Niab

Issue 59 • Autumn 2025

Landmark

Gene editing: shaping the future of agriculture

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Niab

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20 November	**NRoSO Sprayer Operator** • Trained by Syed Shah, Niab • ONLINE

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Mario Caccamo, Chief Executive, Niab • mario.caccamo@niab.com

Shaping the future of agriculture

Breeding new crop varieties remains a slow and laborious process. It can take years, sometimes decades, from the first cross to the commercial release of a new variety. Climate shocks, conflict, and shifting policy outpace genetic progress, leaving yields stagnating in key crops such as wheat.

At the same time, the UK faces the steady erosion of its agricultural base. In a recent report '*UK food security; outlook to 2050*', published online by the policy platform Science for Sustainable Agriculture, former NFU and CLA chief economist Dr. Derrick Wilkinson highlighted the loss of 4.4%, or 771,000 ha, of farmland over the past 25 years. Domestic food production has fallen in parallel, dropping to 65%, its lowest level in half a century. Even more concerning, the report warns that in a worst-case scenario, almost a quarter of the UK's utilised agricultural area could be at risk.

Against this backdrop, the question is unavoidable: can faster adoption of new technologies help us accelerate solutions? Can we realistically aspire to strengthen domestic food production and reduce our dependence on imports?

This *Landmark* issue explores how gene editing, a powerful precision breeding tool, can help address these pressing challenges. At Niab, we are not only investing in biotechnology, but also supporting efforts to modernise the regulatory frameworks that govern its use.

Wilkinson's analysis makes clear that much of the decline in food production has been exacerbated by overly restrictive regulation, which has delayed innovation and limited farmers' options. With proportionate, science-based regulation, precision breeding technologies such as gene editing can transform our ability to feed more people, more sustainably. They will be crucial to enabling farmers to raise yields while using fewer inputs, supporting both profitability and environmental goals.

Encouragingly, positive stories of gene editing research now emerge almost daily. Scientists are developing higher-yielding crops with greater climate resilience, more durable pest and disease resistance, improved nutritional quality, and reduced environmental impact. The combination of precision breeding with digital tools such as artificial intelligence promises to accelerate progress further by fast-tracking the identification of genes linked to key agricultural traits. With tens of thousands of genes within each crop genome, the opportunities for innovation are immense.

Momentum is also building in the commercial sector. Fresh Del Monte has warned of a looming global banana shortage driven by climate change and fungal diseases such as Black Sigatoka and Tropical Race 4. In response, the company plans to begin field testing TR4-resistant gene-edited banana

Niab Chief Executive Professor Mario Caccamo originally joined Niab as the Head of Crop Bioinformatics in 2015, became NIAB EMR's Managing Director in 2017 and was appointed Chief Executive in 2021. A computer scientist by training, Mario has over 25 years' experience in life science research and big data, including specific projects to apply the latest DNA sequencing technologies and bioinformatics methods to advance scientific understanding of crop genetics and the interaction of agricultural crops with their environment. He is currently a Director of the Oxford Farming Conference.

Niab's first precision breeding field experiment; a Crispr/Cas9 edited spring barley with deletions in GSK1, a gene involved in regulating the brassinosteroid pathway. It is expected that the lack of functional GSK1 will lead to maintained grain yield under lower nitrogen input regimes. This picture, taken in early July 2023, shows the barley experimental material being grown for the first time for seed increase to use in subsequent experimental field trials only. The barley plots were grown without a physical cage around them, but were surrounded by an area of spring wheat which was destroyed after harvest, in accordance with the terms of the field release

Photo: Max MacGillivray

Niab CEO Mario Caccamo meeting new Minister of State for Food Security and Rural Affairs Dame Angela Eagle DBE at an industry event in early October 2025

lines. UK start-up Tropic Bioscience is pioneering similar approaches to boost productivity and resilience in novel gene edited banana varieties. Meanwhile, confectionery giant Mars has partnered with gene editing firm Pairwise to protect the cacao crop from mounting threats posed by disease and climate variability.

The scale of global research is equally compelling. According to the EU Sage database, more than 1,000 peer-reviewed studies on gene editing in crops have now been published. These span 76 species and 58 countries: this is a truly global phenomenon. The gene editing revolution is only just beginning, and with it comes the chance to address some of the greatest threats to our food supply. The application of AI to unlock novel gene combinations will only accelerate this transformation.

Britain's scientists are at the forefront of this revolution. Through the Genetic Technology (Precision Breeding) Act, coming into effect this November, we have established one of the most progressive regulatory systems in the world designed to move breakthroughs from lab to field more quickly. At Niab, we are proud to pioneer the use of science and innovation to enhance productivity, with precision breeding as a prime example.

One example of the benefits of gene editing, highlighted in this issue, is the PiperPlus programme: a collaboration between BioPotatoes and The Sainsbury Laboratory. This initiative has produced a cisgenic potato with durable resistance to late blight. PiperPlus potatoes have been trialled at Niab for several years.

This precision-bred variety not only helps growers manage a devastating disease, but also contributes to environmental protection by reducing the need for pesticides.

Niab is also actively involved in ensuring that the current process for registering and evaluating new varieties developed through precision breeding is fit for purpose. This is another example that underscores the value of our expertise in supporting and de-risking the adoption of new technologies As Wilkinson's report makes clear, growing populations and rising pressure on farmland mean that the only way to strengthen food security is to use our land as wisely and productively as possible. That requires farming policies and regulations that are fit for purpose, grounded in evidence, and enabling of innovation, not restrictive of it.

The challenge is urgent. The tools are available. Now we must ensure the will and the policies are in place to seize this opportunity.

This year Mario has had the opportunity to participate in the roundtable discussions of the 30:50:50 initiative: a visionary agenda launched in January this year by the All-Party Parliamentary Group for Science & Technology in Agriculture, and featured on the Niab stand at Cereals Event this summer (Pictured at the Cereals Event with shadow Defra minister Robbie Moore MP and APPGSTA's Daniel Pearsall). The initiative aims to increase UK agricultural productivity by 30% by 2050, while simultaneously reducing the environmental footprint of farming by 50% per unit of output. The most recent roundtable, in September, focused on government policy and brought together key organisations from across the agricultural sector, including AHDB, NFU, and leading research institutions. Niab is proud to sponsor this initiative and play a central role, drawing on our expertise in translational research and our capacity to assess and validate emerging technologies

Sasha Eremina, The Sainsbury Laboratory, Norwich Research Park

PiperPlus: precision breeding for resilient potatoes

In the glasshouses and fields of Norwich Research Park, a quiet transformation is taking place. Potatoes – the world's third most important food crop – are being re-imagined for a future where resilience, sustainability and food security are more urgent than ever. At the heart of this story is BioPotatoes' *PiperPlus* programme, which has turned a long-standing problem for growers into an opportunity to showcase the power of precision breeding.

Dr Sasha Eremina is Entrepreneur in Residence at The Sainsbury Laboratory scoping opportunities for BioP. With a background in bio-innovation, academia-spun start-ups and venture capital, she leads horizon scanning for new traits and supports product approvals and fundraising, while also contributing to TSL-based projects aligned with BioP's mission to advance potato health.

A costly disease

Late blight, caused by the pathogen *Phytophthora infestans*, has stalked potato crops for nearly two centuries. It was the disease behind the Irish potato famine, and it remains the single most expensive pest and disease problem faced by UK potato growers today.

Fungicides and crop losses together cost the farmers an estimated £50-70 million each season. On average, a commercial potato crop may receive up to 15 fungicide sprays a season, costing up to £500/ha. This heavy reliance not only adds cost but also increases environmental impact and accelerates evolution of fungicide resistance in pathogen populations.

The challenge has been clear for decades: how can we equip one of Britain's most important crops with long-lasting resistance to late blight, without sacrificing the qualities that consumers and processors demand?

Building on nature's toolkit

BioPotatoes' (BioP's) answer has been to draw directly from potato's extended family of related *Solanum* species. While cultivated potatoes are vulnerable, their wild relatives carry a vast diversity of natural resistance genes. Identifying, isolating and stacking these genes is the foundation of creating new disease-resistant varieties.

Much of this groundwork comes from over 25 years of research by the Jonathan Jones group at The Sainsbury Laboratory (TSL). Their long-running

Wild potato relative Solanum americanum, source of two of the late blight resistance genes used in the cisgenic material

PotatoPlus programme has uncovered a suite of Resistance (R) genes from wild potato relatives that can recognise the late blight pathogen *Phytophthora infestans*, which prevents the disease from developing. Key sources include *Rpi-vnt1* from *Solanum venturii* and the more recently discovered *Rpi-amr1* and *Rpi-amr3*, from *Solanum americanum*, which together provide strong protection against multiple races of late blight pathogen. The team has also isolated genes conferring resistance to Potato virus Y (PVY) and Potato leaf roll virus (PLRV), paving the way for healthier seed potato production with fewer insecticides required to restrict the aphids that spread the viruses.

By showing that stacking several of these R genes in a single plant can deliver durable, field-tested resistance, the Jones group created the scientific platform for PiperPlus. Their work has gone further still: successive versions of PiperPlus 1.0, 2.0 and 3.0 were developed in Maris Piper to combine late blight and virus resistance while ensuring compliance with the UK's new Precision Breeding regulations. The latest generation, PiperPlus 3.0 is now moving into commercial testing with BioP.

Professor Jones' approach allows resistance genes from wild relatives to be added directly into established commercial varieties, preserving all the qualities that make them popular while equipping them with durable disease resistance.

For BioP, the challenge is to carry this legacy forward – translating world-class science into resilient, market-ready potatoes that farmers can grow with fewer chemical inputs and greater confidence.

Policy shift, science shift

The recent passing of the Precision Breeding Act has created the political and regulatory space for projects like PiperPlus to step out of the trial plots and into real fields. The Act, which applies across England and Wales, allows crops that carry added genes that could have been bred in, to be grown and marketed without the

Cisgenic 'PiperPlus' material in 2025 Niab yield trials, carrying the late blight- and virus-resistance gene stack

heavy regulatory burden that historically accompanied genetically modified organisms.

For potato, the implications are profound. Where once it could take more than a decade and significant investment to bring a disease-resistant variety to market, the streamlined pathway now makes adoption faster and more realistic for growers.

This shift is timely. Climate change is already influencing late blight epidemiology, with earlier outbreaks and more aggressive strains, some of which evade some fungicides, placing even greater pressure on crop protection. PiperPlus is not just a scientific curiosity – it is a practical solution that could transform sustainability in the potato sector.

PiperPlus on show

The project has also captured the public imagination. Since summer 2025, a PiperPlus potato has been part of the Science Museum's *Future of Food* exhibition in London, curated in partnership with TSL. Visitors can see first-hand how modern crop science tackles age-old challenges, standing alongside other breakthroughs in biology and medicine.

Food crops are often invisible in public conversations about science. PiperPlus brings the story of precision breeding to a wide audience – from schoolchildren to policymakers – showing how innovation in the field links directly to the plates on our tables.

BBSRC support for the next chapter

The progress of PiperPlus has been recognised through a new round of funding from the Biotechnology and Biological Sciences Research Council (BBSRC). This follow-on award ensures that the technology can be tested under more commercial conditions, across different environments and with multiple stakeholders in the supply chain. Niab will continue to be a partner in field trials of these new prospective variety lines.

This is more than research funding: it represents a bridge between proof-of-concept science and the practicalities of breeding, regulation and adoption. BBSRC's investment reflects a wider national strategy to embed precision breeding as a mainstream pathway in sustainable agriculture.

What growers stand to gain

For growers, PiperPlus could mean:

- reduced fungicide inputs – cutting both costs and carbon footprint;
- more reliable yields – particularly in seasons when blight pressure is extreme;
- improved seed potato production – resistance to viruses such as PVY and PLRV means healthier seed lots can be produced with fewer insecticide applications. This opens the door to more seed potatoes being grown in England, reducing reliance on Scottish production and the long-distance transport of seed across the UK;
- lower environmental footprint – fewer sprays and fewer tractor journeys reduce greenhouse gas emissions and soil compaction.

Niab 2025 yield trial and tuber multiplication plots of TSL cisgenic material carrying the late blight- and virus-resistance gene stack

Of course, resistance is never absolute. Pathogens evolve, and stewardship will be key. That is why PiperPlus is designed with gene stacking: combining multiple resistance genes so that if one is overcome, others remain active. The strategy mirrors integrated pest management – it is not a silver bullet, but a durable step change.

Industry partnerships and future potential

BioP is working closely with breeders, seed producers, processors and retailers to ensure that PiperPlus fits smoothly into the supply chain. Beyond late blight, the Precision Breeding Act enables science-based approaches that could be applied to other pressing challenges: potato cyst nematodes, blackleg, wireworm resistance, virus protection, or even quality traits such as reduced bruising.

A close collaboration between BioPotatoes and TSL – a world-leading centre for plant immunity research – is central to delivering on this ambitious pipeline of traits. Their scientific discoveries, coupled with BioP's commercial focus, provide the foundation for turning cutting-edge ideas into practical varieties.

This pipeline approach is where precision breeding shows its true promise. Once the principle is proven with late blight resistance, the door is open to a wider suite of traits – all rooted in *Solanum*'s own genetic diversity. And looking ahead, the technology could also become NGT-1-compatible in the EU, creating opportunities to extend these benefits into European markets as regulations evolve.

For BioP, PiperPlus is a starting point. By bridging science and practice, we aim to open the door to bottom-up innovation – giving growers, breeders and supply chains new tools to shape the resilient potatoes they need for the future.

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The Defra GINs – a tonic for UK crop improvement

Dr Phil Howell has been a pivotal part of Niab's pre-breeding group since 2007, working on major pre-breeding projects including the flagship wheat resynthesis programme. He has nearly 30 years' experience of crop genetics and breeding in oilseed and cereal crops, working within the public and private sectors. Prior to joining Niab, he spent almost ten years at Syngenta, including five years as senior UK wheat breeder, leading to several successful varieties. His practical experience and credibility amongst commercial peers has helped to cement Niab's position carrying out pre-competitive breeding research.

Director of Science Professor Xiangming Xu is responsible for developing and delivering the strategy for research activities across the whole of Niab. A crop agronomy graduate from YangZhou University in China, Xiangming completed his PhD in plant qualitative genetics and plant breeding at the Welsh Plant Breeding Station in Aberystwyth in 1989. He joined Horticulture Research International (now Niab) at East Malling in Kent in 1991 as a plant pathologist, becoming Head of Science in 2020, after leading roles in genetics and crop improvement and in pest and pathogen ecology.

For over 20 years, Defra has supported a series of Crop Genetic Improvement Networks ('GINs') in which leading researchers, in conjunction with breeders and other industry stakeholders, work together to support the development of public-good traits to enhance the productivity, sustainability, and resilience of important UK crops and bring them closer to farmers' fields. They were set up to bridge the disconnect between academic research and commercial breeding, the so-called 'Valley of Death', and ensure better communication and connectivity between the two communities. Pre-breeding activities carried out within the GINs generate genetic and genomic resources that are then made available to commercial breeders to use within their own programmes.

The first four GINs, initiated in 2003 and now into their fifth funding cycle, focus on oilseeds (OREGIN), pulses (PCGIN), vegetables (VeGIN) and wheat (WGIN). A fifth, looking at soft fruit (SFGIN), was recently added to the portfolio (Figure 1).

The current phase of funding, which runs from 2024-29 with scope for a further five years of funding after that, brought a slight change in emphasis. The number of crops supported across the entire GIN programme was increased, bringing in a range of related underutilised, minor and novel crops that may become more important in the future, largely informed by a recent review commissioned by Defra on such crops led by Niab.

Work on precision breeding is now also embedded within each GIN, recognising the importance of this exciting technology as the Genetic Technology (Precision Breeding) Act 2023 comes into force. The Met Office is also now working with the GINs, to ensure that the likely impact of climate change on crop performance is considered in ongoing and future projects. Details of all the GINs, including a full list of partners, can be found at https://defracropgenetics.org/.

Outputs to date

Typical outputs include genetic stocks, diversity panels, pathogen collections, molecular markers and marker technologies, mapping populations for trait identification and evaluation, and genomics and bioinformatics datasets. These are passed on to breeders and often find their way into new research projects funded by Defra or other UK bodies such as BBSRC or Innovate UK. As well as regular meetings to update on project progress, each GIN holds an annual stakeholder meeting to report findings more widely and to discuss future directions.

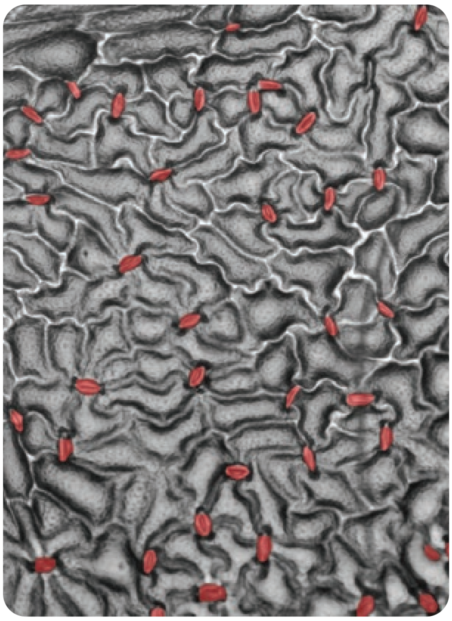
Figure 1. List of crops covered by Defra GINs

GIN	Main crops	Underutilised crops
OREGIN	oilseed rape	*Brassica atlantica* (wild relative of oilseed rape), industrial hemp, sunflower
PCGIN	faba bean, pea	chickpea, common bean, lentil, soybean
SFGIN	blueberry, raspberry, strawberry	blackberry, honeyberry
VeGIN	vegetable brassicas, carrot, lettuce, onion	celery, coriander, leek, parsnip, wild rocket
WGIN	wheat	durum wheat, triticale

Niab involvement

Niab Director of Research Professor Xiangming Xu is leading research at SFGIN, the newest

Figure 2. Magnified image of a strawberry leaf surface showing the density of stomatal pores (coloured in red), part of the SFGIN water-use efficiency work



addition to the platform, together with Niab fruit breeders Abigail Johnson (strawberry) and Felicidad Fernandez (raspberry, blackberry and honeyberry), physiologist Graham Dow and crop transformation researchers Emma Wallington and Julia Lambret. Other key SFGIN partners are based at James Hutton Institute and ADAS.

In strawberry, by far the best-established UK soft fruit crop, work at Niab's East Malling site is focusing on the genetic control of traits which are important for water-use efficiency (Figure 2), including trials grown under different environmental conditions to simulate projected climate change (elevated CO_2 and temperature, reduced water availability). In Cambridge, the Niab team is investigating new DNA-free precision breeding technologies which will simplify gene editing in clonal crops like strawberry and raspberry (Figure 3).

Niab expertise has also been a key part of OREGIN, primarily through the input of break crop specialist Colin Peters and crop pathologist Tom Wood. Tom is also heavily involved in pathology work within PCGIN. The recent addition of minor legumes, including chickpea, lentil, soybean and common bean, has also brought breeder Phil Howell into the PCGIN team.

Niab also plays a role in WGIN, screening diverse materials for resistance to *Septoria tritici* blotch (STB) both in our spore-proof growth rooms and in the field, headed by pathology leader Kostya Kanyuka with Phil Howell. Field testing is carried out at a specially selected site in Devon

Figure 3. Regenerating strawberry plants in tissue culture, part of the SFGIN DNA-free gene editing work

with historically high levels of STB but lower levels of other foliar diseases, in particular yellow rust. Plots are managed by the trial delivery team at our Newton Abbot centre and treated with specific fungicide regimes designed to minimise rust pressure without inhibiting STB development. This has become our major centre for STB field testing (Figure 4), hosting other large screening experiments each year, including for Niab PhD student Anisa Blower; for BBSRC-funded project 'Delivering Sustainable Wheat'; for a large collaborative project with several European breeders; and for private breeding company trials.

Future prospects

As well as the five existing GIN platforms, Defra has just commissioned Niab (led by Phil Howell), in conjunction with UK Agri-Tech Centre, to assess the potential for future genetic crop improvement work. The brief is to consider field and orchard crops not currently supported by GINs but grown at scale (such as barley, oat, potato, beet, forage and fodder crops, tree and vine fruits) and also to assess the prospects for Controlled Environment Agriculture and Horticulture. Niab will be consulting with breeders, growers and other industry stakeholders in the coming months as part of this exercise. Again, precision breeding is included in this review, underlying the central perceived importance of this technology to all aspects of crop improvement moving forward.

Figure 4. STB screening trials at a Niab trials site in Devon, spring 2025

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Registration of precision bred varieties

With new legislation and understanding of the benefits of precision bred plant varieties, questions quickly turn to the statutory testing system and how these varieties will get to the (English) market. The short answer is likely to be "using the current UK system for new plant varieties", but with the caveat that some things will need to be adapted.

Dr Margaret Wallace is the joint Head of Agricultural Crop Characterisation at Niab, working primarily on DUS testing and seed certification, focusing on developing the statutory systems with the implementation of new technologies. Margaret works with the international organisations UPOV and OECD to encourage harmonisation of practices across the member countries and states. Her main areas of interest are the implementation of molecular techniques and automated phenotyping.

The basis for the primary legislation (Genetic Technology (Precision Breeding) Act 2023) is that the resulting plant variety could have been created using traditional or conventional breeding techniques, such as backcrossing or chemically induced mutation. Therefore, it is unlikely that precision bred varieties would be identifiable as such and so, the current testing system for new plant varieties could be applied.

For most of the agricultural species common in the UK, there is a requirement for new varieties to be listed prior to marketing (www.gov.uk/guidance/national-lists-of-agricultural-and-vegetable-crops). This requirement involves two types of testing – VCU (Value for Cultivation and Use) and DUS (Distinctness, Uniformity, and Stability). A variety must have a positive assessment in both tests to be considered for registration. Both tests compare the new candidate with existing varieties.

VCU testing is focused on traits such as yield, disease resistance, standing ability, etc… the types of characteristics a grower would think about when deciding which variety to sow. VCU traits are often breeding aims, so the results of precision breeding techniques are likely to show up here. The new variety must show a clear improvement over the existing varieties in the trial before it can be Listed (added to the GB or the NI Variety Lists, making it eligible for marketing). The procedures for VCU testing are regularly reviewed by the Procedure Development Group for that species. The Group (which includes experts from Niab) can consider the characteristics, how characteristics are recorded, and how the data is analysed. If a plant breeder has introduced a new trait not normally considered in VCU testing, or has additional information about the variety that would assist with the trials, there is opportunity to inform the Animal and Plant Health Agency during the application process (or earlier) for consideration. This is also the opportunity to provide additional information at the point of a variety listing application to state how the variety is seen as an improvement and is suitable for the UK market.

DUS is the lesser known of the two tests required for variety registration. It looks at the phenotype of the variety and uses characteristics such as glaucosity (waxiness) of a wheat ear, or length of an OSR petal, so it does not grab the attention of a grower in the same way as VCU. That does not mean that it is less important. The DUS test compares the new candidate variety with the other varieties to confirm that it is different (Distinct). A new variety must also be Uniform and Stable; this confirms that the new variety is not contaminated with other plants of the same species. There are two outputs from a positive DUS test – the report that allows the variety to

be marketed, and the Official Variety Description. The description will be used throughout the generations of seed production to confirm the identity of the seed crop.

UK DUS examiners (like those at Niab) follow UPOV (International Union for the Protection of New Varieties) guidance (www.upov.int). This guidance means that the testing is harmonised across the global membership. However, local legislation and interpretation of the guidance applies. The UK DUS system accommodates new varieties no matter the breeding method used. The characteristics considered in the test are agreed by NLSC (formerly National List and Seeds Committee,) and the PVSC (Plant Varieties and Seeds Committee). Any new characteristics (including those resulting from traits introduced by new techniques) can be proposed for consideration by the Committees.

Although the requirement for field trials remain the same for a precision bred variety, the National tests may need to be adapted to allow for different legislation in Scotland, Northern Ireland, and Wales. For example, the Act provides powers to amend GMO legislation in England, enabling precision bred plants to be regulated differently to GMOs. As such, UK trial sites outside of England may require the relevant GMO licences to test material produced using precision breeding techniques. How that will affect the testing remains to be seen, particularly for some VCU tests where trials are conducted at several sites to give a representative view of the environmental conditions across the United Kingdom.

There is an expectation that the variety registration process will have an additional administrative obligation for precision bred varieties as there will be requirements for the release and marketing of a precision bred organism as detailed in the Act. This will affect the applicant, APHA, the registration office, and the test providers, not to mention further down the chain for seed production and marketing.

Niab awaits news on the implementation of the Act, with confidence that the technical elements of the variety registration process (the parts we deliver on behalf of Defra and APHA) will accommodate precision bred varieties or can be adapted to do so. We are also watching and waiting to see how the UK-EU reset talks and a Sanitary and Phytosanitary agreement affect the implementation of the Act, or perhaps more broadly the variety registration. Nothing stands still in variety testing.

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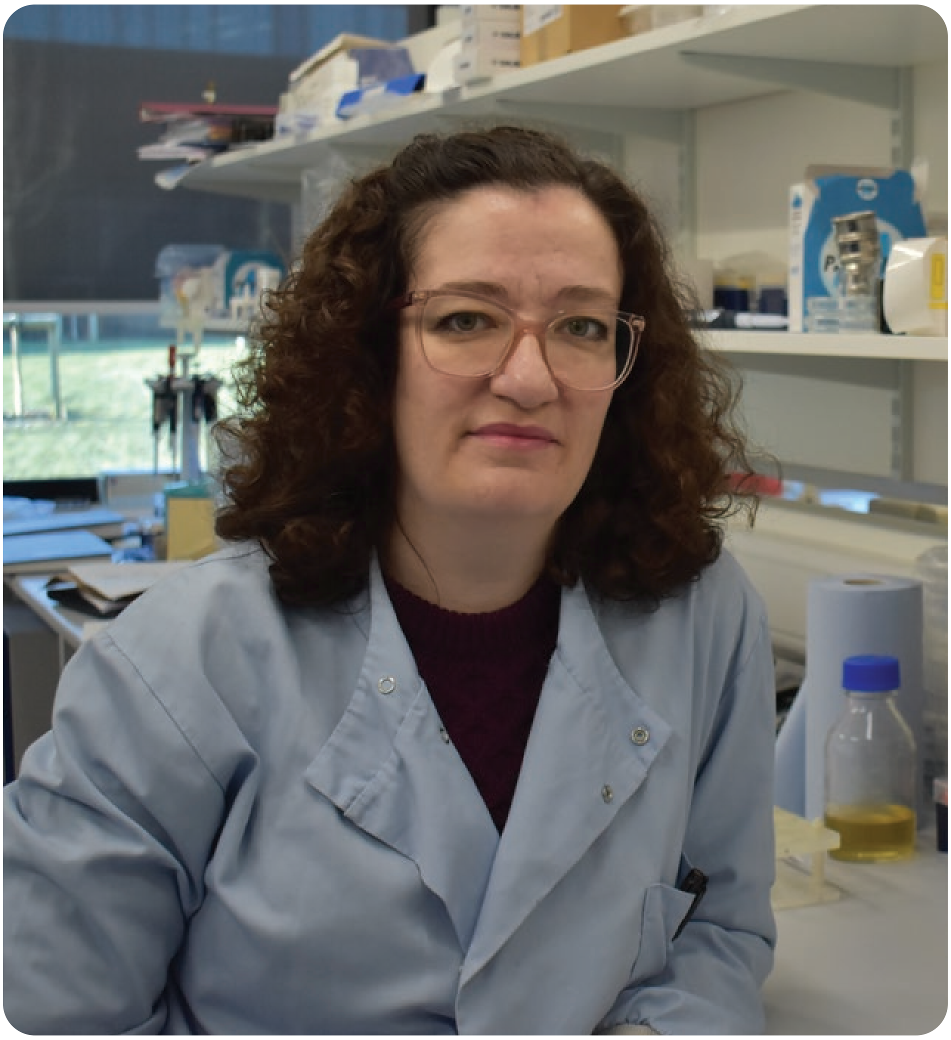
Staff profile – Julia Lambret Frotte



Dr Julia Lambret Frotte is a crop molecular biologist at Niab, working on gene editing in challenging crops. Here, she explains her role in crop precision breeding, how it may help produce varieties more resistant to drought, pests and diseases, plus what excites her about her role at Niab.

What are you currently working on and why is it important?

I'm currently leading the development of a precision breeding pipeline for genetically complex crops at Niab. My work started with potato but has now expanded to strawberry, thanks to significant progress made by my colleague Samaneh Najafi in precision breeding techniques in the soft fruit crop.

Potato and strawberry are important crops in the UK, yet are susceptible to climate variations and pest pressures. There is great market potential in the development of resilient varieties that maintain high yields under adverse conditions, but their genetic complexity makes traditional breeding approaches very challenging.

That's where precision breeding comes in, allowing us to make small editions in very specific parts of the plant genome. It's a very controlled process and the changes do not differ from naturally occurring mutations. But, instead of relying on chance, we guide the process with precise molecular tools. This enables us to switch genes on and off to improve traits such as stress tolerance or yield performance, exactly like domestication and traditional breeding have done so far. But we can do it much faster. The recent approval of the Precision Breeding Act has supported a broader use of genetic innovation in agriculture and food production.

And how do we do this? We start by isolating leaf cells known as protoplasts. We then expose them to the gene editing machinery, which remains active only briefly before being naturally degraded by the cell. These cells are now edited cells, that are then cultured in a medium that promotes division and, over several weeks, they regenerate into whole plants. Each regenerated plant is a product of precise genetic breeding and may carry traits that improve its growth, resilience and productivity.

What are the biggest challenges in your work area?

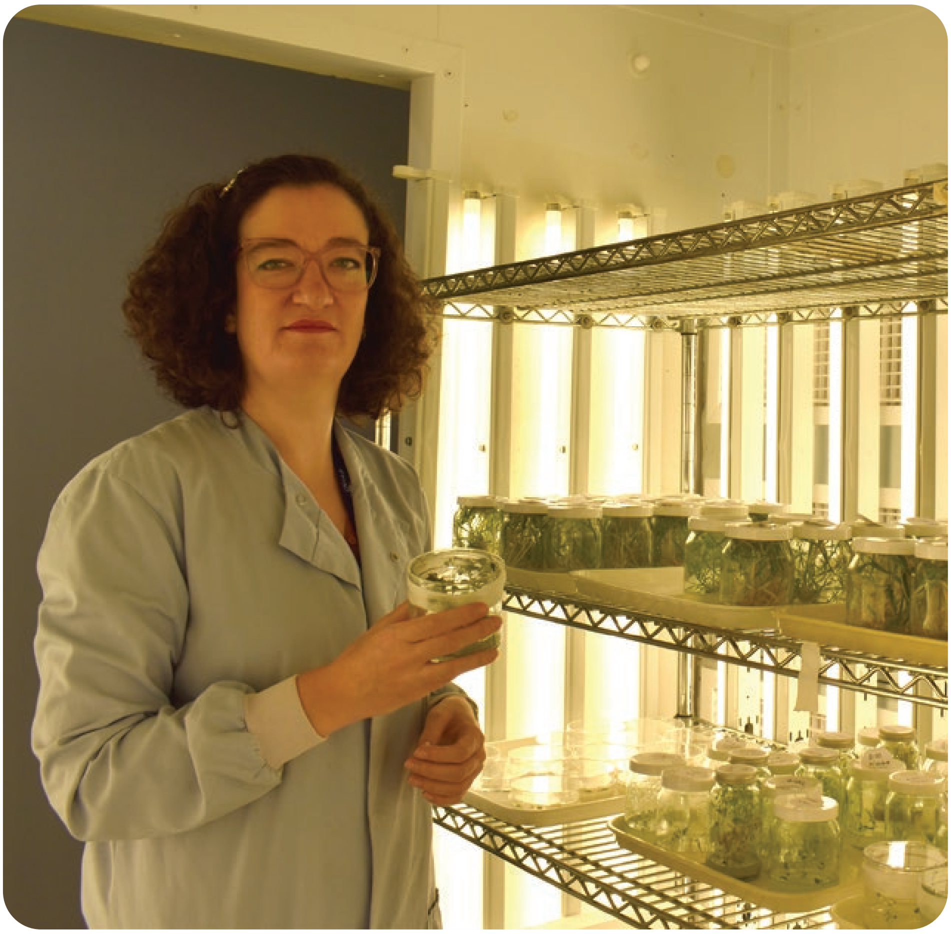
The process involves regenerating a whole plant from a single cell, which is both time-consuming and technically demanding. The protocol itself is highly sensitive, and even minor variations in conditions can mean failure. A lot of attention to detail is required at every step. But the impact of the technology makes the effort worthwhile.

How does your science address the big challenges industry faces?

When we talk about how versatile and transformative precision breeding can be then the sky is the limit. We're just scratching the surface of the potential advances on offer. For example, we have the potential to accelerate the development of higher-yielding food crops with greater climate resilience, more durable pest and disease resistance, reduced environmental impact, and with improved end-use quality and nutritional properties – all of these are win-win outcomes for both food production and the environment. We have the opportunity to tackle many of the major threats facing the security and sustainability of our food supply.

What is your most important research finding?

Niab is still in a early stage of this research, but we have made huge advancements in establishing the protocol. We're making progress to be in a position where we can undertake gene editing faster and on a larger scale. It's very exciting and it has huge potential along the entire crop production pipeline, from pre-breeding research to commercial production.



What excites you about your job?

I think the possibility that my work could improve conditions for farmers and consumers. Crop science is a very wide field and there are so many different things that are important and interesting to be working with.

What's the best thing about working at Niab?

I think Niab has a very special combination of conditions, including working collaboratively with commercial stakeholders and researchers. I really like that balance and enjoy working with the differences and similarities between them. And I find it very rewarding to see the work we develop in the lab having real world application.

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Ryegrass and glyphosate resistance

To fully understand how glyphosate resistance in ryegrass happened and the journey that took us to this position we need to consider agronomy practice over the past 10 to 20 years.

Niab regional and on-farm agronomist in the south-east Keith Truett is a former farm manager with a wide experience of different soil types, crops, large estates and small farm operations cultivations operational detail and organisational logistics, in various parts of the country. He is most at home as part of a team helping to contribute towards the future of the countryside and the prosperity of farmers.

Farms have expanded, equipment become larger and more expensive to run, margins have been squeezed and work pressures have grown to the extent that most are running faster to stand still. Against this background the promise of a reduced workload from a farming method that promises the need for fewer inputs while returning better soil health has been very attractive.

In many cases the principles of 'controlled traffic,' 'conservation ag,' and 'regen ag' have been turned into shortcuts which have abandoned certain elements of good farm practice, giving rise to catastrophic levels of BYDV, huge rises in ergot infested grain plus greater difficulties in controlling both grassweeds and disease. Weeds are, however, restricted to the farm boundary and positive action on farm will give a positive outcome.

Having considered this there are many examples of these practices being implemented well and contributing positively to the farm business. There is no simple message of how to manage these issues and solutions have to be tailored to individual circumstances with specific on farm knowledge. To tackle this situation many need do nothing, having stayed with good farm practice and attention to detail in their agronomic decisions, the crisis is passing many farmers by unscathed. Let us consider how to get everyone to this position.

Ryegrass background

Niab has spent a number of seasons, many trials (Figure 1) and commercial crops looking at the competitiveness and voracity of Italian ryegrass when it becomes resistant to various selective herbicide actives; the individual plants can become immense with over 100 tillers, giving huge levels of seed return. Resistance and reduced efficacy from residual chemistry in ryegrass is widespread and well documented, as are the shortcomings in adopting the strategy which many have used successfully for black-grass. Having considered this the next step was always going to be for this weed to become tolerant of low doses and then resistant to glyphosate.

So, three scenarios – where do we go from here, how do we avoid this issue and finally how do we sort out this problem once it is established on farm?

Firstly, where do we go from here where there is no existing ryegrass issue. The answers are to adopt a zero tolerance attitude, rogue individual plants, inspect regularly and remove any offending possible examples. This includes moving as far as is possible to internal working on farm, avoiding using contractors and restricting who is allowed onto farm.

Where there are neighbours with the issue be especially vigilant on boundaries. In high grade seed crops it is normal practice to establish a 1-3 m buffer of bare soil around the crop with cultivation; this would also prevent the ingress of ergot and injurious weeds. Moving to home-saved seed would also help restrict any risk of contamination. If the farm practice is to bale straw, or to allow others to, and swap this for FYM then perhaps this needs strict control.

Figure 2 shows an area of ryegrass that came from 2-4 individual plants that were not controlled in the previous wheat crop. All the small pale green plants will have the same genetic status and if not controlled prior to establishing a crop will multiply out of control. Here there was the option of placing this field in AHW11 under the SFI scheme. In trying to find the original source, as there were a number of small patches, it was realised that the FYM applied had come from straw sourced from land with a resistant ryegrass burden. Segregate and sell the straw off farm.

No rotational changes should be required but be wary of shortcuts which

Figure 1. Niab ryegrass trials in Kent in 2021

Figure 2. Establishment of resistant ryegrass from contaminated FYM application

allow grassweeds to develop. When using glyphosate follow the Weed Resistance Action Group advice, avoid overuse (e.g. pre-harvest desiccation, multiple stale seedbed applications) and use robust dose rates of reliable products with appropriate water volumes, forward speeds, weed growth stages (i.e. not during stem elongation) and in suitable weather conditions (active growth so avoid frost and drought).

In the second scenario, where first patches of ryegrass are established, gather seed and test to establish the resistance status of the plants concerned. Where glyphosate resistance is confirmed, take these areas out of production long enough to allow weed germination and control these small plants by ploughing or cultivation. Where ploughing, go to 20-25cm with skimmers set to invert all organic material into the bottom of the furrow, this will also need forward speed to be restricted to below 10 kph (6 mph) dependant on soil type. Regular (monthly) cultivation passes will be required if ploughing is avoided and it will not be as effective.

These ploughed areas should be pressed without tines and left untouched until spring when a crop can be established with minimal soil disturbance. This does, however, need to be a crop where selective chemistry can be used to remove any grass that germinates, limiting the grower to maize and root crops. No spring cereals will give full control of ryegrass, and the selective chemistry in pulses and linseed is too unreliable.

The other course of action for this, and where larger areas have developed, is to sow a cheap home-saved seed crop of a winter cereal and forage the crop in the spring before the ryegrass has a chance to create viable seed. Having removed all this material plough as described above, then establish a spring crop, preferably maize or roots. Once this land is ploughed it should not be reploughed for six years. Sowing maize is not essential and some SFI options may help provide some compensatory income, assuming some of the existing options (e.g. cultivated fallow for arable weeds, summer cover crop) still exist in this new era.

The elephant in the room in this scenario is that growers will need a home for the forage generated; a livestock farm or a biodigester operator who can make use of the material. Often, if you can find such an arrangement, there will be a need to take back digestate or muck and, again, the biosecurity alarms should sounding!

Hopefully, those with minimal ryegrass now drop back to being ryegrass free and can assume the position suggested above.

In the third scenario, where resistant ryegrass is established across the farm, there are more difficult decisions to take. First would be to decide what area of the farm can be removed from conventional production to allow the steps described above to be implemented. It must be assumed that some seed return will continue until the whole farm has been cleansed, and that the faster this is achieved the better. Ideally, 50% would work, 30% would be more difficult, any less impractical and risking putting the whole farm back at the beginning with contamination from land with the issue.

Figure 3 shows some simple figures across a 400 ha farm. Operations are entered as a contract fee of £400/ha for each crop, except for fallow and silage where an operation cost is added. The remaining cost in each category is the variable cost for each crop. The income – wheat at 9 t/ha, £180/t; OSR at 3.5 t/ha £400/t; and forage maize at 52 t/ha, £25/t.

In the case of 'carry on regardless' add together the WOSR and wheat margin (£185,600), removing fixed costs, rent and finance, and wait for the yields to plummet. With the forage maize and arable silage route (£269,000), similarly take out costs. In the SFI example, remove 25% and treat as fallow to remove the worst ryegrass, assuming the remainder can be cropped, with £211,300 minus costs as before.

Summary

Carrying on regardless with glyphosate resistant ryegrass is not an option and not even the most profitable route forward, so why would anyone consider this? Finding an on-farm solution which fits every enterprise is, however, much more difficult and challenging, and where Niab Agronomy Membership can help.

Figure 3. Managing removal of resistant ryegrass across a 400 ha farm (£/ha)

Crop and area reduction	Income (£/ha)	Expenditure (£/ha)	Margin (£/ha)	Total margin (£)
Wheat @ 50%	£1,620	£995	£625	£125,000
Maize @ 50%	£1,400	£780	£620	£124,000
WOSR @ 50%	£1,300	£997	£303	£60,600
Cultivated fallow SFI @ 25%	£660	£100	£560	£56,000
Silage	£200	£100	£100	£20,000

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20 years research on black-grass control

Black-grass (*Alopecurus myosuroides*) has become one of the most economically damaging herbicide-resistant weeds in Europe. In the UK, herbicide-resistant black-grass was first identified in 1982 and it has since spread to the majority of farms in England.

Dr Syed Shah has worked in the UK agri-industry for over ten years as an agronomist and crop researcher. He joined Niab in 2019 as a regional agronomist in the south of England and Technical Innovation Lead, providing agronomy advice to Niab members, alongside organising field days and trials plot demonstrations. His main interest is testing innovative products and techniques to reduce reliance on pesticide and fertiliser inputs without compromising yield.

Herbicides have long been the primary method of weed control, but frequent use of the same active ingredient has led to the evolution of resistance. Black-grass causes significant yield losses by competing with crops for key resources, particularly nitrogen and water. Previous studies have shown that densities ranging from 12 to 500 black-grass plants per square metre can reduce wheat grain yields from 5% to 50%, respectively.

Given these challenges, integrating cultural control strategies alongside herbicide use has become increasingly important to manage black-grass populations and slow the development of resistance. Over the past two decades, Niab has conducted extensive research into both chemical and non-chemical control methods. These trials have investigated factors such as drilling date, seed rate, variety selection, and comparisons between 6-row hybrid barley, conventional 2-row and 6-row barley. Other experiments have examined herbicide modes of action, timing (pre-emergence vs. post-emergence), application rates, tank-mix combinations, spray nozzle types and water volumes. Additional studies have focused on cultivation practices and mechanical control techniques such as inter-row hoeing.

Lessons learnt from the research

Pre-drilling cultivation

The strategy of pre-drilling cultivations to stimulate black-grass seedling germination before spraying off with glyphosate can produce a different outcome. Niab trials revealed that in favourable conditions when there was enough moisture for black-grass seed germination, predrilling cultivation stimulated germination. Once the germinated black-grass plants were sprayed off and destroyed, the black-grass plants number was reduced in the following crop. However, in unfavourable (dry) conditions, cultivation can bury seed which may prevent bird's predation and result in higher seedling numbers in the following crop.

Figure 1. Inter-row cultivation can reduce black-grass without herbicides but is highly variable in success

Autumn verses spring ploughing

Autumn ploughing remains the most effective method for establishing a healthy, vigorous crop. This approach not only supports optimal crop development but also plays a vital role in controlling weeds, particularly black-grass, which can otherwise substantially reduce yields. Niab trials indicate that while spring ploughing and deep non-inversion cultivation during spring can deliver promising results, they are generally less effective than autumn ploughing in terms of long-term weed control and soil structure benefits.

A major challenge in spring cropping is the large flush of black-grass that emerges during autumn. To achieve successful spring sowing, it is crucial to manage this early-emerging black-grass before drilling the crop. By carefully timing cultivations, applying pre-drilling glyphosate, and integrating effective weed management strategies, farmers can maximise crop health and productivity while minimising competition from problematic weeds. In Niab's trials, deep non-inversion cultivations in spring have shown better results compared to the same method in autumn, provided that the autumn-emerged black-grass is effectively controlled prior to sowing.

In-row and inter-row hoeing

In-row and inter-row hoeing is a precision cultivation method that mechanically removes weeds within and between crop rows using hoes or blades, either by uprooting or burying them. Several trials conducted by Niab examined the impact of in-row and inter-row hoeing on black-grass control in winter wheat, winter barley, and spring barley crops (Figure 1). The results showed variable effectiveness, ranging from excellent to poor control. This variability can be attributed to factors such as soil type and moisture, weather conditions, hoe design, working depth, travelling speed during hoeing, weed size and the crop's growth stage.

Analysis of the trial data suggested that successful weed control relied on the correct hoe setup, including appropriate blade shape, working depth, and operational speed, to effectively destroy black-grass without damaging the crop. Timing was also critical and the best results were achieved when black-grass was at the 1–3 leaf stage and the crops were well established. It was noted that for the successful destruction of weeds soil conditions should be friable and preferably dry to maximise uprooting and desiccation. Post-hoeing weather also influenced effectiveness, with dry, sunny conditions preventing weeds from re-rooting, while rain following inter-row hoeing reduced the success and allowed new weed emergence. It is worth noting that effective control may require multiple passes. It was concluded that inter-row could reduce reliance on herbicide for black-grass control, however, the better control was achieved when integrated with other strategies, such as competitive crop varieties, delayed drilling and herbicides.

Figure 2. 6-row hybrids provided better black-grass control than 2-row barley

Suppression of black-grass with 6-row hybrid barley

In several trials, the ability of 6-row hybrid barley to suppress black-grass was compared with that of 2-row barley under different nitrogen application timings. The two barley types responded differently to the timing of nitrogen. The 6-row hybrid was most effective at suppressing black-grass when nitrogen was applied early in smaller doses, whereas 2-row conventional barley showed the least suppression under a split-application regime. Overall, 6-row hybrids provided better black-grass control than 2-row barley (Figure 2). This may be due to their higher early vigour and denser canopy, which shades the soil and limits weed emergence. The enhanced tillering and ground cover of 6-row hybrids restrict light and space for black-grass, reducing reliance on herbicides. In contrast, 2-row barley has a more upright, less dense structure and slower early growth, making it less competitive against weeds and often necessitating higher seed rates, vigorous varieties and early nitrogen application.

Drilling date

Drilling date plays a critical role in determining black-grass density within winter wheat crops. Previous research has shown that approximately 80% of black-grass seeds germinate between mid-August and late October, making this window particularly important for management decisions on black-grass control.

Delaying drilling until mid-to-late October can greatly decrease both the number of black-grass plants and the density of ears/m² (Figure 3) thereby reducing overall weed pressure. However, the level of reduction can vary widely depending on the season, location, and crop competitiveness. A poorly established, patchy crop sown in October may perform worse than a well-established, competitive crop drilled in September. Trial data also suggest that the effectiveness of delayed drilling is strongly influenced by autumn rainfall patterns, particularly rainfall occurring around the first drilling date and during the interval between the early and late drilling dates. When soil moisture levels are low early in the autumn, black-grass germination is suppressed, resulting in fewer plants emerging regardless of drilling timing. In such conditions, the benefit of delaying drilling is reduced because there are already fewer black-grass plants present. Conversely, when adequate rainfall promotes early germination, delayed drilling has a more pronounced impact on reducing black-grass populations, making it a more effective cultural control strategy.

Herbicide performance and drilling date

The effectiveness of herbicides can be influenced by the timing of crop drilling, and this relationship is closely linked to soil moisture levels. When soil moisture is high, herbicides generally perform better because adequate moisture helps in the activation, absorption, and movement of the chemical within the soil and onto target weeds. In Niab's herbicide performance and drilling date trials, it was noted that if there was a significant difference in soil moisture between two drilling dates, this could lead to noticeable variations in herbicide performance. Adequate moisture associated with a later or earlier drilling date was more likely to improve herbicide effectiveness. Conversely, if soil moisture was low at later or earlier drilling date, herbicide activity could be limited, reducing its ability to control weeds effectively. Therefore, understanding both soil moisture patterns and optimal drilling dates was essential for maximising herbicide efficiency and achieving successful crop establishment.

Figure 3. Effect of drilling date on % reduction in black-grass heads/m²

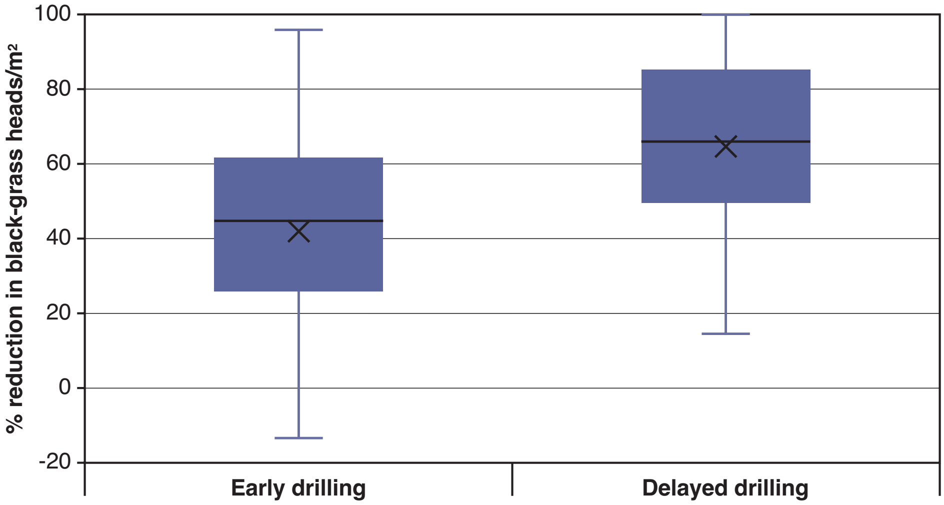
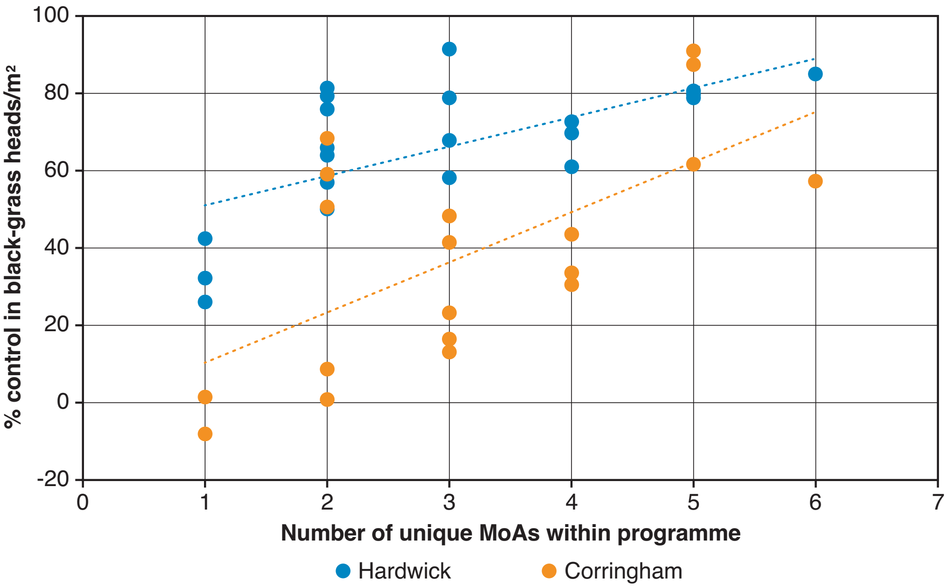


Figure 4. Effect of number of unique MoAs within the programme on black-grass heads/m²



Herbicide and mode of action in a programme

A well-designed herbicide programme is essential for achieving effective control of black-grass, one of the most challenging weeds in cereal crops. While a range of herbicides is available, the most effective options, such as cinmethylin and flufenacet, when used in combination with other herbicides, can significantly improve the level of black-grass control. Multiple Niab trials conducted over the years, has consistently highlighted the importance of incorporating mode of action (MoA) diversity within a herbicide programme. By mixing herbicides with different MoAs, growers can reduce the risk of resistance development and improve overall efficacy against black-grass populations. Particularly in situations where weed pressure is high, increasing the number of herbicides with different MoAs has been shown to enhance the overall level of control, providing more reliable and consistent results (Figure 4). This strategic approach ensures that the herbicide programme is robust, sustainable, and capable of maintaining long-term effectiveness against one of the most persistent weeds in cereal production.

Nozzle types and spray volume

Niab has conducted research into how different nozzle types and spray volumes influence the control of black grass. The type of nozzle used plays a crucial role in determining droplet size, the amount of spray drift, and the overall coverage of the soil surface. These factors are critical because they directly affect how well residual herbicides are distributed across the field.

In addition to nozzle type, other application parameters such as water volume, spray pressure, and forward speed of the sprayer also have a major impact on soil coverage. Adequate coverage is essential for residual herbicides to form an effective barrier in the soil, which is necessary to suppress emerging black-grass seedlings. Optimising all these variables together can significantly improve the overall efficacy of black-grass control programmes. According to research conducted by Niab, the optimal spray volume for a range of residual herbicide products falls between 100 and 200 l/ha. While using higher water volumes can improve coverage, it also increases the overall workload for farmers, as more frequent tank refills and additional time in the field are required. Taking both efficacy and practicality into account, a spray volume of around 150 l/ha represents a sensible compromise, balancing effective herbicide performance with operational efficiency.

Take home messages on black-grass control

1. Integrated weed management is essential
- Reliance on herbicides alone is unsustainable.
- Combining cultural, mechanical, and chemical strategies slows resistance and improves control.

2. Pre-drilling cultivation
- Can stimulate black-grass germination, allowing early control with glyphosate.
- Works best under moist conditions; in dry conditions, buried seeds may survive and increase future infestations.

3. Ploughing timing
- Autumn ploughing is most effective for crop establishment and long-term black-grass control.
- Spring ploughing or deep non-inversion cultivation is less effective, though it can help if autumn-emerged black-grass is controlled beforehand.

4. Mechanical weed control (in-row and inter-row hoeing)
- Can reduce black-grass without herbicides but is highly variable in success.
- Effectiveness depends on soil type, moisture, weed stage (1-3 leaf), crop growth, and weather after hoeing.
- Best results occur with proper hoe setup and multiple passes if needed.

5. Crop choice and management
- 6-row hybrid barley suppresses black-grass better than 2-row barley due to higher early vigour, denser canopy, and faster ground cover.
- Early, smaller nitrogen applications enhance black-grass suppression in 6-row hybrids.

6. Drilling date
- Delaying drilling to mid October can reduce black-grass emergence and density.
- Effectiveness depends on autumn rainfall and crop competitiveness.
- Early or late drilling must be balanced with crop establishment to avoid yield penalties.

7. Herbicide performance
- Soil moisture influences herbicide activation and effectiveness.
- Timing of drilling interacts with moisture to affect control success.
- Well-designed herbicide programmes with diverse modes of action (MoA) reduce resistance risk and improve control.

8. Strategic herbicide use
- Combining herbicides with different MoAs improves efficacy.
- Programmes should be robust and tailored to local black-grass pressure to maintain long-term sustainability.

9. Optimise spray application
- Nozzle choice, spray pressure, speed, and water volume all affect coverage.
- 150 l/ha spray volume is an effective compromise for coverage vs. efficiency.

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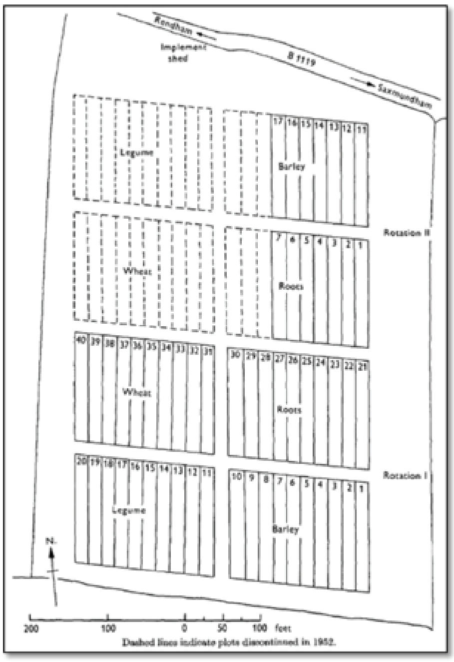
125 years of P research at Saxmundham

Long-term agricultural experiments are a rare and valuable resource, with only ten sites in the UK registered on the Global Long-Term Experiment Network. Thanks to the support of The Morley Agricultural Foundation (TMAF), Niab is fortunate to manage several of these studies, including the Saxmundham Experimental Station in Suffolk.

Dr David Clarke joined Niab in 2017 as a soil and farming systems technician. Since then, he has developed his own research portfolio, completed a PhD, and moved into a specialist role supporting practical research and innovation in farming systems. He works across a wide range of projects, including managing long-term soils and farming system trials and delivering technical research for Niab members, charity-funded work, levy board and the wider industry. This research focuses on soil health, cultivation, nutrient management and rotations.

Established in 1899, Saxmundham is often cited as the third-oldest agricultural station in the UK, with 2025 likely marking the 125th anniversary of the first harvested crops from the site. The station was originally created by the Education Department of East Suffolk Council, namely a Mr. A. Harwood (the field is now named after him), to demonstrate to local farmers that the then-relatively new mineral phosphorus, potassium, and nitrogen fertilisers could meet the nutrient needs of crops and rotations as effectively, if not more efficiently, than traditional farmyard manures. The experiment, known as *Rotation I* (Figure 1), primarily tested the use of superphosphate and muriate of potash, both individually and in combination, against regular applications of farmyard manure.

Figure 1. Trial field layout in 1966 with rotation I (4 blocks now reps) located at the southern end of the field



Newspaper archives suggest that the primary way these early findings were shared with farmers of the day was through open days and guided field tours. An article in the Eastern Daily Press in June 1915 reported:

"A party of nine farmers met at the station on Thursday afternoon. The group were very interested to observe the difference in the herbage of the plots receiving manures." At that time, fertilisers were often referred to as "artificial manures."

As the experiment took hold findings were shared more widely and began to shape modern nutrient management. The earliest image we have from Saxmundham captures the harvested grain from each plot in the 1938 season (Figure 2). Carefully arranged by hand, it looks much like a bar chart, the kind we now generate on computers for trial reports. The timing of the photograph is striking, taken just before the outbreak of the Second World War, a moment when producing enough food was becoming a matter of national urgency. For the farmers and land managers of the time, the image would have spoken volumes, clearly showing how applying phosphorus fertiliser or manure could dramatically boost crop yields compared with untreated plots. These early results were summarised by AW Oldershaw in papers published in 1934 and 1941 and, 110 years later, field tours and written reports are still an effective way of disseminating trial results, with Niab and TMAF running an Open Day for farmers, growers and industry to celebrate the 125 years of Saxmundham in May 2025.

Figure 2. Yield (actual plot produce) from each treatment in 1938. Bag 5 is untreated, Bag 8 K only, Bag 9 P only, Bag 10 P and K fertiliser and Bag 1 farmyard manure

Phase 2 of P research

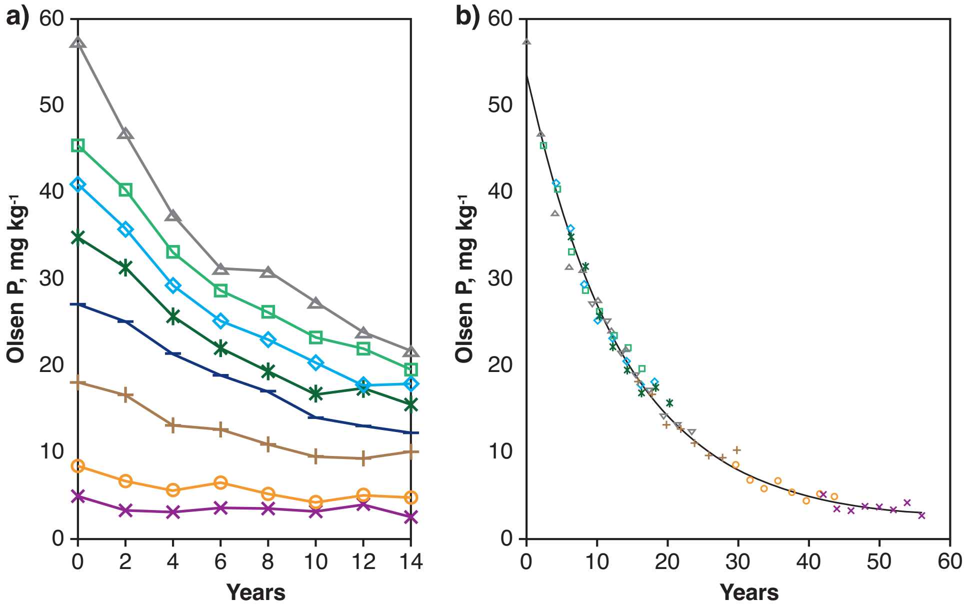
From 1947 until 1963, the Saxmundham site was managed by the National Agricultural Advisory Service, before Rothamsted Research took over through AFRC (now BBSRC) in 1964. This period marked a significant shift in how the site was used to further our understanding of P dynamics in soil and cropping systems.

A key figure during this time was AE 'Johnny' Johnston, who applied the Olsen P method (new at the time) to quantify plant-available phosphorus in soils. Niab's Dr Elizabeth Stockdale recognised Johnny's contributions to agricultural sciences at this year's Open Day, after his death in May 2025 at the age of 96 and a bench was dedicated in his memory for trial staff and samplers to enjoy their lunch, reflecting the lasting impact of his work not just at Saxmundham but on soil and fertiliser research across his lifetime.

In 2019, Johnston and his colleagues published a comprehensive review of 175 years of research on phosphorus management, drawing on results from Saxmundham. On the Rotation II experiment one particularly clever study involved creating a range of Olsen P levels in the soil, from 57 to 5 mg/kg. The plots were then divided into sub-plots to test with and without fresh phosphorus. The decline in sub-plots without fresh P for 14 years is shown in Figure 3a. By 'horizontally shifting' the results over time, the analysis was then able to extrapolate a phosphorus depletion curve spanning nearly 60 years (Figure 3b).

This demonstrated the slow decline of Olsen P in soils, providing the scientific foundation for the maintenance-dressing recommendations now included in the AHDB's Nutrient Management Guide (also known as RB209). This work also highlights the value of long-term experiments like Saxmundham: it provides a rare opportunity to study soils approaching true baseline phosphorus levels. In most agricultural soils, historic phosphorus additions continue to contribute to crop supply, meaning that achieving a fully 'depleted' soil could take decades. At Saxmundham, given a half-life of approximately 10 years, it would take many years for soils to be effectively devoid of historic soil-applied phosphorus.

Figure 3. a) Documents the change in Olsen P from eight treatments (Rotation II) following no P after 1968. b) Shows a fitted curve once the curves from Graph A have been bought into coincidence. Sourced from Johnston, A.E. and Poulton, P.R., 2019. Phosphorus in agriculture: a review of results from 175 years of research at Rothamsted, UK. Journal of environmental quality, 48(5), pp.1133-1144



Phosphorus fertilisers are often cited as having poor efficiency because some of the applied P becomes strongly bonded or absorbed in soil pools with lower availability to plants. This means that the amount available to plants from freshly applied phosphorus can be low in a single year. However, this work at Saxmundham along with studies at other Rothamsted Research sites, demonstrated that when soils are managed appropriately and losses are minimised, phosphorus recovery from inputs can exceed 90% when considered across all the crops of a rotation and this work forms the basis of the soil indices and recommendations we have today.

Updating Saxmundham for modern challenges

By 2010 the site had been discontinued. However, concerns about the sustainability of conventional P sources in terms of long-term supply and market forces have increased interest in creating more efficient systems that rely on smaller P inputs.

To secure the site's future, TMAF agreed a long-term lease from current site owners, the Biotechnology and Biological Sciences Research Council (BBSRC) at a peppercorn rent, allowing the experiments to continue. With the ongoing support and hard work of local grower Alys Kindred, Niab restarted the trials in autumn 2014, with the first five years focused on reinstating the historic treatments and baselining soil properties and crop responses.

This baseline period confirmed that plots which had not received P additions since the 1980s had returned to untreated, Index 0, P baselines. These treatments included an historic bonemeal treatment, an N only treatment and a repeated K only treatment.

In autumn 2019, coincidently the year marking the 350th anniversary of the discovery of phosphorus, three new treatments were introduced:

1. With access to farmyard manure often limited, green waste compost was introduced as an alternative organic P source. Applications match the organic matter inputs of the FYM plots but, due to the compost's lower P content, are expected to maintain soil P indices at a lower level (Index 1). This treatment will allow consideration of whether, through improved soil structure, P uptake can be optimised while soil P is maintained at a lower Olsen P level';
2. To provide comparisons the K only treatment is now receiving small amounts of phosphate to

maintain it at P Index 1 without organic amendments;

3. The development of foliar-applied P products offers the potential to reduce the reliance on soil-applied fertiliser. By spraying these products onto the foliage, they can meet part of the crop's P demand that is not supplied by soil reserves or is otherwise unavailable. To test this, up to four applications of Folex P have been applied through the season.

Figure 4 outlines the modern treatment list at Saxmundham.

Long term trials supporting modern research experiments

The value of long-term experiments lies in their ability to support wider, more targeted studies thanks to their carefully designed underlying treatments. While the Saxmundham site was originally established to investigate how best to manage soil phosphorus, the natural gradients in soil P and other properties such as organic matter have made it a valuable test bed for broader research into nutrient management.

One example is Niab's *Exploiting novel wheat genotypes for regenerative agriculture* project, led by Dr Stéphanie Swarbreck and Dr Nathan Morris. This work examines how modern elite wheat varieties and new wheat genetic material (including synthetic hexaploid wheat derivatives) with greater genetic diversity perform under contrasting farming systems, including reduced or no cultivation and lower nutrient inputs. By assessing these diverse wheat lines on the low-phosphorus soils of the Saxmundham experiment, we will be able to generate valuable insights for breeding wheat varieties that use soil phosphorus more efficiently. In 2025, the large experimental plots were divided into smaller 2 m × 3 m subplots, allowing the performance of these lines to be tested under both low-phosphorus and a reduced nitrogen conditions (Figure 5).

The Saxmundham Experimental Site remains a testament to the value of long-term research. From its first harvest in 1899 to today's more targeted studies, it continues to guide phosphorus management as farming systems evolve.

Figure 4. Current treatment list and target soil indices

Treatment	Annual application	Target P	Target K	
Untreated	–	0	0	No mineral or organic P applied for over 125 years. Consistently maintained at Index 0
Farmyard manure (FYM)	25 t/ha	2	2+	Annual application of cattle manure at 25 t/ha, contributing both P and organic matter
Green Waste Compost (GWC)	~18 t/ha	1	2+	Applied to match FYM's organic matter contribution. With lower P content, it aims to build soil organic matter while keeping soil P at a lower index
Foliar	4 applications of Folex P (15 l/ha, 14% N, 46% P_2O_5)	0	2+	Adaptive management since 2019. Previously an old nitrogen treatment, now receiving foliar-applied mineral P (Folex P) to explore ways of improving P uptake without increasing soil P
P	P_2O_5	2	0	Mineral P or K applied individually to isolate their specific effects
K	K_2O	0	2+	
PK	$P_2O_5 + K_2O$	2	2+	Annual application of mineral P and K fertilisers, maintaining Index 2 for both nutrients
P_LK	$P_2O_5 + K_2O$	1	2+	A former K-only plot now receives limited P to maintain Index 1 as a low-P comparison for GWC treatments

Figure 5. Smaller trial plots at Saxmundham in 2025 as part of the *Exploiting novel wheat genotypes for regenerative agriculture research* project

Annual trial reports and long-term results

www.tmaf.co.uk and **www.niab.com**

Information posters summarising results shown at events and open days

https://www.niab.com/event-hub/soils-and-farming-systems

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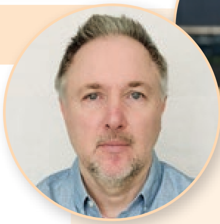


UKCPVS: review of the 2025 season

In 2025, favourable conditions in the north-east of England led to early outbreaks of yellow rust on varieties previously considered resistant. These were reported to the UK Cereal Pathogen Virulence Survey at Niab and subsequently developed into a nationwide epidemic.

First reports

In late winter and early spring 2025, the Niab trials team observed unusually high levels of yellow rust in winter wheat in northern counties such as Northumberland and Tyne and Wear. Worryingly, this was on varieties previously rated as highly resistant at both the seedling and adult plant stages (Figure 1 A-D). This suggested a major breakdown in resistance, soon confirmed by similar reports from across the farming industry. In many cases, the disease continued to progress in adult plants (Figure 1D).

To investigate further, UKCPVS used field-collected leaf samples to isolate and multiply yellow rust spores under controlled conditions on a universally susceptible variety. From this work, three early-season isolates were recovered from KWS Dawsum, Champion, and KWS Palladium. When tested on a standard set of 18 wheat differential lines with known *Yr* genes, all three isolates were found to overcome *Yr15* resistance (Figure 1C).

The *Yr15* gene was originally transferred into commercial wheat breeding programmes from wild emmer wheat in the late 1980s and has provided broad-spectrum resistance to yellow rust for more than 30 years. Genetic testing of two *Yr15*-virulent isolates showed they most likely evolved within the existing Warrior (-) population of the pathogen, rather than arriving as an exotic incursion.

Niab checked AHDB Recommended List winter wheat varieties with DNA markers to determine whether they carried *Yr15*. All 12 varieties previously rated as fully resistant at the seedling stage were found to carry the gene. Amongst these varieties, KWS Dawsum, LG Beowulf and Champion make up

Yellow rust

Dr Charlotte Nellist is a senior plant pathologist, co-responsible for the UKCPVS programme, with interests in disease resistance characterisation on a wide range of crops and understanding how pathogens interact with hosts. This includes previous work on improving durable disease resistance in horticultural crops and studying pathogenicity of the associated *Phytophthora* spp. She completed her PhD at the University of Warwick, studying the 'deployment and mechanism of broad-spectrum resistance to turnip mosaic virus in *Brassica rapa*, Chinese cabbage'.

Huw Davis was the UKCPVS technical manager, monitoring UK cereal rust populations, and detecting any changes that may have an adverse effect on UK agriculture.

Dr Kostya Kanyuka leads UKCPVS and heads the Plant Pathology Department at Niab, managing strategic and applied research on the biology, detection, surveillance, epidemiology and management of diseases and pests of field crops, working with a wide range of academic and commercial partners and customers. Kostya's overall research interest is to understand how pathogens cause disease on plants and how plants resist pathogens at the mechanistic and molecular level with the aim of developing sustainable solutions for disease control in crops.

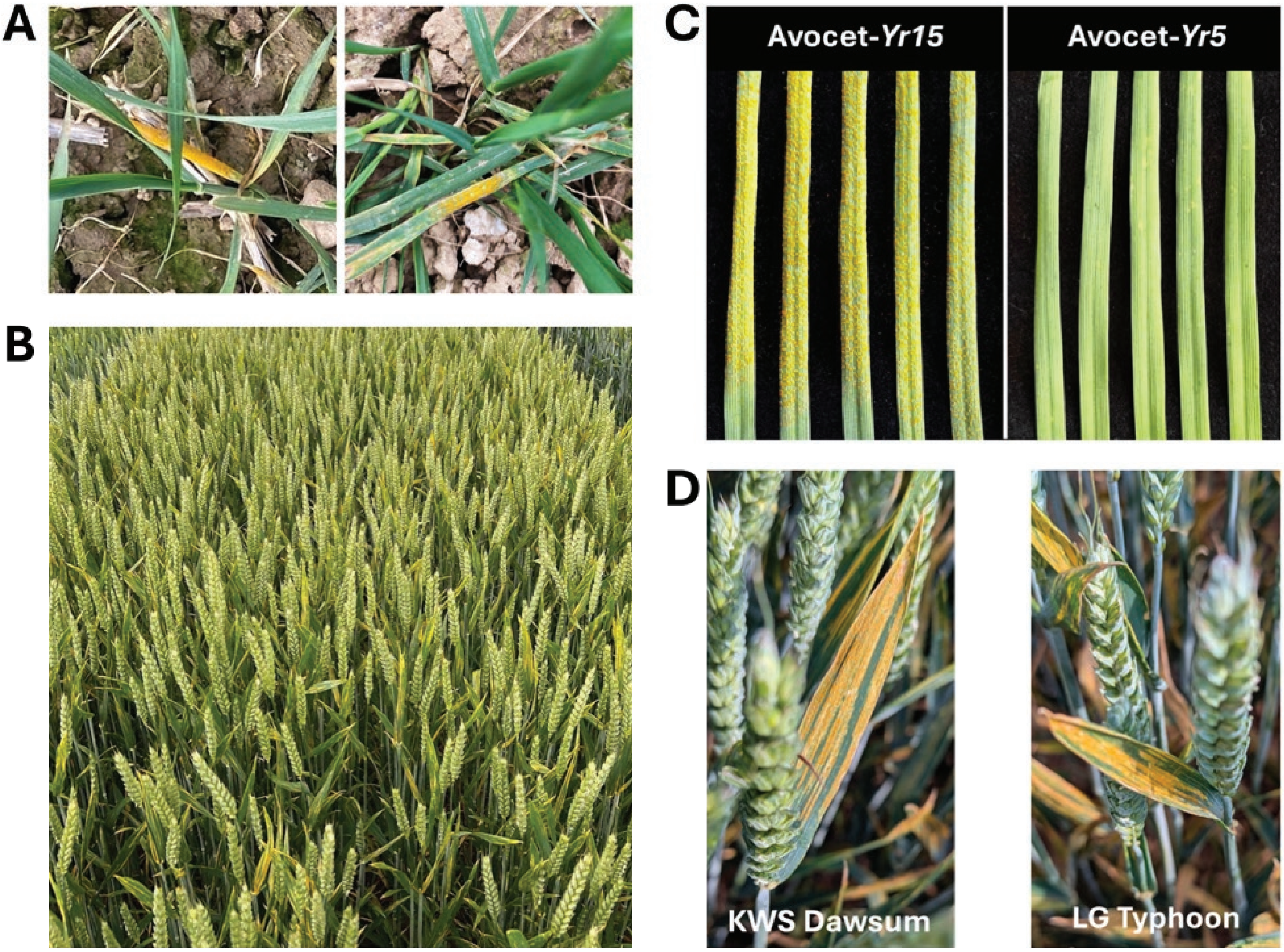
Figure 1. Breakdown of *Yr15*-mediated resistance to wheat yellow rust in 2024/25

A. Severe infection on the previously resistant variety blend KWS Dawsum/Champion in Northumberland, early in the season.

B. Plot-level symptoms on the previously resistant variety Mayflower in North Yorkshire.

C. Seedling susceptibility assay carried out under growth room conditions confirming virulence of the yellow rust isolate WYR25-001 (sampled from the previously resistant variety KWS Dawsum in North Yorkshire) on a differential line carrying *Yr15*.

D. High disease severity on previously highly resistant varieties KWS Dawsum and LG Typhoon in Lincolnshire, late in the season.



around 50% of the certified UK seed market (not including farm-saved seed) in 2024/25 (Figure 2).

Until now, yellow rust strains able to overcome *Yr15* had only been reported in two isolated cases worldwide, with no evidence of spread. The situation in the UK therefore marks the first major breakdown of *Yr15*, with a severe epidemic extending from the Scottish Borders down to Norfolk. The most likely driver has been the widespread use of *Yr15*-carrying varieties, which placed strong selection pressure on the rust population and enabled virulent strains to emerge.

Figure 2. UK market share of varieties carrying *Yr15* in 2024/25

Variety	UK market share harvest 2025 (%)
KWS Dawsum	13.1%
LG Beowulf	10.2%
Champion	9.8%
Other varieties carrying *Yr15*	15.8%
Varieties not carrying *Yr15*	46.3%
Untested	4.6%

Wheat yellow rust 2025

In 2025, UKCPVS received the highest number of yellow rust samples in several years – a total of 257. Most were collected in June (99), followed by May (78) and April (70). The first sample of wheat variety KWS Dawsum received, from North Yorkshire on 25 November 2024, indicates that *Yr15*-virulent strains were already present but went undetected during the 2023/24 season.

Samples came from 29 counties, predominantly Lincolnshire (67), Northumberland (45), and Tyne and Wear (27) (Figure 3). They represented 53 varieties, mainly RL wheats, with Champion (35 samples), KWS Dawsum (22) and LG Beowulf (18) most frequently submitted. Seventeen candidate varieties were also sampled in 2025.

Twenty-one isolates were selected from the samples received based on their geographical origin and the RL rating of the source variety. These were tested at the young plant stage to determine their virulence profiles on differential lines, as well as their ability to infect RL and candidate varieties. Results will be presented in early 2026 at the annual UKCPVS Stakeholder Conference.

Wheat brown rust 2025

In 2025 UKCPVS received only a small number of wheat brown rust samples – just 12 in total. The first received on 9 June, and all others by 25 June. Samples came from four counties: Somerset (7), Cambridgeshire (3), Bridgend (1), and Northumberland (1) (Figure 3). They represented twelve varieties, mostly from the current AHDB RL list.

Ten of the 12 isolates were selected for seedling tests, chosen based on their geographical origin and the RL rating of the source variety. Further testing of these isolates is underway, with results to be shared at the 2026 UKCPVS Stakeholder Conference.

Figure 3. UKCPVS wheat yellow rust samples received in 2025

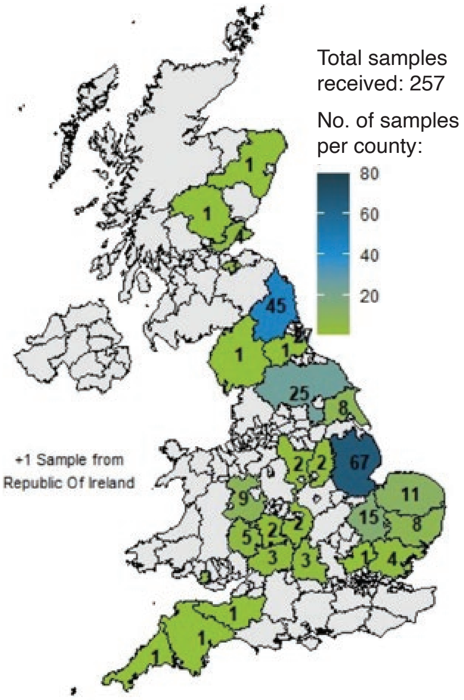
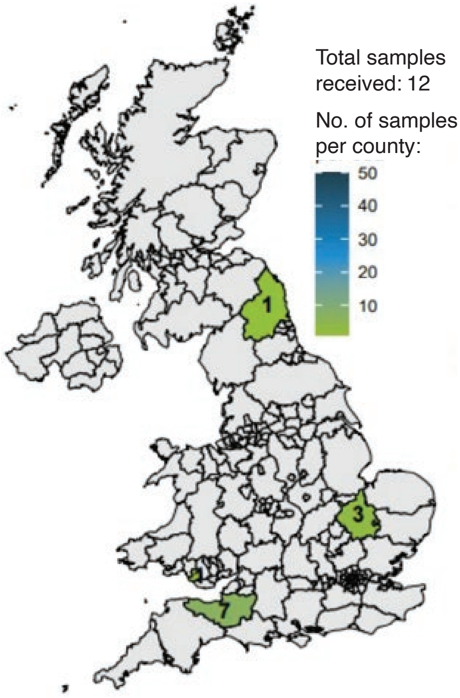


Figure 4. UKCPVS wheat brown rust samples received in 2025



2026 sampling – we need your help

The UKCPVS relies on infected samples sent in by farmers, agronomists, trial staff, breeders, and researchers. In 2026, the survey will continue to focus on wheat yellow rust and wheat brown rust, and we welcome samples from all RL and Candidate varieties across the country.

To build an accurate picture of current UK rust populations, Niab aims to collect representative samples from across the UK. Please send any infected leaf samples in paper envelops, together with a completed sampling sheet including as much detail as possible. Samples can be sent free of charge to Niab by writing 'FREEPOST UKCPVS' on the envelope.

Full sampling instructions are available niab.com or scan the QR code below.

About the UKCPVS

Established in 1967, the UK Cereal Pathogen Virulence Survey routinely monitors the populations of the wheat rust pathogens – yellow rust (*Puccinia striiformis* f. *sp. tritici*) and brown rust (*Puccinia triticina*) – both of which remain important threats to cereal production in the UK. It is funded AHDB and has been managed by Niab since its inception nearly 60 years ago.

UKCPVS

Save the date

Annual UKCPVS Stakeholder Meeting

12 January 2026

Niab, Sophi Taylor Building, Park Farm, Villa Road, Histon, Cambridge, CB24 9NZ

Details on how to register will be available soon via the AHDB UKCPVS webpage.

News from Niab

Niab logo refresh

Niab will be launching a new strategic plan in 2026 that will ensure the organisation remains at the forefront of translating agricultural innovation into products and services essential for increasing the prosperity and sustainability of farmers and growers throughout the UK.

And as part of this programme the Niab logo is undergoing a refresh. The 'swish' and colour remains that same, but the acronym is being retired, recognising Niab as our company name rather than NIAB; it has been 30 years since privatisation and the change away from the original 'National Institute of Agricultural Botany'.

Over the next few months there will be a gradual replacement of the old logo, including our site signage, publications, digital platforms, event materials and presentations.

For a copy of our new logo contact comms@niab.com.

New Board members

This summer, Niab announced the appointments of Richard Taylor and Belinda Clarke OBE to the Board. Mr Taylor, a graduate from UEA and a UK chartered accountant, recently retired after a 36-year career in agritech with Syngenta in the UK and Switzerland. Dr Clarke is the Director of Agri-TechE, the UK's longest-established and largest network connecting farmers and growers with researchers, technologists, entrepreneurs and investors. They join current members of the Niab Board including Dr David Buckeridge (chair), Dr Helen Ferrier, Robert Lowson, Trish Malarkey, Jonathan Regan and Guy Smith.

Richard Taylor

Belinda Clarke

Twelve varieties added to BSPB 2026 Forage Maize DL

Twelve new varieties have been added to the British Society of Plant Breeders' 2025 Forage Maize Descriptive Lists (DL), published in September 2025.

The trial work is carried out by Niab and plant breeders under contract to BSPB, with the data are independently verified and analysed by Niab. The Descriptive Lists are available to download from the BSPB and Niab websites.

The new entrants on the 2026 Favourable First Choice List are KWS Zimo, KWS Reo, Amarola, Agrolino and KWS Portabello from KWS, SU Addition from Bayer and LG31206, Harmony and LG31152 from Limagrain. DKC2742 from Bayer, and MAS 195P and Clifford from Bright Seeds, have been added to the Favourable Second Choice List. LG31152, Harmony, KWS Portabello and KWS Reo have also been included on the First Choice List for Less Favourable sites. No further varieties have been added to the Very Favourable list for 2026.

bspb
PROMOTING SEED INNOVATION

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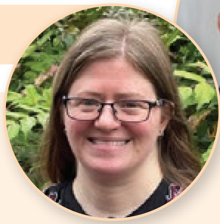
Sarah Arnold • sarah.arnold@niab.com



Too hot to pollinate

For several decades, UK growers have been employing bumblebees (Figure 1) to pollinate protected crops of strawberry and raspberry to ensure that all flowers receive adequate pollination, leading to a high percentage of Class 1 fruit. Before 2015, many employed the imported sub-species *Bombus terrestris terrestris* and *Bombus terrestris dalmatinus*, but since then the importing of foreign species has been banned, so UK growers now need to employ the native species *Bombus terrestris audax*. However, growers have reported poorer pollination with this native species along with increased mortality in some protected cropping environments.

It has been suggested that *B. t. audax* is less tolerant of the higher temperatures experienced by the continental subspecies native to southern European countries which creates a problem for UK growers of protected soft fruit, particularly given the higher temperatures that are becoming commonplace with climate change. Most bumblebee species maintain their colony temperature between 28-34°C, achieving a warming effect by vibrating their bodies and incubating their brood, or cooling by fanning their wings, but such activities draw them away from the foraging and pollinating activities that they are employed for.

During extremely high or low temperatures, these interventions by the bees are far less effective and in heatwave conditions, the hive temperature will reach levels that the bees are unable to regulate and can eventually damage the brood. In countries where high summer temperatures are commonplace, various techniques have been deployed to reduce heat stress on bee hives. One is to position the hive below the ground surface, whilst shading the hive and finding sites with minimal exposure to the sun are also common approaches.

Our UK industry would benefit from identifying the temperatures at which *B. t. audax* noticeably starts to reduce foraging activity and also identify the temperature at which commercial bees struggle to cool their brood. Finding ways of measuring this will allow growers to identify periods when pollinators are unlikely to work effectively alerting them to order replacement hives promptly.

The Worshipful Company of Fruiterers therefore funded a project, managed by Niab, to understand the behaviour of colonies under heat stress, to predict the potential impact on pollination and to explore ways of mitigating heat stress.

Figure 1. Bumblebees are relied upon to improve pollination in strawberry

Scott Raffle is Niab's senior knowledge exchange manager, raising the profile of the research and commercial activities at Niab's East Malling centre in Kent and improving collaboration between researchers and the fruit and wider horticulture industry.

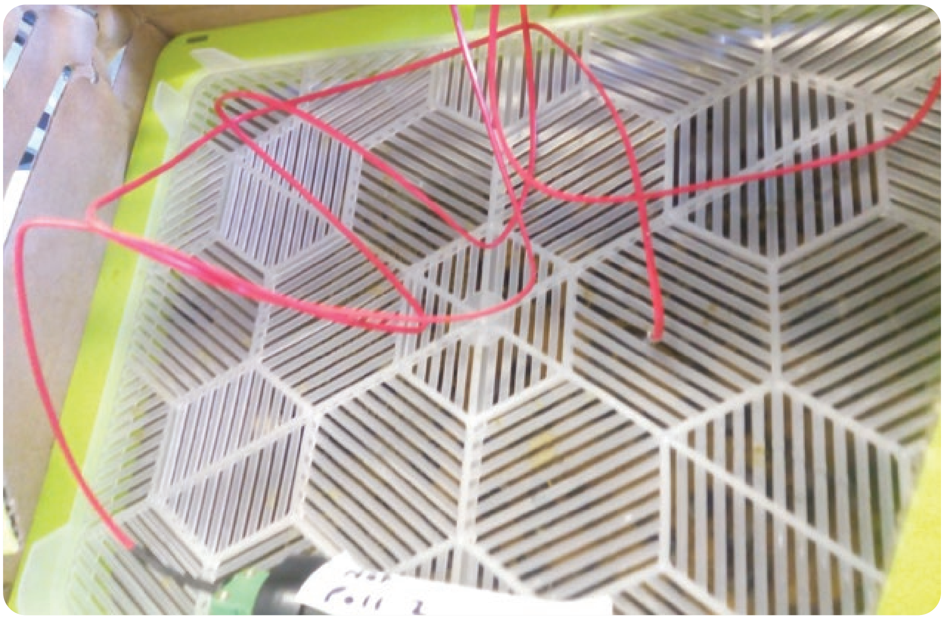
Applied entomology researcher Dr Sarah Arnold specialises in the ecology and biology of pest and beneficial insects in fruit horticulture, both in the UK and overseas. She has a particular interest in the behaviour and ecology of pollinators, and also works on pest-plant and predator-pest interactions in the context of sustainable pest management. Sarah leads Niab's research into the biology and control of a range of crop pests, and into optimising pollinators on UK fruit crops, including by precision management of commercial pollinators.

The work was done at Niab's East Malling site between the spring and autumn of 2024, when 12 colonies of *B. t. audax* were placed either in exposed (hot) locations or sheltered (cool) locations. For four of the colonies, the cool locations chosen were 'bee-pits' (Figure 2) cut into the ground surface, protecting them from extreme heat. Temperatures were recorded on the inside (Figure 3) and outside (Figure 4) of each colony box using thermocouples and the bee activity of each was recorded twice each week by counting the number of bees leaving the hive and the number of bees returning with pollen on their legs.

Throughout the trial, the temperatures recorded outside the colonies varied with weather conditions as expected but in the first 30 days of the trial the internal temperatures were less variable, averaging 33-35°C, suggesting that

Figure 2. Bumblebee hives were positioned in bee pits

Figure 3. Temperature measurement inside the bee hive



young hives may be able to maintain a relatively constant hive temperature, almost independently of the external temperature. However after 30 days the hives appeared to move into a 'senescent' phase when hives failed to thermoregulate as effectively. Whereas young hives maintained a relatively constant internal temperature, the older hives' internal temperature was largely dependent on the external temperature.

In terms of location, hives positioned in exposed locations experienced more extreme high external temperatures (>35°C) and also had more spikes in the recorded internal temperature, indicating that hives in hot locations, such as exposed polytunnels, are likely to undergo heat stress. By comparison, the 'cool' hives did not normally experience such extremes and so their internal temperatures also spiked less.

When assessing the activity of bees at different temperatures and locations, in young colonies, there was little difference in the activity levels between cool and hot colonies at any given internal or external temperature. However, at the highest external air temperatures, older hives positioned in cool sheltered locations appeared to maintain higher activity levels than those in exposed, hot locations.

Within the spring-summer period of 2024, temperatures did not get high enough to cause all hives to reduce activity consistently, and the results showed that at temperatures up to around 30°C, *B. t. audax* is tolerant of summer heat. However, in most summers, temperatures in polytunnels during heatwaves can be considerably higher than this.

So in the short-term, what can soft fruit growers learn from this project? Firstly, where it is safe to do so, Niab recommends that growers implement bee pits in cropping situations which are prone to overheating in summer, especially where temperatures regularly exceed 34°C. For most UK conditions, a basic pit in the ground, with no irrigation or insulation, space around all sides of the hive for air movement, and the hive lid positioned a few centimetres below the soil surface, is likely to be sufficient. Further research is needed to explore different methods of cooling or shading the hives, to optimise the pit depth and size, and measure the impact on activity levels, especially during extreme heatwaves. Growers should also anticipate a drop in performance of bumblebee hives after approximately 30 days of deployment and consider replacing older hives if large temperature changes are forecast.

Figure 4. Temperature measurment outside the bee hive

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Seeking new control products for apple scab

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.

Dr Tom Passey has been part of the pest and pathogen ecology team at East Malling for almost 20 years. He leads day-to-day delivery of a wide range of project work, predominantly in the sphere of horticulture pathology. Tom's PhD was on the subject of apple scab and it remains an area of interest.

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.

In a subsequent project funded through a Growing Kent & Medway Business Innovation Voucher (BIV) and led by BAPL in 2024, Niab 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 (a.i. boscalid + pyraclostrobin),

Figure 1. Conventional fungicide products are diminishing in number

Figure 2. Typical symptoms of scab on leaf

Captan 80 WDG, Delan Pro (a.i. dithianon + potassium phosphonates), Difference (a.i. difenoconazole), Manzate 75 WDG (a.i. mancozeb), Scala (a.i. pyrimethanil), Stroby (a.i. kresoxim-methyl) and Vayo (a.i. mefentrifluconazole). Another treatment included a seven day programme of conventional products mixed with the coded products, whilst a final treatment 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.

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 control plots. 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 also not significantly different to the seven day programme.

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 seven-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 is working with BAPL to seek manufacturer support for authorisation of these products and are currently working towards securing EAMU authorisations for at least one.

Figure 3. Typical symptoms of scab on fruit

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Managing pollination problems in protected crops

Protected cropping systems such as glasshouses, poly-houses and vertical farms offer many benefits, such as lower pest pressure and the ability to extend production seasons. However, despite the many advantages that are conferred by growing fruit crops in these systems, challenges remain around ensuring the pollination services are reliable enough to support fruit production. Pollinators, most often bumblebees (*Bombus terrestris audax*), may show poor performance, high mortality and/or aggression in indoor environments.

Applied entomology researcher Dr Sarah Arnold specialises in the ecology and biology of pest and beneficial insects in fruit horticulture, both in the UK and overseas. She has a particular interest in the behaviour and ecology of pollinators, and also works on pest-plant and predator-pest interactions in the context of sustainable pest management. Sarah leads Niab's research into the biology and control of a range of crop pests, and into optimising pollinators on UK fruit crops, including by precision management of commercial pollinators.

Niab's 'Managing activity of pollinators in protected cropping systems (MAPP-CS)' project, funded by BBSRC and co-funded by the East Malling Trust in partnership with Clock House Farm, Biobest and Buzzup, is investigating the underlying causes for some of these difficulties and testing novel interventions. The first phases of the four-year project have already yielded some useful insights into pollinator behaviour in protected environments, focusing especially on bee-pollinated soft-fruit crops (blackberry and strawberry).

Bumblebees as pollinators

The first question is whether bumblebees are the best pollinators for soft-fruit crops in protected systems, and whether other methods could supplement this effectively. For maximum pollination efficacy in a fruit crop, pollen must be removed from one flower, e.g. by a bee, and then deposited onto the reproductive parts (stigma) of another flower. Optimal fruit-set depends on sufficient pollen being transferred, and ideally even deposition of pollen on to the recipient flower. Options other than bumblebees can include hoverflies (commercially available and non-aggressive, but expensive), or air-blowing using machinery (labour intensive, and may not deposit pollen evenly or accurately). Initial experiments included releases of two species of hoverflies in a large (>3 ha) soft-fruit poly-house and follow-up monitoring to investigate how they dispersed across the crop over the following days. The team found that although some hoverflies were active close to their release point in a crop, for up to seven days, many individuals also moved tens of metres away across the crop over this time.

This means that multiple release points in the crop are likely to be necessary for the best pollination service by hoverflies, ensuring their uniform distribution. Whilst hoverfly adults are delivering a pollination service, their larvae provide aphid control and are worthy of further investigation as hoverflies could provide multifunctional benefits in some crop systems.

The team supplemented the farm's ordinary bumblebee pollination boxes with either releases of the hoverfly *Eupeodes corollae* (a medium-sized hoverfly that can be purchased commercially), or manual air-blowing using a motorised leaf-blower. Both interventions yielded small but significant results for the blackberry crop – hoverfly pollination was associated with a small increase in drupelet size (meaning berries might appear plumper and more juicy-looking), while when the crop received an air-blowing treatment the berries were longer (meaning punnets could be filled faster). This implies that getting pollination right can provide commercial benefits, and that bumblebee pollination can benefit from supplementation by other methods.

Are bumblebees are the best pollinators for soft-fruit crops in protected systems?

Changing light environment for bee and crop health

The second question was, what impact the light spectral environment had on bumblebee behaviour, and thus, pollination. The Niab team investigated the effect of adding coloured films and covers to both the commercial blackberry poly-house walls, and a semi-field strawberry crop in enclosed polytunnels.

Some poly-houses have high levels of bumblebee death in parts of the facility (which may be associated with areas that receive bright sunlight in the late afternoon and evening). The deaths can be mitigated by wrapping the sides of the greenhouse in dark-coloured plastic or mypex, as this reduces bees' tendency to fly towards the light and aggregate on the clear walls. However, black wrapping reduces light to the crop. Niab tested whether coloured films (pink, green) or high-diffusion film (that scatters light without reducing the amount transmitted by very much, creating a blurred effect) would reduce the deaths of bees in facilities in the same way, but allow more light to reach the plants' leaves and improve fruit quality.

Panels of the coloured films were hung along the walls of the poly-house, replacing sections of the previous black wrapping. The poly-house received ordinary commercial bumblebee pollination and Niab monitored the activity of these bees in the crop, as well as the bees' mortality.

In parallel, on Niab's East Malling site, twelve enclosed mini (12 m long) polytunnels containing Malling Supreme strawberries were fitted with the same pink or green film, or were left with only clear rain covers. The mini-tunnels were provisioned with microcolonies (nine bumblebee workers in a small box) of bumblebees, as a normal commercial box would over-pollinate the crop with bees chewing and damaging flowers. The microcolonies were monitored by Buzzup's HiveHeart devices; these are exciting new innovations that provide information about the health of a bee colony.

When both the strawberry and blackberry crops reached maturity, Niab measured fruit size and quality from berries from the different lighting conditions, to see how the films were impacting fruit size, Brix, etc.

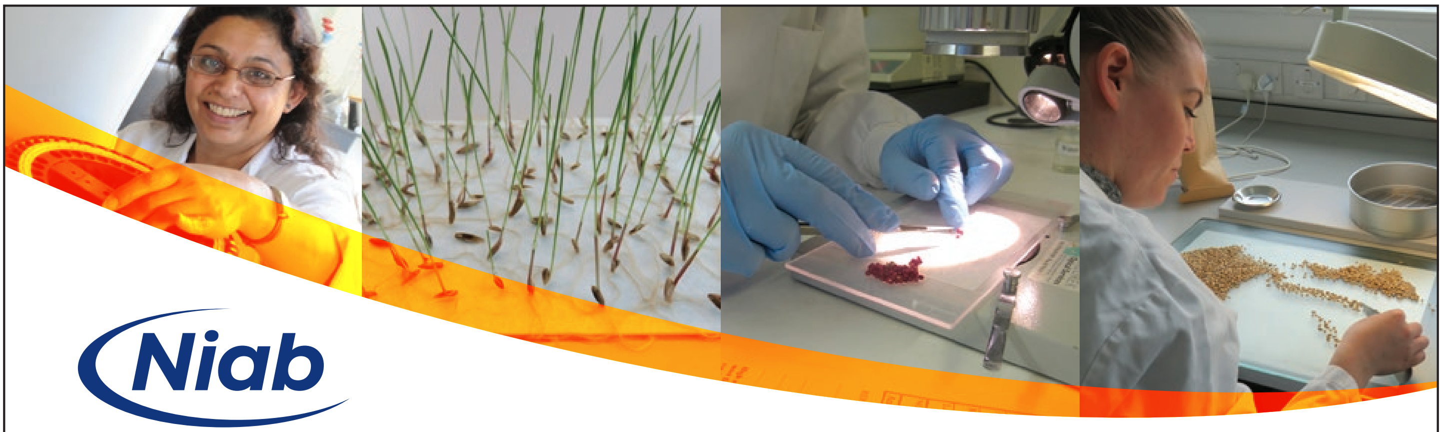
We learned that green film in the commercial poly-house gave the highest bee activity (significantly higher, surprisingly, than high-diffusion uncoloured film which allowed maximum light in). In the mini-tunnels, pink-covered tunnels had the highest bee activity. Pink films also significantly reduced bumblebee deaths – perhaps because bees were then less likely to fly to the walls and get disorientated/stranded. In contrast, more bees died in areas without coloured film in both the setups.

Buzzup's HiveHeart devices gave insights into the bee behaviour inside the nests too; the frequency (pitch) of buzzing noises inside the nest varied a lot between nests and over time. For honeybees, a change to more high-pitched buzzing can be associated with stress or swarming behaviour but the significance for bumblebees is not well understood. Analysing this further may help us to judge stress in bumblebee hives sooner.

When it came to harvest time, however, the fruit from the different coloured film conditions was the same, i.e. the fruit size, mass, quality scores, skin firmness scores and Brix (a measurement that approximately corresponds to sweetness) were indistinguishable, for both blackberry and strawberry. This implies that green and pink coloured horticultural films offer benefits for bee welfare (reducing deaths and possibly colony stress) and activity on the crop, but this does not reliably translate to economic benefits for the farm. Consequently, growers' decisions to invest in potentially expensive coloured film may be determined by factors other than the pure business case. Insect welfare is a growing area of research interest as increasing evidence suggests that they have more advanced cognition than previously assumed.

The work on the commercial crop is being repeated for a second cropping season. This will be in late summer (2025), when honeybees are also used, and environmental conditions are different to the spring crop. The focus during this period will be on monitoring the performance of individual bumblebee colonies in the different crop areas, and gathering data on crop growth and fruit ripening benefits of the different films.

Using pink-covered film in mini-tunnels encouraged bee activity and reduced bumblebee deaths



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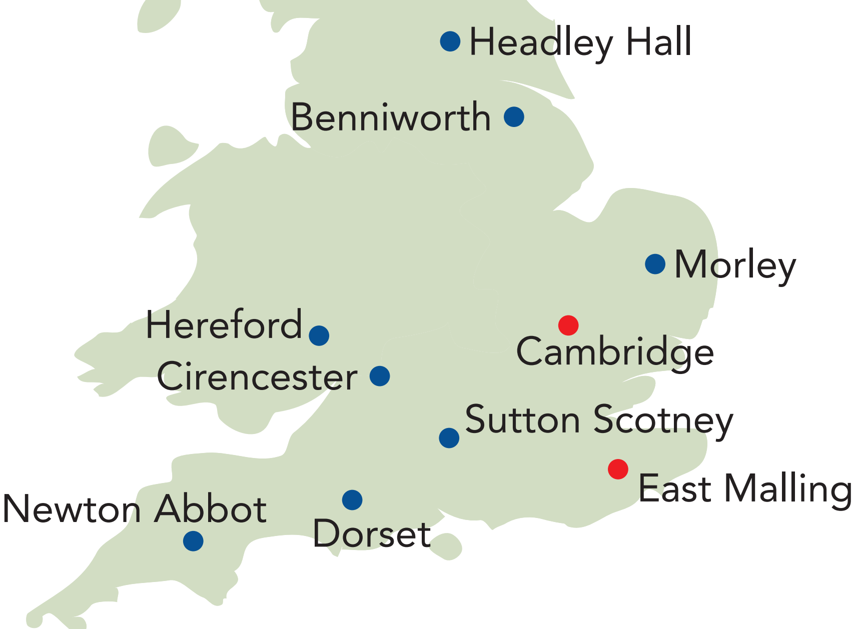

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