GREEN HORIZONS
INSIGHT REPORT:3

Agri intelligence

PROVIDING INTEGRATED WHOLE FARM SOLUTIONS

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Agrii

Parasitised aphid 'mummy'
Credit Lucy Hulmes, CEH

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A BACKGROUND AND INTRODUCTION

GREEN HORIZONS

Green Horizons is Agrii's commitment to sustainable food production, and to taking a lead on principles and practices that can help to create a robust future for UK agriculture.

At its centre is our Five Point Plan to help prepare for, and meet, the challenges of tomorrow, while ensuring that agriculture remains sustainable and profitable.

The **Five Point Plan** covers the action we are taking in each of the following areas:

An Insight Report that pulls together all of the projects, research and ongoing work that Agrii is involved in, within each area, will be produced for each of the five points of the plan. This report focuses on **providing integrated whole farm solutions**.

Our ambitions under this section of the Green Horizons Five Point Plan are covered in detail in this report. **In summary, they are to:**

Advise on more resilient genetics through Variety Sustainability Ratings.	SECTION 1
Develop climate tolerant break crops and associated agronomy advice.	SECTION 1
Ensure all research is driven by Integrated Pest Management (IPM) principles.	SECTIONS 1-6
Employ laboratory screening methods to fast-track biosolutions.	SECTION 3
Establish recognised metrics on use of crop protection products, to reduce negative impacts while maintaining productivity.	SECTION 4

THE CHALLENGE:

Crop Protection Chemistry (CPC) is currently key for growing profitable and healthy food. However, the availability and efficacy of CPC products is gradually declining, posing a threat to the future of food production.

We recognise that to maximise yields efficiently, the industry needs to reduce reliance on CPCs for controlling weeds, pests and diseases.

A future with less reliance on these products is one with increasing adoption of integrated whole farm solutions. Agrii has always supported Integrated Pest Management (IPM) principles, which are now rising up the political agenda, to the heart of sustainable food production.

OUR OBJECTIVES ARE TO:

- Help our growers build business resilience to adapt to climate change.
- Sustainably increase agricultural production and incomes.
- Help to reduce the carbon footprint of our industry and look after the natural environment.

BACKGROUND AND INTRODUCTION

B

THE WHOLE FARM APPROACH: AN OVERVIEW

Integrated Farm Management (IFM) is a whole farm business approach that aims to deliver more sustainable farming. IFM combines the best of modern technology with more traditional methods to help deliver profitable farming that supports the natural environment.

Attention to detail is key: appropriate and efficient use of inputs combined with smarter approaches to business planning and the adoption of innovations and new technologies, all contribute to increasing productivity while protecting valuable resources. IFM is at the centre of what Green Horizons aims to deliver, and forms the basis of Agrii's approach to agronomy.

Integrated Crop Management (ICM) This describes an integrated, holistic approach to the growing of a particular crop and how all the elements of IFM fit together across that crop's whole life cycle.

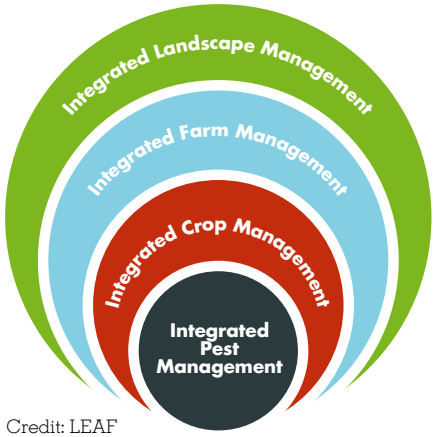
Integrated Pest Management (IPM) is the careful consideration of all available plant protection methods and subsequent integration of appropriate measures that discourage the development of populations of harmful organisms, while keeping the use of CPCs and other forms of intervention to levels that are economically and ecologically justified. *(European Commission definition)*

IPM is the cornerstone of Agrii's approach to sustainable total farming systems, and always has been. Synthetic crop protection products should never represent the first port of call when addressing any agronomic challenge.

Since the launch of Green Horizons, the proportion of Agrii trials including an element of Integrated Pest Management has increased from

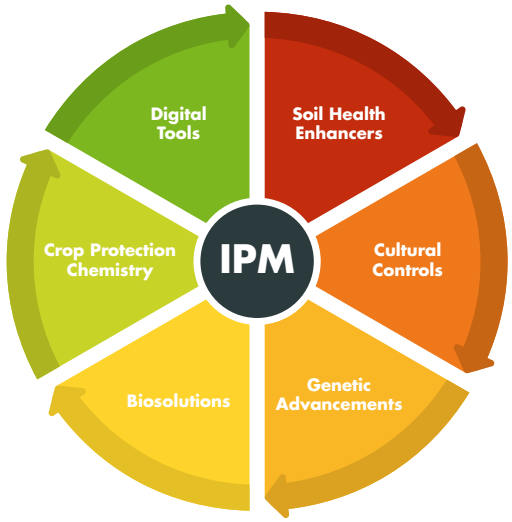
85% to 98%

We are on track to achieve our target of 100% by 2022.



Credit: LEAF

This document is structured around the six parts of the IPM toolbox that make up our IPM wheel.



In their guide to Simply Sustainable Pest Management LEAF identify 8 steps to follow when managing pests on farm:

- **STEP 1** Prevention and suppression
- **STEP 2** Monitoring
- **STEP 3** Decisions based on monitoring and thresholds
- **STEP 4** Non-chemical methods
- **STEP 5** Pesticide selection
- **STEP 6** Reduced pesticide use
- **STEP 7** Anti-resistance strategies
- **STEP 8** Evaluation

You can download the guide here: https://s3-eu-west-1.amazonaws.com/leaf-website/Simply-Sustainable-Integrated-Pest-Management-FINAL.pdf

C BACKGROUND AND INTRODUCTION

IPM IN THE WIDER INDUSTRY

With the loss of synthetic crop protection products and the clear message to reduce our reliance on chemical use, IPM will increasingly become core to sustainable food production systems. Although not legislative, there is evidence to suggest the direction of travel in the UK and Europe.

'Measuring the unmeasurable' is the next barrier to overcome, as well as providing education on how we implement and record this approach.

There are clear challenges and opportunities that arise from these statements. Although beneficial for the environment, such legislation could have a huge impact on our ability to produce quality food, whilst also causing an increased need for education.

We recognise that peer to peer learning is one of the most effective ways for farmers to learn. Through our trials and groups such as our farmer network, we aim to share our knowledge on IPM to the wider industry, and help maximise the benefits of the approach.

> **To support in the reduction of the risks associated with pesticides by setting clear targets by the end of 2022, and improving metrics and indicators, we will:**
>
> **✚ Establish a clear set of targets for reducing the risks associated with pesticide use by the end of 2022...**
>
> *The Draft National Action Plan on the Sustainable use of Pesticides*

> **I want to see massive investment into biodiversity..., so that farmers can increase their yields and cut back radically on the quantities of chemicals they use... In Part Two of the National Food Strategy, I will attempt to lay out a blueprint for a better food system: one that no longer makes us, or our planet, sick.**
>
> *The National Food Strategy, Part One*
>
> *The National Food Strategy (Part Two) is now expected to be published in July 2021*

> **The use of chemical pesticides in agriculture contributes to soil, water and air pollution, biodiversity loss and can harm non-target plants, insects, birds, mammals and amphibians. The Commission has already established a Harmonised Risk Indicator to quantify the progress in reducing the risks linked to pesticides. This demonstrates a 20% decrease in risk from pesticide use in the past five years. The Commission will take additional action to reduce the overall use and risk of chemical pesticides by 50% ... by 2030.**
>
> *The European Union's Farm to Fork Strategy*

BACKGROUND AND INTRODUCTION

CURRENT AND ONGOING AGRII IPM TRIALS WORK

With our aim to incorporate elements of IPM into 100% of trials by 2022 (we're currently at 98%), even when running 'product' comparisons, we are always considering trial design with IPM as a backdrop.

That might be investigating adjuvant use, best timing for efficacy and environmental protection, appropriate rates for efficacy and resistance management, mix partners, variety selection, greener technologies, pest and disease modelling, cultivation or rotation options.

Here are some highlights from our current trials work:

PEST CONTROL IN ARABLE CROPS

Our pest control trials focus on integrated pest management of BYDV and CSFB. They include:

- CSFB larvae modelling trial for appropriate insecticide timing to target larval hatch.
- Large block drill date x companion crop x seed treatment interaction trials and corresponding small plot trials in the same field to help validate results.
- Novel options to bolster or replace insecticide for adult CSFB control.
- Winter wheat and winter barley varieties with genetic BYDV tolerance in trials inoculated with infective aphids.

Please go to **Section 1** of this Insight Report for more information.

BYDV trial at Throws Farm, 2021

WEED CONTROL IN ARABLE CROPS

We currently have 24 weed control trials focusing on integrated weed management, including winter wheat, OSR, spring beans, spring linseed, maize and oats.

Trials are also underway looking at cultural control of ryegrass in large blocks in Yorkshire.

POTATOES

We're currently reprising earlier work on bio-nematicides, but with two new options to investigate their use against potato cyst nematode (PCN).

VEGETABLES

We're investigating the use of biostimulants using carrots and cabbages as the host crops.

We're looking into the effectiveness of bioinsecticides against brassica whitefly, which possesses resistance to a wide range of conventional insecticides.

Trials are planned to investigate some bioinsecticides for control of aphids. Continued regulatory pressures on conventional insecticides have resulted in fewer effective products to use in vegetable crops.

FRUIT

A large proportion of our fruit trials investigate the use of new biological products as alternatives to conventional chemistry on prominent pests and issues within the fruit sector. For example, we're running strawberry and grapevine trials this year focusing on efficacy of biopesticide products against downy mildew.

Agrii's Fruit Team are always looking to make the most from new technology as well as from the trials that they run at the Fruit iFarm in East Malling, Kent. They aim to give their customers the tools they need to set themselves apart from low-priced imported foods by focusing on sustainability and reductions in emissions on farm. Traffic-mapping machinery and movement around the farm can help us to understand where fewer trips can be made and including "no-mow" zones to promote the presence of beneficial insects can reduce the need for insecticides at key times of the year. Monitoring and recording populations of beneficial insects through a '365 day habitat' ecosystem is another tool to show the grower's commitment to, and understanding of, the diverse landscapes we work in.

C BACKGROUND AND INTRODUCTION

FOUNDATION TO FOLIAR

A holistic approach to crop planning and agronomy.

Agrii agronomists take a holistic approach to agronomy, which starts well before the seed is in the ground. Their in-depth knowledge is backed up by results from our vast range of national trials, and our internal specialists in soil biology, cultivations, seed, nutrition, crop protection and precision and digital farming solutions.

As part of this integrated approach, we identify T(-1) as the point of planting and recognise the importance of the planning and preparation required to maximise a crop's chances of reaching its genetic potential.

This can help to identify and target the level of inputs required, resulting in environmental benefits, reduced carbon footprint, greater crop resilience and a higher return on investment.

Please speak to your Agrii contact for more information about our integrated foundation to foliar approach to agronomy and business planning, and the opportunities that exist prior to planting to make the most from your fields.

In terms of ensuring that any seed you plant reaches its genetic potential, it's what you don't do that counts!

CASE STUDY

AGRII FARM PARTNERSHIPS: WORKING TOGETHER TO DELIVER FARM PROFITABILITY

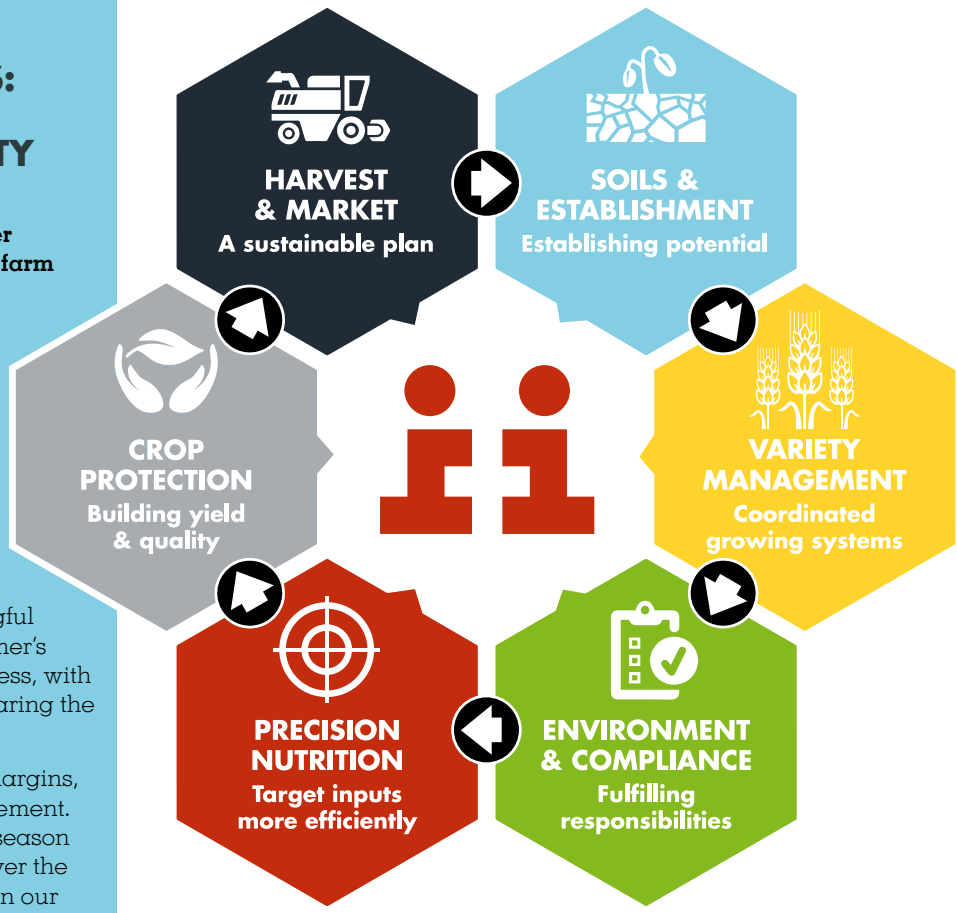
The Agrii Farm Partnership (AFP) approach is a new business model designed to deliver profitability and sustainability for farmers, farm managers and land-owners.

As support payments are phased out and arable margins come under increasing pressure, AFP provides the opportunity for long-term performance driven relationships with progressive farm businesses looking to share in the risks and reward of farming in today's climate. In short, Agrii is made accountable so that when you succeed, so do we.

This approach facilitates a real and meaningful partnership that supports meeting the customer's needs for a profitable and sustainable business, with both parties benefitting from success and sharing the pain of challenging years.

We work to agreed targets including gross margins, making them the success criteria of the agreement. It provides the incentives to out-perform the season by tailoring agronomic management to deliver the most profitable crops. Agrii can be judged on our contribution to productivity on your farm.

Agrii | Farm Partnerships



CULTURAL CONTROLS

1

Cultural controls are practices that reduce pest, disease or weed establishment, reproduction, dispersal, and survival.

Using cultural controls before synthetic Crop Protection Chemistry (CPC), can reduce detrimental effects to the farm ecosystem surrounding the growing environment.

In certain cases, such as Cabbage Stem Flea Beetle (CSFB) in oilseed rape, where CPC is no longer available or has reduced efficacy, cultural controls are an essential part of our armoury. In any case, cultural control principles and practices are key to a regenerative farming approach, (see **Green Horizons Insight Reports 1** and **2**) and play an integral role in IFM, ICM and IPM.

- **Resistance is best managed by reducing the levels of pests, weeds and diseases** before any synthetic crop protection interventions are used. This reduces the selection pressure for resistance.
- **Appropriate choice of crop, variety, seed rate, drill date and cultivations** all have a huge impact in reducing pest, weed and disease pressure.
- **Variety choice** is the cornerstone of cultural control of pests and diseases.
- **Using fewer synthetic chemical inputs** can help minimise the risk to non-target organisms, therefore enhancing biodiversity – as well as lowering input costs.
- **Provision of the correct nutrition**, at the correct time, can help improve the crop's ability to resist pests and diseases.

IN THIS SECTION WE CONSIDER:

- Crop choices and rotations
- Variety choice
- Cultivations
- Habitat creation for natural pest control
- Agronomising nutrition

PART TWO

1 CULTURAL CONTROLS – CROP CHOICES AND ROTATIONS

Practical and varied crop rotations can help to reduce grassweed populations, as well as avoiding pest and disease build-up.

Indeed, crop rotation is one of the oldest and most effective strategies for preventing pest outbreak in annual crops. Rotations that involve crops from different plant families can help to break up the lifecycles of insects, weeds and diseases.

It's therefore also important to choose cover crops from different plant families to your main crops, in order to reduce the risk of these pests transferring over from your crop to the cover crop and vice versa.

Varied rotations also have benefits for above and below ground biodiversity, nutrient and water availability and soil physical properties (more information on the latter benefits in **Green Horizons Insight Report 1: Improving Soil Resilience**).

"We need to think beyond traditional grain and oilseed cropping as we move into an increasingly uncertain food production future. Demand for healthy and functional foods is escalating. Where this is being met, it's almost exclusively with imports.

Yet we know we can grow them here. We also know there's great potential for improving the health and functionality of crops we're already growing, while at the same time contributing towards a more varied and sustainable approach to our rotations."

Peter Smith, Agrii Market Development Manager.

FOCUS ON: HYBRID RYE

Although hybrid rye has been a cropping option for a few years, more recently a number of key agronomic and economic factors have aligned to make hybrid rye a logical answer to many of the new challenges facing UK arable farmers says Ben Lowe, Agrii National Forage Product Manager.

"Current and future limitations on use of agrochemicals, reducing input costs, widening rotations to help control blackgrass, looking at crops with a high tolerance to take-all in the second wheat slot and selecting crops with superior ability to overcome drought conditions all highlight hybrid rye as being an attractive choice for UK growers."

INTRODUCING LIVESTOCK INTO THE ROTATION

Integration of livestock-grazed multi-species leys, cover or catch crops into arable rotations can help to diversify your cropping and extend rotations.

This increases land use diversity with potential benefits for above and below ground biodiversity, reducing build up of pests and diseases, and improving overall soil health, alongside other environmental benefits.

Remember – diversity in both crop rotations and cover crop plant families is important to help manage pest populations and enhance biodiversity.

CULTURAL CONTROLS – VARIETY CHOICE

1

To assist our agronomists and customers in selecting the right variety for the right situation, we run national and regional variety trials, including those found on our iFarm and Technology Centre sites – extending from Carnoustie (Angus) down to Saltash (Cornwall) and from Bridgend (South Wales) across to Great Dunmow (East Anglia).

The detailed data from these trials are used to create the Agrii Advisory List. This complements the AHDB Recommended List, with extra analysis and statistically-robust data from Agrii's extensive national and regional variety testing programme.

Your Agrii agronomist has access to the latest Agrii Advisory List data – please speak to them for more information.

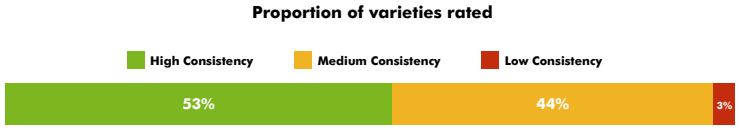
WHAT DO OUR ADVISORY LISTS SHOW?

The variety data gathered from our trials allows us to start to unravel all aspects of variety performance.

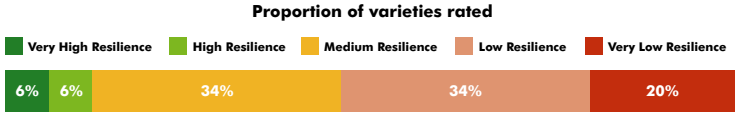
As an example, we are able to look at how consistent varieties are over a period of years. This key feature, combined with yield resilience under disease pressure, gives a valuable insight on how to de-risk crop production.

The data charts on the right summarise 34 winter wheat varieties including 32 from the 2020/21 AHDB Recommended List.

Yield Consistency



Yield Resilience under High Disease Pressure



Please Note: the AHDB Recommenced Lists can be viewed at: www.ahdb.org.uk/rl

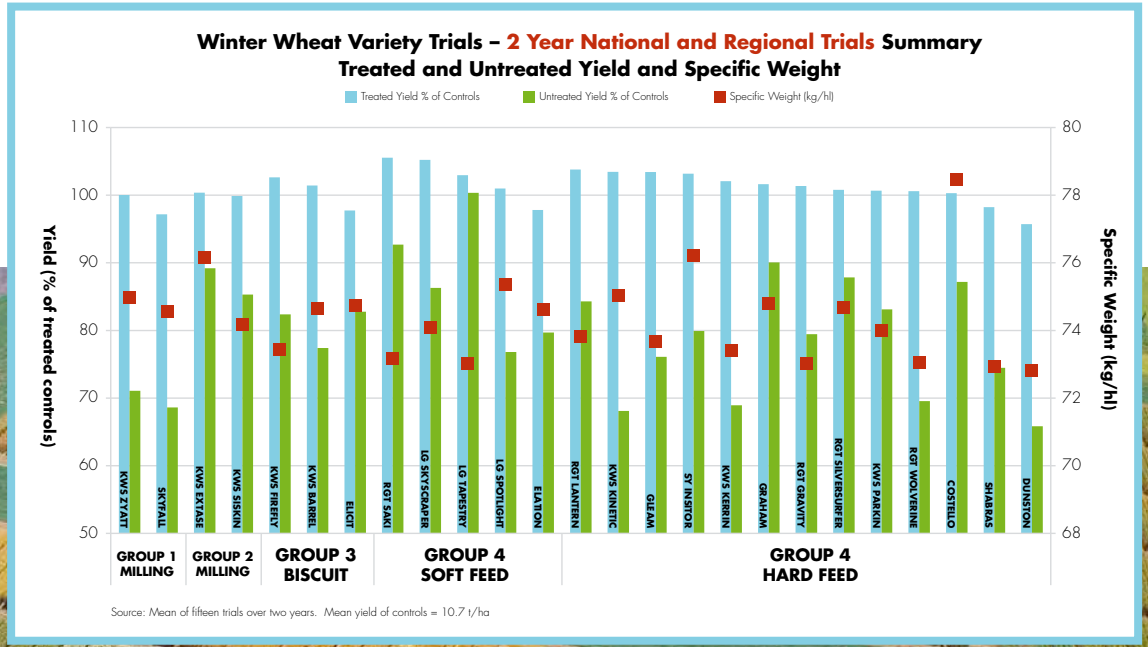
OUR VARIETY TRIALS:

+ **Evaluate the performance** of potential, new and existing varieties on a regional basis.

THE AGRII ADVISORY LIST:

+ **Provides detailed performance data** from our trials and external data.
+ **Combines with 'Blue Chart' profiles** on seed rates and drilling dates experience.

Agrii Advisory Lists are available for winter wheat, winter barley, spring barley and winter oilseed rape.



Source: Mean of fifteen trials over two years. Mean yield of controls = 10.7 t/ha

PART TWO

1 CULTURAL CONTROLS – VARIETY CHOICE

VARIETY SUSTAINABILITY RATINGS (VSRs)

In 2020 we introduced Variety Sustainability Ratings into the Agrii Advisory List.

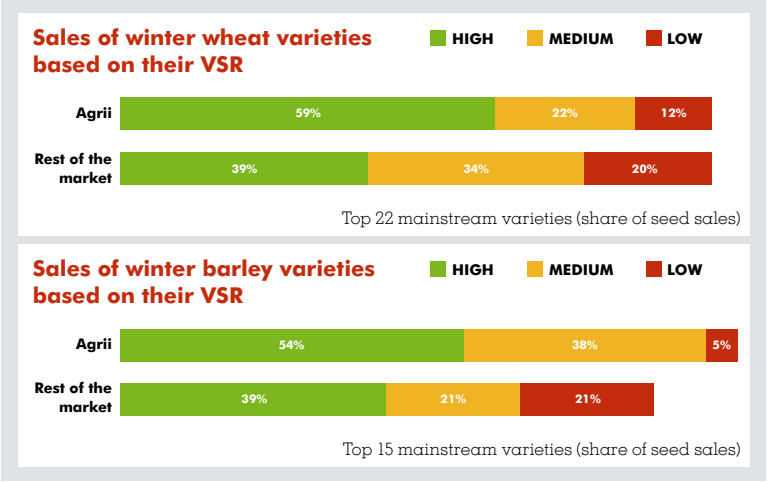
As well as helping individual growers in their variety selection, these sustainability ratings form part of a concerted effort to improve the sustainability of UK arable production as a whole. They raise the technical bar of selecting varieties to a new level.

The Variety Sustainability Ratings provide an unbiased way of comparing the overall robustness and resilience of varieties. Through collating and analysing 'real-time' data, they help us to answer the following questions:

- **Are the varieties technically robust?**
- **Which varieties offer consistent yields and quality and reduce agronomic risk?**
- **Do they provide the flexibility to use crop protection products more efficiently?**

Scores are also added for traits which reduce pesticide usage in the crop, e.g. wheat orange blossom midge, BYDV, TuYV and pod shatter resistance.

The Agrii trend is to choose varieties with a high VSR:



How are Agrii's Variety Sustainability Ratings calculated?

WINTER WHEAT

VSRs are based on:

- Foliar disease resistance
- Lodging
- Orange wheat blossom midge resistance
- Yield resilience and consistency
- Grassweed competitiveness
- Specific weight
- Latest optimum sowing date
- Second vs first wheat performance

Weighted according to their importance, their potential to reduce pesticide use and overall cost/tonne.

WINTER BARLEY

VSRs are based on:

- BYDV (barley yellow dwarf virus) tolerance
- Foliar disease resistance
- Lodging
- Yield resilience
- Grassweed competitiveness
- Specific weight

A weighting is applied to reflect the relative agronomic importance of each character.

OILSEED RAPE

VSRs are based on:

- Autumn and spring vigour
- Height
- Stem stiffness and lodging
- Maturity
- Disease resistance
- TuYV (turnip yellows virus) tolerance
- Pod shatter resistance
- Nitrogen use efficiency

A weighting is applied to reflect the relative agronomic importance of each character.

AGRII ADVISORY LIST

MILLING WHEAT EXAMPLE

	NABIM GROUP 1					
Variety	**KWS Zyatt**		**Skyfall**		**Crusoe**	
Parentage	Quartz x Hereford		C4148 x Hurricane		Cordiale x Gulliver	
Breeder (Country – If not UK)	KWS		RAGT		LG	
Agent – If different	-		-		-	
AHDB Regional Recommendation ( ) = Agrii	UK		UK		UK	
Agrii Yield & Grain Quality – Agrii 3 Year Mean						
UK Fungicide Treated Yield (% controls in trials)	100.6		97.6		Refer to Agrii Milling trial results	
Untreated Yield (% treated controls in trials)	79		74			
Specific Weight (kg/hl)	75.4		75.4			
AHDB Yield & Grain Quality – AHDB RL						
UK Fungicide Treated Yield (% controls)	98.1		96.8		96.3	
East Fungicide Treated Yield (% controls)	98		97		96	
West Fungicide Treated Yield (% controls)	99		97		97	
North Fungicide Treated Yield (% controls)	97		96		93	
Untreated Yield (% treated controls)	79		74		69	
Specific Weight (kg/hl)	77.8		78.4		77.9	
Protein Content (%) – Milling Spec.	13.1		13.2		13.6	
Hagberg Falling Number	267		279		274	
Disease Ratings: Black = AHDB RL data, Red = Agrii data						
Mildew Resistance (1-9)	7.3	-	6.2	-	6.4	-
Yellow Rust Resistance (1-9)	5.0	3.5	3.2	3.4	8.6	9.0
Brown Rust Resistance (1-9)	6.0	6.2	8.3	8.0	2.8	2.4
Septoria Tritici Resistance (1-9)	6.4	5.5	5.8	5.1	6.3	6.8
Eyespot Resistance (1-9)	7	-	6	-	5	-
Carries PCH1 Rendezvous gene for Eyespot resistance	Yes	-	Yes	-	-	-
Fusarium Ear Blight Resistance (1-9)	5.9	S	7.0	MR	6.4	MS
Agronomic Characters: Black = AHDB RL data, Red = Agrii data						
Lodging Resistance – Untreated (1-9)	7.2	6	7.5	8	7.3	7
Lodging Resistance – Treated (1-9)	8.0	7	7.7	9	7.7	7
Maturity (Days +/- Skyfall)	0	+1	0	0	0	0
Agrii Intelligence – Complementary Information						
Yield Consistency	Medium		High		Medium	
Yield "Resilience" under disease pressure	Medium		Low		Low	
Yellow Rust Plant Susceptibility before GS32-33	Susceptible		Susceptible		Susceptible	
Agrii Yellow Rust Diversification Group	A3		O3		O1	
Grassweed Competitiveness	***		****		***	
2nd vs 1st Wheat Relative Performance	Acceptable		Acceptable		Poor	
Suitable for Regions of High Sterility Risk	No		Yes		Yes	
Soil Type Suitability	Heavy Only		Heavy & Light		Heavy only	
Suitable to Drill Early (Before 15th Sept.)	No		No		No	
Latest Optimum Drill Date	End Jan.		End Jan.		End Oct.	
AHDB Latest Safe Sowing Date (Breeder: See Notes)	End Jan.		End Feb. (7th Mar.)		End Jan.	
OWBM Resistance	No		Yes		No	
BYDV Tolerance	No		No		No	
British Cereal Exports (BCE) Rating	*ukp*		-		*ukp*	
SRUC Scottish RL Status 2021/22	Not recommended		Not recommended		Not recommended	
Variety Sustainability Rating	HIGH		HIGH		MEDIUM	

Please Note: AHDB's information contained in this Advisory List is fully acknowledged and denoted as originating from the AHDB RL. (Full RL dataset is available from AHDB at www.ahdb.org.uk/rl)

Key: S = Susceptible, MR = Moderate Resistance, MS = Moderate Susceptibility

CULTURAL CONTROLS – VARIETY CHOICE

1

THE IMPORTANCE OF OUR TUSSOCK TRIALS

We also carry out tussock trials looking at 35 varieties of wheat (2020) across 12 sites.

The tussocks may look fairly unassuming, but in reality, they perform a very specific task.

One of the main objectives of the tussock trials is to assess the risk to current and new varieties from changes in pathogen virulence detected each season.

So in reality because of the genetics added to the plots, we can monitor disease, particularly yellow rust, to assess whether there are any changes.

Indeed, it was in our tussock trials that we noticed a new virulence within the variety Hereford.

This development has taken 3 seasons; following on from an early warning in 2018, we reported in 2019 that virulence was becoming more common.

This season virulence for Hereford increased again and has now became widespread. Other varieties with Hereford in their pedigrees will be at risk.

Tussock trials, Chirnside

1 CULTURAL CONTROLS – CULTIVATIONS

KEY POINTS TO CONSIDER:

- A focus on timely crop establishment helps to ensure a healthy and resilient crop that should be more able to withstand pest and disease pressure.
- Consider recognised pest risks when planning your site management
- Think about trying to preserve natural predator populations when choosing your methods of cultivation
- Consider the risk of green bridge transfer of pest populations
- Rolling after sowing may help to consolidate the seed bed and reduce availability of habitat for slugs. It will also help to conserve moisture for the growing crop.

CULTURAL CONTROL OF WEEDS THROUGH CULTIVATION METHODS

Arable fields have a bank of seeds sitting in the soil waiting to germinate. As weeds become increasingly resistant to herbicides, it is important to avoid them emerging in the crop.

A good stale seedbed will provide the perfect environment for the weeds to germinate and emerge, so that they can be eliminated before the crop is planted.

AGRII AND LEMKEN'S STALE SEEDBED TOP TIPS:

1. **Prior to harvest identify the high risk fields and prioritise cultivation practices.**
2. **Avoid uneven consolidation of the soil surface when creating stale seedbeds.**
3. **Remove flushes of blackgrass as they emerge – you increase the overall germination of blackgrass this way, so the seedbank is reduced.**
4. **Be patient! Emergence will occur even in a drier season – it just takes longer.**
5. **Don't drill until adequate numbers of blackgrass have germinated in the worst fields – this could easily be into a mid-October drilling slot.**
6. **Use a cultivation strategy that enables you to drill the worst fields last – this of course can be on the wettest ground, so soil structure needs to be good to depth.**
7. **If the worst fields have not had high enough germinations of blackgrass in the autumn and the seedbed conditions are poor, Agrii work at Stow Longa has demonstrated that these fields should not then be mauled into cold and wet seedbeds. It is much better to drill in the spring with the relevant choice of cropping, which at Stow Longa was spring wheat.**

More information in the Agrii and Lemken Guide to Blackgrass Stale Seedbeds here: **https://www.agrii.co.uk/wp-content/uploads/2017/08/Guide-to-Blackgrass-Stale-Seedbeds.pdf**

Tussock trials, Chirnside

HABITAT CREATION FOR NATURAL PEST CONTROL

Here we consider the pest predator challenge and how natural pest control can be utilised.

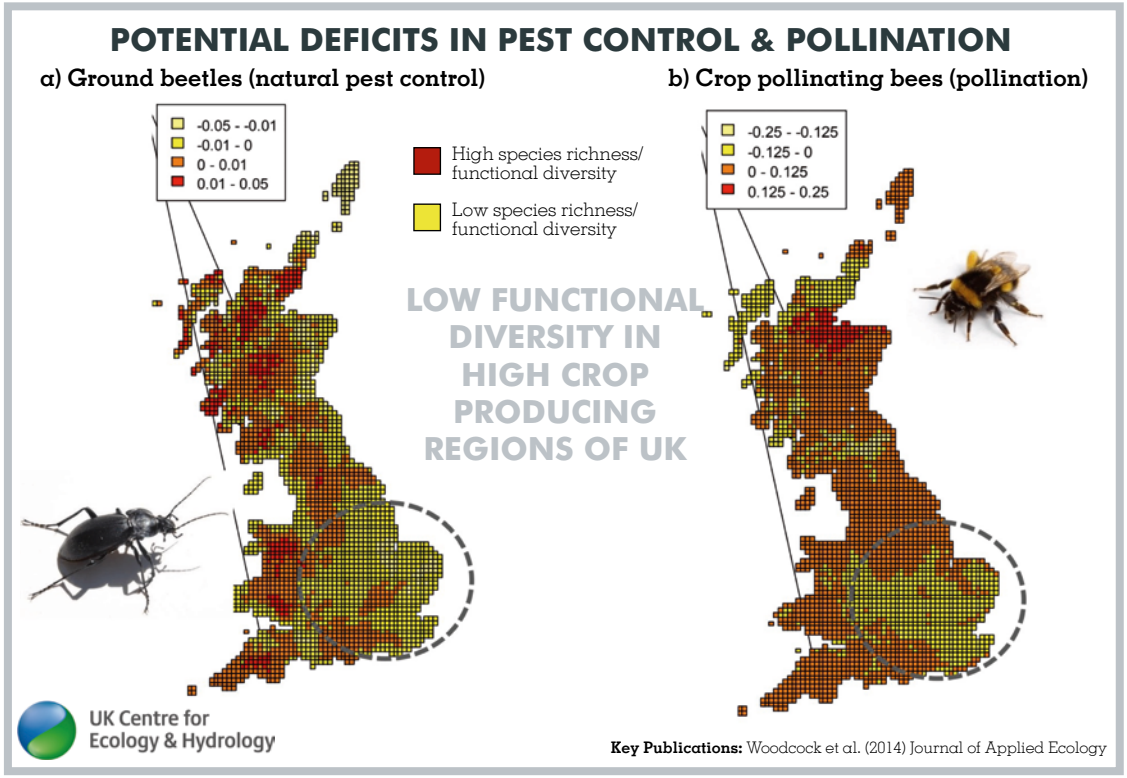
Utilising natural means of pest control is a complex science that is in its infancy. Until now farmers have worked on pest thresholds as a means of deciding when to treat but this oversimplifies the subject. Farmers generally decide on pest control that coincides with other treatments as this reduces costs.

Modern agriculture has resulted in the loss of mixed farming, tighter rotations, and crop specialisation. Many say this style of farming is the result of declining gross margins.

Things to consider:

The maps in the image on the right show that areas of intensive cropping can have the lowest functional diversity of key beneficial species – an issue likely associated with loss of habitat diversity.

We know that beneficial insects require a range of habitats, many of which no longer exist on farmland. The decline in farmland habitats is well documented but the government's Environmental Land Management (ELM) scheme, promises a fresh approach to habitat creation along with appropriate payments: so, could there be new opportunities for natural means of pest control by an increase in useful habitats?



A resilient system will need both species diversity and abundance and a better knowledge of the relationships between insects and plants.

Agrii is supporting the long-term **ASSIST** project which is examining the interactions between farming and the environment. One of the ASSIST treatments is in-field and margin grass and flower mixes designed to provide targeted habitats for a wide range of insect predators and pollinators. We know specific flowers benefit specific insects.

For example, the Umbellifer family, e.g. Cow parsley and wild carrot are good for hoverflies while many of the solitary bees favour yellow Asteraceae (formerly Compositae) e.g. Dandelion and Hawkbits.


Hoverfly larvae which predates on aphids
Credit Lucy Hulmes, CEH

HABITAT CREATION FOR NATURAL PEST CONTROL

We know more about crop pollinators than we do about the interactions between crop predators and pests.

How many beneficials of a given species do we need to deal with a pest attack and how would things vary in different crops?

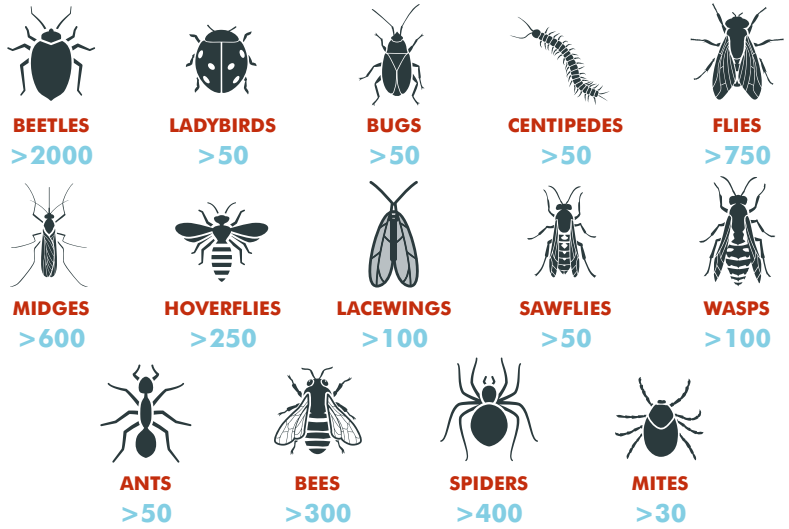
We do know that crop pests generally build up more rapidly than the predators, so a balance needs to be struck.

Research is examining the use of image recognition for crop pests and predators so, in the future, crops can be monitored more regularly which will provide better threshold systems that help in identifying both pests and predator build up.

In the meantime, we need to be able to find and recognise crop predators as well as we can crop pests.

There are many beneficial insects, and some of the more common ones we should be able to recognise. The diversity within these groups is huge:

NUMBER OF SPECIES BY INSECT – UK FIGURES



Slug being eaten by a ground beetle (Pterostichus madidus)
Credit Lucy Hulmes, CEH

DOES IT WORK?

Pywell et al (2015) Wildlife-Friendly Farming Increases Crop Yield: Evidence for Ecological Intensification. Proceedings of the Royal Society B.

The Hillesden project compared a range of habitat types and demonstrated that there was a link between habitat diversity and overall yield increases. This was partly due to the increase in crop pollinators but an overall increase in predator diversity and abundance was also a contributory factor.

In the project's control fields which were normal farming practice, the yields were 38% lower than the experimental treatments. Habitat creation in these lower yielding areas led to increased yield in the cropped areas of the fields, and this positive effect became more pronounced over 6 years. As a consequence, yields at the field scale were maintained – and, indeed, enhanced for some crops – despite the loss of cropland for habitat creation. These results suggested that over a 5-year crop rotation, there would be no adverse impact on overall yield in terms of monetary value or nutritional energy.

This study provides a clear demonstration that wildlife-friendly management which supports ecosystem services is compatible with, and can even increase, crop yields.

The current dependency on insecticides suggests we need to develop a more integrated system. Farmers need to see and understand the scientific evidence and ELM schemes need to reward farmers for a more holistic approach to pest management.

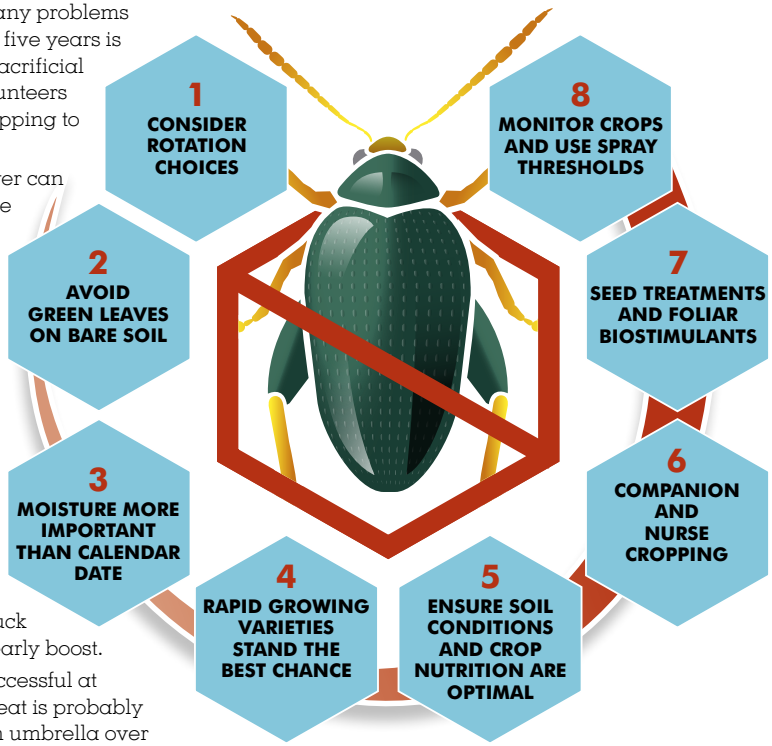
CULTURAL CONTROLS – IN ACTION

1

BATTLING THE BEETLE

The **Agrii 8 Point Plan** for managing Cabbage Stem Flea Beetle in OSR.

1. Close rotations are the cause of many problems in OSR. Growing OSR once every five years is a good target. You could also try sacrificial field boundaries, leaving OSR volunteers in neighbouring fields or block cropping to improve isolation.
2. Drilling into tall straw or green cover can help to camouflage the crop. Nurse crops can also be considered.
3. The most important factor is having adequate seedbed moisture so that seedlings are actively growing by the time of migration.
4. Hybrids such as INV1035, DK Exsteel and Ambassador exhibit fast growth. Anastasia and Aardvark perform well amongst the conventionals, while DK Impressario CL would be Agrii's Clearfield variety of choice.
5. Access to macro and micro nutrients is important. Chicken muck or digestate can give the crop an early boost.
6. Companion crops have proven successful at reducing larval damage. Buckwheat is probably the most widely used and forms an umbrella over the OSR.
7. Take Off OSR seed treatment can help aid establishment. Applying a foliar mix of macro and micro nutrients at the two-leaf stage can give crops a follow-up boost.
8. Check for shot holing at emergence and use yellow traps in the autumn to assess adult CSFB pressure. Chemistry provides only a weak tool to fall back on, so an integrated approach to management is essential.



Agrii's Steve Corbett and Tim Horton walk through the cultural control trials at AgriiFocus and discuss Agrii's 8 Point Plan for consideration before deciding whether to grow OSR.

WATCH:
https://vimeo.com/415927877/4b32ddde11

THE 8 POINT PLAN IN ACTION:

CASE STUDY

ENHANCED ESTABLISHMENT APPROACH RESTORES FAITH IN OILSEED RAPE AT THE DORSET iFARM

Putting all the pieces of a well-researched oilseed rape establishment jigsaw in place has paid handsome dividends for Jim Farquharson and his Agrii agronomist, Todd Jex at the Dorset iFarm near Blandford this season.

"Last season wasn't pretty," recalls Mr Farquharson who runs the family's 400 ha arable business alongside other enterprises. "As well as losing over half our crop, the fields we harvested averaged just 3.3t/ha. Excluding the badly-damaged areas, though, they did 3.9t/ha despite the appallingly wet winter and bone-dry spring; which is about what we normally average. This convinced us the crop was worth sticking-with, providing we could get it established reliably. It's long been our preferred cereal break and best entry for wheat."

WATCH: Tom Perrott and Mat Hutchings explain the work on the 8 Point Plan at the Dorset iFarm here: https://vimeo.com/534092103/b27b20882c

Increasing their OSR area by almost a third after last season's experience wasn't a decision the team took lightly. Indeed, they only took it armed with a clear set of establishment improvement imperatives:

- Leaving a long enough barley stubble;
- Establishing a strong buckwheat companion ahead of the crop;
- Minimising soil disturbance at drilling;
- Placing a specialist starter fertiliser with the seed;
- Using a proven fast-developing as well as vigorous hybrid;
- Drilling into moisture after the middle of August; and,
- Minimising other inputs until the crop is securely established.

"Interestingly, putting all the pieces of the establishment puzzle into place seems to have protected the OSR as effectively from our partridges as it has from the flea beetle," reflects Mr Farquharson. "There's plenty of water to go under the bridge yet, but this season is really beginning to restore our faith in the crop."

PART TWO

1 CULTURAL CONTROLS – IN ACTION

BLACKGRASS MANAGEMENT AT THE AGRII STOW LONGA TECHNOLOGY CENTRE

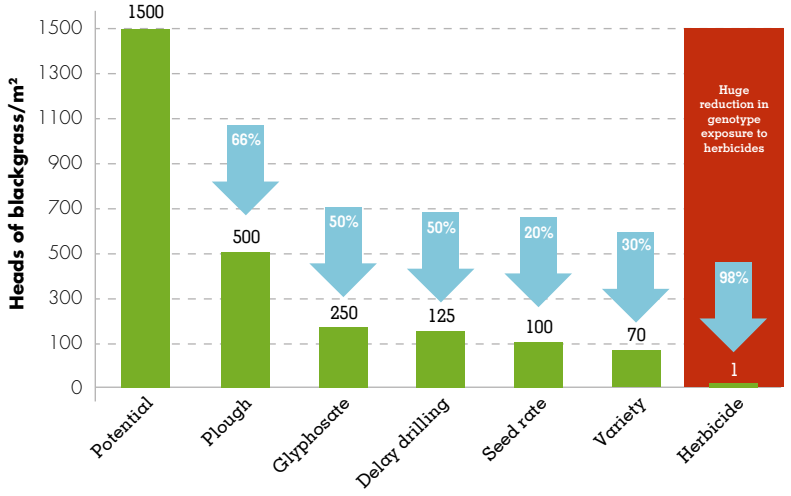
Herbicides continue to have a valuable role to play in countering the serious challenge of blackgrass. But growing resistance problems mean the chemistry available must be employed in the best possible way. It also needs to be closely integrated with a whole range of cultural controls to ensure wheat production continues to be sustainable.

Agrii has been exploring as many opportunities as possible for doing so at Stow Longa since 2000, in a range of integrated blackgrass management trials and studies.

From this work, and studies by Dr Stephen Moss at Rothamsted and other UK specialists, it has become clear that a number of techniques used in combination offer the opportunity to drastically reduce the blackgrass burden facing herbicides in the wheat crop. The most valuable in this respect are:

- **Rotational ploughing**
- **Pre-planting glyphosate**
- **Delaying drilling**
- **Higher seed rates**
- **Competitive varieties**
- **Rotation options**

Figure 1: Potential cumulative benefit of cultural control in blackgrass



Even without the need for spring cropping or other rotational changes, applying the results of these investigations to the initial 1,500 heads/m² blackgrass population at Stow Longa shows the extent to which this could be possible (Figure 1).

RESULTS FROM AGRII TRIALS

Independent multi-factor trials at Stow Longa (over 21 years) and our other iFarm trials across the country, have demonstrated what impact can be made on blackgrass and gross margins through a diversified rotational strategy.

The blocks at Stow Longa are combinations of cropping options and within each block there is a plough-based system, deep one pass cultivating to 12-15 cms and a catch / cover crop area, which has been min-tilled.

The key points from this work are:

- **Cultivations are very much part of the overall strategy** – but do them early after checking soil structure.
- **Plough as a reset** followed by shallow cultivations (with catch / cover crops?!)
- **Drill later** – allow six weeks between the main cultivation and drilling but watch out for a dry September.
- **Don't keep moving the ground**, blackgrass will grow in the germination zone without further action – leave the rest of the seedbank out of the way.
- **Glyphosate using a good product** and a decent rate a few days before drilling, incorporating a water conditioner if required to prevent lock-up.
- **When you drill** – just drill, don't cultivate.
- **Carrying on regardless without changes** to cultivations and crop type x drilling date, has a serious impact on yield and therefore income.
- **Strongly consider rotations** and their positive contributions towards lowering blackgrass numbers and increasing gross margins.

GENETIC ADVANCEMENTS

2

There are always exciting trait developments happening in the breeding industry but it's often hard to get an accurate timescale on their delivery to the farm gate. Some traits are developed in-line with end user requirements, others bring agronomic traits which if implemented well can have a significant effect in the implementation of IPM on farm.

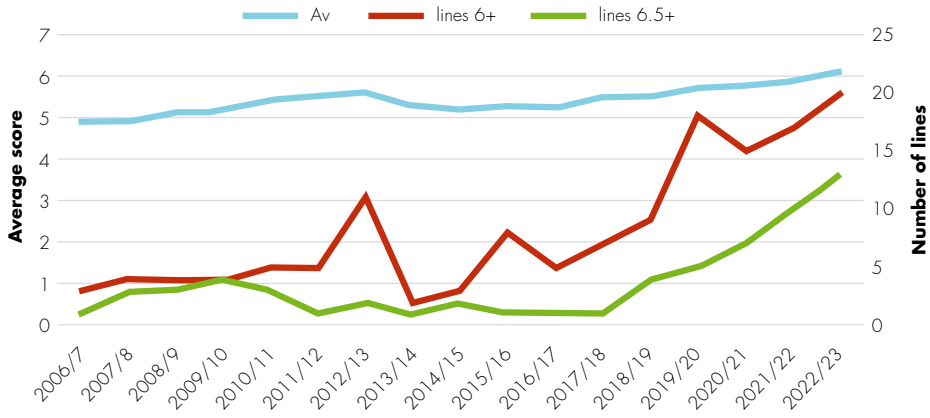
SEPTORIA

Over the last few seasons we have seen an increase in variety introductions with increased *Septoria* resistance. Historically the highest levels of resistance were coupled with poorer grain quality. UK plant breeders have worked to increase the level of *Septoria* resistance available and have broken the link to poor grain quality.

The results of this work are shown in the graph in figure 1. The top line shows the steady rise of the average score across the whole Recommended List. The lower lines show the dramatic increase in varieties with the higher levels of resistance.

The value of *Septoria* resistance is widely recognised and it is just one of the components which contribute to the Agrii Variety Sustainability Rating (VSR) (please see Section 1 for more information). Yield at all costs is no longer king, profitable yield is king which means a greater role for robust varieties on a modern farm.

Figure 1: Increases in varietal *Septoria* resistance between 2005-2021



WHAT ARE GENETIC TRAITS?

A trait is a specific characteristic of an individual, inherited from its parents, which gives that individual its characteristics and appearance. Traits are determined by genes, and also by the interaction between the environment and genes.

PART TWO

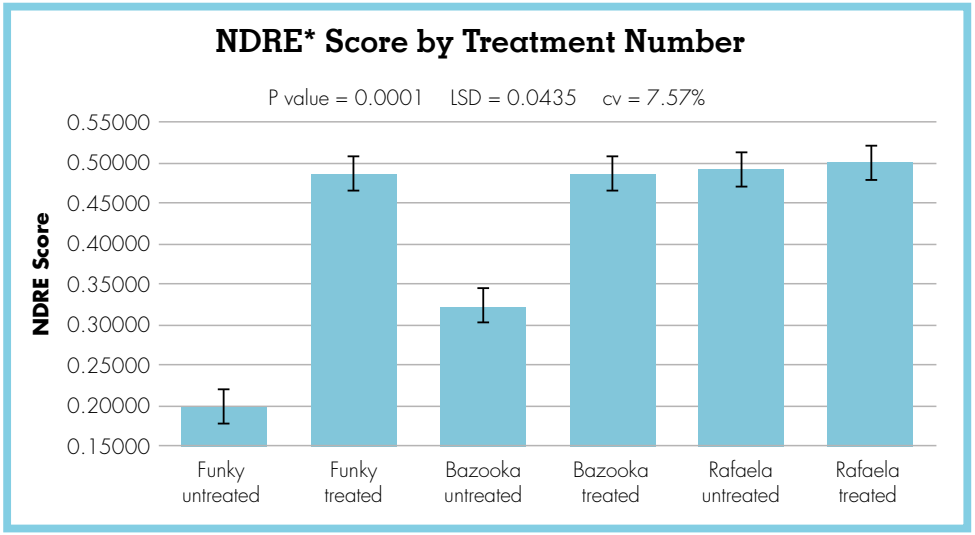
2 GENETIC ADVANCEMENTS – BYDV

The second example of a strong trait ready to be utilised is that of BYDV tolerance and resistance arriving in the market in both winter wheat and winter barley.

Within wheat, RAGT have brought the BDV2 gene conferring BYDV resistance, while in barley the YD2 gene conferring tolerance can be found. Tolerance genetics stop BYDV affecting yield components but don't impede its movement around the plant. Resistance genetics do interfere with the virus and so are classified differently. Both mechanisms offer yield security and do not require aphid control in most situations. Very large numbers of aphids can cause direct feeding damage, while aphids left uncontrolled by cold weather can survive to give further generations of winged aphids which may cause further risk to other crops.

Inoculated trials reproduce very high aphid pressure but illustrate how effective the tolerance genes are (figure 2). Plots were +/- insecticide spray 3 days later. The graph below shows the crop biomass recorded at the end of March 2021 and illustrates the effects of BYDV in plots in susceptible and tolerant barley varieties.

Figure 2:



KEY AREAS FOR UTILISATION ARE:

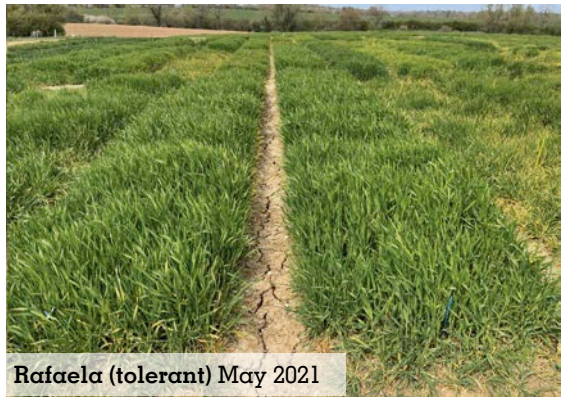
- **High risk areas such as the south of the country and coastal regions**
- **Higher risk fields with historic BYDV pressure**
- **Areas for earlier sowing to negate BYDV risk**
- **Headlands where a pyrethroid buffer zone exists**
- **Direct drilled crops, direct transfer of aphids from host cover crop species**
- **Grain aphid (*Sitobion avenae*) insecticide resistance presents an issue**

Utilising varietal resistance is the cornerstone of IPM strategies on farm. Employing varieties with the correct set of resistance characteristics reduces risks to the farm business, saves money and protects the environment.

*Normalised Difference Red Edge (NDRE) imagery is a method of determining crop health to detect changes in chlorophyll content within the leaf and through the plant canopy.

Funky (susceptible) May 2021

Bazooka (susceptible) May 2021



Rafaela (tolerant) May 2021

GENETIC ADVANCEMENTS – GENOME EDITING

2

Genome editing is a vast and complicated subject that has received a lot of press coverage in recent years. On such a technical subject it is hard to know where to start, so in writing this we hope to explain how plant genetics have evolved to this point and where new technology might take us.

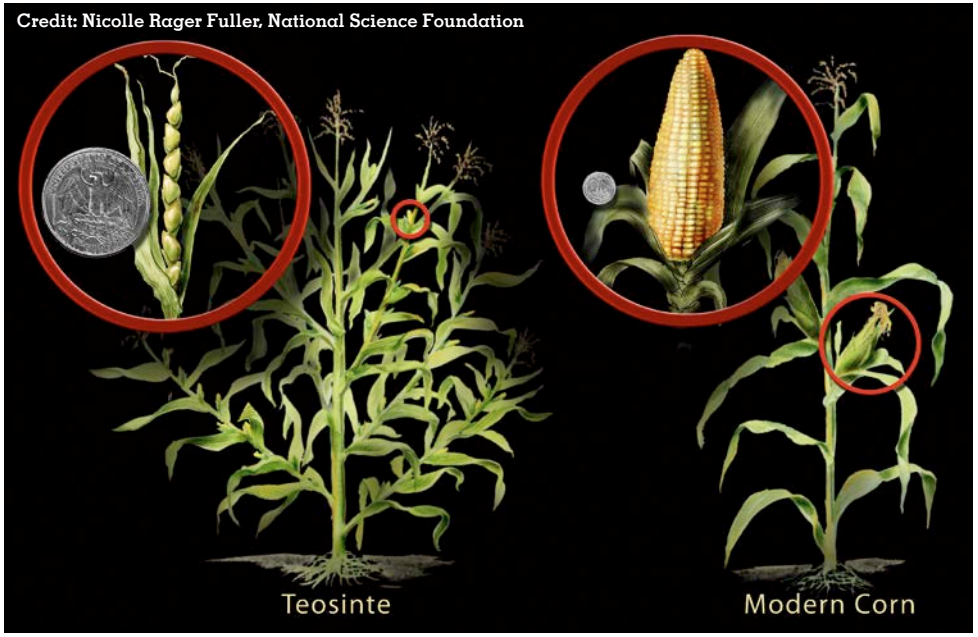
Plants, like animals, have been domesticated by humans since the dawn of civilisation. All species have a range of genetic diversity within their DNA coding. These differences are brought about spontaneously in nature either within the organisms' natural cycles or by an external factor. Internal variation is largely brought about when the "copy and paste" process of cell division goes a bit wrong, while external influences such as radiation can change the DNA in living cells. These can create differences in the plant, sometimes good, sometimes bad. Throughout history, humans consuming these plants have identified changes in the plants they considered "good", changes such as improved disease resistance, fruit size or yield. These plants were not eaten but kept and cultivated, hence shifting the population. A spectacular example of domestication is that of teosinte, a small, hard seeded plant native to Mexico, which is the forebear of modern maize.

In more recent times, human understanding of genetics has improved. One notable advancement being in 1865 with Gregor Mendel's Laws of Inheritance, and the pea flower experiment everybody remembers from biology lessons. After 13 years of work, in 2018, 200 scientists from 73 institutions across 20 countries produced a genome sequence (DNA map) of modern wheat. Bigger than the human genome by nearly five times, they identified 108,000 genes across the 21 chromosomes. Understanding what this all means, how it works and why, is the role of modern genomic science. Today's plant breeding marries both traditional plant selection in the field (selection by eye) with increasing knowledge of the genetic blueprint to help understand and predict performance. Combined, these result in faster delivery of sustainable solutions, for example breeders now have more knowledge about resistance genes rather than having to follow the 'suck it and see' approach required in the past. New knowledge and technology speeds up this process, while open access libraries of information are available for all types of businesses across the globe.

The last time that genetics came under close public scrutiny was when GMOs (Genetically Modified Organisms) came into the spotlight. The European Union defines GMOs as "an organism, with the exception of human beings, in which the genetic material has been altered in a way that does not occur naturally by mating and/or natural recombination".*

Genome editing, scientists point out, is different from this definition. The mechanisms happen in nature, and much work is ongoing at governmental level to define this. There is great interest in the plant, animal and human science arenas as a research tool and as a mechanism to make small known genetic changes to specific genes. These changes could be to activate "sleeping" genes that could, for example, improve drought tolerance characteristics, create bigger grain

Credit: Nicolle Rager Fuller, National Science Foundation



size or increase levels of Beta Glucan in barley. More importantly there are options to turn off genes known to have negative implications. It is suggested that susceptibility to *Septoria* was increased when breeding increased rust resistance and eyespot resistance between the 1950s and 1980s. There are also genetic options for improving grain quality, and the ability to lower the gluten content or decrease asparagine levels in wheat have been cited as achievable amongst the scientific community.

The European Commission (EC) recently published a report highlighting the challenges surrounding new genomic techniques (NGT) **. The EC acknowledged their potential role in developing a more sustainable food system and recognised that the existing GMO legislation from 2001 is not suitable for these technologies. New genomic techniques such as genome editing therefore pose difficult questions both socially and legislatively. There is an urgency of action required by humanity where new technologies may play an important role but they must be explained in a clear and transparent way so that the public are presented with all the facts from which to make informed decisions.

* DIRECTIVE 2001/18/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 12 March 2001, 02001L0018 — EN — 27.03.2021 — 007.001 — 2.

** https://ec.europa.eu/commission/presscorner/detail/en/ip_21_1985

3 BIOSOLUTIONS

PART TWO

FIRSTLY, WHAT DO WE MEAN BY BIOSOLUTIONS?

For the purposes of this document, Agrii views biosolutions as being evolving technologies that may be used as well as, or instead of, conventional synthetic Crop Protection Chemistry (CPC) products to enhance crop health, plant metabolism, yield, crop protection, nutrient use efficiency or reduce the effects of stress.

They include the following:

BIOSTIMULANTS

A material that contains substance(s) and/or microorganisms whose function, when applied to plants or the rhizosphere, is to stimulate natural processes to benefit nutrient uptake, nutrient efficiency, tolerance to abiotic stress, and/or crop quality, independent of its nutrient content.

ENDOPHYTES

A bacterium or fungus that lives within a plant without causing apparent disease. Endophytes may enhance host growth, nutrient uptake and improve the plant's ability to tolerate abiotic stresses such as drought and decrease biotic stresses by enhancing plant resistance to pests and pathogens.

ELICITORS

Extrinsic or foreign molecules often associated with plant pests and diseases. They attach to special receptor proteins located on plant cells and trigger intracellular defence signalling. This can result in enhanced synthesis of metabolites which reduce damage and increase resistance to pest, disease or environmental stress.

BIOPESTICIDES

Crop protection agents based on living micro-organisms or natural products. They include bioinsecticides, biofungicides and bioherbicides.

WHY ARE WE INCREASING OUR COMMITMENT TO 'FAST TRACKING' THE DEVELOPMENT OF BIOSOLUTIONS?

As with all new technologies which become available to UK farmers, Agrii operates a 'What Works?', evidence-led approach. Our Green Horizon manifesto states that we will be fast-tracking the research and testing of biosolutions in order to introduce them as rapidly as possible onto the UK market.

Why have we taken this decision?

- **We need alternative agronomy solutions:** Conventional Crop Protection Chemistry (CPC) is becoming more challenging to discover and more expensive to achieve the high standards required by the UK registration system. Therefore, we have gaps in the 'agronomy toolbox' that need a solution. Biosolutions are getting more reliable and may help plug that gap.
- **To use in Integrated Pest Management programmes:** Biosolutions may in some cases be a more benign partner to CPC products when used in IPM programmes. In addition, they may help protect CPC products and reduce selection pressure for pest, weed or disease resistance.
- **To speedily identify potential biosolution candidates to refine priorities for small replicated plot trials:** These are expensive to do and the failure rate for achieving statistically significant field results is high. Development of a 'fast-track' method for screening allows rapid identification of potential candidates, allowing us to be more targeted with the resources we have.
- **They may play a role in the drive toward zero residue food production:** Identification of reliable biosolutions which might enable reduced rate CPC products to be used, would help lower residues in food stuffs.

READ: Biosolutions explained here:
https://www.agrii.co.uk/wp-content/uploads/2021/03/BioSolutions-Explained-March-2021.pdf

SOME EXAMPLES OF AGRII TRIALS FOCUSING ON BIOSOLUTIONS:

SEED TREATMENTS

We're looking at a wide range of crops to understand the effects of biostimulant and endophyte seed treatments.

FOLIAR BIOSTIMULANTS/ ELICITORS

We're looking at the contribution of a range of plant health products, elicitors and biostimulants to disease tolerance, phytotoxicity, stress reduction and yield.

The aim is to determine whether we can reduce fungicides and maintain disease control and yield with elicitors. What's the best rate and timing for these products?

Our Green Horizons trial set at AgriiFocus, West Lutton and Lenham, evaluates a standard and reduced rate fungicide programme together with a reduced rate fungicide programme bolstered by biosolutions, across 14 varieties at each site.

POTATOES

We have been investigating a range of eight biostimulants, mostly amino-acid based with different partner materials and from different sources, e.g. seaweed.

We have also run a number of trials with plant elicitor ProAct and calcium supplements and have seen an uplift in tuber calcium levels.

This is an important factor in mitigating tuber quality issues such as internal rust spot.

Read more in the news story here:
https://www.agrii.co.uk/blog/trust-the-science-when-choosing-bio-stimulants/

CASE STUDY

VALUABLE ALTERNATIVE TO MULTI-SITES AT T0

Two years of Green Horizon-related agronomy trialling have highlighted a valuable T0 alternative to multi-site fungicides in the annual battle against *Septoria*, paving the way for the increasingly broad use of biosolutions in mainstream wheat disease management.

Already fully registered in the UK as a 'plant defence natural stimulator for the control of a range of diseases in winter wheat', the brown algae-derived elicitor, Iodus (laminarin) has been shown to reinforce cell walls and stimulate the production of fungal toxins and pathogenesis-related (PR) proteins to arrest the movement of *Septoria tritici* and mildew, in particular.

"A little like vaccination in animals, Iodus acts systemically to switch on plant defences," notes Agrii Head of Technical, Clare Bend. "It sensitises new as well existing growth to respond more rapidly to attack, making it a very useful option for early season disease management.

"In recent years we've tested almost 150 biosolution-based products in small plot trials with a success rate of just 15%. Amongst these, Iodus stands out for giving repeatable reductions in *Septoria* infections and useful wheat yield benefits.

"Dose-response work from SRUC shows an optimal application rate of 0.75 l/ha giving the same level of *Septoria tritici* control as folpet at its standard 1 l/ha rate.

"As part of a T0 programme in our 2018 trials, this rate of Iodus delivered the same 0.5t/ha response as 1 l/ha of chlorothalonil. And across 27 of our own T0 trials and those of other independent organisations in 2019 and 2020 it gave an average yield benefit of 0.3t/ha – almost identical to the 10-year average T0 response we see in our *Septoria* control work."

These results leave Clare Bend and her technical team confident that the algae-derived Iodus could help fill the early-season gap left by the withdrawal of chlorothalonil, helping to take the pressure off Septoria actives through the most robust protective and anti-resistance strategies.

While it clearly has a place in *Septoria* control, they warn that the jury remains firmly out as far as rusts are concerned, making a rust-active partner essential for many at T0. This is all the more so important taking into account:

- **The much greater yield impact that rusts can have**
- **The particular susceptibility of many of today's varieties**
- **The greater risk yellow rust represents for later drilling**
- **The extent of rust infections evident across the east of the country this season**

"With so much more interest and investment, biologicals are really coming of age," points out Clare Bend. "As well as protecting, enhancing or safening conventional chemistry, we see them being valuable in helping to offset the loss of actives and increasing restrictions on where and when they can be used. They should also help us in limiting the use of conventional chemistry, coping with increasing climatic uncertainties and minimising residues.

"Well-planned prevention with all the tools at our disposal is so much better than cure with diseases like *Septoria* and rusts, reducing the amount of chemistry needed and the growing risk of infections getting out of control."

"However, for the most consistent results bio-solutions, in particular, need to be employed in the right place at the right time and with the right partners as part of well-researched programmes. That is, after all, what IPM is all about."

CASE STUDY

SMARTGRASS AND PHYSIOCROP TRIALS IN PEMBROKESHIRE

Grassland managers and livestock farmers facing grazing deficits following a cold and dry spring could consider using an amino acid-based biostimulant to help increase grass growth.

Agrii's process with biosolutions, as with all its trials, is to ensure advice given is proven in the field before general release. Initial trials with biostimulants such as the plant-based amino acid containing PhysioCrop, suggest they could play a role in reducing stress, particularly drought, by helping encourage plants to produce increased quantities of photosynthetic pigments, such as chlorophyll and carotenoids. These can reduce stress in the plant and promote growth.

Replicated trials were started three years ago at one of Agrii's Green Horizons Network farms in Ludchurch, Pembrokeshire. Initial results were good, and results this spring from autumn-sown trials using Agrii's own Master Leys mixtures, applying PhysioCrop with the growth promoting gibberellic acid-containing product SmartGrass, produced an extra 2.350 kg/ha of first cut grass compared with the control, highlighting how biostimulants can be a benefit in higher stress conditions, says Dai Llewellyn, the Agrii agronomist in charge of the trials.

Where SmartGrass was used alone without the PhysioCrop the improvement in grass yield over the control was around 1,000kg/ha, he adds. SmartGrass can only be used once in a season and not after 30 April. The harvested plots measuring 150m by 23m, and repeated four times in the field, were weighed over a weighbridge.

"In a very cold dry spring we have seen the benefits of adding SmartGrass to grass to increase yield. The addition of PhysioCrop also made a big difference, which was not a surprise after a small trial with another biostimulant last year also showed improved yields in dry stressful conditions.

"Over half of the yield increase came from the use of the biostimulant so I think any time it's dry in the summer, and you can get it on before, I believe you would see a response," says Mr Llewellyn.

"Responses are likely to be greatest in intensively managed leys", he adds. "A similar trial on the farm in a five-year old sward showed a similar yield response to SmartGrass with a smaller uplift from the PhysioCrop."

The two trials also highlighted the difference in total grass production between new and older leys, he says. "Our new leys compared with the older ones on the farm are producing nearly 50% more grass."

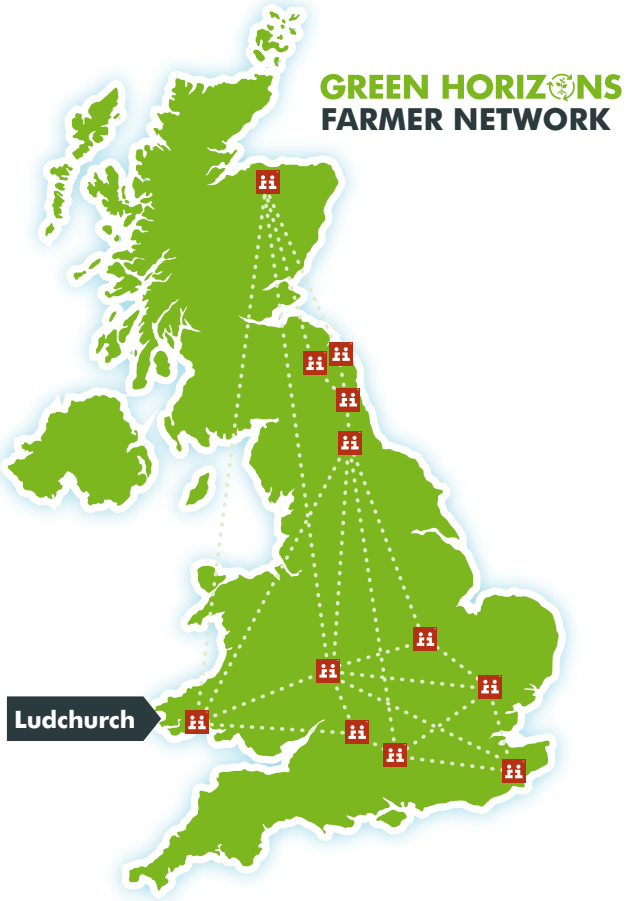
"It's another reminder to growers that the value of reseeding must not be underestimated in mitigating the effects of extreme weather events, which are becoming increasingly common" says Ben Lowe, Agrii National Forage Product Manager.

"There's also the potential to adapt mixture choices to the soil and field conditions. For example, if you know an area always suffers in drought conditions, perhaps consider seeding that part of the field with a mixture that contains a festulolium species such as Agrii's Drought Master, which with its deeper rooting can handle stress better."

BENEFITS ON MYCORRHIZAL POPULATIONS

An additional benefit seen in the areas treated with PhysioCrop and SmartGrass, was an uplift in the presence of soil mycorrhizae, which were visibly higher than in the untreated areas.

WATCH: Dai Llewellyn discussing the trials results:
https://vimeo.com/545648020/c57f9b7df8
https://vimeo.com/555319131/e9c06dc46d



HIGH SUSTAINABILITY VEGETABLE SEED TREATMENT CENTRE AT THROWS FARM

Currently being built at Agrii's Throws Farm Technology Centre in Essex, this new facility will allow high value vegetable seed to be treated with the greatest precision, temperature and moisture-control care for the best seed quality and protection.

In parallel to this Agrii has entered into an exclusive distribution agreement with leading Dutch organic coatings specialist, Ad Terram, giving the UK seed industry access to a growing range of environmentally friendly, rapidly biodegradable, microplastic free film coatings. Specific biostimulants and approved fungicide and pesticide products can be included to order as part of the high technology film-coating process which offers a range of natural pigment colourings for better field visibility. These 100% organic, non-polymer, non-bioplastic coatings are supplied as pre-mixes containing Ad Terram's own range of biostimulants that promote nutrient uptake and increase stress tolerance for stronger, healthier crops.

"Our new facility will consider all treatment options for the vegetable seed trade," explains Agrii Executive Director of Seed, Lee Robinson. "This is based upon the need for a broad range of options and the growing importance of environmental sustainability in the UK field vegetable market. The facility will look to offer film coating and pelleting technologies with expansion into priming and encrustment technologies to deliver a complete range of options."

"Our aim is to deliver the highest quality treatments to a range of vegetable seed, supported by our R&D, and ensuring that our customers have an environmentally responsible and sustainable option."

Lee Robinson, Agrii Executive Director of Seed

For more details or to enquire about seed treatment options please contact **Agrii Customer Services** on **0845 6073322** or email us at **customerservice@agrii.co.uk**

4 CROP PROTECTION CHEMISTRY

A key part of Integrated Farm Management and Integrated Pest Management is reducing our reliance on synthetic crop protection product inputs.

Reducing reliance on these inputs could have widespread positive implications for the natural environment including air/water quality, soil health and biodiversity. It could also improve business resilience and allow us to respond to changing attitudes towards input use.

The previous sections of this document consider cultural controls and biosolutions as alternatives to traditional crop protection chemistry.

In this section, we look at how all of these methods of reducing the use of synthetic crop protection products are being used in an integrated approach as part of the **Field of the Future Project**, and the work that is being done as part of Green Horizons to **establish recognised metrics** on the use of plant protection products.

CROP PROTECTION CHEMISTRY (CPC) AND CROP PROTECTION PRODUCTS (CPPS)

The term CPC is utilised throughout this document when referring to synthetic or traditional crop protection products. The term CPP is used to encompass all crop protection products, including both synthetic chemistry and biosolutions.

DEVELOPMENT OF CROP PROTECTION CHEMISTRY PRODUCT METRICS

The use of synthetic crop protection chemistry in the UK has been monitored by FERA over the last 50 years. They survey a sample of farms to estimate national use in the Pesticide Use Survey by weight of product and number of treated hectares.

These estimates are limited in what they tell us of the likely unintended effects of pesticide use as they take no account of the concentration or toxicity of the products we are using.

Agrii's Mark Dewes has been evaluating a range of different synthetic crop protection product (CPP) measurement systems as part of a Post Graduate course in Sustainable Food Production at Aberystwyth University, and the table below compares some of the systems in current use. Pesticide legislation and industry self-regulation is evolving.

Capturing real, quantitative and qualitative data to assess and influence trends which minimise the unintended impact of pesticide use is our objective. We have begun a project to model our synthetic crop protection product use through Treatment Frequency Index (TFI) both with and without the weighted index provided by the Harmonised Risk Indicator (HRI) as used in the EU.

These changes appear to represent the best next steps as we continue to work alongside manufacturers and other stakeholders who share the same aims.

SYSTEM	COUNTRY	DESCRIPTION	ACCOUNTS FOR COMPARATIVE RISKS TO		SIMPLICITY	DATA CAPTURE	
			HUMANS	ENVIRONMENT		EASE	RELEVANCE
Weight	UK	Quantitative	●	●	●●●●	●●●	●
Treated Ha	UK	Quantitative	●	●	●●●●	●●●	●
TFI	France	Qualitative	●●	●●	●●●	●●●	●●
HRI	EU	Weighted index	●●●●	●	●●	●●	●●●
GHS	Global	Weighted index	●●●●	●	●●	●●	●●●
Pesticide load	Denmark	Multi-factor index	●●●	●●●●	●	●	●●
EIQ	US	Multi-factor index	●●●	●●●●	●	●	●●
SYNOPS/EYP	Germany/ Netherlands	Environmental model	(●●)	(●●●)	(●)	(●)	(●●●)

GREEN HORIZONS CHALLENGE PROJECT

At our Midloe Grange Net Zero iFarm, our Green Horizons Challenge Project aims to bring together all of the aspects discussed in this Insight Report to develop and demonstrate 'the field of the future'.

AIM: to devise a way to grow a high yielding winter wheat with reduced conventional inputs, supported by 'green technologies' and following IPM principles.

TARGET: to achieve as close an economic outcome as possible to conventionally grown wheat, with a lower carbon footprint – alongside/as part of a Net Zero iFarm.

R&D AREAS TO BE INCLUDED AS PART OF THE CHALLENGE PROJECT:

- Varieties/genetics
- Cover crops
- Healthy soils
- Crop nutrition/NUE
- Environmental improvement
- IPM
- Biosolutions
- Water resource quality improvement

This project is being supported by:

CORTEVA agriscience · UPL OpenAg · BAYER · BASF We create chemistry · FMC An Agricultural Sciences Company · INTERAGRO THE ADJUVANT EXPERTS

PART TWO

OLD HOPYARD – IFM / IPM IN PRACTICE

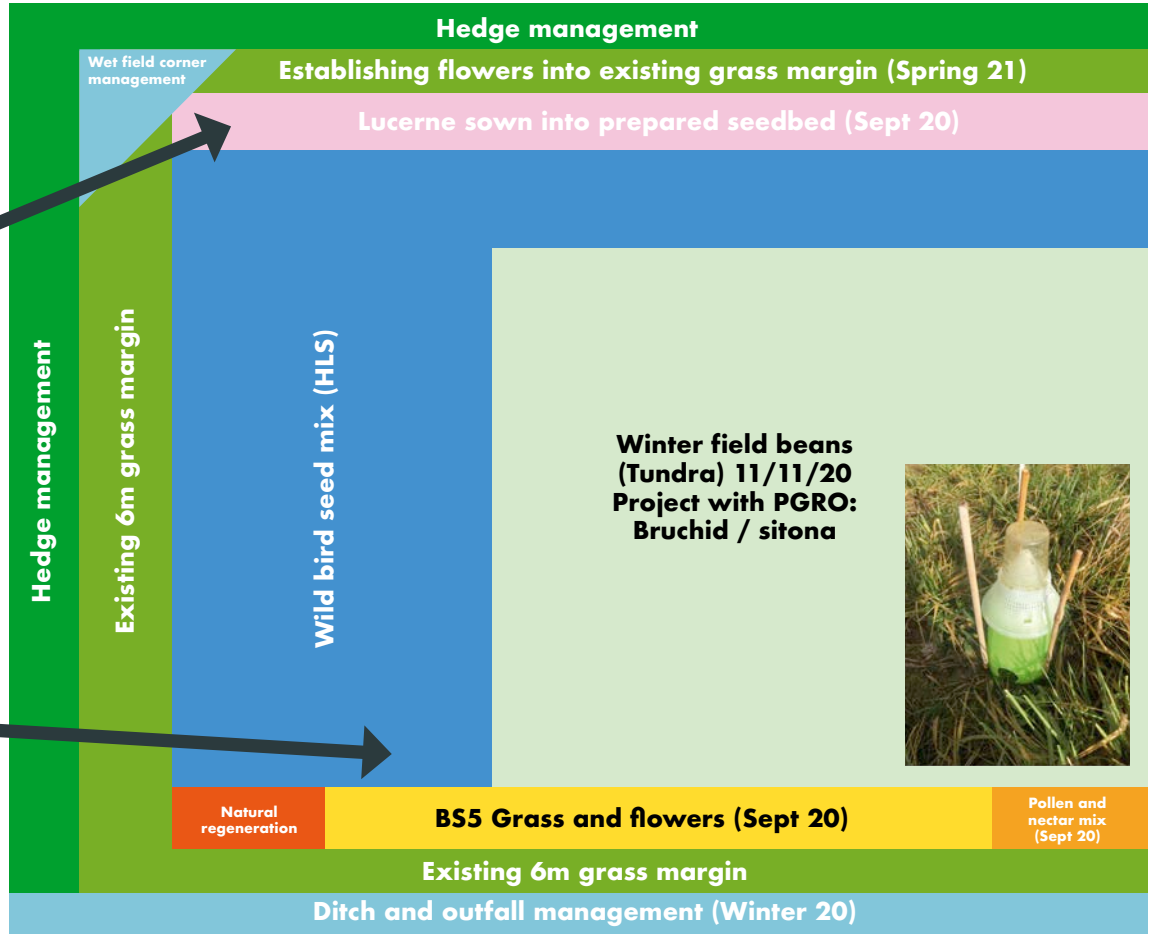
In the Old Hopyard field at Midloe Grange, the team are working with PGRO to try different mixes in the field margins, with different management regimes, to determine which deliver the most benefits.

The team are looking at benefits in terms of environmental delivery (e.g. through providing food for pollinators) and reduced reliance on synthetic crop protection products (by encouraging beneficial species).

This work will also stand the farm in good stead for future government land management schemes, allowing them to determine which mixes and management regimes provide them with the greatest environmental return, and increase their likelihood of receiving payments through ELMS.

WATCH:
In this video, David Felce (Farm Manager at Midloe Grange) talks through the results that he and Wildlife Farming Consultant, Marek Nowakowski have seen so far in the different management areas.
https://vimeo.com/568503099/c536781391

The results from the established grass margins show that establishing the most effective and beneficial mixes might take a bit of effort early on, but that if we get them right they can last a long time and deliver big results over a number of years.



NUTRIENT USE EFFICIENCY WORK AT MIDLOE GRANGE

As part of the Field of the Future Project at Midloe Grange, the team has been carrying out a wide range of work looking at nutrient use efficiency, and how a more targeted approach can be taken to nutrient application, as well as the role of Enhanced Efficiency Fertilisers (EEFs) such as Agrii-Start. (Please see Green Horizons Insight Report 2 for more information on EEFs).

At Midloe Grange, Green Area Index (GAI) maps have been used to target nitrogen, so that it's applied only where it's needed, in the quantity in which it's needed. In the example in Figure 1, the nitrogen requirement was calculated based on GAI. The GAI was assessed in March and ground-truthed by cut and weighed samples.

Figure 1

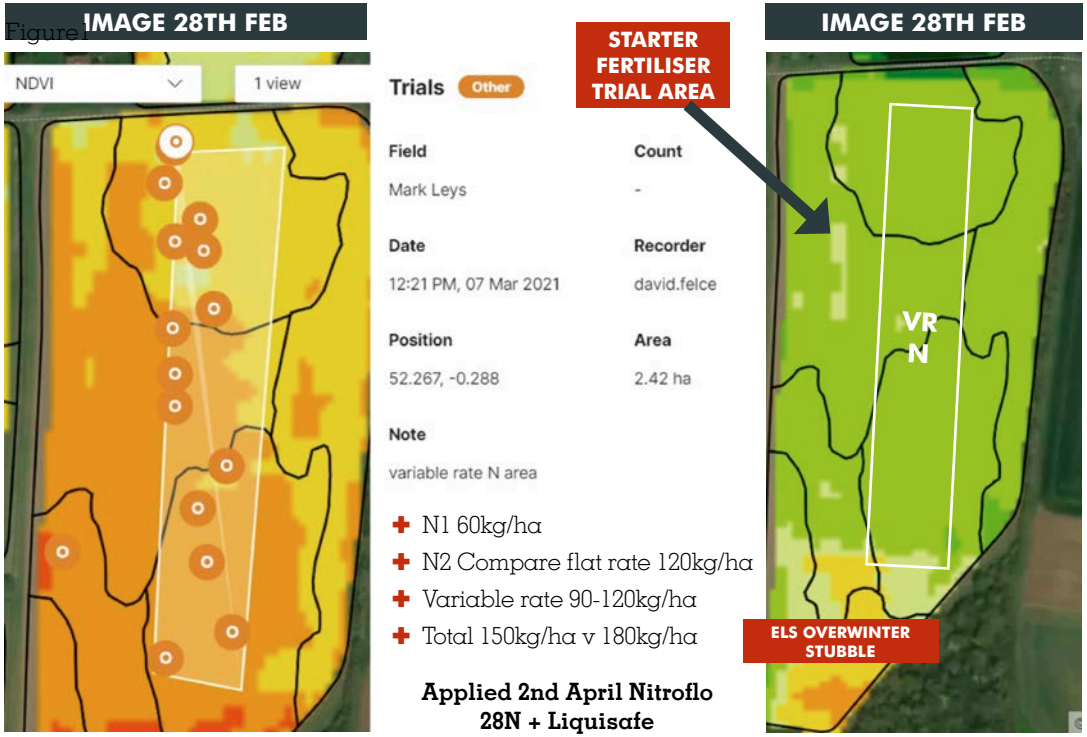
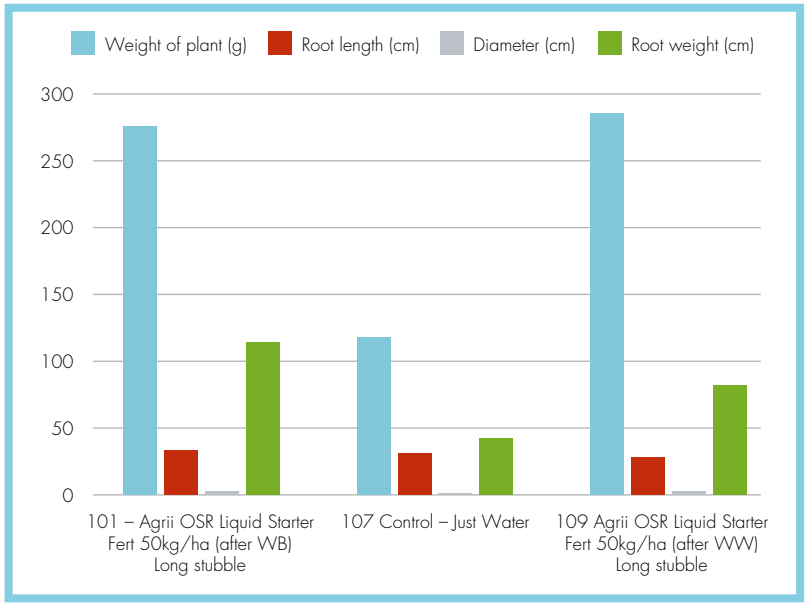


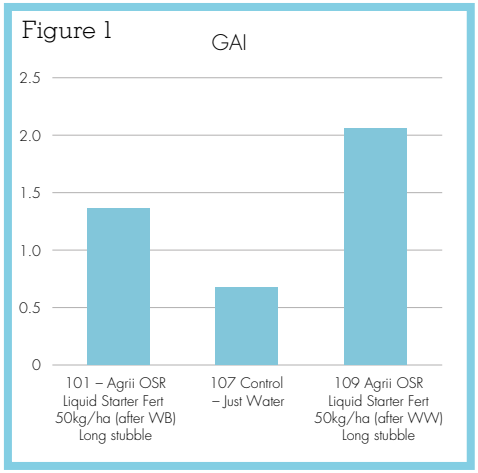
Figure 2: Seedbed nutrition – effect on GAI and spring N requirement…



This was then used to create a map of different N requirements based upon canopy and consequently a variable rate application map, in order to compare variable rate to flat rate N application.

This was in addition to the starter fertiliser inputs, the effects of which could be seen not only at establishment, but also in the crop the following spring (figure 2).

Figure 1



5 DIGITAL TOOLS

Digital tools aid decision making in the context of Integrated Farm Management (IFM), providing actionable insights and, at the same time, enabling the implementation of sustainable agriculture.

Specifically, digital tools can support decisions on if, when, where and what to apply, but ultimately the users are those who will take these decisions by combining the information and knowledge generated by the tools with personal experience and wisdom, neither of which can be digitised.

The ability to identify the right time, place and product for action based on actual or forecasted risk/need allows us to optimise the use of resources, increase their efficiency and thus achieve satisfactory yields, while at the same time also preserving farmers' profitability and minimising impact on the environment. On page 33 you can find two examples of digital tools available through Contour, for BYDV and *Septoria* risk management.

Risk levels and information produced by the digital tools must be used in combination with, and not as a substitute for, agronomists' and farmers' personal knowledge of the farm, their ability to spray in a timely fashion and local conditions.

DIGITAL TECHNOLOGY FARMS

The Digital Technology Farms (DTF) project is a farmer-led initiative which involves ten Agrii growers, their agronomists and digital agronomy specialists RHIZA. The project, which was set up in autumn 2019, focuses on field scale trials conducted on farm which are designed to put digital technologies through their paces. The idea being that they will demonstrate their most profitable use and provide the broadest base for future improvements.

The digital support tools that we have available in our armoury are essential to our trials. In **Contour** the NDVI and GCVI imagery allows us to track crop biomass within the trial fields across the season. This is important especially for guiding variable rate nitrogen application, which determines where to focus the highest and lowest rates of nitrogen at the different timings across the growing year. It allows the creation of fertiliser solutions based on individual farm requirements.

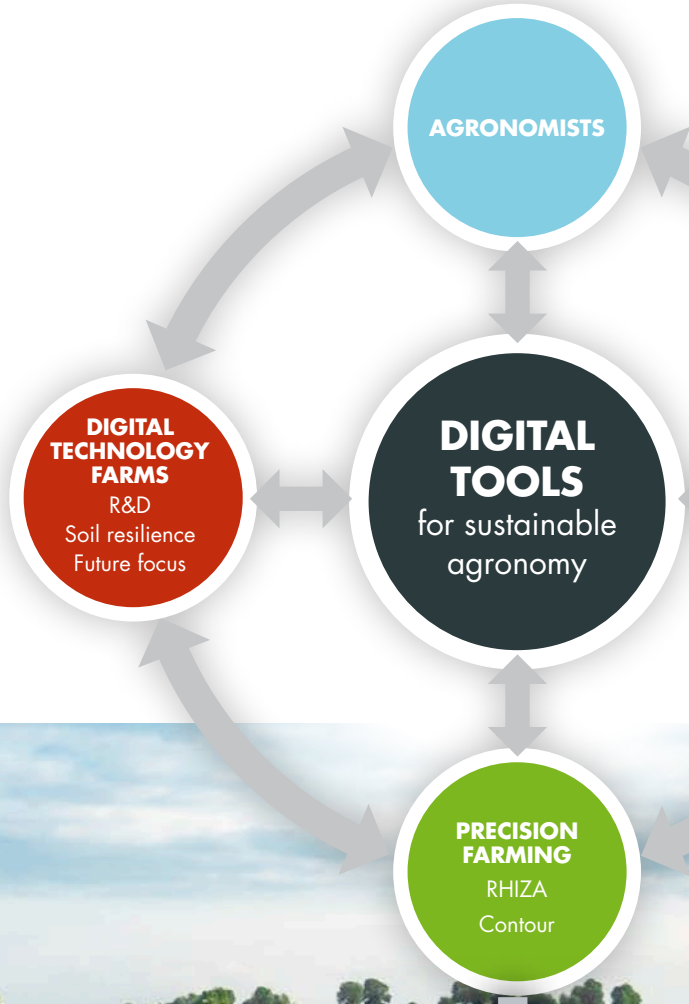
We are also able to visually see where different seed rates or targeted nutrition has been beneficial and this complements crop assessments and plant counts taken in field.

We are able to draw polygons and drop pins on **Contour** to input data or mark areas of disease or weeds that could impact on trial results. This is especially useful as a record to refer back to when needed and we can know exactly where this data has been taken. This is important if we need to look at soil texture data to understand trends or when monitoring crop biomass through imagery.

Please see page 33 for more information on some of the DTF work that we're doing this year.

DIGITAL TOOLS

5



MODELLING TOOLS

Agrii's agronomists and farmers have access to a wide range of digital tools delivered via the **Contour** platform and the **Rhiza Connect** mobile app.

Contour offers a suite of features for precision farming, with a focus on nutrition and seed planning, and tools for informing an Integrated Pest Management (IPM) approach to managing wheat.

Rhiza Connect gives easy access to weather data and forecasts for the entire UK, including spray conditions and frost risk, and weather-driven models for speciality crops, such as potatoes and fruit.

Both systems, by means of data integration and models, can provide information and generate knowledge upon which the users can act by deciding to either visit the field for monitoring purposes or to schedule an application of inputs, e.g. nutrients or plant protection products.

Please see the examples on **BYDV and *Septoria*** on page 33 for more information on some of the tools available.

RHIZA

RHIZA is the digital/precision farming partner for Agrii, servicing 750K Ha with digital tools and precision farming services. **RHIZA** delivers decision support tools, based around quality soil data, nutrition, pest and disease modelling and crop growth data, and combines these with Agrii's R&D data on the **Contour** platform and the **Contour** scouting application for farmers and agronomists.

RHIZA delivers its services via account managers embedded into the Agrii agronomy teams, which allows both agronomists and account managers to align their knowledge, delivering a completely integrated approach to crop management. This process allows agronomists to take advantage of the digital tools when advising farmers but also have the support of account managers 'down the farm drive' with the growing complexity of the precision farming arena.

The **Contour** platform allows farmers to view their data in one place and with the various levels of precision farming available, can also take advantage of variable rate planning functionality.

Along with the **Contour** platform **RHIZA** has a scouting application, **Contour Mobile**, which allows growers and agronomists to crop walk using **RHIZA** 'layers'. Soil sample results and satellite biomass imagery, give users the ability to focus in on areas for further investigation. Observations can then be placed and used in future decision making. It allows the development of tailor-made nutritional and other management solutions bespoke to your crop's expected output.

RHIZA

PART TWO

FOCUS ON: VARIABLE RATE PLANNING TOOLS AVAILABLE WITH RHIZA

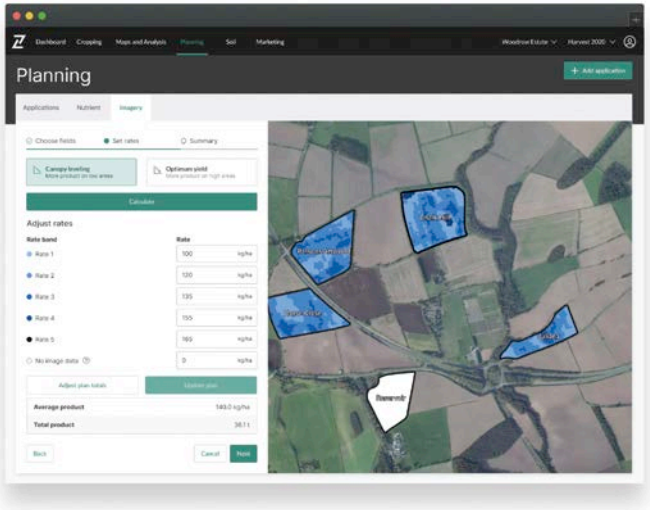
RHIZA

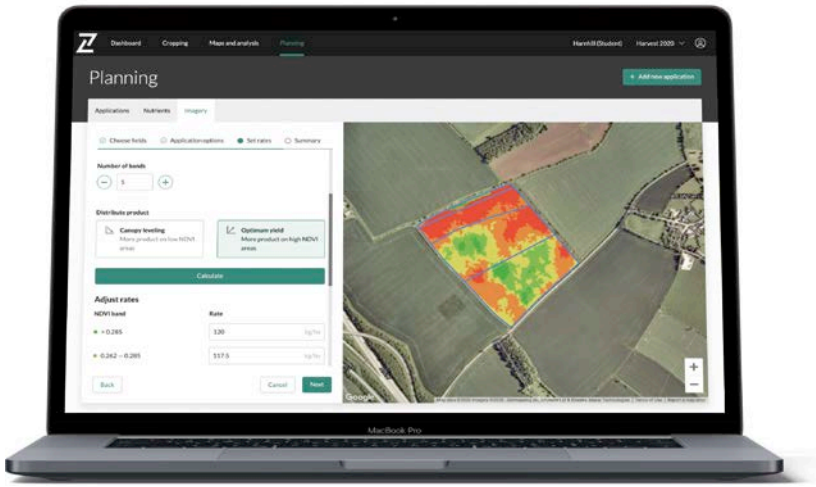
Variable rate as a concept, started with soil sampling and P&K planning, and has now evolved to cover most inputs on farm. In today's market, with the use of satellite imagery, seed, nitrogen and crop protection products can all be varied to tailor application rates to the target in the field at a pricing point accessible to all.

Whilst VR capabilities gives growers the ability to tailor inputs, the benefits need to be clear and margin over input costs (MOIC) need to be measured. Agrii's Digital Technology Farm (DTF) trials (please see page 33 for more information) give RHIZA Account Managers the data to drive clear, quantified decisions when creating plans for growers.

Using the digital armoury available in the decision making process, growers and agronomists can be more accurate with applications, at better timings and also have a better product choice based on data collected from trials and information from digital tools.

Variable rate applications will also have a large part to play in ELMS and other legislation that will be coming through in the next few years. Clean water/air and responsible use of products can all be effectively managed with the integration of digital agronomy (of which variable rate application plays a large part) into the farm business.





CASE STUDY

VARIABLE RATE LIQUID FERTILISER APPLICATION

Location: **Oak Tree Farm near Northallerton**

Sprayer: **Agrifac sprayer operated by Agrii contracting team**

Nutrition applied: **Liquid 13.4% N, 17.5% SO_3 (114kgN/ha at 850l/ha)**

VR map on Agrifac AgLeader display

Phil Reed and his Agrii team created their variable rate (VR) nitrogen plan for Oak Tree Farm using satellite (NDVI) imagery from RHIZA's free Base service. The team didn't end up using any more or less fertiliser than if they'd gone with a blanket approach, but the aim was to apply nitrogen exactly where it was needed, to create more of a level canopy and ensure less wastage to the environment.

"I'm impressed with how this worked" says Mr Reed. "I'd like to try doing our next VR lime application using NDVI imagery with the Agrii contracting team's lime spreader."

CONNECTING DIGITAL TECHNOLOGY FARMS AND RHIZA

The Digital Technology Farm trials for the 2020/21 season have been conducted in wheat crops, both winter and spring with focus on the following:

- **Variable rate seeding**
- **Tailored nutrition, with focus on both macro and micro nutrition**
- **Variable rate nitrogen**
- **Variable rate nitrogen with the inclusion of Agrii Liqui-Safe**

As well as the above trials, for this year we are also starting work looking into variable rate plant growth regulators in winter wheat and winter oilseed rape. We are able to use up to date satellite imagery to highlight the areas of the crop within a field with higher and lower biomass and create our variable rate plan accordingly.

There has been great interest over the past couple of years in the use of nitrogen inhibitors to reduce loses to the environment through denitrification and leaching. We know that the revised Agricultural Bill sets out to reward farmers for safeguarding the environment as well as aiding us to reach crucial goals on climate change. This has therefore focused us to develop our trials to maximise nitrogen use efficiency.

A large proportion of the DTF farms operate using liquid nitrogen products, therefore we saw an opportunity to combine Liqui-Safe into our nitrogen programmes and feature variable rate applications. Liqui-Safe is a urease and nitrification inhibitor for liquid fertilisers. The inclusion of Liqui-Safe allows us to reduce the number of splits being put onto the crop and we are able to put a higher loading of nitrogen on earlier in the season.

We have five Liqui-Safe trials running this year, all applying 60% of their total nitrogen to the crop at the first application with the inclusion of Liqui-Safe. This was then followed up 3-4 weeks later with the remaining nitrogen applied as split tramlines with half variable rate and half flat rate. Bedfordia Farms who are one of our DTF farms have found it beneficial to incorporate Liqui-Safe into their programmes:

"We used Liqui-Safe in conjunction with our applications of pig slurry, digestate and liquid fertilisers to try and minimise any losses and maximise utilisation of our applied nitrogen. We applied Liqui-Safe in combination with 90kgs of N in early March followed by 180kg of available N as pig slurry straight out of the finishing unit in the third week of April."

"We have also applied 210kg of N in one hit with 2.4 litres of Liqui-Safe to fields which had bio-solids pre-drilling last autumn. The wheat treated with Liqui-Safe, as described above, looks superb, particularly considering the conditions into which it was drilling."
Ian Rudge, Arable & Operations Manager, Bedfordia Farms.

Ian Rudge (left) and JJ Ibbett (right), Bedfordia Farms

SEPTORIA RISK TOOL

***Septoria* is the major foliar disease of wheat in the UK.** Tolerant varieties and a later drilling date are two cultural control solutions to reduce potential disease build-up especially early in the season; nevertheless, during the growing season fungicide applications timed at key phenological stages are the most effective measures for the control of *Septoria*.

The **Contour** *Septoria* risk tool supports decisions for a better fungicide choice and dosage. Risk levels are farm specific and indicate the current level of disease pressure based on the combined role of rainfall and temperature and on the varietal susceptibility to the disease.

The detailed progression over time of the risk is displayed on a graph together with daily rainfall, which is the main driver for *Septoria* development. The distribution of rainfall provides a visual indicator on when to spray, based on when rain is forecast.

BYDV TOOL

BYDV is a viral disease transmitted by aphids to winter cereals. The key to reducing the risk of infection is to limit aphids entering the crop by means of cultural control solutions and to suppress the numbers of aphids feeding on the crop with foliar insecticide. Please see page 7 for more information on Agrii's BYDV trials work and page 20 for varietal resistance and tolerance to BYDV.

The **Contour** BYDV tool helps to target BYDV insecticide sprays by identifying when is the best time for application, that is when the second generation of wingless aphids is produced and before population levels become exponential leading to a high risk of BYDV incidence.

A timely application positioned according to risk allows us to achieve maximum efficacy and avoid unnecessary sprays, which could drive an increase in resistance.

The BYDV tool uses field specific information, such as drilling date, the date of the last insecticide spray and daily average temperature. Risk levels are displayed on a map at a hyper-localised field level and over three date ranges: today, 5-days ahead and 10-days ahead.

CASE STUDY RHIZA CONNECT IN ACTION

Local data informs land management to protect water quality in the River Colne Catchment.

A new partnership project, to provide local weather data to inform land management decisions and protect water quality, has been launched in Essex's River Colne Catchment.

Since 2016 Anglian Water has been working in partnership with UK agronomy specialists Agrii and Dutch technical experts at RMA to create the RHIZA Connect weather app, which is now being made available to farmers and land managers. The app combines information from weather stations, as well as in-field moisture sensors and other data, like the amount of water flowing in field drains. It uses this to provide information to help farmers decide when to undertake operations such as spraying, fertiliser application or cultivation, while also keeping them informed of changes in the catchment and connected watercourses.

The data generated from Anglian Water's own weather stations, and the 230+ operated by Agrii, will also help manage water abstraction and treatment activities, as Catchment Advisor for Essex and Suffolk Gary Hodgetts explains: "This project is part of Anglian Water's wider commitment to catchment management – we want to utilise remote sensors to help turn the Colne Valley into an 'intelligent catchment' for the benefit of everyone. We hope that what is trialled and developed here can be rolled out to other catchments in the Anglian Water region.

"Weather affects raw water quality and availability, which ultimately influences our ability to utilise it. RHIZA Connect provides highly localised, at a glance, data that is simple to use and which highlights the challenges and constraints faced by farmers due to changing weather patterns, helping our staff understand the pressures that land managers are under."

Nick Winmill of Agrii explains that the app also adds additional data from drain flow sensors and soil moisture probes where available. "This means that we can improve decision making with hard data, a process known as decision support," he says. "This allows farmers to make more informed decisions about key inputs and the timing of operations to ensure we are not increasing the risk of pollution, for example by applying fertiliser or disturbing the soil when it is at risk of washing away."

The first farmers began to use the app towards the end of last year and, the rollout will continue throughout the summer.

One farmer using the app is Andrew d'Angibau from Wick Farm, at Aldham. He comments, **"I regularly use the app to review the local rainfall we have or have not had, plus monitor temperature – specifically for frosts. Both of these factors, alongside wind speed and soil saturation trends, help inform my land management decisions, such as the timing of plant protection product applications."**

THE RHIZA CONNECT APP & DASHBOARD

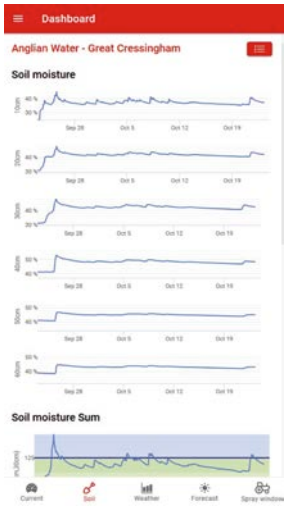
RHIZA

The new RHIZA Connect app provides a one stop platform to view:

- **Weather station data in various formats**
- **Two and eight-day weather forecast**
- **Spraying conditions forecast**
- **Detailed soil moisture information**
- **Crop disease forecasts**

The modular design of the RHIZA Connect app will allow additional monitoring activities to be hosted for on the go data access and decision support, subject to appropriate sensors being available, for example:

- **Drain flow**
- **Water body, level and flow**
- **Real-time soil nutrient sensing e.g. nitrate-N, potash, phosphate**



To sign up and access the new RHIZA Connect app please contact Rhiza Weather on email rhizaweather@agrii.co.uk or call 03300 949 150

Soil health enhancers such as mycorrhizal fungi are interesting new arenas for broad acre crops; although they have been used widely in ornamental and fruit production. Recent research work suggests benefits but currently cost in use is quite high.

There are a number of approaches and products claimed to improve soil health and resilience, although this is a lengthy process. Techniques for improving organic matter might include the following, but these will take time before they have a material effect:

- **Direct application of organic matter (compost, farmyard manure (FYM) for example)**
- **Incorporating straw**
- **Growing green manure and cover crops**
- **Introducing grassland or herbal leys into the rotation**

Obviously attention to drainage, rectifying compaction, minimising erosion and run-off through the use of winter cover will all play their part in soil improvement. In addition, there are an increasing number of products coming onto the market purporting to enhance soil properties and improve the level of biological activity.

The Agrii R&D team is investigating these claims in some detail as none of these products are subject to regulation in the UK, so proof of concept is needed.

A QUICK GUIDE TO DEVELOPING TECHNOLOGIES

Product types might include the following, most of which have been tested through the Agrii trials programme with varying degrees of success:

STRAW BUSTERS to accelerate straw breakdown have been marketed for a while. These usually consist of microbes which are intended to accelerate the decomposition of crop residues, by synthesising enzymes that attack cellulose. Claims include boosting nutrient availability, increasing beneficial microbes, humus and improving soil structure. Products are applied as spore solutions direct to stubbles after harvest.

Applications of **ARBUSCULAR MYCORRHIZAL FUNGI** (AMFs) to top-up natural levels. These AMFs are naturally present in healthy soils and form important root associations with crops to help enhance nutrient and water uptake by extending root systems. Products on the market often contain live spores which may be applied with nutrients and other growth promoting fungi and bacteria. They are widely used and accepted in Horticulture and Amenity sectors where visible and measurable benefits on root and shoot growth can be seen. So far they have made little impact on agriculture as applied products due to variable results and a high cost. In agriculture the focus has been more on ways to minimise the disruption to these soil assets by attention to cultivations and rotational choices.

COMPOST TEAS to improve percolation and soil structure. These are highly concentrated mixtures of microbes, mainly used in amenity situations like golf courses to improve turf health and rooting. The preparation process usually involves dry compost and non-chlorinated water brewed together with a catalyst, then applied thorough a normal field sprayer. They have not been evaluated very much in agriculture; but some limited data (not validated by Agrii) in wheat and barley exists suggesting yield increases are possible through regular application.

SOIL CONDITIONERS that help to alleviate some of the negative effects of soil compaction. These soil amendments allegedly improve water and nutrient filtration through the soil profile. They contain organic or inorganic products such as gypsum, slate, polysaccharides or sewage sludge. Depending on the product, claims are made for improved nutrient availability, drainage, the exchange of water and air in clay soils etc.

SOIL SEALANTS to reduce wind blow. Light sandy or black organic soils can be prone to wind blow which (aside from losing a valuable resource, i.e. soil from the field) can disrupt plant establishment, impact pre-emergence herbicide performance and reduce crop safety. Products are available that are applied pre-emergence, capping the soil and so claim to reduce soil losses.

We're currently trialling **MOLASSES-BASED PRODUCTS** in our five year Nutrient Use Efficiency (NUE) trials and multiple tramline trials across the country, with a view to improving soil food web activity and increasing NUE.

Agrii-Start Release

AGRII-START RELEASE

A proven tool for phosphate management within the soil

Agrii trials spread across a wide variety of soil and crop types throughout the country have shown consistent results with use of Release:

- Increased soil and Olsen P levels in the presence and absence of phosphate fertilisers.
- Significant growth in Green Area Index (GAI) and roots that are untreated.

These trials have demonstrated the ability to reduce phosphorous applications in combination with Release.

The reduction has significant benefits for the environment and the reduction of the carbon footprint for the crop.

PART TWO

BRINGING IT ALL TOGETHER

Agrii actions relevant across all five Insight Reports:

- Green Horizons Challenge Field of the Future reduced input R&D project (more detail included in the table).
- Agrii annual Innovations Award Scheme (please visit www.agrii.co.uk/greenhorizons for more info).
- Fast-track biosolutions screening programme (more detail in the table and on page 22).
- Accredited environmental training (please see Insight Report 2 for more info).
- Extended enterprise benchmarking.
- General company drive towards net zero (please see Insight Report 5 for more information).
- Target of 100% of Agrii trials to include an IPM element by 2022.

This Action Plan will be continually updated as our work progresses.

You can view updates at **www.agrii.co.uk/greenhorizons**

Agrii's Action Plan for Integrated Whole Farm Solutions

Action	Details	Timescale	Where to go for more information?
Fast-track biosolutions screening programme being run with our sister company, Fortgreen	With Fortgreen, we are trialling more than 130 biostimulants, elicitors, endophytes and biopesticides. With a high failure rate of these products, we are looking to develop a screening method to speed up the trialling process.	Ongoing	Please visit page 22 for more information
Increase the proportion of our trials that include an element of IPM	We are working to ensure 100% of our trials include am element of IPM. Currently (in 2021) we are at 98%, so on track to reach our 2022 target.	By 2022	Please visit page 7 for more information
Establish recognised metrics for use of crop protection products	We are working with a range of stakeholders to recognise an appropriate metric for measuring the patterns and risks of crop protection products as a way of validating the widespread adoption of IPM.	Ongoing	Please visit page 26 for more information
Advise on more resilient genetics through our Variety Sustainability Ratings	We have seen a large increase of the proportion of varieties sold with a high sustainability rating, and these have surpassed the rest of the market sales for both winter wheat and barley.	Ongoing	Please see page 12 for more information
Develop climate tolerant break crops and associated agronomy advice	Look at alternatives break crops to OSR, that help to build business resilience.	Ongoing	Please see **Green Horizons Insight Report 4** for more information.
Increase the widespread adoption of IPM	Through our events, networking groups and advice, we aim to educate and encourage the update of IPM on farm.	Ongoing, with discussions broadening across all trial sites	Please visit **www.agrii.co.uk/events** for more information.
Engage with the wider industry on IPM topics	Working with leading associations to understand how to assess and validate IPM adoption.	Ongoing	Please see **Green Horizons Insight Report 5** for more information.
Digitally enable decision making on farm	Provide tools that can be used in conjunction with agronomic advice to identify risk, to better target the use of chemical products.	Ongoing	Please see page 33 for more information

WHERE NEXT?

For more information on anything that you've read in this brochure, or to discuss how to develop integrated whole farm solutions for your farm, please get in touch with your usual Agrii contact, call us on 0845 607 3322 or email info@agrii.co.uk

You can also keep up to date with the latest news from our environmental improvement projects as part of Green Horizons at **www.agrii.co.uk/greenhorizons**

INSIGHT REPORT:1
IMPROVING SOIL RESILIENCE

INSIGHT REPORT:2
ENHANCING THE ENVIRONMENT

This is INSIGHT REPORT:3
PROVIDING INTEGRATED WHOLE FARM SOLUTIONS

INSIGHT REPORT:4
INCREASING FARM PRODUCTIVITY AND VIABILITY

INSIGHT REPORT:5
EXTENDING STAKEHOLDER ENGAGEMENT

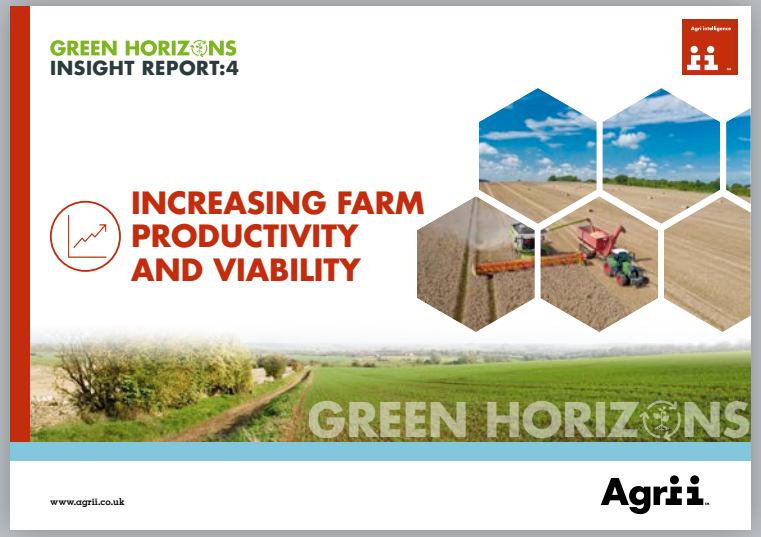
This Insight Report is one of five produced as part of Green Horizons: Agrii's Commitment to Sustainable Food Production.

Find out more at:
www.agrii.co.uk/greenhorizons

The next Insight Report in this series is

INSIGHT REPORT:4

INCREASING FARM PRODUCTIVITY AND VIABILITY



PART THREE

GLOSSARY

Arbuscular Mycorrhizal Fungi (AMFs)
A type of soil health enhancer, these fungi are naturally present in healthy soils and form important root associations with crops to help enhance nutrient and water uptake by extending root systems.

Bioinsecticides
This term describes pesticides derived from natural materials such as animals, plants, bacteria or certain minerals.

Biosolutions:
A biological or naturally occurring solution to a problem. In this context – the possibility of utilising naturally occurring organisms for pest control.

Biostimulants:
A plant biostimulant is any substance or micro-organism applied to plants, seeds or the root environment with the intention of stimulating natural processes, to benefit nutrient use efficiency and/or tolerance to physical (abiotic) stress and/or crop quality traits. This effect is independent of the substance's nutrient content. This means that a biostimulant's main role should not be to provide fertilisation or pesticidal activity. This definition is currently under debate/review.

Compost teas
A type of soil health enhancer, these are highly concentrated mixtures of microbes mainly used in amenity situations to improve turf health and rooting.

Conservation Agriculture:
The terms conservation agriculture and regenerative agriculture tend to be used interchangeably, but conservation agriculture has three guiding principles rather than five: minimum soil disturbance, maintenance of permanent cover and encouraging a wide diversity of crop species.

Contour
A digital platform that offers a range of precision farming features, allows farmers to view their data in one place and provides variable rate planning functionality. Contour Mobile is a scouting app that allows growers and agronomist to crop walk using RHIZA 'layers'.

Crop Protection Chemistry (CPC) and Crop Protection Products (CPPs)
The term CPC is utilised throughout this document when referring to synthetic or traditional crop protection products. The term CPP is used to encompass all crop protection products, including both synthetic chemistry and biosolutions.

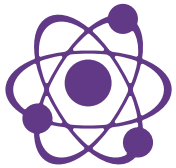
Cultural controls:
The practice of modifying the growing environment to reduce the prevalence of unwanted pests. Using cultural control before chemical control can reduce detrimental effects to the ecosystem surrounding the growing environment.

Digital Technology Farms (DTFs)
The DTF project is a farmer-led initiative involving Agrii growers, their agronomists and digital agronomy specialists, RHIZA. Digital technologies are put through their paces on 10 Digital Technology Farms throughout the country, the idea being that they will demonstrate their most profitable use and provide the broadest base for future improvements.

Disease Resistance
Relative to a susceptible plant, disease resistance is the reduction of pathogen growth on or in the plant, and consequently a reduction in disease.

Disease Tolerance
This term describes plants that exhibit little disease damage despite substantial pathogen levels.

Elicitors:
An elicitor is a molecule that triggers the hypersensitivity response in a plant. Elicitors can attach to special receptor proteins located on plant cell membranes. These receptors are able to recognise the molecular pattern of elicitors and trigger intracellular defence signalling. This response results in increased synthesis of metabolites which reduce damage and increase resistance to pest, disease or environmental stress.



Endophytes:
Often a bacterium or fungus, which lives inside a plant for the entirety of its life cycle without causing apparent disease. Most endophyte/plant relationships are not well understood. Some endophytes may enhance host growth, nutrient acquisition and improve the plant's ability to tolerate stresses such as drought, and decrease biotic stresses by enhancing plant resistance to insects, pathogens and herbivores.

Genome editing
The manipulation of genetic material of a living organism by deleting, replacing or inserting a DNA sequence. In agriculture this technique is typically used with the aim of improving a crop's yield or characteristics.

Genome sequence
All of the genetic material of an organism, consisting of its DNA.

Genetic traits
A trait is a specific characteristic of an individual, inherited from its parents, which gives that individual its characteristics and appearance. Traits are determined by genes and also by interaction between the environment and genes.

Green bridge
This is any green plant material which survives between crops and acts as a host for pests and diseases. These plants provide a 'bridge' between cropping seasons for pests and diseases, enabling them to spread and infect subsequent crops.

GLOSSARY

Integrated Farm Management (IFM):
A whole farm business approach that aims to deliver more sustainable farming. IFM combines the best of modern technology with more traditional methods to help deliver profitable farming that supports the natural environment. Attention to detail is key: appropriate and efficient use of inputs combined with smarter approaches to business planning and the adoption of innovations and new technologies, all contribute to increasing productivity while protecting valuable resources.

Integrated Crop Management (ICM):
This describes an integrated, holistic approach to the growing of a particular crop and how all the elements of IFM fit together across that crop's whole life cycle.

Integrated Pest Management (IPM):

The careful consideration of all available plant protection methods and subsequent integration of appropriate measures that discourage the development of populations of harmful organisms, while keeping the use of PPPs and other forms of intervention to levels that are economically and ecologically justified. IPM offers a toolbox of techniques that can be tailored to different cropping systems, climatic conditions, pest pressure and availability of solutions. By using a combination of techniques to manage a combination of approaches to crop threats, IPM can be seen as a systems based approach where the entire system effect is greater than the sum of individual components.

Nitrification inhibitor
These compounds protect against denitrification and leaching by retaining fertiliser nitrogen in the ammonium form, thereby increasing the nutrient use efficiency of fertilisers.

Regenerative Agriculture:

Regenerative agriculture is all about regenerating degraded soils to improve soil biology, enhance the water cycle, increase carbon drawdown and improve nutrient cycling. There are five key guiding principles to regenerative agriculture: keep the soil surface covered as much as possible, try to limit physical soil disturbance, integrate grazing livestock into the system, keep living roots in the soil for as much of the year as possible, and encourage a wide diversity of plants and crops to increase soil biodiversity.

RHIZA Connect

This is an app that provides a platform for viewing weather station data from across the country, two- and eight-day weather forecasts, spraying conditions forecasting, soil moisture information and crop disease forecasting. Please speak to your usual Agrii contact for more information on how to access the app.

Soil conditioners
A type of soil health enhancer, soil conditioners aim to alleviate some of the negative effects of soil compaction.

Soil health enhancers
Products and approaches claimed to improve soil health and resilience (please see page 35 for more information).

RHIZA
This is Agrii's digital and precision farming partner, bringing together the combined capabilities of SoilQuest and IPF to deliver digital tools and precision farming services to 750K Ha across the UK.

Soil sealant
A type of soil health enhancer, these can reduce wind blow and consequent erosion.

Stale seedbed
This is a weed control technique whereby a seedbed is created some weeks before the seed is due to be drilled.
The intention is to germinate dormant weed seeds moved to the soil surface during cultivation so that young weed seedlings can then be easily eliminated.
Download the Agrii guide to stale seedbeds https://www.agrii.co.uk/wp-content/uploads/2017/08/Guide-to-Blackgrass-Stale-Seedbeds.pdf

Straw buster
A type of soil health enhancer, these usually consist of microbes that are intended to accelerate the decomposition of crop residues.

T(-1)

Agrii identifies the T(-1) crop timing as the time of planting. The Foundation stage of crop planning, identified by Agrii, is characterised by a range of opportunities that exist pre-planting to maximise that crop's chances of reaching its genetic potential.

FIND OUT MORE ABOUT GREEN HORIZONS:

Visit **www.agrii.co.uk/greenhorizons** or scan the QR code

Contact us at: **info@agrii.co.uk**

Go to **www.agrii.co.uk/events** to sign up for our latest Green Horizons webinars and view past events

THE GREEN HORIZONS FARMER NETWORK

This network of like-minded Agrii customers is working collaboratively, sharing knowledge and answering its own questions around how to produce sustainable and profitable food. Please get in touch for more information about how to get involved.

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