GREEN HORIZONS
INSIGHT REPORT: 1

Agri intelligence

IMPROVING SOIL RESILIENCE

www.agrii.co.uk Issue 2 – February 2022

Agrii

In this example, mixed rye, mustard and vetch covers preserve a good soil structure

CONTENTS

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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 will help enable farmers and growers to meet the likely future demands of measures contained within the 25 year Environment plan, Agricultural Bill/ ELMs and net zero targets.

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, has been produced for each of the five points of the plan. This report focuses on **improving soil resilience**.

SOME OF THE CHALLENGES THIS DOCUMENT AIMS TO ADDRESS:

- Uncertainty over future subsidies and possible reduced productivity.
- Habitat and species decline.
- Future resilience required to adapt to climatic changes such as drought and increased rainfall.
- Increased pest, weed and disease resistance and loss of crop protection products.
- Restrictions on fertiliser use.

Our ambitions under this section of the plan are covered in detail in this report.
In summary, they are to:

Develop and adapt independently validated measurements of soil health.	**SECTION B**
Improve soil health through value chain and scientific collaborations.	**SECTIONS 1-5**
Expand the range and use of fertilisers with a low carbon footprint.	**SECTION 5**
Increase adoption of tailored nutrition programmes through soil/tissue sampling and using RHIZA digital.	**SECTION 5**
To provide a science based route map for those looking to move to a conservation/regenerative approach to help maximise success and minimise the risks.	**SECTIONS 1-5**

Our Action Plan for Improving Soil Resilience can be found on **page 36**.
This Action Plan will be continually updated as our work progresses.
You can view updates at **www.agrii.co.uk/greenhorizons.**

The future of UK farming depends on our stewardship of the natural resources that form the basis of food production – air, water and soil. Our objectives are:

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

This document provides a practical approach to improving soil health and resilience.

Our aim is to help our customers create resilient and profitable enterprises that are based on a thriving natural environment.

BACKGROUND AND INTRODUCTION

A

REGENERATIVE AGRICULTURE AND BEYOND

Our approach is based upon, and goes beyond the traditional tenets of conservation or regenerative agriculture.

Decades of research at our Technology Centres, and in conjunction with our partners on a range of research projects, have shown us the importance of looking at the whole farming system. This holistic approach requires consideration of all aspects of land management in our decision making, and how all the different elements of the farm's natural environment interact with each other. It also takes into account the effect the farming system has on soil, water, air and the wider landscape – 'public goods'.

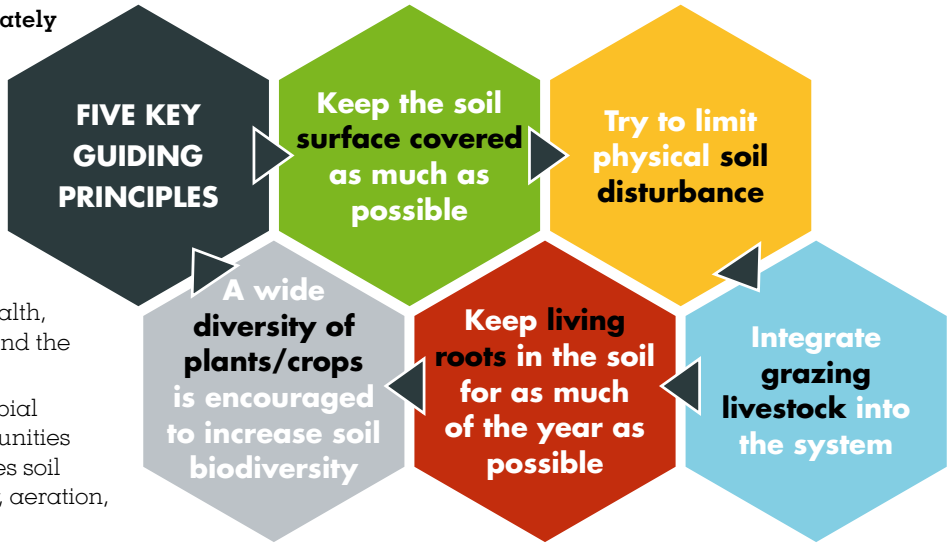
It looks at the different influences or pressures that different farms may experience – soil types, disease pressures, weather variations, and considers the best overall approach for management. This ecosystems approach is balanced against the needs and requirements of the viability and profitability of the farming business.

This document outlines Agrii's approach and research across all of the elements of regenerative and conservation agriculture, as well as the new technologies available to us that can help to improve soil resilience.

WHAT IS REGENERATIVE AGRICULTURE?

Regenerative agriculture is all about appropriately assessing and managing our soils to:

- **Improve soil biology.**
- **Enhance the water cycle.**
- **Increase carbon drawdown.**
- **Improve nutrient cycling.**



HOW?

- Soil organic carbon is a key driver for soil health, playing a large role in ecosystem functions and the soil's Water Holding Capacity (WHC).
- Without carbon-based organic matter, microbial communities cannot thrive. Microbial communities drive soil aggregation which in turn enhances soil structure and stability, improving workability, aeration, infiltration and WHC.
- Regenerative practices can increase carbon drawdown and minimise carbon losses, helping towards the NFU's net zero carbon ambition.

WHY?

- Soil is a finite resource and is being lost through erosion and degradation.
- Farm ecosystems need to be robust to cope with, and react to, more frequent extreme weather events.
- ELMs will be based on clean air and water, biodiversity and improved resource use efficiency – regenerative practices could help to improve some or all of these.

By increasing Soil Organic Matter (SOM) by just 0.1% (ie. 4.0 to 4.1) an extra 8.9T of carbon will be sequestered per hectare, per year. That's the equivalent of the emissions products by 7 cars for a year! (Data from FCT).

The terminology 'regenerative agriculture' tends to be used interchangeably with 'conservation agriculture' but CA has three guiding principles rather than five:

1. **Minimum soil disturbance.**
2. **Maintenance of permanent soil cover.**
3. **A wide diversity of crop species.**

A BACKGROUND AND INTRODUCTION

HEALTHY, RESILIENT SOILS: A PRACTICAL APPROACH

This document is structured around healthy, resilient soils being at the centre of the farming system.

Our approach to improving soil health and resilience considers **five key areas** that should be viewed in integration in a whole farming system approach with healthy soils at its centre.

The key is to pick the right strategy for you, your crops and your enterprise.

Variety choice and cultural control of weeds, pests and diseases can also play an important role in increasing the resilience of your farming enterprise and improving the long term health of your soils.

You can find out more about the work that Agrii is doing in these areas in **Insight Report 3**: **www.agrii.co.uk/greenhorizons/integrated-whole-farm-solutions/**

Please get in touch for more information.

1 APPROPRIATE CULTIVATION FOR YOUR SITUATION

- Maximise crop establishment.
- Reduced compaction.
- Better root development.
- Improves soil water content.
- Improves soil fertility and structure.
- Reduced erosion and run-off into water courses.
- Lower carbon footprint.
- Reduced grassweed pressure.

PAGES 14-21

2 CONSIDER CONTINUOUS COVER

- Protects soil structure – reduced erosion.
- Maintains soil nutrients.
- Increased biological activity and soil organic matter – active roots.
- Maintains soil moisture.
- Protects soil surface from intense rainfall events.
- Biodiversity benefits.
- Reduced inputs.
- Reduced run-off into water courses.

PAGES 22-24

3 DIVERSIFICATION OF CROPPING AND ROTATIONAL STRATEGY

- Improved soil biodiversity.
- Improved soil physical properties.
- Increase water availability and efficiency.
- Fewer inputs required.
- Increased economic and climatic resilience.
- Future-proofing your business.
- Reduced pests/disease/weeds.
- Increased weed control.
- Nutrients distributed throughout soil profile.

PAGES 25-28

HEALTHY SOILS / RESILIENT FARM

5 ADOPTION OF NEW TECHNOLOGIES

- Improved soil biodiversity.
- Fewer inputs required.
- Reduced carbon footprint.
- Biodiversity benefits.
- Targeted inputs reduce costs.
- Reduced inputs to water courses.

PAGES 31-33

4 INTEGRATION OF LIVESTOCK INTO THE ROTATION

- Improved soil health.
- Reduced risk of soil erosion and diffuse pollution.
- Improved landscape biodiversity.
- Health benefits for livestock.
- Extended rotations.
- Maintains soil nutrients.

PAGE 29-30

WHY IS SOIL HEALTH IMPORTANT?

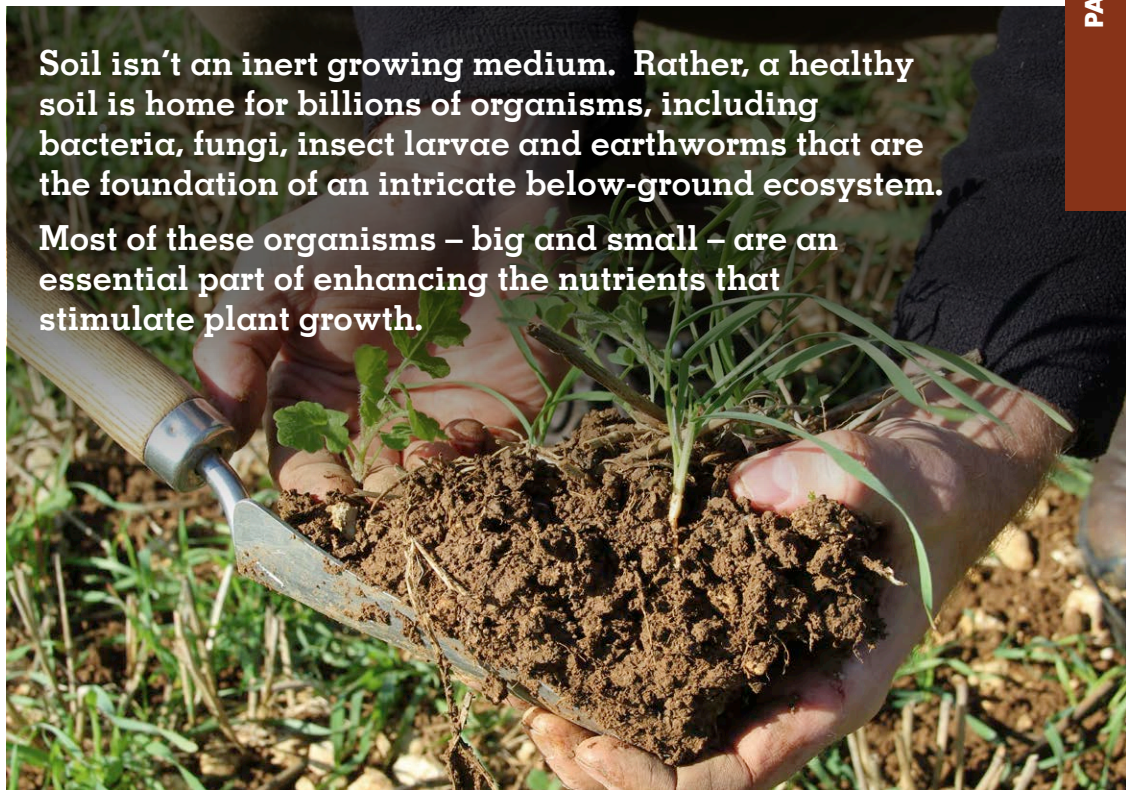
B

THE IMPORTANCE OF HEALTHY SOILS

Soil is fundamental for crop production, supporting delivery of 95% of the UK's food, and storing around 80 years' worth of GHG emissions in the form of carbon.# Soil health can be defined as the continued capacity of a soil to function as a vital living ecosystem that sustains plants, animals and humans. Healthy soils grow healthy crops that are better able to withstand disease and compete against grassweeds.

SOIL IS AN ECOSYSTEM THAT CAN BE MANAGED:

- A healthy soil provides a habitat for soil microbes to flourish and diversify – providing the nutrients that crops need to grow and prosper.
- Soils store two thirds of the fresh water on the planet* and this function is determined by the level of organic matter in the soil. The loss of soil biodiversity reduces its water infiltration capacity, as well as its capacity to store water, lowering food production and worsening the impact of drought.
- The carbon contained within soil organic matter represents one of the largest carbon stocks on Earth and plays a major role in mitigating climate change. In the UK our soils hold an estimated 9.8 billion tonnes of carbon.** When soil is eroded, the carbon stored in soils is lost in the form of greenhouse gases. Globally it is estimated that 26% of the carbon stored in the top one metre of soil has been lost since pre-historic times (FAO 2015).
- A well structured soil anchors crops and plants – allowing root systems to extend downward through the soil and in turn stabilise plants so that they can grow efficiently.
- A well structured soil allows less erosion by wind or rain and reduces the likelihood of flooding due to improved porosity.
- The minerals and microbes in soils help to filter, buffer, degrade and detoxify potential pollutants – including industrial by-products and atmospheric pollution.



THE 'ONE HEALTH' CONCEPT

Shows the relationship between ecosystems – soils, plants, animals and human health as being closely intertwined. (Adapted from: *The soil- human health nexus.* Edited by Rattan Lal, 2021.)

Harper Adams University

Agrii was one of the founding partners of the Harper Adams Soil and Water Management Centre. For more information on the Centre's work, please see **Green Horizons Insight Report 5.**

#Environment Agency 2019 * IUCN - www.iucn.org/resources/issues-briefs/conserving-healthy-soils **Soil Association figures

C MEASURING SOIL HEALTH

HOW CAN WE DEFINE SOIL HEALTH?

Soil health was only identified distinctly as being separate to soil quality in the late 1990s, and remains poorly defined in other than general terms. Despite the wide range of biological tests being offered and promoted, there are no agreed protocols by which to measure.

While it's relatively easy to list the key characteristics of a healthy soil, the complexities involved mean all the main bio-indicators being put forward to measure it – from soil organic matter to total microbial biomass and earthworm populations – have clear limitations. Not least because physical structure and pH are so intimately inter-related with biology in determining it.

Despite the challenge, we need to know the health status of our soil, in order to know whether we are managing it in a sustainable way and how best to monitor any changes.

10 KEY CHARACTERISTICS OF A HEALTHY SOIL:

1. Good tilth.
2. Sufficient depth.
3. Reasonable pH.
4. Balanced nutrient supply.
5. Small population of pathogens and pests.
6. Large population of beneficial organisms.
7. Good drainage and water holding capacity.
8. Low weed pressure.
9. Resistant to degradation.
10. Resilient to unfavourable conditions.

SOIL HEALTH BIO-INDICATORS?

Reliable indicators that allow comparison across ecosystems would be a useful basis of a system for evaluating a soil's health status. To be a reliable indicator of soil health, the parameter should be:

- ✚ Sensitive to variations in land management.
- ✚ Correlated with soil functions.
- ✚ Useful for explaining environmental processes.
- ✚ Comprehensible and useful to land managers.
- ✚ Easy and inexpensive to measure.

Indicators for soil biology have been developed only recently. Unfortunately these indicators have often not been produced in parallel with necessary guidance and tools to allow them to be exploited on farm.

IMPROVING OUR UNDERSTANDING OF SOIL BIOLOGY:

As part of the Achieving Sustainable Agricultural Systems (ASSIST) programme, researchers from Agrii and the UK Centre for Ecology and Hydrology (UKCEH) are working to achieve a far better understanding of soil biology to inform future agricultural and environmental policy and practice.

This project has now extended full DNA analysis of soils to 386 samples from 185 arable fields across southern and eastern England.

Initial DNA barcoding work carried out as part of the project identified no less than 62,000 different bacteria, 2,000 different fungi and 4,000 different eukaryotes in samples comprising just 0.5g of soil from Agrii's Stow Longa site.

The team's DNA analysis has also highlighted valuable differences in soil biology under different soil management regimes, offering the opportunity to secure real and lasting improvements in both crop and environmental health.

What the study is confirming so far is that regularly disturbing microbial populations with cultivation or failing to provide them with sufficient organic matter to feed on will lead to less desirable soil communities.

These are also less likely to be stable, more prone to domination by coloniser species and potentially more vulnerable to environmental change.

By marrying detailed information from field records, RHIZA soil analyses, hyper-local weather statistics and crop yields with organic matter analysis and microbial DNA characterisation, the aim of the project is to develop an industry-leading database of soil biology interactions to support science-based improvement efforts.

Arrows indicate direction of change with number of arrows indicating magnitude of differences		Reduced tillage – no Cover Crop				Cover Crop + min tillage				Effect on crop
		Karat (shallow)	Karat (deep)	Straw rake + natural fallow	No Cover Crop/ Conventional plough	Phacelia	OR	White Mustard	Black Oat + Radish	
	Soil Organic Matter	↓	↑	↑↑	↓	↑	↑	↑	↑↑	
Possible beneficial micro-organisms	Bradyrhizobium	↑	↑↑	↑	↓	↑	↑	↑	↑	N fixing
	Verrucomicrobia	↑	↑	↑	↓	↑↑	↑↑	↑	↑	N fixing
	Metarhizium	↓	↑	↑	↓	↑↑	↑	↑	↑↑	Takeall decline
Potential pathogens	Phytomyxea	↓	↔	↓	↑	↓	↓	↓	↓	Club root
	Plamodiophora	↓	↓	↓	↑	↓	↓	↓	↓	Cabbage club root
	Pythium A & B & C	↑	↑	↑↑	↑↑	↓	↓	↓	↓	Root rot - beneficial subspecies?
?	Pythium D	↔	↔	↑	↓	↑	↑↑	↑↑	↑↑	

Changes in microbial populations under different regimes at Stow Longa

DEVELOPING A CARBON:CLAY INDEX

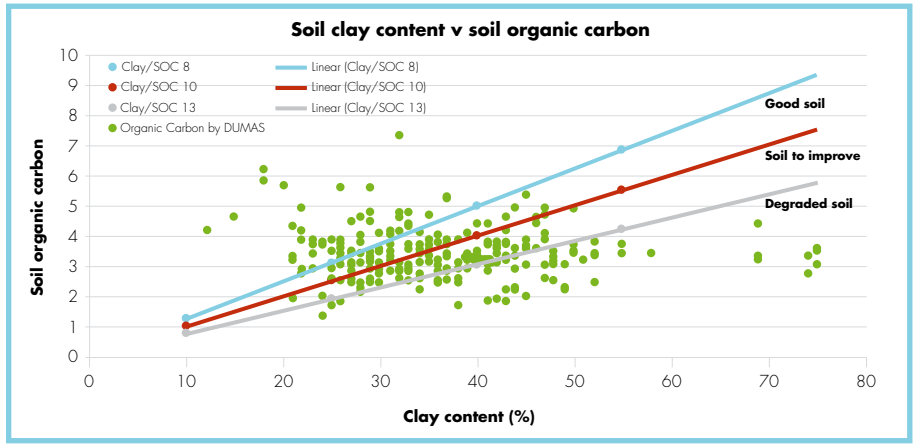
Following publication of initial work looking at the soil carbon:clay index by Steve McGrath and his team at Rothamsted*, it was decided that as well as continuing their work on DNA barcoding, the ASSIST team would also look at the analysis of the clay:organic carbon ratio of the 386 field soil samples to determine whether this could be utilised as a useful indicator of soil health. In addition to a comprehensive soil analysis, information on previous inputs, cultivations and yields was also collected.

Their results showed a good fit with the national soil survey-based soil degradation work published by the Rothamsted team.

"Removing the obvious extremes from our analysis shows an interesting distribution of soils against the 8:1, 10:1 and 13:1 clay:organic carbon ratios suggested by the Rothamsted work, as the dividing line between good soils, those needing improvement and those suffering from degradation."

Andrew Richards, Agrii Senior Agronomist and Project Manager

Agrii and UKCEH soil samples (2019) set within the quality parameters identified by the Rothamsted team



*Credit for Rothamsted parameters in the graph above: Prout, J., Shepherd, K., McGrath, S., Kirk, G., Haefele, S. 'What is a good level of soil organic matter? An index based on organic carbon to clay ratio'. European Journal of Soil Science, June 2020. https://doi.org/10.1111/ejss.13012.

UK Centre for Ecology & Hydrology

assist

CAN A CARBON:CLAY INDEX PROVIDE A UNIVERSAL AND SIMPLE TEST FOR MEASURING SOIL HEALTH?

As a result of this work we are confident that the organic carbon:clay index offers considerable potential for a universal and simple measure of soil condition.

The index is considered to be much more useful than soil organic matter (SOM) alone, because it accounts for the interactions between organic matter and texture, that mean that the higher the clay content of a soil, the greater the level of organic matter needed for it to be resilient. It also allows for the fact that the binding capacity of clay particles means that SOM takes longer to both build and degrade in higher clay soils. Soil type therefore determines the potential storage of soil carbon.

The carbon:clay index approach is well supported by studies being carried out in other parts of Europe as well as the UK.

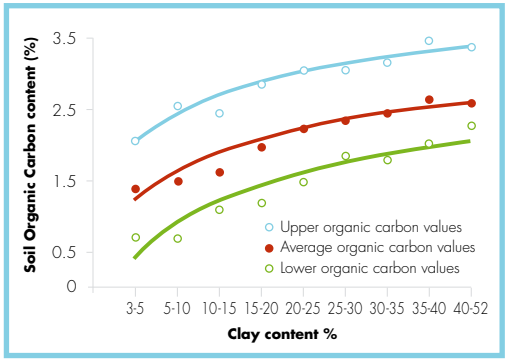


Image adapted from: Hoyle, Frances & Baldock, Jeffrey & Murphy, Daniel. (2011). Soil organic carbon – role in rainfed farming systems with particular reference to Australian conditions. 10.1007/978-1-4020-9132-2_14.

As part of the Agricultural Bill, and within ELMs, the UK government defines and supports the delivery of public goods delivered by farming.

The carbon:clay index provides supporting evidence for the key areas incorporated within the soil standards that form the Sustainable Farming Incentive within ELMs:

1. Carbon sequestration.
2. Improved nutrient use efficiency.
3. Resilience to compaction.
4. Improved water infiltration – reduced run off and flooding.
5. Improved water holding capacity.
6. Resilience of crop yields to extreme climate (e.g. drought).

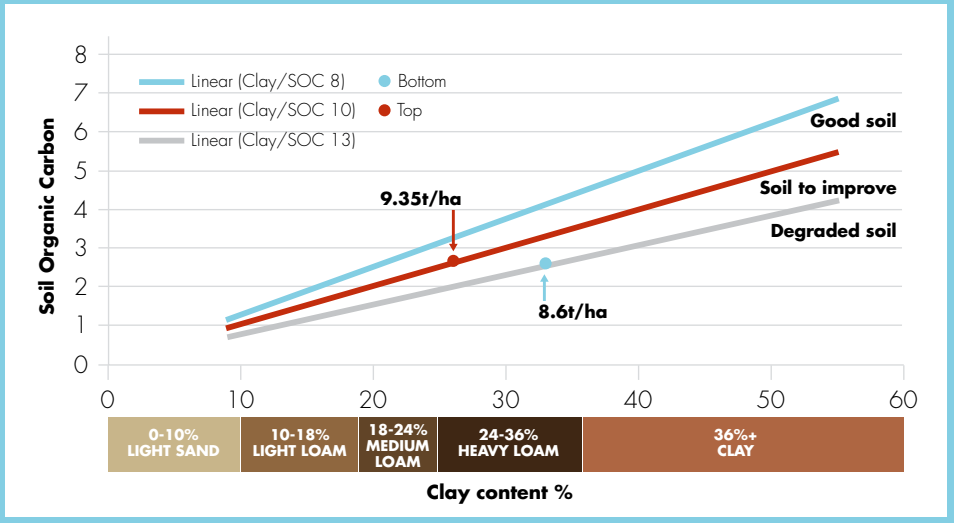
"Chalk soils have proved difficult to obtain both accurate clay and organic carbon content from. Some ground chalk inevitably seems to get classified as clay in texturing work, while free carbonates can lead to an over-estimation of carbon levels. We are working with independent soil scientist Dr Stephen Hemmings and the commercial labs to address these issues."

Andrew Richards, Agrii Senior Agronomist

MEASURING SOIL HEALTH

THE BRACKLEY iFARM LOW CARBON WHEAT PROJECT

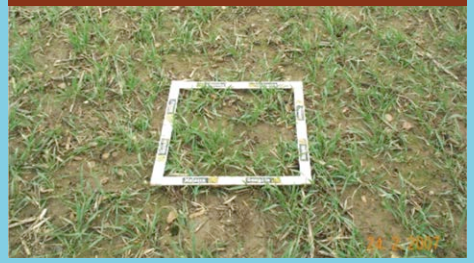
As part of this project the Brackley iFarm team used the percentage of clay content versus the percentage of organic carbon as an indicator of the soil suitability for direct drilling. The results from the trials resulted in a 0.75 t/ha penalty in yield on land that fell into the soil to improve/ degraded category due to inconsistent establishment and resulting ear numbers.

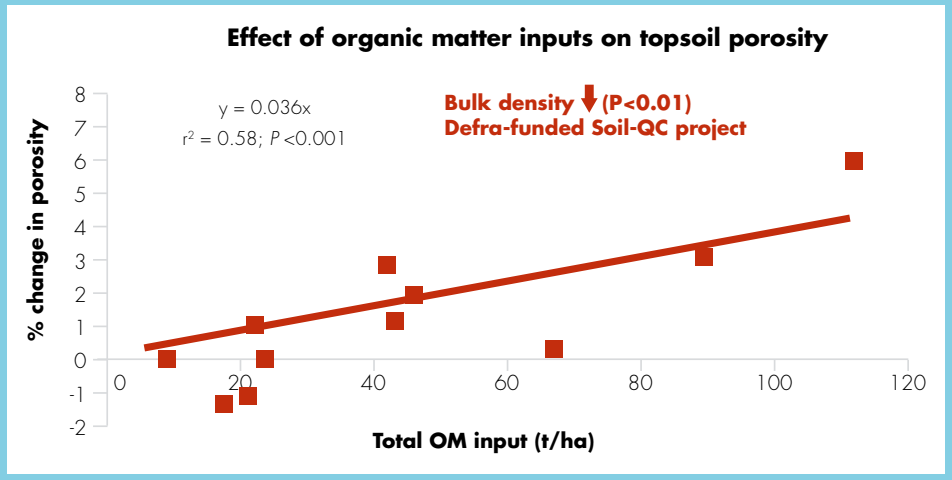


Organic matter inputs can also have a positive effect on topsoil porosity, improving water infiltration. You can see the visual results in these images from the Brackley iFarm Low Carbon Wheat Project:

DIRECT DRILL + COMPOST

DIRECT DRILL – NO COMPOST





TRACKING SHORT-TERM CHANGES

It has taken decades of ignoring soil organic matter to degrade our soils, and it will take many years to build it back up again – particularly on high clay soils. If we keep doing the 'right' things, we will start to see valuable improvements in key aspects of soil health, like workability and porosity, well ahead of any measurable increases in soil carbon. A different test is required to pick up small changes found in the first few years when we're trying to improve soil health.

Currently with UKCEH, we are looking at 'active carbon' as offering the greatest promise as a measure of short term / incremental changes in soil health. Active carbon typically comprises 5-20% of soil organic matter and represents the carbon actually available as food to micro-organisms. Although relatively new in the UK, this approach has been widely used for a decade or so in North America and elsewhere.

Please see the Dunkirk Farm case study on page 23 for more information.

THE VALUE OF MANURING

D

CASE STUDY

TRIALS HIGHLIGHT RELATIVE ORGANIC MANURE VALUE AT AGRIIFOCUS

Results from Agrii research at the AgriiFocus Technology Centre near Swindon show that organic manuring can give significant improvements in soil health and productivity in a relatively short time. However, the type and scale of improvements may vary widely between different manures, making it important to employ the right manure both for the conditions and the task in hand.

Fully replicated treatments of chicken manure, biosolids, farmland manure and green compost were applied and incorporated to deliver exactly the same levels of total nitrogen/year. A double rate of green compost was also included.

- The most impressive soil organic matter improvement (from 2.7%-4%) came from our double rate of green compost addition (200 t/ha in all).
- 40 t/ha of chicken manure boosted the average organic matter to just under 4%. However, chicken manure actually decreased the earthworm population.
- High rate compost and biosolids gave the most significant increases in earthworm populations.
- Farmyard manure (FYM) gave by far the best wheat performance.
- All regimes improved water infiltration rates, with FYM performing noticeably better than the other regimes.

These results underline how much more there is to improving arable performance through organic manuring than just improving the key soil health indicators of organic matter levels, earthworm populations or infiltration. There may be more carbon in green composts and chicken manures, but they aren't nearly such good food sources for soil micro-organisms as FYM. The acidity of chicken manure is also quite obviously a negative factor as far as earthworms are concerned.

The straw in FYM is good for soil structure and drainage and may also be making a valuable impact to potash levels. Biosolids on the other hand can be useful in increasing phosphate indices.

ORGANIC MANURES AND THE FARMING RULES FOR WATER (FRfW)

The FRfW were introduced in 2018 to fulfil obligations on diffuse pollution under the Water Framework Directive (WFD). The aim is to protect watercourses from nutrients through soil testing, proactive nutrient management planning and reference to professional skills and advice as required.

There are eight rules on managing fertilisers and manures and three on managing soils. Specifically, rule one states that application to cultivated land must be planned in advance to meet soil and crop needs and not exceed these levels. Planning must take into account where there is a significant risk of pollution and the results of testing, which must be done at least every five years.

Compliance with the rules is managed by the Environment Agency (EA) and a recent clarification of Rule 1 by the EA has confirmed that farmers must demonstrate that the timing and quantity of organic matter applied is in accordance with crop and soil need at the time of application. This applies to all types of organic manure and effectively makes most autumn/winter applications challenging to justify, except to a crop that has a nitrogen fertiliser requirement in those seasons (e.g. winter oilseeds and grass to support late season growth).

Please get in touch with your usual Agrii contact for more information. There's also more information at: **https://www.gov.uk/guidance/rules-for-farmers-and-land-managers-to-prevent-water-pollution**

FOCUS ON FRUIT:

The use of green compost mulches in young orchards, not only suppresses weed competition during early establishment but also increases soil organic matter (SOM) and carbon sequestration.

The additional benefit of increased water holding capacity helps with tree health and fruit quality by providing resilience to drought stress events.

C MEASURING SOIL HEALTH

Soil Resilience Strategy

The Agrii Soil Resilience Strategy is our R&D based soil service that translates the research carried out as part of the ASSIST Project into a practical, usable audit, and a route map for improvement. It uses physical, chemical and biological soil assessments with scientific interpretation to develop strategies that help farmers and growers achieve their overall objectives and become more sustainable.

WHAT CAN THE SRS OFFER?

FLEXIBLE PACKAGES
Our strategy offers a flexible set of packages, which are tailored to your objectives and management practices.

A SERVICE TO SUIT YOU
From a full soil structural and infiltration assessment, right through to monitoring carbon stratification, we can provide a service that will suit you.

PRACTICAL SOLUTIONS
Our action plans are designed to provide practical, science-based solutions for your business based on resources and objectives.

MAXIMISE YOUR POTENTIAL
Combined with our digital services, we target areas that will enable you to maximise the potential to improve efficiency on your farm.

THE SRS IN PRACTICE...

FARM OBJECTIVE
My field is constantly waterlogged over winter. How can I improve infiltration?

INVESTIGATION
Agronomist talks through field history and identifies the appropriate assessments to help identify what the issue is...

ANALYSIS
Assessments undertaken in the field and samples taken for laboratory analysis...

INTERPRETATION
Report is provided and discussed with the grower. An action plan is agreed between farmer and agronomist...

IMPLEMENTATION
Field is monitored for any improvements – timeframe for revisits agreed.

EXPERIENCES FROM OUR GREEN HORIZONS FARMER NETWORK

OBJECTIVE:
Carbon and net zero

David White, Hawk Mill Farm, Cambridgeshire

"We are all recognising more and more that soil is the basis of every farming business. The science tells us that our soils are both a source and, importantly, a sink of carbon, meaning that they have a fundamental role in helping us to reach net zero. Assessing and measuring the soil carbon and biological activity across our farm has meant that we've been able to see, in practice, the improvements in our soils since we started to adopt more sustainable soil management practices 6 years ago. It's never too soon to start measuring and therefore have a benchmark to help chart improvements."

OBJECTIVE:
Baseline data

Peter Cartwright, Revesby Estate, Lincolnshire

"For us, collecting meaningful data has been key in helping us to reduce our cultivations, because it's allowed us to see what is working and has helped us plan how to do it better. The baseline data that we've collected at Revesby has shown us that a gradual move towards direct drilling can enhance both soil health and improve crop production at the same time."

OBJECTIVE:
Targeting cultivations

Luke Medd, West Whorley Hill, County Durham
(Agrii Innovation Award Winner, 2021)

"We've been working to improve the resilience of the soils on our farm, and become more sustainable in our overall approach. I'm looking forward to seeing the results from the regular SRS assessments that we're going to be carrying out along the way, which will allow us to gain a better understanding of both what is working well, and what isn't, so we can adapt our approach accordingly."

For more details on the SRS please go to www.agrii.co.uk/greenhorizons/soil-resilience/

OUR SOIL RESILIENCE STRATEGY (SRS)

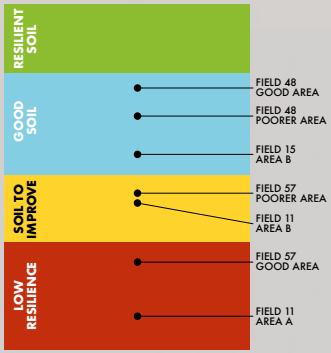
Understanding that every farm is unique, we build our packages based around farm objectives, that cover every aspect of soil health:

Biology

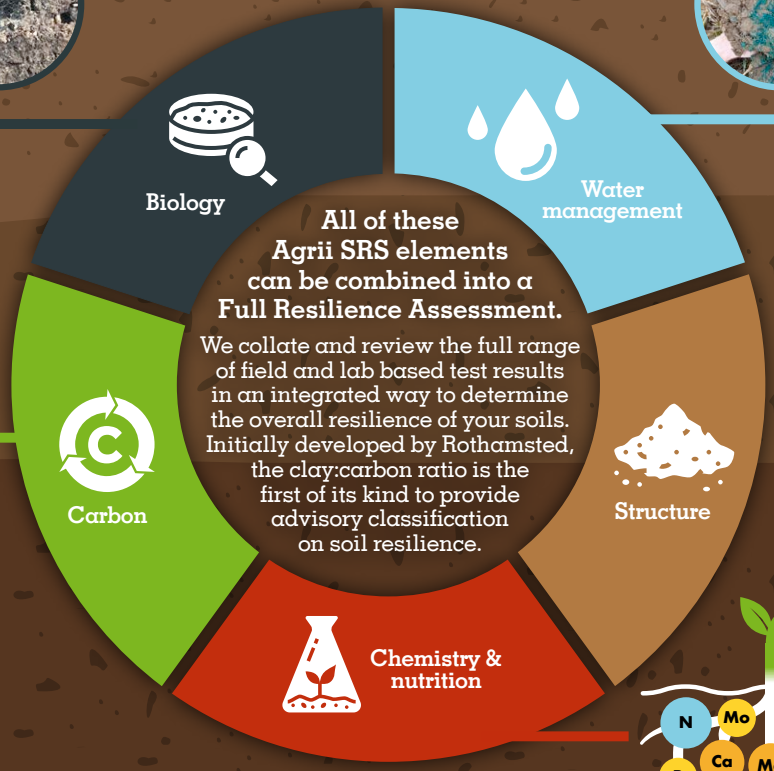
Through a combination of laboratory Solvita tests and in-field assessments, we can identify biological activity and population diversity in soils.

Carbon

The SRS protocol follows globally recognised standards for measuring soil carbon. This can help to set you up for monitoring progress towards net zero. It can also quantify the direct impact of soil management practices.



Resilience scale for Revesby Farm



Water management

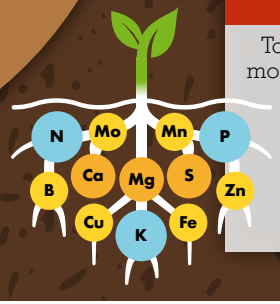
Understanding how water moves through the soil profile can help determine infiltration capacity during heavy rainfall.

Structure

Starting with soil texture, the physical component of the soil is about how the minerals and organic matter aggregate to form soil structure. A visual evaluation of soil structure (VESS) is used to help devise appropriate management strategies.

Chemistry & nutrition

Targeting nutrition has never been more important, with increasing costs and tightening of legislation. Broad spectrum soil analysis enables a more targeted and justified approach to nutrient application, minimising financial and environmental losses.



1 APPROPRIATE CULTIVATION FOR YOUR SITUATION

By assessing each component of the soil profile and its constituents, decisions can then be made regarding the most appropriate type, timing and depth of cultivation to create the optimum growing environment.

A 'GOOD' SOIL

As the mineral components are fixed, and organic matter is generally slower to change, the only things we really influence when we cultivate our soils is to alter the balance of air and water.

The aim is to achieve a structure that gives a 25:25 equilibrium to create a friable aerobic topsoil. This is vital to both plant growth and greenhouse gas emissions, as compacted, wet soils that become anaerobic will release nitrous oxide (N_20), which is around 300 times more damaging than $C0_2$.

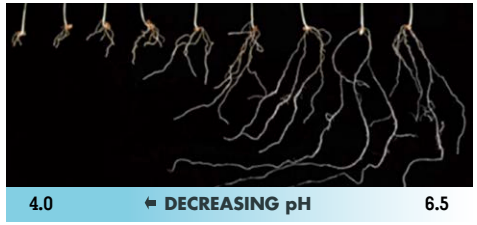
SOIL PH

Whilst not in itself a cultivation, maintaining the correct pH of the soil is often linked to soil type and is important to support good root growth and availability of nutrients. It should be considered alongside cultivation choices to correct deficiencies in the topsoil.

Effect of pH on nutrient availability

Soil acidity	Nitrogen	Phosphate	Potash
	N	P	K
pH 5.0	53%	34%	52%
pH 6.0	89%	52%	100%
pH 7.0	100%	100%	100%
pH 8.0	100%	53%	100%

Effect of pH on root growth



SOIL TYPE

Whilst there is a huge variation in soil types across the country, farm and even the field, there are a number of factors that we cannot change:

- Their location / local rainfall / climate / elevation etc.
- The mineral content and depth of topsoil; sand, silt, clay.
- The underlying material, impermeable clay, chalk, limestone, etc.

These have a fundamental bearing on how the soil will respond to cultivations, or the lack of them, in order to create an ideal environment in which to place seeds and support their growth.

However, there are also many factors which we can influence with targeted management to achieve the optimum situation, taking into account the factors above:

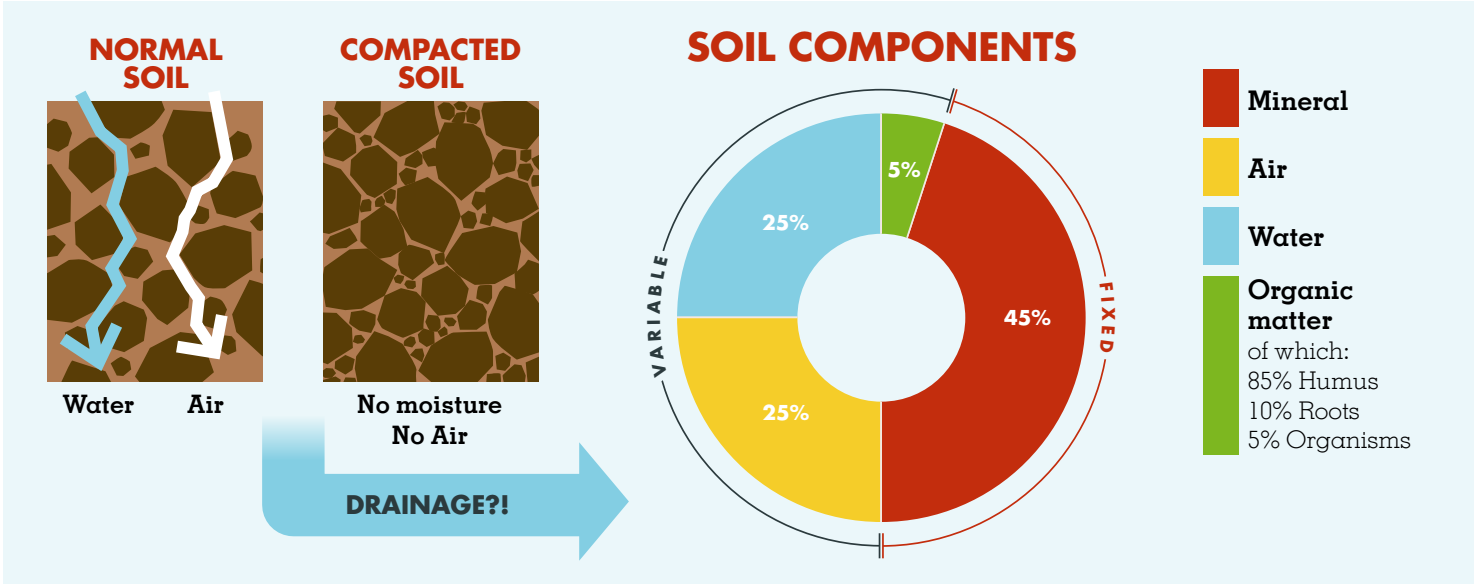
- **Drainage**
- **Soil structure**
- **Seedbed structure**
- **Organic matter**
- **Soil fertility, pH**
- **Soil stability**

Inevitably, these factors do not exist in isolation, but are interlinked and also connect with other areas of integrated, or total farm management, such as crop rotations, variety / species choice, cover / catch cropping and nutrition. Only by understanding and accounting for these can we hope to achieve a truly sustainable, viable farming system relevant to each individual farm's circumstances.

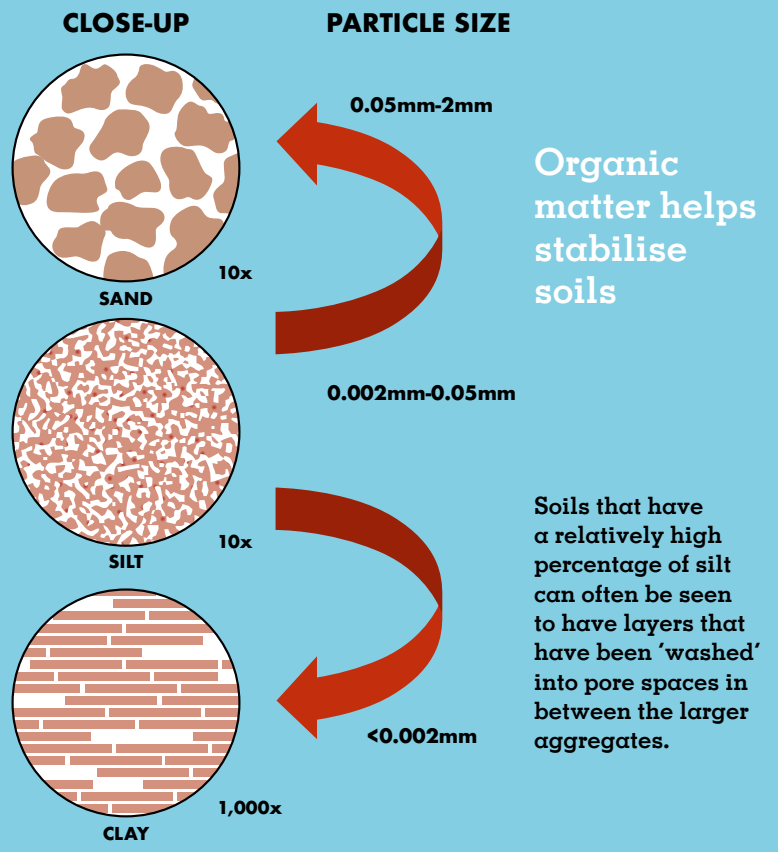
Once you have a good handle on the type and health of your soils, you can identify practices and methods to help improve or maintain soil health, and prioritise field operations based on this information, available resources (machinery, personnel and time), pest, weed and disease pressures and cropping.

Cultivation options that you could consider for arable crops include:

- **Plough as a reset if required**, followed by shallow cultivations (with cover / catch crops where possible).
- **Consider the combination of 'metal and roots'** to target specific layers and then support structure with roots.
- **Drill later** – allow 6 weeks between the main cultivation and drilling but watch out for a dry September!
- **When you drill – just drill,** don't cultivate – this ensures minimal soil disturbance since harvest of the previous crop.



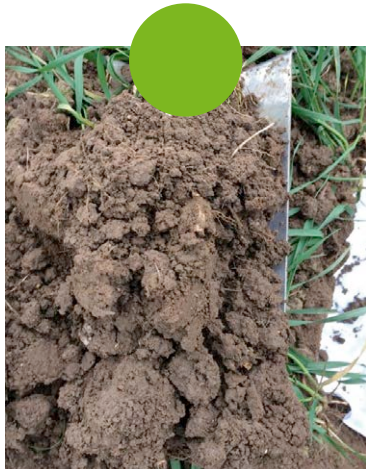
THE MINERAL CONTENT OF SOILS



Silt does not naturally fracture like clay and also unlike clay does not hold plant nutrients. However, it does tend to cause impermeable layers that can contribute to wetter soils and associated problems with blackgrass.

MANAGE FIELDS ACCORDING TO THEIR STATUS

- Check for any drainage issues that need dealing with prior to cultivation – please see **Green Horizons Insight Report 2** for more information on drainage: **www.agrii.co.uk/greenhorizons/the-environment/**
- Check pH status of the field – correct if low.
- Assess field status for grassweed pressure **RED**, **AMBER**, **GREEN.**
- Assess soil condition / structure **RED**, **AMBER**, **GREEN.**
- Prioritise '**GREEN**' fields for earlier drilling, where soil status is also **GREEN.**
- Target cultivations to address **AMBER** and **RED** field soil conditions.
- Then drill **AMBER**, followed by **RED** grassweed fields.
- Consider different crops / rotations to accommodate the above.



GOOD CONDITION VS = 2
Soils have many macropores between and within aggregates associated with readily apparent good soil structure.

VS = Visual Scoring

MODERATE CONDITION VS = 1
Soil macropores between and within aggregates have declined significantly but are present on close examination of clods, showing a moderate amount of consolidation.

POOR CONDITION VS = 0
No soil macropores are visually apparent within compact, massive structureless clods. The clod surface is smooth with few cracks or holes, and can have sharp angles.

1 APPROPRIATE CULTIVATION FOR YOUR SITUATION

SOIL HORIZONS

(O) (Organic layer)

Surface horizon
Drilling zone
Herbicide zone
0-50mm

A

Drill type / grassweeds

Subsoil horizon
Soil structure zone
50-200mm

B

Cultivation type / depth – 'low disturbance restructure

'Subsoiling' depth

Substratum
Drainage zone
200-600mm

C

Natural or piped?

The example above shows a clay loam: it is Hanslope Series chalky boulder clay.

TARGETED CULTIVATION

Your soils can be restructured while keeping horizons intact. If you have identified a restricted layer in your soil profile, target the cultivation at that problem, without disturbing the rest of your soil structure.

- Create a friable, aerated drilling zone to provide good soil / seed contact and aid establishment, root development and improve nutrient availability.
- Look to retain or restructure vertical fissuring to improve drainage, root penetration and development and access to moisture reserves later in the season.
- Work when soil conditions are appropriate to the chosen cultivation method at the required depth.

SOIL CONDITIONS AFTER BEANS

Ideal seedbed structure; no need to mix horizons

Low grassweed pressure.

Soil horizon A/B Friable drilling and nutrient exchange zone.

Soil horizon B
Vertical fissures but with 'columnar strength' to support weight.

This example shows a clay loam: it is Hanslope Series chalky boulder clay.

METAL, ROOTS OR BOTH?

HANSLOPE SERIES CHALKY BOULDER CLAY (HEAVY LAND)

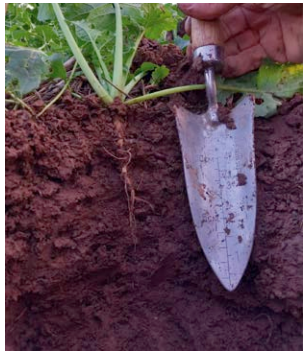
No cover crop, no cultivation

Cover crop, no cultivation

Cover crop + cultivation

COTSWOLD BRASH, LIGHTER LAND

Compacted surface layers
Horizontal fissures
Shallow cultivation and / or cover crop



Fine crumb structure
Can lack stability and 'slump' or 'cap'

Cover crop
Roots holding soil structure and stability

TOP 10 MIN TILL TIPS FOR HEAVY LAND AHEAD OF SPRING SOWING

1. **Use the combine as the first cultivator**, chopping and spreading straw and chaff sufficiently evenly and well for the best incorporation, with stubble length depending on the drill to be used;
2. **Cultivate as soon after harvest as conditions allow** to give the maximum time for weathering and the greatest amount of grassweed germination ahead of sowing;
3. **Examine the soil profile carefully** in several parts of the field and set-up the machinery to remove any particular structural concerns;
4. **Work only as deeply as necessary** to loosen the upper layers of soil, leaving it to crop rooting to achieve any deeper soil structuring needed;
5. **Only work the soil when moisture conditions allow** the right degree of machinery penetration on the one hand and soil shattering on the other, and never when it's in a plastic state;
6. **Ensure sufficiently even and effective incorporation of straw**, chaff and air for the most effective bacterial residue breakdown in the surface horizon;
7. **Avoid mixing soil layers to maintain vertical fissuring** and keep deeper buried grassweed seed out of the germination zone;
8. **Choose, set-up and use cultivators to produce clods of the right size** to weather down well without slumping – especially where there is significant silt content in the soil;
9. **Leave a level but well-ridged soil surface** that will permit effective surface water penetration over the winter as well as weathering down well; and
10. **Stay off the ground entirely until drilling** – except for pre-planting glyphosate – moving as little soil as possible with the drill for the least grassweed emergence with the crop.

1 APPROPRIATE CULTIVATION FOR YOUR SITUATION

PART TWO

MACHINERY V. BIOLOGY

What do you do if your farm has grassweeds and there is a need to press the plough 'reset' button?

- Control grassweeds in a non-plough system using other cultivation / cultural control techniques.
- Build soil structure resilience going forward to move to a direct drill situation.
- Increase soil health as far as possible.
- Use rotations as part of a cultural control strategy and conservation and regenerative agriculture approach.

All the above have featured at Stow Longa over the last 20 years and all have been achievable. But costs must be closely monitored, and not just input costs. Establishment costs vs. expected grassweed control and profitable yield is a very fine balance.

AFTER PROLONGED PERIODS OF WET WEATHER...

Tips to aid quicker recovery of soil health:

DRAINAGE
Ensure excess water can drain away quickly; check that ditches are flowing freely. Overgrown hedges and trees shade headlands, preventing surface drying.

FROST
Wait for significant sharp frosts before attempting cultivation. If the frost has only penetrated surface layers, going too soon can cause more damage.

CULTIVATING SPRING CROPS?
Keep cultivations to a minimum, to create enough friable soil. Ideally cultivations should be carried out as soon as conditions are suitable, but still well ahead of expected drilling date.

RESTORATION
Aid soil restoration by carrying out drainage work, or possibly planting mustard to act as a 'water pump' and help dry out the soil in preparation for drilling.

HEADLANDS
Consider sowing headlands separately, or possibly think about a grass margin as a longer-term option for very wet or shaded areas.

AGRII TRIALS — FOCUS ON BLACKGRASS

Don't keep moving the soil, blackgrass will grow in the germination zone.

What is painfully obvious from work at Agrii's Stow Longa site is that carrying on regardless without changes to cultivations, crop type and/or drilling date is losing serious amounts of money...

MORE INFORMATION ON THIS IN SECTION 3: CROP ROTATION AND DIVERSIFICATION STRATEGIES

CASE STUDY — SETTING UP HEAVY LAND FOR SPRING SOWING WITHOUT THE PLOUGH AT GLEBE FARM

Heavy ground for spring sowing needs to go into the winter both weatherable and weatherproof as well as compaction-free and bacterially active.

At Roy Ward Farms in Lincolnshire, a state-of-the-art iFarm soil management trial is evaluating the effectiveness of 10 different min-till cultivators.

"This will allow us to see whether shallower cultivation and less soil movement at drilling could offer significant savings in fuel costs and time while maintaining the high levels of cereal performance and blackgrass control achieved at the farm in recent years" says Trials Manager, Steve Corbett.

"We haven't ploughed any ground here since 2002" continues Andrew Ward. "Having built up our soil structure and organic matter levels well over the years, as well as getting on top of blackgrass, we're now wondering if we could reduce the depth of our cultivation and degree of soil movement at drilling. Our current trials work on the site will help us to find out exactly what – if anything – we stand to gain from any change and whether any savings and improvements would be sufficient to justify the expense."

CASE STUDY

USING STRIP-TILL TO ESTABLISH MAIZE DIRECT INTO A STANDING CROP

SHANAEL FARMS, EVESHAM

Steve Miller has grown maize for many years at Shanael Farms and is now exploring an alternative way to establish the crop using fewer cultivations.

With the support of KRM machinery and John Deere dealership, Tallis Amos Group, the Agrii team are working to explore the use of strip-till as a method of maize establishment worked directly into a grass sward in autumn. The use of RTK technology allows drilling to precisely follow these "strips" in the spring.

The strip-till machine ensures the removal of any compaction below the grass roots in the soil profile whilst the crop benefits from reduced moisture loss during germination and later through the summer. At harvest the ground should also be much more stable to carry machinery and less liable to soil damage, compaction and excess runoff.

Steve hopes that this technique could change the future of establishing his maize crops, with minimal soil disturbance, reduced surface erosion and reduced carbon losses to the atmosphere.

You can find out more about this case study in the case study section of the Agrii website at **www.agrii.co.uk/news/case-studies**.

We'll be adding to this case study as the work progresses.

THE IMPORTANCE OF PLANNING TO AVOID PITFALLS IN A TRANSITION TO NO-TILL

Regenerative agriculture based on the least possible tillage is attracting growing interest across the UK for the opportunities it offers to improve soil health and resilience, increase farmland biodiversity, and cut carbon emissions.

However, direct drilling experiences of the past make it essential to introduce regenerative techniques in carefully-planned ways, if a number of dangerous pitfalls are to be avoided.

While no-till farming is a viable and valuable goal for many growers, it is important to make sure the transition to no-till is carefully planned, before ditching cultivation equipment.

During the 1990s, when a wholesale move to minimum tillage swept across the country, largely driven by a sharp fall in wheat prices, many heavy land producers looking to cut costs by switching to large sets of discs in place of the plough, ran into serious issues with compaction. This meant they had to invest in larger tractors and deep-loosening tines to aid sub-surface drainage, leading to even greater compaction. Blackgrass in particular, profited from both the impeded drainage and lack of burial, increasing the reliance on chemistry for control, and, in turn, pressure on herbicide resistance.

"Rather than attempting to reset soil structure each year with heavy tillage trains, many growers would have been better-off taking a step back and asking themselves whether their soil structure and drainage were good enough for reduced tillage" says Agrii Senior Agronomist, Andrew Richards.

Andrew urges growers keen to reduce tillage to the bare minimum to keep this at the forefront of their minds today to avoid similar pitfalls; especially so with the last two autumns highlighting the increasing unpredictability of UK weather.

He points to recent examples of farms spending upwards of £70,000 on no-till disc drills but unable to close the seed slot adequately on heavier land, with seed rotting or eaten by slugs. That's if they have been able to travel at all.

"It is essential we all have a planned approach to weaning soils off tillage, rather than just jumping in at the deep end. Which drill to buy should be our very last question."

CASE STUDY

ZERO-TILL DEVELOPMENT AT LORD & HUNT'S EARLS HALL FARM, ST OSYTH, ESSEX

After five years of no-till, preceded by more than 15 years of minimum tillage on heavy land at Earls Hall Farm, David Lord and Guy Hunt have seen yields maintained and soils more resilient and forgiving in extreme weather.

"Our heavy ground is much better structured and healthier for the fact that we've avoided deep cultivation for so long" says David Lord. "Cover crops have proved to be an essential part of our no-till system, improving the soil microflora and fauna to the extent that most of our soils now have organic matter levels of around 4.5%". David and Guy have found that minimum soil movement aided by cover cropping has helped to improve the structure, drainage and water holding capacity of their soils, and their land now carries heavy equipment well – provided they don't travel at the wrong time of course.

They've also found that with increased soil health has come reduced reliance on fertiliser and fungicides. "We've seen a big reduction in our blackgrass burden across the site" continues David. "This seems to be a result of the combination of low soil disturbance, cover cropping and the diverse rotations that we've adopted – including wheat, beans, rape and spring cereals. Going forward, the challenges we face include how to replace rape in the rotation and how best to prepare our farming system to maximise future payments for public goods – as well as how to incorporate livestock into our system."

"This has been by no means a quick fix for us – these improvements have taken place over many years, but we hope they will stand us in good stead for any future challenges that are thrown our way."

David Lord and Agrii Agronomist, Vicki Brooks

WHAT SHOULD ANY PLAN FOR A TRANSITION TO NO-TILL CONSIDER?

1. Is the ground suitable for no-till?

Studies suggest that about 70-75% of the UK arable area could be managed in this way. But particularly careful consideration needs to be given to ground where permanent grass dominated before the food production drive of WW2, often in lower lying areas and without drainage systems.

2. Sub-surface drainage

For suitable land, underlying drainage problems must be dealt with before moving to no-till. This is best judged after periods of significant rainfall when underlying problems will be clearly evident in wetter areas or ponding. Rectifying these issues could be as simple as clearing out ditches or jetting existing land drains, with heavy clay soils likely to benefit from a mole draining, even where permanent under-drainage isn't in place. Or it might be necessary to make a larger investment in drainage, which is probably best done rotationally over time to spread both the cost and impact. Please see Green Horizons Insight Report 2 for more information on drainage.

3. Correct pH

Determine where you are with your pH levels and correct them if necessary.

4. Organic matter content and cover crops

Look at your organic matter content and consider incorporating manures before you cut back on tillage. Cover crops and to a lesser extent, crop residues, can be valuable in protecting soils and maintaining soil structure in no-till regimes. But there is extensive trial evidence to show that roots alone are most unlikely to improve the structure more than marginally. And while cover cropping can build soil organic matter, this will be a very slow process.

When considering cover crops, take the opportunity to look at how extra diversity can be introduced into the whole rotation. Keeping active roots in the ground with a wider array of crop species will increase the diversity of soil biology. In turn, this can have a positive impact on organic matter, soil structure and overall soil health without necessarily compromising margins.

5. Machinery

On the machinery side, growers may benefit from gradually reducing tillage intensity by modifying existing machinery, before splashing out on an expensive new direct drill. Lifting the discs out of work on a cultivator drill can be valuable in reducing the level of tillage too, as can be changing from the likes of a Horsch Joker disc cultivator to a Cruiser tine machine, capable of working at shallower depths.

> 'Second-hand tine drills can be a useful bridge from intensive cultivations to no-till, starting with crops like beans and gradually moving to cereals as soil workability improves. An element of Controlled Traffic Farming (CTF) can also reduce compaction from trafficking across the field, and can lead to success in the transition to no-till'.
>
> **Andrew Richards, Agrii Senior Agronomist**

The regenerative agricultural goal for most is to have an ultra-low disturbance disc drill as the sole establishment method. While many are making this approach work once soils are well-structured and organic matter levels sufficient, it is important to maintain flexibility in the system to allow for increasingly more unpredictable weather systems. The aim has to be to build long-term strength and resilience into our soils, but no matter how good a soil becomes, 120mm of rain in a week in August is always going to create problems when we need to use a large modern combine and weighty grain trailers.

Some no-till drills are also heavy by nature, meaning they just aren't going to be able to travel without damaging the ground in extremely wet autumns. We need to be willing and able to use a low disturbance subsoiler or a lighter weight tine drill with a shallow cultivator should the need arise.

Agrii is working with University College Dublin and Harper Adams on a compaction depth prediction tool which if successful will enable areas of depth of required cultivation to be identified.

2 CONSIDER CONTINUOUS COVER

PART TWO

Continuous, permanent soil cover can be achieved with crop residues and/or the use of cover / catch crops. It acts to prevent soil degradation and erosion – physically protecting the soil from the weather with consequent reduction in soil and nutrient erosion (leading to improved soil productivity), water evaporation, temperature fluctuations and surface sealing and crusting.

In the right place, catch and cover cropping can noticeably improve the health, workability and resilience of soils as well as making valuable contributions to environmental protection. Cover crops can also help to increase organic matter content, providing a food source and habitat for soil micro-organisms. In addition, incremental increases in soil organic matter, even if small, are actually very valuable in reducing the farm's carbon footprint.

To be cost effective, it's important to ensure that cover crops are well planned and managed. They must also be carefully matched to the available machinery and resources – especially at the outset. And they require patience, persistence and fine-tuning to really deliver the goods.

CASE STUDY

USING STRIP-TILL TO ESTABLISH MAIZE DIRECT INTO A COVER CROP

SPRINGHILL FARMS, EVESHAM:

Nick Reynolds is working with the Agrii team on a strip-till approach to both maize and vegetable crop establishment on land at Springhill Farm. Working strips into autumn cover crops, their initial results demonstrate that this technique is helping the soil to hold onto nutrients, maintaining its stability and preventing erosion – providing an ideal seeding zone for seeds or brassica transplants.

You can find out more about this case study in the case study section of the Agrii website at **www.agrii.co.uk/news/case-studies**.

We'll be adding to this case study as the work progresses.

KEY FACTORS FOR SUCCESS

JOHN VICKERY, AGRII REGIONAL TECHNICAL ADVISOR

- Perhaps the single most important lesson we've learned from our trials is the need to tailor the selection and management of species and mixes for particular conditions and requirements.
- Spring plant types tend to be best for the rapid autumn establishment and growth required, but given enough time and temperature they can run to flower and even seed. This increases the C:N ratio, making them slower to rot down and diverting N from the following spring crop.
- If you want a cover that's slower to develop, stays closer to the ground, is more prolific in its rooting and better able to withstand cold temperatures, then it's better to choose Hungarian vetch. Conversely if you want the rapid top growth more suited to a shorter term catch crop or OSR companion, purple vetch is likely to be preferable.
- Choose components that both do the job you want and work well together. Too much white mustard can dominate a mix and out-compete other species. But phacelia's root architecture does essentially the same soil structuring job, and the crop is less competitive early on. Phacelia and mustard are good at drying soils out for late autumn or spring drilling, but you need deeper rooting species like radish if more soil structuring is your aim.

Using a range of species within cover crop mixtures provides a diversity of root architecture as well as nitrogen fixation.

HINTS, TIPS AND POSSIBLE PITFALLS:

- **It's important to match seedling depth** to species and sow as soon as possible after combining the previous crop to give sufficient thermal time for the best rooting and overall biomass development.
- **Slugs can proliferate** following cover crops if the soil biology is not sufficiently well developed to incorporate and break down residues rapidly.
- **Covers can also act as a green bridge** for insect pests like aphids and diseases like clubroot.
- **Residues can also get in the way** of spring crop establishment if winter covers are not destroyed early enough.

Cover cropping and strip-till ahead of Sugar Beet. Species used here include phacelia, purple vetch, linseed, berseem clover and black oat.

CONSIDER CONTINUOUS COVER

2

EXAMPLES FROM AGRII CUSTOMERS:

One Agrii customer in Kent is using a stripper header on his combine for more rapid and efficient harvesting. The standing straw residue has proved to provide an excellent environment for the direct drilling of both commercial crops and catch and cover crops.
You can view a video of this work at **www.agrii.co.uk/news/case-studies**

Cover crops at South Farm, Tarrant Hinton: The team at South Farm are currently going through a transition from a predominantly plough-based system to adopting an entirely zero-till system. Three years ago they embarked on a cover crops and soil health project with their Agrii agronomist, Mat Hutchings. The project began with strips of different cover crops, straights and mixes, being drilled and monitored through the autumn and winter. By year two, the team had managed to get the majority of local machinery dealers involved and had also started working closely with Wessex Water.

Together they have designed a chequerboard type trial looking at different establishment systems and cover crop mixes crossed by various fertiliser programmes. The aim is to get the best establishment out of the cover crop, balanced against cost, as well as monitoring nutrient capture and release. Working with Agrii and the farm team, Wessex Water have installed porous pots and taken soil mineral nitrogen (SMN) samples from across a range of plots to monitor nutrient loss.

CASE STUDY

DUNKIRK iFARM, NEAR GATESHEAD: COVER CROP TRIALS

At Dunkirk Farm, the team are utilising regenerative techniques and cultural controls in a drive to increase the resilience of their soils and overall farm business for the long term.

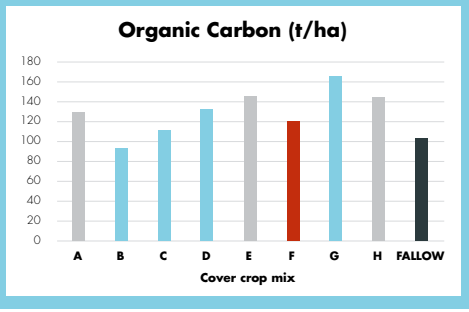
No insecticides are used on the farm, and they're moving towards a complete no-till approach. In addition to this, together with the local Agrii team, they've developed trials looking at different cover crop mixes – measuring soil organic carbon, active carbon and microbial biomass to determine the impact of cover crops on overall soil health.

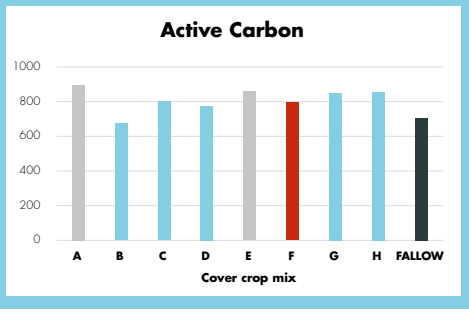
"The results from our trials show that diverse mixes offer a greater overall benefit to soil health from a biological point of view" says Agrii agronomist, Rob Bowes. "Our results have also shown that the bigger the biomass above and below ground, the higher the initial carbon drawdown. In addition, cover crops have brought both high nutrient retention and biological activity to the iFarm soils, especially compared with fallow fields."

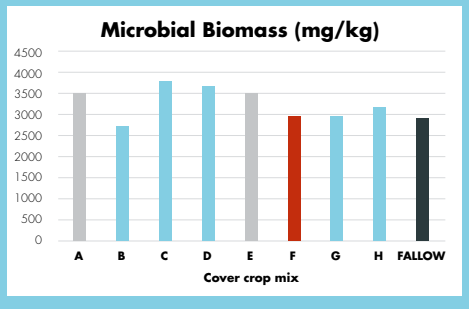
Rob shares his top tips for choosing a diverse range of species that will help to achieve your overall aims:

- **Cover crops should always be used as part of a complete systems approach** to improving soil health, including crop rotation and field cultivations.
- **Choose the C:N ratio of the mix based on what you want to achieve.** A cover crop that has a mixture of C:N ratios will provide soil microbes with a diverse diet. Soil microbes need the soil C:N ratio to be 24:1 – one third of this carbon is used as food and two thirds is used for energy to decompose residues and cycle nutrients. An active carbon test is a key measure of short term carbon storage and gives an indication of the amount of carbon available to keep microbes alive and functioning healthily in the soil. See **page 9** for more information.
- **Buckwheat** is fast to establish, can attract beneficial insects when in flower, and its ability to mine phosphate is unrivalled – it's unattractive to cabbage stem flea beetle, which also makes it an ideal companion crop for OSR.
- **Legumes** tend to offer high root biomass and are quick to establish, ensuring high nutrient capture. They have a very low C:N ratio, such as vetches (12:1).
- **Phacelia** is winter hardy and its fibrous roots mean that its nutrient and water content is high (C:N ratio 20:1).
- **Tillage radish** produces a huge tap root and is good for increasing drainage and alleviating compaction (C:N ratio 35:1).
- **Oil radish** tends to offer more lateral roots than the tillage radish and a big enough tap root to alleviate surface compaction (C:N ratio 30:1).

"In other trials at Dunkirk Farm, looking at companion crops in OSR and utilising the same soil health principles, we have seen a reduction in weed pressures and high cabbage stem flea beetle control as a result." Rob Bowes, iFarm Agronomist







2 CONSIDER CONTINUOUS COVER

PART TWO

Over the course of our Agrii independent trials programme we have drilled, assessed and harvested more than 600 cover crop plots. Insights built from this evidence and subsequently used commercially include;

Can we get any control of blackgrass from cover crops?

Yes, possibly but certainly not guaranteed. Cover crops are just one part of the solution.

Do cover crop species give improvements to soil structure?

Yes, if established well, but this does not necessarily lead to absolute responses in yield over cultivations.

Which species will dry the soil best for late autumn and spring drilling?

Phacelia and mustard amongst others.

How do we best establish different mixes?

Good seed / soil contact and drill early.

Any yield increases from using cover crops?

Not reliably on a heavy land sites with blackgrass, but good results on lighter land without grassweed issues.

Are cover crops really contributing to soil health and can this help with sustainability going forward?

We have very good indications that they do deliver soil health and improved organic matter content longer-term.

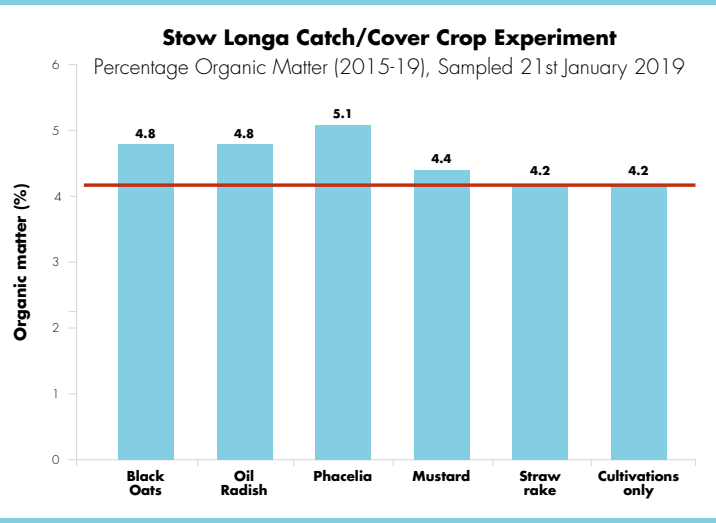
"To get the most from covers you have to treat them as crops. Unlike the warmer areas of France and the USA where most of the original work on covers was done, our research here and at other sites across the country underlines the fact that they need to be drilled early. On heavy land where this is not practical, a rotational summer cover crop may well have a place where looking to improve soils."

Andrew Richards, Agrii Senior Agronomist

CASE STUDY

Noticeable increases in soil organic matter have been achieved through cover crops at our Stow Longa Technology Centre without any organic manuring.

Suggestions of better overall soil biological activity recorded in Solvita testing have been confirmed by detailed soil microbial population studies.



An increase in organic matter of just 0.05%/year could be enough to turn a farm carbon neutral.

DIVERSIFICATION OF CROPPING AND ROTATIONAL STRATEGY 3

No matter what your rotational plan, lessons learned in previous years and the weather throughout the growing season will add an extra dimension of potential risk and reward.

Practical and varied crop rotations can help to:

- **Maintain biodiversity above and in the soil.**
- **Improve soil physical properties.**
- **Contribute nitrogen to the soil / plant system.**
- **Increase water availability and efficiency.**
- **Avoid plant diseases.**
- **Reduce grassweed populations.**

However, tillage, the cropping system and their interactions may have significant impacts on crop production and soil water status. Hence, a holistic view should be taken when considering rotational strategies, ensuring that you adopt an integrated approach.

RESULTS FROM AGRII TRIALS

More than six years of independent multi-factor trials at Stow Longa and our other iFarm sites 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.

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 appropriate rate a few days before drilling.
- **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.

3 DIVERSIFICATION OF CROPPING AND ROTATIONAL STRATEGY

ROTATIONAL STRATEGIES AT STOW LONGA

This example shows two blocks in our rotations trial (right).

Here side by side are two second wheats, showing that depending on the history of the field and rotations, you can either be very successful at containing blackgrass numbers, or indeed fail to do so.

The impact of different cultivations can be seen in this winter beans example (below).

The photos taken on April 12th show the difference between the ploughed area (strip-till) versus the catch / crop area which was established by a direct drill. The blackgrass burden in the catch / crop area is plain to see and of course disappointing, particularly in a break crop where we are trying to use the opportunity to reduce blackgrass seed return.

"Cropping should be dictated by previous levels of blackgrass – if the levels are high, change your strategy!"

WHAT IS THE IMPACT OF DIFFERENT STRATEGIES ON GROSS MARGIN?

RESULTS FROM AGRII TRIALS

More than six years of independent multi-factor trials at Stow Longa and our other iFarm sites 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.

Gross margins summarised to harvest 2021 are now extensive, but here we can see the best versus the worst in gross margin terms from Stow Longa.

Everything is costed from the cultivations, drilling, seed, fertiliser and agchem – plus of course the levels of blackgrass within the various rotations and cultivation strategies.

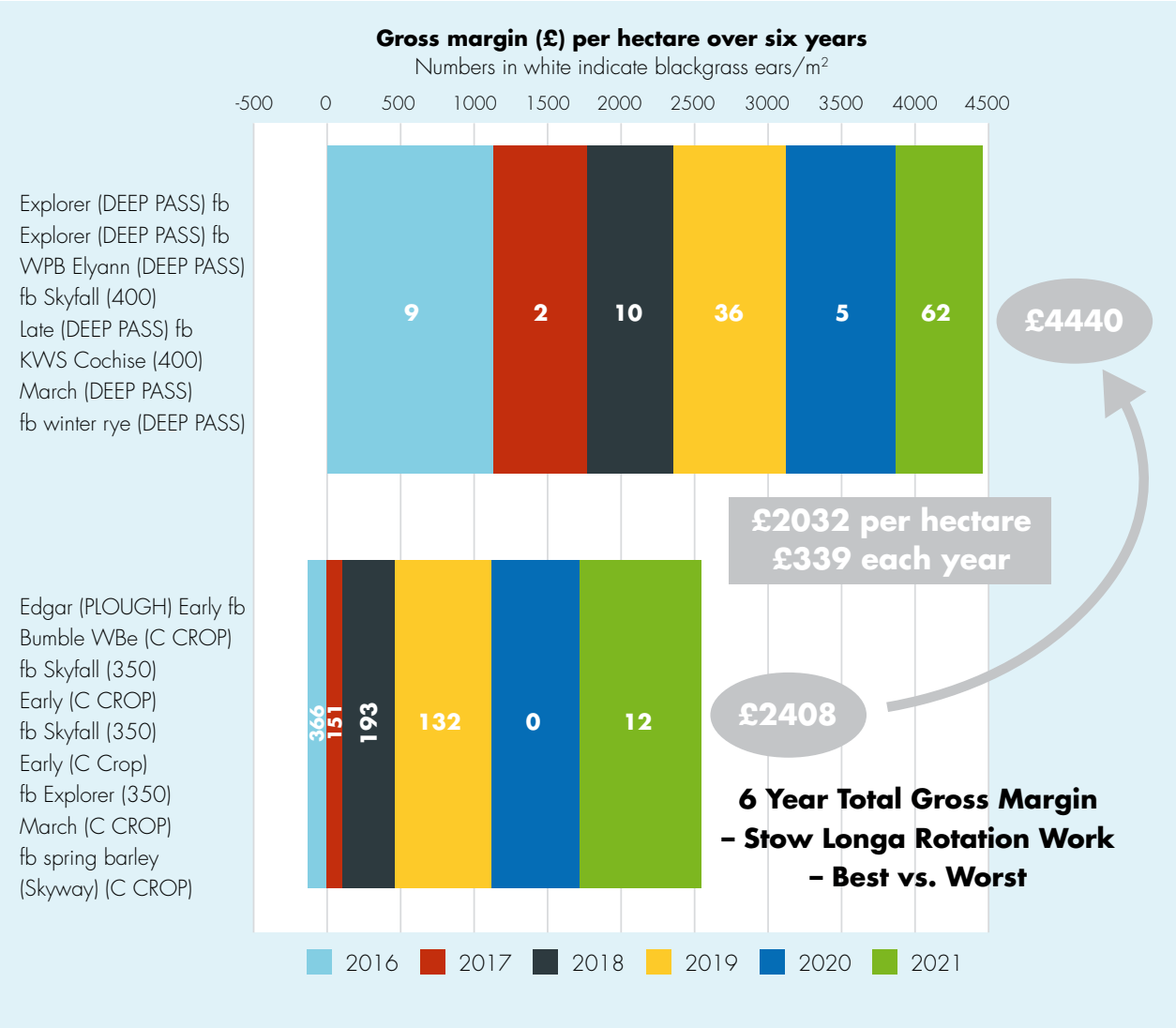
Although there is a common theme here where both the previous crops were winter wheat, it is worth noting that the early drill (beginning of October) timings combined with the previous crops in the rotation performed badly.

On the other hand, where the previous two crops had been winter wheat, now drilled late (third week October), we have a completely different gross margin.

The work also shows that spring cereals can make a real change to blackgrass numbers and deliver a decent gross margin. Results indicate that you can drill spring cereals very successfully on heavier land IF the ground is set up well.

The gross margin swing over six years = £2032 per hectare, equivalent to £339 per year.
In 2020 the equivalent figures were £2552 per hectare, or £510 per year over five years.
This shows that the gap narrows when the worst block has been proactively managed by adding spring barley into the rotation!

So the attention to detail around previous grassweed history, cultivation strategy, the soil structure and drilling dates all contribute towards successful and sustainable crop production.



3 DIVERSIFICATION OF CROPPING AND ROTATIONAL STRATEGY

BEYOND TRADITIONAL CROPPING...

We are continuing to work hard to bring innovation crops to market – especially with many farmers looking at alternatives to OSR. For example, chickpeas have been identified as a good potential legume option with ready markets. We're halfway through our planned evaluation and so far they've ticked some useful boxes. We are fine-tuning the agronomy and will continue to work on this through the course of the next year.

Naked and waxy barleys, haricot beans, chickpeas and a wide range of specialist and novel wheats could offer exciting opportunities for UK growers to add value to their cropping, both economically and rotationally to provide alternative and varied cropping in the rotation and increase resilience to climate change and other agricultural challenges.

"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

INTEGRATING LIVESTOCK INTO THE ROTATION

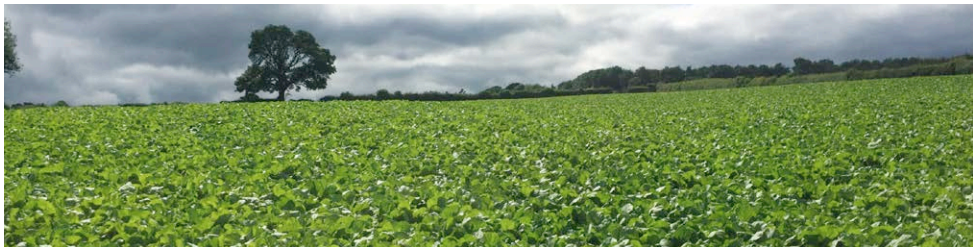
4

LIVESTOCK GRAZING OF COVER OR CASH CROPS ON ARABLE LAND NOT ONLY PROVIDES A NATURAL SOURCE OF ORGANIC MATTER, BUT ALSO ENCOURAGES NEW PLANT GROWTH, WHICH INCREASES THE AMOUNT OF CARBON RETURNED INTO THE SOIL, DRIVING NUTRIENT CYCLING AND RECYCLING.

Multi-species leys, which are complex mixtures of grasses, legumes and herbs are becoming increasingly popular as they have been shown to provide benefits for livestock, biodiversity and soil health. This means that for livestock farmers, there may be opportunities for animals to benefit from the same strategies that improve soil fertility and productivity.

The mix of different species used in multi-species leys can also provide greater resilience to climatic extremes. Grasses, legumes and herbs all have different rooting structures and lengths which will also help with soil conditioning. The long deep tap roots will also mine minerals from greater soil depths, making them available to the livestock via the natural mineral rich forage, which also helps with livestock health. Due to their long rooting system, many of these legumes and herbs and certain grasses also provide valuable forage in drought-prone areas as the deep rooting systems scavenge for moisture from the soil depths.

Integration of multi-species leys into arable rotations extends the rotation and consequently increases land use diversity with potential benefits for below and above ground biodiversity, improving soil biodiversity and reducing the risk of soil erosion and diffuse pollution.



PART TWO

4 INTEGRATING LIVESTOCK INTO THE ROTATION

TOP TEN TIPS FOR MULTI-SPECIES LEYS

1. Mix selection:
Make sure the species contained within the mix are suited to the soil type.
For example, chicory provides a natural beneficial effect in reducing livestock worm burdens and is also the finest species for busting through soils.

1(b!) Go big and adjacent:
Plant a big enough area and in adjacent fields to allow stock to be moved quickly and easily every day. As a rule, cattle should not be on one area for more than 24hrs and sheep one week, but growth rates will vary depending on the month and weather.

2. Sowing timing:
Plant at a shallow depth of no more than 8-12mm after an early sown cereal crop which has had the straw baled and removed to avoid high levels of unbalanced carbon. Look to plant into or just ahead of moisture in early August or undersow into a spring barley crop at the tillering stage in mid April. Roll well with heavy ring rolls, twice if necessary. This presses in stones and ensures maximum seed to soil contact as well as discouraging slugs.

3. Negative effects of herbicides:
Avoid the use of sulphonyl urea herbicides and DFF in the preceding cereal crop as herb species and legumes are very sensitive to herbicide residues.

4. Slugs:
Moisture will be important for establishment but be prepared to apply slug pellets.
Be extra vigilant when leys are establishing under a spring barley canopy. Extra effort will be required to look.

5. Stimulating grazing:
Try to mob graze with sheep for just a day or two, only once all species have established, to stimulate growth and knock down the early dominant species. This may be in mid September for a spring undersown crop or the following April for an August sown ley.

6. Nutrition:
Avoid applying inorganic nitrogen or herb species will be swamped by grasses. Organic manures can be used if they contain lower available nitrogen such as farmyard manure. Remember these leys thrive as the summer progresses but start slowly they as they are not an Italian Ryegrass ley.

7. Manage stock:
These leys are tremendously productive from May through to October but do not over-graze. Mob graze with sheep or cattle down to 10-12cm and then move to the next paddock. If silage or haylage is taken (avoid hay to minimise seed return) ensure mowers have skids right up to ensure delicate clover crowns are not damaged and regrowth time is rapid.

8. Take care in wet weather:
The leys are very resilient but do not allow livestock to trample the sward to a mud bath in bad weather. Use a paddock system and keep them moving to a new area each day. On heavy ground this will take a high degree of stock management, planning and electric fencing.

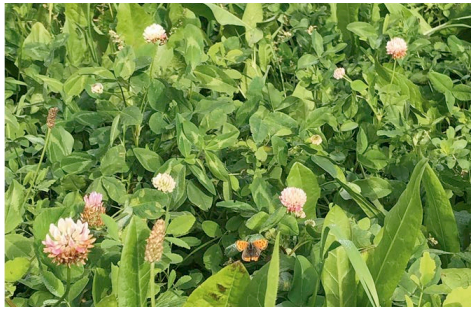
9. Plan ahead:
Try and stagger the establishment and destruction of the leys across several seasons. Establish a new field as you take another out of production. This may mean sacrificing some of the first fields after two or three years initially but avoids bulk changes which are high risk.

The swards should last four to five years if managed carefully and it is important to maximise longevity to split the seed cost over more seasons.

10. Destroy at least six weeks before the next crop:
Winter cereals are the ideal crop to follow the leys. Ensure the grass is sprayed off in August at least six weeks before planting wheat or barley. Treat wheat with a frit fly insecticide and direct drill so as not to disturb any grassweeds that have been left buried. The first crop following the ley will be slow to develop due to the high level of carbon and low amount of free nitrogen so a September drilling date is highly recommended.

Early loading of spring nitrogen will be required in this subsequent cereal but the release of organic nitrogen will start in May and June. The second combinable crop to follow will benefit most from the ley as much of the organic nitrogen from legumes will be available after 12 months.

Alternatively, you can also consider practices with different timelines for destruction of leys going into following wheat crops, to balance risks to the following crops.



ADOPTION OF NEW TECHNOLOGIES

5

The potential for new technologies to help growers and their agronomists sustainably increase the productivity of their arable, vegetable and fruit enterprises, is immense. Agrii is committed to the development of new technologies to help develop a more sustainable future for UK agriculture.

New technologies come in many guises, whether it be new crop protection products, alternative biosolutions, genetic advancements, use of big data to refine decision-making, or alternative methods of establishing crops – all have the potential to help with the twin goals of sustainable, and profitable, food production. Through our comprehensive research programme these new developments are put through their paces and if shown to deliver benefits, Agrii will promote their use to our customers based on the facts and evidence from our own and other independent trials organisations.

Integrated Pest Management

(IPM) is the cornerstone of Agrii's approach to sustainable total farming systems, and always has been. Crop Protection Products (CPPs) should never represent the first port of call when addressing any agronomic challenge. Figure 1 summarises the tools we have in our IPM toolbox, all of which feature in our trials programme.

Genetic advancements have recently provided the UK with improved variety characteristics, such as reduced pod shatter in oilseed rape, tolerance to BYDV in barley and improving *Septoria* resistance in wheat, to name but three.

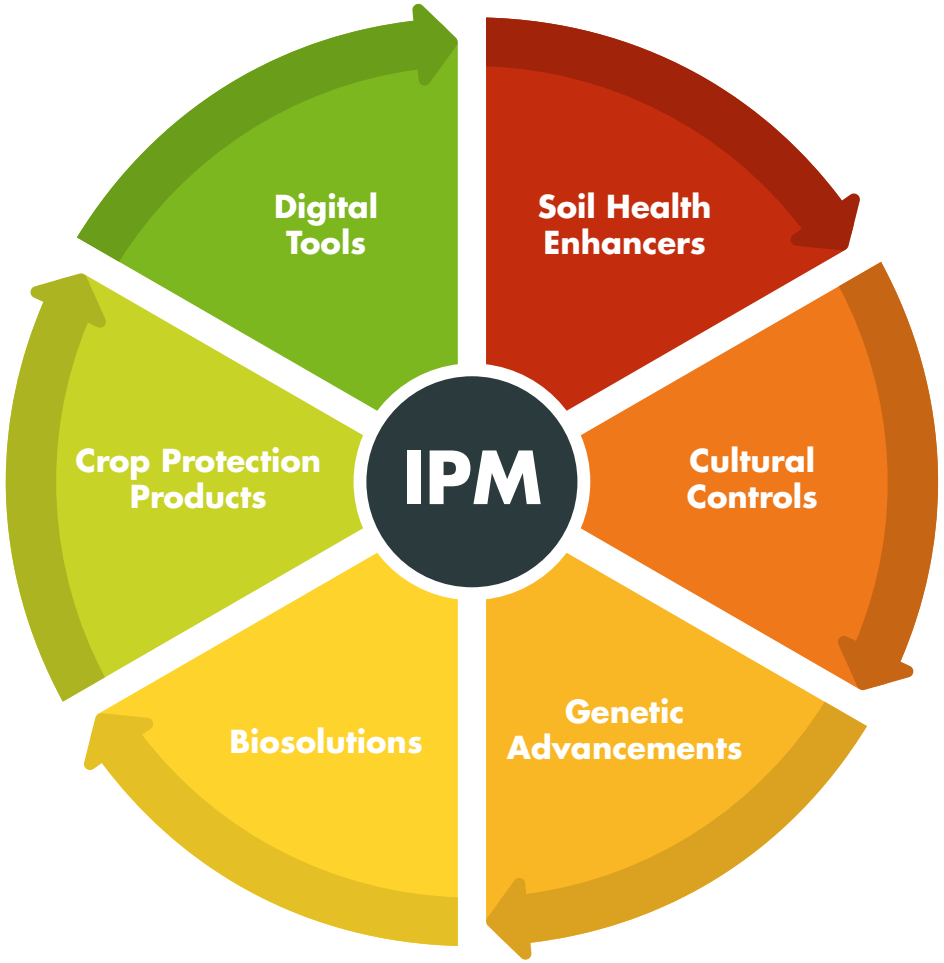


Figure 1: Summary of tools in our IPM toolbox

Agrii has worked to summarise these characteristics into an easily understandable Variety Sustainability Rating (VSR) system as part of our Advisory List for wheat, barley and oilseed rape, to encourage sensible variety choices to be made. Please see **Green Horizons Insight Report 3** for more information on VSRs: **www.agrii.co.uk/greenhorizons/integrated-whole-farm-solutions/**

Biosolutions are also becoming much better understood. Agrii has now trialled more than 130 biostimulants, elicitors, endophytes and biopesticides, and we are working hard to separate fact from fantasy as these begin to flood onto the UK market.

All sorts of claims for these products have been made, and we have learned, as with other emerging technologies, that it is as important to identify where they don't work, as well as where they might have a place. We have defined some very clear positions where benefits have accrued; but we have to recognise these technologies are less reliable than conventional products.

Out of the 130 tested, around 25% are showing promise; and some of these have actually been part of our portfolio for 20 years or more and are well tried and tested. Laboratory and glasshouse tests are allowing us to prioritise those that go into field trials.

5 ADOPTION OF NEW TECHNOLOGIES

Adjuvant technology has advanced considerably in the last decade and offered reliable improvements in product targeting, retention and performance, as well as associated benefits to the environment including drift reduction. We are currently working with manufacturers of these technologies to explore the potential of "bio-adjuvants", products with cleaner labels that still deliver the benefits.

"Tailored rate" water conditioners too, are a focus for our research team to help get the most from products we prescribe – hard water is affecting the performance of some active ingredients.

New **Crop Protection Products** are still coming to the market but are few and far between, with ever more stringent environmental and operator safety requirements before they gain approval. As Agrii always has done, we have been putting these into trials three years before they come onto the UK market in order to identify what benefits they bring over older chemistry.

We will seek to adopt new chemistry where possible due to improved safety, but only where the return on investment makes sense for our customers. Working to economic thresholds is a critical driver, and fundamental to Agrii's IPM ethos.

Protecting the natural resource provided by our soils, and reducing agriculture's carbon footprint are strong drivers for new technology development.

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.

These fungi, present in all soils to a greater or lesser extent, aid the use and uptake of nutrients, but can be disrupted by certain cultivation systems / crop rotations. The natural population is likely still to be there and given the right habitat and food supply may well re-establish themselves.

Agrii's focus more recently has been around **targeted nutrient applications**, using RHIZA variable nutrition systems, and also new technology **Enhanced Efficiency Fertilisers** such as the Agrii-Start range, which have a lower carbon footprint than conventional products.

As part of the Green Horizons Initiative, Agrii launched several Net Zero iFarms during 2020 / 2021 which will form a platform to learn together over the coming decades.

Please see **Green Horizons Insight Report 3** for more information on our approach to cultural controls: **www.agrii.co.uk/greenhorizons/integrated-whole-farm-solutions/**

RHIZA

DIGITAL AGRONOMY

Our RHIZA precision and decision support tools are designed to support the most timely and effective decision making.

These tools harness the power of modern information technology to help reduce the uncertainty and guesswork involved in key management decisions by the most effective analysis, interpretation and integration of agri-intelligence data from a variety of sources.

- Hyper local weather data helps to analyse and predict pest and disease pressure.
- Variable rate planning and targeted nutrient programmes reduce inputs.
- Growth stage prediction for more accurate application timings and planning.
- In conjunction with RHIZA, Agrii has put into place an array of precision and digital trials across its network of iFarms around the UK, to test the value of current digital agronomy and data-based information systems, demonstrate their most profitable use, and provide the broadest base for future improvements.

THE FERTILISER CHALLENGE: IMPROVING NUTRIENT USE EFFICIENCY (NUE)

Our in-depth research into nutrition, the consequent development of our Agrii-Start enhanced efficiency technology and our focus on precision agronomy have always been centred around achieving more with less.

Never has this been more appropriate, with the hike in gas prices in the second half of 2021 severely impacting nitrogen fertiliser availability and prices in the UK and Europe. Subsequently, fertiliser export bans in China have reduced phosphate availability and increased prices, and the lack of availability of MOP has also resulted in higher prices, making fertiliser planning very challenging across the UK and Europe.

New limitations on use of organic manures in England under the clarification of rule 1 of the Farming Rules for Water (FRfW) (please see **page 11**) have exacerbated the situation.

Please speak to your agronomist for more information on any of the subject on this page.

There's also more information on the work we're doing around improving Nutrient Use Efficiency in Insight Reports 2, 3 and 4:

Here we outline five agronomy strategies, focused on maximising efficiency to drive farm resilience, that could help:

1. Improving soil structure

- Appy organic matter if possible within the constraints of the FRfW.
- Consider cover crops for future organic matter improvements and their ability to fix nitrogen.
- Attend to any drainage issues for maximum root development.
- Think about liming as optimum pH is critical for maximum nutrient access.

2. Crop rotation/seed rates

- With differential fertiliser requirements between crops, consider changes to your rotation.
- Consider upping seed rates if nitrogen is limited.

3. Feed to need: plan and target fertilisers carefully

- Look at your break even ratios and feed to need.
- Test soils for nitrogen: use Soil Mineral Nitrogen (SMN) or N Min tests combined with measuring captured nitrogen (RHIZA) in crop canopies to understand how to best manage nitrogen applications.
- Consider foliar nitrogen and integrate alongside bagged nitrogen if appropriate.
- Ensure potassium is balanced with nitrogen – its synergistic effect ensures maximum effect from applied nitrogen.
- Incorporate sulphur to improve nitrogen use efficiency.

4. Consider biosolution options for boosting biomass and NUE

- Take-Off is a biostimulant seed treatment for spring OSR that can help early nitrogen metabolism.
- Zax/i-Man seed treatments are options for spring cereals – both zinc and manganese aid nitrogen utilisation.
- Ensure other micronutrients are balanced according to need.
- Use the Agrii/Lancrop tissue testing service in-season to accurately determine need.

5. Growth regulators and fungicides – for physiological benefits

- Proven rooting improvements from some early season PGR use in cereals – speak to your agronomist.
- Improved greening has been documented from some strobilurin and SDHI fungicides – please speak to your agronomist.

INSIGHT REPORT 2:
www.agrii.co.uk/greenhorizons/the-environment/

INSIGHT REPORT 3:
www.agrii.co.uk/greenhorizons/integrated-whole-farm-solutions/

INSIGHT REPORT 4:
www.agrii.co.uk/greenhorizons/farm-productivity-and-viability/

PART TWO

BRINGING IT ALL TOGETHER

IN SUMMARY, BUILDING SOIL RESILIENCE DEPENDS ON:

Understanding your soils and building up a picture of their health and status, and a plan for improvement.

Patience and a practical approach to developing and understanding what the right approach is for your business, soil type, location, and local situation and challenges. There is no one-size-fits-all answer.

Taking an integrated view on cultivations, rotations, ground cover, technology and pest and disease management. All of these areas and the linkages between them must be viewed together in a holistic, total farming approach.

Taking the time to understand your soils and develop the right approach for your business now, will help to maximise its resilience and profitability in an uncertain future. **Please get in touch to discuss how this could work on your farm.**

PART THREE

CASE STUDY

HIGH SUSTAINABILITY FARMING APPROACH PROVES ITS WORTH ON THE COTSWOLDS

Diversity, flexibility and capacity are the cornerstones of the successful high-sustainability contract farming business built by Toby Baxter for a growing number of landowners on the western edge of the Cotswolds over the past decade.

He and his Agrii agronomist, John Vickery, have never been afraid of doing things differently. That's why around half of their first cereals are no longer wheat; they routinely employ double cereal breaks and four-year herbal leys; no-till and year-round soil cover are their standard practices; and all of their cropping is closely integrated with both beef and sheep enterprises.

Toby Baxter comments "Building resilience is our whole focus. For the most part, we're not on 10t/ha-plus wheat land here. But we've found we can generate reliable margins from even the thinnest, stoniest ground with the right approach."

Crop diversity

More than 10 different combinable crops are routinely grown across the 1400ha of ground currently being farmed in joint venture contracts. These are complemented by a wide range of forage and cover crops, all supporting extensive beef and sheep grazing.

This diversity, a highly flexible rotational approach and sufficient machinery, seed

BRINGING IT ALL TOGETHER

and grain handling capacity give both the land and business the greatest ability to cope with changing environmental and economic conditions.

Minimal soil movement

"We went into no-till on our first 380ha contract farm near Tetbury in 2012 and it hasn't been without its challenges" explains Mr Baxter. "But we prepared the way with min-tilling and were guided by the expertise of no-till specialist, Steve Townsend. So, the mistakes we made were manageable. The biggest lesson we've learnt is never to go on the land when conditions aren't right," he says.

"No-till definitely improves the health and carrying capacity of the ground, but it's a long-term business. And because you're only working such a small amount of the soil you have to give the land time to dry out on its own after rain. Which means sufficient flexibility and capacity so you never drill before it's ready – otherwise most of your management is fire-brigade."

Flexible rotations

To ensure the flexibility they need, Toby Baxter and John Vickery have abandoned the idea of fixed rotations. They have an overall plan, but what is grown each season is dictated by the weather, more than anything else. Having their own facilities mean they can clean and dress seed the day they drill. Equally, having two different drills means they can choose either tines or discs to suit the ground conditions.

Undoubtedly the single most crucial ingredient for success has been getting livestock back into the arable rotation in a substantial way. As the business has grown, greater reliance has been placed on forage breaks as well as cover crops both for an expanding sheep flock and a New Zealand-style, year-round grazed beef enterprise recently developed.

"Grazing cover crops adds to their value considerably," Mr Baxter points outs. "It provides a timely injection of extra fertiliser-saving and soil-improving fertility while decimating any slugs. It also allows us to turn arable challenges into livestock opportunities."

Flexible thinking

In addition to herbal leys, Toby Baxter and John Vickery are currently introducing a two year fodder beet and Westerwolds ryegrass break into their regime for winter grazing.

These will be carefully strip-grazed over the winter and the plantings swapped over for the second year. They will then go back into the arable rotation in the third spring, profiting from a vast amount of muck as well as a good clean break and having finished 180 beef animals and wintered a further 180 youngstock.

Mixed farming as a basis for building soil resilience

This latest innovation typifies their determination to make the very most of the synergies between crop and livestock production progressively lost over the past 50 years; synergies they firmly believe will be increasingly important to the sustainability of many farming businesses on more marginal arable ground in future.

"The addition of livestock as well as sufficient cropping flexibility and diversity is essential to our no-till recipe which, in turn, is essential to supporting the most cost-effective outdoor stock production," Mr Baxter observes.

"Re-establishing the value of mixed farming like this can only happen with sufficient capacity and scale, though," adds Mr Vickery. "Technology can help. But fundamentally you can only get the flexibility you need with enough people, machinery, facilities and, of course, teamwork. The recipe developed here certainly won't suit everybody, but I defy anybody not to learn something valuable from it."

A REGENERATIVE AGRICULTURE RECIPE FOR RESILIENCE IN THE COTSWOLDS:

- Diverse and flexible rotations.
- Year round soil cover.
- No-till.
- Cropping closely integrated with livestock enterprise.

PART THREE

THE AGRII ACTION PLAN FOR INCREASING SOIL RESILIENCE

Agrii actions relevant across all five Insight Reports:

- Field of the Future reduced input R&D challenge project (please see **Insight Report 2** for more information)
- Agrii annual Innovations Award Scheme
- Fast-track biosolutions screening programme
- Accredited environmental training
- Extended enterprise benchmarking
- General company drive towards net zero (please see **Insight Report 5** for more information)

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

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

Action	Details	Timescale	Where to go for more information?
Launch of Soil Resilience Strategy Service.	**Page 13** of this Insight Report.	January 2022.	**www.agrii.co.uk/greenhorizons** (soil resilience tab) or please speak to your agronomist.
Continuing collaborative partnerships.	This includes current work with partners including: - Harper Adams - Soil and Water Management Centre - Consus – University College Dublin - Origin and Science Foundation, Ireland - The ASSIST project - UKCEH - Rothamsted	Consus – Improving NUE – developing a compaction prediction model 'soft tread' – summer 2022. UKCEH – expansion of soil biology project looking at soils in the north region – summer 2021. ASSIST Part 2: will run for three years until 2024.	**www.agrii.co.uk/greenhorizons** (soil resilience tab) for project updates. Soil and Water Management Centre's. Soil and Water Conference 2021. Please also see **Green Horizons Insight Report 5** for more information on our work to extend stakeholder engagement.
Develop and communicate trials and work around regenerative and conservation agriculture.	Ongoing trials work, development of literature and knowledge exchange opportunities.	Ongoing.	**www.agrii.co.uk/greenhorizons** (soil resilience tab) for project updates. Soil and Water Management Centre's Soil and Water Conference 2022.
Development of three Net Zero iFarms and use of Farm Carbon Toolkit to develop net negative carbon budgets for those sites.	Three sites: South Wales, Bishop Burton and Midloe Grange. Working with ADAS as part of the YEN Zero Network.	Net Zero iFarm demonstration sites set up March 2021, annual reports and on-site virtual engagement events from 2021 onwards.	More information in **Green Horizons Insight Report 2**.
Continued support of the Soil and Water Management Centre's Soil and Water Conference.		January 2022 annual conference.	Details of the 2020 conference here: **www.soilandwater.org.uk/the-2020-soil-and-water-management-centres-virtual-conference/.**
Sharing of best practice for improved soil resilience through Green Horizons Farmer Network.	GH Farmer Network launched March 2021.	GH Farmer Network launched March 2021. Annual Network events to be held from 2022 onwards.	Updates at **www.agrii.co.uk/greenhorizons.**
Expand range and use of fertilisers with a low carbon footprint. Aim for 20% of Agrii fertiliser sales to have low carbon footprint (currently at 11%).	Product development and trials ongoing. Internal and external communication programme ongoing.	By 2023.	More information on **page 33** of this document.
Increase use of RHIZA for VR fertiliser and the use of in-season GS specific foliar applications.	Overall promotion of tailored nutrition approach.	Ongoing.	More information on **page 32** of this document.
Fast-track biosolution screening programme being run with our sister company, Fortgreen, in their cutting edge laboratory and glasshouse facilities.	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.	More information on **page 31** of this document.

WHERE NEXT FOR MY FARM?

For more information on anything that you've read in this brochure, or to discuss how to improve the resilience of the soils on 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 soil resilience projects as part of Green Horizons at **www.agrii.co.uk/greenhorizons.**

This is INSIGHT REPORT:1
IMPROVING SOIL RESILIENCE

INSIGHT REPORT:2
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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:2
ENHANCING THE ENVIRONMENT

GLOSSARY

Active carbon:
An indicator of the small portion of soil organic matter (SOM) that can serve as a readily available food and energy source for the soil microbial community.

Adjuvants:
Substances used to enhance the effectiveness of pesticides, herbicides, insecticides, fungicides and other agents that control or eliminate unwanted pests.

Biopesticides:
A contraction of 'biological pesticides' which includes several types of pest management intervention, through predatory, parasitic or chemical relationships. In the EU, biopesticides have been defined as a 'form of pesticide based on micro-organisms or natural products.' They are obtained from organisms including plants, bacteria and other microbes, fungi, nematodes etc. They are often important components of IPM programmes, and have received much practical attention as substitutes to synthetic chemical PPPs.

Biorational pesticide:
Any pesticide material that causes no harm to humans or animals and does little or no damage to the environment.

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.

Carbon drawdown:
This is the removal of carbon dioxide from the atmosphere, and its storage, e.g. in soils or vegetation.

Carbon footprint:
The amount of carbon dioxide released into the atmosphere as a result of the activities of a particular individual, organisation, or community.

Carbon sequestration:
Carbon dioxide is the most commonly produced greenhouse gas. Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide. It is one method of reducing the amount of carbon dioxide in the atmosphere with the goal of reducing global climate change.

Carbon stocks:
The quantity of carbon contained in a 'pool' or reservoir or system that has the capacity to accumulate or release carbon. Soils can be described as a carbon pool.

Climate change mitigation:
Actions that can avoid and reduce the emissions of greenhouse gases into the atmosphere, and actions that can reduce the impact of resultant global warming on populations and practices – improving resilience to the impacts of climate change.

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.

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.

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.

Enhanced efficiency fertilisers:
Forms of fertiliser, including nitrogen fertilisers, designed to reduce nutrient losses to the environment and increase nutrient availability to crops.

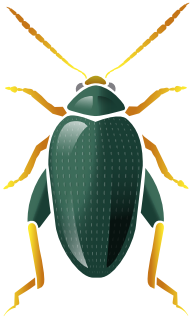
Environmental Land Management (ELM):
The ELM scheme is the cornerstone of the UK government's new agricultural policy. Founded on the principle of 'public money for public goods', ELM will provide a powerful way of achieving the goals of the 25 Year Environment Plan and commitment to net zero emissions by 2050, while supporting our rural economy. More information at **www.gov.uk/government/publications/environmental-land-management-schemes-overview/environmental-land-management-scheme-overview**

GLOSSARY

Greenhouse gases (GHGs):
Gases that contribute to the greenhouse effect (or warming of the earth's atmosphere) by absorbing infrared radiation. Greenhouse gases trap heat – they let sunlight pass through the Earth's atmosphere, but prevent the heat that the sunlight brings from leaving the atmosphere. Many GHGs occur naturally in the atmosphere, while others are synthetic. Carbon dioxide, methane and nitrous oxide are all naturally occurring greenhouse gases, however human activity has led to their rapid release into the atmosphere – accelerating the greenhouse effect.

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 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.

Mycorrhizal fungi:
Mycorrhizal fungi establish a mild form of parasitism that is of mutual benefit – both the plant and fungus benefit from the association. The fungi effectively extend the root area of plants and are extremely important to most wild plants. They can enhance soil nutrient absorption by the plant, improve water uptake and biosynthesis of biostimulants and other compounds – enhancing the plant's flexibility to cope with environmental stresses.

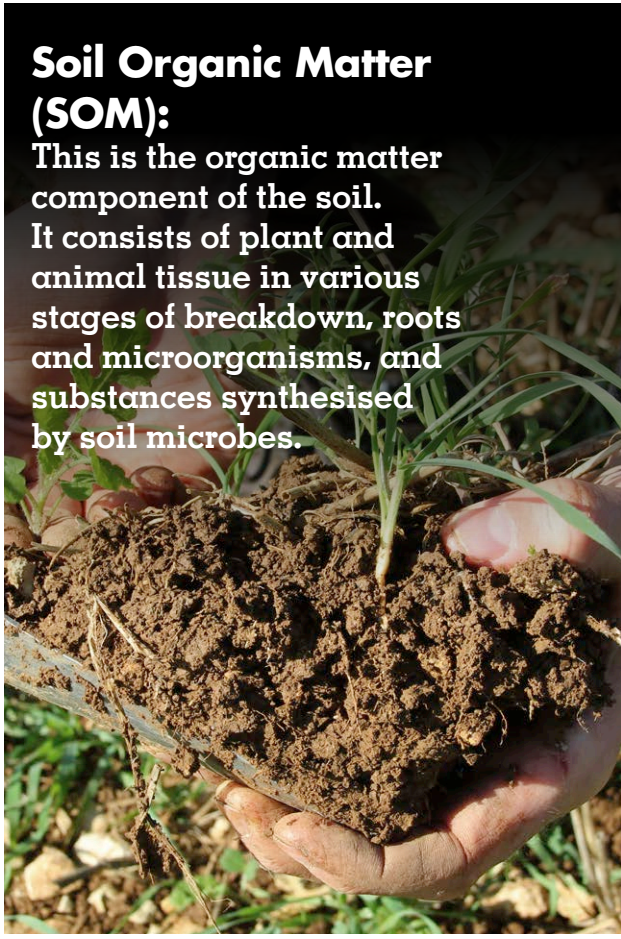
Net Zero:
Refers to the balance between the amount of greenhouse gases produced and the amount removed from the atmosphere. We will reach net zero when the amount we add is no more than the amount taken away. The NFU has set the goal of reaching net zero greenhouse gas (GHG) emissions across the whole of agriculture in England and Wales by 2040.

Nutrient Use Efficiency (NUE):
A measure of how well plants use available mineral nutrients. NUE can be defined as yield (biomass) per unit of nutrition input.

Plant Protection Products (PPPs):
Traditionally 'pesticides' that protect crops or desirable or useful plants.

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. Please see **page 5** for more information.



Soil Organic Carbon (SOC):
This refers only to the carbon component of organic compounds in the soil. SOM is difficult to measure directly, so laboratories tend to measure and report SOC.

FIND OUT MORE ABOUT GREEN HORIZONS:

Visit: **www.agrii.co.uk/greenhorizons.**

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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