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Landmark

ISTA celebrates 100 years of seed testing with Niab

ISTA Secretary General Andreas Wais views the wheat pre-breeding research with Niab's Richard Horsnell

In this Issue


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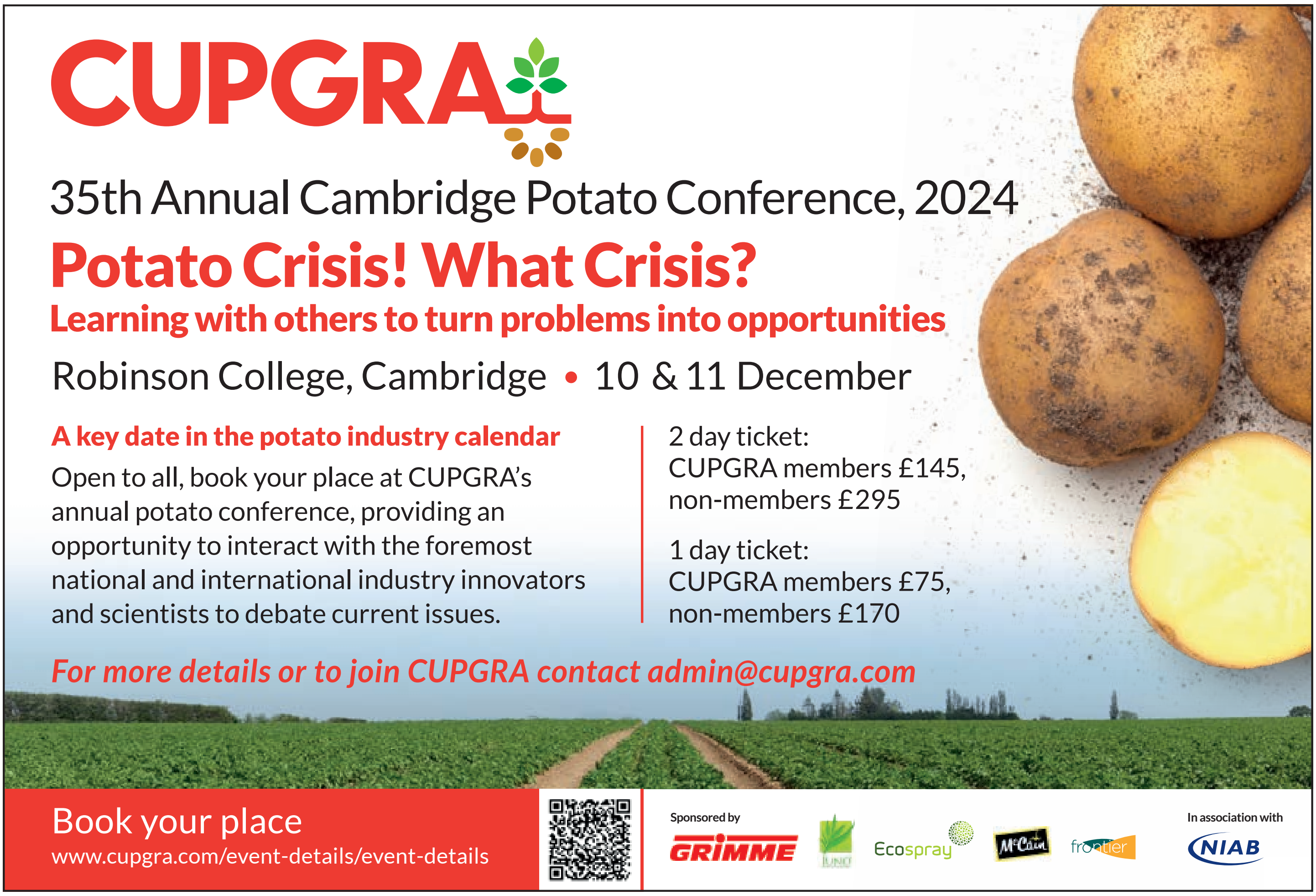
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Why farm productivity matters

Professor Mario Caccamo is Niab Chief Executive appointed in October 2021. He originally joined Niab as the Head of Crop Bioinformatics in 2015 before taking the position of Managing Director of NIAB EMR in 2017. 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.

The 2024 harvest might come to be the poorest in a generation. Current forecasts predict a 20% reduction in UK wheat production. This dents the Government's ambition to maintain food production, one of the three objectives set by Defra's Farming and Countryside programme.

The National Audit Office, a public body that examines taxpayer-funded investments, has already raised questions about Defra's progress its objectives. The 2024 harvest results only confirm these concerns.

The same report asked whether we have the data needed to assess the impact and effectiveness of Defra's schemes. Without baselines and robust metrics, we lack the tools to monitor progress. This severely limits our ability to adjust our trajectory and respond to factors beyond our control, which are bound to happen.

Adding to this year's poor cereal harvest results, the decline in the UK's self-sufficiency in vegetable oils is another example of the deterioration of food crop productivity. British vegetable oil production has halved in the past decade, and now accounts for just 20% of domestic demand. This is a direct consequence of the loss of effective neonicotinoid crop protection chemistry to manage pests such as cabbage stem flea beetle.

The success of oilseed rape, fuelled by genetic advancements, resulted in a significant increase in the area grown in the UK from the early 1980s onwards. It was the nation's break crop of choice. However, it has now almost vanished. The decline of this important flowering crop, caused by policy-makers withdrawing neonics, is paradoxically expected to have a negative impact on the pollinating insects they were seeking to protect.

Adverse weather and the reduction of crop protection products are also responsible for the steady decline in the British potato crop. The harvest in 2023 ranked as one of the smallest since 2003, coming second only to 2012, which experienced severe flooding. More concerning is the consistent downward trend with fewer hectares planted year-on-year.

With the shift to regenerative practices in UK agriculture supported by the Sustainable Farming Incentive (SFI), it is crucial to assess whether we are adequately enhancing farm-level productivity and protecting domestic food production levels. This Landmark issue discusses the new SFI actions and the opportunities they bring.

We can only supplement a reduction in domestic food production by importing more. Relying on global markets not

Defra minister Daniel Ziechner, pictured here on a visit to Niab in 2019 with Prime Minister Sir Keir Starmer and Niab's Dr Phil Howell, has confirmed the secondary legislation needed for the implementation of the Precision Breeding Act will be introduced only has adverse economic implications but is also directly at odds with the Government's commitment that 'food security is national security'.

In an increasingly unstable world, recovering from a global pandemic and facing the triple shock of war, spiralling energy costs and extreme climate events, we must be cautious about pursuing agricultural policies which reward farmers to adopt lower-yielding practices, or to take farmland out of production altogether.

At the very least, we must properly monitor and understand the impact of those policies in terms of productivity and domestic food output.

The good news is that we have today tools at our disposal to help ensure not only that food production can keep pace with the needs of a growing population, but also that the impact on the environment can be reduced over time. In the UK, advances in crop genetics, precision engineering and smart agronomy are all helping to improve farming efficiencies and productivity while reducing agriculture's environmental impact.

The Centre for Ecology and Hydrology (CEH) released a report in October 2023, stating that there have been significant long-term improvements in invertebrate biodiversity in rivers across all regions of England since 1989. These improvements are noticeable in different types of landscapes, such as upland, lowland, rural, urban, and areas with varying levels of arable farming. This is a good indicator of improvements in both soil and water quality, and certainly not the collapse in aquatic life depicted by some.

In England we also can take the lead in Europe by bringing to market the benefits of new genetic technologies such as gene editing. The recent announcement by Defra food security minister Daniel Zeichner is welcomed in this context. He confirmed that the secondary legislation needed for the implementation of the Precision Breeding Act will be introduced as soon as Parliamentary time allows.

New genetics technology will play a central role in the future of agriculture. A study by the Humboldt Forum for Food and Agriculture Research in 2021 emphasises the vital contribution of genetics in enhancing farm-level productivity over time. The study found that without new crop varieties from 2000 to 2020, UK crop yields would be 19% lower and that, to meet food demands, an extra 1.8 million hectares of land would be required, leading to over 300 million tonnes of additional greenhouse gas emissions.

Of course, we could be making even faster progress with greater access to improved genetic technologies.

Combined Peterborough and Cambridge Authority Mayor Dr Nik Johnson toured Niab's Cambridge Park Farm facilities in September with CEO Mario Caccamo, including the new vertical farming unit. Over the past five years, Niab has invested £3.5 million of funding from the CPCA in facilities, laboratories and glasshouses, to help support small and start-up-companies specialising in cutting-edge agritech areas like plant genetics, pest management, soil health, AI, and farm robotics

Progressive legislation such the Precision Breeding Act will be required to accelerate the deployment of new technologies. It is time to reap the benefits of the taxpayers' investment in discovery science. The need to speed up change is urgent.

In a recent article, Graham Brookes, a UK agricultural economist, observes that GM crop adoption globally has increased food production by almost 1 billion tonnes (1996-2020). Additionally, it has reduced the environmental impact of pesticide use by over 17% and carbon emissions by 39.1 billion kg, equivalent to removing 25.9 million cars from the roads.

Indeed, a growing body of peer-reviewed scientific literature now confirms the demonstrable environmental benefits of GM crops, yet British growers currently cannot access these transformative technologies.

At Niab we pioneer the use of technology and science-based innovation to promote farming productivity. One example is the work we do as global leaders in promoting seed testing uniformity world wide. In July we celebrated in Cambridge the centenary of the International Seed Testing Association (ISTA) which was founded in 1924 and initially chaired by Niab's founder Sir Lawrence Weaver.

In response to claims advocating for a shift to agroecological farming practices, I argue that our focus should be on enhancing access to innovative farming technologies to improve productivity, rather than changing course.

Niab CEO Mario Caccamo spoke at a 2024 Labour Party Conference fringe event on plant-based innovation and economic growth, alongside NFU President Tom Bradshaw, AgriTechE Director Belinda Clarke OBE and Dr Richard Harrison, Managing Director of the Plant Sciences Group at Wageningen University in The Netherlands

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Comparing Sustainable Farming Incentive 2023 and 2024

Sustainable Farming Incentive (SFI) 2023 was closed to new applications on 10th June 2024, with general applications opened for SFI 2024 on 22nd July. So, what is the difference and what is the application process?

The main difference is SFI 2024 has a lot more options than SFI 2023 did, with over 100 compared to 23. The 2024 scheme is not linked to BPS claims, so is open to any farmers or land managers who have 'management control' of the land for the agreement period and the land is deemed eligible. The need to have at least 5 hectares of land also no longer applies. Many of the 2024 options have been brought in from the Countryside Stewardship Scheme programme and sometimes modified to fit better alongside other SFI options. A very common modification is reducing the time the options needs doing to three years, but some are for five years.

Some options will also now require approval (endorsement) by Natural England or Historic England; one of these (GRH6) is open for applications now. Others will follow later in 2024 for actions for farmland wildlife, habitats on grassland, heritage, wood pasture, orchards, coastal habitats and waterbodies. These will be published on the 'Find funding for land or farms' online tool before they are available for applications.

Payments are also planned to be available for having educational visits.

SFI 2024

For full information, supporting documents and application process – search for SFI 2024 on www.gov.uk and click on the 'Expanded Offer for 2024' or scan the QR code.

Phil Humphrey has worked as a field agronomist and farm adviser, working mostly with combinable crops, maize and grassland. He now supports Niab Agronomy and Farming Systems teams, with input into a range of projects, including FFRF.

Will Vaughan-France is Niab's regional agronomist covering the south west and is also the membership services development lead. He is based in Somerset with his own farm and has experience in a range of technical and commercial organisations.

Greg Crawford studied agricultural business management at Newcastle University. He went on to work for various agribusinesses working across arable, beef and horticulture before joining Niab in 2022 as the farm business resilience consultant. Greg's role is visiting participants of FFRF to complete the farm business review and report that forms the initial stage of the FFRF support, before signposting to specialist technical advice.

The application process

The application mechanism is broadly the same as it was for SFI 2023. If you already have an SFI 2023 agreement, you will need to do a separate, new, application for SFI 2024. This will not affect the 2023 agreement you already have, it will just be additional to it, and be on a different start and finish time.

Currently, there is still a need to submit 'An Expression of Interest' form online to the Rural Payments Agency (RPA) before being invited to make an application. Once invited to apply, there are 60 days to complete an application.

Where an application includes endorsed options, the endorsement process may delay an application being accepted. Defra suggests this can be avoided by applying under a separate agreement for endorsed options.

Defra and the RPA has produced a short, six minute, video to help applicants through the application process, available on YouTube – '*How to apply for the Sustainable Farming Incentive Expanded Offer*'.

For an individual business, deciding how best to knit different agreements together will need to be considered during the application process. Advice and help from an agronomist or farm adviser should be considered, though there is no need to employ such a person.

An introduction to SFI 2024

A summary of the 102 options and their ID codes is available in 'Annex B' of the main Defra document (see side box – SFI 2024 Options).

Defra has attempted to help people interested in applying through the maze of options by introducing a funding selection tool. This tool allows applicants to select options they are most interested in via land type (arable, grassland, upland etc) and via 'area of interest' (e.g. boundary management, soils, water quality, historic environment etc.). The 'areas of interest' relate to how Defra views the option categories, which do not always tally with how a grower might think.

This tool can be accessed at https://www.gov.uk/find-funding-for-land-or-farms.

Alternatively, it is quite easy to look at the list of options in the contents section of the PDF version of the handbook document, and click on the option title to go directly to the details of that option.

Limited area options

There are currently ten options, referred to as 'limited area options' that count towards the maximum of 25% of the eligible farmed area rule that was brought in earlier this year. These are:

1. CIPM2: Flower-rich grass margins, blocks, or in-field strips
2. CAHL1: Pollen and nectar flower mix
3. CAHL2: Winter bird food on arable and horticultural land
4. CAHL3: Grassy field corners or blocks
5. CIGL1: Take improved grassland field corners or blocks out of management
6. CIGL2: Winter bird food on improved grassland
7. WBD3: In-field grass strips
8. AHW1: Bumblebird mix
9. AHW9: Unharvested cereal headland
10. AHW11: Cultivated areas for arable plants.

Applicants can select as many 'limited area' actions as required, but the total eligible area entered must not be more than 25% of the total agricultural area of the farm. For example, if the total agricultural area of the farm is 100 ha, only a total of 25 ha of eligible land can be entered into any combination of one or more of these 'limited area' actions.

For the purpose of these 'limited area' actions:

- 'farm' means all the land parcels linked to the Single Business Identifier (SBI) at the point of application for an SFI agreement – these parcels are shown on digital maps; and
- 'agricultural area' means the area in each land parcel that is registered with an arable, permanent grassland or permanent crops land cover.

Defra will keep this 25% limited area action rule under review, including whether it should apply to the following actions in future:

- AHW3: Beetle banks;
- AHW5: Nesting plots for lapwing;
- AHW12: Manage woodland edges on arable land; and
- SCR1: Create scrub and open habitat mosaics.

The 'SFI 24 limited area actions calculator' can be used to help calculate the eligible area limit for the next application.

'SFI 2024 Option' types

Figure 1 outlines how Defra is categorising the SFI 2024 options, indicating how option types are grouped. Option codes carried over from 2023 now have a 'C' in front of their previous codes, for example, SAM1 is now CSAM1.

Figure 1. SFI 2024 Options

Soils – 7 options, 1 plan and 6 land management options (mostly cover crops), including no-till farming.

Integrated pest management – 4 options, 1 plan and 3 in-crop management.

Nutrient management – 3 options, 1 plan and 2 for legume growing.

Precision farming – 4 options for use of specific precision working equipment, including variable rate fertiliser application.

Boundary features – 5 options, 1 for hedgerow condition assessment, 4 for hedgerows, hedgerow trees, banked hedges or dry stone wall management.

Buffer strips – 8 options around either field headlands, ponds or trees.

Water bodies – 9 options, 2 for actual management of the feature, and 7 for protection via either buffering or reducing inputs, including nil fertiliser.

Farmland wildlife (arable and horticultural land) – 15 options for habitat creation or food provision, including overwinter stubbles.

Farmland wildlife (grassland) – 11 options for habitat creation, food provision, or reduced inputs, including the endorsed GRH6 option.

Species recovery and management – 4 supplement options for rare native livestock breeds.

Heritage – 5 options for management of traditional farm buildings, historic engineered waterbodies and archaeological features.

Moorlands – 11 options, 1 for condition assessment and 10 for livestock management. Additional payment for group applications on common land is still included.

Organic farming – 14 options specifically for organic farmers.

Agroforestry – 2 options to maintain existing projects.

Many options are for three years. However, some organic options are only for one-two years as they assist with organic conversion, whilst currently 10 options are for five years:

- BFS6 (6-12m habitat margins by watercourses);
- GRH6 (Management of priority habitat species-rich grassland. This is an option that needs to be endorsed by Natural England);
- GRH11 is the cattle grazing supplement to GRH6 and some other grassland options;
- SCR1 (Creation and management of scrub habitat);
- HEF5,6 & 8 (Vegetation management on archaeological sites, and management of engineered historic waterbodies); and
- WBD4, 5 & 9 (Arable conversion to grassland and reduced inputs on intensive grassland by environmentally sensitive watercourses).

Further comments on some of the SFI 2024 options

Since the initial launch of the SFI 2024 management options details in May 2024, there have been alterations; the current guide now runs to 435 pages rather than 366. Some options likely to appeal to farmers are those that effectively provide payment for actions that may already be practised, such as variable rate fertiliser application (PRF1) and no-till farming (SOH1), which have already been backed by capital grants through the Farming Equipment & Technology Fund (FETF). There is also an increased suite of options that allow land to be fallowed, including basic and enhanced overwinter stubbles (AHW6 and AHW7); overwinter, spring or summer cover crops (CSAM2, SOH2 and SOH3) and legume fallow (CNUM3).

Some options have had what some may describe as 'loopholes' closed. The aim being to provide more certainty that the aims of the scheme are achieved and that 'the spirit' of the scheme is better protected. Examples include:

- CNUM3: legume fallow – now needs to provide overwinter cover as well as spring and summer flowers. Therefore, spring sowing followed by an autumn sown cash crop is not possible;
- CAHL2: winter bird food on arable or horticultural land – now needs to provide flowers in spring and summer as well as providing bird food until February. Early spring sowing is therefore necessary; and
- PRF1: variable rate fertiliser – this must be for the application of major nutrients, defined as nitrogen, phosphate, potash or magnesium. So, use to only supply more minor nutrients or lime is not allowed.

There are now more habitat management options (many brought across from Countryside Stewardship Scheme), and a good number of options for grassland, primarily aimed at providing incentives to reduce inputs in long term and upland-type grassland. These are considered in more detail in '*SFI grazing options and overseeding grassland*' by Ellie Roberts in this issue of *Landmark*.

With option payments ranging from a few £/ha to over £1,000/ha, and the ability to 'stack' some options together on the same area of land, the scheme is well worth looking at. For any farm business though, choices should be made that complement the aims of the business rather than focusing too much on only choosing higher paid options. Payments have been set to reflect a combination of income forgone and the environmental value generated.

Which options are best for an individual business will therefore depend on factors such as the value that can be reliably achieved from farming it to maximise food production, versus combining food production with varying amounts of environmental stewardship – or improving profitability by selective use of non-crop options. Some examples of this are explored in '*Economics of crop and variety decisions*' by Will Vaughan-France in this issue of *Landmark*.

Through the Future Farming Resilience Fund (FFRF), Niab offers free advice to qualifying businesses* to help them make the best choices for their individual circumstances, either for SFI applications or wider business needs. For FFRF supported advice, please contact Greg Crawford at gregory.crawford@niab.com or 07453 965836; or click on 'register for support' at www.futurefarmingresilience.com.

* Businesses that receive direct payments (BPS) or are in a Higher Level Countryside Stewardship Scheme.

SFI grazing options and overseeding grassland

Ellie Roberts is Niab's forage crop specialist, managing the statutory and commercial forage crop trials programmes alongside providing technical and scientific knowledge on forage crops to Niab members, APHA, seed companies, commercial businesses and educational organisations. She works with industry in developing research and training projects alongside contributing to Niab's agronomy guides and publications.

The new 2024 Sustainable Farming Incentive (SFI) offer includes an expanded number of options for managing grassland and forage maize.

Incorporating legumes and herbs into existing long-term grassland is being reviewed for the potential to increase carbon capture as part of Niab's Centre for High Carbon Capture Cropping (CHCx3) research project. We are linking with seed companies Barenbrug, DLF, Germinal and Cotswold Seeds to monitor 18 farms around the country. In addition, we have begun developing a '*Herbal leys and diverse swards farmer and adviser network*' which will increase interaction between industry organisations and their activities, improve access to technical information and support, provide informative video diaries and mentoring.

Increasing grassland species diversity can bring multiple benefits, not just increasing carbon capture in soils but also improving soil health, nutrient use efficiency, biodiversity and climate change mitigation; all whilst supporting healthy and efficient livestock performance on lower inputs. This timely work marries well with the 2024 SFI offer which includes a number of options with payments for increasing species diversity in grassland swards and temporary leys.

SFI option 'CSAM3: *Herbal leys*' has a payment of £382/ha per year over three years. It can be rotated but the benefits are greater for soil structure, health and carbon capture when kept in situ for at least the full three years. The aim of this option is to provide varied root structures with a mixture of grasses, legumes and herbs that flower from late spring into the summer months. These leys can produce high yields of high-quality forage with minimal use of fertiliser. Depending on the plant species used they can continue to perform well during dry summers. Maintaining an existing herbal ley will also qualify for the payment if it is not already being paid for under another stewardship agreement.

Under this SFI option, a minimum of one grass species, two legumes and two herbs must be grown; this can be as a simple mixture or a more complex one with additional species. The CSAM3 herbal ley must be established by early autumn and no more than 40 kg N/ha should be applied per year.

The most widely used herbs for productive leys are ribwort plantain/ ribgrass (*Plantago lanceolata*) and chicory (*Chicorium intybus*). Plantain can tolerate a pH range from 4.2 to 7.8 but grows best at 5.8 and can provide >20% crude protein (CP) with D-values up to 68. It can also reduce enteric methane production. Chicory can tolerate a pH range from 4.8 to 6.5 but grows best within 5.6-6.0. It can provide 18% CP and 11 MJ ME/kg dry matter with a D-value of >70 as well as reducing enteric methane production. Plantain and chicory perform well in free-draining soils and benefit from the inclusion of legumes for their source of nitrogen.

CENTRE FOR HIGH CARBON CAPTURE CROPPING

Both of these robust, deep rooting, mineral mining herbs are available in highly palatable, commercial varieties/ mixtures and support high growth rates in lambs and beef cattle. If chicory starts its reproductive phase, the blue-flowered stem is well lignified and less palatable for grazing and care must be taken, if cutting, to ensure adequate stem bruising to prevent damage to silage wrap. However, the timing of cutting and grazing can restrict the tendency for chicory to begin reproductive growth. This is most easily managed by the careful timing of rotational, strip or mob grazing methods, where the ley is grazed for one or two days and then left to recover. Chicory also reduces bloat risk from legumes and reduces gut worm burdens.

Where conditions are less favourable for these herbs or if legumes are preferable, SFI option 'CNUM2: *Legumes on improved grassland*' aims to have

legumes growing from spring until early autumn to help increase nutrient use efficiency, with some legumes benefiting soil structure and health. This option has an annual payment of £102/ha over three years. One or more of red clover, white clover, alsike clover, sainfoin, lucerne and bird's foot trefoil can either be included along with grasses in a full reseed or can be stitched in or broadcast onto an existing grass sward. Existing grass-clover swards can also be included in this option if not already being paid for under an existing stewardship agreement.

When adding legumes and herbs to existing grassland, timing is critical. Warm moist soil is essential but as this also favours vigorous grass growth, autumn establishment is often more successful than spring as grass growth rates will be slowing down, giving more chance for young seedlings to take hold after the existing sward has been tightly grazed. Soil tests and any necessary liming should be carried out beforehand. Some soil disturbance through scratching/harrowing before broadcasting or shallow slot seeding/direct drilling, followed by rolling, should create the good seed to soil contact needed. The application of nitrogen should be avoided as this will boost the existing sward more than the new seedlings. Broadleaved weeds (such as docks, thistles and nettles) should be controlled before sowing as pesticide use is only allowed for spot treatment on mixed swards to avoid damaging the herbs and legumes.

Red clover is deep rooting, drought and water-logging tolerant and high in protein but can be more difficult to establish in existing grass swards than white clover so careful management is needed. Lucerne, sainfoin and birds-foot trefoil can be slow to establish but can support excellent lamb/beef growth rates, even during dry summers. These legumes are usually included in reseeded herbal leys rather than being added to an existing sward. If you have had experience of incorporating these legumes into existing grassland, we would be very interested to hear from you (ellie.roberts@niab.com, 07734 567597).

Adjusting the management of grassland

Existing, highly diverse, priority habitat grassland can receive £646/ha annually under SFI option 'GRH6: *Manage priority habitat species-rich grassland*', over a five-year period. Restoring existing grassland to an appropriate priority habitat, such as lowland calcareous grassland, lowland dry acid grassland, lowland meadows, upland hay meadows; purple moor-grass and rush pasture is also eligible under this option, endorsed by Natural England.

Managing grassland with very low nutrient inputs (CLIG3) has an annual payment of £151/ha for three years and aims to provide nectar and shelter for invertebrates (beneficial insects) and food for farmland birds as well as minimising nutrient runoff. This option limits the use of nutrient applications to 12 t/ha of cattle FYM or equivalent fertiliser from other manures.

In both these latter options, mechanical activities, such as mowing, must not disturb breeding birds or damage nests. If being mown, this grassland must not be grazed or cut for a continuous period of around eight weeks during the spring and summer months to allow flowering grasses and wildflowers to set seed. Herbicides are only permitted as spot sprays to control injurious weeds, invasive non-native species, nettles or bracken.

Other options that can include some grazing include 'CSAM2: *Multi-species winter cover crop*', which must include at least two species from at least two different groups from brassicas, legumes, cereals/grasses and herbs. It can be grazed but must retain a well-established cover over the winter months.

'SOH2: *Multi-species spring-sown cover crop*' can also be grazed off to destroy it but only for the two weeks prior to sowing the next crop. This option does not allow inclusion of 'game cover' species such as millet, maize or sorghum.

Options when growing maize

Undersown maize can be included under option 'SOH4: *Winter cover following maize crops*' (£203/ha). The understorey can be grazed after the maize harvest, as long as good cover is maintained over the winter months. Alternatively, establishing a quick growing cover crop as soon as possible after harvesting the maize (usually no later than mid-October) can also be grazed, as long as cover is maintained over winter (an article on insights to date on undersowing maize will be included in the next edition of *Landmark*).

Niab Grower Survey Herbal and multi species leys

As part of the CHCx3 project Niab is looking at herbal leys, their potential for carbon capture and how to increase the rate of uptake for their beneficial effects (carbon capture, forage system resilience, livestock production and health, soil health, supporting biodiversity and other ecosystem services).

Help us by filling in the survey by scanning the QR code with your smartphone, covering your experience with herbal leys.

Niab is also looking for experienced and potential growers to join an interactive, information network for growers – please contact ellie.roberts@niab.com to join.

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Economics and crop and variety decisions

The calculation and prediction of gross margins for individual crops has been standard practice in agriculture for a considerable time and is a useful measure of the headline profitability of a crop. However, it is limited by its exclusion of the operational resources (labour and machinery) and the often-simplified averaged agronomic inputs.

Over the past two seasons, within the Niab Agronomy Membership, we have been investigating the profitability of individual crops, varieties and agronomic scenarios including whole rotations. As examples we have investigated questions such as:

1. What are the economics of choosing a lower yielding high disease resistance variety versus a higher yielding moderate resistance variety?
2. Do varieties carrying Barley Yellow Dwarf Virus resistance or tolerance compare favourably with susceptible types considering a change in insecticide use, number of sprayer passes and the Sustainable Farming Incentive (SFI) Zero Insecticide payment?
3. What is the premium required for milling wheat profitability to exceed feed wheat accounting for differences in yield, growing costs and the reliability of achieving full premiums.
4. How is the profitability of oilseed rape affected by changing from conventional to hybrid oilseed rape and what is the effect of crop loss and establishment?
5. Does growing a crop to fit an SFI payment option such as low input cereals compare favourably with growing for outright output?

When looking a crop profitability scenario, we must make many assumptions, and those will determine the outcome so in interpreting results it is critical to understand the assumptions made and whether they apply in any individual situation.

In the two scenarios outlined below common assumptions have been made, for example that operational costs have been costed per operation to produce the crop up to the point it enters an on-farm store. Each operation has been costed at National Association of Agricultural Contractors (NAAC) published contractor rates which should allow for some margin within the operational costs. When considering crop output, we have used AHDB 2024/25 Recommended List data to ascertain the yield differences between varieties in different scenarios. The resultant operating net margin is designed to accommodate more of the direct costs of the crop than a gross margin calculation traditionally involves. This operating net margin then indicates the crops contribution to overall business admin, finance and property overheads including the capacity to pay rents.

Will Vaughan-France is Niab's regional agronomist covering the south west and is also the membership services development lead. He is based in Somerset with his own farm and has experience in a range of technical and commercial organisations.

Scenario 1: the economics of stronger disease resistance in winter wheat

To show this there are three examples outlined in Figure 2, comparing three winter wheat varieties (Figure 1): a highly

Figure 1. Winter wheat variety information from AHDB 2024/25 Recommended List

	Variety A	Variety B	Variety C
AHDB RL 24/25 Treated Yield (%)	106	97	102
Septoria resistance rating *	7.9	8.9	4.9
Yellow Rust resistance rating *	8.0	8.9	6.7
Brown Rust resistance rating *	4.7	5.7	5.4

* 1-9 scale, where 1 is least resistant and 9 is most resistant

Figure 2. The economics of stronger disease resistance in winter wheat

	Variety A	Variety B	Variety C
Yield (t/ha)	10.18	9.32	9.79
Price (£/t)	180	180	180
Output (£/ha)	1,833	1,677	1,763
Variable costs excluding fungicides (£/ha)	405	405	405
Fungicide costs (£/ha)	127	79	173
Gross margin (£/ha)	1,302	1,201	1,189
Operational costs (£/ha)	471	456	471
Operating net margin (ONM) (£/ha)	831	745	718
ONM at -£25/t wheat price (£/ha)	577	512	473
ONM at +£25/t wheat price (£/ha)	1,086	978	963

disease resistant variety (Variety A – Champion); a modest disease resistance but higher yielding variety (Variety B – Mayflower); and a lower disease resistance variety with middle yield (Variety C – LG Skyscraper).

For consistency each scenario is based on the same drilling date and inputs, except fungicides, and in the case of variety B one less sprayer pass as no T0 fungicide is applied. The appropriate fungicide spend for the control of diseases is calculated based on the fungicide strategies outlined in the Niab '*Agronomy Strategies 4*' document, issued in spring 2024, for a higher-pressure region such as the South West. In calculating output, the AHDB RL control yield has been reduced by 15% to bring it into line with more typical field level yields and then apply the varieties % of control yields to determine the variety yields.

It can be seen from the operating net margins that the difference in yield between varieties A and B is a more significant driver of the change in the margin than the lower growing costs of variety B with its stronger disease resistance. In the case of the lower resistance variety C its yield benefit vs the cleaner variety B is not significant enough to outweigh the higher fungicide requirement. In this situation changes in wheat price from £155/t to £205/t do not change the order of variety margins.

If the model was re-run in an environment where the disease pressure was lower, for example a later sowing date or a drier region, then the fungicide cost difference would narrow and yield would be a stronger driver. At which point variety C may overtake variety B in profitability.

Scenario 2: the economics of a BYDV tolerant winter barley versus an intolerant type

In both winter wheat and winter barley there has been a welcome introduction of BYDV resistance (wheat) and tolerance (barley). Currently there is also one winter barley AHDB candidate with BYDV resistance. Insecticides to control BYDV are low cost but consideration must be given to the cost of any extra sprayer passes, the risk of longer-term resistance from frequent use and the environmental cost on non-target species.

In this scenario (Figure 3) a comparison of two current feed winter barley varieties is made, one with tolerance and one intolerant type. The assumption is that BYDV is successfully controlled by either application of insecticides or the tolerance. There are three examples, covered in Figure 3:

1. an intolerant variety that requires two BYDV insecticide treatments (LG Caravelle);
2. a tolerant variety treated with one insecticide (KWS Feeris); and
3. the same tolerant variety with no insecticide use and the receipt of the SFI zero insecticide payment.

In all three examples the crops are sown at the same time, have the same input programme (bar insecticides) and the only operational cost difference is the number of insecticide sprayer passes. The herbicide programme is assumed to be pre-emergence only and so the insecticide passes are not applied with any other herbicide inputs. Yields are calculated using the same methodology as the previous wheat example.

The yield difference between the varieties is modest and whilst the cost of insecticides is very low the operational cost differences are more significant as a sprayer pass costs more than the insecticide it applies. Where it is possible to receive the £45/ha for not using an insecticide under SFI and the BYDV is successfully mitigated by the tolerant variety then this shows a higher level of profitability than an intolerant variety. The critical factor here is that the variety trait is not costing significant yield, and the tolerant varieties are performing near a par with the intolerant standards.

The two scenarios consider a set of absolute values based on the assumptions made, what they do not is explore the role of these characteristics in risk management. Whilst theoretically rational to focus on income maximisation the difference between a lower risk option like variety B in the wheat disease scenario vs higher return variety A can be considered a risk premium and thus, we need to consider if the difference, in this case £86/ha, is sufficient extra return for the increased is risk. This will be a decision for individual growers considering the resourcing of their business and capacity to absorb risk. It is a decision that is best made from the analysis of the data as the risk premiums will vary with genetic improvement and evolution in farming systems.

Figure 3. The economics of a BYDV tolerant winter barley versus an intolerant type

	Example 1 (intolerant)	Example 2 (tolerant + 1 insecticide)	Example 3 (tolerant + SFI payment)
Yield (£/ha)	8.83	8.50	8.50
Price (£/t)	165	165	165
SFI (£/ha)			45
Output (£/ha)	1,457	1,402	1,457
Variable costs excluding insecticides (£/ha)	463	463	463
insecticides (£/ha)	4	2	0
Gross margin (£/ha)	990	937	994
Operational costs (£/ha)	456	441	426
Operating net margin (ONM) (£/ha)	534	496	568

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Crop varietal differences under contrasting N scenarios

AHDB Report RR100
Impact of different crop nutrition scenarios on cereal and oilseed varietal performance 2024.

The application of synthetic nitrogen fertilisers is a major contributor to the carbon footprint of crop production especially for wheat, oilseed rape, barley and oats. Finding ways to reduce the application of synthetic nitrogen fertiliser without compromising the yield and quality is critical to the aim of achieving Net Zero by 2050. Earlier in the year, Niab responded to a call from AHDB to conduct a scoping review on the 'Impact of different crop nutrition scenarios on cereal and oilseed varietal performance'. Niab teamed up with ADAS to produce a report, including reviews of both the peer-reviewed and grey literature, for example reports from AHDB or Defra projects. It was found that there were differences both in the number of reports and the conclusions for each crop. The results for each crop are summarised in this article, though we found no publications for triticale, rye or linseed, and very little information on spring-sown crops.

Nitrogen Use Efficiency

There are many Nitrogen Use Efficiency metrics that may be useful to measure in experiments testing varieties, including N Utilisation and Uptake Efficiencies (Figure 1). The most commonly used NUE metric (kg grain/kg N available) should be treated with caution as it reflects yield measured at a specific N rate.

Winter wheat

Overall, there is strong evidence in the peer-review literature supporting varietal differences in winter wheat performance under different N regimes, though reports from the grey literature are less compelling. There are reports suggesting European markets, for example Denmark, have been able to produce 'HYLO' – High Yield Low Optimum – varieties capable of maintaining yields at relatively low N rates due to breeding the varieties at low N rates, but these varieties are not cultivated in the UK. Therefore, there is scope for UK breeders to investigate low N breeding programmes to screen

Dr Stéphanie Swarbreck is Niab's group leader for crop molecular physiology, studying how plants integrate and respond to different environmental conditions such as nutrient availability and the presence of neighbours, for example black-grass.

Dr Nathan Morris is Niab's farming systems and soils specialist with over 15 years of applied soil and nutrient management experience. He has a strong interest in cropping systems and nutrient interactions and the impact on crop productivity.

Colin Peters is Niab's break crop specialist, providing specialist technical and scientific knowledge on the evaluation, selection and management of crop varieties, focusing on break crops including oilseed rape, linseed, pulses, sugar beet and other minor crops.

Figure 1. Nitrogen Use Efficiency metrics

NUE metrics	Calculation
Nitrogen Use Efficiency (NUE)	kg grain yield/N available (soil N + N fertiliser) in kg/kg
Grain N offtake	Yield dry matter x grain N% in kg N/ha
N harvest index (NHI)	Grain N offtake/Total crop N uptake in %
N uptake efficiency (NUpE)	Total Crop N Uptake/(soil N + N fertiliser) in %
N utilisation efficiency (NUtE)	Grain yield (kg/ha)/Total crop N uptake in kg DM/kg N
Simple fertiliser recovery	Total Crop N uptake/N fertiliser applied in %

for varieties which can perform better at reduced N rates. There should also be strong interest in these varieties from farmers who want to reduce the carbon footprint of their wheat production.

Barley

Overall, there is some evidence that breeders have improved different NUE metrics for barley which has increased yields and N fertiliser rates and decreased grain N content. There is little evidence to suggest different contemporary barley varieties can maintain productivity at lower N rates, or that yield ranking changes can be observed consistently across different sites and seasons.

Oats

Five peer-reviewed papers were evaluated and overall showed that modern oat varieties do not consistently change in yield ranking orders and effects on NUE metrics are negligible or inconsistent between sites. However, there is some evidence that modern varieties have improved NUE at higher N rates, compared with older varieties.

Oilseed rape

For OSR, trials in these crops are already challenged by weather and pest issues. Additionally, because of the nature of OSR, varieties often need differential and careful management and it has been raised by breeders that the nuances in management required would vary from season to season, and, if NUE information was included may not be easy for levy payers to interpret. Overall, it is concluded that OSR AHDB Recommended List trials should not include differential N rates.

Recommendations

A key recommendation to AHDB was for the Recommended List trials to include winter wheat varieties testing under two N levels; current RL protocol and a reduced N rate. In the short-term, this would aid levy payers in selecting current varieties suited to lower N input. In the longer term, this would stimulate breeders to start selecting in a low N environment, or to submit varieties that have demonstrated NUE (and HYLO) traits into the RL system where they might not previously have been tested. It was noted at the stakeholder meeting that breeders need time to adapt and that a phased-approach may be more beneficial.

Niab also highlighted that additional data on varietal performances under contrasting N application and on a larger scale should be available to AHDB, via the Recommended List trial. However, these data are not easily accessible for researchers to mine.

Breadmaking wheat: does 13% still represent a realistic target post-Ukraine?

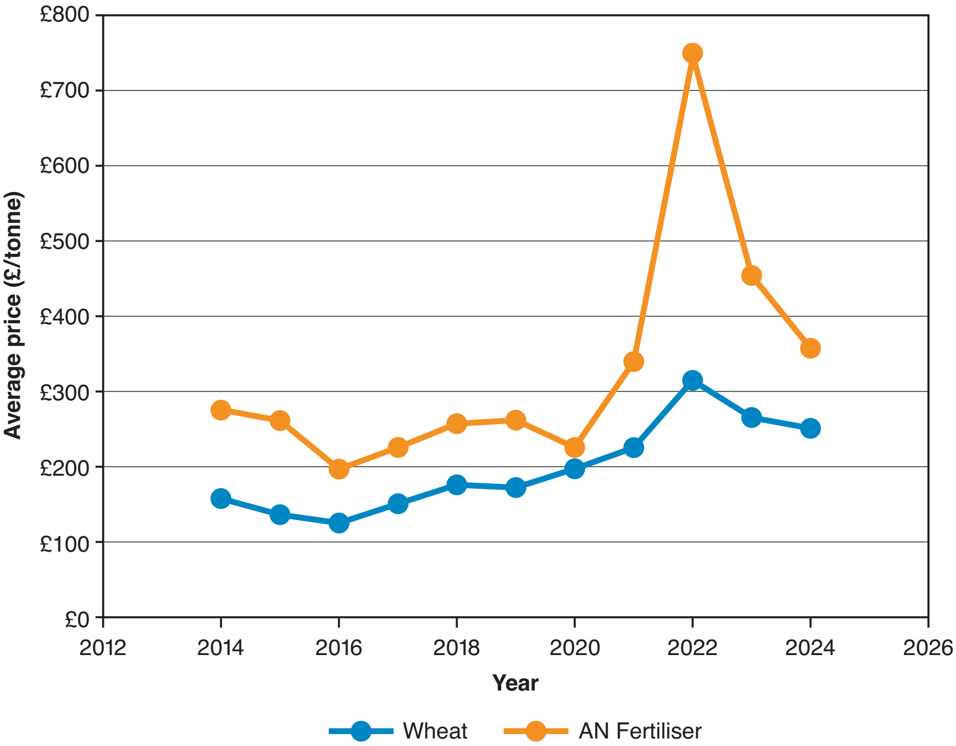
Chair of the NFU's National Crops Board Jamie Burrows farms 1,000 ha of cereals in Hertfordshire and Norfolk – a mix of owned, tenanted and contract farming agreements. He first got involved with the NFU locally after graduating from Harper Adams University in 2005, before taking a regional and then national role. He is also an ex-Cereals Development Programme participant, and keen to get others involved in these types of initiatives. Jamie is passionate about achieving the best for cereal and oilseed producers, and is proud to represent the cereals interests of members in England and Wales.

NFU

Over the past year, the National Farmers Union (NFU) has brought together industry colleagues for a wheat protein roundtable, as part of a discussion on how the combinable crops sector can meet sustainability requirements in the face of increasing environmental demands, including reductions in nitrogen fertiliser use and its associated carbon footprint. The roundtable comprised of representatives from NFU, AHDB, Agricultural Industries Confederation (AIC), UK Flour Millers, British Society of Plant Breeders, Niab and Defra, looking on how to address the challenge faced by UK growers in attaining sufficient grain protein to meet breadmaking wheat specifications.

This challenge has been brought into sharper focus by the recent volatility of nitrogen prices (Figure 1). Following the fertiliser crisis, where costs spiralled out of control after the combined effects of a gas price increase and the Russian invasion of Ukraine, growers were forced to make difficult decisions about how much nitrogen fertiliser they could afford to apply to crops. A recent NFU intentions survey showed that growers are removing risk from their farm business by reducing nitrogen fertiliser use, which might involve moving away from growing breadmaking wheat. Food supply chains are facing rapidly increasing demands on sustainability, and direction from government, policy and consumers is not always aligned. Industry policy on breadmaking wheat must encourage investment to help the sector align with the demands of the supply chain and strike a balance between food production and sustainability.

Figure 1. Nitrogen fertiliser price against Group 1 wheat price (AHDB)



The UK milling market typically uses four million tonnes of domestic wheat combined with one million tonnes of imported wheat to produce four million tonnes of flour each year. The demand for breadmaking wheat is growing, but pressure on arable land use is also increasing. The breadmaking wheat sector is aware of the sustainability challenges it faces, and notes that extreme weather events can have a large impact on protein quantity, quality and functionality. This means that, as is the case for farmers growing for any market, the ultimate outcome of the grain quality is not fully within the farmer's control.

The sector is committed to 13% protein content in breadmaking wheat for a number of reasons. Further down the supply chain, consumer expectations demand a particular type of loaf, which in turn means the baker requires specific flour, which the miller must deliver at a particular protein specification. Sufficient high quality gluten is required to hold the bread together, which only increases in importance when products such as seeds and fruit are added to a traditional white loaf.

Protein is therefore fundamental to the breadmaking process. Bakers know the minimum protein they need, from which varieties, to make a consistent loaf of bread, especially when automated processes are used at scale. Gluten protein is the key driver of flour functionality and baking, which drives the grain specifications demanded of the grower.

Millers and bakers work closely with plant breeders to identify the best and most consistent wheat varieties for different end-markets, updating the UK Flour Millers Wheat Guide each year. Combined with varietal tests conducted ahead of harvest, the protein content itself is a proxy for functionality, allowing the market to trade around a recognised industry value. While millers would prefer to buy on functionality itself, this is currently not possible to test effectively at intake, so they instead combine prior knowledge of variety performance with protein quantity testing of grain consignments.

Millers are prepared to buy lower protein samples in years when it has been difficult to reach 13% content, and they can take fallbacks in certain varieties down to 12%. However, to maintain consistency in the baked product, this protein must be replaced, through blending with high-protein breadmaking wheat from other countries such as Canada and Germany or adding concentrated wheat gluten.

If the standard protein specification for UK breadmaking wheat were hypothetically lowered from 13% to 12%, for example to reduce nitrogen fertiliser requirements, this would leave no margin for error for further fallbacks. Furthermore, imports of high-protein breadmaking wheat would increase to maintain flour functionality, reducing both the demand for domestic breadmaking wheat and the premium paid, to account for the elevated costs of importing more high-protein wheat. The solution to sustainability is not to offshore our output.

UK growers are recognised to produce some of the highest quality and most sustainable food in the world, supported by a climate which is well suited to growing crops such as wheat. The sustainability attributes of high-protein wheat imports are not measured and do not necessarily reach the same levels expected of home-grown breadmaking wheat. This could put added pressure on UK growers to farm in a certain way whilst trying to compete with imports produced to a different standard.

When considering current commercial wheat varieties, a third required more than 280 kg N/ha to reach milling specification and a further quarter required more than 300 kg N/ha (Figure 2). The general understanding is that on average an additional 40 kg N/ha increases grain protein by 0.5%, an additional 80 kg N/ha increases grain protein by 1.0%, and an additional 120 kg N/ha increases grain protein by 1.3%. However, in AHDB trials some varieties actually performed better at lower nitrogen applications than higher applications.

Plant breeders are heavily invested in developing new varieties, and millers are in a much stronger position than they used to be when it comes to variety availability to deliver products at a specification demanded from further down the supply chain. Current trials work is looking at a range of options to

NIR wheat protein testing by Niab's Analytical Services improve the offering to farmers, with the hope that new varieties can be brought to the market which reduce the risk associated with growing breadmaking wheat. The focus is on developing more sustainable varieties which sit above the grain protein deviation line – a direct measure of how efficiently a plant is converting nitrogen into protein content as well as yield.

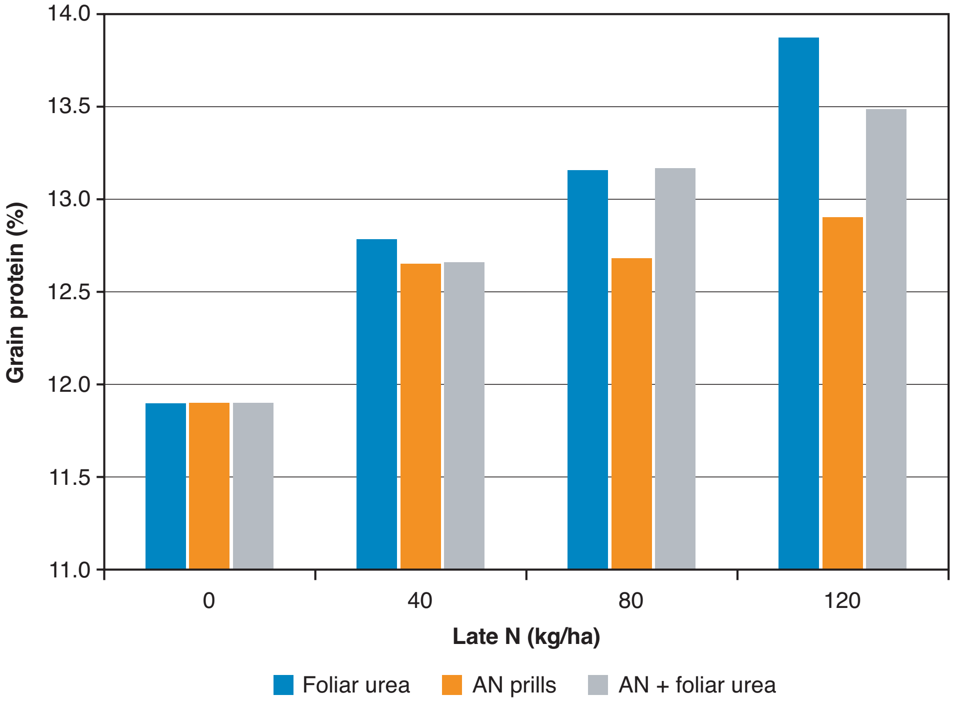
Varieties with improved nitrogen use efficiency are already in development, which is a key factor growers would like to be able to consider when making variety choices ahead of planting. Research from a BBSRC LINK Project (*Low protein wheat for breadmaking*, AHDB Project Report 621 (2020)) suggests that reaching the required grain protein quantity from lower nitrogen applications could come from the efficient translocation of nitrogen into the grain and increased proportions of total glutenin, which results in greater dough elasticity.

Whilst precision breeding should not be considered a silver bullet to improving plant varieties, there is research (‘*Enlisting wild grass genes to combat nitrification in wheat farming*’) which indicates promising opportunity for improved nitrogen use efficiency. Wild grass genes conferring biological nitrification inhibition (BNI) could be used to reduce the impact of nitrogen fertiliser when growing wheat, through the production and release of nitrification inhibitors from the plant roots. The research demonstrated that the introduction of the BNI trait did not negatively impact grain protein levels whilst boosting grain yields, thus reducing the carbon footprint per tonne of breadmaking wheat produced.

The most effective boost to grain protein levels is shown to have come from late applications of nitrogen fertiliser at the milky-ripe stage of grain fill. Foliar urea has been shown to deliver a greater increase in grain protein content than ammonium nitrate, with no detrimental impact on baking quality (*Foliar-applied nitrogen for grain protein and canopy management of wheat,* AHDB Project Report RR47 (2001)).

Assessing the nitrogen status of a crop accurately is often challenging, and has made it difficult for growers

Figure 2. Overall effect of timing strategy and N rate on grain protein content (ADAS, 2005) Source: AHDB



For modern variety crops to achieve 13% protein:

- **6 out of 16 (38%) needed >280 kg/ha N**
- **4 out of 16 (25%) needed >300 kg/ha N**

to decide how likely a late nitrogen fertiliser application will be in their crop reaching grain protein specifications. To make the best prediction of grain protein content ahead of harvest, growers should use the wheat ears rather than the whole plant material to conduct the assessment, and used dried material rather than plants straight from the field (*Predicting grain protein to meet market requirements for breadmaking and minimise diffuse pollution from wheat production*, AHDB Project Report 483 (2010)).

Plant nitrogen content can be rapidly analysed using near infrared (FT-NIR) assessments to enable quick nitrogen fertiliser decisions, utilising research which has established a maximum grain protein forecasting system to justify whether a foliar application of urea is a worthwhile investment.

The roundtable concluded with an understanding that it is in the interest of the whole breadmaking wheat supply chain to deliver research and investment into producing sustainable breadmaking wheat. Whilst various research has been undertaken on measures which could reduce the nitrogen requirement for a breadmaking wheat crop, the fact remains that growers in the UK are still reliant on nitrogen to meet the specifications demanded by the supply chain.

It is also important for the new government to understand the challenges of growing a breadmaking wheat crop within a sphere of crop production that faces increased scrutiny over its sustainability. In the current environment, it is difficult to see how growers can guarantee to produce breadmaking specification wheat whilst also reducing the carbon footprint of that same crop.

The demand from the wider supply chain for environmental data will only increase, and there may well be a time when the value that can be derived from a more sustainable feed wheat crop exceeds the value of a less sustainable breadmaking wheat crop. It is vital that leaders within the industry continue to work together to deliver the best suite of options for growers to ensure they can remain a strong primary producer for the UK breadmaking sector.

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Ergot – the orphan disease

Dr Lesley Boyd leads research programmes that focus on understanding wheat-fungal pathogen interactions. Her current work focuses on wheat-rust and wheat-ergot diseases. She is an internationally recognised expert on wheat-rust genetics and biology, and a member of the UK Millers Ergot Working Group.

Ergot is the scourge of cereal farmers. Caused by the fungus *Claviceps purpurea*, the disease results in ergot sclerotia replacing grain. The disease can be difficult to spot in the field, and is often only detected at harvest, when blackish ergots can be seen protruding from florets (Figure 1).

These ergots are full of toxic alkaloids that are detrimental to human and animal life. In the Middle Ages ergot alkaloids were responsible for a condition known as St Anthony's Fire, in part due to the high consumption of rye in the human diet. Rye, being an open flowering cereal, is more prone to ergot infection.

While ergot does not have a significant effect on grain yields, contamination with ergot sclerotia can result in rejection of grain for human and animal consumption, depending on the levels of ergots. In 2022 the European Union (EU) introduced new regulations, lowering the limits of ergot sclerotia allowed in grain. In addition, new regulations on the levels of ergot alkaloids that could be present in cereal products were introduced.

Figure 1. Ergots seen on wheat ears just before harvest 2024

C. purpurea is a pathogen with a wide host range, the same strain being able to infect wheat, barley and rye, as well as a wide range of wild grass species, including blackgrass, a common problem for cereal production in the UK. The fungus infects the female parts of flowers (florets), filling the ovary space, where the seed would have developed, with a mass of fungal tissue. Spores are released from infected flowers some 14 days after infection, suspended in a sugary suspension known as honeydew (Figure 2a), which can be transferred to clean florets by insects and rain splash. The fungal mass then develops into an ergot sclerotia which is the overwintering structure of the pathogen (Figure 2b).

C. purpurea produces a range of ergot alkaloids that are highly toxic, with the highest levels being found in sclerotia. These alkaloids are thought to protect ergot sclerotia from predation while over wintering on the soil surface. Ingestion of these alkaloids through contaminated cereal products causes a range of symptoms, including gangrene, convulsions and psychosis, and in sufficient quantities can result in death.

Ergot sclerotia can be removed from grain post-harvest using colour sorting and gravity tables, however, these cleaning methods are not 100% effective, and do not address the risk of ergot alkaloids being transferred onto healthy grain.

AHDB-funded Niab research

confirmed that alkaloids can be transferred to healthy grain both through contamination of grain loads with sclerotia and in the plant, the alkaloids moving from florets infected with *C. purpurea* into uninfected florets where an otherwise healthy seed is developing (*Determining the routes of transmission of ergot alkaloids in cereal grains*. AHDB Project Report 603 (2019), Niab *Landmark* 37, pp12-14).

Consequently, the EU introduced regulations limiting the levels of ergot alkaloids allowed in food products made from cereals. On 1st January, 2022 EU Regulation 2021/1399 set the maximum levels of ergot alkaloids in milled wheat, barley and oat products at 0.1 mg/kg, and 20 µg/kg for infant food products. New regulations on ergot sclerotia contamination of grain were also introduced, reducing the levels of ergots allowed in wheat, barley and oats for human consumption to 0.02% (0.2 g/kg; previously 0.05% (0.5 g/kg)). While ergot sclerotia limits in rye currently remain at 0.5 g/kg, they will drop to 0.2 g/kg on 1st July 2025.

At present management of ergot relies on farm practices, there being no effective chemical controls or assessment of ergot resistance in cereal varieties. While ergots can remain viable from two to four years, work at Arvalis, France has shown that burying ergots, by at least 5 cm, can reduce ergot infection in subsequent years. The establish of grass margins around areas of cereal cultivation are often blamed for high incidences of ergot in the crop. However, work undertaken at Niab, from 2004-2009, suggested that the occurrence of grass weed infestations within the crop, in particular blackgrass, played a bigger contributing factor (Figure 3) (Towards a sustainable whole farm approach to the control of ergot. AHDB Project Report RR465 (2009)). The AHDB Harvest Report for w/e 14 August 2024 commented that "Given the weather this year and bare patches in fields, grass weed pressures have been high. This has been observed with increased prevalence of ergot in some samples. Ergot has primarily been seen as coming from grass weeds rather than cereal crops."

Figure 2. Wheat ears infected with ergot. (a) Honeydew containing fungal spores. (b) Ergot sclerotia, the over wintering stage of the pathogen

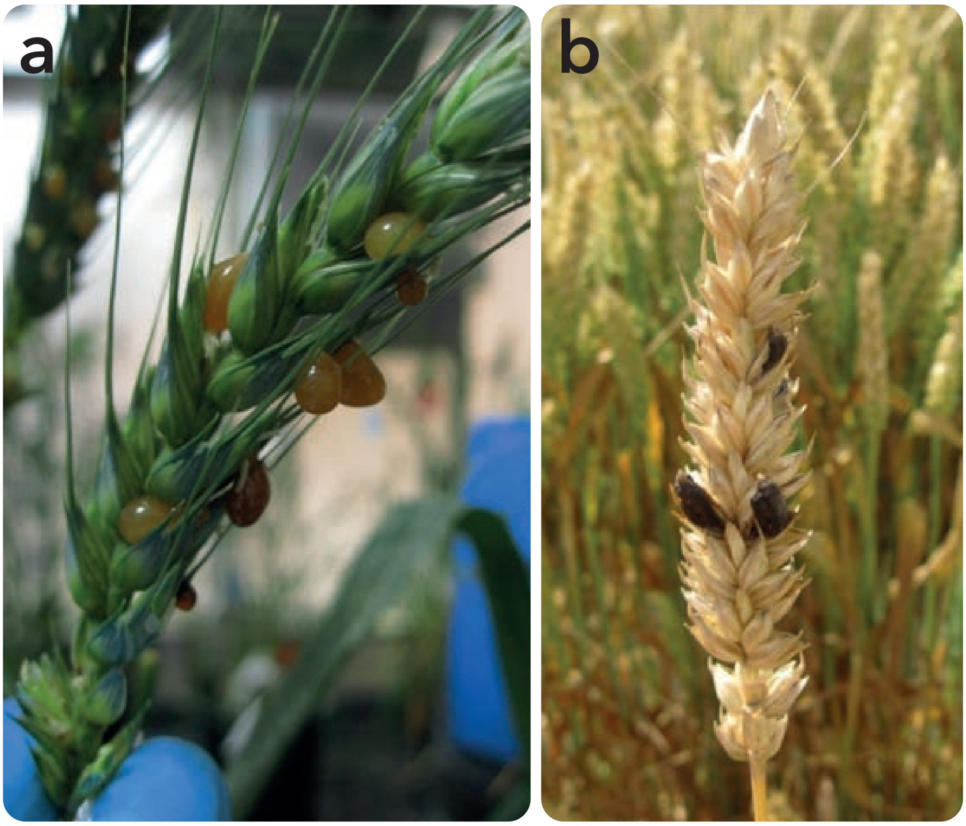

Figure 3. Ergots on blackgrass ears

Helen Appleyard • helen.appleyard@niab.com

ISTA celebrates Centenary in Cambridge

The International Seed Testing Association (ISTA) was invited by Niab to host its 100-year anniversary meeting and celebrations at the Cambridge Union Society and Cambridge Guildhall in July 2024. ISTA was created, with a vision of achieving uniformity of seed testing worldwide, during the 4th International Seed Testing Congress, held at the National Institute of Agricultural Botany in 1924 and chaired by Niab's founder Sir Lawrence Weaver. With 26 countries at the inauguration ISTA was founded with a mission to develop and publish standard procedures for seed sampling and testing.

Since its beginnings ISTA has continued to uphold standards in seed testing, publishing the International Rules for Seed Testing annually and developing its own quality assurance standard and accreditation scheme in the 1990s. ISTA has grown and now has 83 member countries, with 244 member laboratories – 150 accredited to ISTA's quality assurance standard. ISTA's work lies at the heart of the global effort for food security for all, by ensuring the integrity of seed quality assessment processes, which in turn gives farmers access to high quality seed.

The Official Seed Testing Station for England and Wales (OSTS) at Niab helped to organise the ISTA Centennial Meeting and held an international workshop on seed purity and seed identification for 24 seed analysts from Europe and South Africa at Niab Park Farm. The OSTS is proud to be an ISTA accredited laboratory and has been involved with ISTA from its inception.

The Centennial Meeting's first day seminar 'Seed quality assurance: a critical component of food and nutritional security' was opened by Niab CEO Professor Mario Caccamo with guest speakers Rosie Riby, from the Agricultural Industries Confederation, Fera's Victoria Barton FERA and Niab's Professor Ji Zhou. The seminar covered the topics of seed storage, importance of germination testing, high throughput sequencing for pathogen detection and variety identification for traceability.

The Conference featured ISTA committees presenting their work from over the past year; ISTA has 20 committees, made up of seed scientists from around the world including the UK. These committees cover sampling, seed purity, germination and vigour and work to improve seed testing practices, including new technologies such as image analysis with AI to develop seed testing aids in the future.

ISTA and the International Seed Federation also held a meeting on quality seed production for resilient and sustainable agriculture, chaired by Anna Hill of BBC Radio 4's Farming Today. The

Helen Appleyard is responsible for managing and delivering Niab's laboratory services work, including, as Chief Officer, the work of the Official Seed Testing Station for England and Wales, based at Niab. The OSTS, established in 1917, is contracted to carry out ISTA tests for customers on behalf of APHA. To enable the OSTS to carry out this function the laboratory at Cambridge is accredited and audited by the International Seed Testing Association.

The first ISTA meeting at Niab in Cambridge in 1924 topics covered were diversity in crops for future needs, new technologies and innovations in seed production and the importance of seed quality assurance for food and nutritional security.

Delegates, from agriculture ministries and seed companies around the world, were invited to tour Niab's Park Farm site, on the outskirts of Cambridge, including visits to the OSTS, seed health testing, DUS spring barley plots, crop transformation facilities and Niab's wheat pre-breeding programme in the glasshouses. A tree was planted after the tour by Mario Caccamo and ISTA's president Keshavulu Kunosoth to commemorate the Centenary celebrations.

Niab CEO Professor Mario Caccamo welcomes delegates to the Centenary Meeting

Niab's David Hunt showcases the facilities and equipment in the OSTS to ISTA President Keshavulu Kunusoth


Delegates from the 2024 ISTA Centenary Meeting visit Niab at Park Farm

Staff news

Dr Martin Dougherty joins Niab in November 2024 as Chief Operating Officer, bringing 30 years of scientific, operational and leadership experience in the UK research and innovation sector. He will oversee Niab's corporate services and contribute to the development of our business strategy. Martin joins us from the Wellcome Sanger Institute and has previously held similar roles at the Medical Research Council Laboratory of Molecular Biology and the Royal Statistical Society.

Dr Mark Fletcher is Niab's new Head of Agronomy Services, leading the team of 20 agronomists and consultants delivering technical and consultancy services across the country. He joined in July 2024 and will also oversee the translation of Niab's wide-ranging research programme, including member-funded agronomy trials, into on-farm advice to support productive, resilient, regenerative farming for members, customers and stakeholders. Mark is the primary contact in Niab's external interactions relating to strategic agronomic issues, alongside dealing with technical enquiries and production of the portfolio of agronomy publications available to subscribing members.

Niab's Farming Systems team welcomed back research agronomist **Dr Joe Martlew** this summer. Based in the north of England Joe has over 10 years applied agricultural research experience, with expertise in soil science, machinery and agronomy. With a mixed background in commercial and academic roles, Joe has a strong interest in how farm management approaches are brought together into resilient farming systems and will be a regular face at Niab's field and agronomy events and conferences.


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Training the next generation of applied bio-scientists

The Collaborative Training Partnership for Sustainable Agricultural Innovation (CTP-SAI) is a £4.6 million, seven-year PhD programme that began in October 2022, tasked with training the next generation of crop scientists. It aims to tackle some of the biggest challenges in broad-acre agriculture through a collaborative training partnership, working with some of the industry's leading agribusinesses, charities, research organisations and universities. It is funded both by UKRI BBSRC and the industry partners within the consortium (Figure 1). There are 38 fully funded studentships in the programme, with around 10 starting each year between 2022 and 2025.

The CTP-SAI is unique in that all the PhD projects are built collaboratively; each studentship is developed with an industry, academic and institute partner to ensure that key questions can be answered in a range of crops that are relevant to each part of the field to fork supply chain.

As the programme developed, a very clear message from the industry consortium was the need for skilled post-doctoral scientists that had a wider understanding of how businesses operate. In response, the consortium has partnered with Management Development Services (MDS), which runs one of the leading graduate placement programmes in the agri-food sector. MDS is providing bespoke training in key business readiness skills and will be coordinating high quality placements with our industry partners.

The Partnership welcomed its first intake of eight PhD students in October 2022 (Figure 2) and the second cohort of eight students in 2023 (Figure 3), with the students based around the country at CTP-SAI Partner Universities. The CTP-SAI Summer Conference is a great opportunity for the students to meet in-person to build their scientific networks, to enjoy face to face training from MDS and present their work to the Consortium as posters in their first year or presentations in their second year.

An additional 14 students start their PhDs in the academic year from October 2024 whilst the fourth and final cohort of students will join in 2025; the partnership is currently designing collaborative projects for these studentships and recruitment will begin in October 2024.

The collaborative design process has created a very diverse suite of projects with a varied portfolio of crops and research questions being covered. Research topics range from gene characterisation in 'Supporting future wheat improvement underpinned by novel genetic diversity for root traits',

Dr Fiona Leigh is a senior research scientist at Niab. With over 20 years' experience of characterising genetic diversity of crop plants and their wild relatives, Fiona is part of the Plant Genetics department. She is also the CTP-SAI programme manager at Niab, on behalf of G's.

CTP Sustainable Agricultural Innovation

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Figure 1. The CTP-SAI consortium, led by G's Growers

'Develop and apply SMRT-AgRenSeq to potato tuber diseases' and 'Disrupting the "master regulators" of cyst nematode parasitism' though to large scale data in 'The application of satellite remote sensing and machine learning for modelling impacts of regenerative farming practices'. Sustainability is a key topic in projects including 'Developing net zero wheat varieties', 'Optimising pollination of *Vicia faba* for enhanced crop yield and to support biodiversity' and 'Assessing efficient application and emission reduction from the use of low carbon footprint fertilisers in potato agronomy'.

More information about the programme is available at www.ctp-sai.org. The CTP-SAI is an exciting and rewarding programme, and it is a privilege to support the next generation of plant scientists as they start their careers in applied research.

Figure 2. The first cohort of CTP-SAI students at their induction day in 2022

Figure 3. The second cohort of CTP-SAI students at their induction day in 2023

News from NIAB

Nine varieties added to BSPB 2025 Forage Maize DL

Nine new varieties have been added to the British Society of Plant Breeders' 2025 Forage Maize Descriptive Lists (DL), published in September 2024. 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.

KWS Granturismo, KWS Bravo, KWS Kampinos, KWS Temprano, Papageno and Rejko from KWS, alongside Promise, AYA and Duke from Limagrain, Justice from Grainseed Ltd, and Starlord and MAS 075B from Bright Seeds are new entrants on the 2025 Favourable First Choice List.

LID0720C from Grainseed, along with RGT Muxxeal and RGT Buxxton from RAGT and KWS Leto from KWS, have been added to the Favourable Second Choice List. KWS Temprano, KWS Leto, KWS Bravo, Rejko, Duke, Aya, MAS 075B and Starlord have also made it onto the First Choice List for Less Favourable sites.

The Very Favourable Descriptive List, produced from a separate trial programme to test later maturing varieties with the highest yield potential for anaerobic digester feedstock, now has the addition of two more varieties from Grainseed Ltd; Micheleen and Jakleen.

BCPC Digital Knowledge Bank

The British Crop Production Council (BCPC) has expanded its online Knowledge Bank, at www.bcpc.org, to include over 30 years of technical reports and information from the former Weed Research Organisation (WRO).

The resource offers free open access to information, reports and papers from BCPC conferences and symposia reports dating back to 1954, and now includes over 120 technical and annual reports from the WRO – available online for the first time since their original publication.

The digitisation project was arranged by the BCPC with funding from Chadacre Agricultural Trust, Felix Cobbold Trust, Perry Foundation, Douglas Bomford Trust and The Morley Agricultural Foundation, and organised by the AgriFood Charities Partnership (AFCP).

Soft Fruit GIN launches

Niab, with James Hutton Institute and ADAS as key partners, is leading a new five-year £3 million genetic research programme that aims to advance the breeding of more sustainable and resilient varieties of soft fruit crops in the UK. The Defra-funded Soft Fruit Genetic Improvement Network (GIN) began work this summer, and follows in the footsteps of major agricultural crops, including pulses, oilseed rape and wheat, with a co-ordinated research approach to pre-breeding genetics of key traits and new breeding tools. These GINs have provided a key link between industry and academia to ensure that genetic research addresses the needs of the industry, and tackle some of the longer-term issues through breeding efforts.

Professor Xiangming Xu, Director of Research at Niab, explains that the Soft Fruit GIN will advance new biotechnology tools and generate significant genetic data and resources. "The results will help breeders introduce beneficial traits so crops can be grown more productively, with less environmental impact."

Specific targets include understanding genetics of improved tolerance to pests and diseases and increased water and nutrient use efficiency in strawberry and raspberry. It will also develop genetic tools and resources for two underutilised soft fruit crops – blackberry and honeyberry – to assess whether there is potential to increase their production in the UK.

The Soft Fruit GIN will be run in close partnership with the soft fruit industry and the research outputs will be made freely available.

Professor Xiangming Xi, Director of Research, Niab

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Coir recycling offers savings for soft fruit growers

Over the past few decades there has been a major shift from soil into soilless media in UK strawberry and raspberry production. With the phasing out of peat, coconut fibre (coir) has become the preferred substrate. Compared to field soils, coir helps growers to produce consistently higher yields. However, an increasing demand for coir, limited availability and volatile shipping expenses have resulted in increased costs for growers. The carbon footprint associated with shipping substrate from Asia is also a concern, whilst additional labour costs are incurred in replacing and disposing of waste coir.

Scott Raffle is Niab's Senior Knowledge Exchange Manager, raising the profile of the research and commercial activities at Niab East Malling and improving collaboration between researchers and the fruit and wider horticulture industry.

Dr Matevz Papp-Rupar is a research leader in the pest and pathogen ecology team at East Malling. With over ten years of experience in plant pathology, his focus is on the development of sustainable, ecological approaches to the control of plant pathogens and improving resource use efficiency in horticulture. He is currently investigating the biological control of apple canker and bacterial canker of cherry, along with natural resistance to ash dieback.

There has therefore been increasing pressure on the industry to find ways of extending the life of coir. Growers have so far been reluctant to use it for more than a few cropping seasons due to concerns over pest, disease and weed build-up, reducing both yields and the quality of the fruit produced. Niab has been working with Overland Ltd to investigate the potential for re-using strawberry coir substrate.

Initial work was done in an EU-funded Interreg project, Horti-blue C, where coir bags used for strawberry production were directly re-planted by removing the original plants and planting fresh plants into the same planting holes. It was found that where the coir was devoid of pathogens Junebearer varieties would tolerate such replanting with little decline in yield. However, everbearer varieties performed less well, with a yield decline of 6-7% occurring year on year. This is thought to be caused by a reduction in air filled porosity (AFP), and changes to chemical and microbial properties of the coir as it gets older.

Overland has subsequently developed an automated process to recycle coir from strawberry bags which includes automated, low labour removal of bags from the tunnels (Figure 1), followed by the removal of plastic, plant leaves, roots and crowns, to leave clean coir (Figure 2). The coir is then treated in various ways before making it available for growers. Overland funded Niab to do further work to assess how the cycles of both growing and recycling change coir properties over time. We found that the water holding capacity increases while the AFP decreases in recycled compared to virgin coir. The extent of this change varied with different coir manufacturers. Changes also occur in pH, electrical conductivity and nutrient content. Interestingly, levels of crown rot (*Phytophthora cactorum*) tend to increase in directly re-used and composted coir compared to virgin, but this has not been evident in the fully recycled coir that Overland is producing.

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

Growing Kent & Medway input

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

Results to date

At a commercial site (Kelsey Farms), the everbearer strawberry variety Katrina was planted in virgin Legro coir bags and compared to Overland's recycled coir in bags as well as re-used coir (planting directly into used bags). Each of the three coir types were used in nine commercial tunnels (over 3,000 bags per coir type) and irrigation was run independently for each coir type. Sadly, during harvest the virgin and re-used coir were mistakenly picked and recorded together, so the recycled coir was compared to both virgin and directly replanted coir together. The yields were similar (ca 1.3 kg per plant) and no differences were found in pests (thrips), weeds or crown rot pressure between coir types, but there were visual differences in plant growth. In the recycled coir, plants appeared to be stronger and cropped 7-10 days earlier than the virgin coir bags. The plants grown in recycled media also used 12% less fertigation over the season. This reduction in water use in recycled material was especially prominent during hot days. The grower was very happy with the performance of the recycled media and its management, and the trial has been repeated this season. In 2024 we repeated similar trials comparing the growth of everbearers in recycled coir with virgin coir and also with a 50/50 mix of virgin and recycled coir. This should give growers more confidence in the material whilst assessing other options.

At Niab's East Malling site, the everbearer variety Malling™ Supreme was planted in a small trial with both virgin and recycled Legro and Cocogreen coir in troughs rather than bags. Separate irrigation rigs were used for recycled and virgin media but not for each coir brand. The two recycled coirs used 4% less water than virgin. Reduced need for wetting up and maintaining moisture in recycled material at the start of the season was the primary reason although reduced water use on the hot days due to the higher water holding capacity of the recycled coir also contributed.

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

The total yield from recycled coir was slightly lower comparing Legro recycled and virgin coir. This was due to the virgin materials of both brands being fairly comparable in terms of water demand, but recycled materials with different previous growing histories were not. Namely, recycled Legro material had much higher water holding capacity compared to recycled Cocogreen. This meant that recycled Legro coir was over-irrigated and recycled Cocogreen under-irrigated resulting in slight yield reduction. It highlights the need for different irrigation/fertigation regimes with different coir types, or at least to use separate valves to manage coir moisture adequately.

In summary, to date Niab has demonstrated that recycling coir offers much better potential than either re-using or composting coir and recycling can achieve strawberry yields and quality that is comparable to virgin material. The rate and level of physical and chemical degradation does vary depending on the coir type, manufacturer, and growing history but we believe that cost effective coir recycling is possible with little yield reduction. However, it is important that the irrigation and fertigation of crops grown in recycled coir are managed separately from virgin coir, to adjust for the lower AFP in the recycled product, otherwise over-watering can occur leading to root death and reduced yield and quality.

Further work is planned to optimise the recycling process to better preserve and improve the physical properties, mitigate any chemical imbalances and residual, pests, weeds and pathogens which might be linked to the slight yield decline. Additionally, root microbiome of strawberry grown in virgin and recycled coir is being investigated to identify any other microbial imbalances. An economic and environmental impact analysis of recycling coir will also be carried out and will include total costs and environmental impacts of substrate production/recycling, use on the farm and disposal.

Niab hosts annual Controlled Environment User Group Conference in Cambridge

Exploring the use and supply of sustainable Growing Media, was the main focus of the Controlled Environment User Group's 2024 conference, held at Niab in Cambridge in September.

The industry association (www.ceug.ac.uk) highlights the management and use of controlled environments for plants, invertebrates, and ecosystems. The two-day conference, 'Sustainability through Innovation', saw 80 delegates from across trade and academia take part in a mix of talks, panel discussions, facility tours and glasshouse demonstrations, emphasising the importance of adapting with industry changes and how the move to advanced technologies can aid the switch.

The CEUG workshops and demonstrations on using peat free growing media covered best agronomic practices, alongside dealing with the challenges of nutritional deficiencies like nitrogen lock up, the supply of raw material, costs and food safety concerns, and discussions on how growing media mixes can change over time potentially affecting experimental designs/protocols.

Specific speaker topics included glasshouse coating technology, waste-to-growing media solutions, cold plasma seed treatment for vertical farms, alternative substrates for commercial vertical farming, and development of organic, peat-free blocking media designed to support the process from sowing to transplanting in the field.

As host, Niab's expanding role as a leader in supporting research and development within this niche, but increasingly important, sector featured heavily. Delegates toured the Park Farm site with its soil-bedded glasshouses, vernalisation chambers, range of lighting set ups and specialist facilities. The vertical farm unit and pathology growth chambers were also key stops, providing insight into the latest research and development activities at Niab. Demonstrating growing media trials in Niab's own controlled environment facilities, glasshouse agronomist and conference chair Ben Tea concluded, "Niab's mission is to unite research and industry together, and this event perfectly demonstrated that goal. It bridged the gap and facilitated valuable knowledge exchange."

Speakers: Lambda Agri, Tumblebug, Zayndu, GrowUp Farms, Coventry University and Riverford Farms. Exhibitors: Niab, Michell Instruments Ltd, Alphatech Ltd, Hettich, TCE Electrical Ltd, Bridge Greenhouses Ltd, Vaisala, Intelligent Horticultural Solutions, Weiss Technik UK Ltd, Conviron, Heliospectra AB and Kroptek Ltd.

NIAB

Glasshouse Services

Testing beyond the field

Glasshouse facilities

Our glasshouse facilities at Cambridge and East Malling (Kent) reflect modern commercial services and feature:

- Offer a complete bespoke package from trial design, trial delivery, data collection, analysis, and reporting
- Approximately 6,500 m^2 of controlled environment glasshouses and specialist plant growing facilities combined across the sites including spore-proof growth rooms, growth chambers, containment and vertical farm unit and vernalisation areas
- Ability to provide small pre field scale trials supporting R&D and proof of concept projects.

Glasshouse capabilities

- Biostimulant trials
- Nutrition and water management
- Seed bulking
- Fertiliser and crop protection products
- Herbicide efficacy trials
- Growing media trials.

Niab glasshouse services include:

- Experimental design
- Impartial assessment
- Phenotyping
- Data handling and analysis
- Genetic resource maintenance
- Specialist plant husbandry
- Additional analytical services available via Niab LabTest

Testimonial:

"We are a young start-up company with no track record in agriculture. When we mention that we are undertaking trials with Niab, we get a positive response from potential customers or partners. Working with Niab helps us to demonstrate that we want to produce robust evidence about our product that stands up to scientific scrutiny."

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Giving businesses access to R&D support: Breaking down barriers

Four Business Innovation Vouchers awarded to enable organisations to work with Niab research specialists at East Malling

Innovation is critical to accelerating commercial growth. For smaller businesses with limited resources however, finding the time and finances to focus on their research and development needs can be challenging.

This is where the Growing Kent & Medway programme steps in. Niab leads this five-year regional programme, designed to accelerate innovation in horticultural and plant-based businesses. It is funded by UKRI's Strength in Places initiative.

One of Growing Kent & Medway's aims is to facilitate smaller businesses to collaborate with research organisations and access expertise and facilities, which would otherwise not be available to them, helping them to unleash their full potential. A funding competition was introduced to enable UK-based SME's to apply for finance to access technical support from research specialists in the Kent and Medway area.

The 13 successful applications were from a wide range of organisations, addressing various challenges in the horticultural and plant-based food and drinks sector. They were assessed on their innovative ideas to develop new, more sustainable, products, processes and production systems.

Four of the winning projects teamed up with Niab researchers to use their expertise and the specialist growing facilities at the East Malling site.

Raising the bar for alcohol-free wine

A successful proposal from specialist UK import wine brokers, HWB Group, is enabling them to work with Niab's Wine Innovation Centre at East Malling. Their project is aiming to create the first UK-based alcohol-free wine.

Led by Niab's oenologist and viticulturist, Dr Belinda Kemp, they will explore innovative fermentation and de-alcoholisation techniques using locally sourced produce from Kent.

The aim is to create alcohol-free wines that preserve the character and health properties within the fruit, responding to the rising demand of health-conscious consumers for premium alcohol-free wine.

Jerome Harlington, CEO HWB Group, said: "We aim to pioneer a new market segment with a product that reflects the rich heritage and exceptional quality of UK viticulture. We felt that Kent reflects among the best produce the UK has to offer, and working with the research team at Niab is the perfect base to carry out this groundbreaking project."

Sustainable pest and disease management for fruit crops

Spotted wing drosophila (SWD) is a major pest of UK soft fruit crops, and Niab's Dr Michelle Fountain has been leading the UK research effort into this pest for over a decade.

British Berry Growers, the industry body, secured a Business Innovation Voucher to explore a new biological control method for the pest. They will be developing a tool that can be used commercially in outdoor UK field conditions that boost the population numbers of SWD's natural predators.

Dr Louise Sutherland, British Berry Growers said: "This is an exciting opportunity to work with Niab's world-leading entomological team to develop a new and innovative way for UK soft fruit growers to boost natural biological controls."

Another industry body, British Apples and Pears, secured a Business Innovation Voucher to run commercial orchard trials of a novel product to control apple scab, a disease that leaves unsightly lesions on apples and makes them unmarketable.

The team will test the products alongside traditional control products as part of a crop management programme and help translate the trials into practical recommendations for growers.

Aridiom Sanex provides decontamination products to a range of industries. Their Business Innovation Voucher provides them with an entry into the horticultural sector by teaming up with strawberry growing experts at East Malling. They will testing how to optimise the decontamination process of strawberries, reducing pests and diseases during the growing season. They will look at the impact on the quality of produce and whether the shelf-life of strawberries can be extended post-harvest, all while ensuring food safety standards are met.

Growing Kent & Medway awarded £320,000 of Business Innovation Vouchers to 13 businesses to work with specialists at Niab, University of Greenwich and University of Kent. This was the second funding round. If you would like to find out more about Growing Kent & Medway and their funding opportunities, visit growingkentandmedway.com/

Xiangming Xu • xiangming.xu@niab.com

Alternative management strategies to combat apple replant disease

Niab's Director of Research Professor Xiangming Xu is responsible for developing and delivering the strategy for research activities across the whole of Niab. This is in addition to his role in co-ordinating research activities at East Malling. A crop agronomy graduate from YangZhou University in China, Xiangming completed his PhD in plant quantitative genetics and plant breeding at the Welsh Plant Breeding Station in Aberystwyth in 1989. He joined Horticulture Research International at East Malling in 1991 as a plant pathologist with leading roles in genetics and crop improvement and in pest and pathogen ecology.

Replant disease symptoms, causal agents and current management

Poor establishment of apple trees on soils where the same, or a closely related species, has grown previously is a well-known problem worldwide, commonly known as *Apple Replant Disease* (ARD). Uneven growth across the orchard, stunting, and shortened internodes on shoots are typical symptoms of replant disease (Figure 1). ARD symptoms can manifest within three months of replanting. When the roots are examined, root tip necrosis and reduced root biomass can be seen; existing roots become discoloured and deteriorate. Although many ARD-affected trees will survive, overall fruit production and quality can be significantly reduced by up to 60% for the duration of the tree's commercial life (Figure 1). ARD in dessert and cider apple production (including in nursery) represents a considerable financial risk to the industry. Replant disease has also been reported in other plants; members of the Rosaceae, such as cherry, peach,

Figure 1. Symptoms of apple replant diseases (ARD): uneven growth, reduced tree vigour and reduced fruit production potential. Trees in the photo were replanted into a previous apple orchard

plum, strawberry, rowan and rose, are especially prone to the problem.

Poor tree growth can result from a plethora of abiotic and biotic factors. Abiotic factors include diminished soil fertility, degraded soil structure, and phytotoxic compounds produced from crop residues in soils. The identity and consistency of individual biotic factors that give rise to ARD are often debated. More recent research supports the theory that biotic factors are the main cause of ARD. ARD issues occur globally in all major apple producing areas indicating that specific soil characteristics are unlikely to be a primary cause of the replant problem. Fumigating soils with broad-spectrum biocides leads to significant increases in growth of young trees in comparison with non-fumigated plots, suggesting that the causal agents are of biological rather than physical origin. It is therefore now generally accepted that ARD is a disease-complex primarily caused by microbial pathogens. A group of fungal and oomycete agents contribute to ARD worldwide, including the oomycetes *Pythium* and *Phytophthora* and the fungi *Cylindrocarpon*, *Rhizoctonia* and *Fusarium*. The presence of parasitic nematodes can exacerbate ARD severity probably because nematodes damage the roots, facilitating infections by pathogens.

Current ARD management strategies are generally based on the principles of exclusion (crop rotation and tree placement within an orchard) and soil treatment. ARD causal agents show limited spread in soil such that trees replanted in the former grass alleys of old orchards are less affected by ARD, but growers have rarely acted on this knowledge. Exclusion of apple orchards from a site for five to eight years (rotation) is commonly recommended to reduce disease severity in replant sites. However, in the long term both strategies are impractical for perennial crops on a commercial scale, and economically unattractive to both growers and nurseries. Traditional broad-spectrum fumigants have been banned or their use is severely restricted. Biofumigants, especially brassica seed meals appear to offer reproducible reductions in ARD; but their principal market as biofuels and oils makes them uneconomical as pre-plant treatment of horticultural land.

During the last decade, Niab at East Malling has secured several grants to investigate ARD biology and develop alternative management strategies, including funding from BBSRC HAPI, BBSRC PhD training programme (CTP for Fruit Crop Research), and the EUH2020 programme (Excalibur project). Here we summarise key results from recent research studies at East Malling that are pertinent to commercial apple production.

ARD causal agents varied with sites

A specially designed sampling scheme was used to identify ARD candidate causal organisms. Rhizosphere and bulk soils were sampled from neighbouring pairs of healthy and ARD-affected trees at several sites and subjected to high throughput sequencing. The results showed that candidate causes for ARD varied greatly among locations. At one orchard, *Pythium intermedium* is identified as a candidate ARD pathogen, which has previously been reported as a causal agent of apple in Washington, USA. In another orchard, we failed to identify any candidate ARD pathogen; however, healthy trees are associated with increased abundance of two arbuscular mycorrhizal fungal (AMF) groups. This finding supports previous results that AMF inoculations of apple seedlings led to reduced ARD symptoms (but not effective against oomycete pathogens). Healthy trees in two Dutch orchards had much higher relative abundance of many bacterial groups, including commonly known plant growth promoting rhizobacteria (PGPR), than in ARD-affected trees. In both Dutch and UK apple nursery beds, bulk soil microbiome differed greatly in the nursey bulk and rhizosphere soils from those in the immediate adjunct virgin soil; however, we did not find any known pathogens associated with rootstock beds.

In another dessert apple orchard, *Ilyonectria macrodidyma* is identified as one candidate ARD pathogen by comparing microbiome in the original tree stations and in the adjacent grass alley. *Ilyonectria macrodidyma* is a pathogen of woody plants, frequently found in soil samples from tree rows and not the grass alleys. Furthermore, Niab clearly demonstrated that the spatial structure of soil microbiome differs significantly between original tree rows and the adjacent grass alley, probably associated with the vegetation type and agronomic practices applied.

The effects of one or more members of the ARD complex on ARD were investigated in several selected rootstocks with contrasting characteristics, focusing on: 1) the nature of the interactions between putative ARD causal agents and ARD severity, and 2) whether rootstock characteristics modify ARD severity. Controlling all three ARD components (oomycetes, fungi, and nematodes) led to the best root development. Furthermore, there is evidence for competitive interactions between oomycetes and fungal pathogens in infecting apple roots. Rootstocks did not affect the extent of root necrosis (as a proxy for ARD severity) but significantly differed in their root volumes.

Developing and evaluating alternative management strategies

Several alternative management strategies were studied to combat ARD and improve tree establishment following planting. Specific management strategies investigated include: 1) using a rootstock that is different from the previous one, 2) replanting trees in the alley instead of the original tree stations, and 3) individual and combined use of AMF, biopesticides and PGPR products.

Figure 2 shows the visual evidence that replanting trees in the previous grass alley can significantly improve tree establishment and subsequent growth, compared to the original tree stations, namely reducing ARD development. The annual tree girth expansion has been consistently greater for those trees planted in the alley than in the original tree stations within the six years of replanting. Moreover, it was demonstrated that ARD severity is partially controlled by host rootstock. Planting the same rootstock or rootstock with closely related parentage in the original tree station

Figure 2. Tree development in a cider orchard where cv. 'Worcester Pearmain' scions, grafted to several rootstocks, were planted in 2016 with the trees on the right planted in the previous tree station row and the trees on the left planted in the corresponding alleyway between the previous rows

to the previous rootstock had more severe ARD symptoms. Overall, the impact of changing planting location on ARD severity was more profound than rotating rootstocks.

A trial was conducted at planting to evaluate the effects of individual and combined soil amendments on apple establishment and subsequent growth/fruit production. Individual and combined use of biopesticides (one fungal and one bacterial), PGPR (two strains) and AMF (*Diverspora* sp.) were applied at planting in March 2020. Tree girth 20 cm above the graft union has been measured annually in spring; fruit production was also assessed annually.

Application of AMF and biopesticides at planting led to greater girth expansion rate, a respective increase of 9.3% and 12.7% over the corresponding untreated trees. Amendments with both AMF and biopesticides led to nearly 22% increase in annual girth expansion over the unamended control. Amending soils with PGPR at planting time did not have significant effects on tree growth. Fruit yield (number of fruit and weight) varied greatly across the years. Applying biopesticides at planting increased marketable fruit weight and number but only in 2021. On average, biocontrol amendments led to 25.6 fruit per tree, compared to 23.0 without amendments. Similarly, for fruit number, in 2021 AMF treatment led to 25.3 fruit per tree, compared to 23.3 without AMF treatment.

Ongoing research

With support from Frank P Matthews Ltd. and the National Association of Cider Makers, Niab recently secured further funding from the 'BBSRC Follow-on' funding scheme to continue research on developing and evaluating an integrated approach to manage ARD. This integrated strategy is based on a holistic approach to minimise ARD at planting by combining the following measures: 1) planting in the alleyways (not in the original station), 2) using a rootstock genetically distinct from the previous one, 3) amending soils with specific biopesticides; and 4) amending soils with beneficial microbes such as AMF, or organic composts. The first two measures can be viewed as site-independent whereas the exact implementation of the last two measures may depend on site-specific factors, such as soil characteristics and inoculum pressure of specific ARD causal agent(s).

Apple replant research projects at Niab are funded by: (1) BBSRC HAPI Scheme (grant number: BB/M01777X/1) and a consortium of industry partners – HEINEKEN UK Limited, Frank P. Matthews, Fruittree Rootstock Holland B.V., Vermeerderingstuinen Nederland, and A.C. Goatham & Son; (2) BBSRC Collaborative Training Partnerships (CTP) for Fruit Crop Research; and (3) European Union's Horizon 2020 research and innovation programme under grant agreement No 817946 (Excalibur project).

Staff profile – Dr Nichola Hawkins

Dr Nichola Hawkins is a research scientist at Niab, based in Cambridge, working on fungicide resistance. Antibiotic resistance is a well-known problem in healthcare but similar problems are seen in agriculture, with resistance to the fungicides, herbicides and insecticides that are used to protect our crops. Niab Landmark finds out more about the work Nichola is doing to get one step ahead of the ever evolving pathogens.

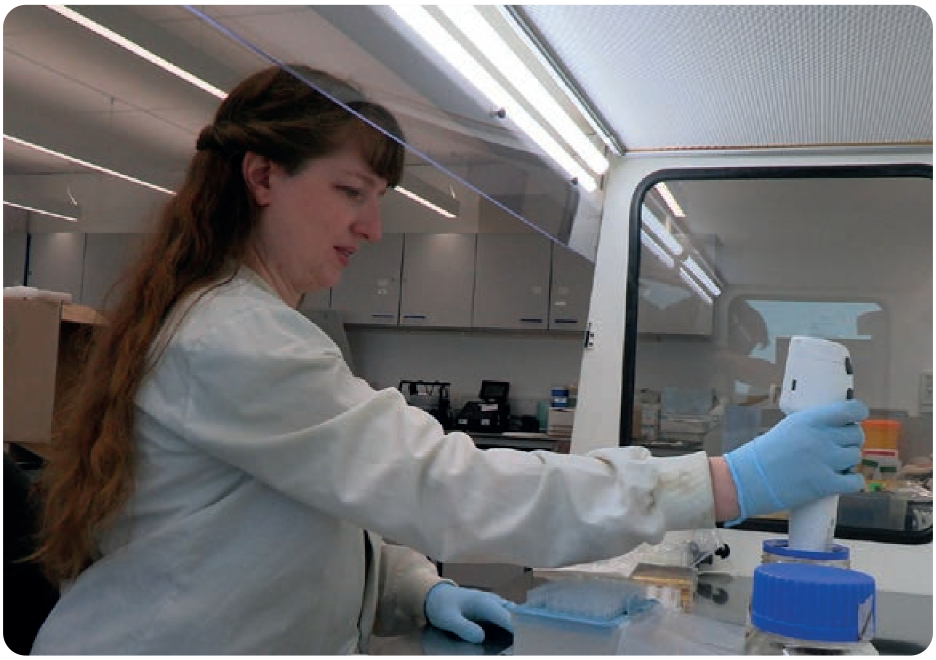
How does your work in the lab translate to the field?

I have a mixture of projects, some are more on the theoretical side, but will have implications in the longer term. For example, if a new fungicide comes along, how can we better predict the risk of resistance and what mutations should we be looking out for before they happen? But, I also have work that is relevant right now. Niab receives samples from growers and agronomists of disease infected wheat from around the country. We test them to see what resistance is out there, if current fungicide products and active ingredients are still working and what shifts are happening. That's something we feed back to growers, including via fungicide and resistance management guidance, that they're applying right now.

I also have a BBSRC-funded project, 'Predicting the durability and resistance risk of crop protection measures through experimental evolution of plant pathogens', that's trying to get one step ahead of the pathogens in the field. We're experimentally evolving resistance in the lab to see what will happen next. It should mean that we're ready for any resistance development and better prepared if, or when, it happens in the field.

What are the biggest challenges in your research area?

The big problem is the huge diversity of pathogens that are out there. First, in terms of the range of diseases, so we might see different diseases coming up each year, depending on the weather and other external pressures, and potentially more diseases coming in as the climate changes. And secondly, because there of the genetic diversity within any one species.



How does your science help with food security?

Pests and diseases are one of the biggest threats to food security. Some estimates suggest we lose a third of potential agricultural production each year due to pests and diseases and would lose as much again without the crop protection that we currently have in place. But with these fast-evolving pathogens there is constant risk both to the current crop protection, but also as new tools come online. It's a cliché to say that there is no silver bullet in crop protection, but what this means is whatever new crop protection tool comes along, if you rely exclusively on that one thing then actually you're just really strongly selecting for any pests or pathogens that can overcome it.

What do like most about working at Niab?

At Niab you're surrounded by people all working towards a common goal of sustainable agriculture. In the pathology team, there is my work on fungicide resistance, but there are other teams working on how pathogens are shifting their virulence and what varieties they can infect. We're all piecing together a picture of what these pathogen populations are doing and so we can give all-round advice on Integrated Pest Management, knowing that it's backed up by all those different areas of scientific expertise.

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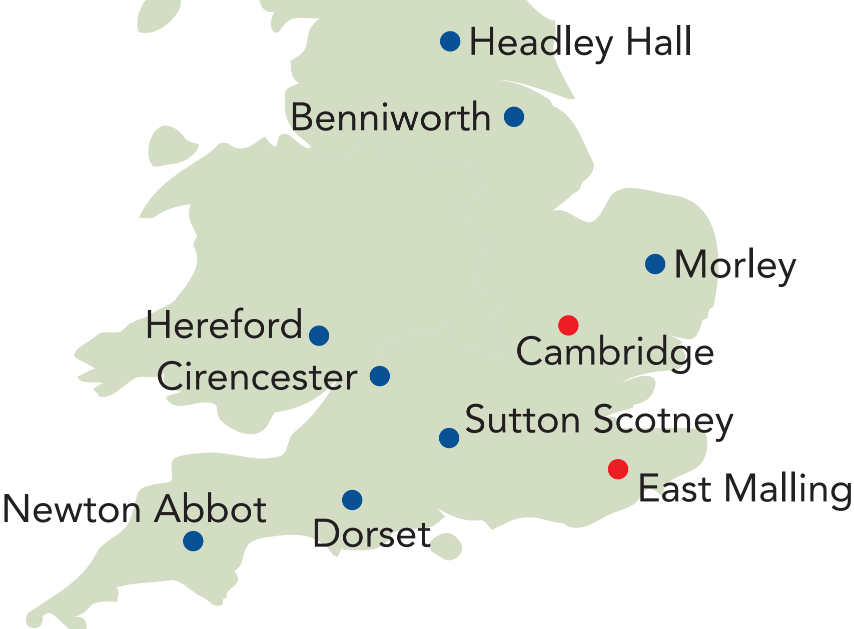

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