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TECH FARMER

TECH MAGAZINE

TECHNOLOGY FOR FARMING

The wheats that could feed the world

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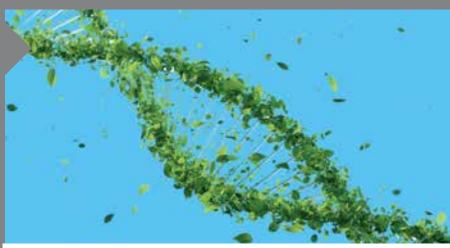

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UNLEASHING THE POTENTIAL OF **AGRI-TECH**

WRITTEN BY CHRIS FELLOWS

In the realm of agriculture, a technological revolution is underway, reshaping the landscape from traditional practices to cutting-edge innovations. This transformation, encapsulated by the term "agri-tech," is not merely about mechanised machinery or futuristic drones; it represents a multifaceted evolution that spans the entire agricultural supply chain not just changes on farms.

Agri-tech embodies a spectrum of advancements that are revolutionising production, bolstering productivity, and addressing pressing challenges within the agricultural sector. From harnessing the power of Artificial Intelligence (AI) and machine learning to embracing biotechnology and precision technology, agri-tech is propelling agriculture into a new era of efficiency, sustainability, and resilience.

At its core, agri-tech encompasses a diverse array of innovations aimed at optimising every facet of agricultural operations. Whether it's employing robots for labour-intensive tasks, leveraging AI to enhance animal welfare, or harnessing biotechnological solutions to bolster crop resilience and nutritional content, the impact of agri-tech reverberates throughout the agricultural landscape.

- **Artificial Intelligence and Machine Learning**
- **Biotechnology**
- **Precision Technology**
- **Smart Farming**
- **Vertical Farming and Indoor Agriculture**
- **Drones and Earth Observation Technologies**
- **Water Management Technologies**
- **Aquaculture Technologies**
- **Livestock Genetics and Veterinary Science**

The potential of agri-tech to drive growth, sustainability, and resilience across the agricultural sector is immense. By fostering cross-sector collaboration and embracing farmers as well as farming, agri-tech innovations can unlock new opportunities for agricultural productivity, profitability, and environmental stewardship.

As we embark on this journey of technological transformation in agriculture, farmers need to stand as beacons of innovation. We need to guide the sector towards a future where agriculture is not only productive and profitable but also sustainable and resilient. Farmers and researchers need to work together, listen to each other and create solutions that really drive change not just sound good in a presentation.

IT'S 2030 – HAS **FOOD SECURITY** IMPROVED?

Tom Allen-Stevens travels forward to 2030 and looks back at what progress has been made since 2024 to improve agricultural productivity.

What goes around comes around, it seems. The debate about food security and nanotechnology that we're currently having in the first few months of 2030 has echoes of a very similar discussion that preoccupied many in the industry six years ago. What's even more interesting is how the seeds of today's debate were sown (quite literally) in the second issue of Tech Farmer published back in March 2024.

Cast your mind back six years to that time – swathes of the country were under water following what was then one of the wettest winters many of us had experienced, although it seems tame compared with the extremes climate change has thrown at farming since. It came on the back of the first signs of food shortages that then really came to fruition and hit the nation hard during 2025. Empty supermarket shelves started the stir of unease, and it was probably these that prompted Steve Barclay, who was then Defra Secretary of State, to suggest at the Oxford Farming Conference in January 2024 that "food security is national security".

The call to protect our food security was one the NFU had repeatedly made to successive Conservative governments ever since the UK voted to leave the EU in 2016, as Baroness Batters to this day continues to remind the House of Lords at every opportunity she's given. But it had fallen on deaf ears as ministers (including the hapless Liz Truss) sold out UK Farming in various bids to grasp at trade deals.

Finally, however, the message seemed to have sunk in. It was even repeated by former Prime Minister Rishi Sunak when he appeared at the NFU Conference in February 2024, and told delegates "I have your back". Many asked then whether it was too little, too late to save an agriculture that subsequently underdelivered so seriously on the nation's food needs during 2025. The haphazard way with which the government had thrown its £427M budget underspend on agriculture into productivity measures in the dying days of its last term in office has been the subject of too many Parliamentary Select Committees.

But there was one element of common sense that wove its way into policy at the time, and was thankfully picked up by the incoming Lib/Lab Coalition: the Agritech Delivery Fund. In particular there was the spending committed to genetics and plant breeding, that quite literally sowed

What are the prospects for the genetic advances that produce bigger, bolder grains, first seen in gene-edited Cadenza in 2024?

the seeds of the advances we have in UK arable fields in 2030.

And that brings us back to the March 2024 edition of Tech Farmer. The issue focused on genetics, and featured on its front cover an article on the latest advances in gene-editing ready to come into the field from John Innes Centre and Rothamsted Research – the article appeared on p8.

Surely it's no accident that the same genetic edits found in that Cadenza wheat Professor Uauy held in his hand in 2024 are in the variety that tops, by a country mile, the AHDB Recommended List for 2030/31? An ever-increasing number of growers are now benefiting from the new premium paid by food manufacturers for the low acrylamide Group Three wheats that produce more healthy biscuits and breakfast cereals. And the world's first commercial sward of high energy ryegrass is due to be cut this spring, with the potential to bring down methane emissions by up to 25% from the dairy cows it's fed to.

You could argue these advances pale into insignificance compared with the LowN wheats now available to growers across the globe. Biological nitrification inhibition in wheat was largely unknown when the March 2024 edition of Tech Farmer landed (see p48), but it's tipped to deliver reductions in nitrate pollution alone of as much as 20% by the middle of this decade, before you even consider the productivity increases that farmers will benefit from.

Interesting too that biotech giants Wild Bioscience (p14), CDotBio (p42) and TraitSeq (p20) were somewhat quaintly referred to in that issue of Tech Farmer as "agtech start-ups". And those were the days when World FIRA (p34) was little more than a hackathon with a few odd robots awkwardly manoeuvring around fake vineyards. Just 2500 visitors in 2024 – dwarfed by the crowds who flocked to Toulouse in Feb 2030 to see the latest jaw-dropping advances in fundamental autonomy and AI.

While these advances are awesome, the rather more sobering discussions at the 2030 event revolved around responsible use of technology. Global beef markets are still reeling from the effects of the 2029 nanotechnology scandal, that saw almost $1bn of US beef removed from supermarket shelves and incinerated. The USDA has yet to pinpoint how batches of zeranol growth hormone were contaminated with military-grade RNAi nanotechnology.

The inquiry isn't being helped by the deep-fake videos circulating on social media that have framed everyone from Chinese terrorists to the US president herself. There is talk that this is an AI breach – a deliberate attempt by non-human intelligence to cause harm, although such a serious breach is fiercely denied by all signatories of the 2023 Bletchley Declaration.

But here in 2030, it's raised once again the issue of food security, and at its heart is the technology garnered to increase agricultural productivity. So what do we learn from when this was last an issue six years ago?

There was much talk about food security at the 2024 NFU Conference (we didn't have space for coverage in the March issue, but Tech Farmer did attend). Recriminations were directed at the government for failing to implement recommendations on a National Food Strategy made by Henry Dimbleby (that's still gathering dust) while questions were asked about a Land Use Framework (that never materialised). Whether these would have staved off the National Food Crisis of 2025 remains a divisive issue.

What was interesting was the approach taken by the Foods Standards Agency on food produced from precision-bred organisms, unveiled shortly after the conference. The new regulations trod the very fine line between securing consumer confidence and enabling new genomic technologies. It set out to be "as efficient and proportionate a system" as it could be.

If 2030 agricultural productivity figures are anything to go by, the approach seems to have worked. Following Brexit, the UK dropped from the top quartile in Europe to the bottom. The most recent figures suggest the UK is back in the top quartile and the trajectory is promising. Arable crops are where the UK performs best, and that's no surprise given the UK took the steps to ensure enabling legislation, while Europe continued to drag its heels on gene-editing.

But perhaps what shouldn't be overlooked is the role farmer-led innovation has played in advancing crop genetics. The collaborative platform set up to do this, led by farmers and first described in March 2024 Tech Farmer (p9), now leads the world in testing novel traits – dozens of pre-commercial varieties have passed from the lab to farmers' fields where they've been scrutinised and appropriate agronomy developed. It's an open and transparent forum that generates trust in new technology. As Tom Clarke wrote in his column at the time: "when farmers collaborate they create value, and are able to capture it too" (p6).

There are considerable challenges with ensuring AI and nanotechnology can be trusted within our food system. But they have to be faced and overcome if we're to advance as a society. The genetics revolution has shown us that proportionate regulation and the involvement of farmers bring results. So these are challenges we should be ready for.

Tom Allen-Stevens farms 170ha in Oxfordshire and leads the British On-Farm Innovation Network (BOFIN).

FEATURE

FARMER FOCUS
TOM CLARKE

Can the Worm Turn?

Write about the future of farming, they said. We'd like your thoughts on the innovations that will help or hinder agriculture in the next 10 years. After I penned a sort of agricultural sci-fi column a few years ago in Farmers Guardian, I've clearly gained a reputation.

I actually farm in a fairly low tech way, on a thousand acres (400ha) of lowland peat and silt in the Cambridgeshire fens. Nearly all my machinery is second-hand, rented or has been on our farm longer than me. Yes, we use satellite imagery and GPS to make variable rate applications and seed plans. Yes, I've tried releasing sacks of predatory insects instead of insecticide. And yes, I now treat my farm-saved seed with endophytic bacteria which are meant to fix nitrogen from the air. But these are all practical steps driven by financial savings, or open-minded trials which tinker at the edges.

I don't consider myself very futuristic. If you came to look around my muddy, and increasingly ramshackle farmyard, I think you might agree.

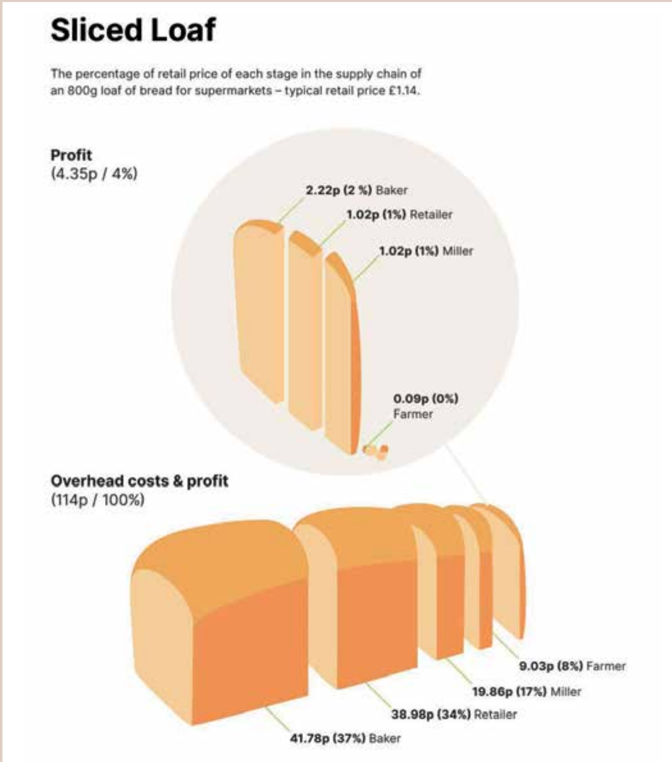
At the same time, I farm differently than my dear old Dad did. I took over from him unexpectedly 15 years ago, when he died from cancer. I hadn't been a farmer. I was living and working in London as a management consultant. So I came to the business knowing nothing, willing to learn, open to any idea that could prove it might work.

Innovation is more a state of mind than a new gizmo. It's finding out what works, what doesn't, and how to do it better.

In the last decade and a half I've come to know a lot of farmers – and they've shown me there are as many different ways to innovate as there are to cook a potato. For some it's all about the kit - the diesel heads. For some it's the quality of the end product, or serving the customer. For increasing numbers it's all about the soil and "biology". But for all of us in the years ahead, it will be more and more about remaining economically viable.

Arable farmers are in a uniquely disadvantaged economic position. There are lots of us, and we produce huge amounts of interchangeable commodity products. Because none of us produce enough to have any bargaining power, we are each price takers. When you then consider that our costs too are increasingly outside our control it's easy to write off the whole industry as a bad job. Except, people need to eat – and the only place that comes from is agriculture. Economically, we are plankton: feeding everything, by being fed on.

Exploitation of farmers by bigger economic fish means we in turn must exploit our own resources. This is often our own labour, or the labour of our family members. It is also our natural capital – eroding what our farms can sustainably generate by maximising inputs and cultivations for short term gains.



Even so, many farmers make a negative return on their capital, selling produce below the cost of production. Even when there is a return, as a proportion of the final product it's tiny. The campaign group Sustain calculated that the whole profit on a £1.14p sliced white loaf, is 4p. The miller and the retailer each get a quarter of this. The farmer's reward is 100 times less than that, 0.09p – if they get anything at all.

Subsidy is what used to make this mad system tick over. It allowed farmers to sell food below cost, and meet high environmental standards, without going bust. That subsidy is now nearly all gone.

Forgive me for being blunt; the future of farming in this country won't be secured by a new widget, genetic wizardry or planting with the phases of the moon. We need a way for farmers to capture more of the value they create. Without that, our food system has no future.

When farmers collaborate they create value, and are able to capture it too

I asked attendees of this year's Oxford Farming Conference a simple poll question: "Are UK farmers in competition with each other?" - 75% of respondents said "Yes". Well, if we are, we shouldn't be.

Anyone reading this smugly thinking that their regen system, profitable diversifications, or multi-thousand hectare scale will see them through are still operating in a false comfort zone. Anything you can do on your own farm won't be enough. The farm gate is no drawbridge. To influence the world beyond – where the return we make is really set - we need to change our mindsets, leave our farms and team up. We will need to create new organisations and business models that bring farmers together and pool our resources. It's the only way we can exert any economic power. It's also tried and tested.

Who are you paying when you buy a Limagrain seed variety? French farmers.

Any idea who owns the largest milk companies in the world? Dairy Farmers. To be precise: Kiwi, Danish, US, Dutch and Indian dairy farmers.

Do you know the name of the EU's biggest retail bank? Credit Agricole – a French farmers' bank. In the Netherlands

Green Farm. Photo credit: Glynis Pierson

Green Farm from above. Photo credit: Glynis Pierson

too, the mighty Rabobank was started by farmers, for farmers.

In hundreds of examples from Japan to India, Brazil to Germany; when farmers collaborate they create value, and are able to capture it too. Why not here?

Already farm clusters are quietly assembling across the country; farmers who are beginning to see collaboration as the best way to access the new environmental payments.

A bigger and better beacon is the NFU Sugar Board (of which I'm an elected member). It has special legal status to negotiate the annual sugar contract on behalf of all growers. This year, we really flexed those collective muscles and, because of grower unity amid a mighty stand-off with a multinational megacorporation, were able to capture more than 25% more value from rising world markets for every sugar beet grower.

We need more collective producer organisations, ready to capture value and even take ownership of the supply chain. NFU Sugar is a one-off. Its unique position will be hard to replicate: but farmers do hard things every day.

Be in no doubt, the big fish won't hand over value easily. The recent bust up over the Greener Farms Commitment shows the widely-held expectation that farmers are supposed to just hand it all over, and be grateful for the business.

What supply chains really need now is our data; information only we can provide about our environmental footprints. We have become so used to passing up the value of our produce, I fear too many of us think we have to hand over this new value from our data too. But this is an opportunity to draw a line in the soil. Data is a lot easier to pool than wheat, cattle, or even sugar contracts, and collectively we have a monopoly on it. Can the worm turn?

With political, market and climate instability rising around the world, farmers everywhere are protesting. Most of these demos are asking for more from governments. A few are forming political parties, perhaps to become part of governments, or to wreck them. I say, the solution to economic problems is economic action.

Tom Clarke is a 4th generation fenland farmer from Cambridgeshire. He sits on the NFU Sugar Board and on the AHDB board as Chairman of the Cereals and Oilseeds Sector Council. The views expressed in the article are entirely his own, but he is happy for other people to share them.

THE POWER OF **DIVERSITY**

Written by Tom Allen-Stevens

A change in English law now allows certain gene-edited crops to be grown on commercial farms. Tech Farmer visits the scientists working with a new farmer-led platform that will make the first three introductions.

Rarely would you find so many misfits in the same place. Looking closely you can see spikelets within a wheat ear that seem to have spawned sub-spikelets. Misshapen ears. Short and stubby. Long ears with seemingly impossibly lengthy grains.

They seem unnatural, but they're not, explains Professor Cristobal Uauy, group leader in wheat research at the John Innes Centre, Norwich. "This is natural variation that's already out there in the fields. What we're doing is trying to combine genetics and genomics with the biology of the plant – understand the genes that govern yield."

That's why the weird wheats are intensively wonderful to Cristobal and his team. They're a route to understanding the genes and promoters of the MADS-box transcription factors they're studying. These are associated with genes that govern diverse developmental processes, such as meristem specification, flowering transition, seed, root and flower development, and grain ripening.

"Yield is very complicated, just like intelligence in humans – many genes affect it," explains Cristobal. "So we're trying to break it down into these smaller components – what makes the grain heavier or longer or wider."

There's one wheat in particular we've come to see, and Cristobal alights on a collection of potted plants, puts one on the floor and bends its ear so that the glumes separate in an arch. You're struck by the size of the florets. "This is Fielder, a spring wheat that scientists study a lot, so we know its genome. We've edited this at a very precise point so it produces these larger grains."

Wheats with unusual characteristics suggest they are a source of genetic diversity, so are closely studied.

The grains are in fact around 5% bigger than the unedited original, they have a higher thousand grain weight (TGW) and specific weight. So does that translate into a higher yield? "There's a consistently higher specific weight, which is exciting for millers, but so far we haven't seen a major yield effect," notes Cristobal.

"The next step is to see how it works in the field. And that's a critical step, because a plant can perform one way in a pot, but very differently in a farmer's field. We need to know how these novel crops will behave under a commercial cropping regime, and whether its unique aspects can be enhanced through agronomy."

This work is now set to get underway, thanks to a new farmer-led platform set up by the British On-Farm Innovation Network (BOFIN), working with industry partners (see panel opposite). The plan is that this Fielder wheat will be one of the first three gene-edited cereals to be grown in commercial fields by farmers. "We have less than 1kg of seed at the moment, but we will multiply up enough for agronomic field trials and then for commercial crops, planned to go in the ground in spring 2026."

Bigger, bolder grain

The discovery of this bigger, bolder grain happened over 250 years ago. "It was originally characterised in 1762 by botanist Carl Linnaeus, who documented the long grains, glumes and lemmas of a Polish wheat, *Triticum polonicum*. But exactly what gene controlled this has remained a mystery," notes Cristobal.

Pivotal work was carried out by James Simmonds at John Innes Centre, who managed to create a stable cross of the wheat with Paragon. "We thought we had a pretty good idea of the gene responsible, but it wasn't until the wheat genome was published in 2018 that we knew for sure."

Cristobal explains that wheat, a hexaploid, has three copies of its genome, making it one of the most complex of all organisms with around 16 billion letters. An international collaboration resulted in a map of the wheat genome and has accelerated understanding and the roles of specific genes.

"We've identified the gene

The edited Fielder wheat has notably larger glumes.

responsible as *VRT-A2* (Vegetative to Reproductive Transition). The genes that govern glume development are the same in all wheats, but the sequence that regulates it are different."

What the team discovered was that *VRT-A2* has the effect of "putting the brake" on glume development at a particular point in the plant's growth. There's a misexpression of this gene in the Polish wheat so that glume development continues unabated. Using CRISPR, the team has now replicated this effect with a sequence rearrangement in the DNA of VRT-2A, bringing the bigger, bolder grains to Fielder.

"What we want to understand now is how this *VRT-A2* expression is controlled by the edit we've made. There are downstream genes that will be affected and we want to identify these and look to see how agronomy can influence the resulting traits."

Nor is *VRT-A2* the only gene in the MADS-box the team is studying. An international collaboration including JIC has identified *SVP-A1* (Short Vegetative Phase) that has a similar effect. "The gene also appears to have an influence on glume length, so again it's not until we bring this out into the field that we can look at how to manipulate it."

The next step is to see how the wheat works in the field – critical, because a plant can perform very differently to how it does in the lab.

Another promising route is *GW2*, a gene that regulates grain width. The team generated mutant wheat lines where the effect had been knocked out of autumn-sown variety Cadenza through TILLING (see panel on p10).

"We generated mutants that had the change on just one of the wheat's three genomes, on two and also on all three. Here we achieved an increase in TGW of 6%, 12% and 21% respectively. However, again we have seen no increase in yield, and what's more, it resulted in lower tiller numbers. But an interesting aspect is that protein content was higher – you'd expect a dilution effect, but this didn't occur."

Work is now underway to edit the *GW2* gene in Skyfall, with a true PBO expected in about 18 months. "We have colleagues at JIC who are developing other wheat PBOs, for example with high iron or zinc content in the grain. There is also robust yellow rust resistance coming through," notes Cristobal.

The plan is to put all of these traits through the farmer-led platform as enough PBO material comes available. "It's fascinating for us as scientists realising what can be achieved with new genomic technologies. We want farmers to see this for themselves in their own fields and bring about a revolution in how we grow wheat. We think the improvements we can now bring forward in plants will not just help the environment, but bring greater food security for all people around the world."

Applying PROBITY to new genomic techniques

A Platform to Rate Organisms Bred for Improved Traits and Yield (PROBITY) is a new industry-wide initiative led by BOFIN. It brings scientists, plant breeders and food processors together with farmers and agronomy research specialists to explore gene-edited crops.

The platform has been made possible by new legislation that allows precision-bred organisms (PBOs) to be grown on commercial farms in England (see panel on p10). PROBITY aims to explore the attributes of novel crops in a transparent and open forum. Up to 25 English farmers will carry out on-farm trials and produce enough material for batch-processing or feeding trials of the first three PBOs, which are already in multiplication plots at UK research institutes.

These will feed through into agronomy trials and breeder plots in the 2024/25 cropping year, with the first crops grown on commercial farms the year after. Around 12 novel traits have already been identified and are expected to follow into the platform, creating a pipeline of new breeding technology.

The platform is designed to complement the existing route to market for conventionally bred crops, says BOFIN. PROBITY specifically aims to address traits where the value and market attraction may currently be unclear, as well as a testbed to import or export novel traits.

Importantly, BOFIN says the varieties multiplied up will be non-commercial, with the emphasis being to test a novel trait and give breeders the confidence to bring these into the latest varieties. For more information, email info@bofin.org.uk.

English farmers will carry out on-farm trials and produce enough material for batch-processing or feeding trials of the first three PBOs.

Jargon-buster: what does it all mean?

Mutagenesis is a change or edit in the plant genome that confers a new trait. Such mutations occur naturally every day, when a plant comes under stress, for example, or it can be induced through human intervention. A small change in the genome may switch off the activity of a particular gene which allows or inhibits a property, and it's these phenotypical changes breeders have sought out for generations to progress their lines.

Mutagenesis differs from **Transgenesis**, where DNA from another species has successfully been combined into the genome of the host plant. These are universally classified as **Genetically Modified Organisms** (GMOs). In the UK and across the EU, the release and cultivation of GMOs is highly restricted, although they are allowed in imported food and feed for livestock from parts of the world, such as the Americas, where they are widely grown.

Cisgenesis is where DNA is artificially transferred between organisms of the same species, such as from a wild relative to an elite potato variety to confer blight resistance. In Europe at least this is still classified as GM as nucleic acid sequences must be isolated and introduced using the same technologies that are used to produce transgenic organisms.

For decades, scientists have induced mutagenesis to bring about new traits, or phenotypical variations, using chemicals or radiation. **TILLING** (Targeting Induced Local Lesions in Genomes) is a powerful reverse genetics method used in plant sciences which allows the identification of point mutations, introduced randomly throughout the whole genome by chemical mutagenesis.

More recently, more precise gene-editing techniques such as **CRISPR-Cas9** have been introduced. CRISPRs are short RNA sequences introduced into the host plant that recognise a specific stretch of genetic code. Cas9 enzymes partner these sequences and cut the host DNA at specific locations.

The cell tries to repair the damage, and that's when the mutation occurs. By using different enzymes and techniques, researchers can deactivate or alter – edit – specific parts of the genome, thereby conferring traits.

Legislation around **New Genomic Techniques** (NGTs), such as CRISPR, is changing. In England, the Genetic Technology (Precision Breeding) Bill was enacted in 2023. This allows the release and marketing of precision-bred plants, which had previously been restricted by European legislation governing GMOs.

It affects cases where NGTs have been used to edit a plant genome to bring about traits that, according to scientists, could have happened naturally. Where this is the case, these plants are now treated as **Precision-Bred Organisms** (PBOs) – effectively the same as conventionally bred.

The legal change applies in England only – devolved governments have yet to follow suit – and while similar legislation on NGTs has recently passed through the European Parliament, it's yet to be adopted in EU member states.

In the UK and across the EU, the release and cultivation of GMOs is highly restricted.

Supply chain benefits from novel crops

Biscuits and breakfast cereals from the first gene-edited wheats grown on commercial farms in England are the plan as part of the new BOFIN farmer-led platform set to put the novel genetic technology to the test.

The wheat is the first of its type to have been put through field trials in Europe. It has a novel trait that naturally improves its performance when its products are toasted or baked, according to Professor Nigel Halford who has led the work at Rothamsted Research.

"We have edited lines of the variety Cadenza using CRISPR-Cas9 so they have less than 10% of the levels of asparagine found in commercial wheat. This is an amino acid that occurs naturally in cereals, but during cooking at high temperature, such as baking or toasting, asparagine is converted to acrylamide," he explains.

Previous research has shown this carcinogen exceeds current Benchmark Levels in 23% of biscuits and as much as 33% of breakfast cereals. These Benchmark Levels are expected to be reduced in the EU later this year, along with the setting of maximum legal limits. "Food manufacturers currently use processing techniques and additives to bring acrylamide levels down below Benchmark Levels. They have indicated there will be high demand for a wheat that achieves this naturally."

Work at Rothamsted has focused on asparagine synthetase (*ASN*) genes responsible for most of the production of asparagine in the grain. "*ASN2* is by far the most active, and Claire is a variety that has a natural mutation such that it lacks an *ASN2* gene on one of its three genomes," explains Nigel.

Using TILLING (see panel on p10), the team managed to 'knock out' (or silence) the *ASN2* genes on the other two genomes. But this older form of mutagenesis has been found in field trials to result in a yield penalty. CRISPR is a more precise technique, and the team now has

The edited lines of Cadenza have less than 10% of the levels of asparagine found in commercial wheat.

Working with farmers, Navneet Kaur and Nigel Halford plan to multiply up enough of the edited Cadenza to process into biscuits and breakfast cereals.

lines of Cadenza with a triple knock-out of *ASN2*, along with some with a second gene, *ASN1*, similarly silenced. Initial tests have shown some of the novel lines produce undetectable levels of acrylamide when baked into bread.

It's one of these, line 59, that will be put through the farmer testing platform, led by BOFIN. This will be grown in farmers' fields alongside the TILLING Claire and unedited originals to confirm the attributes already demonstrated in Rothamsted field trials.

"Line 59 has less than 10% asparagine compared with unedited Cadenza, with no yield penalty. The plan is to produce as much as 100t by harvest 2026, which will be processed into biscuits and breakfast cereal from well-known brands," notes Nigel.

"Once the farmers have grown this wheat in their fields, food manufacturers have seen how it performs, and consumers have actually held the product in their hands, we believe that will address any reservations there may be over the value of this advance in plant-breeding technology."

For Nigel's colleague, Dr Navneet Kaur, the move into commercial fields is a natural progression of the science the team has applied in the lab. "Along with work to apply edits that reduce asparagine, we're also testing all the material to ensure there are no undesirable effects on milling quality – we've found none in the CRISPR-edited lines so far. We've also been looking at agronomic factors that affect acrylamide – sulphur is a key nutrient and a deficiency gives rise to higher asparagine levels."

The potential for targeting other natural amino acids is also being explored. "We have some promising lines of wheat with high lysine content. As a home-grown feed wheat they have the potential to displace imported soya in livestock rations. The PROBITY platform will be ideal to test the value of this trait once we have generated true PBOs," she notes.

Promise brings prospect of high-lipid forage

It's long been the Holy Grail for livestock nutritionists: studies suggest higher dietary lipid concentrations in cattle fodder can improve productivity and reduce methane emissions by up to 5% for each 1% increase in lipid content.

Now there's a new gene-edited crop with a marked increase in the lipid content of its leaves and stem. This will be grown on commercial farms in England as part of the new BOFIN farmer-led platform. The fodder will be fed to dairy cows with output and productivity closely monitored to see if expected increases in energy values of more than 0.5MJ/kg of dry matter (DM) are achieved.

The edit has been made in Golden Promise barley by Professor Peter Eastmond of Rothamsted Research. He accepts that barley is not traditionally chosen as a forage crop, but is confident the transformation can be made in ryegrass. "We chose Golden Promise because it's easy to transform. Ryegrass is harder and does not self-pollinate, which makes things more complicated. But previously it was thought you couldn't edit this change into a grass crop – we've shown that you can."

Peter's work started in bioenergy crops, the goal being to store more lipids in leaves to boost the energy value of the resulting biomass. "Plants can store oil in seeds, but in leaves there's limited capacity, partly because they break down the oils," he explains.

In 2006, Peter discovered and characterised a plant gene called Sugar-Dependent1 (*SDP1*). He found it was largely responsible for the breakdown of the storage oil triacylglycerol and that disrupting this gene leads to accumulation in leaves. A further breakthrough came when his team discovered a way to switch on a dormant gene without inserting foreign DNA and creating a GMO.

"Grasses with a lipid content of 8% of dry matter – more than three times their natural content – have been achieved, but only through inserting foreign DNA, making them GM. A gain-of-function is not something you can usually achieve with CRISPR, which is associated with turning genes off," explains Peter.

The Rothamsted team showed that a gene can be brought under the control of a promoter from an upstream gene by using CRISPR to delete the intervening genomic sequence. They fused the promoter of a non-essential photosynthesis-related gene that's switched on in leaves, to the Diacylglycerol

Peter Eastmond has developed a gene-edited barley with a marked increase in the lipid content of its leaves and stem.

Acyltransferase2 (*DGAT2*) gene that's normally switched off.

"*DGAT2* makes an enzyme that's known to synthesise triacylglycerol and its overexpression can drive increased oil production." The work, in the model plant species Arabidopsis, resulted in the oil content in the leaves increasing by around thirty-fold, when *SDP1* was also disrupted – the combination of the two processes is thought to be key.

The plan is to work with specialists at Aberystwyth University to bring the same genetic breakthroughs into ryegrass.

But could the same transformation be made to grass species? "It was touch-and-go because, although Golden Promise is easy to transform, grasses are very different to Arabidopsis. We made the edits during COVID, just before lockdown, which meant we couldn't get to the lab to analyse the results," recalls Peter.

But when they returned it was good news. Barley has two copies of *SDP1*, and out of 160 lines they found just one with a rare, and very much prized, double knock-out. "We found this resulted in a 1% increase in lipid from 2.5% DM to 3.5%. The increase is substantial and the trait is heritable, which is a big relief. What's more it's a true PBO."

The barley went through field trials in 2023 and is now being multiplied up for the PROBITY platform. The aim is to produce enough in harvest 2025 for bench testing of the fodder with full feeding trials conducted by a major dairy co-op on farms in 2026. The fodder will be harvested before the ear has set from 1ha strips grown next to unedited Golden Promise to compare its performance in the field.

Peter accepts it's not the finished product. "Really, we need at least a 3% increase – up to 7-8% of DM would be optimal. But we know this can be achieved, because it's been done through transgenesis. What's more we've been working in this area for more than 20 years and have achieved successes that had been thought were not possible previously."

His team will be working with specialists at Aberystwyth University to bring the trait into ryegrass. Scientists at IBERS are world-renowned for their work in developing high-output grasses. "It'll be tough, because transformation efficiency in ryegrass is low," notes Peter.

"But that's why it's so important we prove the outcome through the PROBITY platform – these sorts of advances in ryegrass breeding simply won't happen unless breeders have the confidence it'll be worth the effort. With the on-farm work, we take the trait through those steps and remove the barriers."

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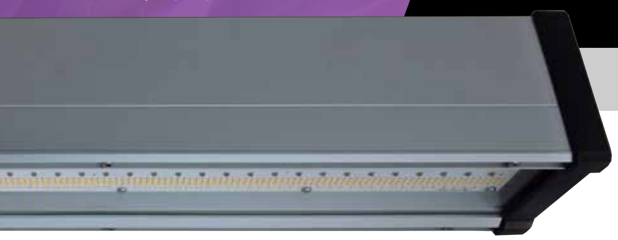

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SEEDS OF A WILD IDEA

Written by Tom Allen-Stevens

Wild plants could hold the genetic key to a step change in productivity across major agricultural crops. *Tech Farmer* visits the labs of a new start-up that's sifting through the genomes.

Ross Hendron looks up at the ear of the wheat plant he has just pulled down off the shelf of the growth room.

"At the moment it's just one plant," he says, and turns his gaze to the dozens of companion plants sitting on the shelf under the bright LEDs. "We have to pick which of these will work best, and we won't know for sure until we have enough seed to test them in the field. But the lab tests have proved promising."

What Ross holds in his hand could represent a step change in yield that is beyond the capability of any wheat currently under cultivation anywhere in the world. The variety is Cadenza that has been edited at precise points in its genome to improve its photosynthetic ability.

Improving a crop plant's photosynthetic ability is just one of the changes Ross Hendron and his team are developing with the material in the growth rooms of Wild Bioscience's new facility near Oxford.

But just because current wheats don't have the ability to do this themselves, that doesn't mean it's not in their nature. According to Ross and his team at Wild Bioscience, a spin-out biotech firm from Oxford University, it may be a case of waking up a gene already present in the wheat genome.

> *"A subtle tweak can make a step change to how efficiently a plant behaves."*

"Wheat's been cultivated as a crop for about 10,000 years, but in evolutionary terms, that's nothing," he says. "There are many wild plants that have dealt with climate shocks that cultivated plants have never even experienced on a farm. But if you look closely at the genome, they all share a similar genetic hardware."

This insight originated in the lab of Professor Steve Kelly, where Ross joined as a PhD student in 2016. Steve's lab develops and uses computational approaches to understand the genetic basis for how plants work. His group uses these insights to investigate fundamental questions in the evolution of plants, such as how photosynthetic pathways have evolved, and why some plants grow faster than others.

It's this approach that the team at Wild Bioscience have been exploring since Ross and Steve founded the business less than three years ago. £12 million of venture capital has sped it on its way, and now there are offices, growth rooms, labs and a team of 20 staff in Milton Park, just a few miles from Oxford, where the vision began.

"But it's a challenge – the genomes of wild plants generally haven't been mapped," notes Ross. "Wheat has, but it's a complex genome of 17 billion letters. However, if you look closely, there are some plants that have evolved the ability to turn on certain characteristics. Crop plants have much of the same genomic architecture, but haven't inherited these characteristics."

It's these that give a cactus its ability to survive in desert conditions, for example. Find the genetic secrets to survival in these harsh environments and you have the potential to bring about a transformation, he points out. "A subtle tweak can make a step change to how efficiently a plant behaves. You then use machine learning to target that."

Ross and Steve had been looking closely at the signalling molecules that are used to tell a cell to develop chloroplasts. While all plants use these to drive photosynthesis in certain cells, such as in the leaf and stem, many different wild plant species have evolved the ability to turn these on in specific cells – an ability wheat currently doesn't share. "But the tweak has to be precise – get it wrong and you get chloroplasts in roots and flowers," notes Ross.

It was during Ross' PhD research that he and Steve first managed to put this theory into practice. "The first plant I transformed was *Arabidopsis* – a type of plant scientists often use because we know so much about the genome. I made many different transformations, and I guess the seminal moment for both of us was seeing them develop – there were some that just stood out in the greenhouse as significantly ahead of the rest in terms of their growth."

Since then, the work of Wild Bioscience has focused on developing interesting genes and characteristics in widely grown broad-acre crops, chiefly soya, maize and wheat. Most of the novel prototype plants are GMOs, genetically modified with a piece of plant DNA. This has proven the technology, and there are one or two crops, notably soya, that have now progressed as far as field trials grown in South America. Tight regulations for growing GMOs in the UK and EU severely restrict putting the crops in the field here, and they would be unlikely to be commercially grown.

But the team is now working on editing the genome of farmed crops to achieve the same transformative leap, using new genomic techniques (NGT). Also called precision-bred organisms (PBO), these are plants where scientists have made a small and precise edit to its DNA that could have happened naturally. Legislation passed in 2023 has now allowed these crops to be grown in the field in England without the restrictive GMO regulations, with similar laws currently passing through the European Parliament.

This Cadenza wheat has been edited at precise points in its genome to influence signalling molecules used to tell a cell to develop chloroplasts.

That means progeny of the wheat plant that Ross carefully places back on the shelf can come into English farmers' fields without restrictions. "It's part of a programme we've branded Wild Solar, which encompasses the changes in photosynthetic efficiency," explains Ross as he shuts the door of the growth room, leads the way to another door and opens its hatch. Peering through the glass reveals more brightly lit plants, this time soya.

Alongside Wild Solar, the company has recently introduced Wild Carbon, which uses the roots of crop plants to create what Ross describes as a "revolution" in long-term carbon sequestration. "Plants are masters of moving CO_2 around," he enthuses, his face lit up as he looks on his soya plants through the window.

"This is mostly to do with producing sugars, and you don't want to mess with that process as it affects yield."

Ross explains that most of the CO_2 taken up by plants is drawn into cells in the leaf and involved in photosynthesis. Wild Carbon is designed to bypass photosynthesis and store atmospheric CO_2 via the roots directly into the soil where it will stay locked up. "The potential of this technology is vast, as it could turn farmland into the world's largest CO_2 storage facility without effecting crop yield or changing land use."

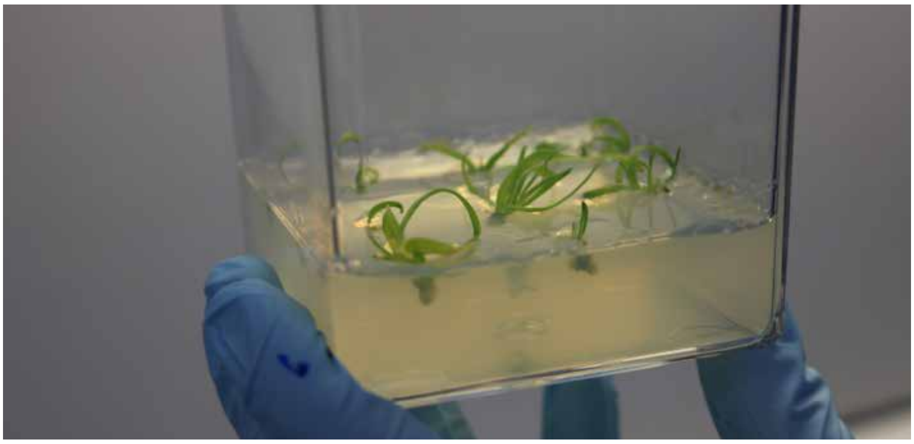
The Wild Bioscience team believe they may have found the genes that enable this and sequences of DNA have now been transferred into some of the lines in this very room. "These GM soya plants look promising," says Ross as he closes the hatch.

A window on Wild Carbon – soya plants that have been altered to sequester and store significant quantities of carbon long term, without a drop in yield performance.

"But it doesn't have to be GM. The gene we've brought in is controlled by a promoter sequence. We can edit the plant to turn on and off a different promoter sequence to act on the exact same gene that soya already has in its genome, and we believe that will have a similar effect."

And it doesn't have to be soya. In the early stages of exploring a genetic alteration, when trying to establish the phenotypical change that results, soya is actually harder than wheat to edit, he continues. But wheat is hexaploid, so there's additional work needed to determine how the appropriate gene should be edited over the three copies of its genome.

"Here we're looking at a gain-of-function, so we believe we only have to turn on one gene in one genome to get the gain. What's exciting, though, is that this means there are many different ways we can explore how to combine the benefits of these approaches to boost both yield and carbon removal in the same plant."



At the very start of their journey, first generation edited wheat plantlets are regenerating from embryos.

The Wild Carbon work is some way off application in the field, particularly for NGT lines. But Ross is confident the Wild Solar wheat is almost ready, and just needs to be multiplied up. "One of the big challenges we have as scientists is to replicate the same changes we see in the lab out in the field," he notes.

"Field trials are a crucial step in seeing how these novel plants interact with the environment and the agronomy applied to them on commercial farms. We're at the very beginning of our journey there."

This is where farmers can help. As soon as enough material is available, agronomy programmes will need to be shaped and soil and field conditions explored to get the best from the novel crops.

Ross believes this will also address the reservation some people have for the technology. "Once these crops get out into the field and farmers can see the benefits, I hope it will demonstrate the impact precision breeding can have.

"There are many societal benefits we can deliver with these novel methods that simply cannot be achieved through traditional plant breeding. Once the products are available to farmers and consumers, I think the narrative will change and this will create more choice for farmers."

As a scientist Ross is also keen to get feedback from farmers interested in growing NGTs. "I know there are many farmers who are excited about new technology, but what motivates those who are adept with a pipette may be different to what drives those who tend the land. I think there are passion points we share, and it's these we can explore once these novel crops are in farmers' fields and showing their worth," he concludes.

Almost ready for field trials, as soon as enough material is available, agronomy programmes will need to be shaped and soil and field conditions explored to get the best from the novel crops.

EVOLUTION BECOMES REVOLUTION WITH AI

Written by Lucy de la Pasture

Foundational artificial intelligence may still be in its infancy, but it's already being used to help bring new varieties with better traits to farmers' fields. *Tech Farmer* takes a look at some of the AI innovations that are set to speed up the breeding pipeline.

Imagine having a brain that never gets tired and retains every last piece of information it has ever learned. A brain that can see patterns in data and make complex calculations in millionths of a second.

These are just some of the capabilities artificial intelligence (AI) is already bringing to our everyday lives as groups of AI technologies form systems capable of performing tasks that traditionally have required human intelligence (known as foundational AI).

The computational power of artificial intelligence (AI) has a very natural fit with plant breeding as nature tends to follow mathematical rules. Gregor Mendel is regarded as the 'father of genetics' because he worked out so much about how traits are passed from one generation to the next using just maths.

From his experiments in peas, Mendel developed a mathematical formula that explained the frequency with which each trait appeared. He also observed dominant and recessive traits despite having no knowledge of DNA or genes.

Modern plant breeding still follows Mendelian processes, but the advent of molecular-based marker-assisted technologies to identify genes has sped up the process considerably compared with phenotypic screening alone. Now advances in technology, such as cloud computing and increased processing power, are moving speed breeding up another gear.

For Bayer, the journey began over a decade ago when the company began to integrate data science into its breeding programmes to help optimise the process.

"We started with a simple idea and that was to take 'the breeder's equation' and work out how to apply machine learning to optimise every term in that equation", explains Phani Chavali, who leads Bayer's US data science team in plant breeding.

The breeder's equation is used to predict breeding outcomes by indicating how strong the response to selection will be as a result of the additive genetic variance within a trait, and the selection applied to that variation. Phani explains that by using AI and machine learning models, Bayer has become better at predicting outcomes, essentially speeding up selection for genetic gain.

"We have developed genomic selection, which is a machine learning model that uses genotyping data to predict the performance of different genetic material. And using that information, we can advance varieties in the breeding pipeline without actually testing them in the field," he explains.

"We also use machine learning to select new breeding crosses, and to advance the progeny from these new crosses into subsequent years."

This AI assistant is helping breeders select the most promising candidates and it relies on cloud-based algorithms built on a foundation of roughly 1.7 trillion calculations. These models have enabled a dramatic shift in the scale and speed of the breeding pipeline, and over the past 15 years it has saved the company from running around 8000ha of field trials.

"On average, 5.2M predictions run each day to support the breeding programme. That's a huge number and the amount of data we collect to feed the algorithms is over one petabyte [there are 1,024TB in one petabyte]," says Phani.

Advances in AI capabilities have enabled Bayer to embark on a new phase in its plant breeding in the past few years, with the aim of leaving the Mendelian processes of probability behind.

"The idea behind this 'precision breeding' strategy is to make a shift from selecting the best to designing the best," he says.

Computer vision

Another plant breeding company is combining other dimensions of AI – machine learning and computer vision – with autonomous robots.

At its US breeding facility in Illinois, KWS is using AI to collect vast amounts of phenotypic data that hasn't been humanly possible before. Here, the TerraSentia robot can be found trundling noisily up and down the alleyways that run between the trial plots at the huge wheat variety trials site, snapping photos as it goes.

In the past few years, advances in AI capabilities have enabled Bayer to embark on a new phase in its plant breeding which aims to leave the Mendelian processes of probability behind, says Phani Chavali.

The phenotyping robot was developed by EarthSense, an agritech start-up based at the State's university. The company's co-founder and chief technology officer, Girish Chowdhary, describes some of the challenges they faced when creating the TerraSentia robot.

"The idea behind this 'precision breeding' strategy is to make a shift from selecting the best to designing the best."

"It's moving in a very noisy and uncertain environment. We've tried to account for that by building a ruggedised robot so it can work well and collect good data under these conditions.

KWS is using the TerraSentia robot to collect phenotypic data at its trials site in Illinois. PHOTO: KWS.

"Cameras can move around because the surface the robot is working on isn't very stable, and they can also be blown about by the wind. We've incorporated allowances in our machine learning algorithms to account for any variability in the data due to these issues."

The robot routinely does the legwork that humans would do, but it's the AI, or computer vision that's currently learning to interpret the images the robot is capturing that could be the game-changer.

Girish describes the machine learning process as creating a large set of data labelled by humans. The data is fed to machines and its software generates knowledge from experience by means of repetition, identifying patterns in the data that relate to traits, diseases, or growth stage, for example.

Its neural network is then able to create a new mathematical model, an algorithm, as it 'learns'. Once the artificial intelligence has obtained enough knowledge from humans, it uses it to compare new images and identify phenotypic expressions. In the case of the robot, it evaluates the pictures of plants without the need for human assistance.

KWS wheat breeder Mark Christoper explains how the robotic trials are going. "The fact that the robot can operate continuously and independently means it's able to collect data on more material than we've been able to in the past. This will allow us to make more informed selection decisions, especially in our younger generation breeding nursery where we have hundreds of thousands of individual rows and it's just not feasible for humans to collect all the data."

Wheat breeder Mark Christopher is measuring the height of wheat in the field, a task the TerraSentia robot is now being trained to perform. PHOTO: KWS.

So far, the trials work has shown that the AI model is able to identify traits such as awn type and heading date using plant images from the trial field. It's also highly accurate, with results showing that the AI detects emerged ears with 96% reliability and that it can identify whether an ear is completely awned, or not, 92% of the time.

More recently the data collected has been expanded to look at additional traits such as plant height and disease severity.

"Comparing robotics and humans, they each have their own strengths. The robot will be very good at providing very objective, high-quality data for specific traits, but the human is required for making those subjective advancement decisions. And then there are certain things that the breeder's eye is required for," he adds.

It's an important point that humans are not being replaced in the breeding process, but instead AI is augmenting their decision-making, adds Mark. "Data provided by the robot will add precision to the decisions that we make, and this will help us produce better varieties."

Predicting germination

There are other tasks where AI and machine learning could lend plant breeders a helping hand – one of those is germination testing. Recently, researchers have taught a new tool – SeedGerm – how to do it using machine-learning-driven image analysis.

The innovative machine has been developed to perform the process in a semi-automated way and is the result of a collaboration between the Earlham Institute, the John Innes Centre, Syngenta and NIAB.

Carmel O'Neill, research assistant in the Penfield Group at John Innes Centre explains that currently most seed germination is recorded manually. "Compared with this, SeedGerm presents fast, accurate, high-throughput screening and will be of major interest to crop seed production companies and research programs screening large germplasm collections."

SeedGerm uses a cabinet equipped with cameras which take photographs throughout the germination process, documenting each stage from imbibition (seeds taking up water) through to the emergence of the root, and further changes in the newly growing plant.

Supervised machine learning is used to automatically determine how germination is progressing by comparing images. Algorithms can be trained to predict how likely it is that a seed has germinated based on measurements extracted from an image that relate to the seed's size, shape, and colour.

Seed germination experts from Syngenta have confirmed the effectiveness of SeedGerm for measuring germination rate and seedling health across five major crop species, including tomato and oilseed rape, opening the way for SeedGerm to replace manual seed scoring.

In addition, the power of SeedGerm to measure phenotypic changes over time has further novel applications in crop improvement research. Many of the characteristics that can be measured help to estimate performance in the field in terms of canopy closure, weed suppression and predicted yield.

RNA Sequencing

While AI is already bringing evolution to breeding programmes, the main focus in plant breeding is on DNA and the genes within it. But a revolution may be brewing that's focussing on sequencing RNA and the importance of gene expression.

In simple terms, genotyping data identifies the DNA sequence and provides an indication of potential (the presence or absence of a gene that are predictive for a desirable trait), whereas RNA sequencing (RNA-seq) gives biological meaning (or what will likely happen) by quantifying how much the gene will be expressed and other coregulated genes.

"This is significant because it highlights a limitation when only using DNA-based methods for marker-assisted breeding," says Dr Joshua Colmer, cofounder and CEO of agritech startup TraitSeq. "Analysing DNA alone doesn't present the full picture, especially in cases where traits are complex – meaning they're affected by multiple genes."

AI is being harnessed at TraitSeq to produce prediction models from RNA-sequencing data. This will help breeders select for complex traits, believes Joshua Colmer.

Many of the traits that plant breeders are looking for are complex in nature, such as drought tolerance or nutrient use efficiency, and consequently these characteristics are hard to breed for.

TraitSeq's platform technology uses bespoke machine learning methods

TraitSeq technology can be used as a phenotyping tool under varying environmental conditions, negating the need for costly field trials.

and bioinformatics tools to identify biomarkers. These are then used to train phenotypic prediction models for complex traits in crop plants. Using its proprietary RNA-seq analysis methods, the company aims to help breeders by predicting phenotypic outcomes for complex traits to help inform selection decisions and optimise breeding programmes.

TraitSeq's IP was developed by Joshua during his PhD at the Earlham Institute, where he used machine learning to develop models that were able to successfully predict outcomes from RNA-seq data to a high level of accuracy – including the prediction of turnip mosaic virus infection, human cancer subtype classification, and the diagnosis of COVID-19 infection.

It's this computational capability that could bring a new dimension to plant breeding. The technology has the ability to accurately predict measurable targets that relate to changes in phenotype, physiology, or metabolism under varying environmental conditions.

"We could predict the field performance of a trait based on glasshouse trials, for example. This is also an aspect that crop protection companies are interested in to help them screen potential new active ingredients – identifying those that are likely to fail in the field so that they can be removed from the innovation pipeline without running costly field trials," explains Joshua.

The same can be done in variety trials which could significantly speed up the breeding process. "What is exciting is that where traits were previously difficult or expensive to measure in field trials, TraitSeq can be used as a predictive phenotyping tool. As sequencing prices continue to fall, it will become a more cost-effective way to phenotype those traits and implement them into a breeding program.

"The types of traits this is applicable to aren't limited to yield, disease resistance or nutrient deficiency. It could be applicable to quality traits like protein content or water absorption for baking quality," he adds.

Another advantage of RNA-seq technology is it reveals how genes regulate each other. "With a sufficiently large data set, you'll be able to identify genes that regulate the expression of other genes. And by manipulating the expression of transcription factors, it might be possible to predict how that could affect other traits [such as yield] downstream."

It's still early days for the company that has recently spun out of the Earlham Institute and received funding from UKRI's Innovation to Commercialisation of University Research (ICURe) pilot programme. This backing, together with substantial funding from Anglia Innovation Partnership and Innovate UK, is enabling TraitSeq to work with companies on pilot projects.

The biggest hurdle to commercialisation at the moment is the current cost of RNA-seq compared with genotyping, reflects Joshua. "Breeding companies have invested significant resources into marker-assisted breeding methods and developing genotyping platforms. The assays they use cost on the scale of pence per datapoint, whereas RNA-seq is around £200 per sample. It's a huge difference in cost so we have to demonstrate there's a lot of added value in RNA-seq technology, particularly in its ability to enable the prediction of complex traits."

Joshua predicts the cost of the testing will come down considerably. "It's not unreasonable to expect RNA-seq to be £30-50 per sample in three to five years. However, we can use qPCR as another means of quantifying gene expression, which is a much cheaper method. Once our algorithms identify gene expression markers for a complex trait from RNA-seq data, we can develop a qPCR assay to test for it which brings the cost down to around £10 per sample.

"All the while we are constantly developing our computational platform for RNA-seq data analysis. So once the technology becomes cheaper and more widely adopted, we aim to be the go-to solution for companies to obtain meaningful insights from the big data they will be generating," adds Joshua.

And there's no doubt that big data, in all of its guises, is informing food production throughout the value chain. Yet the advancement of AI isn't without concerns.

In a cautionary tale, The Matrix hit the big screen 25 years ago. Set in 2199, the film depicts humanity enslaved by a cyber intelligence that it had created – 'the machines' had taken over. The reality in 2024 is that much of AI use is pretty mundane but the potential for misuse remains. So to protect against this, UNESCO set out an ethics framework for AI systems in 2021, one of which is that human supervision is vital.

Perhaps the ingenuity of humans in creating AI capabilities will be invaluable in meeting the world's climate and food security challenges. As long as 'the machines' won't be making the actual decisions...

AGRONOMIST IN FOCUS...

SFI FUNDING BRINGS PRECISION PROMISE

Written by Steve Butler, Precision Specialist at Agrovista

There are new payments to encourage the uptake of precision farming, and increasingly powerful platforms to implement it. *Steve Butler*, Agrovista precision specialist, examines some of the benefits on offer.

Precision farming has been gaining traction on UK farms for the past 20 years, aiding crop production, farm efficiency, grower knowledge and ultimately, business profitability.

One of the key contributors that has helped increase the speed of uptake over the past decade has been variable rate (VR) technology, thanks to improvements in data collection and interpretation as well as ongoing advances in application technology.

As such, VR has become a proven practical tool that is no longer an overly complex or expensive addition to farming practices.

The introduction later this year of Sustainable Farming Incentive (SFI) payments for VR applications, along with Farming Equipment and Technology Fund (FETF) grants to help with the cost of equipment, make it even more attractive.

This, and the fact that an ever-growing number of farms have access to VR machinery, is likely to encourage a further significant uplift in the number of growers using VR.

SFI payments are worth £27/ha/year, where "VR application technology is used to apply nutrients on arable, horticultural land or improved permanent grassland, to match the nutrient needs of crops in different areas within land parcels". This provides a fixed-cost benefit against the variable costs of nutrients even before growers know the extent of nutrient variation across their land.

The ability to apply key nutrients, such as nitrogen, phosphorus, potassium, manganese and lime, as well as seed, to match crop demand helps make more efficient use of targeted inputs. This can lead to higher yields and more even crops, creating further efficiencies with fungicides and herbicides, helping fields perform nearer to their true potential.

Of course, the field maps required for VR are only as good as the data used to make them. Advanced software, such as OneSoil Pro now on offer from Agrovista, processes up to seven years of existing satellite imagery to analyse individual fields.

This takes into account NDVI (vegetation index), soil brightness (soil type) and elevation. The data is then crunched, dividing the field into zones based on crop productivity potential.

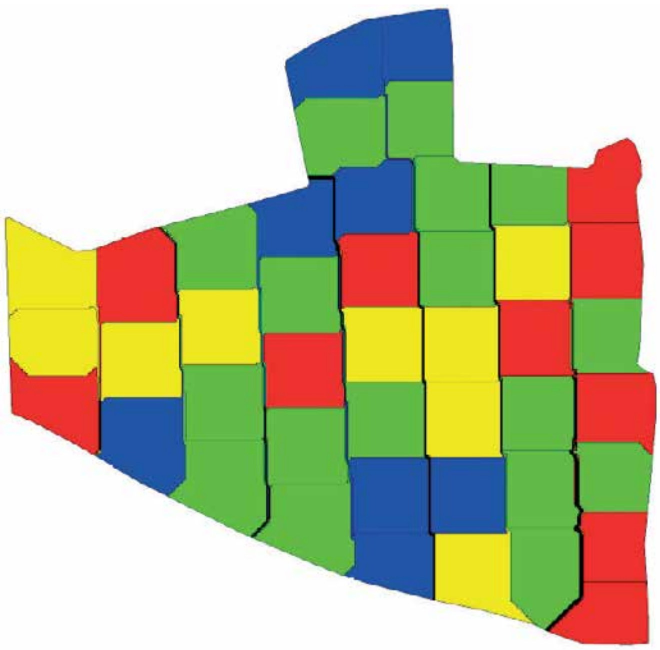
Yield maps can also be uploaded to enable the software to generate a yield report for the different zones, to aid decision making further.

Control strips can also be established automatically within separate productivity zones, enabling growers to assess the effect of different input rates on crop yields over several seasons to fine-tune applications.

The system also highlights the productivity percentage change when creating VR applications of seed or fertiliser compared with standard rates for each zone. This shows how different zones are responding to various rates of inputs. providing a basis for discussion how these could be tweaked to further improve crop performance.

Variable rate nitrogen

Targeting nitrogen according to crop potential helps to minimise losses to air and water, so is more environmentally beneficial than flat-rate applications. It also helps to even up crops, typically leading to 3-5% yield increases.



OneSoil Pro VR nitrogen maps are based on NDVI satellite data updated every 2-3 days, offer a near real-time snapshot of crop growth. Users can choose 3, 5 or 7 zones and choose how much to increase or decrease the rate from the standard application for each one.

Of course paybacks are still potentially very good without SFI funding – at current values a 3% yield increase on an 8t/ha crop of wheat would be worth £40/ha uplift in return, around nine times the cost of a platform like OneSoil Pro.

Variable rate seed

Applying seed variably is not new, but the accuracy of the operation is constantly improving. Many growers have used the +/- buttons on their drill box to increase rates on heavier parts of a field or areas prone to sub-standard establishment.

This basic form of VR continues, but the amount of data we can incorporate into today's maps creates a far more robust and simple-to-use system, which is also a step up from the soil maps that have been the mainstay of VR seeding in recent years.

VR seed applications are based on all the data sources mentioned above. As with nitrogen, growers can split fields into 3, 5 or 7 productivity zones on which to base seed rates. Increasing and, in some cases, decreasing rates in areas according to in-field potential maximises return on seed drilled. We have seen an average yield increase of 4% using this technology.

Soil sampling

Grid mapping is where precision farming started in the UK. It is a basic, yet very important technique designed to bring and maintain soil nutrient levels to a given index, utilising VR technology on the fertiliser spreader.

Splitting fields into 1ha grids takes P, K, Mg and pH management to the next level. Using this information a bespoke plan for each field can be created and inputted into the display in the tractor cab for VR application, potentially improving efficiency and reducing input costs.

Given the importance of good soil sampling, and now with SFI funding available for soil management planning, Agrovista plans to use OneSoil Pro to place soil sampling points based on productivity zones rather than a standard grid system, offering even more accuracy to target remedial measures across the field than in the past.

In summary, precision farming offers much to enhance a farming business from both a cost and environmental aspect. If you already have the equipment available but don't make use of it fully, or have the correct equipment but possibly just need an unlock from your tractor dealer, there is no reason not to try even just one field for VR of some sort.

Adopting VR will help you farm more effectively and efficiently, whilst helping to maximise profit from every hectare.

Working together

Agrovista Precision's team can advise on a wide range of displays and in-cab controllers to enable VR applications. We can identify what can be done with a farm's existing equipment or if additional leads or controllers are needed, for example.

For more information, please email **precisionauk@agrovista.co.uk**

USE **ANALYTICS** TO IDENTIFY THE BEST INVESTMENTS FOR YOUR **NO-TILL OPERATION**

Written by Noah Newman and published by No-Till Farmer, 30 January 2024

Clay Mitchell, no-tiller and co-founder of farmland venture capital firm Fall Line Capital, delivered a presentation at the 2024 National No-Tillage Conference on what no-tillers stand to gain from working with ag startups and new technologies.

During the presentation, Clay questioned how to identify the best investments for your no-till operation.

"It's important for all of us making investments around the farm to consider the expectations of ROI," says Clay. "For example, I put up a new storage building this year, poured some concrete and bought electronics. What's my expectation for the return on each of these things?"

Clay takes an analytical approach to answering that question using the graphs below.

The graphs on top show the price changes of certain services and items from 1998-2018 (Historical Price Changes) and where Clay expects them to go over the next decade (Conceptual Future Price Changes). The graph in green (Lifespan Ratio X Components to One Component) compares the lifespan of systems with multiple components and systems with a single component. He describes the beta number in the green graph as follows:

"With a low beta (0.5) probability distribution, there are high failure rates initially, like the electronics that don't work, but ultimately work if you fix the bad plug," says Clay. "The high beta (10) represents things that wear out, like cultivator shanks and transition cones. When your machines are down, how often are you dealing with wear out failures, and how often are you dealing with things that are low beta?

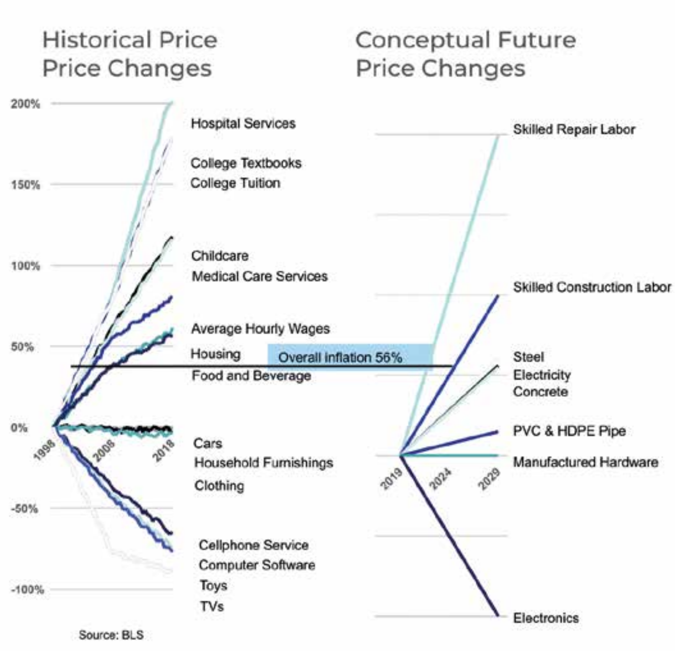
"The overall message here is to think about it in an analytical way. Look at your system and identify places where you could build redundancy. Ask yourself which things are most likely to fail. And be aware, as you're adding a lot of complexity to machines, there can be a cost to that.

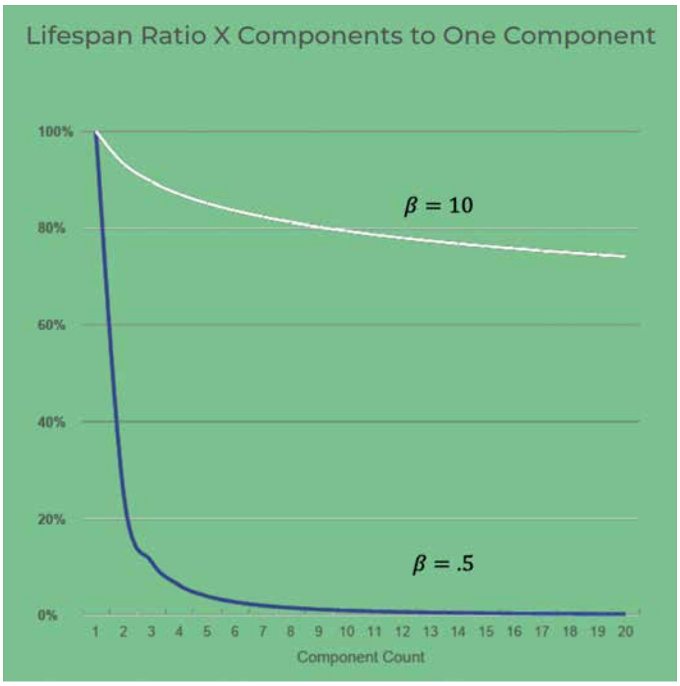
"Unless I can operate without the extra feature, is there a limp home feature? Can I run without it? Or am I adding things that I must operate for the system to work? And if that's the case, then you may need to simplify and back down, but it's worth thinking through and trying to be analytical about it."

Building redundancy in a system is key to maintaining its reliability and elongating its lifespan, but unfortunately, there isn't a lot of redundancy with farm machinery right now, says Clay.

"I'm a pilot, and we have a lot of systems that are completely duplicated on an airplane," he says. "There's redundancy for the fuel system, navigation systems and radios. If one fails, there's another one.

"I can't think of anything on the combine that works that way. If the chopper bearing goes out, you don't just hit the backup, you've got to fix it. As these machines get more complex, we're just adding all these things that have to work.





Airplanes are complex, too, but there are extreme efforts that are put into maintenance, repair and engineering that comes with a high cost to make sure everything is reliable."

Looking at the graphs above, the inflation rate for hospital services, college textbooks and tuition have gone way up, whereas TVs, toys and computer software have plummeted. What does this information mean for your operation?

"I imagine that skilled labour is going to go way up in cost," says Clay. "The complicated stuff that's breaking down a lot is going to cost more and more to fix. Electronics are going to come down.

"For the things I expect to go up, there's also more of a willingness to pay for them to make sure you're building them in a reliable way that makes them last for a while. For example, the PVC and steel for our irrigation systems have doubled or tripled in price since we've installed them. It's made for a better investment, and it was good that I put a lot of effort into making them reliable," he concludes.

Clay Mitchell

SOIL ASSOCIATION EXCHANGE

BUILDING BUSINESS RESILIENCE THROUGH MEASUREMENT

Ben Makowiecki, Agricultural Sustainability Director at Lloyds Bank, sets out the Bank's ambition and actions in supporting agricultural businesses to reach net zero.

Building resilience is much talked about in UK agriculture. We all know the myriad pressures the industry is facing – from a changing climate, reduced government financial support, and a valid focus on the need to produce and eat more of our UK grown food.

Understanding how your farm is going to respond is crucial, so as part of our longer-term commitment to the sector, we provided initial funding and support to set up Soil Association Exchange. Exchange has been developed by a team of industry experts, scientists, and farmers and is designed to look at the entire farm – not just carbon – to help farmers measure their whole farm's impact over six key areas, including soil health, water, and biodiversity. It provides a platform to input and store that information and offers access to a host of support and advice, including benchmarking tools that help compare an individual farm to industry averages and tools to help navigate funding.

How Soil Association Exchange works

There are two ways to access Exchange:

Exchange Explore is a free version of the online measurement tool where a farmer enters their own environmental data like soil samples, bird counts and so on. They can then benchmark against other farmers and seek advice and funding information.

Exchange Excel is a bespoke paid-for consultancy version involving a farm visit to collect data, as well as remote data like satellite information. A local Exchange agricultural adviser then creates an improvement plan with the farmer, which they can choose to implement, and helps identify appropriate financial rewards, including reducing costs and extra income. Farmers can also choose to share their data with others, for example, higher up the supply chain, to prove the impact of their practices.

Measurement

Measuring environmental outcomes can be complicated. To ensure the credibility and constant improvement of how to measure sustainability, Exchange always makes its measurement methodology open to critique and commissions a leading scientist to review methodology. It also works with farmers, scientists and industry to ensure metrics work for everyone involved. The methodology is reviewed by an independent scientific advisory panel. So from soil structure and chemistry, to woodland connectivity, nutrient runoff and water quality, and greenhouse gas emissions, this means the measurement protocol and end-to-end process of generating an ecological farm score has been thoroughly researched and planned.

Such measurement is very encouraging, especially to Beth Metson, head of farming advice at the Soil Association Exchange. "This is where we think we can really add value to every farm we visit. The data is fundamental – but it is the translation of the data into tangible actions that farmers think is truly valuable. Seeing where you might not have scored so well, and creating an action plan of what you can do to improve over time." Exchange therefore pairs the advice a farmer receives with practical guidance on where they might access funding, helping to incentivise a busy business with many priorities "Without profitability we won't have these businesses to look after the environment, so farmers need to be fairly rewarded for all the different solutions that they're part of."

Finance

Exchange can assist farmers in navigating financial options, including grants to reduce water pollution, sequester carbon, improve biodiversity, and a host of other measures including government schemes.

Improving farm resilience is also of benefit when it comes to borrowing money. From a Lloyds Bank perspective, an environmentally sustainable farmer is a financially sustainable farmer. We want everyone to transition to a point where they can mitigate the risks and become more financially sustainable. There are providers now offering discounted

rates for sustainable projects – but it's the additional income stream from environmental credits that will drive real change. Farmers have a huge opportunity to reach net zero for the agricultural industry and to sequester carbon for other industries, and financially benefit from that, which is so important.

The future of farming

We're now also seeing farmers buy into the broader rationale and relevance of what Exchange is trying to achieve. A good example of this is Robert Fleming from Castle Sinniness Farm, who saw the benefits being more than just measurements. "We got involved very much to help our own business decision making, and that goes hand-in-hand with doing the right thing environmentally. We need to take responsibility for what we do, and for where we stand now – so we know the story from the very beginning."

Knowing there are options to how a farmer decides to engage with Exchange is something Jerry Alford, farmer, and Soil Association advisor, suggests is where things get really exciting. "We can't get on the ground and visit every single farm in the UK. But having an option for farmers to input their own data and start using the platform themselves, even if they are smaller farmers, is a great ambition. Farmers know their land inside out, but having one place that pulls it all together will be tremendously useful for them, and in the future, they will be able to see the impact of the changes they make now, which will be really powerful."

Whichever way a farmer decides to work with Exchange, I can't help but share in Jerry's excitement as the potential behind what Soil Association Exchange and its partners can provide to UK farmers over time is definitely something worth investing in.

If you would like to find out more about Exchange, please visit
www.soilassociationexchange.com

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FEEDING THE WORLD OR SEEDING UNKNOWNS?

New legislation now allows the growing of certain gene-edited crops in England. *Professor Jonathan Jones*, group leader at The Sainsbury Laboratory, Norwich, calls for a fresh approach to rules preventing the cultivation of GM crops. But *Roger Kerr*, chief executive at Organic Farmers & Growers urges caution over moves into new genetic technologies.

Professor Jonathan Jones, group leader at The Sainsbury Laboratory

The European Parliament has voted to approve amendments to legislation on New Genetic Technologies which sets Europe on course to relax regulations on certain gene-edited plants.

I've been using the GM method to confer specific traits on plants for 40 years. It enables benign and useful crop modifications to reduce the environmental impact of agriculture, especially by using genetics to replace the pest and disease control methods currently provided by agrochemistry. I'm still regularly astonished at the way this nature-based solution to crop improvement has been so misrepresented and vilified.

It is now more than 13 years since my team at The Sainsbury Laboratory in Norwich first conducted field trials of potatoes modified using the GM method to resist late blight disease. Those early trials were not near market – they only carried one resistance gene – but we now have Maris Piper lines with three resistance genes that are likely to remain resistant for a long time. Farmers currently spray around 15 times per year to control late blight. This requirement could be removed (although some sprays might still be required to control early blight).

Maris Piper lines with three resistance genes to late blight almost remove the need for farmers to spray to control the disease, but are currently only available to growers in the US.

The Conservative government pledged post-Brexit to liberate Britain's "extraordinary" biosciences sector from the EU's anti-GM rules, and "to develop the blight-resistant crops that will feed the world." Might this finally become possible?

Credit where credit is due, of course. Through the Genetic Technologies (Precision Breeding) Act, the UK government has moved to exempt gene-edited crops from those restrictive GMO rules where they contain no foreign DNA or could have been obtained through 'conventional' breeding methods. This is great progress and I congratulate the ministers who made the decision to move this legislation forward and the hard-working and professional civil servants who implemented it.

The European Parliament has now voted to approve amendments to legislation on New Genetic Technologies (NGTs). The new framework for NGTs sets Europe on course to regulate certain gene-edited plants in the same way as their conventionally bred counterparts.

For crops developed using the GM method, by contrast, the mood remains decidedly frosty among lawmakers on the Continent, and still cautious in the UK.

Many of the politicians who argued in favour of the Precision Breeding Act sought to emphasise the distinction between GM and gene editing, with the clear implication that GM crops are in some way less desirable, or perhaps even more risky, than gene-edited crops. This view has zero scientific validity and is exasperating for plant scientists like me who have devoted their entire careers to using

Greenpeace's opposition to Vitamin A-enriched Golden Rice has been characterised as "a crime against humanity".

the method for crop improvement.

It ignores the fact that GM techniques can deliver outcomes that other crop-breeding technologies cannot, for example in areas such as more durable pest and disease resistance, photosynthetic efficiency, nitrogen fixation and adaptation to climate change and abiotic stresses. It also ignores the emerging evidence from modern genomics of massive structural and other genetic variation within our crops before they even get near any Agrobacterium that might modify them. Compared to pre-existing variation, the variation we introduce using either GE or GM methods is tiny; we have lost all sense of proportion.

When the GM method was first deployed, some thought there might be "unknown unknowns we didn't even know we didn't know about". The "precautionary principle" was used to justify restrictive regulation of a crop improvement method that not only had never caused harm but had in fact resulted in benefits such as reduced insecticide applications. The precautionary principle understandably leads to regulation based on extreme risk aversion when knowledge is limited; such regulation should be reversible when decades of experience demonstrate that this risk aversion is no longer justified.

Scientific and regulatory agencies worldwide have repeatedly and consistently confirmed the safety of GM crops and foods. There has not been a single confirmed case of a negative health outcome for humans or animals from their consumption. Year after year, the technology has delivered significant economic and environmental benefits in those countries which have embraced its use. This scientific and empirical evidence has accumulated over almost 30 years from commercial cultivation and use of approved GM crops around the world, on a total area now exceeding 200 million ha.

In 2014, for example, a comprehensive meta-analysis of 147 studies found that growing GM crops helped reduced pesticide use by 37% while increasing crop yields (ie reducing the land required for crop production) by 22% and allowing more sustainable farming practices such as min- and no-till.

More recently, UK-based PG Economics concluded that GM crops have increased global food, feed and fibre production by nearly 1 billion tonnes (1996-2020), whilst helping farmers to reduce the environmental footprint associated with their crop protection practices by over 17%. The technology has also reduced carbon emissions, by an estimated 39.1 billion kilograms, arising from reduced fuel use of 14.7 billion litres and equivalent to removing 25.9 million cars from the roads.

These are hugely impressive results, but it turns out they represent only a fraction of the technology's promise.

So while the adoption of GM crops has demonstrably contributed to increased crop yields, reduced pesticide use and lower carbon emissions, recent research published in the American Economic Review suggests that national bans or overly-restrictive rules on GM crop cultivation have also limited those global gains to just one-third of the technology's potential. The study's authors also note than poor countries would benefit most from lifting such restrictions.

That's why the green NGOs campaigning against GM crops have so much to answer for. And why Nobel Laureate Sir Richard Roberts characterised Greenpeace's opposition to Vitamin A-enriched Golden Rice as "a crime against humanity."

It is also why the UK government should re-evaluate its implementation of current GM regulations and explore the potential for more proportionate risk assessment and data requirements, based on the specific properties conferred by each introduced trait, the intended use and the receiving agricultural environment.

Given the UK's academic plant science and commercial plant-breeding expertise, the country has a great opportunity to use the GM method for the benefit of its citizens, to reduce the environmental and biodiversity impact of agriculture and to enhance international food security. It offers the potential to decrease the land required to meet our food needs and so free up more space for nature, decrease our dependence on food imports and our reliance on agrichemicals, and so decrease the economic and environmental costs of food production.

GM crop innovations developed in the UK are already being commercialised in other countries with more proportionate regulatory regimes. Outside the EU, the UK is no longer bound by an approach to regulation that is based on the scientifically unjustified idea that there are intrinsic risks in using the GM method. Instead, it can take advantage of the experience of almost 30 years of commercial use of GM crops to ensure its regulatory processes are proportionate to the potential for risks of specific traits in individual organisms, rather than the technology that delivers those traits.

Spurning the use of GM creates a substantial, and avoidable, opportunity cost, and that is why we urge the UK government to take a fresh look at the UK rulebook on using the GM method for crop improvement.

Roger Kerr, chief executive at OF&G (Organic Farmers & Growers)

Organic advantage

With the government giving the green light to genetic modification (GM) in the Genetic Technology (Precision Breeding) Act 2023, it is now more critical than ever to ensure the implementation of this new legislation protects the integrity of crop and livestock genetics, the environment and human health.

As a consequence of the new legislation a robust regulatory framework surrounding this must be enforced to ensure the responsible roll out of this largely untested new technology.

The organic sector has successfully operated under such a regime for the last 30 years where assured food safety and supply chain integrity has taken precedence in ensuring consumer confidence.

Given genetic editing (GE) is a new, powerful and largely novel technology there is no arguable reason why genetic engineering should not have to comply with a stringent oversight regime to ensure the integrity of UK food and farming is protected.

While there is the possibility of genetic engineering advancing some genetic traits in crops and livestock, there is also the real potential for negative outcomes, a significant concern recognised by 88% of individuals and 64% of businesses who said they supported the continuing regulation of genetically modified organisms (GMOs).

Coexistence legislation to ensure effective separation of GE and non-GE derived foods would give citizens the ability to decide which they want to consume.

The genetic composition of plants and animals has evolved to respond to the conditions they find themselves in and human intervention has sought to manipulate those traits that are advantageous through a natural process of selection.

Genetic engineering attempts to subvert this process through the introduction or silencing of genes through direct invasive manipulation of a plant or animal DNA. We are told this is natural, but that is far from being the case.

We simply cannot ignore the scientific evidence that genetic editing or modification has led to unintended consequences. This was the case of CRISPR-Cas being used to dehorn cattle in the US, which inadvertently introduced antimicrobial resistant genetic sequences.

The history of chemicals such as paraquat and DDT shows the dangers of releasing materials en masse into the environment when we do not fully understand their impact.

The problem with genetically engineered material is once it is released it cannot be withdrawn, as the material will have pervaded the environment and so the precautionary principle must be strongly adhered to.

Deliberate release of genetically edited materials must only be approved when a sufficient independent assessment has been made to ensure there are no risks of damage to human health or the natural environment.

Where a technology is unproven any use must be properly monitored to ensure an evaluation of their effects can be properly calculated over time.

Moreover, significant emphasis must be placed on whether any intended release is truly beneficial to the community and fulfils the necessary criteria for sustainable development.

OF&G is by no means anti-progress, but there is a lot more that can be done, indeed that is being done, before we reach for what some suggest is a 'silver bullet'.

If we deal with the fundamental farming and societal issues first and get to 98% of where we need to be using nature-first approaches, and then GE takes us that last 2% over the line, that may be all for the better.

But starting with GE, thinking it

is going to solve all our problems, is a back-to-front approach. Especially when there is a complete lack of any assessment (long- or short-term) into potential hazards to human health or the environment from its use.

Scientific research has shown the organic approach to food and farming helps by moving the damaging implications of over-production and over-consumption to within safe limits and planetary boundaries, balancing trade-offs in ways that are beneficial to the environment, while feeding the world.

The aim in organic food systems is to replace synthetic chemistry by working with and restoring natural ecosystems. The success of this approach is clear and evidenced by the successful work of organic farmers in the UK and around the world over many decades.

Natural plant-breeding methods have achieved much over many centuries and could achieve much more, especially when focused on less intensive and less extractive systems, where increased funding would provide further focus on the development of traits appropriate to restorative farming systems.

If 10% of English farmland was converted to organic as part of a wider multifunctional land use framework, it would deliver significant benefits. It is an area equivalent to a threefold increase from today's 3.5% of land certified organic.

The aim in organic food systems is to replace synthetic chemistry by working with and restoring natural ecosystems.

It is a relatively small percentage, but with enormous gains for the environment. It would result in a 3.64% decrease in English agriculture related greenhouse gas (GHG) emissions, which is equal to more than one million tonnes of CO_2e per year – the equivalent amount of carbon sequestered by a third of a million acres of broadleaved woodland while producing food.

There are worries that genetic engineering attempts to subvert the process of natural selection through the introduction or silencing of genes.

Having no synthetic nitrogen applied across this 10% of English organic land would mean 9.4% reduction in total N consumption, which is equivalent to 179,000 tonnes less ammonium nitrate used per annum, while the removal of pesticides would mean taking out one million kg of insecticide, fungicide and herbicide active ingredients each year.

These are staggering figures that risk being overlooked by those blinkered by the GE promise.

This would also see farmland biodiversity restored in abundance – 78% more earthworm species, 35% more farmland birds, 23% more pollinators and 21% more field margin plant species, with soil biomass doubled.

The legally enforced organic regulation prohibits GE because it represents an unnatural and potentially environmentally destructive approach to food production.

Choosing organic represents an opportunity for shoppers to avoid consuming genetically altered food, assuming Government brings in coexistence legislation that ensures the effective separation of GE and non-GE derived foods. By doing so, this would give citizens the ability to decide whether they want to consume foods containing GE derived ingredients or not.

To that end, considered and progressive policies from government that support UK farming in delivering climate-friendly, people-positive food production and a real commitment to a consistent, thorough and well-resourced system-wide strategy is necessary.

This, alongside rigorous independent oversight and a clear definition of those technologies that represent a possible risk to the environment and human health.

Indeed, all these factors working together are going to be fundamental to this country's ability to feed ourselves and protect our natural and farmed landscapes through what is predicted to be a very turbulent time for us all.

SPRAYER TECH
IN FOCUS...

SPRAYING IN A SMALLER WINDOW

In a particularly challenging season for field operations, Amazone's *David Thomson* considers how new tech can help get the job done.

In a constant battle with the British weather, growers are always on the lookout for spraying solutions to get the job done in a timelier manner, and this season has been a case in point. A plethora of storms have plagued field operations and have left many fields impassable for a significant period of the 2023/24 growing season, with a large proportion of farmers holding out for a drier spring drilling period. For crops that are established, the struggle now begins with getting onto these fields without causing irreparable damage – it's where a well thought-out spraying outfit helps to get you through without a hiccup.

New sprayers are getting bigger, and while Amazone strives to keep weight down, we also focus on optimising weight distribution. The new self-propelled Amazone Pantera 7004 brings the Pantera 4504 from a volume of 4720 litres up to 7000 litres. Additionally, the new Pantera has a new chassis, integrating slope compensation as well as the ability to offset the track width from front to back, so the soil is travelled over just once. Although the Pantera's tank volume has significantly increased, the extra kerb weight empty is only marginal, as well as maintaining the 50:50 weight distribution found in the Pantera 4504.

With the UX trailed sprayers, whatever the spray tank level, the tractor always has an optimal drawbar load, ensuring there's traction without getting bogged down. Adding a front tank to the UF mounted sprayer brings higher capacity with improved weight distribution. These are available with capacities up to 3500 litres. The continuous mixing between the front and rear tank means the two tanks

behave as one, with minimal operator input required.

Spray technology is rapidly changing with precise and accurate agrochemical application being key to maximising chemical efficacy whilst minimising costs, and for this we've introduced the DirectInject system for Amazone trailed and self-propelled sprayers. A 50-litre neat-chemical direct-feed system provides quick metering of additional plant protection agents on demand. This allows a quick response to changing field conditions where a specific agrochemical may be required to be added or removed from the chemical mix.

At the push of a button, or through variable rate maps, a neat chemical is injected and mixed into the secondary circuit, with a reaction time of 30m. The treatment area can thereby be limited to where a certain pest is present, or applied chemical can be reduced near watercourses. DirectInject is available on UX 01 Super range of trailed sprayers which now includes tank capacities from 4600 to 9000 litres as well as the tandem axle, 12000-litre capacity machine.

Amazone's L3 boom has now been extended with the newly released 48m wide version, including newly developed SwingStopPlus as standard on all booms over 39m. SwingStopPlus is a further addition on the SwingStop technology which uses gyroscopic sensors on the boom tips to counteract and dampen any boom oscillation. SwingStopPlus can dampen both sides independently, resulting in the elimination of under and over spraying on boom tips as booms swing forwards and backwards, typically a considerable concern for larger boom widths.

Amazone's ContourControl boom guidance system is now also supported on the UF mounted sprayers. The fully automatic hydraulic boom guidance system with side-independent positive and negative angling has been available on Amazone self-propelled and trailed sprayers for a number of years. Now passed on to the UF range, it allows allows the boom to follow highly uneven topography yet still maintain an optimal distance to the target surface across the full working width, even on extremely hilly terrain.

Across the trailed and self-propelled ranges, AmaSelect smart individual nozzle switching enables additional precision with curve compensation for even dose rates across the boom even while turning. CurveControl achieves this by calculating the boom speed at each individual nozzle and automatically changing the nozzles or nozzle combinations to maintain dose rate and droplet size. This significantly reduces under- and over-dosing, especially along headlands and in areas of tight cornering, such as around telegraph poles.

At the Cereals Event this summer, we will be demonstrating the attributes of the AmaSelect system with row spraying, spot spraying and CurveControl.

FIRA FIRES UP ENTHUSIASM FOR **ROBOT TECH**

Written by Tom Allen-Stevens

The World FIRA event near Toulouse, France, brought together agricultural robotic enthusiasts from across the globe. Tech Farmer was there to spot the bots with promising potential.

With 35 autonomous solutions on display and demonstrated, more than 70 exhibitors and 2500 visitors, World FIRA (Forum for Agricultural Robotics) is gradually establishing its reputation as the world's largest exhibition of agricultural robots.

The three-day event, that took place at the beginning of February was its eighth edition (the second from the field), bringing farmers, scientists, investors, journalists, and robotics enthusiasts from over 50 countries to the Agrobiopôle near Toulouse, France. Organised by the Global Organisation For Agricultural Robotics (GOFAR), it runs in conjunction with FIRA USA, with the next event taking place on October 22-24, 2024, in Sacramento, California.

The fifth FIRA Scientific Workshop explored four of the challenges facing robotics, and in particular how it helps farmers meet agroecological targets. FIRA's first Hackathon tested the latest algorithms in a head-to-head problem-solving exercise to develop solutions for improving robotics safety. And start-ups got the opportunity to pitch to World FIRA investors.

At the heart of the show were demonstrations of autonomous robots, specifically designed for crops. There was a marked emphasis on kit for the European market, with plenty of innovations for vineyards, orchards and specialist crops. Row-crop growers had to search a little harder among the exhibits for credible autonomous successors to the tractor and implement. Nevertheless, a few solutions stood out in the triticale, garlic, bean and radish demonstration plots.

A star attraction was the **Robotti** by Danish manufacturer **Agrointelli**. It received the gold medal, voted by participants as Best World FIRA Robot. The new Robotti LR (Long Range) was on show, with the older 150D due to be phased out in 2024.

The key difference with the LR is that it has just one 72hp diesel engine, whereas the 150D has a gas-guggling pair. One engine has now been switched out for a larger 300-litre diesel tank, which means the LR can run non-stop for up to 60 hrs before refuelling.

The Robotti boasts a high on-wheel torque, improved hydraulics and a lifting capacity of 1.2t on its Cat 2 linkage. You can opt to have a PTO installed which gives you 540rpm at 14kW/18hp.

The 3t modular design allows you to vary working width from 1.5-3.3m. Typical tasks are seeding, weeding, ridging and spraying, with some of the K.U.L.T. kit ideal for the jobs, propelled autonomously at speeds up to 8km/h. The wider width and speed has come in as a result of the Bosch RexRooth-based hydraulic propulsion system, introduced with the LR in 2022.

The Agrointelli Robotti was voted as Best World FIRA Robot.

At FIRA, Agrointelli was keen to show off its latest advance: Control Tower – software designed to provide farmers with greater control of the Robotti's autonomous mechanism.

The Robotti has already been driving either in row-by-row scenario, grouped in several rows or in an optimised route-driving pattern. New patterns include "Coiled" as well as "Back and Forth", claimed to add stability, reduce tilting and side slip while driving, especially when working in vegetables grown in raised beds.

When using this pattern, both sides of the Robotti drive in tracks in the same state, so either both sides are worked or left out. Load-dependent planning allows you to optimise operations based on the capacity of the implement. It means you can specify the maximum area or the number of rows to be worked out, aligning with the available resources.

Also new is Subfield Management, allowing you to sub-divide fields with unconventional shapes and designs. Each subfield is given its own AB line, which means the autonomous driving aligns with field terrain conditions.

"Robotti Control Tower makes constant upgrades and improvements automatically while the machine is online," notes Ole Green, Agrointelli founder and CEO. "They're also available for most of our older Robotti versions."

UK farmers can now take advantage of the new precision farming actions available through the Sustainable Farming Incentive (SFI) points out Tom Beach of Autonomous Agri Solutions, UK agents for Agrointelli. "It qualifies for the £150/ha payment for robotic mechanical weeding," he says.

UK farmers can now receive £150/ha SFI payment for robotic mechanical weeding, points out Tom Beach.

The cost of owning a Robotti has now been made easier through the Robot as a Service option, which gives you the use of a Robotti with logistics support and full software back-up for £35,000 per year. "The cost in a 2023 pilot in sugar beet worked out at £70/ha per pass over 150ha for drilling and all the weeding – three to four passes," adds Tom. The robot's suitable for sugar beet and field vegetables, but "not quite ready" for cereals.

From the Agrobiopôle you can just about see the headquarters of **Naïo Technologies**, which is where FIRA began. Naïo is the natural host of the event, and the full family of its robots were on display to greet participants.

The one to watch is Naïo **Orio**. Launched in 2022, it's a seeding, weeding autonomous tool carrier. Orio is 100% electric with a 12kW battery kicking out a 20kW peak from a

The Orio is a seeding, weeding 100% electric autonomous tool carrier.

21kWh battery pack (32kWh from the HD versions). There are two widths, with the Narrow spanning up to 2.15m and the Large reaching out to 2.38m.

Orio puts the tool carrier on a three-point Cat 2 linkage arm with a 700kg lift in the middle of its chassis, which spans a total length of 4.28m. There's a range of compatible weeding and seeding tools, including the K.U.L.T. precision hoe, with an optional camera-guided sideshift to add auto-guidance to inter-row weeding. Sugar beet is the furthest into arable row crops you can take the Orio, with field vegetables, tree nurseries and speciality crops, including raised beds, where it's most at home.

Augmented Agronomy is how Naïo gives its customers the confidence to leave the robots on their own in the field to do the job at hand. Naïo technicians help you create the geofencing maps and teach you how to launch autonomous modes. This complies with CE certification with back-up LIDAR and bumpers in case an unexpected item turns up in Orio's working area. It'll then do its thing, on its own, traveling up to 5.5km/h for up to 10hrs on a full charge. Orio is priced at €200,000 (£171,000).

Just 1m wide, Naïo Jo is ideal for narrow and hilly vineyards.

Joining Orio in the field was the Naïo **Jo**, a compact, tracked autonomous bot that can do mechanical weeding on the row and inter-row, seeding, mowing, furrow tracing and carrying. Just 1m wide, it's ideal for narrow and hilly vineyards, and also has potential in speciality crops and orchards, running at a maximum speed of 2.2km/h for up to 12hrs on a full charge. "Jo was designed with the Comité Champagne as a machine to manage the narrow vines and really sharp U-turn bends in Champagne vines," notes Naïo marketing manager Flavien Roussel. It's priced at €100,000 (£86,000).

Also running in the field was the

Flavien Roussel says Orio is Naïo's most versatile machine.

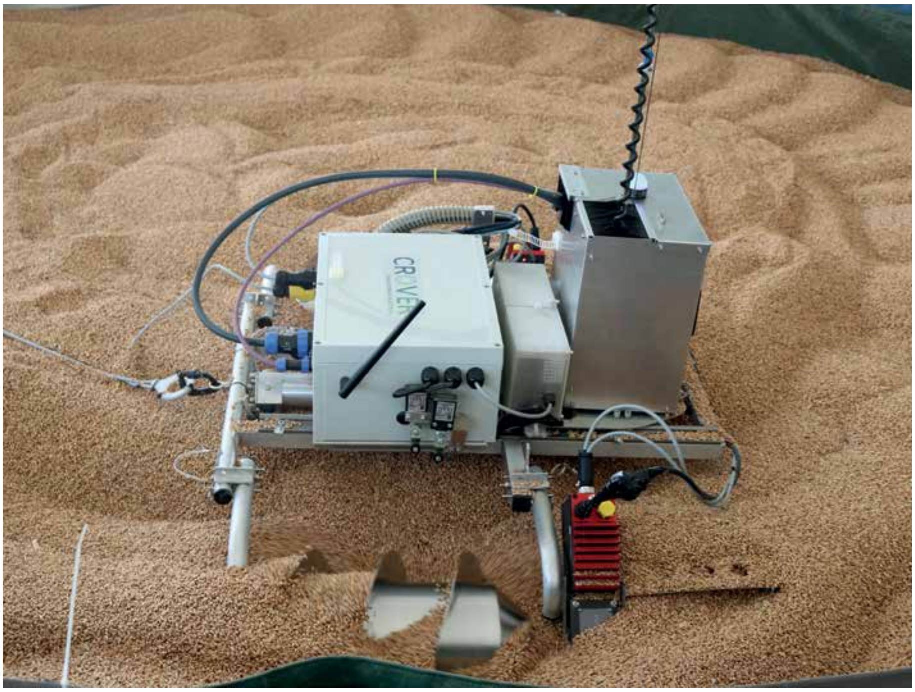
Naïo **Ted**, a specialist tool for vineyards that straddles the vine for mechanical weeding and cultivation. A 12kW drivetrain keeps it going for up to eight hours and will set you back €200,000 (£171,000). Then there's **Oz**, where it all started for Naïo, with over 300 units now sold. Weighing just 180kg, Oz has a tool carrier that can lift 60kg. It can seed, plant and mechanical weed for up to eight hours on a full battery charge, autonomously working off waypoints with obstacles detected through a pressure-sensitive sensor on the front. It's priced at €40,000 (£34,000).

Oz is where it all started for Naïo.

"Oz came about from demand by asparagus growers to reduce the labour burden. It's a tool for smallholders and nurseries with around 2.5ha. The first prototype attracted huge interest, and that's what got us started," recalls Flavien. Crowd-funding and a cash injection from the French BPI bank sped the start-up on its way, and it successfully raised a €32M round led by Mirova in November 2022.

The only notable Brit creation at FIRA was **Crover**. The grain-management tool has lost its curious rattle shape and no longer burrows into the heap. Now it's a bot that sits on the top of the grain, crawling along on two Archimedes screws with a probe, currently 1.5m long, although a deeper one is in development.

"There were a number of challenges with the burrowing Crover," explains



Crover no longer burrows into the heap but crawls along the top on two Archimedes screws.

the company's Gianlorenzo de Santis. "Navigating accurately was one of them and there was a lot of friction and drag."

The prototype is expected to be market-ready by the end of the year, and will be available to rent at £5000/yr or buy with its full web platform at £15,000.

The **Robot One** from **Pixelfarming Robotics** in the Netherlands drew a crowd. Fully electric, there's a 13.5kWh battery on board while three large solar panels keep it powered up. Robot One is a weeding tool, working on the principle of "Scan & Act". It uses 14 high-resolution depth-sensing cameras to create a 3D depth map of the field.

This is when it then gets interesting. The unit can be trained to detect specific weeds that are then targeted for treatment using tools mounted on up to 10 controllable arms that are independently adjustable in row. There are hoes that can be substituted for a streamer, rotor harrow or L-Bow, boasting 2mm accuracy along its 3.5m working width (5m for the Robot One L).

New to the Robot One is laser-weeding with up to 40 130W lasers capable of zapping up to 400,000 weeds per hour. Targeted at the organic and regen market and capable of working relatively large-scale, the Robot One is priced at €249,000 (£213,000).

Odd.Bot chose FIRA to unveil its new **Weader** that can be mounted onto any self-driving carrier. Twinned with weed-detection software, Weader can identify and precisely remove weeds within the crop rows, even in high-density plantings, without harming the intended crops. With a pull or a push, depending on the size and type of weed, each arm can remove up to two weeds per second.

The Weader can identify and precisely remove weeds within the crop rows.

Aimed at organic field vegetable growers, The Weader was developed in the Netherlands through a collaborative initiative with farmers participating in the Odd.Bot Trailblazer Program and Wageningen University.

German autonomous implement manufacturer **K.U.L.T. Kress** presented its new aiLaser at FIRA. The laser technology can control weeds in the immediate vicinity of the crop without affecting the soil structure from as early as the cotyledon stage. Optical sensors continuously capture images of the crop, with weeds identified through AI, which are denatured in a targeted way by the heat of the laser.

K.U.L.T. Kress' InRow eActuators work in between plants within the row to hoe the soil as close to the crop as possible.

The K.U.L.T. **iScan** module can also be used to control in-row weeds mechanically. The plant-recognition system analyses images to detect the precise location of crop plants. The **InRow eActuators** then work in between plants within the row to hoe the soil as close to the crop as possible.

Hoes on the Robot One's controllable arms can be substituted for a streamer, rotor harrow, L-Bow or even lasers.

BIG DATA – FARMING'S FRIEND OR FOE?

Written by Chris Fellows

Unlocking the potential of big data can lead to smarter farming, but there are complex interactions and challenges to navigate.

In the dynamic landscape of modern agriculture, the integration of big data technologies has revolutionized the way farmers operate and make decisions. Smart farming, fuelled by the inseparable relationship between production and consumption of data, presents both opportunities and challenges that necessitate a deeper understanding of its intricate dynamics. Addressing critical questions raised by farmers and practitioners is paramount to unlocking the full potential (and potential farm level profitability) of big data in agriculture.

The dual role of farmers: users and co-producers of data

In the realm of smart farming, farmers assume a multifaceted role as both consumers and co-producers of data. They harness the insights gleaned from data analysis to address real-time challenges while simultaneously shaping the information landscape through their management practices. This duality presents a unique challenge to the institutionalisation of big data, as every decision made by a farmer influences the quantity and quality of the data generated. Understanding the nuanced interplay between farmers' actions and data production is essential for fostering effective integration of big data into agricultural practices.

Big data isn't bad when it's helping you grow better yields, but just sending farm data down the supply chain carries with it risks.

Navigating complexity: farmers' adaptation to evolving data

Unlike traditional tools, big data are characterised by continuous evolution, with each action generating new insights and altering the nature of the tool itself. Farmers must adapt to this ever-changing landscape by developing new knowledge and skills to effectively harness the potential of big data. However, the increasing complexity of data analytics poses a significant challenge, raising questions about farmers' capacity to comprehend and utilize complex insights. Balancing the need for sophisticated data analysis with practical decision-making processes is crucial for enhancing the effectiveness of big data in agriculture.

Quality assurance in big data analytics

The exponential growth of data in agriculture raises concerns about data quality and reliability. While the sheer volume of data may seem promising, bigger does not always equate to better. Biases and inaccuracies introduced during data-handling processes can compromise the integrity of insights derived from analytics. Moreover, the transformation of raw data into actionable information adds another layer of complexity, influencing the accuracy and interpretability of results. Addressing the quantitative and qualitative aspects of data transformation is essential for ensuring the reliability of information provided to farmers.

Empowering farmers' decision-making

Big data analytics are often touted as decision-making tools that guide farmers towards optimal solutions. However, the extent to which data inform decision-making processes varies, with farmers interpreting and utilising insights in diverse ways. While data-driven solutions offer specific pathways for action, they may also constrain farmers' creativity and experimentation. Understanding the nuanced relationship between farmers and big data is essential for designing strategies that empower rather than restrict decision-making autonomy.

Ownership, privacy, and data governance

The collaborative nature of big data poses challenges regarding ownership and privacy rights. Unlike tangible assets like tractors, data lack clear ownership, leading to uncertainties surrounding data exchange and customisation. Farmers' reluctance to share data stems from concerns about privacy and the potential misuse of their information by external actors. Establishing transparent data governance frameworks that safeguard farmers' interests while facilitating data sharing is crucial for fostering active engagement and trust within the agricultural community.

Motivations and community dynamics

Exploring farmers' motivations and goals sheds light on the underlying factors driving their adoption and use of big data. Farmers' actions are influenced by a complex interplay of economic, social, and psychological factors, highlighting the importance of understanding individual and collective motivations. Moreover, the dynamics within agricultural communities shape the adoption and utilisation of big data, with diverse actors contributing to value creation and innovation. Collaborative efforts that integrate resources and expertise are essential for realizing the full potential of big data in agriculture.

Rethinking value creation and institutional arrangements

The distribution of power and value within agricultural communities is shaped by investments in technology, expertise, and resources. While big data providers play a pivotal role in data collection and analysis, farmers' active engagement in value creation is essential for fostering sustainable agricultural practices. Collaborative value-creation frameworks that transcend traditional hierarchies empower all stakeholders to contribute meaningfully to the agricultural ecosystem. Moreover, establishing clear rules and norms governing data use and exchange is vital for ensuring equitable participation and fostering trust among community members.

In conclusion, the integration of big data holds immense promise for revolutionizing agriculture and addressing global food security challenges. However, navigating the complexities of smart farming requires a holistic understanding of the interactions between farmers, technology, and the broader agricultural community. By addressing key questions and challenges, stakeholders can work towards harnessing the transformative potential of big data to create a more sustainable and resilient agricultural future.

A LIGHT SHINES ON
VERTICAL FARMING

In the second of a series exploring the technology of vertical farming, *Alessandro Oliveri* of igrox SRL looks at the influence of wavelength and LED efficiency.

Put simply vertical farming is regular indoor farming but instead of spreading out the growing areas across one plane the growing areas are spread up on multiple planes. This requires a lot less ground space and the increased density is a much more efficient use of indoor space. But it is not right for every plant species and can incur other difficulties.

One example of a hurdle to overcome is managing the thermals produced by such densely packed lighting. The only way to overcome this is by cooling the environment sometimes at great cost. One of the reasons why it is so important to use high quality efficient lighting. Generally speaking, the more efficient the LED lighting is, the less heat output it will produce per Watt of electricity consumed.

In the realm of vertical farming, where every square inch counts, maximising efficiency is paramount. One critical aspect that significantly impacts efficiency is the selection of the light spectrum. The spectrum of light utilised in vertical farming not only influences plant growth but also affects energy consumption, yield, and overall sustainability.

Choosing the right spectrum tailored to specific crops' needs is essential for optimising photosynthesis and promoting healthy plant development. Different wavelengths of light have varying effects on plant physiology, influencing factors such as flowering, nutrient absorption, and overall biomass production. Moreover, spectrum selection directly impacts energy efficiency. By harnessing the precise wavelengths of light required for optimal growth, vertical farms can minimise energy waste and reduce operational costs associated with lighting systems.

The spectrum's importance extends beyond mere growth stimulation; it also influences the nutritional quality and taste of harvested crops. Fine-tuning the light spectrum can enhance nutrient content, flavour profiles, and even shelf life, offering consumers fresh and high-quality produce.

Innovations in LED lighting technology allow vertical farmers to customise light spectrums with unprecedented precision, targeting specific plant growth stages. By harnessing these advancements, vertical farms can achieve higher yields, lower resource consumption, and greater sustainability.

In our experience there are no right or wrong light recipes in absolute terms, lighting systems and spectrum selection must be studied and optimised together with all the other technologies and strategies inside the farm.

For example, density of plants in the cultivated area and duration of the growing cycle has an impact on the spectrum optimisation, high density and long growing cycles require a different light spectrum than lower densities or shorter cycles.

With regards to energy consumption, thanks to the latest development in LED lighting technology and the manufacturers working side by side with farmers and growing facilities, high quality lighting systems offer huge advantages over lower quality budget options. To put that in numerical terms, the highest quality LED horticulture lighting manufacturers can help vertical farms produce up to 227g of fresh salads per kWh of energy used for lighting. This represents a great step forward in terms of sustainability and over double what a non-tailored spectrum or budget LED horticulture lighting product could offer.

By understanding and harnessing the importance of the correct light spectrum selection and by working with premium LED lighting manufacturers that use the latest technology in an ethical and sustainable manner, vertical farmers can unlock the full potential of their operations, cultivating healthy crops while simultaneously advancing the future of sustainable agriculture.

RESISTANCE IS FUTILE

Written by Mike Abram

Three start-ups are looking at new ways to deliver effective crop protection solutions that could overcome current resistance issues. *Tech Farmer* gets the insight.

Tiny carbon particles, not dissimilar to burnt sugar, could hold the key to a completely new method of delivering crop protection.

First discovered in 2004, carbon dots are extremely small spherical nanoparticles made from carbon, explains Dr Heather Whitney, a plant science researcher at the University of Bristol and co-director of CDotBio, a spin-out company aiming to unlock the potential of carbon dots in agriculture.

"There are various types of these particular nanoparticles, but the version we're using is basically burnt sugar. Whenever you cook food, or burn a carbon source, pyrolysis will lead to the production of carbon dots."

It's not quite as simple as just burning stuff to produce the carbon dots, she stresses. "What the chemists do is very precise, so you know exactly what you're getting out, otherwise you can produce something that isn't very good for plants."

Heather had previously investigated natural nanostructures in plants and their biological impacts.

"For example, if you look at a petal's surface it has textures. These are at the micro scale – around 100 micrometres in size, which is the sort of size that gives a tactile feel for a bee.

"But we also found that on the petal surface there are natural nano structures – another scale down. So the surface of a petal has individual cells – usually conical shaped – and overlaying each cell are striations and ridges. These are at the nano scale.

"And at the nano scale these ridges interact with light, so the petal surface can give rise to iridescence and structural colour because of the interaction with light waves," she explains.

That led to a PhD student, Dr Tom Swift, working at the Bristol Centre for Functional Nanomaterials, to start researching whether fluorescent nanoparticles could enhance photosynthesis in plants. "Obviously increasing crop yield and carbon capture is important," Heather says.

Helped by Prof Carmen Galan, who was making fluorescent nanoparticles for research into their biomedical properties at the university, the first type of nanoparticle Tom made were a disaster, Heather recalls.

"They were completely toxic to plants. But the next ones he made were carbon dots and he found these were both very effectively taken up by the plant and appeared to enhance plant growth."

Quite how and why these carbon dots improve growth is still being debated, Heather says. "There's a number of theories, which are all interlinked with photosynthesis."

One hypothesis is they might help optimise photosynthesis under high light levels. "Although plants use light for photosynthesis, if there's too much, something called photodamage occurs and the plant shuts down their systems. If that happens for too long, you're not optimising photosynthesis and the theory is that carbon dots could be helping with that."

But the more exciting discovery was that the plant will take up carbon dots in the process of taking up water, giving the potential for using carbon dots to carry a payload into the plant.

"This is when we started trialling using the carbon dots to carry small amounts of nucleotides into the plant leaf."

The reason for the trial linked back to Heather's research on iridescence in plant leaves, when she found that plants with this property were also genetically recalcitrant.

That means that the plant cannot be genetically transformed by any of the well-established methods of modification, such as using Agrobacterium tumefaciens.

"What was exciting is that when we tried using carbon dots to carry nucleotides into some of these genetically recalcitrant plants, it appeared to work in all of them.

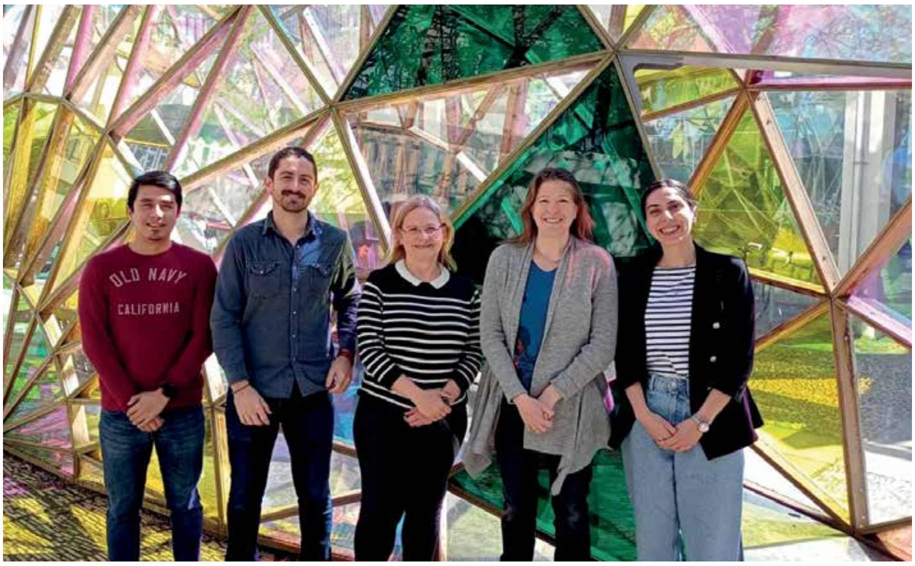
"We appear to have a system that can carry nucleotides into a mature plant using any method that can apply water."

That opens up a wide range of possibilities for the how the discovery could be used commercially, but the initial focus is to develop biopesticides, explains CDotBio's Dr Teo Garcia-Millan.

"There is an urgency to find new ways to treat or protect crops because farmers have lost a lot of tools to do that, and the situation is changing because of how our climate is altering.

"So we are focused on developing biopesticides that are selective for specific crops or pests without having any damaging effects to the environment and human health."

The initial target is to use RNA (ribonucleic acid) silencing to target specific Lepidoptera species – damaging pests such as fall armyworms, cotton bollworms and corn borers are in this order – with the US seen as a key initial market because of a more certain regulatory pathway, Teo suggests.



CDotBio is a spin-out company of University of Bristol aiming to unlock the potential of carbon dots in agriculture.

The principal role of RNA, which is made up of nucleotides like DNA (deoxyribonucleic acid), is to act as a messenger, converting the genetic information stored in DNA, into a format used to build proteins.

Researchers have found that it is possible to use that capability to also disrupt gene activity, by delivering a chunk of RNA, which instead of instructing a gene to make a protein, switches that gene off.

"We appear to have a system that can carry nucleotides into a mature plant using any method that can apply water."

"If you can deliver that in a way that a pest or insect takes it up, you can actually target a single gene in a single insect species and shut that gene down," Heather explains. "If that's an essential gene, it's an effective way of weakening or killing that pest.

"And because it is sequence specific you can make sure you are only targeting a single pest species, which massively reduces off-target effects."

Another advantage of the technique is that if the pest starts to develop resistance, for example by slightly changing the DNA code in the gene to switch it back on, it is possible to modify the sequence to potentially overcome the resistance.

It's not just pests that this technology could target – it's also possible that it could be used for weed control, Heather points out.

"A key challenge for farmer is that weeds, like blackgrass, are developing resistance to herbicides. The genes that cause that resistance are known, so potentially you can use RNA to silence the resistance genes, so those blackgrass plants are no longer resistant to herbicides.

"There is also potential to try combinations of ways of increasing the stress in a particular plant so that it can't cope with herbicides or help reduce the amount of herbicide needed," she suggests.

A key next step is getting the carbon dot technology registered as an inert material, initially in the US, with regulatory approval for any biopesticides delivered by the carbon dot likely the responsibility of partners developing that type of application.

"We're trying to create something which analogous to the Apple App store or Google Play Store," Teo says. "It's a platform to deliver the apps – the RNA silencing genes – to the plant.

"That type of technology is being developed by other companies, which is very exciting, and we want to help unleash this potential in agritech applications, including agrochemicals."

Moa Technology moves step closer to delivering new herbicides

New herbicides with novel modes of action discovered by start-up agricultural biotechnology company Moa Technology are set to begin field trials in 2024 in locations around the world including the UK.

The firm, which was spun out of the University of Oxford's plant science department in 2017 uses ground-breaking research by co-founders Prof Liam Dolan and Dr Clément Champion, to find potential new herbicides that can tackle herbicide resistant weeds.

More than 750,000 chemical and natural products have been screened using its high throughput Galaxy platform, which uses miniaturised plants to looks for unique symptoms, with around 60 new novel modes of action identified.

These miniaturised plants can only be seen through a microscope, says Dr Virginia Corless, Moa's chief executive officer. "We treat these with a chemical, whether a synthetic one made in a lab or a natural chemical from an organism, and use high content imaging to closely observe the symptoms we see in the miniaturised plants to get an indication of the mode of action.

"By understanding the symptoms we see from commercial modes of action available in the market, and using a much higher resolution of symptomology, we are able to quickly and efficiently identify chemistries that are doing something different," she explains.

"So in that very first step of screening, we're able to identify areas for further research that are likely to have a novel mode of action different from what is available today."

The Galaxy platform uses miniaturised plants to looks for unique symptoms, with around 60 new novel modes of action identified.

Moa's process differs from the approach used by agchem companies, which first looks for efficacy on larger plantlets in glasshouses followed by mode of action further along the process.

"With Galaxy we're simultaneously getting an indication of efficacy and novelty of mode of action."

Virginia Corless uses a higher resolution of symptomology to identify novel chemistries.

New modes of action are critical, she says, for overcoming resistance.

Once discovered the next step of the process is using a combination of genetics and lots of other data from tools that look in detail at what is happening at a cellular level, to crack the puzzle of what these new chemistries are doing, she says, helping to identify the target protein in the weed for the chemical's mode of action.

That early knowledge of mode of action helps both efficiently optimise identified compounds into better products and identify and address potential toxicity and environmental safety issues from the start.

The first raft of potential new compounds has successfully come through rigorous tests in glasshouses to begin field trials this year, with at least one in the UK with further sites in two or more of Europe, North America and Australasia.

"These will not only test weed control efficacy against appropriate commercial standards but also crop selectivity," Virginia adds.

While she was not prepared to say at this stage what those weed targets are, she says there is a lot of diversity within the firm's pipeline. "We are looking at both broadleaf and grassweeds, different timings of activity and all the different profiles that could be of value to farmers."

Commercialising what she describes as a diverse pipeline is likely to require a portfolio of approaches, she suggests, including partnerships with various types of partners at different stages of the commercialisation process.

"From our perspective, one of the most important things is continued stewardship and partnership of our products as they move towards the market. We believe the new herbicides we're discovering have the potential to make a big impact for farmers and for sustainability, and it's important to us that we continue to have a role in stewarding to ensure they do so as they move towards commercialisation."

Gene editing firm seeks to resurrect varietal disease resistance

When diseases overcome resistance genes in crops, that's usually the end of that gene's usefulness to plant breeders, who move on to look for another source of disease resistance to breed into a variety.

But Resurrect Bio, spun out of The Sainsbury Laboratory in Norwich, is looking to restore those resistance genes using gene editing.

"Our system is quite unique," says chief executive officer Dr Cian Duggan, "in that we initially bypass crop and pathogen experiments.

"Working with a crop is the real bottleneck in disease resistance trait discovery, as it takes a long time to grow, and then doing experiments with pathogens takes even longer.

"We bypass all of that using a computational biology approach to understand the relationship between the crop resistance gene and the pathogen, and then crucially use a model organism, which enables us to express a gene of interest in just a few days."

The team uses both to figure out which resistance gene is being defeated by which pathogen gene, and then uses gene editing to make changes to overcome that.

"In some cases that can be just one DNA base change, as was the case in our proof of concept against potato cyst nematode in potatoes."

Cian Duggan uses a computational biology approach to understand the relationship between the crop resistance gene and the pathogen.

The native resistance genes are then edited in the crop to do large scale trials, with Resurrect Bio striking licencing deals with breeders to bring the trait to market.

Initial targets for the technology are diseases in soybeans, including Asian soybean rust and yield-thieving soybean cyst nematodes, but the firm has built a platform technology that is capable of dealing with any crop, most pathogens and some pests, Cian says.

A FAMILIAR FIELD

Global FieldID is a way of harnessing data to create "Nature Intelligence", argues *Davide Ceper*, CEO of Varda, the company that created it.

The transition towards a nature-positive food system requires a good and enabling data exchange across the agricultural supply chain. To achieve this, it's crucial to establish trusted connections and the flow of data across the entire supply-chain, from farmers to businesses, all the way down to end consumers.

That's where Varda has set its stall, and this enabling is no easy task. Nor is it made any easier by the tools and processes currently in place. Data in the agriculture industry is extremely fragmented and while the role of technology in generating evidence on what is happening at field level has led to tremendous progress, siloed data, limited use of standards and concerns about data governance make the landscape very complex to navigate.

Only truly concerted action between all parties will be able to provide us with an agricultural system that not only benefits us all, but more importantly, benefits the planet.

Creating a public digital service

When businesses, academia, government, civil society and other groups work together, it can be a powerful force for driving change. It's very important to enable these different stakeholders to provide complementary information and solutions. When collaboration is done right, it can be transformative in taking on complex issues such as the food industry's transition to nature-positive. However, the agriculture industry is extremely complex and collaboration is often hampered by the lack of a "common language".

Imagine living in a town where every business, citizen, and public service provider names streets in a different way: it would be impossible to provide a unique address and do simple tasks such as receiving mail or arranging to meet. Rather than having a 'unified picture', everyone's knowledge of the space would be limited to their usual areas of interest and never beyond. This is exactly what happens today in agriculture. Each company maps the land in their supply-chain to provide services to farmers, or to invest in carbon offsets, for example, creating a 'multiverse' of overlapping mapping systems that describe the same land in uncoordinated and often conflicting ways.

This makes it impossible for stakeholders in the industry to effectively communicate and share actionable information (or 'intelligence', as we say) in a way that is compatible with other stakeholders and with farmers. While each organisation may have a piece of information, without a scalable and standardised reference system, data discoverability becomes extremely complex. Making the most out of agricultural data needs to begin with an easy-to-use system for all.

Fragmentation and data silos have been a key challenge for years. While many startups focus specifically on micro-level compatibility between different services, a broad, systematic approach that can cover the entire world is required to democratise access to data and create the conditions to mobilise climate finance for the transformation of the sector.

Global FieldID

This system was created to tackle the challenges associated with data fragmentation and provide a unified geospatial reference system for farm and field-level data. The service first creates a registry of field polygons at the national level, and then keeps track of subsequent changes in their shapes over time. By assigning a unique alphanumeric code to each plot of land, the Global FieldID system creates a simple way to transform spatial information into standardised codes. These can then be used freely by stakeholders across the supply chain, including digital farming tool providers, farmers, purchasing managers and more.

Available as an API and with an easily accessible user interface, the service seamlessly integrates with existing platforms, automatically syncing updates to fields across all linked Global FieldID applications.

Users can locate a field and know its ID by querying via specific latitude and longitude coordinates, an area of interest on the map, or also via their 'own' polygons (the application will return a matching score and assign the most probable ID or send an error message). Most importantly, since the database cannot be 100% accurate in describing millions of polygons, it is possible to add or modify the database by drawing or uploading new field boundaries.

Global FieldID is a foundational service for a future regulatory scenario where location information is going to be extremely relevant to document and report nature and climate-related impacts of supply-chains and to mobilise the required evidence from farmers and data partners. It is engineered to consolidate information from multiple digital farming tools, sensors, and external partners, into a unified dataset.

The service can also serve as a streamlined way to onboard farmers onto digital farming applications, by allowing them to upload or import their fields on a free service, without the need to define them repeatedly. By connecting existing tools with the API, the platform facilitates easy integration with farm management systems, enabling farmers and agribusinesses to exchange IDs without any change to their current workflows.

The common geospatial reference can be used for data sharing, therefore documentation of farming practices becomes easier and less cumbersome.

The difference in mapping fields across the world

The intricacies of mapping agricultural

fields vary across different parts of the world, reflecting the diversity in landscapes and farming techniques. In countries like the United States, the task is comparatively straightforward due to the presence of large, clearly marked fields. These extensive, regular plots are easily identifiable and can be mapped with distinct boundaries that are visible via satellite imagery. This clarity and consistency simplify the process of data gathering and field recognition.

In contrast, certain farming systems present a more complex picture. In smallholder markets with tiny land parcels or where tree crops are cultivated, for instance, the delineation of actual boundaries is much more complex. Mapping smaller plots with freely available remote sensing imagery can be challenging and may significantly increase the costs of providing and maintaining these services, potentially to unsustainable levels. Other factors like frequent cloud coverage may make the process complicated too.

This is where Global FieldID features become useful. The system's strength lies in its user-centric approach, allowing for alternative (including private) sources of data to be ingested, and users (farmers, agronomists, retailers) to modify and more accurately define their own field boundaries. By allowing users to delineate their own fields, the system ensures that each plot is accurately represented, considering its unique characteristics.

This adaptability highlights the significance of Global FieldID as a universal solution. It facilitates effective field mapping across different regions, accommodating the broad spectrum of agricultural practices and conditions. The capacity for users to contribute precise, localised data enhances the system's overall accuracy and relevance, building over time to what could become the most accurate source of agricultural-related location information.

The 'split-and-merge' functionality helps maintain accurate historical records of field geometries' evolution. Every change is carefully recorded to maintain an ongoing history of the land plots.

In essence, Global FieldID is a hybrid between 'Google Maps' and 'Wikipedia'. A universal tool creating de facto standardisation in geospatial reference systems to more efficiently and transparently enable data exchange in agriculture, leading the way for more climate finance, better services and cheaper access to capital for farmers that invest in regenerative farming practices, for example.

The bottom line

As a system based on network effect, Global FieldID's effectiveness depends on widespread adoption. As more farmers and organisations adopt the system, the chances for effective collaboration across the entire supply-chain increases. We believe that this will be key to transitioning towards a nature-positive food system.

For this reason, Varda and its parent company (Yara International) have decided to offer the service under a multi-stakeholder, not-for-profit consortium, to ensure it will provide benefits to all industry actors, in particular to farmers that are facing increasing pressure to comply with regulations requesting evidence about farming practices.

The consortium will be aimed at forming an 'Open Nature Intelligence Exchange' (ONIX), which will serve as a federated network comprising data and solution providers. Its purpose is to accelerate systemic agricultural transformation through the secure sharing of data among stakeholders at all stages of the value chain.

At the heart of ONIX's mission lies a goal to support the frontlines of food production - farmers - by mobilising more funds to aid them. There will be a difficult, and sometimes risky, transition to new farming practices, but it will be crucial to offer a new source of revenue through the data that is generated, as well as recognising their role as stewards of their lands.

Davide Ceper, CEO of Varda

THE TRAIT THAT COULD **TRANSFORM WHEAT FARMING**

Written by Tom Allen-Stevens

The discovery of a grass that makes its own antibiotics may have wide-reaching implications for restoring soil health and improving water quality. *Tech Farmer* considers the implications of the trait for UK wheats.

There's a type of grass that thrives in the tropical pastures of Colombia that confounded scientists for decades. Brachiaria has been dubbed as a 'wonder grass' for its ability to grow in soil that has negligible mineral nitrogen, and no means to sequester it.

Scientists at the Japan International Research Center for Agricultural Sciences (JIRCAS), led by Dr Guntur Subbarao, unlocked the secrets to this remarkable biological phenomenon. Now they've bred this ability into modern wheats – high-yielding elite wheat lines are currently in the field that produce the same yield and quality as their parent control with 40-50% lower nitrogen inputs.

Guntur Subbarao has been studying Brachiaria and its ability to grow in soil that has an almost complete lack of mineral nitrogen.

They've also shown there's a staggering potential for these curious crops to reduce massively the estimated 70% of nitrogen lost from soils and washed into the world's waterways. Most of this is applied as synthetic fertiliser – a global consumption of 150M tonnes that's responsible for 5% of total greenhouse gas emissions.

What's more, according to Guntur, farmlands are increasingly leaking out this overapplication of fertiliser. "They're leaking nitrogen uncontrollably. And if you can't keep nitrogen in soil you can't keep the carbon in either," he says.

So what is the secret to keeping nitrogen from being leaked out? Guntur explains it comes down to "a little bacteria" that lives in the soil and eats ammonium, that binds to soil particles, and excrete as nitrates by-product. "Many plants can use nitrates as a nitrogen source, but nitrates require more metabolic energy to assimilate, thus expensive for plants to metabolize compared to ammonium. In addition, another major problem is that nitrates cannot bind to the soil and wash out."

The Green Revolution, while it transformed global food grain production, has brought about a 30-fold increase in nitrogen fertiliser consumption. This, he says, has disrupted the complex microbial networks in the soil and changed their population dynamics. "These little bacteria that used to perform a small, subdued microbial activity, have grown now into a monster. It's consuming nearly 95-99% of the fertiliser nitrogen and spitting it out into harmful nitrates and nitrous oxide (N_2O) gas. We should question whether we are applying nitrogen fertilisers to feed crops or to nurture this monstrous nitrogen-eating bacteria."

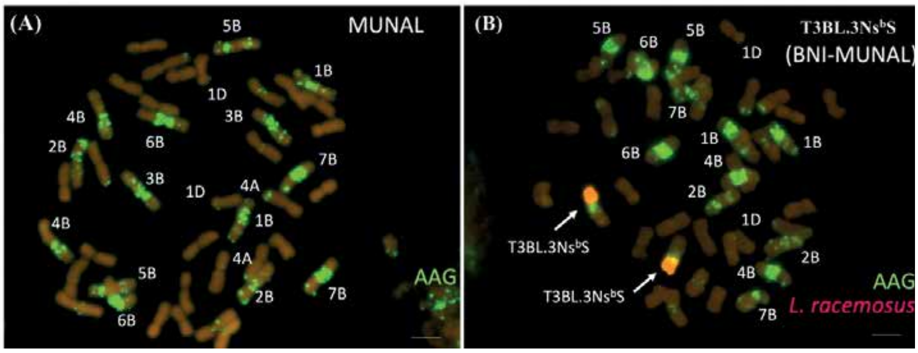
Guntur believes this has made soils of the modern farming systems increasingly sick. "When you are sick, you take antibiotics. And that is what we discovered about Brachiaria. It produces large amounts of antibiotics from its root systems. These antibiotics tightly control the nitrifying bacteria. It doesn't kill the bacteria, but just keeps them in a kind of coma state."

What the team at JIRCAS realised was that this natural Biological Nitrification Inhibition (BNI) allowed plant roots to moderate the conversion of N in the soil precisely to its needs. "The plants learn to use every picogram of N that's available."

The concept was introduced in 2006. "At first no one believed us – the plant-nutrition community tried to shut us down. We had to prove certain plants were exhibiting BNI," recalls Guntur.

"The big breakthrough came when we developed an assay that detected the presence of BNI. That allowed us to really understand the phenomenon – what controls it, how it is regulated and what makes it effective and stable in soil systems. We published what became a landmark paper in PNAS (Proceedings of the National Academy of Sciences of the USA) during 2009."

But then the funding for the research program came under threat. "So we set about exploring important staple crops such as sorghum, wheat, and maize for a BNI trait."



The chromosome arm that carried the trait was successfully transferred into a modern Mexican wheat.

The function was detected and characterised in sorghum in 2011. But the big goal was wheat and maize as they consume nearly 50% of the nitrogen fertilisers applied to farmlands globally. "We worked with commercial wheat lines from across the world, but couldn't find a single one that had a significant BNI capacity."

Eventually the team found two wild wheats with the BNI trait – Leymus racemosus and Leymus mollis. "We identified the chromosome arm that carried the trait – 3NsbS – and successfully transferred this into a modern Mexican wheat, Munal, in 2021."

"The plants learn to use every picogram of N that's available."

DNA analysis of rhizosphere samples has shed light on the effect of the Watkins lines on the soil microbiome.

And with this came another big breakthrough. "We thought the entire elite agronomic architecture of the crop would change, that we would need decades of backcrossing to take out undesirable traits from wild wheat that we'd introduced. But to our amazement, there were no detectable differences, apart from a high level of production of BNI. We even checked the production of bread-making quality."

This discovery has profound implications – it meant the trait can now be safely crossed into any modern wheat lines, without the need for genetic modification nor any novel genetics. To date there are five wheat lines that carry the BNI trait, including Borlaug 100, an elite-wheat variety from Mexico's International Maize and Wheat Improvement Center, CIMMYT, which has spearheaded the Green Revolution by developing high-yielding semi-dwarf fertilizer-responsive wheat varieties.

But Guntur believes the potential for the BNI wheats goes much further. Studies indicate BNI wheats not only suppress nitrification potential, but also reduce N_2O emissions, a major greenhouse gas emitted from farmlands. In addition, they alter N metabolism to improve its use efficiency in the plant and raise N uptake from soil organic matter under low N conditions.

"They perform in both high and low-fertility situations and in a few years from now, will be available to all farmers. Our hope is that in the next 10 years, most of the wheats grown in different parts of the world would have this ability built in as a core trait," he says.

"These large amounts of antibiotics from wheat root systems will bring a natural control to nitrifying bacteria and reduce the amount of nitrogen fertiliser applied in future. It'll improve the health of our soils, the state of our waters, and stop so much fertiliser going to waste."

UK introductions

Discussions are currently underway to bring the BNI wheats into studies at the John Innes Centre, Norwich, presenting the prospect of introducing the traits into UK commercial lines.

But they're not the only wheats that exhibit this curious ability to suppress the activity of nitrifying communities within the soil microbiome. Work has been ongoing as part of the WISH-roots project (Wheat Roots Improving Soil Health) to investigate cultivars with unusual rooting ability. Two in particular have been identified with nitrification potential and will be brought into farmers' fields for testing in a commercial setting.

The Watkins lines in the trial responded to the application of the fertiliser and immediately started to control the nitrifying microbes.

The project is a three-year programme of work involving a consortium of seven research institutes across Europe, China and South Africa. The aim is to explore the ability of the wheat roots to control the soil microbiome to improve soil health and optimise rhizosphere nitrogen cycling and availability.

Maria Hernandez-Soriano, shown here with a colleague, has been investigating historic wheat cultivars with specialised root traits for control of nitrogen transformation in soil

"Modern wheat varieties seem to have lost the capacity to control nitrification," notes Dr Maria Hernandez-Soriano, who leads the JIC team on the project. Field trials have been exploring the attributes of ten landrace varieties from the Watkins collection, along with ten durum wheats. "We've selected these Watkins wheats because previous studies have shown they are good at controlling nitrogen transformation in the soil."

The wheats have come from a collection of 826 cultivars, collected from over 32 countries around 100 years ago by AE Watkins,a civil servant who worked with the board of Trade in London . The collection is now looked after at JIC and their phenotypic traits and genomes are being explored through a number of ongoing projects.

"We've been studying rhizosphere soil samples collected from the 20 cultivars and analysed these for microbiome composition, using DNA sequencing, and potential nitrification rate using a novel nitrate-selective sensor."

Maria's been looking closely at the activity of two of the most prevalent nitrifying communities, Nitrososphaera and Nitroscosmicus archaea. These have become the biomarkers in the rhizosphere of modern cultivars following N-fertiliser application, to the detriment of other communities.

“The abundance of these microbes in soil dramatically increases when you apply ammonium-based fertilizers, rapidly turning ammonium into nitrate, which is highly soluble and easily lost to the environment through leaching or gas emission as nitrous oxide,” explains Maria.

“We’ve narrowed down ten Watkins lines that react to the application of the fertiliser. They immediately control the microbes and slow down that transformation.

“We have found higher N availability for plants and lower N microbial consumption in the rhizosphere soil across those Watkins lines, compared with modern wheat varieties. Two lines in particular stand out – Watkins 238 and 580.”

These two lines are now being multiplied up as part of a separate, £1M Defra-funded project led by the British On-Farm Innovation Network (BOFIN). TRUTH (Thriving Roots Underpin Total soil Health) is a three-year project during which farmers are work with scientists to understand soil and root health and improve crop productivity. On-farm trials will be carried out by Root Rangers, up to 30 progressive UK growers. They will receive training to study and sample wheat roots, with rhizosphere samples sent to JIC for DNA analysis.

“In the final year of the project, for 2026 harvest, the Root Rangers will each get the opportunity to grow one or both of the Watkins lines to see for themselves how they perform next to their farm-standard wheat. They’ll also study the effect on the rhizosphere of nitrogen application, to see for themselves the activity of the nitrifying communities and how the Watkins lines suppress it,” she says.

Previous trials at JIC have identified several quantitative trait loci (QTLs) or areas of the wheat genome responsible for the nitrification inhibition trait using crosses of Paragon and Watkins 238. The next step is for breeders is to incorporate this trait into current elite varieties.

“These wheats definitely have the potential to make a huge improvement to nitrogen use efficiency. The plant will regulate better fertiliser transformation and uptake and have more time to use it, rather than having these inefficient spikes. That could also mean a decrease in the amount of fertiliser applied and less losses to the environment – it’s a win on many levels,” concludes Maria.

The first half of the article on the work of Dr Guntur Subbarao at JIRCAS, was first published in Views on Agriculture, **www.viewson.ag**.

For more information on TRUTH, go to **www.truthproject.uk**

NO-TILL'S FUTURE DEPENDS ON **PRACTICAL TECH & REGULATION**

Written by Mackane Vogel, Assistant Editor, No Till Farmer

New technology in the world of no-till needs to be solutions-oriented in order to reach farmers in a timely manner

No-till farming, much like agriculture as a whole, has evolved a lot over the last several decades. From new machinery and technology to scientific solutions for weed suppression, there is always something new being introduced to no-tillers. But according to Robert Saik, an agricultural technology expert, he thinks that there is one major obstacle keeping new technologies from being smoothly implemented into the agriculture industry.

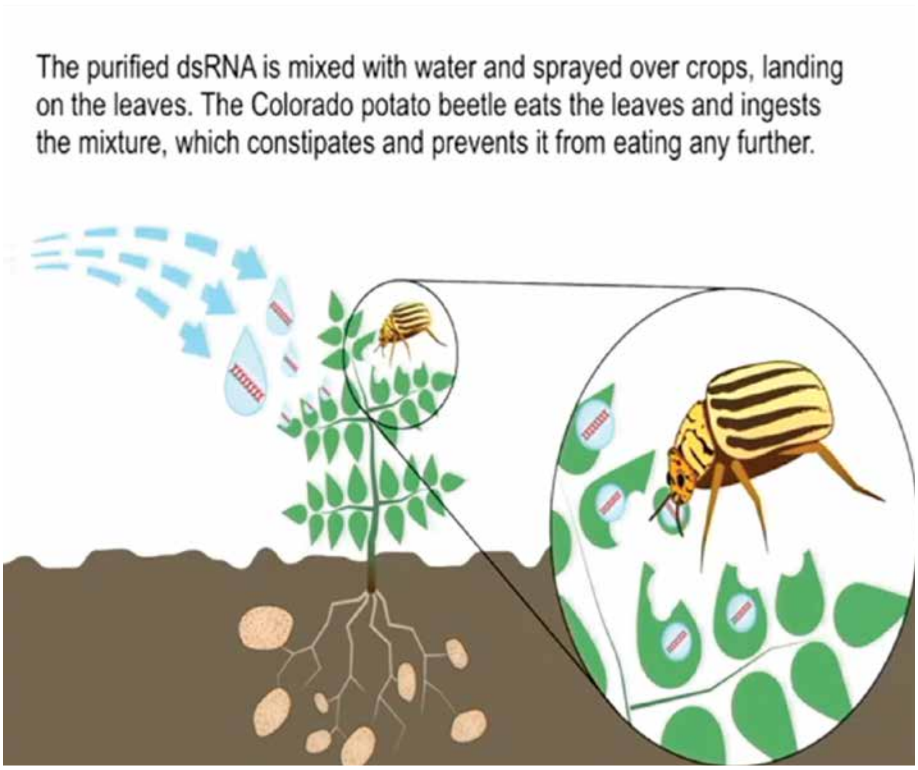
"It's called confi dence," Saik says. "Th e only way to get the confi dence level up is to talk to people who have been there and done that. I argue that the best expert to help your farm is probably somebody you don't know yet."

But Saik also believes that making no-till successful in the future is not only the responsibility of the farmer. He thinks that consumers and politicians also need to recog-nize their role.

"My main concern for the future of no-till and agriculture as a whole is the disconnection of consumers, and in particu-lar, politicians from the pragmatism of agriculture," Saik says.

One key trait that almost every farmer possesses, accord-ing to Saik, is the ability to adapt and change on the fl y. Saik believes this is crucial for the success of no-till in the future.

"People make mistakes in their career, but you learn from them," Saik says. "People seem to forget that we are pretty good at learning, unlearning and relearning in agriculture."



RNA MESSENGER TECHNOLOGY. Colorado potato beetles, Varroa mites, two-spotted spider mites, pollen beetles and fall armyworms are just a few of the pests that are current-ly being combated using RNA messenger technology. The graphic depicts how this technology could work to fight Colorado potato beetles.

Ag History

To understand where no-till is headed in decades to come, it's important to take a look at the his-tory of no-till and agriculture. Accord-ing to Saik, there are 5 main categories of agriculture's evolution: muscle, machinery, chemistry, biotechnology and convergence.

"The era of muscle was really just trading horse, oxen and human calories for food calories," Saik says. "It was a slow, laborious process usually involv-ing the tilling of land. Then kerosene and diesel fuel came along as well as machines. We're still in the machinery age. The machines are bigger and more advanced but that part continues on.

"Then came all of the chemistries that we used, and we start-ed to figure out how to control weeds and insects in different-ly. We're still in the chemistry age, but the chemicals we use are more precise now. And genetic engineering came after that. But today we live in an era of convergence, and you can't separate the technologies. And I argue that biotechnology and digital technology, machinery, remote sensing, computing power — all of it is coming together."

Saik says that because of all this convergence, it can be hard for farmers to keep up, and as a result, it can cre-ate what he calls "technology gaps."

"The things that our iPhones can do that we don't use them for, the things that your tractors and combines and sprayers could do that you don't use them for, those are some of the technology gaps," Saik says. "We can use our imagination to make new technology work for each individual's needs."

Technology as a Solution

Saik says while technology could provide solutions to reducing fertilizer costs and agriculture's environmental footprint, there are also government regulations as well as consumer stigmas that could get in the way.

"The future could be organic, but it would have to be genetically modified organic," Saik says. "Because the only way I see us being able to reduce a lot of the pressure that we have to fight insects and diseases is genetic engineering. Organic of the future would have to be genetically modified, or it could utilize technology. It could be geo-mechanically organic like robots or laser beams, but either way, it's GMO."

Specifically, RNA messenger technology is important in the world of agriculture right now. Colorado potato beetles, Fusarium, fall armyworms, these are all insects and diseases that people are working on right now using RNA technology. But Saik says it is important to make sure that the right kind of regulations are in place to allow people to start work-ing with these kinds of compounds.

Saik says that one of his main worries is that too many pol-iticians pass policies that may look OK on paper but are unrealistic and not pragmatic in the world of a farmer. Sri Lanka is one example. The country passed a law in 2021 that essentially banned the importation of synthetic fertilizers and crop protection products.

"At that moment in time, you were able to predict the downfall of Sri Lanka because tea production fell," Saik says. "They weren't able to trade tea. Foreign currency started to fall. Farmers said, 'There's no point in farm-ing anymore.' They haven't got the tools to farm."

Consumer's Role

Saik feels strongly that no-tillers can do a better job of embracing technology faster on the farm.

"Our current adoption rate is simply too slow," Saik says. "There's a lot out there and not enough making it to the farm fast enough."

But to help solve this problem, Saik believes it might be beneficial to think about crops from the consumer's stand-point. "Consumers will continue to demand convenience and transparency," Saik says. "They want transparency so they can build trust with the people who grow their food."

Part of the issue is that there are so many different labels on food products at the grocery store that it can be confusing and misleading for consumers.

We are pretty good at learning, unlearning and relearning in agriculture...

"Maybe a sustainability index would be better on food products," Saik says. "Maybe a consumer would be inclined to pay more money for a food with a higher sustainability index. I think this is where we need to go."

Saik's idea for a sustainability index on food would have a scale based on answers to questions about soil testing, use of slow-release nitrogen, crop rota-tion, soil health focus and more.

Keeping It Simple

Much of the latest technology is meant to help give farmers detailed reports on each of their fields and how their crops are performing, but Saik thinks it's pos-sible to give a farmer too much data. A large quantity of data can distract from the true problems in the field. Farmers and agronomists alike can be managing dozens or even multiple hundreds of fields at a time and simply want to wake up in the morning and know which field demands their atten-tion first.

"If you don't have good agronomy and apply it to precision ag, all you've got is poor agronomy precisely applied," Saik says. "Technology will tell a farmer where he has a problem and what the problem might be, but why is the problem there and how to fix it — that's going to be the realm of the human being for a long time."

Saik believes there needs to be a focus on the bottom line, and new technology and the world of "digital agriculture" should solve existing problems.

"Digital agriculture fits especially well into no-till," Saik says. "Digital agriculture fits into strip-till, cover crops, all of this because it reduces your environmental footprint. It makes efficient use of labor. And I think we're going to see more and more of that. At the end of the day, it's about dropping profit into your pocket. That needs to be the focus."

Fungicide performance trial (J Blake)

LEVY-FUNDED TRIALS HELP FINE-TUNE **FUNGICIDE CHOICE**

AHDB

AHDB Technical Content Manager Jason Pole explains the role of the fungicide performance information in choosing the best technology to protect crops.

About the tool

For 30 years, there's been a trusted team that's tested the efficacy of chemistry used to battle major crop diseases in the fungicide performance project. The wheat trial series is the oldest, going back 30 years (1994), followed by barley (2002) with oilseed rape introduced in 2006.

Fungicides can make big differences to yield, as illustrated by the yield-pushing protocols in the Recommended Lists (RL) trials. For winter wheat, the current fungicide-treated, five-year (harvest 2019–23) control mean yield is 11.04t/ha, which compares with 8.77t/ha for the fungicide-untreated control mean. Even varieties with relatively high levels of disease resistance, like KWS Extase and Mayflower, show a yield benefit of more than 0.5t/ha from fungicide treatment (on average).

Understandably, many farmers want to drive down input use to optimise return on investment. This is where fungicide performance data can help. It can be used to identify the best products and calculate appropriate doses – in the context of local (and frequently fickle) disease risks. Even if you delegate decisions to the agronomist, fungicide performance data can inform discussions to ensure the approach taken fits in with your farm's aims.

Trial background

To maximise treatment differences in the trials, the team selects high-risk sites and susceptible varieties to the target diseases, which currently are:

- **Wheat** – Septoria tritici, yellow rust, brown rust, and fusarium and microdochium
- **Barley** – rhynchosporium, net blotch, ramularia, mildew and brown rust
- **Oilseed rape** – light leaf spot and phoma

For cereal and oilseed rape trials, treatments are applied once and twice, respectively. Four doses are used to allow the creation of the classic 'dose-response' curves, which generally show how much more disease control and yield uplift is associated with higher doses. The curves also reveal the relative performance between products.

For cereals, the doses are quarter, half, full and double the recommended label rate (the latter improves the 'fit' of the curve but is not published). For oilseed rape, the doses are quarter, half, three-quarters and full (higher doses are not used in order to avoid growth regulatory effects).

Septoria trials

As the most damaging foliar disease of UK winter wheat, Septoria tritici has the most trials, with seven replicated trial sites in 2023 (shown in the table). Septoria fungicides are tested as either a T1 (GS32), T2 (GS39) or an intermediate timing (emergence of final leaf 2), with trials classified as having either protectant (P), eradicant (E) or mixed (M) activity.

Table 1. Trial site information (2023)

Site	Spray timing (activity)	Winter wheat variety
England (Herefordshire)	T2 (E)	Elation
England (Hampshire)	T1.5 (P and M)	LG Skyscraper
Scotland (East Lothian)	T2 (M)	KWS Barrel
Ireland (Carlow)	T2 (P)	Graham
Wales (Cardigan)	T2 (P)	Elation
England (Shropshire)	T2 (M)	LG Skyscraper
Scotland (Dundee)	T1 (P)	KWS Barrel

The full data spans several seasons. For example, the current over-year (2021–23) data for septoria control in a protectant situation is based on 17 trials (see dose-response curve example).

Fungicides tested in the septoria trials in 2023

- Arizona: folpet (multi-site)*
- Proline 275: prothioconazole (DMI/azole)*
- Myresa: mefentrifluconazole/revysol (DMI/azole)
- Peqtiga: fenpicoxamid/inatreq (QII)
- Vimoy: isoflucypram (SDHI)
- Ascra Xpro: bixafen + fluopyram + prothioconazole (SDHI + SDHI + DMI/azole)
- Revystar XE: fluxapyroxad + mefentrifluconazole (SDHI + DMI/azole)
- Univoq: fenpicoxamid + prothioconazole (QII + DMI/azole)

*Only tested at full dose in 2023.

Untreated fungicide performance plots at a Cereals Event

The project also compares new (pre-registration) active ingredients against established standards, which allows the rapid release of efficacy data when new products hit the market.

For the first time, the winter 2023/24 data included information on a new SDHI-based product called Vimoy (from Bayer, marketed as 'Iblon'), which has isoflucypram as the active ingredient.

Vimoy demonstrated broad-spectrum activity against

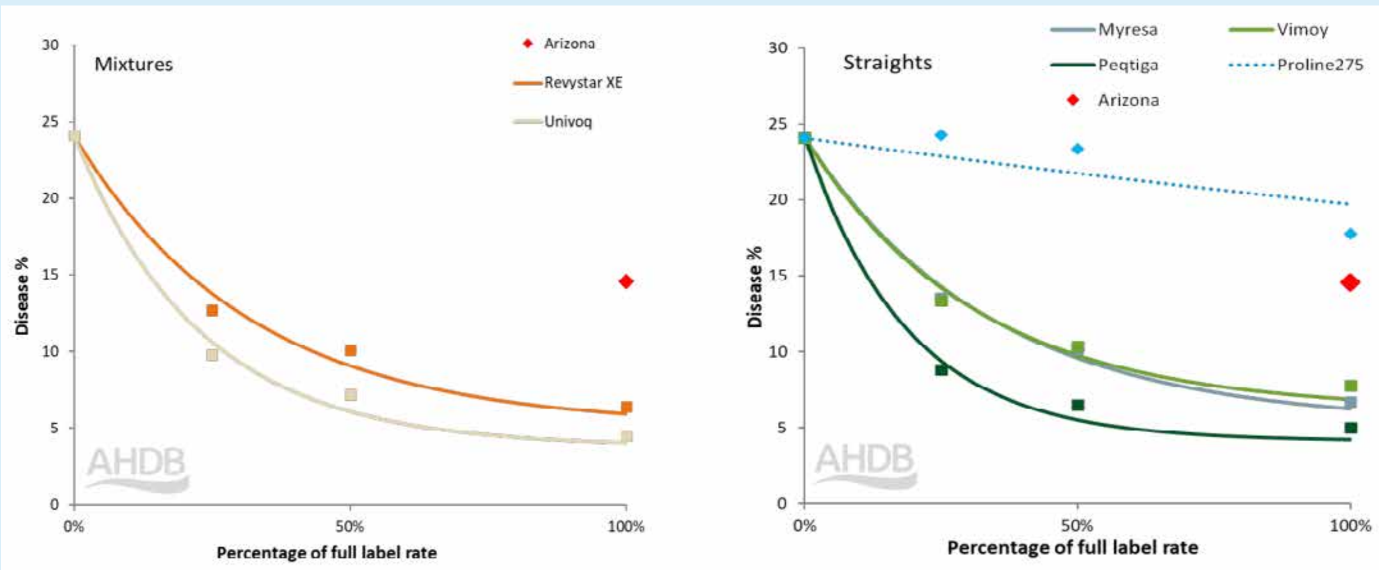


Figure 1. Septoria control: over-year (2021–23) fungicide performance data

the diseases evaluated. Using it in conjunction with prothioconazole is a good resistance-management tactic and may improve overall control, although no data on this was included in the latest data set. However, mixtures of active ingredients (rather than straights) gave the largest benefit to disease control and yield protection in these trials.

Septoria pressure swings

Last year provided a tough septoria test. Wet and cool conditions in spring boosted the disease in many areas – as observed in fungicide performance trials, RL trials and commercial crops.

In RL trials, despite the use of a robust fungicide programme weighted towards T2, the disease was commonly seen on the most susceptible varieties. In some trials, it looked like the disease could run out of control. However, the hot, dry spell in June helped to curb its development.

We used to try to keep disease below 5% in fungicide-treated trials. If disease was above this, the yield information would not have been used in the main data set. However, with today's chemistry, it is increasingly hard to keep disease this low and we were forced to rethink how genetic potential was assessed. We now include data from fungicide-treated yield trials where disease reaches up to 10%, even above this if the protocol has been followed.

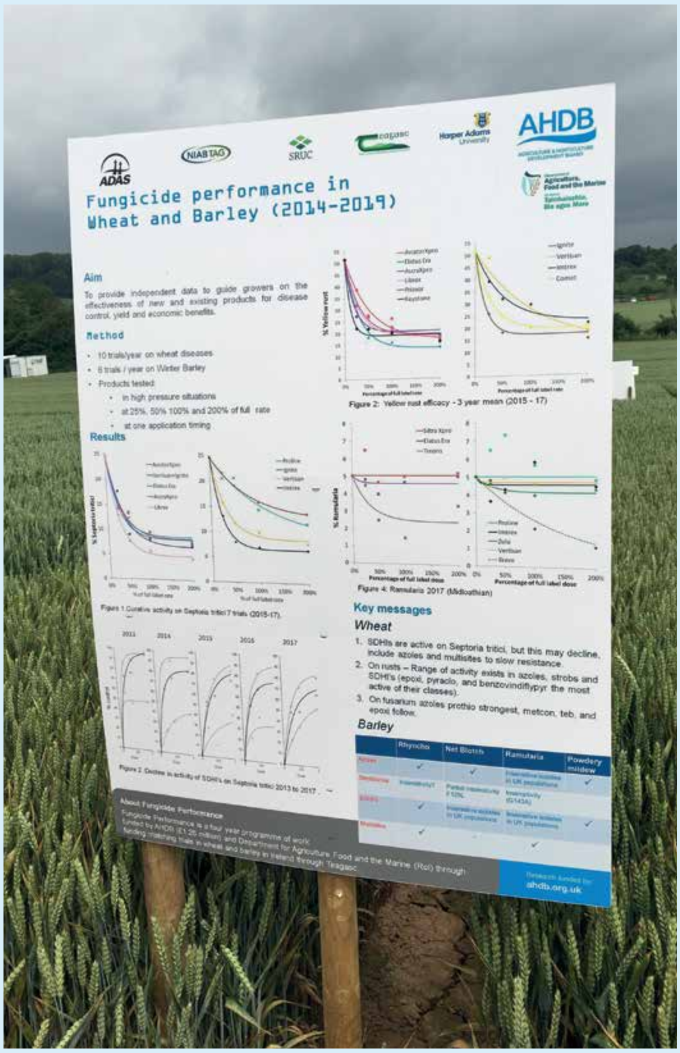
Despite the high levels of septoria in 2023, RL 2024/25 disease rating calculations take account of year-to-year differences in disease pressure, so the ratings held up well. This is good news, as varietal resistance is the foundation of disease control, helping to underpin less intensive fungicide programmes, especially in low-disease-pressure seasons. Recent on-farm trials, as part of the Strategic Cereal Farm network and ADAS fungicide margin challenge, show the best margins can be achieved with low-to-moderate fungicide inputs.

It's also worth noting that AHDB has commissioned work to provide more information on variety performance in lower-input scenarios, with the research due to report its findings in spring.

AHDB fungicide-resistance monitoring detected no major shifts in fungicide sensitivity in septoria pathogen populations in 2023. However, to continue to protect efficacy, always follow labels and resistance management guidance. It is particularly important to use a dose that will give effective disease control for the disease pressure and variety. Fungicide performance data can show where good levels of control can be obtained with lower doses and which ones need doses to be kept up. For resistance management, it is also important to combine septoria-active-fungicide mode of action groups across the programme and protect straights in mixtures.

Value for money

The AHDB sector plan for Cereals & Oilseeds (2022–2027) has scope to fund independent product testing, like in the fungicide performance project, if it is likely to provide a good return on investment. However,



Fungicide performance board at an ADAS-AHDB open day in Herefordshire (2018)

calculating such returns is a challenge for many research projects, including fungicide performance. The project's information is just one part of a complex decision-making process. Often, results arrive at the farm indirectly too (via an agronomist).

In 2021, AHDB commissioned an independent evaluation. The evaluators worked with farmers (150), all advised by independent agronomists, and identified a typical net yield gain worth £17.67 per hectare associated with a change to a superior fungicide product. With this figure in mind, it would only require positive fungicide decisions driven by this work on a few thousand hectares to cover the cost of the project (approximately £125,500 per year). It gave the AHDB Cereals & Oilseeds sector council confidence to continue investment in the project.

As part of the evaluation, telephone interviews (17) identified ways to improve the project. Generally, agronomists were relatively happy. AHDB works closely with agronomists because of their role in developing practical field-level recommendations. However, the focus on the agronomist may come at a cost, with a feeling that the project is too disconnected from farmers.

So, why not take time to connect with the latest data and talk through the results with your trusted on-farm adviser?

DATA-DRIVEN DECISIONS OPEN UP NEW OPPORTUNITIES

Bringing all the data together within a management system has allowed a Lincolnshire arable business to rationally assess new markets. Farm manager *Nick Young* discusses the changes with Agrii.

The 1200ha Holton Farms in north-east Lincolnshire is fully invested in precision farming technology. From automated guidance and yield mapping to soil texture analysis to variable-rate seed maps, these systems deliver a range of management benefits, believes farm manager Nick Young.

Bringing the layers of data together in a single program to enable management decisions that support the future viability of the business, however, has been central to unlocking the true potential of the information collected.

Nick reckons data in all its forms has been central to improving profitability. Its evaluation has helped determine the extent to which the estate should engage in the sustainable farming incentive (SFI) and consider how interest in carbon sequestration might come to be an opportunity.

Crop yield data is collected by the John Deere 790 combine harvester fitted with the firm's proprietary GreenStar system. GreenStar is also fitted to the farm's SAM sprayer while the fleet of CASE IH tractors use CASE's native program, AFS Connect. The tractors connect to the farm's two seed drills, a John Deere 750A and a Weaving Sabre Tine.

Apart from the yield recording capability of the combine harvester, which is a genuine form of data generation, both GreenStar and AFS Connect are designed to promote operational efficiency through automated guidance and section control. This may be enough for those who wish to save on fuel or crop inputs through reduced overlap. But Nick believes the insight to be harnessed from layering data from multiple sources will be central to accessing new markets such as carbon trading.

"Soils, and specifically management actions to promote and protect them, are a priority of the SFI with new actions set to be added to the list of options for 2024. It is not yet clear what will be required of land managers, but having good data on the soils that span the farm will make it easier to assess the viability of such actions be they under the SFI or Countryside Stewardship. The same applies to the hedgerow and buffer strip options while the addition of four new 'precision farming' actions under the SFI for 2024 is to be welcomed," he says.

Like many farms and estates, Holton Farms has many miles of hedgerows and ditches in need of maintenance. It also has a legacy of field drains that are coming to the end of their life.

Many of the these were installed in the 1970s and '80s and are now needing to be replaced. To fulfil this, a programme of works spanning 15 years will see new drains installed. Running in parallel is a two-year programme with a contractor operating a tree shear to clear overgrown ditches and dykes.

To bring all the data together for complete analysis, Holton Farms turned to Rhiza. The priority was to produce soil conductivity maps that would be the foundation of a move to variable-rate seeding. This is done within the rotation, but the aim is to scan roughly 150ha each year beginning with those soil types with a higher magnesium content. On non-mapped fields, Normalized Difference Vegetation Index (NDVI) and Green Chlorophyll Vegetation Index (GCVI) imagery is used to produce seed maps.

These maps are produced by David O'Donohoe, the Rhiza crop input specialist for the region, and sent via wireless connection from the Contour platform direct to the tractor console. "The maps are impressively accurate - more than once I've worried we'll run out of seed, but it hasn't happened yet," notes Nick.

Seed maps can also be adapted to reflect areas where rates are to be increased for other reasons, such as previously identified patches where blackgrass presents a challenge or on headlands where compaction might hinder establishment. Using the Rhiza

platform also makes life easier, he finds, and removes delays and difficulties in getting equipment to work together.

Having maps based on soil zones has become especially worthwhile. The soils at Holton Farms range from 93% sand through to some beautiful-to-work loamy clays. "When the drill operator, who has been on the farm for 43 years, tells you the system is not just easy-to-use, but also worthwhile it is immensely reassuring. Aside from the saving in seed costs, the crops develop far more evenly. To the operators, this is highly satisfying."

From a management perspective, Nick believes one of the main advantages of the Contour platform is that it serves as a single point for data analysis. "Being able to layer soil maps, field boundaries, satellite imagery and both NDVI and GCVI makes analysis easier and more complete.

"Through the Contour platform we also produce variable rate fertiliser maps based on soil analysis for nitrogen applications in sugar beet and nitrogen and phosphate at drilling in oilseed rape. The assessments so far, suggest it will be less worthwhile in combinable crops, but that may change."

The contrasting soils and the irrigation capacity needed to sustain them are the basis for the cropping rotation.

On the lighter soils, the rotation typically comprises six crops: winter barley – oilseed rape – rye – carrots – spring barley – spring beans. The rye was introduced in 2021 as an alternative cereal and for its suitability to lighter soils – at 300 litres per tonne of grain produced its water requirement is typically 25% lower than that of wheat or barley. While it does well, it may be that the area is reduced to make way for forage maize which brings management advantages through time savings and a later harvest.

On the heavier land the intention is to have 200-250ha of winter wheat, but this is weather and rotation dependant.

It is on the lighter land that soil scanning and testing is proving especially worthwhile, says Nick. "The SFI offers several options whereby the focus is on improving organic matter content; we are already applying large quantities of organic amendments in the form of manure, compost and digestate, so having data to hand that supports the SFI's objectives is to the benefit of our application."

Like many other farms, Holton has its share of small fields – the average field size is 12 ha – and while the temptation is simply to take the smallest or most inaccessible fields out of production, there are other considerations. Yield maps help to inform such matters. Beginning with the least productive parcels of land or those in need of remedial work, such as addressing compaction or where drainage needs attention, the intention is to place this land into the SFI.

Exploiting the opportunity presented by the SFI and HLS is an objective for the farm. "Like many other holdings, there are parcels of land that for one or more reasons are not worth farming in the current climate. The most suitable course of action in such circumstances is to take them out of production. Placing them into an environmental scheme that offers financial compensation for doing so, is the logical option."

The precision farming tools adopted over recent years are central to identifying these land parcels, beyond the obvious array of small or out-laying fields. Unproductive headlands, field corners and the like all up for consideration.

Quality mapping data has also helped Nick appreciate the effect of one particular threat to production: compaction. "It is the biggest impediment to performance at Holton, but its presence is not always obvious from a height of six feet."

In many respects, compaction is unavoidable and efforts to correct it often conflict with how the farm seeks to manage and protect its soils. "Using the RHIZA Contour platform, it was possible to assess the impact on crop performance and determine the cost to the business. It quickly became clear that correcting the issue would more than pay for itself and, consequently, the cultivation regime has since been amended."

Under pressure to cut costs, protect soils and store carbon, the farm moved to a direct drill approach wherever possible. This has worked well so far, but with sugar beet and other root crops in the rotation and large quantities of muck applied, the plough remains a vital piece of equipment.

Balancing this dilemma means ploughing is limited to where it is needed to bury muck. This is normally ahead of sugar beet, but is otherwise avoided, especially on the sands due to the risk of wind blow. Where autumn land is not ploughed, a Sumo Trio with or without discs to a depth of 200-250mm is the extent of the cultivations.

All of the above reflects the pressure to cut costs while maintaining output and promoting the environment that many others across the industry face. Where Holton Farms differs from some is perhaps how it has chosen to employ technology in a bid to achieve these ambitions. It also reflects a view of how the regulatory landscape is changing and the opportunities this may bring.

Nick highlights the SFI as an example. "We've generated a lot of data mainly in the form of visual assessments such as yield maps, soil texture or aerial imagery. These have been used to support both variable seed rates, identify underperforming areas in need of attention, and parcels of land suited to environmental schemes," he notes.

"And it probably won't stop here. The SFI is likely to be just the first of a series of policies that seeks to encourage farmers to change behaviour. Large consumers such as Nestlé, PepsiCo and General Mills have either introduced or are developing policies that pay for much the same type of activity as the SFI, but in a more targeted manner.

"The data captured so far will be central to determining interest in such schemes should the opportunity arise, but more will be needed to demonstrate their value to society."

The emerging market for carbon is another case in point, reasons Nick. "The capacity of soil to store carbon for the long term is currently the subject of great debate and there is open disagreement about the methodology employed to calculate it, but such issues will be resolved. Of less debate, is that this carbon is likely to be of increasing interest to consumers although it is less clear how as an industry, we can profit from this."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volodrone-and-john-deere - future precision application trials

PRECISION FUTURE FOR **PESTICIDE APPLICATION**

Precision application techniques enable farmers to deliver products more effectively and with greater accuracy onto intended targets, says *James Thomas*, Syngenta Head of Precision Agriculture EU+.

Rapid adoption of precision application techniques gives the potential to get a better result from every gramme of active ingredient in the field, and reduce the risk of any active finding its way out of the field and into the environment. Both those objectives make absolute sense, for the farmer to achieve a better result in economic yield and crop quality, and for wider ecological protection.

Across the EU there has been a stated position to see a 50% reduction in pesticide use by 2030. While the UK is no longer bound to abide by the EU legislative framework, there will inevitably be some consensus in common standards and conditions. Although recent reports of farmers' direct action in the EU has seen some publicised watering down of political proposals and omissions of immediate pesticide targets, in reality those pressures are not going to go away.

There is a wider societal desire for reduced reliance on pesticide use. Growers can respond by looking at ways to implement changes as quickly and effectively as possible that will demonstrate continued capability for productive agriculture, within the constraints of the tools available.

Environmental protection is higher on the agenda and more rigorously policed than ever. More sensitive testing can now detect residues in food and the wider environment at infinitesimally small levels. While the science may say that level of exposure is of no consequence, inevitably the drive will be to see zero tolerance of

Optimising sprayer set up and nozzle selection first step in precision application detection.

Precision application techniques have the potential to help growers to meet the primary challenges of regulatory measures, including reducing spray drift and its impact on off target crops or features, such as water courses and environmental areas; mitigating the risk of point source contamination during the filling and operation of sprayers; preventing exposure of operators during application and cutting potential for residues in food products to a minimum.

Mapping & set up for precision application

Adopting precision application technology will also enable growers to radically change their approach to crop agronomy. Historically the approach to any weed, pest or disease issues has primarily been a broad-brush blanket approach to treating the whole field the same. Now, a combination of advanced monitoring and detection, with precision application techniques can enable targeted application only when and where the challenge presents. That offers huge potential to reduce the overall level of product use - thus meeting legislative obligations for reductions, along with lowering production costs and improving efficiency.


Syngenta optical spot spraying trials to target grass weeds in pasture - Ireland 2023

It also opens the exciting potential for new products designed specially for targeted application that could never be economically viable on a broad-acre field application basis.

The potential for precision application is two-fold – to protect the chemistry that we have for longer within the regulatory framework, and to potentially enable more new products to be developed.

Increasingly new actives are being introduced with either a reduced number of applications or lower rates of application permitted. With only one or two applications, it becomes even more important to target treatment more effectively. Precision application techniques have shown the potential to deliver the same, or better, results, from significantly reduced active ingredient use.

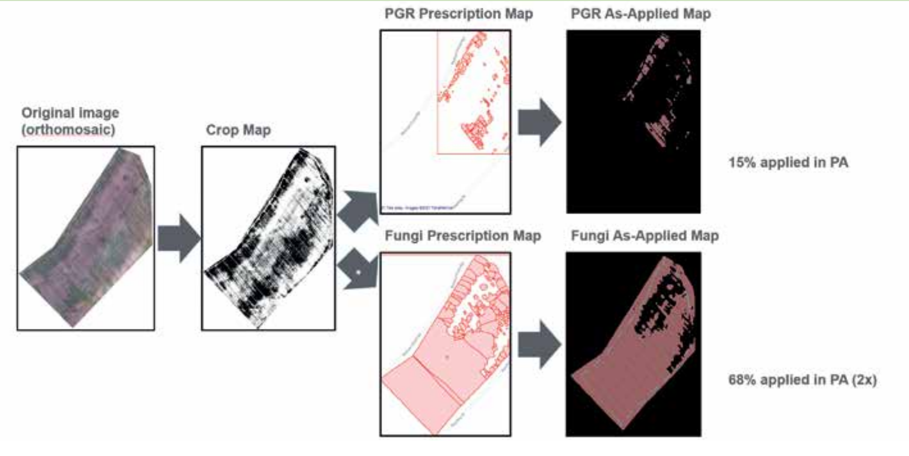
The future also holds the introduction of more biological products, for use in their own right or as integrated strategies with conventional pesticides. Precision application also has an essential role in the development of biological products. With the extensive trials and Syngenta R&D investment with biological products, it is understood that the results require more nuance and as a result the outcomes can be less consistent than with traditional CP products. This further emphasises the importance of accurate and timely applications.

The first step to precision application, which doesn't require any great investment or new technologies, is getting the basics right with the farm equipment currently being used and integrating optimum ways to deliver products, including nozzle selection; water volumes; adjuvant formulation technology and sprayer set-up.

Within Syngenta, the R&D investment is looking at precision application technologies that will meet objectives for growers to improve productivity, while also fulfilling regulatory objectives. The primary focus areas within that include weed control, including grass weeds in cereals and clean seedbeds; insect pests in high value vegetable and fruit crops where losses can be catastrophic and disease control including open field crops.

When we start to look at more


Syngenta trials for inter-row precsion herbicide application in cereals



Prescription mapping for variable rate application in oilseed rape

specialist developments in precision application, there are a number of approaches that can be taken to better target treatments, compared to broadcast spraying.

The first technology that has been established for many years is band application, where the spray is just focused on a specific defined target area within the field, be that directly on the crop plants for a pest or disease, or the soil between the crop with a strip herbicide, for example. Band application works extremely well in row crops, such as vegetables or sugar beet and typically offers 40-60% reduction in spray use. Camera operation to ensure accurate row following can fine-tune targeting, but is always limited by relatively slow work rates, typically less than 8 km/hr.

In Syngenta trials for cavity spot control in carrots, for example, the band application of SL567A fungicide achieved the same levels of disease as overall treatment, with up to 40% reduction in fungicide use.

The next stage would be prescription application, looking to adjust the appropriate amount of a product applied on an area defined by a pre-generated pattern, more akin to variable rate seeding or fertiliser applied to the crop, but adapted for crop protection spraying.

New uses for crop protection rely on detection and treatment algorithms, which can be successfully generated on a field scale by satellite or drone, to create a prescription map. The process is relatively simple, but in practice has generated some significant challenges. The human eye and agronomists skills are incredibly adept at detecting issues in the field, compared to digital imagery. Artificial Intelligence has come on leaps and bounds, but still lags way, way, behind in terms of accuracy.

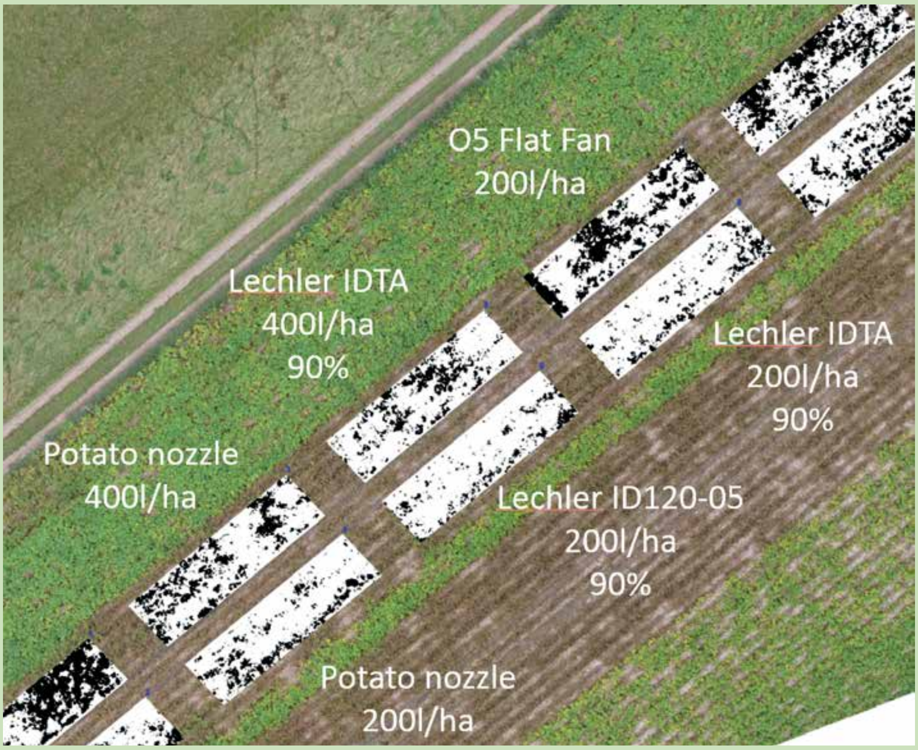
The other challenge is the technological interface between the digital mapping interface and the application equipment, which in many instance is hugely complicated. Actually getting system to deliver desired results is also being compromised by limitations for controlling existing sprayers – if the map wants to treat one small patch, but the sprayer can only be controlled in boom sections, the precision potential is being seriously compromised. Smaller sections, or individual nozzle switching does give the granularity to put the technology into practice.

Direct chemical injection systems overcome the limitations posed by tank mixes in enabling successful variable rate applications, while pulse width modulation (PWM) technology does enable far better integration for variability while retaining droplet spectrum to optimise product performance.

In Syngenta trials in oilseed rape, the technology did enable up to 85% reduction in PGR treatment and 30% saving in fungicide use across a mapped field, offering significant savings and better matching the state of the crop.

Thirdly prescription banding integrates both technologies, to only place a spray application around where a seed or plant is growing in a closely defined target area.

Finally, within the realms of current technologies, bringing the best elements of precision agriculture together into optical spot spraying that offers the same advantages in a



Syngenta nozzle trials for precision application in potato desiccation completely dynamic and autonomous decision-making system operating in real time.

The principle of using sensors mounted on the sprayer to detect targets in the crop, and transform that information to switch on or off the nozzles, can give ultimate control. There are already a number of businesses starting to utilise the technology and, for some crops and some targets, it is working well to deliver savings in excess of 80%.

The challenge, as with prescription mapped systems, is with generating the algorithms to reliably drive the technology. Where there is clear differentiation between the target and the non-target, such as clumps of grass weeds in a stubble – or green on brown – for example, it can deliver excellent reliability at high speeds and efficiency, particularly in areas with low or patchy weed populations.

Syngenta optical spot spraying trials to target grass weeds in pasture - Dorset 2023

Drone technology potential for futire specialist precision application

In Syngenta trials for green-on-green optical spot spraying, however, while the sprayer technology and nozzle switching has undoubtedly shown promise to target specific weeds and reduce overall product used, the software and algorithms have yet to prove sufficiently reliable and consistent in field operation.

The concept of being able to better target specific weeds in grassland, for example, has enabled the control of yield robbing docks, thistles and nettles, while leaving desirable clovers and herb-rich pastures. At the same time up to 60% reduction in product use during standard field-scale sprayer operation offers significant savings and compliance with dairy farmers' customer demands for more sustainable farming practices.

There is a lot of talk about drone application in the sphere of precision application. It does have certain benefits and potential uses, including removing risks to operators in complex situations and giving access to difficult or dangerous positions. In specialist agriculture and amenity sector the technology may offer significant advantages and attractions. The technology will be able to make use of optical spot spraying innovation as it develops, but with the need for miniaturisation down to on-board drone scale. However, for broadacre crop, and certainly within the current legislative framework, drones are unlikely to feature without significant future investment.

Precision application developments continue to move at a fast pace. Each iteration is more reliable and offers greater advantages. The challenge for growers is often at what point to adopt the technology and which options to invest in that will be future proofed for the farm business.

But the direction of travel towards more precise techniques that allow better target application is essential for the efficiency of farm production. And with better targeting comes the chance to meet regulatory objectives, that will assure future product availability.

James Thomas - Syngenta

WHAT IS **AGRI-TECH** AND HOW CAN IT HELP **ACCELERATE GROWTH** IN THE UK'S AGRICULTURE SECTOR?

Written by Phil Bicknell, CEO of Agri-Tech Centres

The importance of soil health for holistic, regenerative and sustainable farming practices is increasingly well recognised; healthy soils promote good carbon sequestration and biodiversity outcomes, and there are brilliant agri-tech innovations that can boost sustainable production.

Agri-tech is revolutionising production and productivity and offers opportunities in every type of agri-business across the entire supply chain. From finding solutions to climate change challenges and issues around disease prevention and labour availability to boosting productivity and profitability. The term 'agri-tech' now covers an extensive range of innovations that span far further than farm-focused machinery drones and spreadsheets.

From robots picking produce in nurseries to overcome labour issues, to biotechnology improving our crops' health and alternative proteins, the transformational impact of technology – agri-tech – on agriculture and the wider agro-industrial is vast.

A huge area of agri-tech is the ability to provide farmers accurate real-time insight on their business. From soil health and quality monitoring, to affording the opportunity to forecast and predict yields. The Agri-Tech Centres are looking at technologies that enable this under one of our strategic theme of 'Intelligent Agriculture' an area that utilises data, remote sensing robotics and AI, to enhance and transform current agriculture practice. In a recent project with AgriSound and a Dorset farmer we were able to use a combination of artificial intelligence and bioacoustics sensors to collect data 24/7 to establish a biodiversity baseline of birds and pollinators across the farm. Another great example is working with new novel chemical free weeding robotic developers Earth Rover in developing and trialling their concentrated light autonomous weed and scouting robot that uses AI and satellite enabled technology to identify and eliminate weeds. Both examples of intelligent agriculture being used to support sustainable farming.

The Agri-Tech Centres are creating greater cross-sector working opportunities and systems-wide approaches to agri-industry challenges, with thriving soils being fundamental to the overall health of the agri-system and food production.

The role of livestock and soil in the global carbon cycle is also well recognised in agri-tech innovation was to the fore in CIEL's Net Zero & Livestock report, "Bridging the Gap", a guide to informing and accelerating new innovation which will enable progress on the road to net zero. The report highlighted innovative approaches to optimise soil carbon sequestration and remove carbon dioxide, such as multi-species swards, forage crops and the potential for biochar application, as well as the research needed to support the development of some of these technologies.

Finally, adoption is a key part of the merging Agri-Tech Centres' vision and future work areas: in becoming the UK's largest dedicated agri-tech organisation we shall accelerate adoption rates by supporting co-developed solutions, de-risking technology, demonstrating benefits and collating and disseminating evidence to inform adoption investments across the sector; We.

The opportunities for agri-tech innovation across the agri-industries supply chain are limitless. Scientific research and the development and deployment of technology-driven innovations are having a significant impact on the productivity, profitability and sustainability of businesses across every area of the agri-industries.

To capitalise on this opportunity we need a unifying force to generate greater cross-sector working across agri-tech's wide-ranging ecosystem of agri-tech start-ups and scale-ups, established agri-tech businesses, academics and scientists, investors and end users.

This is why I'm delighted to be leading the newly merged Agri-Tech Centres at this critical juncture. We will create the largest dedicated agri-tech organisation in the UK, one that the entire agri-systems supply chain can trust for leadership and guidance on progressing transformational change that benefits humanity and the planet. By taking a systems-wide approach to the many challenges in the agri-industries sector and nurturing cross-sector collaboration, we can provide a major boost to agri-tech innovation. We can connect agri-tech innovators and businesses to world-class knowledge, funding, expertise and facilities that will save them time and accelerate the progress. We plan to drive responsible agri-innovation at unprecedented levels, securing society's supply of food, fuel and fibres and stimulating economic growth for the UK and beyond. If any of this has grabbed your attention, get in touch at **info@agritechcentres.com**

Phil Bicknell, CEO of Agri-Tech Centres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THE VITAL ROLE OF HUMUS

After a wet winter, *Steve Holloway*, Soil Fertility Specialist with Soil Fertility Services, considers what can be done to breathe new life into sad soils.

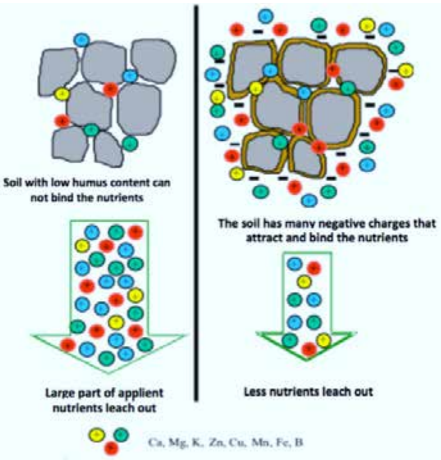
When soils sit wet over extended periods consequences can arise, including the development of anaerobic conditions in the soil.

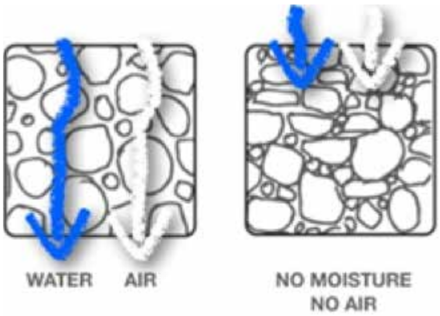
This is because water-logged soils lack sufficient oxygen supplies to allow the beneficial aerobic micro-organisms to support healthy plant growth. This can lead to a decline in soil fertility and nutrient availability. Additionally, prolonged wetness contributes to a decrease in soil temperature.

Colder soils can impede seed germination and slow down root development, affecting the overall growth and vigour of these crops. This reduced metabolic activity can also limit nutrient uptake and photosynthesis, further compromising yield potential.

Imagine how much more productive your soil would be if it could hold onto water in drier times; what if the soil "sponge" was large enough to soak up excessive rainfall, limiting the standing surface water - and what if that sponge could also hold onto more nutrition for the growing crop that could be used in times of need?

It's worth considering the different holding capacities of soil constituents for water and for nutrients. If you flattened out the same volume of sand and clay, sand would cover a dining table while clay would cover about an acre.





Humus, however, has over four times the surface area of clay and can also hold up to 90% of its weight in water. These qualities underlie its importance, which is why we should be improving its levels in the soil.

Humus is the result of things rotting down; it cannot decompose any further. It acts as food for soil dwellers and performs much like a soil glue, creating stable aggregates, and ultimately, will be the "biological buffer" in times of hardship. So how do we begin to build this safety net?

It might be easier to consider what destroys it: Excess tillage and fertiliser can effectively burn off organic matter by speeding up its breakdown process, thus creating a less stable form of carbon. In times of need the plants and their biological neighbours will use this valuable, but depleting resource. Some soil systems are already completely depleted and, without this safety net, have a narcotic dependence on synthetic inputs.

For humus to form it requires a mix of aerobic and anaerobic soil conditions, where fungi and bacteria break down the organic matter (OM) into its simplest elements. Some of the OM resists complete breakdown and undergoes a transformation into a more stable, complex, organic, material known as humus. This process is called humification. Humus is highly resistant to further decomposition, making it a vital and longer-lasting component of soil.

Just applying compost and FYM to the field won't guarantee a healthy content of humus. OM, including muck and compost, has to fully break down to form humus. So it's the rate of decomposition, rather than volume of OM, that brings humus. You need soil dwellers like fungi and microbes to turn OM into humus, so having soil that can breathe is critical to the critters.

The regen farmer may say they are "maximising soil biodiversity and utilising cover crops, minimising soil disturbance," when simply put, it is about improving your soil and get it cycling air, water, and nutrition better.

For years, Soil Fertility Services have been recommending Humic SC to growers where soils haven't quite been performing as well as they should. It helps the soil breathe better by actively opening those tighter spaces. Humic SC contains anionic surfactants that act as "soil conditioners" by modifying the surface properties of water and soil, making it easier for water to penetrate compacted or tight soils. This promotes even moisture distribution, better root growth and an overall improvement in soil structure which leads to better biological activity.

Steve Holloway, Soil Fertility Specialist with Soil Fertility Services

THE UNKNOWN OFFERS A **NEW APPROACH**

Feed the soil to nurture new thinking in farming, suggests *Grant James*, business development manager at Sea2Soil

Agriculture has landed at a very interesting turning point. The last 50 years are marked by a heavy reliance on NPK fertilisers. Industry evolution has been steady, and change has been minimal.

The times ahead for all of us working within it, however, are exciting. They may hold incomparable potential and opportunity as we begin to navigate through a massive transformation.

It's a future that's hard to predict, but that element of the unknown is where I believe we can tap into a whole new approach. This will be led by creative thinking and application and eventually new methods will be accepted as normal practice.

Soil health is where knowledge is ramping up, and its importance of it to all of us in agriculture is rising up the agenda. We're taking great leaps in the understanding of our biodiversity and our underground 'livestock'. As in the biometrics of humans, the microbes in the soil hold the key to health and longevity.

The transition into biodiversity that the wider industry has taken tentative steps towards is akin to the smart phone and its development. What we see today is only the beginning of the sustainable applications to the benefit of the industry. Development continues at pace behind the scenes, all with the promise of delivering the extraordinary.

But the process of change to a high biodiverse soil structure is never rapid. Years of good practice will pass before soil structure builds up to a detectable level of benefit and change. But the rewards are clear:

1) Lower fuel use

2) Easier workable soil

3) Fast straw breakdown

4) Increased porosity

5) Healthier plants

6) Increased photosynthesis

7) Carbon return

8) Improved water quality

9) Enhanced fungicide activity

10) Possible reduced synthetic nitrogen applications

Not all these benefits have yet been quantifiably recorded on a regular basis with trials data. However, with the combination of less soil movement and beneficial soil activators/biostimulants to feed the microbes during the growing season, many farmers who have committed to feeding the underground livestock are seeing positive results over time, both across the UK and EU.

Grant James believes we're taking great leaps in the understanding of our biodiversity and our underground 'livestock'.

Feeding the microbes, balancing the fungi and bacteria in the soil, brings the plants that grow in it increased access to the nutrients they need, to help secure the productivity growers strive for, and to help them thrive under several stressful conditions.

Soil activators and bio stimulants increase better organisation of the soil organic matter and its fertility over a long period of time, resulting in constant quality and yield from season to season.

The Sea2Soil team work closely on joint ventures, trials, and farm demos and with the addition of international food processors, can deliver an active sustainable map to support farmers and growers through the change to regenerative farming practices.

For more information, email **grant.james@pelagia.com** or visit **www.sea2soil.co.uk**.