use efficiency in strawberry and raspberry. It will also develop genetic tools and resources for minor crops such as blackberry and honeyberry to support increased production in the UK.

Developing genetic tools to support privately-funded soft fruit breeding programmes

PEST AND PATHOGEN ECOLOGY

Sarah Arnold, Applied Entomology Researcher

Title: Too hot to pollinate? Pilot data on temperature regulation in commercial bumblebee hives
Funder: The Worshipful Company of Fruiterers
Term: February 2024 to November 2024

Soft fruit growers using bumblebees for pollination are only permitted to use the native subspecies *Bombus terrestris audax* which could be less active and less tolerant than other species in hot conditions. Bumblebees regulate the temperature in their nests by wing-fanning to cool the brood, but this distracts them from their pollination work. This project seeks to identify the temperature at which these bees start cooling the hive and the temperature at which cooling is no longer effective. The results will highlight any shortcomings in this species and identify periods when alternative pollinators are required.

Growers need to identify periods when bumblebees are ineffective at pollinating flowers

Michelle Fountain, Head of Pest and Pathogen Ecology

Title: Optimising deployment of sterile insect technique to control spotted wing drosophila in blackberries: Black-Spot

Funder: Innovate UK: Defra and UKRI Farming Innovation Programme

Industry partner: BigSis

Term: March 2024 to February 2025

Sterile insect technology (SIT) has been developed by BigSis and Niab in a previous IUK funded project as a novel method to control spotted wing drosophila (SWD) in strawberry, raspberry and cherry. No SIT work has yet been carried out on blackberry, a crop with a growth habit and extended ripening period that lends itself to SWD attack. This project will quantify the effect of SIT in blackberry compared to an untreated control, whilst also employing detailed field data to produce a predictive model for SWD populations, which could transform the targeting of sterile male releases.

Quantifying the effect of sterile insect technique to control SWD in blackberry

PEST AND PATHOGEN ECOLOGY

Michelle Fountain, Head of Pest and Pathogen Ecology

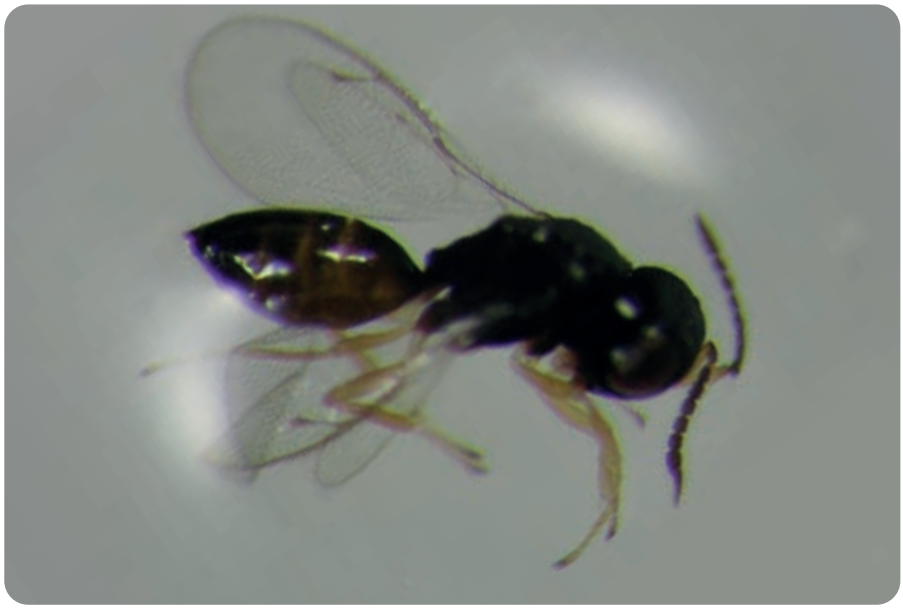
Title: Augmentoria to boost natural biological control

Funder: Growing Kent & Medway Business Innovation Voucher

Industry partners: British Berry Growers and W. B. Chambers

Term: April 2024 to March 2025

Parasitoids (tiny wasps that lay eggs inside their prey) can contribute to biological control of spotted wing drosophila (SWD). The parasitoid *Trichopria drosophilae* is known to prey on SWD but is non-native to the UK and is not licenced for use here. This project will investigate the use of our generalist UK parasitoids by developing robust and practical augmentoria. Fruit inoculated with fruit flies is deposited in these tent-like structures which prevent flies from escaping but allow parasitoids to emerge into surrounding areas potentially reducing reservoirs of SWD in hedgerows and woodlands.



Investigating native parasitoids for SWD control

PEST AND PATHOGEN ECOLOGY

Francis Wamonje, Entomology Research Leader

Title: Isothermal detection of cryptic thrips

Funder: Innovate UK

Term: April 2024 to March 2025

With western flower thrips (WFT) having developed resistance to spray control products, growers have successfully employed biological control methods in recent years, but other species such as rose, rubus, onion and flower thrips are also known to cause damage. It is very hard for growers and agronomists to distinguish between species, some of which are not harmful to the crop. This project aims to develop a rapid molecular detection tool that can easily be used in the field to identify WFT. If successful, the same principle will be used to develop similar tests for other species.

A rapid molecular detection tool is needed to identify thrips species

PEST AND PATHOGEN ECOLOGY

Sarah Arnold, Applied Entomology Researcher

Title: Managing the activity of pollinators in protected cropping systems (MAPP-CS)

Funder: Biotechnology and Biological Sciences Research Council

Industry partners: Agriculture Investments Ltd, Biobest Ltd, Buzzup, Clockhouse Farm and The East Malling Trust

Term: May 2024 to April 2028

Soft fruit production under fixed protective structures is highly dependent on introduced bumblebees (*Bombus terrestris*) for pollination. Their performance under such structures can be less reliable as they can be less active, suffer from higher mortality and sometimes fail to return to the hive, resulting in lower fruit yields and quality. This project will research the drivers of pollinator underperformance in enclosed systems, including lighting and navigational factors, and trial a range of affordable interventions to improve pollinator activity, reduce mortality and improve profitability.

Seeking to understand the underperformance of pollinators under protection

PEST AND PATHOGEN ECOLOGY

Michelle Fountain, Head of Pest and Pathogen Ecology

Title: MiDeVa: Integrating mite dispersal with UV treatment in strawberry

Funder: Growing Kent & Medway Prototype and Demonstrator fund

Industry partner: Saga Robotics Ltd (Lead)

Term: May 2024 to February 2025

The regular distribution of predatory mites on soft fruit crops for pest control involves expensive hand labour. Saga Robotics has already developed autonomous robots that provide targeted ultra-violet (UVC) treatment to control powdery mildew in strawberry crops. This project aims to develop an innovative dual-function for these robots enabling them to simultaneously disperse predatory mites alongside UVC treatment. Niab will examine how the concurrent UVC treatment and mite dispersal influence distribution and survival of the mites and hence pest control.

Investigating the impact of UV light on survival of introduced predatory mites

PEST AND PATHOGEN ECOLOGY

Sarah Arnold, Applied Entomology Researcher

Title: FLYTHRIVE: Hoverflies for aphid control in soft fruit

Funder: Innovate UK

Industry partners: Olombria (Lead), Asplins, The Summer Berry Company and The Natural Resources Institute

Term: June 2024 to May 2026

Control of aphids in soft fruit crops is becoming increasingly difficult with very few effective conventional chemical aphicide products authorised for use. Previous studies have shown that hoverflies can contribute significantly to aphid control in protected crops as adults released into the crop can seek out aphid colonies even in dense foliage, where they lay their eggs. Emerging larvae are voracious predators of the aphids with a single larva able to consume hundreds of aphids. This project will test and develop bespoke native hoverfly species blends to control key aphid pests of soft fruit crops under protection.

Testing native hoverfly species blends to control aphids in protected soft fruit

Xiangming Xu, Director of Research

Title: Soil health: Developing agronomic practices to improve soil health and crop productivity

Funder: Horizon Europe

Industry partners: A total of 19 other partners from EU countries will collaborate with Niab

Term: June 2024 to November 2027

Several EU-funded projects have investigated methods of improving soil management practices and creating viable and sustainable alternatives to peat as a soilless substrate. The data and outcomes of one of these projects 'EXCALIBUR' will now be exploited by transforming agri-food by-products either into soil fertilising products or sustainable alternatives to peat substrates. Within the project, Niab is working with ReCoir Ltd to recycle and repurpose spent coir for fruit and vegetable production.

Assessing lettuce growth in recycled coir

PEST AND PATHOGEN ECOLOGY

Xiangming Xu, Director of Research

Title: Sustainable management of apple replant disease

Funder: Biotechnology and Biological Sciences Research Council

Term: October 2024 to September 2026

It is now generally accepted that apple replant disease (ARD) is a disease-complex primarily caused by microbial pathogens. Recent research at East Malling funded by BBSRC and the EU has shown that disease severity is reduced where newly planted trees are planted on a rootstock genetically distinct from the previous one and the trees are in the previous grass alley. Amending soils with specific biopesticides and microbes or organic composts further reduced the problem. In this project, Niab will evaluate an integrated approach to control using all these treatments in combination.

Evaluating an integrated approach to controlling apple replant disease

Project summaries

CROP SCIENCE AND PRODUCTION SYSTEMS

Mark Else, Head of Crop Science & Production Systems

Trevor Wignall, Operations Manager, The WET Centre

Matching supply with demand for nutrients in raspberry fertigation

Title: SMARTFert+: Soft fruit: Nutrient sensors and related technology to improve productivity and reduce waste

Funders: Innovate UK and The East Malling Trust

Industry partners: EDT DirectION (Lead), Netafim UK Ltd (Lead) and New Farm Produce Ltd

Term: March 2024 to February 2025

There is pressure on growers to use fertiliser products more efficiently. Not only have fertiliser costs risen sharply over recent years, but overuse is wasteful, percolative losses can contaminate water supply, and excess nitrogen can be converted to nitrous oxide which is deemed to be 300 times stronger than carbon dioxide at trapping heat in the atmosphere, and so there are strong environmental arguments for using nitrogen more effectively. In raspberry, too much nitrogen can also lead to excessive plant growth, which directly increases water use, cane management and picking costs, whilst also increasing the risk of fungal disease and reducing light levels in the crop canopy.

In a previous Innovate UK funded project, Niab adapted a mathematical model to predict the plant's nitrogen demand based on growth stage. Inputs are adjusted to account for the effects of environmental variables such as temperature on nitrogen demand and partitioning. The model gave rise to a 76% reduction in nitrogen use (Figure 1) compared to a commercial nitrogen fertiliser regime and a 37% reduction in water use, without affecting marketable yields or berry quality. In addition leaf and cane growth were reduced leading to lower harvest and cane management costs.

Figure 1. N model (right row) reduced N use by 76% compared to commercial control (left row)

The project

Niab employed EDT directION's hand-held in-line NPK sensors to study nutrient delivery in real time, which will in turn enable fertiliser formulations to be adjusted more readily to better match demand with supply.

The nitrogen demand model was adjusted for a Malling Bella primocane raspberry crop, to account for the biomass produced per hectare including the number of canes produced per pot and the planting density. The work also considered if current fertiliser recommendations are sufficiently accurate for modern production systems, whilst assessing the purity and consistency of made-up fertiliser formulations and consistency of fertigation delivery.

Results

Using the nitrogen demand model during the vegetative phase of growth, nitrogen inputs from the model were compared to a commercial control. Total seasonal Class 1 yields of 5.2 kg/pot were picked from the control compared to 5.0 kg/pot from the nitrogen demand model. The model gave rise to water savings of 35% and nitrogen savings of 48% over the season compared to the commercial control. Dry matter (cane and leaf growth) production was lower under the nitrogen demand model in July and August.

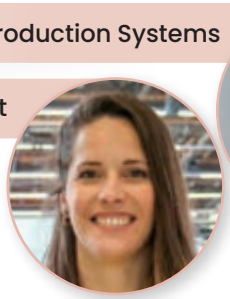
In testing the in-line NPK sensors for checking the feed solutions being delivered (Figure 2), they were found to offer accurate and precise quantification of N and K concentrations with P concentrations measured using a two-step manual process. Measurement kits were launched by EDT directION for commercial use by growers in 2024.

Any future work will need to quantify any legacy effects of low-N treatments in subsequent cropping seasons, identify the optimum planting density or number of canes per linear metre of crop row in commercial production, whilst also automating real-time measurements of NPK and Ca. In addition, growers will need help and support to implement low-input growing of commercial varieties and this would require testing the nitrogen demand model on commercial sites, monitoring its performance and developing a user-friendly version for growers. We are also beginning to quantify the impact of low-nitrogen treatments on nitrous oxide emissions.

Figure 2. Nutrient delivery systems used for Malling Bella

Mark Else, Head of Crop Science & Production Systems

Katia Zacharaki, TCEA Soft Fruit Specialist



Maximising strawberry yield potential

Title: Optimising the propagation environment in TCEA systems to maximise strawberry yield potential in all production systems

Funder: Defra Farming Innovation Programme

Industry partners: Vertical Future, Berry Gardens Growers Ltd, The Blaise Plant Company Ltd, Cocogreen Ltd, Clock House Farm Ltd, Delta T Devices Ltd, Hugh Lowe Farms Ltd, Linton Growing Ltd and University of Reading

Term: June 2023 to May 2026

In recent years, Niab has been experimenting with strawberry production (Figure 1) in Total Controlled Environment Agriculture (TCEA) growing systems using the new growth chambers at East Malling that were built with funding from Growing Kent & Medway, The East Malling Trust, and Kent County Council. We have more than doubled the yield expected from the commercially grown everbearer varieties Malling Champion and Malling Ace by providing optimum light, temperature, and humidity over a period of 12 months in these controlled growth chambers. In our earlier work, the Class 1 yield recorded per plant in Malling Champion averaged 2.6 kg, but varied from 1.6 to to 3.2 kg, despite being grown in the same way under these optimum conditions. If all of the plants consistently yielded 3.2 kg, the impact on fruit production and resource use efficiency could be huge, and so we have turned our attention to developing new ways to improve the consistency of propagule quality.

The project

Working with a multi-disciplinary team of researchers, technology companies, and growers, Niab aims to develop a method to produce high quality, virus-and disease-free strawberry plant propagules in TCEA systems with assured high cropping potential. The experiments begin with tissue-cultured plants, which are then raised to become the so-called "mother plants." These mother plants have been grown in Vertical Future's prototype strawberry propagation facility at East Malling using LED lighting, with the aim of accelerating runner production and generating healthier daughter plants in a more consistent environment. The daughter plants have been planted in coir substrate and moved to a second compartment, where they have undergone flower induction treatments before being exposed to chilling conditions.

Results so far

The project will compare the marketable yield and fruit quality of these high-health plants with those from commercially-propagated plants provided by our partner propagators. These comparative trials will take place in 2025 in three production environments: conventional polytunnels, glasshouses, and TCEA systems.

Figure 1. Strawberry appears to be an ideal candidate for vertical farming

Mark Else, Head of Crop Science & Production Systems

Niab Plum Demonstration Centre – the highlights

Since 2022, the Plum Demonstration Centre at East Malling has been funded by an industry consortium (Figure 1) of plum growers and marketing agents, who have taken an active role ensuring that the work is of direct relevance to the sector. Of greatest interest to the consortium have been a rootstock/tree architecture demonstration orchard, a tree management area where different pruning approaches and efficient irrigation scheduling have been demonstrated, and a variety trial area where 23 new selections and varieties were planted to extend the season of production.

Rootstock/tree architecture demonstration

This orchard was the first to be planted at the PDC in 2016, so yield data has been gathered since the first fruit was picked in 2017. The orchard was planted with 10-tree unreplicated plots of Victoria on four different rootstocks (Wavit, VVA1, St Julian A and Pixy) using four different tree architectures (Narrow A Frame, Narrow Table-Top, Super Spindle and Oblique Spindle).

The Narrow A Frame and Narrow Table-Top trained trees were planted at a density of 2,381 trees/ha, while the Spindle trees were planted at half the spacing, and so double the density at 4,762 trees/ha. Three of the rootstocks (Wavit, St Julian A and Pixy) were planted using all four training systems, but VVA1 was only planted on Super Spindle and Oblique Spindle training systems. In addition, two single rows were planted on St Julian A rootstock using one row of Fan training and one row of Candelabra training. As the original orchard planting design was not fully replicated, yield data could not be analysed statistically.

The accumulated yield data has been gathered over seven seasons, although no fruit was picked in 2021 following complete flower loss as a result of 16 frost events in April 2021. Of particular note, the top three highest accumulated Class 1 yields per tree to date have been recorded on Wavit/Narrow A Frame (56 kg), St Julian A/Narrow Table-Top (51 kg) and Wavit/Narrow Table-Top (48 kg) systems, all at a tree density of 2,381 trees/ha. However, as they are planted at twice the usual tree density, the highest accumulated marketable yields per hectare to date have been recorded on Spindle trained trees including VVA1/Oblique Spindle (38 kg/tree), Pixy/Super Spindle (31 kg/tree) and St Julian A/Oblique Spindle (28 kg/tree).

Figure 1. Work at the centre has been funded and governed by a consortium of plum growers

Of the two single rows of Victoria on St Julian A rootstock, the Fan system (Figure 2) produced an even higher Class 1 yield per tree than any of the replicated plots (85 kg/tree) which equated to the fourth highest yield per hectare (1,587 trees/ha), while the Candelabra system produced 53 kg/tree at the same tree density.

The average fruit fresh weight was compared in 2023 when all trees were fully mature, with fresh weight ranging from 40.3 g to 56.8 g per fruit. Victoria on the VVA1/Oblique Spindle recorded the highest fruit weight as well as the highest accumulated yield per hectare.

When interpreting this data, growers should be aware that it is not statistically robust and should also note that, despite producing high yields per hectare using the Spindle training system, a number of VVA1 rootstocks died either during establishment or in the early years, whilst all of the other rootstocks prospered. Growers should also weigh up the benefits of the high yielding Spindle

Figure 2. A single row of fan trained plums performed well

system against the increased establishment costs incurred using double the density of trees, along with additional picking, pruning and maintenance costs. Insufficient funding was available to record and compare the pruning and tree management costs of each system.

Pruning and tree management

A more recently planted orchard including Victoria, Malling Elizabeth (formerly P7-38) and the early Malling selection P6-19, all on Wavit rootstock, was established at a closer row spacing so it could be covered by polytunnels. A total of eight rows (four Victoria, two Malling Elizabeth, two P6-19) were covered with four tunnel bays. Originally designed to demonstrate the benefits of protecting plums on fruit quality, the consortium has preferred to use it to compare pruning techniques and more efficient sensor-driven irrigation scheduling techniques.

All eight rows are supported on a post and wire system and trained as a hedgerow. In the early years after establishment, the trees grew very strongly so the consortium worked with Niab farm manager Luis Felgueiras to reduce the vigour using a combination of hand pruning in May and root pruning, which was carried out in February before bud break.

In seeking to reduce tree management costs using hand labour, the consortium compared the impact of hand pruning in late spring (May) with mechanical pruning of the sides and tops of the canopy above the top support wire. In 2022, this mechanical hedge pruning was carried out on a single row of Victoria in the second week of July following the longest day, and this stopped all growth for the remainder of the year. In 2023, this row had the most balanced growth, best fruit set, and highest marketable yield of all the rows in this orchard. The other rows had been left unpruned until May 2023, when hand pruning aimed to reduce tree height to the top wire, remove upright and over-vigorous growth, remove bare unproductive wood, tie down branches where appropriate, and return the rows to an A-shape where the tree structure had been lost.

In 2023, the same Victoria row was pruned mechanically after harvest, whilst pruning of the other rows was delayed until May 2024. By summer 2024, although the growth of the mechanically pruned row was balanced, there was less fruit set, particularly lower in the canopy. In contrast, the hand pruned trees had a better set of fruit, primarily forming on the outer canopy which had formed during the 2023 season. This demonstrated that although hedge pruning the outer canopy saves on labour costs, if insufficient new growth has formed in the centre of the canopy, growers run the risk of reducing yield potential. The consortium agreed that where hedge pruning is used in future, hand thinning unproductive wood between trees in the crop row is essential to encourage the development of new fruiting wood.

In 2023, the new variety Malling Elizabeth had become over-vigorous, but following root pruning in February 2024, tree vigour was significantly reduced and gave rise to a much more open canopy with better light interception. The fruit set was rather light, but the best fruit was found on wood that was growing at a horizontal angle rather than on more up-right vigorous growth.

Irrigation scheduling and management

Niab has done extensive work on irrigation scheduling techniques to improve water and fertiliser use efficiencies in apple, pear and sweet cherry, but little has been done on plum. To inform their irrigation strategies during fruit development and cropping, the consortium wanted to assess how far the soil could be dried before yield or fruit quality began to decline.

Initial work in the uncovered tunnelled area has been done by installing soil matric potential sensors at a depth of 15 cm, 30 cm, and 45 cm under representative trees (Figure 3). Soil matric potential values were averaged across the rooting zone, and irrigation (and fertigation) was initially triggered at a soil matric potential value of -60 kPa (a measure of how hard the tree roots work to remove water from the soil) across the rooting zone. This irrigation threshold was then gradually lowered through the season to a value of -100 kPa, then further to -150 kPa. No negative impact on yield or fruit

quality was recorded at this matric potential.

Further work to improve our understanding of precision irrigation and nutrition of plums is required and the consortium is also interested in learning how to improve production efficiency and lower emissions in plum growing. At the time of writing, the team at Niab East Malling is working with some consortium partners on a new three-year IUK-funded project led by Norton Folgate Ltd, the aim of which is to improve water and fertiliser use efficiency in stone fruit production by developing real-time sensor systems to help to manage and mitigate the risks of low-input growing practices.

Variety trial

The most recently planted orchard at the PDC is a variety trial. Containing 23 varieties and numbered selections (Figure 5) that spread the season from early July to October (Figure 4), yields per tree were recorded in 2022 and 2023. Average accumulated yields per tree were recorded over seasons 2022 and 2023 from 11-16 trees of each variety. The highest three yields have been produced so far from Tophit (31.3 kg/tree), Jubileum (20.5 kg/tree) and Victoria (20.1 kg/tree) although it is unwise to draw conclusions from only two years of data.

Figure 3. Fruit Focus visitors learn about the systems being employed to manage soil water

Figure 4. Twenty three different varieties have been assessed including the late variety Haganta

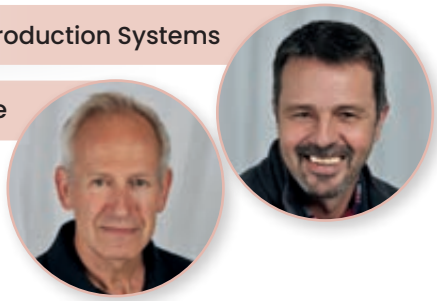
Figure 5. Varieties in trial at the Niab Plum Demonstration Centre

Variety	Cropping season
Herman	Early July
Katinka	Mid July
Malling™ Elizabeth	Mid July
Juna	Mid July
Meritare	Late July
P6-19	Late July
Opal	Early August
Lancelot	Mid August
Avalon	Mid August
Jubileum (Jubilee)	Mid August
Reeves	Mid August
Ferbleue	Late August

Variety	Cropping season
Top Five	Late August
Victoria	Late August
Haroma	Early September
Seneca	Early September
Marjory	Early September
Top Taste	Mid September
Coe's Golden Drop	Mid September
Laxton's Delicious	Mid September
Top Hit	Mid September
Haganta	Late September
Top End	Late September

Mark Else, Head of Crop Science & Production Systems

Trevor Wignall, Operations Manager, The WET Centre



Niab's WET Centre provides useful legacy for soft fruit growers

After eight years of statistically-robust research and demonstration activity (Figure 1), the precision production of soft fruit at Niab's WET Centre drew to a close in 2024. Set up in 2017 following extensive water use efficiency research at East Malling, the WET Centre has successfully led the industry in responsible and efficient use of water whilst showcasing the latest irrigation and tunnel technologies and investigating ways of improving resource use efficiency and productivity.

Early work demonstrated that water savings could be achieved by using precision irrigation (PI) tools, a sensor-based, fully automated system that consistently supplies sufficient water to achieve a target run-off volume from coir bags or containers, and ensures that plant demand is met with supply at different developmental stages and in variable weather.

With commercial strawberry growers typically irrigating substrate-grown crops to 15-20% run-off (Figure 2), the Centre has demonstrated how growers can reduce their total water use each season by up to 33%. This has been achieved by employing PI that relies on some of the most advanced technology, allowing us to reduce the level of run-off to less than 5% of input volume without any significant difference in Class 1 yields or any compromise in fruit quality.

Precision irrigation has also been combined with rainwater harvesting and re-use, to enable the Centre to achieve 90% self-sufficiency in water (Figure 3), even in very dry summers such as 2018. This not only improves local water security, but also reduces the volume of acid needed to acidify rainwater compared to mains water. Its use also reduces water flow from polytunnels, improves humidity control within the tunnels and lowers the risk of soil erosion and compaction.

Research carried out at East Malling between 2011 and 2013 showed that the UK industry average use of water for an everbearer strawberry crop amounted to 82 m^3/tonne of Class 1 fruit produced. Typically, at the WET Centre, a figure of 43 m^3 has been achieved through PI and at best it has been lowered to 34 m^3. A more recent grower survey in 2023 showed that the most efficient grower had used 60 m^3 for an everbearer crop, demonstrating industry improvement since the Centre was set up.

All of this progress was achieved with the help of the WET Centre partners who have provided funding and access to the latest available technology. Berry Gardens Growers Ltd, Cocogreen, Delta-T Devices and Netafim UK Ltd have been an

Figure 1. The Centre has demonstrated precision production to the industry

Figure 2. Measuring run-off from bags at the WET Centre

Figure 3. Precision irrigation has been combined with rainwater harvesting and re-use to achieve 90% self-sufficiency in water

integral part of the Centre since its inception along with original partner New Leaf Irrigation, and they were later joined by the AHDB, Yara, Stoller and associate partners H. L. Hutchinson and Weatherquest, all taking an active role in shaping the work of the Centre. In addition, the rainwater harvesting system and work was funded and supported by Kent County Council.

A crucial feature of the WET Centre has been the division into a 'commercial area', which mirrors typical commercial practice, and an 'advanced area', which incorporates the latest technologies to more precisely control the polytunnel phytoclimate. Not only have visitors to the site viewed this in action, but our scientists have been 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.

Having highlighted methods of using water more efficiently, attention turned to maximising yield potential from everbearer strawberry plants. Comparisons between the commercial and advanced areas demonstrated significant differences in marketable 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 height 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 1ºC reduction in temperature in June and July and up to 7ºC in August 2020, and so the improved internal climate control from auto-venting could have significant benefits in terms of cropping potential in hotter years. In addition, since manual venting of tunnels is time-consuming and therefore expensive, auto-venting could also help to lower labour costs.

In each growing season, a strong correlation between light availability (Figure 4) and Class 1 yields was recorded in everbearer varieties. This was particularly noticeable when comparing seasons 2020 and 2021 - exceptionally high PAR throughout the 2020 season led to 50% higher yields in Malling Champion compared to 2021 when the accumulated PAR over the growing season was much lower. Differences in PAR were also recorded within tunnels, leading to Class 1 yields differing by as much as 12% in rows just two metres apart within one tunnel bay - this equates to a yield differential of over 11 tonnes per hectare.

As a result of higher levels of PAR being recorded in the middle rows of a six-row tunnel bay, Rows 3 and 4 produced the highest Class 1 yields and the outside

rows (1 and 6) the lowest. The efficiency of photosynthesis was highest in Row 4 and also higher in the morning than in the afternoon. Row 1 on the eastern side was also found to produce higher yields than Row 6 on the west, due, we think, to higher PAR in the morning when photosynthetic efficiency was at its highest. In an attempt to increase yields in Row 6 to match those in Row 1, additional LED lighting was installed in 2024 and applied every morning between 5 and 9 am during cropping. The effects of this treatment on cropping potential will be quantified in future work.

In the final three seasons the everbearer strawberry Malling Ace was used for demonstration at the Centre. In contrast to Malling Champion which was planted at a density of eight plants per metre in a staggered layout in the coir bag, the density of Malling Ace was reduced to six plants per metre, planted in a single line. Commercial grower experience of planting Malling Ace at this lower density had unexpectedly resulted in higher yields per plant. Lower density planting also improves air movement around the plant, reducing humidity, and leading to improved control of powdery mildew, to which Malling Ace is sensitive. In 2023, another low light year, the plants produced an average of 1 kg per plant, and despite some early symptoms of powdery mildew being identified during weekly crop monitoring, a spray programme relying on products with both preventive and curative properties, ensured that little fruit was lost to the disease.

Other studies have taken place during the lifetime of the Centre to compare strawberry bag colour, tunnel polythene, and dripper numbers in strawberry bags. Class 1 yields were found to be 5% higher in white Cocogreen bags compared with black Cocogreen bags. Class 1 strawberry yields were found to be 16% higher under clear polythene compared to yellow polythene, a result that reflected the history of higher yields being achieved under higher light levels. In work with Malling Ace planted at the lower density of six plants per metre in a line, bags with seven drippers produced higher yields (15 g more Class 1 fruit per plant) than those with five drippers, but seven drippers used 3.2 litres more water per plant (10.5% increase). However, these results were not statistically significant so should be interpreted with caution.

The WET Centre has led the industry to reducing the average water use per tonne of fruit produced, it has generated benchmark data for realistic net-zero targets, and also delivered benchmarking for comparative performance of other growing environments including glasshouse and total controlled environment agriculture or vertical farming systems. It has also successfully developed more precise growing conditions to maximise yields and fruit quality, and coupled with rainwater harvesting has demonstrated ways in which local water security can be improved. Identifying how important light is to productivity has led to further Niab research to develop improved propagation systems for maximising propagule quality and cropping potential of strawberry.

Figure 4. Measuring photsynthetic activity

Belinda Kemp, Viticulture & Oenology Research Leader

Supporting the UK grape and wine industry

With the continuing planting of new vineyards and the corresponding expansion of the UK wine industry, Niab has responded by developing a research facility to support the needs of UK grape growers and wineries. Overseen by Niab viticulture and oenology research leader Belinda Kemp, the aim of our applied research is to determine sustainable grape growing and winemaking techniques, while improving juice and corresponding wine quality. We have been liaising closely with the UK wine industry to develop new research projects whilst promoting the results of a Defra funded project to investigate the potential impact of groundcover management practices in commercial vineyards.

Research vineyard and Wine Innovation Centre

Planted in 2015, the Niab research vineyard at East Malling (Figure 1) is used for scientific and demonstration purposes. The vineyard has been set up as a showcase vineyard that represents best practice viticulture, and to trial innovative approaches to grape growing. It has recently been restructured with in-kind help from VineWorks and now contains the varieties Bacchus, Chardonnay, Divico, Pinot Blanc, Pinot Meunier and Pinot Noir, with the rootstocks 3309C, SO4, 5BB and 101.14. Pinot Iskra and Pinot Kors, two Italian disease resistant grape varieties are being planted in 2025.

Results of the Defra funded project on groundcover management practices can be found in the article opposite.

A new Growing Kent & Medway project has recently begun called *VineAI: Artificial intelligence for fungal disease management*. Early detection of fungal diseases in vineyards is crucial if growers are to prevent disease spread and reduce the number of crop protection products used to manage the problem. Conventional crop monitoring by vineyard managers using human eyes does not always identify problems quickly enough. In this project, Deep Planet is working with Niab and four UK vineyards Chapel Down, Gusbourne, Nyetimber and Rathfinny Wine Estates, using satellite imaging and machine learning, to accurately detect and predict early infections of Botrytis, powdery mildew and downy mildew (Figure 2).

Figure 1. Niab's research vineyard at East Malling

The Wine Innovation Centre was built with funding from Growing Kent & Medway, Kent County Council and The East Malling Trust, who have also purchased state-of-the-art fermentation tanks (Figure 3 – overleaf) and a unique grape juice and wine chemical analyser called a SPICA (the only one in the UK) for the laboratory. Two new oenology projects have begun in the past year in the Wine Innovation Centre.

Enartis is funding a new research project focused on Chardonnay base wines destined for sparkling wine production. Incidences of calcium tartrate crystals have

Figure 2. We want to identify downy mildew as early as possible

become more frequent around the world, especially in sparkling wines. Calcium levels of 60-80 mg/l can result in crystal formation but the precise circumstances such as chemical composition of the wine, ambient temperature range, and storage conditions remain unknown. Calcium levels can increase during production due to various factors that include the initial calcium levels in the juice, calcium level in the winery water, chemical de-acidulation using calcium carbonate if juice is not filtered, and some bentonite products that contain calcium, although other compounds like malic acid reduce the incidence of crystallisation. Enartis is funding Niab to compare six different treatments before and after fermentation to assess their impact on calcium concentrations and therefore the likelihood of calcium precipitates forming. The crystals that result from calcium precipitation can be mistaken for glass shards by customers, and therefore can be the cause of a product recall and the wines removed from the market.

Figure 3. Preparing fermentation tanks for our research projects

Lallemand is funding a project to investigate if acid management techniques used in the UK influence the flavour of English Chardonnay still wine. Seven acid management methods are being compared to a control. These include chemical de-acidulation, co-inoculation of different lactic acid bacteria during alcoholic fermentation as well as sequential bacterial inoculation, which is after alcoholic fermentation. The resultant research wines will be tasted at the Niab Wine Clubs and winemakers will identify and quantify flavour differences.

To disseminate our research results and increase viticulture and oenology knowledge transfer with the UK wine industry, Niab Vine & Wine Clubs have been set up. Details of the clubs can be found on niab.com.

Flora O'Brien, Root and Soil Biologist

Crop cover research

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

Funders: Defra Farming Innovation Programme, Innovate UK and The East Malling Trust

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

Term: May 2022 to October 2024

Niab's soil scientists are increasingly aware that poor soil health can give rise to inconsistent grape yields and juice quality, which can lead to costly interventions in the vineyard and winery. Cover crops could play a significant role by enhancing soil health through their effects on soil carbon content, hydraulic conductivity, biodiversity, and soil structure.

The project

Niab has investigated the potential impact of vineyard groundcover management practices by comparing soil health, vine growth and juice quality between a range of inter-row cover crop treatments, as well as different under-vine management strategies comprising herbicide applications, a mechanical method (under-vine cultivation), and a control using weed strimming alone. The comparisons were made on three sites including the East Malling Research Vineyard and two commercial vineyard sites at Chapel Down and Gusbourne. The cover crop mixes included phacelia, faba bean, an annual mix of rye and vetch, and a perennial mix

containing creeping red fescue and three clover species. The control treatment consisted of alleyways that were maintained as before, with natural/spontaneous vegetation that is regularly mown. Hot and dry conditions in 2022 resulted in poor establishment of the cover crops, so work was done in that year to compare different methods of sowing and management. Better conditions in 2023 allowed improved establishment enabling comparisons to be made between the crop cover mixes, and the project was extended into 2024 to acquire an extra season of data.

Results

In 2023, some statistically significant results were recorded in the faba bean plots (Figure 4) which established particularly well on all sites. There were significantly higher concentrations of soil phosphorus (P) in the faba bean treatment at both the Gusbourne and Chapel Down sites relative to the control, but no differences were found at East Malling. Potential benefits of increased soil P includes enhanced tolerance of the grapevine to copper toxicity, and, in some instances, increased number and weight of clusters and berries. However, it will need careful monitoring since excess soil P can have a negative impact on berry quality.

Other trends have appeared over 2023 and 2024. In both years, although not statistically significant, soil nitrate levels in the faba bean plots were much higher than in the control plots at both Gusbourne and East Malling and the same increase was seen on all three sites in 2024 in both faba bean and phacelia plots (Figure 5).

On all three sites, soil moisture levels were lower in all the crop cover treatments compared to the control, suggesting that soil aeration could be improved where crop covers are planted.

In 2023, chlorophyll levels in vine leaves were significantly higher in vines adjacent to faba bean alleyways at both Gusbourne and Chapel Down and, and this same trend was observed at East Malling in 2024.

The effect of cover crops on vine canopy varied between years, but there was a trend toward higher vigour in vines adjacent to faba bean and phacelia at all three sites in 2024. It is surmised that this may have resulted from the additional nitrate measured in these plots. In addition, the annual mix of rye and vetch at East Malling and Gusbourne was associated with increased vigour in 2024. This may require additional management interventions to limit the increased disease pressure and reduced grape juice quality that can result from high vigour.

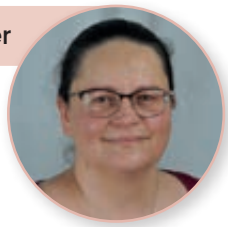
In terms of grape juice quality, significantly higher levels of yeast assimilable nitrogen (YAN) was recorded in grapes from vines adjacent to the faba beans at Gusbourne compared to the control in 2023. This may be attributed to the nitrogen-fixing capacity of the beans resulting in greater nitrate availability to the vines. In 2024, there were trends showing higher YAN content in all crop cover treatments than in the control treatment, although the increase was not statistically significant.

It should be stressed that we cannot draw firm conclusions from these results as the findings were not repeated in both years of the trial and in some cases, only trends have been recorded. However, the work has demonstrated that cover crops can benefit several aspects of soil health (improved nutrient content, better water management) and the vine (e.g. chlorophyll content, YAN). Vine growers considering using cover crops are encouraged to think carefully about how best to establish them, seek guidance from others who have experience of using them and be patient in the early years.

Figure 4. Faba bean plot at East Malling

Figure 5. Phacelia growth at Chapel Down

Feli Fernández, Senior Plant Breeder



Supporting the industry through genetic research

Niab has supported the fruit industry for many years through its various breeding programmes which have delivered new apple and pear rootstocks to the industry along with new varieties of all tree fruits and soft fruits. We have recently embarked on a Defra funded project with ADAS and the James Hutton Institute called the 'Soft fruit genetic improvement network' (GIN) to develop new breeding tools to support privately funded soft fruit breeding programmes. Some of our latest genetic research has included management of the East Malling Rubus Breeding Consortium and a Growing Kent & Medway funded project to speed up the process of breeding new apple varieties.

Celebrating the achievements of the East Malling Rubus Breeding Consortium (2015-2025)

The East Malling Rubus Breeding Consortium (EMRBC) was established in 2015 as a commercial partnership with major UK and international businesses with the shared goal to develop new varieties of raspberries and blackberries for both amateur and professional markets. Over the past decade, the breeding programme has aimed to enhance fruit quality, shelf-life, yield, fruit size, and adaptability to various growing conditions in raspberry and to develop a pipeline of blackberry germplasm with similar objectives in mind.

The consortium was set up to exploit the pre-existing pipeline of material resulting from uninterrupted raspberry breeding at the East Malling site since 1920, and to build on the 2013 Niab East Malling/Lubera partnership to develop garden varieties.

Developing new berry varieties is a long process that begins with thousands of seedlings from selected parents being raised and selected and subsequently trialled according to agreed breeding objectives. Blackberry breeding was initiated within the consortium in 2018, at the specific request of the commercial partners. Since then, the programme has dedicated 25-30% of effort and budget to this crop but the pipelines for both raspberry and blackberry are at very different stages.

Over the life of the consortium, around 23,500 raspberry and 5,500 blackberry seedlings have been raised. Progenies were generated every two years alternating between both crops with seedling numbers increasing from around 5,000 in the 2016/17 period to around 9,500 in 2022/23. The current pipeline includes, alongside unselected seedling populations, 300 raspberry and 39 blackberry preliminary selections and breeding lines, 39 raspberry and 15 blackberry selections in trial at Niab and 40 raspberries in propagation for first trials in 2025. In both crops, the material comprises both primocane- and floricane-fruiting germplasm with 50% of the breeding effort in

Figure 1. Malling Bella displays its fruit well to pickers

raspberry dedicated to double cropping types (i.e. late-season primocane-fruiting genetics that divide their crop between the first and second season of the life of the cane).

Key breeding objectives for raspberry include excellent fruit quality and shelf-life, high yield and large fruit size, simple cane architecture with ease of picking followed in importance by pest and disease resistance and environmental adaptation. For blackberry, the objectives also prioritise fruit quality, shelf-life and high yields of large berries but special attention has been given to selecting thorn-free material, especially for primocane types where most commercial varieties are still thorny.

The consortium has so far released two varieties for the professional market, Malling Bella (Figure 1) and Malling Charm. Malling Charm is still undergoing agronomical optimisation but Malling Bella has established itself as a very popular variety with around five million plants sold in the last four years. Demand for the variety continues to increase with orders in excess of two million plants for 2025. Malling Bella's success has been driven by the uptake from our partners in Spain where the variety is very well adapted to the climate, ensuring out of season supply to UK retailers. Currently, seven advanced selections are either under evaluation by UK growers or in the process of being made available for trials in the EU. Two of those are exclusively floricane-fruiting, three are primarily primocane-fruiting and two are double cropping types.

Other outputs from the project include seven varieties released by Lubera aimed exclusively at the garden market: Malling Passion, Malling Happy and Summer Chef (2018); Lowberry Baby Dwarf (2019); Abundance® Spineless Red, Schlaraffia® Plentiful® and Schlaraffia® Naschmich®' (2021) with more likely to come in the near future. Building on the success of the programme, Niab has also engaged with UK partners to deliver two related Growing Kent and Medway research projects and with the CTP for fruit crop research scheme to support a PhD studentship currently investigating the genetics controlling primocane fruiting.

Chambers Ltd (UK grower), Onubafruit SCA (Spanish cooperative) and Lubera GmBH (Swiss garden-market nursery) have been the core partners with Niab throughout the life of this project. Perfection Fresh (vertically integrated Australian fresh produce company) joined in 2016, Blaise Plants (UK propagator) joined in 2018 followed by Tobi Seeobst AG (Swiss marketing desk) in 2020. Two producer organisations, The Greenery B.V. (NL) and Berry Gardens Growers Ltd (UK) were also members between 2018 and 2024. As the project nears its conclusion in early 2025, Niab is talking to existing members and actively seeking new partners to continue building on the success of the EMRBC under a different corporate model.

Abi Johnson, Senior Plant Breeder

Speed breeding of apple

Title: Next generation apple breeding for resilient UK production
Funder: Growing Kent & Medway
Industry partner: Worldwide Fruit Ltd
Term: June 2023 to June 2025

The length of time it takes for apple seedlings to flower, coupled with the industry need to breed trees with resilience to a range of fungal diseases, is the focus of this project. Niab is working with Worldwide Fruit Ltd to evaluate a range of speed breeding techniques in an effort to shorten the breeding cycle for apple, whilst at the same time employing genomic markers to identify potential resistance prior to flowering. By combining techniques, it is hoped that the 20-25 year timeframe from crossing to the release of superior apple varieties, will be significantly reduced (Figure 2). Initial results suggest that this is possible but ongoing experiments need to be completed before any tangible results can be concluded.

Figure 2. Novel breeding methodologies might cut the time to release new apple varieties

Michelle Fountain, Head of Pest and Pathogen Ecology

Understanding the impact of landscape complexity on pest control and pollination: ecosystem services to strawberry

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

Funder: Defra SusCrop ERA-Net

Industry partners: Berry Gardens Growers and Avalon Fresh

Term: February 2023 to January 2026

Intensive horticultural practices which focus on expansive cropping with little consideration to a patchwork of habitats within a landscape, can lead to a homogenous growing environment which does not deliver ecosystem services and can require increased inputs to obtain pollination and pest control. In the past, fruit crop management has not always taken account of biodiversity and the ecosystem services provided to the grower on farms. The use of some crop protection products can disrupt non-target insects such as pollinators and natural enemies further exacerbating the production of poor quality fruits. With fewer authorised conventional spray products available than ever before, Niab researchers are increasingly working with growers and other industry partners to harness naturally occurring, introduced beneficial arthropods and biocontrol agents, to develop novel and more sustainable crop production strategies.

We understand that increased biodiversity on a farm can lead to more resilient ecosystems (Figure 1), which give more long-term assurance of pollination and pest regulation. However, these require a holistic understanding of the ecological mechanisms at work including understanding how landscape structure and complexity affect the supply of 'agroecosystem services', or put another way, the ability of the landscape structure to provide natural forms of pest and disease control.

The project

Niab is one of a European science partnership. The partners are investigating the effect of landscape complexity over time and land cover/productivity dynamics on the above and belowground ecosystem services in a range of European

Figure 1. Increased biodiversity on a farm can lead to more resilient ecosystems

Figure 2. Landscape heterogeneity shapes the composition of beneficial organisms

agricultural landscapes. Niab is leading the work package on insect diversity with a focus on the analysis of above-ground functional diversity.

Results to date

In the early stages of the project we developed and tested metabarcoding methodology for parasitoid and solitary bee identification and have started building a database of genetic information on parasitoids and bees that will be freely available in the open-access GenBank data repository. Using the technology, we have been monitoring changes to pollinator and parasitoid diversity across three landscape habitat configurations of varying heterogeneity. It was observed that parasitoid abundance and diversity varied between the sites suggesting that landscape heterogeneity (Figure 2) plays a pivotal role in shaping the distribution and composition of these beneficial organisms.

Across 18 commercial strawberry crops in England (including Kent, West Midlands and southern England), the work has identified 14 species of solitary bees in addition to bumblebees and honeybees. Five families of parasitoids have been identified emerging from aphid mummies, with those from the Braconidae family being the most abundant.

The most abundant and commonest species of parasitoid on a third of the sites was *Lysiphlebus testaceipes*, which is native to North and South America, possibly the first time it has been reported within the UK landscape. It is regarded as a species of warmer climates, but is now suited to the current UK climate. A hyperparasitoid wasp *Alloxysta chinensis* was also detected for the first time in the UK. These findings have significant implications for the development of sustainable pest management strategies that harness the power of natural enemies to reduce reliance on conventional spray products for control.

The generation of DNA barcodes for most collected samples in this project and their subsequent submission to the GenBank database represents a significant contribution to the growing body of genetic information on parasitoids and bees. This open-access resource will serve as a valuable tool in guiding evidence-based decision making in agricultural landscape management. The availability of these genetic data will also enable the development of more accurate and efficient monitoring tools.

The findings of the work will ultimately guide policy and actions on fruit farms to adapt to climate change.

Charles Whitfield, Crop Protection Scientist

Precision orchard management

Title: POME: Precision Orchard Management for Environment

Funder: Innovate UK: Defra and UKRI Farming Innovation Programme

Lead partner: H. L. Hutchinson

Industry partners: H. L. Hutchinson, The Acclaimed Software Company, Outfield, Fotenix, Antobot, NP Seymour, HSE Chemicals Regulation Division, Avalon Fresh, AC Hulme, Plumford Farm, University of Kent and Loughborough University

Term: October 2023 to September 2027

There is substantial variation between trees in commercial orchards in terms of vegetative growth and size, and even greater variation in yield. A previous Innovate UK project has developed a prototype orchard 'Precision Variable Rate Spray' system (Figure 1) that can take account of tree size and apply a measured volume of spray to match the size and canopy density of individual trees, thereby reducing overall spray use which can optimise orchard treatments and be beneficial to the environment. This was achieved by using LIDAR (LIght Detection And Ranging) scanning of trees to map their height and density. Specialised software was developed to calculate a variable rate prescription map from the canopy data. The software uses the prescription map to control individual nozzle output as the spray machine passes along the rows.

A key element of this system is that scanning of the trees is decoupled from the spraying, i.e. scanning can be done at a different time to the spraying. This means that the system can utilise a wider range of data sources and there is advanced knowledge of precisely how much product and water is required, but the system needs very accurate positioning to spray the right amount in the correct locations.

The project

The aim of the previous work was to prove that the concept could work. This new project will further develop techniques to quantify canopy density, fruit load and presence of pests and diseases, and calculate yield estimates and prescription maps to manage tree growth, crop load and spray application.

The scanning, data processing, and precision of the variable rate spray system are being advanced so that a wide range of crop management products can be applied with high levels of spray efficiency. The new system will be able to import data from many sources, such as aerial maps from drones and soil maps, enabling more advanced prescription maps to be developed.

Figure 1. Prototype precision variable rate spray system on display at East Malling

The aim is to develop a viable precision orchard management system that is ready for market in the next four years.

Results so far

The starting point was to gather data about the health and growth autonomously for every tree in an orchard, rather than relying on the agronomist or grower having to walk up and down rows looking for differences or potential issues. This is being collected in different ways including the use of tractor mounted sensors to identify any variations in tree health or development, use of drone surveying to map blossom intensity and fruit load of individual trees across the entire orchard, and also the use of robotic scanning from the ground for disease detection. The robot surveys will be done autonomously at night using

specialised lighting and cameras. The robot allows very high detailed scanning done at low speeds which would not be practical for a tractor-based operation.

These sources of data will be brought together into the software platform where it is analysed and interpreted to generate a prescription map of the orchard for a range of crop management products. This process could include areas of specific disease or variability in the size, density and crop load of individual trees – a major cause of sub-optimal yield and quality in commercial fruit orchards. By mapping and then treating these areas according to requirements the system will save inputs and improve the productivity of the trees.

In the first year of the project, a prototype sensor tower has been developed along with spray software that calculates three-dimensional prescription maps (dose adjustments occur in x, y, and z axes relative to the tree rows). The prescription maps can be created from crop parameters such as canopy density or blossom/fruit density. The sprayer then follows the prescription map, applying adjusted doses to sections of individual trees (Figure 2).

The commercial partners are continuing to develop their aerial survey and data analytics process so that they can feed better data into the spray software on the tractor. The results of this, when combined with additional data from the tractor and robot based surveys are being used to build new yield forecasting models.

Academic partners are developing software pipelines for generating extremely high precision digital twins of orchards which can be used for training machine learning models, and identifying subtle differences in the trees at high spatial resolutions.

Orchards are a challenging environment for robots to autonoumously navigate in due to the trees and other structures interferring with satellite signals and the lack of distinguishing features within orchards. A new solution for autonomous navigation in orchards is being developed (Figure 3), which will also enhance the tree surveys. In addition, a disease detection system has been developed which can be deployed on the robot and later the tractor. This will be tested on site at Niab and later on commercial orchards.

Figure 2. The sprayer applies adjusted doses to individual trees

Early spray deposition trials have been carried out to compare a standard constant rate sprayer with the precision variable rate sprayer. The results demonstrated that the variable rate sprayer was accurately following the prescription maps and generated significantly more uniform deposition in all canopy positions, but the mean deposition per leaf needs to be increased. The variable rate sprayer also dramatically reduced spray drift by more than 50% when compared to the constant rate sprayer.

The next stage of the project is carrying out further development of the precision spray system, including electronics, software, dose adjustment algorithms, localisation and sensors. More spray trials will be carried out to include fruitlet thinning and crop protection products. The robotic platform will be field-tested to assess its disease detection, whilst drone surveys will be carried out with high precision mapping of tree metrics. The initial yield forecast model will be tested and developed.

Figure 3. Antobot 'scout' robot collecting data to develop systems for autonmous navigation

Matevz Papp-Rupar, Plant Pathology Research Leader

Understanding the links between soil microbiome and carbon storage

Title: Exploring the links between soil microbiome and carbon sequestration in a cross-section of agricultural soils (arable, pastural, orchards)

Funder: Growing Kent & Medway Business Innovation Voucher

Industry partner: Verdant Carbon

Term: June 2023 to May 2024

Soils provide a natural sink for carbon dioxide but we need to improve our understanding of how the soil microbiome can be manipulated to improve soil carbon storage capability.

The project

Niab worked with Verdant Carbon in this Growing Kent & Medway project to understand the links between soil microbial abundance/diversity and the volume of carbon sequestered in different agricultural crops. They aimed to identify any correlations between levels of specific soil microbes and soil carbon content across the soil profile (10-60 cm) and between soil management practices (regenerative and conventional).

Results

In the project, soils were sampled at two depths (15-30 cm and 45-60 cm – Figure 1). Total soil organic/residual/inorganic carbon and soil nitrogen was determined at Verdant Carbon using the internationally recognised Dumas Combustion analysis method. Microbial analysis was done using Microbiometer and Soil Food web assessments at Verdant carbon, and state-of-the-art molecular tools (qPCR, amplicon sequencing) at Niab to determine the diversity and abundance of the bacterial and fungal species in the soil. The data was collected from both arable soils and pasture soils.

A comparison of fungal to bacteria ratio (F:B) obtained with different microbial analysis methods was done to determine if methods at Verdant Carbon agree with methods at Niab. The effect of farming type (arable or pasture), sampling depth and total organic content (TOC) on microbial abundance and diversity was measured to find potential associations between the quantity of carbon and microbial populations.

The ratio of fungi to bacteria (F:B) measured with Microbiometer and Soil Food Web analysis did not correlate with molecular measurement (qPCR), which was the only method that produced results in line with the literature.

There were greater numbers of bacterial and fungal communities found in the top soil (15-30 cm) compared to subsoil (45-60 cm). This effect was more pronounced in arable fields than pasture. Fungal communities were found to be richer in arable fields compared to pasture while there were few differences between bacterial communities on both farm types. The relative abundance of bacterial and fungal organisms was not affected by soil nitrogen levels.

The microbiome in arable fields was largely unaffected by various levels of TOC. In contrast the microbiome in grasslands was more affected by TOC with many fungal and bacterial species either increasing or decreasing in response to TOC. Among the species that significantly increased their relative abundance with increased soil TOC were potentially beneficial microbes (eg. nitrogen fixing and mycorrhizal fungi), but also some known pathogens such as *Ilyonectria robusta*, so it seems that increasing soil TOC levels could therefore have both plant growth promoting and disease promoting consequences.

This collaboration led to further IUK/Defra funded work where Niab and Verdant Carbon aim to develop a holistic soil biological health assessment.

Figure 1. Verdant Carbon sampling soil in field

Matevz Papp-Rupar, Plant Pathology Research Leader

Louisa Robinson-Boyer, Plant Microbial Interactions Research Leader

Seeking new management approaches to apple canker

Niab and other organisations continue to work to identify new control measures for apple canker, one of the highest research priorities for all UK apple growers. Caused by the pathogen *Neonectria ditissima*, apple canker can give rise to 10-20% tree losses per year in young orchards in the early years after establishment. In a recently completed project funded by AHDB, a Trichoderma-based biocontrol product and a conazole-based fungicide offered some decrease in canker incidence on infected trees. This was only effective when inoculum levels were lower and neither product is currently authorised for use on apple. Niab's latest two research projects have been revealing some useful results.

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

Funders: Growing Kent & Medway and The East Malling Trust

Industry partners: Agrovista and Avalon Fresh

Term: May 2022 to October 2024

Despite spending a significant number of years researching ways of controlling apple canker (Figure 1) using both conventional and novel approaches, control options continue to be expensive, time consuming and can have limited impact. Niab's Pest and Pathogen Ecology team at East Malling is increasingly seeking to harness existing ecosystems on fruit farms as an alternative way of gaining natural control of both insect pests and diseases of fruit crops.

The project

Partnering with Agrovista and Avalon Fresh in a Growing Kent & Medway funded project, Niab sought to amend the soil with microbial products to improve both the health of the tree and its resilience to withstand attack from pathogens such as *Neonectria ditissima*, the cause of apple canker.

Arbuscular mycorrhizal fungi (AMF) and two biological control products based on *Trichoderma harzianum* and *Trichoderma atroviride* were the chosen soil amendments. AMF are commercially available for use by growers. They have been extensively studied and are believed to improve soil structure, health and nutrient and water uptake enhancing tree health, tree growth and resistance to pathogen infection (biotic and abiotic stress). *Trichoderma harzianum* is currently approved for use on protected soft fruit crops under permanent protection full-enclosure structures to control fungal diseases.

Figure 1. Apple canker spreads rapidly and can lead to 10% of trees dying every year after planting

In contrast, *Trichoderma atroviride* is currently approved for use on apples to control canker, but as an overall spray application.

Two trials were set up, the first to investigate the use of commercial AMF and Trichoderma-based products applied to newly planted Gala orchards to assess their impact on canker development. The second trial was set up to assess methods of increasing the populations of AMF in established orchards with the hope that increased AMF would lead to increased tree health.

Results

Increasing resilience in newly planted orchards

Four planting sites were selected by Agrovista and Avalon Fresh on commercial farms that are prone to waterlogging and two further sites were chosen on a farm that is prone to drought. All trial sites, which had previously been cropped with apples, were planted in spring 2022 with 150-200 trees per site and treated at planting with an AMF product, a Trichoderma-based product or a combination of the AMF and one Trichoderma product.

The AMF product chosen was RootGrow, containing

six AMF species and supplied by PlantWorks UK, whilst the two Trichoderma-based products chosen were Trianum-P (*Trichoderma harzianum*) supplied by Koppert and Vintec (*Trichoderma atroviride*) supplied by Certis Belchim.

The roots of trees treated with a Trichoderma product were dipped in a 10 litre bucket containing a solution of the product for 2-3 seconds while mixing the solution. Trianum-P was mixed at 0.1 g/tree in 0.1 litre of water and Vintec at 0.2 g/tree in 0.1 litre of water. Inoculated trees were positioned in the planting holes and the remaining inoculum was poured directly on the tree roots in the planting holes at around 80-90 ml/tree.

AMF inoculum (RootGrow at 50 g/tree) was sprinkled over the wet roots pre-treated with a Trichoderma product. Where AMF was used alone, the roots were dipped in water before the AMF inoculum added, thus ensuring that the inoculum adhered to the roots.

In 2023 and 2024, at each site, the Niab team, along with industry partners Agrovista and Avalon Fresh, recorded canker incidence, tree mortality and tree growth every six months, and yield was recorded at the end of each season. All of the plots were compared to untreated control sites.

There were no statistically significant differences between AMF and/or Trichoderma amended trees and the unamended control. However, there were some very encouraging trends. Amendment with AMF alone, Trianum alone and AMF + Vintec all showed a reduction in tree mortality, and in the AMF + Vintec treatment by up to 50%. This reduction was most noticeable on sites with the highest tree mortality rates. The AMF treatments also consistently reduced mainstem cankers on all sites, with the AMF and Vintec treated trees displaying the greatest reduction, although different products delivered different results depending on the sites. The effect on peripheral and total number of cankers varied depending on the site and the canker load. There were no significant positive or negative effects on fruit yields between treatments. However, there was a significant difference between and within sites. All treatments caused a slight (not significant) reduction in tree growth in the first year after planting compared to untreated control, although this reduction was not present by year 2 .

Increasing AMF populations in established orchards

The team also assessed methods of increasing mycorrhiza populations in established orchards. The first involved planting specific wildflower species in the alleys that are known to support the growth of naturally occurring and introduced mycorrhiza, whilst the second inoculated AMF around existing tree roots using a modified root pruner with an attached stocks applicator,

Figure 2. AMF were inoculated on tree roots using Agrovista's modified root pruner

Figure 3. The wildflower mixes established very well on all of the sites assessed

developed by Agrovista (Figure 2).

Three mature orchards were chosen by Agrovista and Avalon Fresh, including two Gala and one Egremont Russet. In each orchard, wildflowers were sown in the alleyways either with or without additional AMF inoculum (RootGrow) and compared to a grass alley control. The wildflower mix contained ten species, eight of which are reported to have associations with AMF. The seeds were sown at a rate of 4 g/m^2 and where added, AMF at 2 g/m^2. In addition, separate tree rows were root pruned on one side either with or without added AMF (10 g/tree) applied continuously with the stocks applicator and compared to an unpruned control with grass alleyway.

A soil assessment of AMF propagules was made before the treatments were applied, followed by periodic assessments of AMF populations in the grass alleys, wildflower alleys and apple root zones. In addition tree girth, fruit yield and fruit quality were recorded over two seasons.

The wildflower mixes established very well on all of the sites assessed (Figure 3). The baseline assessment of the soils before treatments showed undetectable levels of AMF in all of the trial orchards. However, after two years, there were AMF propagules recorded across all of the treatments. Both wildflowers alone and wildflowers with added AMF increased AMF root colonisation in all orchards. No differences in AMF were detected in the apple root zone, but the roots analysed were from the base of the tree and further work is required before conclusions can be drawn on this.

Tree growth was found to be reduced by root pruning whilst root pruning and wildflowers alone both reduced fruit size and diameter. However, the addition of AMF negated any reduction in growth and restored fruit size and diameter to that recorded in the untreated control. All of the treatments significantly increased Brix levels in harvested fruit, particularly in the AMF plots.

Conventional canker treatment

In a final work package in this project, an assessment of the efficacy of a range of novel canker treatments was made over two seasons in a Gala orchard at East Malling with very high canker inoculum levels. The treatments included a range of plant protection products, biocontrol agents, biostimulants, resistance elicitors and some other commodity substances. All treatments were applied as sprays to the trees, between three and five times from the end of harvest until 100% leaf fall.

Two products including 'hydrated lime' (CaOH) and a new fungicide from Bayer showed promise. Further work is needed to develop a lime product that is both easier and simpler to apply. A similar low pH product produced by Omex is now being tested by Niab. A Bayer product is also being further tested to seek an EAMU authorisation.

When applied at leaf fall, none of the biocontrol products, biostimulants or defence elicitors offered any level of control, so further work may be required to consider alternative application timing for these.

Matevz Papp-Rupar, Plant Pathology Research Leader

Xiangming Xu, Director of Research

Title: Sustainable management of apple canker

Funders: Biotechnology and Biological Sciences Research Council and The East Malling Trust

Industry partners: Worldwide Fruit and Avalon Fresh

Term: October 2023 to September 2025

Niab has been investigating the exploitation of endophytes to manage apple canker, 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). Further work needs to be done to identify endophytes that offer control of apple canker.

Another lead worth following up relates to symptom development on different growing sites. It has been noted that trees propagated in the same field of the same nursery have exhibited very different levels of canker development when grown on different farms and planted in different fields. Niab is keen to compare the soil characteristics such as pH and nutrient levels of different sites to understand if soil conditions are influencing canker development.

The project

In this BBSRC funded project, Niab is studying a bacterial endophyte from the genus *Sphingomonas* associated with both scion genetics and canker tolerance. *Sphingomonas* bacteria

are also known to promote plant growth. In addition, Niab is trying to understand if endophytes persist from season to season or whether repeated application is necessary every year.

The soil investigation work is funded through this BBSRC project along with additional funding from British Apples and Pears Ltd (see new projects section). Niab is investigating the links between mainstem canker incidence (likely from latent nursery infections) in commercial orchards and soil pH, organic matter and macro/ micro nutrient levels. This could help growers to select sites with lower risks to canker development during tree establishment.

Results

The bacterial endophyte research is currently in progress and no results are available at the time of writing.

Throughout the soil work, with the help of the apple growing community, we considered 160 orchards from 12 different farms which varied considerably in varieties and age. We selected 80 orchards, including the varieties Gala, Braeburn, Jazz and Cox which were all under 15 years of age. In each orchard we assessed levels of canker across a grid iron area of the crop and selected five trees with the highest levels of canker and five with the lowest levels. We sampled soil under each of these trees to identify what might be responsible for the differences in canker incidence. After analysing each soil sample, we tried to correlate soil parameters with canker incidence.

The study indicated that several soil parameters may be affecting the level of apple canker in apple orchards. Increases in soil calcium (Ca), cobalt (Co), copper (Cu) and phosphorus (P) levels were all associated with higher canker. In contrast, increases is soil pH, sulphate (SO_4) and zinc (Zn) were associated with lower canker levels. These results may provide new ways to manage apple canker through soil nutrient management. The evidence however, is not yet strong enough for this result to be included in new management practices. To achieve that, we need to analyse many more orchards across different farms, management regimes and soil types.

PEST AND PATHOGEN ECOLOGY

Xiangming Xu, Director of Research

Advancing knowledge of apple replant disease and its management

With the recent increase in apple fruit wall production systems (Figure 1) on old orchard ground, there has been a corresponding increase in apple replant disease (ARD) which has significantly reduced the financial returns in the early years after establishment. 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.

Past research has shown that fumigating affected soils with broad-spectrum biocides has given rise to significant increases in growth of young trees compared with non-fumigated plots, suggesting that the cause of the disease is a biological rather than a physical problem in the soil. It is now generally accepted by scientists that ARD is a disease-complex primarily caused by microbial pathogens. The oomycete pathogens *Pythium* and *Phytophthora* along with the pathogenic fungi *Cylindrocarpon*, *Rhizoctonia* and *Fusarium* are all thought to contribute to ARD across the world. The presence of parasitic nematodes can also exacerbate ARD severity, probably because the nematodes damage the roots, facilitating infections by pathogens.

The pathogens associated with ARD show limited spread in the soil so that trees planted in the former grass alleys of old orchards are less affected by ARD. Modern ARD management strategies are therefore based on a combination of rotating tree placement in the orchard and biological soil amendments with microorganisms that improve root growth during tree establishment. In the past decade, led by Xiangming Xu, Niab has secured a number of grants from BBSRC and the EU to investigate ARD biology and develop alternative management strategies.

Figure 1. Apple fruit wall systems are commonly established on old orchard sites

Figure 2. Replanting in the alley of a previous orchard improved establishment

Figure 3. Recording tree girth expansion

Causal agents vary with site

Some of our work has focused on identifying the pathogens causing ARD. A technique employing high throughput sequencing was used to compare soils from neighbouring pairs of healthy and ARD-affected trees at several sites. The candidate causes of ARD appeared to vary greatly between locations. In one orchard, *Pythium intermedium* was identified as the candidate pathogen – which has previously been reported as a causal agent of ARD in the USA.

In another orchard, no pathogen was identified, but an abundance of arbuscular mycorrhizal fungi (AMF) were found to be associated with healthy trees. Similarly soils around healthy trees in two Dutch orchards had a much higher abundance of plant growth promoting rhizobacteria (PGPR), than in ARD-affected trees.

In another dessert apple orchard, when comparing soils around the tree stations with adjacent soils in the grass alley, the pathogen *Ilyonectria macrodidyma* was found in the tree rows but not the alleys. The soil microbiome of both areas was also found to differ significantly.

Further work was done to investigate the effects of one or more pathogens of the ARD complex on several selected rootstocks with contrasting characteristics, focusing on; 1) the nature of the interactions between putative ARD causal agents and ARD severity, and 2) whether rootstock characteristics modify ARD severity. It was found that controlling all three ARD components (oomycetes, fungi and nematodes) led to the best root development. Rootstocks did not affect the extent of root necrosis, but significantly differed in their root volumes.

Developing alternative management strategies

Attention turned to assessing three different management strategies to combat ARD:

1. Using a rootstock different from the previous one
2. Replanting trees in the alley instead of the original tree stations
3. Individual and combined use of AMF, biopesticides and PGPR products.

Work on rootstocks demonstrated that trees planted in the same tree stations as the previous orchard using the same rootstock or one with closely related parentage, displayed more severe ARD symptoms.

Replanting trees in the alley of a previous orchard (Figure 2) significantly improved tree establishment and growth in the first six years compared to planting in the previous station. Recorded tree girth expansion (Figure 3) was consistently higher for trees planted in the alley. Overall, the impact of changing the planting location on ARD severity was more profound than rotating rootstocks.

In work to assess the use of soil amendments, the combined use of AMF (*Diverspora* sp.) and biopesticides (one fungal and one bacterial), when applied to the soil at planting, led to nearly 22% increase in annual tree girth expansion compared to the unamended control. The individual products did not interact with each other. Amending with PGPR at planting time had no significant effect. In one season only, both AMF and biocontrol amendments led to increased fruit numbers and marketable yield.

New research

With support from Frank P Matthews and the National Association of Cider Makers, Niab has recently secured funding from BBSRC to continue our research into developing an integrated strategy based on a holistic approach to minimise ARD at planting by combining the use of previous alleyway planting, a rootstock genetically distinct from the previous one, and soil amendments using biopesticides, beneficial microbes such as AMF or PGPR, or organic composts.

Tom Passey, Principal Scientific Research Assistant

Seeking new control products for apple scab

Title: Integration of novel products into apple scab management
Funder: Growing Kent & Medway Business Innovation Voucher
Industry partners: British Apples and Pears Ltd
Term: May 2024 to April 2025

Apple scab continues to be a major challenge for UK apple growers, particularly in seasons like 2024 which was particularly wet at key times of the year leading to periods where risk of infection was high. The problem is being exacerbated by the continuing loss of conventional fungicides that were previously relied on for control (Figure 1). In 2023, Horticultural Crop Protection Ltd (HCP) and British Apples and Pears Ltd (BAPL) funded Niab to compare the efficacy of bacterial biocontrol products, inorganic compounds and plant elicitors with two conventional fungicides for apple scab control.

The trial was carried out under protection. One product (plant elicitor/metal compound) appeared to have efficacy both pre- and post-inoculation. One product (plant elicitor) appeared to reduce scab when used pre-inoculation (preventively), and an inorganic compound appeared to reduce scab post-inoculation (curatively).

Two of the products, which are coded for commercial reasons, are authorised in the UK on other crops, while the third currently has no authorisation in the UK.

The project

This latest project funded through a Growing Kent & Medway Business Innovation Voucher (BIV) and led by BAPL, set out to assess the efficacy of these three coded products in an outdoor orchard setting. Each product was applied on its own every seven days and compared to an untreated control plot. They were also compared to a commercial standard seven day spray programme which contained products that growers would currently rely upon, some of which are at risk of losing their current authorisation on UK apple. It included products such as Bellis, Captan, Delan Pro, Difference, Manzate, Scala, Stroby and Vayo. Another treatment included a seven day programme of conventional products mixed with the coded products, whilst a final programme employed a disease risk programme to dictate whether a spray was required at all.

Scab infection was assessed throughout the season on rosette leaves in May, on the bottom five leaves of extension shoots in June and on the top five leaves of extension shoots in July (Figure 2). Assessments were also made on fruitlets and on fruit at harvest.

Figure 1. Conventional fungicide products are diminishing in number

Results

The 2024 season was conducive to scab infection with a mix of dry and wet days increasing disease pressure and high levels of scab were recorded on the untreated

Figure 2. Typical symptoms of scab on leaf

control plot. On the assessments of rosette leaves and bottom leaves of the extension shoots, all of the treatments significantly reduced the incidence of scab compared to the untreated control while all the treatments except one of the coded products significantly reduced scab incidence on the top five leaves of the extension shoots. All the products reduced scab incidence on both the fruitlets and fruits at harvest (Figure 3) although to varying levels.

Of the two coded products that reduced infection significantly, one of them compared favourably with the standard seven day programme, whilst both the standard seven day programme combined with the coded products and the risk-based spray programme appeared to work equally well and were not significantly different.

One of the two coded products that performed well gave rise to some phytotoxicity on the leaves and some russet on the fruit. The risk-based spray programme used only nine spray applications compared to twelve used in all the other programmes and this reduced the cost of this programme by £65/ha compared to the standard 7-day programme.

In summary, all three coded products reduced scab when used as individual sprays, two more successfully than the third. When used together in a programme, the new products seemed to work as well as the standard programme. The product that gave rise to phytotoxicity and russeting would need further investigation before seeking authorisation on apple. HCP and BAPL are currently working towards securing EAMU authorisations for at least one of the coded products on apple.

Figure 3. Typical symptoms of scab on fruit

PEST AND PATHOGEN ECOLOGY

Xiangming Xu, Director of Research

Fundamental research into cherry canker

Title: Predicting the emergence of host-adapted bacterial phytopathogens

Funders: Biotechnology and Biology Science Research Council, 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.

It is known that this bacterial pathogen enters woody tissue through leaf scar wounds on cherry trees during the autumn months, leading to infection of the woody tissues (Figure 1) as the trees move into dormancy. The bacteria overwinter and give rise to canker lesions on branches. In spring, the bacteria are washed by rain onto leaves and blossom. *P. syringae* survives through spring and summer on the surface of cherry leaves (as epiphytes) without causing disease symptoms. During the summer, this pathogen may infect fruits leaving necrotic spots, and/or enter leaves through the stomata causing leaf spot symptoms and eventually 'shot-holes' in the leaves.

This BBSRC, NERC and Scottish Government funded project offered the chance to undertake fundamental research into the spring/summer stage of the lifecycle of the pathogen when the bacteria are living freely on the surface of leaves as epiphytes.

Figure 1. Infection of woody tissue in cherry

The project

Niab examined how populations of these epiphytes change on the leaf surface and how they vary in time and space in both the crop and in wild settings. It also investigated how the populations are influenced by the environment, how they are associated with plant species other than cherry, how agronomic practices affect the populations, and whether the pathogenicity of bacterial isolates are affected by the host or the environment.

Results

The project initially investigated how the environment was influencing populations of *P. syringae* (pathovar *syringae*). Cherry orchards and related plant species in nearby woodland were surveyed in Kent, south west England, Herefordshire and Scotland. Leaves were sampled in spring and autumn over two years, from different varieties (Sweetheart, Penny, Lapins and Kordia). The wild species sampled included wild cherry, cherry plum, blackthorn, wild strawberry, hawthorn and ash. Molecular sequencing techniques were used to study the population dynamics. The results revealed that the proportion of potentially pathogenic isolates of *P. syringae* is far higher in Kent and south west England, particularly in cherry orchards. In contrast, the proportion in Scotland was close to zero. We now need to find out why the proportion is so low in Scotland and if this is influenced by climate. This could have relevance to cherry production and management in different regions of the UK.

Work at East Malling also investigated the impact of covering the trees with tunnel films and the influence of nitrogen application. Covers on the crops greatly affected the microbiome (the community of microorganisms living together) on the cherry leaves, and in particular the fungi. Polythene covers also reduced the diversity of *Pseudomonas* strains on the leaves along with the spread of the pathogens from cankered wood in the trees. The use of fertigation to increase nitrogen levels around the tree roots was found to reduce the impact of infection, leading to smaller cankers.

A third study has been examining the genetic factors that affect adaptation of *P. syringae* to its host. The question the scientists wanted to answer was whether pathogenic pathogen isolates can pass their pathogenicity to non-pathogenic isolates on the leaf surface? Can evolution of the genetics of the bacterial pathogens occur rapidly? We found that on a single leaf surface, there is great variation in the pathogenicity of the bacterial isolates, but also that pathogenicity can be transferred by a phage (bacterial virus) from a known pathogenic strain to another non-pathogenic strain.

The final piece of research sought to understand if we are able to use genomic information to predict whether a particular isolate of *P. syringae* can infect cherry. This work employed machine learning along with published sequence information together with new information generated from this project, to predict the host range for *P. syringae* isolates. This led to discovery of a prediction algorithm that yielded a prediction accuracy exceeding 80%.

Francis Wamonje, Entomology Research Leader

Surveillance for the brown marmorated stink bug

Title: Brown marmorated stink bug – UK surveillance
Funder: Defra
Term: April 2024 to March 2025

Figure 1. Adult BMSB

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. The pest (Figure 1) not only causes damage to fruit (Figure 2) but can also wander into homes in the autumn to keep warm (Figure 3), emitting an unpleasant odour. Niab has monitored for the presence of the pest since 2021, providing early warnings to inform mitigation strategies against potential establishment.

The project

As a result of increased sightings in 2023, this project has been conducting further surveillance in 2024 using pheromone traps located in municipal gardens in the south east of England and Bristol, motorhome and caravan storage sites, sites where previous catches have been made, and other sites highlighted by a prediction model. A programme of outreach to motorhome and campervan owners is also taking place.

Figure 2. Typical damage to apple

Results

A total of 35 strategically placed traps were co-ordinated through a network of volunteers, including those from the Natural History Museum and the Royal Horticultural Society. In addition to these sites, the 2024 surveillance programme included traps deployed in response to confirmed sightings of BMSB.

There were 22 confirmed sightings of BMSB in 2024, the highest number recorded in a single year since monitoring began. Significantly, two of these were the first recorded sightings of juvenile stages of BMSB in the UK providing evidence that BMSB can reproduce under UK conditions. While 2023 saw our first report of multiple insects attributed to a single sighting, this trend continued in 2024, with at least nine of the 22 sightings involving multiple insects.

Approximately 50 insects from three different sites have been retrieved and sent to Niab for rearing and overwintering, with the potential for use in experiments in 2025.

The surveillance programme has recorded increasing numbers in and around caravans and motorhomes returning from overseas where the pest is established. Niab is working with the UK's caravan and camping clubs to alert travellers (Figure 4) to be on the lookout for the hitchhiking bugs in their vehicles and to contact bmsb@niab.com if they find any to help track and monitor the spread.

Figure 3. Overwintering bugs seek shelter indoors

Figure 4. BMSB Alert to caravan and motorhome users

Michelle Fountain, Head of Pest and Pathogen Ecology

Exploring new solutions for apple and pear pests

Title: PAPPLe II: Integrated pest and disease management in apples and pears
Funder: British Apples and Pears Ltd
Industry partner: University of Greenwich (Natural Resources Institute)
Term: April 2024 to March 2026

The number of plant protection products authorised for use on apple and pear continues to decline and the loss of broad-spectrum organophosphate products and more recently neonicotinoid products is resulting in increasing populations of pest species which were previously controlled by these products. Synthetic pyrethroid products offer some control but these are very harmful to naturally occurring and introduced beneficial insects, leading to serious disruption of integrated pest management programmes. The selective product Batavia (a.i. spirotetramat) can be effective against sucking insect pests such as aphids, but it is only fully effective if applied during a short period in the season when specific conditions prevail.

British Apples and Pears Limited recognises the desperate need to channel its research funds into developing effective alternative control measures for spring damaging pests and aphids. Most important are rhynchites weevil, apple sawfly, apple blossom weevil and the weevil pest of pear *Anthonomus spilotus*. Of the aphid pests, the greatest priority is the highly damaging woolly apple aphid (WAA - *Eriosoma lanigerum* – Figure 1) which has become so difficult to control in recent seasons.

Figure 1. Woolly apple aphid is difficult to control

The project

For the spring pests, the project aim is to develop semiochemical attractants that mimic the odour of apple and pear blossoms and spring shoots. Niab is working with the Natural Resources Institute to develop and test these odour blends to attract the spring pests. Any blends that are successful could be combined with visual attractants and further developed with a commercial partner to produce commercially available traps that attract and catch the pests. Using these traps for precision monitoring would help to reduce the population sizes over a number of years and subsequent crop damage.

For WAA, research has been set up to investigate the use of

Figure 2. Wignests provide refuge for predators

Figure 3. Volatiles were collected from pear trees

introduced earwigs as a means of biological control. The European earwig (*Forficula auricularia*) is a pest of some crops, but in apple and pear, it is a voracious predator, feeding on several insect pests, most notably aphids including WAA. Earwigs are nocturnal and previous research at Niab has demonstrated that they are happy to hide by day in commercial predator refuges, hung in the canopy of the tree, called 'Wignests' (Figure 2), available through Russell IPM. In this project, six plots of nine Gala apple trees in three different Gala orchards, were inoculated with Wignests containing five earwigs each and compared to adjacent plots with no earwigs or refuges, to assess their commercial potential for controlling WAA.

Results

In the work to develop attractants to spring pests, 38 collections of volatiles were made from intact pear trees (Figure 3) in the field between the period from swollen bud to blossom time. Similarly, 24 volatiles were collected from apple trees during the period between tight cluster to bloom. Relatively small volumes of volatiles were collected from the bud stage of growth, but much larger volumes from the flowers. One and two major components were identified from apple and pear respectively. These compounds will next be analysed by gas chromatography (GC) coupled to electroantennogram (EAG) recording from the antennae of the representative pest species, and the blends of compounds identified will be tested in field trapping experiments in spring 2025.

In the work to assess the potential to introduce earwigs to apple orchards for WAA control, the results demonstrated that their impact was negligible or at best, inconsistent between orchards and seasons. In one of the three orchards tested, the results were more positive, as the numbers of WAA in this orchard generally declined in the earwig treated compared to the untreated plots. On this site, the numbers of WAA on shoot leaf notes were lower, especially in the middle of the growing season (June and July) after deployment of earwig loaded Wignests. However, this finding was not replicated in the other two orchards. Further research might address reports suggesting that low earwig numbers have been recorded in orchards where management practices have changed such as less frequent mowing and the incorporation of cover crops. In addition, results may be compounded by the application of WAA sprays like Batavia.

Michelle Fountain, Head of Pest and Pathogen Ecology

Evaluating different management approaches to SWD control

Growers are under pressure to reduce reliance on conventional spray products to provide effective control of spotted wing drosophila (Figure 1). Progress has been made in finding alternative approaches, including the use of precision monitoring in the winter months, use of bait sprays, and the development of Sterile Insect Technique (SIT) by commercial company BigSis. However, other potential management and control approaches need to be evaluated. Niab has been working with industry partners on two projects, one to investigate a push-pull approach to control and another to identify any variety resistance that might be utilised by strawberry or raspberry breeders.

Title: Innovative push-pull control of spotted wing drosophila, an invasive pest of fruit crops

Funder: Innovate UK

Industry partners: Russell IPM, Rumwood Green Farm, University of Greenwich (NRI) and W. B. Chambers

Term: April 2023 to March 2025

Previous research carried out by PhD student Christina Conroy as part of the CTP for Fruit Crop Research studentship scheme, identified a chemical repellent that causes a reduction in egg laying in strawberries up to six metres away from the sachet containing the repellent. Other research has demonstrated how precision monitoring traps can be used to reduce overwintering populations in habitats such as woodland adjacent to fruit crops in the winter.

The project

Working with industry partners, Niab aims to combine these findings into a push-pull approach to improve management and control of the pest. They set out to test the repellent compound in raspberry crops then carried out further trials in a commercial strawberry crop, combining the repellent inside the crop (to push the pest out of the crop), with a lure around the perimeter of the crop (to pull the pest away from the crop). Further work was done to optimise existing repellents and attractants for use by commercial growers.

Results

Disappointingly, in testing the repellent compound in 12 m long mini-tunnels planted with raspberry, no clear reduction in SWD egg laying was recorded, despite increasing the dose of the compound.

Figure 1. Adult male SWD

In the push-pull experiment in a commercial strawberry crop over two years, no reduction in egg laying was recorded. Further testing was done using double the number of repellent dispensers, sampling fruit close to dispensers, deploying dispensers in the crop from planting onwards, and including Russell IPM's commercially available MagiPal (Figure 2). MagiPal, demonstrated to attract natural enemies into crops, was also shown by Christina Conroy in the laboratory to be repellent to SWD. However, despite making these adjustments, no further egg reductions were observed. These results were disappointing and demonstrate how difficult it is to control SWD in a commercial setting even though laboratory and small field tests can initially look promising. It is likely that other factors in commercial crops prevent the repellent working. For example the size of the fields and how the fly perceives the cropping area through vision, detection of fruit and yeast volatiles, and climatic conditions.

In seeking to optimise attractants (the pull component), the Niab team had an idea of a component that might be blended into the liquid products developed by Russell IPM to improve attraction. Liquid baits were compared to standard commercially available liquid baits in field trials. Encouragingly, the newly developed Russell IPM blend was as attractive as the standard Gasser bait which is no longer available. This was an encouraging result, showing that a UK produced bait can be substituted for a bait produced overseas, thereby

Figure 2. Both MagiPal and the prototype repellent in a commercial crop

reducing transport costs and carbon footprint.

Niab is extremely grateful to the commercial growers who hosted this research, without whom the work would not have been possible.

Previous work by Niab has shown that practising winter precision monitoring year after year can help to reduce local numbers of SWD on farms over time and particularly in crops in the spring. Traps should be positioned in hedgerows and woodland, especially in areas of bramble, elder and ivy.

Michelle Fountain, Head of Pest and Pathogen Ecology

Feli Fernández, Senior Plant Breeder

Title: Screening for resistance to spotted wing drosophila in strawberry and raspberry accessions

Funders: Growing Kent & Medway and The East Malling Trust

Industry partners: Asplins PO and W. B. Chambers

Term: May 2022 to October 2024

Another approach to control that has not been fully explored is fruit variety resistance to SWD. Ripening soft and stone fruits are highly attractive to adult SWD, with the female making an incision in the skin of the fruit and laying eggs under the surface. The resulting larvae feed on the flesh of the fruit, leading to fruit collapse and an unmarketable product. If any accessions (varieties, selections or species) of soft fruits are found to have berries that are less attractive to SWD or that inhibit egg laying or larval emergence, we could then investigate the fruit traits that are associated with this and utilise such traits in fruit breeding programmes.

The project

Niab screened many accessions of strawberry and raspberry to identify if any show tolerance to SWD. Across the life of the project a wide range of strawberry and raspberry genotypes were chosen based on their origin and pedigree. The material tested was diverse and included differing traits like skin colour, skin firmness, flesh firmness, size, and sugar levels (Brix). The aim was to identify any correlations between fruit traits and emergence of adult SWD from the fruit.

A total of 76 accessions of strawberry and 36 accessions of raspberry were planted in an SWD proofed tunnel on a commercial soft fruit farm, by kind permission of W. B. Chambers, who maintained the plants throughout the project. Fruit was picked throughout the season, brought back to Niab laboratories where fruit traits were assessed and the fruit exposed in containers to adult female SWD. The number of eggs laid in each variety was recorded and the adult females then removed. Following 14 days, the number of emerging adults was counted from each of the original berries. In addition, strawberries were tested for attraction to SWD in a choice test in the laboratory, pitching more versus less susceptible varieties against each other.

Results

In the first year results for strawberry and raspberry were very promising, as there was found to be statistically significant variation in the numbers of adults emerging from different varieties. The genotypes used were grouped together based on the level of emergence. For those genotypes where a lack of emergence was found, some fruit quality traits were correlated. In particular, the levels of Brix (for strawberry and raspberry) and the skin colour (strawberry) appeared to influence the level of SWD emergence from fruit.

The work was repeated in the second year for both strawberry and raspberry, but this time the order of susceptibility changed between accessions. Brix was a less reliable predictor of fruit vulnerability and colour also failed to give an indication of SWD egg laying.

Figure 3. A wide range of strawberry material has been tested for resistance to SWD

In the laboratory choice tests (Figure 3), adult female SWD were also not influenced by which fruits they lay their eggs in – it seems they just lay on the first fruit they come across.

This project highlights that growers should not rely on varietal planting to control SWD as this can vary between years and females' SWD drive to lay eggs is difficult to deter. It should be noted that SWD can lay eggs in unripe fruit rendering soft fruits particularity vulnerable to SWD damage.

Michelle Fountain, Head of Pest and Pathogen Ecology

Employing baits in attract and kill strategies for fruit crops

Title: Novel attract and kill strategies for control of UK fruit crop pests: ProBandz

Funder: Innovate UK

Industry partners: Microbiotech Ltd (Lead), Russell IPM Ltd, Driscolls Genetics Ltd, Plumford Farms Ltd, New Farm Produce Ltd, Littywood Farm Ltd and Chandler & Dunn Ltd

Term: March 2024 to February 2025

Niab has previously collaborated with Microbiotech to demonstrate the use of bait sprays to successfully control spotted wing drosophila (SWD) in soft and stone fruit crops. One of the successful baits was further developed by Niab, Microbiotech and Russell IPM to create the new bait spray adjuvant ProBandz, now commercially available from Russell IPM. The research demonstrated that by applying 40 l/ha of a narrow band spray of large droplets to the foliage of the crop (Figure 1) combining ProBandz (5%) with 50% or less of the recommended rate of a plant protection product such as Tracer (a.i. spinosad) or Exirel (a.i. cyantraniliprole), was as effective at controlling SWD as a full rate overall crop spray of Tracer or Exirel. In trials, reducing the rate as low as 4% was equally effective.

Adult flies are attracted to the bait ingredient (ProBandz) and feed on the narrow band of sprayed foliage, ingesting the plant protection product which kills them. This system avoids the control product being applied to the fruit, reducing the risk of residues whilst also reducing exposure to naturally occurring beneficial insects, introduced predators and pollinators, minimising disruption to IPM and expensive biocontrol programmes. Avoiding the use of an overall crop spray also avoids contact with the adult SWD and reduces the risk of pest resistance developing. Time required for spray application is lowered by approximately 85% compared to full rate sprays and water use is also significantly reduced.

Previous research by Niab PhD student Csaba Nagy at East Malling has shown that sugar baits can distract ants from aphid colonies (Figure 2) in apple trees, exposing the aphids to predation from other insects. It was not clear if ProBandz would be effective at deterring ants from visiting aphids.

Although earwigs are useful predators in apple and pear orchards, feeding on pests such as codling moth, aphids and psyllids, on strawberry tabletop systems they hide under the grow bags in the daytime, emerging at night, and sometimes feed on strawberries. Harvesting live earwigs from strawberry crops would provide a free supply of predators for introduction to apple and pear crops providing pest control. It would be useful to investigate if earwigs could be attracted to ProBandz for this use.

Figure 1. Bait spray being applied to a reduced area of cherry canopy

The project

The research was split into three parts, each assessing the impact of baits as a means of managing pest control. The first part assessed the efficacy of ProBandz used as a bait spray with Hallmark for SWD control. The second trial assessed different formulations of ant bait to distract them from rosy apple aphid colonies on apple trees. The third tested an attractive bait developed by Russell IPM in a trap with the intention of attracting earwigs into the trap which is clipped to a tabletop in a strawberry crop.

Results

Hallmark use with ProBandz as a bait spray

In testing, 5% ProBandz was added to 8% of the standard Hallmark rate and applied as a band spray to strawberry and compared to full rate Hallmark applied as an overall spray for SWD control. The results demonstrated that Hallmark was as effective at controlling SWD when used as a band spay with ProBandz than a full rate spray without the bait. Hallmark is broad-spectrum and can damage introduced predators and natural enemies in crops so applying as a narrow band spray of large droplets and at a lower rate with the bait should minimise disruption to IPM programmes. Bait sprays are only permitted for use with

products that have standard or EAMU authorisations, and not emergency authorisations. As Hallmark has an EAMU authorisation for use (either outdoor, protected or both depending on the crop) on most fruit crops that are susceptible to SWD, it could be used as a bait spray for eradicating SWD populations once a crop has ended.

Using Hallmark in this way after harvest would minimise disruption to IPM programmes and help to reduce SWD populations going into the winter. This type of use could be particularly helpful where different varieties or different fruit crops such as cherry or blueberry ripen and are harvested sequentially with SWD moving onto unpicked varieties as the previous ones are harvested. A similar situation can occur on mixed farms where SWD may move from cherry to raspberry as the season progresses. It should be noted that the bait or adjuvant label always requires operators to use only 50% or less of the maximum product rate recommended on the product label.

Microbiotech also screened a range of other insect targeted plant protection products in the laboratory, including Decis, in combination with ProBandz, but none of these were effective at controlling SWD.

Figure 2. Ants attending rosy apple aphid colony

Figure 3. Earwig exposed to different attractants

Baits to distract ants from aphid colonies

Although previous sugar baits have deterred ants visiting aphids ProBandz was not attractive to ants and did not prevent rosy apple aphid damage. In addition, most ant baits are highly water soluble and not rain resistant or require a high level of labour to deploy. The Russell IPM team developed different formulations of ant baits which were subsequently tested for longevity in the British weather and attraction to ants. By the end of the project, with Niab, a formulation was developed which could be tested in the future for efficacy against rosy apple aphid damage.

Baits for trapping earwigs on tabletop strawberry crops

Niab compared an attractant from the Russell IPM Wignest device with fish formulations commonly reported to be attracted to earwigs (Figure 3). The Russell IPM bait was more attractive and was further field tested in a range of different trap types attached to tabletop strawberries. Russell IPM further developed the trap which is now commercially available as an earwig trap and lure (Earwig Catcher and *Forficula auricularia* Lure). Further work is needed to test the density of traps needed in a crop and the regularity of topping up the earwig lure to reduce economic damage to the fruit. Thought should be given to providing a way to release them in apple and pear orchards to improve pest control in these crops whilst reducing damage to strawberry.

PEST AND PATHOGEN ECOLOGY

Xiangming Xu, Director of Research

Improving the management of *Mucor* and *Rhizopus* on strawberry

Title: Predicting strawberry fruit infection by *Mucor* and *Rhizopus* using climatic conditions and pathogen inoculum levels

Funder: Biotechnology and Biological Sciences Research Council and The East Malling Trust

Industry partner: Berry Gardens Growers

Term: June 2023 to November 2023

Mucor piriformis and *Rhizopus* species cause soft rots of strawberry fruits (Figure 1) and in recent years, appear to have become more prevalent on crops grown under protection where temperature and humidity levels are generally higher. Much research has been done over the years on *Botrytis cinerea*, which causes grey mould of strawberry. On unprotected strawberry crops *B. cinerea* has been shown to infect strawberry flowers and fruits before harvest and the use of conventional fungicide sprays to protect developing flowers and fruits has been demonstrated to reduce the levels of infection and fruit spoilage.

More recent research on protected crops has shown that the level of *B. cinerea* infection occurring during flowering and fruit ripening is far less than in unprotected crops and that nearly all crop losses occurred from post-harvest rot development stemming from pre-harvest latent infection. Rapid removal of field heat after harvesting and subsequent cool-chain management has been sufficient to control the disease. However, much less is known about the epidemiology of *M. piriformis* and *Rhizopus* species. Previous experiments at Niab (funded by Berry Garden Growers) demonstrated that neither *Mucor piriformis* or *Rhizopus* species are likely to infect strawberry flowers or green fruit, but that fruits become increasingly susceptible from the green stage onwards.

The project

Niab set out to sample immature fruit from strawberry plants grown under protection to estimate the level of fruit infection by *Mucor* and *Rhizopus* within a given 24 hour period. The aim was to combine the new data with those data obtained from a previous Innovate UK project (**PROFITs – project number 132749**) to develop predictive models for Mucor and Rhizopus.

Results

A total of 266 samples of strawberry fruit at the white or ripe stage were obtained in three years under both

Figure 1. Soft rots of strawberry have become more prevalent in recent years

Figure 2. Disease incidence was higher on white fruit than on ripe fruit

Innovate UK and BBSRC funded projects. As expected, disease incidence was higher on ripe fruit than on white fruit (Figure 2): 12.1% vs 2.8% (*Rhizopus*) and 6.4% vs 1.4% (*Mucor*). Trapped inoculum counts were lower in 2023 than in 2018 and 2019. The overall *Mucor* incidence was 2.2%, 5.0% and 7.2% for 2018, 2019 and 2023, respectively; the corresponding values for *Rhizopus* were 4.3%, 19.3% and 3.4%.

To develop predictive models, Niab recorded temperature and relative humidity at an interval of 20 min for each 24 hour sampling period. Modelling results suggested that it is the variability in climatic conditions, particularly vapour pressure deficit, rather than the absolute level, which appears to be more important in influencing infection of strawberry fruit by *Mucor* and *Rhizopus*. The importance of variability in climatic conditions on microbial development was also recently confirmed at East Malling – survival of biocontrol organisms on strawberry flowers and leaves is mainly affected by the daily variability in vapour pressure deficit. Sadly, the present modelling results indicated a low level of predictability of soft rot incidences on strawberry fruits, supporting previous results in artificial inoculation research under controlled conditions at East Malling. This may indicate that climatic conditions are unlikely to be the main factor limiting infection of fruit by *Mucor* and *Rhizopus* for the main strawberry production season in the UK.

The present study also suggested that inoculum is just as important as we initially believed for predicting the incidence of soft rots. It could be because the level of *Mucor* and *Rhizopus* inoculum at the sampled locations was already high, and hence not a limiting factor for disease development. It could also be due to the way the inoculum level was estimated in our field sampling. We need to develop new tools for accurate and rapid in situ inoculum quantification.

Although post-harvest rapid cool chain management is not as effective at controlling soft rots as *B. cinerea*, it can still delay their progression. In addition to searching for alternative products to suppress inoculum production and minimise infection, strategies are needed to minimise local inoculum through maintaining strict levels of crop hygiene and rapid removal of crop debris, damaged and overripe fruits. Soil management in protected table-top strawberry production may still be necessary to reduce inoculum load and disease pressure. The population dynamics of *Mucor* inoculum is known to be affected by soil moisture and temperature, and thus using cover crops may be necessary to ensure good ground vegetation.

Francis Wamonje, Entomology Research Leader

Developing new biocontrol for large raspberry aphid

Title: A phenology-perceptive integrated biocontrol programme for large raspberry aphid (*Amphorophora idaei*) control: PHENCONTROL

Funders: Growing Kent & Medway and Innovate UK

Industry partners: Asplins PO, Biobest and Rumwood Green Farm

Term: May 2023 to May 2025

Control of aphids on raspberry was relatively simple in the past, with a wide selection of aphicides available to UK growers. However a progressive withdrawal of control products over the past decade or more has left raspberry growers with few effective options. Early season population increases of the large raspberry aphid (Figure 1) have become particularly common in glasshouse and protected crops and despite relying on biological control options, levels of control have been inadequate, in part because their deployment has not aligned with seasonal variations in aphid populations and crop growth. Previous genetic resistance bred into raspberry varieties is also absent in modern varieties. Improved forms of management and control are urgently needed.

The project

Niab aimed to develop an integrated biocontrol programme for raspberry that provides adequate protection against aphid herbivory and damage across all stages of aphid and raspberry phenology. We chose three routes to achieve this, firstly by trying to identify an optimal parasitoid species mix which will spread uniformly across the plantation. We also set out to investigate novel ways of spreading *Chrysoperla carnea* (green lacewing) eggs across plantations to control hot-spot outbreaks of aphids whilst testing a strategy to deploy *Micromus angulatus* (brown lacewing) for predation of aphid eggs and spring hatching female aphids, when temperatures are still low.

Results

In the parasitoid work, we studied the range of naturally occurring parasitoid species found in raspberry plantations between April and September and at different distances from a hedgerow. From April to June, *Aphidius ervi* was the predominant species found, but from July until September, there was an increase in other Aphidius species. The composition of parasitoid mixes provided by biological control suppliers would need to reflect these differences across the season.

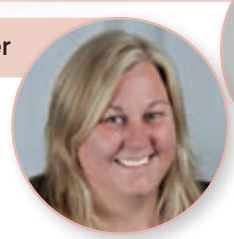
In the work to improve the application spread of green lacewing eggs, we compared different liquid suspensions incorporating stickers in which to hold the eggs and apply them to the crop. Egg adherence to the leaves is critical to successful deployment of green lacewing eggs. One product was found to stick the eggs to the leaves better than another product or water. The rate of egg hatch was not affected by the choice of product.

In experiments to assess the efficacy of brown lacewing predation of large raspberry aphid eggs and spring hatching females, we set up a bioassay in a perspex box using a raspberry cane with developing bud and leaf growth inoculated with large raspberry aphid eggs. We introduced brown lacewings and assessed the egg hatch and aphid numbers at different temperatures and at different durations after predator introduction. Aphid numbers were reduced using introduced brown lacewings compared to the untreated control and the effect increased both with time and temperature. This suggests that early season deployment of brown lacewing is possible at relatively cool temperatures and that predation is likely to increase with temperature, but more research is needed to better understand optimum rates of introduction and the level of success.

Figure 1. Developing a biocontrol programme for large raspberry aphid

Matevz Papp-Rupar, Plant Pathology Research Leader

Louisa Robinson-Boyer, Plant Microbial Interactions Research Leader



Seeking improved consistency in raspberry propagation

Title: Improving propagation efficiency and production sustainability in intensive cultivation systems for a Kent-bred raspberry variety

Funders: Growing Kent & Medway and Innovate UK

Industry partners: Blaise Plants, NSA Plants and Recoir

Term: May 2023 to April 2025

The annual demand for high-quality long-cane raspberry material is continuing to rise, but demand is outstripping supply and the quality of plants purchased is not always uniform, with survival rates lower than growers would expect. The industry needs to find a way of producing consistently higher quality canes with root systems that can sustain growth and production of high yields of raspberry.

The project

Arbuscular mycorrhizal fungi (AMF) and plant growth promoting rhizobacteria (PGPR) have been extensively studied by Niab and others, and are known to enhance root growth in various ways. Both are commercially available for use by growers. AMF have been shown to increase plant health, water and nutrient uptake and resistance to biotic and abiotic stress whilst PGPR's are known to fix atmospheric nitrogen, enhance phosphorus availability to the plant, increase natural plant hormone production and contribute to organic matter.

Virgin coir substrate is sterile and not only lacks plant nutrients, but also lacks a balanced diversity of soil microorganisms. Previous research to colonise virgin coir with AMF has given mixed results, but if this process could be improved, it is thought that the propagation of raspberry, cane establishment and growth might be enhanced (Figure 1). This project set out to question whether microbial amendments to both virgin and recycled coir will enhance raspberry tip propagation and whether they might

Figure 1. Might AMF enhance root growth and cane establishment in coir?

improve primocane and long-cane crop establishment and production. Finally the project aimed to investigate the suitability of re-used coir from strawberry crops for commercial raspberry production.

Results

Raspberry tip propagation

Malling Bella raspberry plants were planted into 7 litre pots of virgin coir amended with AMF and grown for eight months. The roots were then harvested and transplanted into cutting trays and the emerging shoot tips were recorded (Figure 2). Compared to roots which had not been treated, the AMF-treated roots produced increased shoot numbers for cuttings and also improved survival rates of these cuttings, although the results were not statistically significant. A similar trend was seen in AMF-treated Malling Bella canes grown in the field. The treated plants produced more spawn than the untreated.

Primocane crop establishment and production

In 2023, Malling Bella tips were planted into pots of virgin coir amended with AMF, PGPR, both AMF & PGPR or neither. The canes were mown down and grown and cropped in 2024. There were no significant differences in yield or waste fruit, although a slight yield increase occurred in PGPR-treated coir. However, AMF treated coir gave rise to a significant increase in berry size, whilst PGPR resulted in a slight increase in berry size that was not statistically significant. The AMF treatment also led to a three-day delay in the time taken to get the first ripe fruit.

Long-cane crop establishment and production

In 2023 long cane Malling Bella was also planted into pots of virgin coir which was amended with AMF, PGPR, both or neither, however in contrast to primocane production, there were no significant differences in growth or yields.

Figure 2. AMF treated roots produced higher numbers of shoots for cuttings

Figure 3. Raspberry canes were grown in coir recycled from strawberry production

Suitability of recycled coir for raspberry production

To assess the performance of raspberry in coir recycled from strawberry production, pots of both virgin and recycled coir were planted in 2023 either with or without AMF using Malling Bella either as a primocane or a long cane (Figure 3). The primocane crop was mown down in 2023, cropped and recorded in 2024. The long cane was cropped in 2024.

In the primocane crop, there was no significant difference between recycled and virgin coir, although the recycled coir produced a slight increase (not statistically significant) in Class 1 yield and a significant reduction in waste fruit. However, the berry size increased significantly with the addition of AMF in the recycled coir.

In the long canes, there were no significant yield differences between treatments, although there was a slight reduction in Class 1 yield in recycled compared to virgin coir but also a slight reduction in waste fruit. However, where recycled coir was treated with AMF, an increase in berry size compensated for the reduced yield in recycled coir alone, increasing the yield to that achieved in virgin coir.

Trends so far

Further assessments will be made, and data will also be collected from the 2024 planted primocane in 2025. However, the results so far suggest that treatment with AMF increases berry size in both virgin and recycled coir, that recycled coir from strawberry crops is likely to be good for raspberry crops, and that the addition of AMF to recycled coir can help to sustain yields at the level expected from virgin coir.

Matevz Papp-Rupar, Plant Pathology Research Leader

Coir recycling offers major savings for soft fruit growers

Title: Second Life: development of sustainable recycled growing media
Funders: Overland Ltd, Growing Kent & Medway and The East Malling Trust
Term: April 2023 to March 2025

There has been a major shift in soft fruit production in the UK out of field soils and into soilless substrates, and with government policies aiming to reduce reliance upon peat, the majority of production is now in coconut coir. However, the increasing price of coir, limited availability and volatile shipping expenses have resulted in increased costs for growers. The carbon footprint associated with shipping substrate from Asia is also a concern, whilst additional labour costs are incurred in replacing and disposing of waste coir.

There has been much interest in re-using, composting or recycling coir although growers have so far been reluctant to use at scale due to concerns over pest, disease and weed build-up reducing both yields and the quality of the fruit produced. An early EU funded research project carried out by Niab identified that Junebearer strawberry can be replanted in used coir bags with little effect on yield as long as no disease was observed in the first year. Everbearers on the other hand suffer around 7% year on year yield decline when grown in reused coir bags.

Overland has developed an automated process to recycle coir from strawberry bags which includes automated, low labour removal of bags from the tunnels (Figure 1), followed by the removal of plastic, plant leaves, roots and crowns, to leave clean coir (Figure 2). The coir is then treated to reduce the risk of pests and diseases, before making it available for growers.

Overland partnered with Niab to do further work to assess how the cycles of both growing and recycling change coir properties over time. We found that the water holding capacity increases while the air filled porosity (AFP) decreases in recycled compared to virgin coir. The extent of this change varied with different coir manufacturers. Recycled material also has slightly lower pH, higher electrical conductivity and higher nutrient content compared to virgin coir. Levels of crown rot (*Phytophthora cactorum*) tend to increase in directly re-used and composted coir compared to virgin, but this has not been evident in the fully recycled coir that Overland is producing.

The project

Overland and Niab secured further funds from Growing Kent & Medway to accelerate this research and bring sustainable recycled coir media into commercial strawberry production. The aims of the project were to 1) develop energy efficient and robust procedures to eliminate pest, pathogen and weed risks in recycled material; 2) to demonstrate the use of recycled media on a commercial scale and develop wrap around agronomy advice; 3) compare lifecycle analysis of the virgin and recycled coir to measure any economic and environmental gains from using recycled media.

Figure 1. Overland has developed an automated process to recycle coir from strawberry bags

Results

In work to eliminate pest, pathogen and weed risks from recycled coir, a heating process was developed and refined which successfully inactivated pest, pathogen and weed seeds from the substrate. Further work was done to study and compare the microbiome (community of microorganisms) within both virgin and recycled coir. We investigated fungal, bacterial and oomycete organisms in each coir type collected from a commercial scale trial during peak harvest.

A greater biodiversity of fungi was found in virgin coir compared to recycled and within these, we recorded more potential fungal pathogens on the roots of strawberry plants grown in virgin coir compared to recycled. These pathogens included species of Ilyonectria, Neopestalotiopsis, Verticillium, Mucor, Macrophomina and Fusarium. We also found more Colletotrichum and Penicillium species in virgin coir but not all of these are considered pathogenic. In assessing beneficial fungi, we found more Trichoderma (both commercial biocontrol species and others), Metharizhium and Serendipita in virgin coir. In contrast we found more Rhizophagus species (beneficial arbuscular mycorrhizal fungi) in recycled coir.

Bacteria were more diverse in recycled coir, but some were more prevalent in recycled and others in virgin coir. Potentially pathogenic groups were again found to be more abundant in virgin coir.

Of the oomycetes (pathogens such as Pythium and Phytopthora species), very similar levels were recorded in virgin and recycled coir. There was a very slight increase in *Phytophthora cactorum* in recycled coir.

It is worth noting that no disease symptoms were observed on plants grown in virgin or recycled coir.

In work to demonstrate the use of recycled media on a commercial scale, the everbearer variety Katrina was planted in virgin Legro bags, directly reused Legro bags and Overland's recycled Legro bags at a commercial site (Kelsey farms) in 2023. Each coir type was used in nine commercial tunnels (over 3,000 bags per coir type) with an independent irrigation schedule. Sadly, during harvest the virgin and re-used coir were mistakenly picked and recorded together, so the recycled coir was compared to both virgin and directly replanted coir together.

The yields were similar (around 1.3 kg/plant) and no differences were found in pests (thrips, aphids, weevils), weeds or root rot pressure between coir types, but there were visual differences in plant growth. In the recycled coir, plants appeared to be stronger and cropped 7-10 days earlier than the virgin coir bags. The plants grown in recycled media also used 12% less fertigation over the season. This reduction in water and fertiliser use in recycled material was especially prominent during hot days. The grower was very happy with the performance of the recycled media, and has since expanded its use to over 200,000 pots of raspberry. A similar trial was repeated in 2024 at a Summer Berry Company site in Chichester, where 1.45 kg of fruit per plant (variety Favori) was produced in both recycled and virgin coir with 8% water and fertiliser saved in recycled media. The trial was done in troughs where roots could be inspected fortnightly. More uniform and higher density roots were observed in recycled material.

Figure 2. The removal of plastic and plant debris leaves clean coir

At Niab's East Malling site in 2023, the everbearer variety Malling Supreme was planted in a small trial with both virgin and recycled Legro and Cocogreen coir in troughs rather than bags. Separate irrigation rigs were used for recycled and virgin media but not for each coir brand. The two recycled coir samples used 4% less water than virgin. Reduced need for wetting up and maintaining moisture in recycled material at the start of the season was the primary reason although reduced water use on the hot days due to the higher water holding capacity of the recycled coir also contributed. The total yield from recycled coir was slightly lower comparing Legro recycled and virgin coir. This was due to the fact that virgin materials of both brands were fairly comparable in terms of water demand, but recycled materials with different previous growing histories were not. Namely, recycled Legro material had much higher water holding capacity compared to recycled Cocogreen. This meant that recycled Legro coir was over irrigated and recycled Cocogreen underirrigated resulting in a slight yield reduction. This highlights the need for the of use different irrigation/fertigation regimes with different coir types, or at least to use separate valves to manage coir moisture adequately.

In 2024, low grade, single crown, bare rooted Malling Centenary plants were planted in virgin and recycled material as a worst case scenario experiment. Yields were very low in both coir types (75-95 g/plant), but the plants yielded significantly more fruit in recycled material.

In an exercise to compare the carbon footprint of using recycled versus virgin coir, Niab and Overland calculated that removal-recycling-delivery of recycled coir emitted around 40% less CO_2 than sourcing virgin coir shipped from Sri Lanka.

In summary, to date we have demonstrated that recycling coir offers much better potential than either re-using or composting coir. Recycled material can achieve strawberry yields and quality that is comparable to virgin material. Recycled coir poses no greater pest, disease or weed threat than virgin coir and there were fewer pathogenic fungi recorded in recycled coir compared to virgin, although there was a very slight increase in the oomycete *P. cactorum* in recycled coir. The rate and level of physical and chemical degradation does vary depending on the coir type, manufacturer and growing history but we believe that cost effective coir recycling is possible with little yield reduction. However, it is important that the irrigation and fertigation of crops grown in recycled coir are managed separately from virgin coir, to adjust for the lower AFP in the recycled product, otherwise over-watering can occur leading to root death and reduced yield and quality.

Training new scientists for fruit research

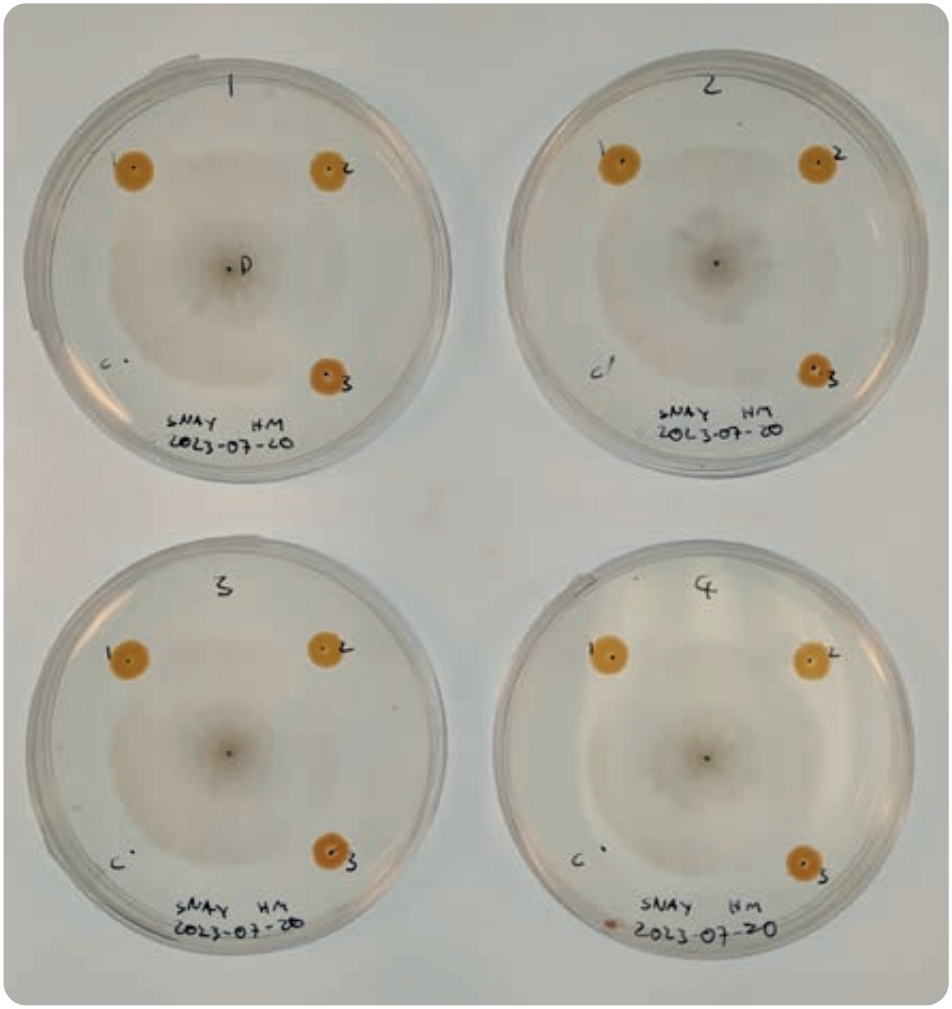
Researchers at Niab's East Malling site have been supporting the fruit industry since 1913 and, over the ensuing years, we have been able to develop and train new generations of scientists to work in fruit and horticulture research. With reduced funds available to support their development, Niab was pleased to team up with lead partner Berry Gardens Growers Ltd in 'The Collaborative Training Partnership for Fruit Crop Research' (CTPfFCR), a training scheme for new scientists.

Funded by the Biotechnology and Biological Sciences Research Council (BBSRC) along with industry partners AHDB, Berry Gardens Growers, 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.

Since its inception in 2017, 15 students have been awarded a PhD and it is anticipated that by the time the scheme ends in September 2025, 38 researchers will have been trained. After graduating, a number of the students have progressed into fruit research roles spanning academia and industry, which is of course the primary aim of the training scheme. However, the industry does not just benefit from the students' future careers. The scheme was set up to ensure that students studied research topics that were of high importance to the fruit industry and would deliver results that could either be adopted by growers or would inform future research and development projects.

All of the projects being worked upon and those completed have been grouped into four categories including: Artificial intelligence and robotics, Crop science and production systems, Genetics, and Pest and pathogen ecology. They were all developed by research scientists working with the CTP's fruit industry partners to identify high priority topics which need investigation, to ultimately benefit fruit growers. Most of the students have worked with research supervisors at Niab's East Malling site, whilst some others have been based at the CTP's partner universities including Cranfield, Essex, Harper Adams, Lincoln, Nottingham and Reading. Within their four-year training period, the students also receive 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.

Figure 1. Hamish McLean has been screening Sphingomonas bacteria for controlling apple canker



At the time of writing, a number of students are either writing-up or have submitted their theses for assessment. The students from the final cohort of the scheme continue their research on a wide range of topics.

On apple, at East Malling, Hayden Tempest has been investigating the predation of woolly apple aphid by earwigs using radio tagging while Hamish McLean is investigating potential biological control methods for apple canker (Figures 1 and 3). Katie Stewart is working on novel methods for controlling apple scab

and Haidee Tang is using climatic and imaging data to predict apple fruit ripeness (Figure 2).

At the University of Lincoln, 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. At Reading University, Emily Johnstone is investigating ways to maximise optimum strawberry fruit size for sale to multiple retailers, by manipulating nitrogen input and strawberry growth.

Also on strawberry, 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, while Camila Gonzalez is working with the genetics team, using a combination of genetic mapping and gene editing to understand the control of flowering.

On raspberry at East Malling, Deborah Babalola aims to understand the genetic control of primocane vs. floricane fruiting habit and earliness of fruiting in both raspberry types.

Back to strawberry, and at the University of Essex, Mengjie Fan is investigating the use of blue light with the intention of boosting yields late in the season, whilst at Harper Adams University, Laura Martinez is studying why the potato aphid, a common pest of strawberry, is not reliably controlled by aphid parasitoids.

Comprehensive information on all the completed and ongoing projects can be found on the dedicated website at: ctp-fcr.org.

Figure 2. Haidee Tang is investigating new techniques for measuring apple ripeness

Figure 3. Assessing the impact of waterlogging on apple canker development

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, Canterbury Christ Church University 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 Nikki Harrison, Growing Kent & Medway supports 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 have invested in new research facilities and technical expertise, business support activities, 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 Berry Gardens Growers, Richard Hochfeld Group, Smurfit Kappa, Thanet Earth, Worldwide Fruit and The Kent and Medway Economic Partnership.

We are managing our investment through several areas of activity which include the development of new research facilities, research funding grants and business enterprise support. This support includes free business mentoring, food accelerator programmes and business masterclasses, along with bringing together the region's expertise in areas such as alternative proteins, sustainable production, sustainable packaging and skills.

Early work

Initial funds were used to build and develop high quality, state-of-the-art research facilities for the horticultural, food and drink sector. At Niab's East Malling site, Growing Kent & Medway funds were pooled with those from Local Growth Funds from Kent County Council and the East Malling Trust to build our 'GreenTech Hub for Advanced Horticulture'. These state-of-the-art facilities include brand-new glasshouses, polytunnels and growth room facilities (Figure 1) allowing our scientists to undertake cutting-edge research to support horticultural industries. New modern facilities were also built for the University of Kent (Biotechnology Hub) and University of Greenwich (Medway Food Innovation Centre) to provide the industry with technical support and modern research and development facilities. In September 2023, Canterbury Christ Church University was welcomed into the programme, and through this partnership, we launched our new Industrial Agri-engineering Hub.

Figure 1. State-of-the-art growth rooms allow our scientists to undertake cutting-edge research

Growing Green

Following a successful initial pilot in 2022, the Growing Green sustainability training programme and grant was rolled out in 2025 with improved features. The programme was set up to provide an incentive for small and medium sized enterprises in the horticulture, food and drinks sector to move to net zero. It focuses on upskilling and improving the knowledge of the participants, so they can confidently implement strategic improvements to their business. Networking with similar businesses to share ideas and learn from each other is another important element. Businesses participating in Growing Green in 2025 can apply for a grant of up to £7,000, receive accredited training and get a professional membership.

Improving sustainability is a high priority for many horticultural growers, particularly as their customers set stringent environmental standards through their insurance schemes. While there is widespread awareness and willingness to reduce carbon footprint, knowing which measures to invest resources in can be challenging. With many ways to measure environmental

sustainability, identifying which changes will have the biggest impact, on both emissions and bottom line, can be difficult to navigate. The training provided by Growing Green aims to help business owners to identify the optimum changes that they need to make to have greatest impact.

Several fruit businesses benefited from the pilot Growing Green programme in 2022. Roughway Farm is a family-run business in Kent producing fruit and Kentish Cobnuts (Figure 2). Their existing nut de-husking process led to damaged fresh nuts, which reduced their market value and storage potential, leading to food waste. Through Growing Green, they worked with a local engineer to innovate a new de-husking process which removes the leafy outer husk, separating the husks and nuts with minimal damage to the fruit. The team have found an opportunity to valorise the waste husk material, creating a new revenue stream. They are also able to offer a de-husking service to other local growers. The new system also means that they can process the produce closer to harvest, dry the nuts more quickly and store them at ambient temperatures, rather than the normal cold stores. This further reduces their carbon emissions and cuts their energy costs.

Tom Cannon, Roughway Farms said "The Growing Green programme has been helpful in giving us business tips, like developing waste streams. There are many areas in our business where we can reduce our carbon emissions. It has helped us think about how we de-carbonise but also grow the business, and you want to do both".

Another mixed farm, E. H. Holdstock and Son, based near Canterbury, used their Growing Green grant to move from an overhead irrigation system to a trickle irrigation system in their orchards (Figure 3). Their action plan estimated this would save around 58% of water use, and reduce their diesel use by 71% due to reduced

Figure 2. Tom Cannon's family farm produces Kentish Cobnuts

evaporation and water run-off, and shorter running hours. Support from the team also enabled them to introduce dosemeters, so their fruit trees could be fed while irrigated.

Research grants

Through Growing Kent & Medway, £5 million is allocated to invest in grants ranging from £5,000 to £350,000 for innovative projects that aim to solve problems in horticultural, plant-based food or drink production. A number of fruit-related research projects have been funded and the progress on some of these is summarised in this Review.

In apple, Niab has been investigating new approaches to controlling apple canker and developing novel breeding methodologies that will enable a shorter breeding cycle and ensure a faster route to market for resistant varieties of apple.

In cherry, the University of Greenwich has been investigating ways of extending storage life using controlled atmosphere conditions.

In soft fruit crops, Niab has been assessing a range of strawberry and raspberry varieties to identify if any of them show resistance to spotted wing drosophila, which would help to direct strategies in future breeding of these fruits. Work has also been carried out to investigate the sustainable use of recycled growing media for strawberry and raspberry crops.

In strawberry, the Niab genetics team has been using 'state of the art' phenotyping and genomics to breed strawberry varieties with improved plant architecture that will improve the presentation of the fruit to pickers, thereby reducing harvesting costs.

Figure 3. E. H. Holdstock has installed a trickle irrigation system in their orchards

In raspberry, Niab's pest and pathogen ecology team has been investigating methods to improve the propagation efficiency of raspberry to ensure that every cane has a maximum yield potential, whilst also researching ways to improve integrated and biological control techniques for large raspberry aphid.

In tomato, Niab plant physiologists have been investigating ways of increasing tomato plants' ability to withstand rising temperatures by increasing the levels of iron and ascorbic acid (vitamin C) in the plant.

Business Innovation Vouchers

One of the remits of Growing Kent & Medway is to support and enhance sustainability and circularity within horticultural, food and drink businesses. To this end, 'Business Innovation Vouchers' have been made available to support innovative ideas that businesses need to research and develop. These might help to reduce carbon emissions, reduce resource use, reduce water or food waste in production processes, or develop more sustainable packaging. The vouchers contribute 50% of the research costs in projects costing between £20-60K, thereby funding between £10-30K, depending on total project cost. This money effectively pays for a research organisation, while the business benefiting pays the other half, either in cash or 'in-kind' contributions.

In the first round of Business Innovation Vouchers, eleven projects were funded, five of which are relevant to fruit production. The University of Kent worked with Sharpak Aylsham to develop a more sustainable soaker pad for use in raspberry punnets, and they also worked with J. L. Baxter & Son to explore the bioactive and nutrient components of Nashi pear juice (Figure 4), which is purported to have a number of health benefits. The University of Greenwich worked with A. C. Hulme & Sons to develop improved long-term low oxygen storage of Gala apples, and also with Edward Vinson Ltd to select raspberry breeding material with improved texture quality. Niab has been working on a project with Verdant Carbon to understand the links between the abundance and diversity of microbials in soils and the potential for storing carbon.

Figure 4. J. L. Baxter explored the nutrient components of their Nashi Gold pear juice

In a second round of Business Innovation Vouchers that began in 2024, twelve projects were funded, three of which are directly relevant to fruit growers. Niab has been working with Aridom Sanex to investigate a novel decontamination process on strawberry fruits to assess if it helps to maintain quality and improve shelf life. Working with British Apples and Pears Ltd, Niab is testing some promising new apple scab control products in a commercial orchard to investigate their potential for integration into existing commercial control programmes. The Niab team is also working with British Berry Growers and W. B. Chambers to explore the potential of deploying generalist UK parasitoids to provide natural control of spotted wing drosophila in this country. More details about these projects are found in the New Project section of this Review.

Prototype and Demonstrator Fund

Growing Kent & Medway has also created a Prototyping & Demonstrator Fund, which provides grants of up to £150,000 to develop and deliver new technologies for the sector. Two of these projects are of interest to the fruit sector and involve Niab. In the first, Deep Planet Ltd is working with Niab and five UK vineyards to employ artificial intelligence to accurately detect and predict early infection by Botrytis, powdery and downy mildew to replace current inefficient methods of monitoring. In the second, Niab is working with Saga Robotics Ltd to develop a system for delivering predatory mites to strawberry crops using robots already developed to deliver ultra-violet treatment for powdery mildew control. Further details can be read in the New Project section of this Review.

Business Sustainability Challenge

The Business Sustainability Challenge has supported businesses with innovative ideas by providing grants to fund work between £10-50,000, to aid sustainable production, products or packaging in the horticulture or plant-based food and drinks sector. One fruit related project was funded to allow A. C. Hulme & Sons to work with the University of Greenwich to investigate ways to improve the energy efficiency of their apple cold stores, without compromising the quality of the fruit.

Other forms of business support

Since the Growing Kent & Medway programme began in 2021, it has offered support to businesses in ways other than just research and development. The Food Accelerator Programme was set up for small and medium sized businesses and startup companies to develop a plant-based food or drink product and help to transform business ideas into commercial reality. To date, more than 90 businesses have used the programme and benefited from technical, business and financial support through masterclasses, in-person workshops, expert guidance, monitoring schemes and peer-to-peer training. Participating businesses also have access to the technology hubs and facilities available through the research organisations.

A Business Mentoring Support programme has also been organised to provide 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. Help is offered in areas including market research, sales, people management, finance and legal, through to supply chain development or marketing strategies. Growing Kent & Medway is indebted to a great many mentors who have given up their time for free to share their wealth of experience and expertise to support newcomers to the sector who are starting out on their own business journey.

Figure 5. Be Your Own Boss has provided free entrepeneurial and kitchen skills to young people

In our most recent form of business support, a new support programme called Be Your Own Boss has been set up to provide free entrepreneurial and kitchen skills training in a welcoming environment to young people aged 18 to 24 years (Figure 5). Following a successful pilot in Margate in 2024, the current programme is being run in collaboration with The Sunlight Development Trust, an independent voluntary organisation in Gillingham, aiming to improve physical and mental well-being, social inclusion, and health equality by strengthening their local community.

Be Your Own Boss is designed to address the barriers young people face in being self-employed or starting their own business. Youth unemployment in Medway is currently 6.5% compared to 5.6% in Kent and 5.4% across Great Britain. Providing young people with the confidence and skills to create their own business can help them explore different career paths, ultimately leading to growth in the local economy and potentially creating new employment opportunities.

The programme provides participants with a combination of business skills, kitchen training and real world insights. The sessions cover a diverse range of topics including identifying target customers, market research, branding, marketing, social media and finance.

Kamil, a participant in the original pilot programme highlighted his experience of the programme, saying "I feel more confident... I have enjoyed meeting new people and working together as a group". Another participant, Caleb, emphasised its distinct approach, stating, "To my knowledge, this is the only course that offers such experience... so this is a unique course".

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, scan the QR code:

NIAB

Fruit

For further details or information about Niab Fruit contact: horticulture@niab.com

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