ISSUE 7 | OCTOBER 2019

DIRECT DRILLER MAGAZINE

THE FUTURE OF YOUR SOILS

IS RYE THE ANSWER?

ALSO IN THIS ISSUE

NET ZERO FARMING
Page 90

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DIRECT DRILLER MAGAZINE

Issue 7
October 2019

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INTRODUCTION

MIKE DONOVAN, EDITOR

A very warm welcome to this new issue of Direct Driller. There's much to get your teeth into, including topics that are new but highly relevant. A glimpse into the future shows new crops on the cusp of becoming commercial. Why, for example, have we yet to realise the potential of rye? And in the longer term, what are the chances of growing perennial wheat in the next 20 years? I like magazines which surprise me, and this one certainly does, with topics far removed from data technology, satellites, drones, robots etc.

Here we have features which look at progress and technology which have yet to hit either the farming or national press headlines.

This issue has its feet very much on the ground. Contributors have real exper-ience and expertise in both the practice and science of using and managing soil. Those planning to start No-till will find James Warne provides dozens of tips on pg 56. On pg 84 Andy Howard has some startling figures about real farm profitability. Those farmers whose cropping is restricted to the three cereals and osr may well find 'buckwheat', 'phacelia', burseem clover' and so on somewhat daunting. Yet they make a valuable contribution to farming systems, so it's worth getting acquainted with these strangers!

This issue of Direct Driller shows that the pace of change in the industry is not confined to electronics and mechanics.

Once again we must thank those very many people in companies, institutes, universities who choose to support us, and of-course the numerous farmers who share their thoughts and farming methods. They all help to make this publication essential reading. If you have something important to say do please get in touch with Clive or Chris – info@directdriller.com or me - **mike@farmideas.co.uk**

Mike Donovan, editor

NO-TILL BY NUMBERS

We are often asked how many of the UK's farmed acres are direct drilled. It isn't easy to answer exactly, but the easy answer is that it is always increasing. Data seems to suggest between 8% and 12% is no-tilled, but given all the confusion over naming, we are not sure that even this is correct. We've heard government officials talk about minimum-till, when they mean no-till and trying to explain to the same officials about strip-till, no-till and zero-till leaves you little hope of getting the right data out of any survey.

However, we know it is growing out of being a niche to being "normal". Although we secretly think some of these no-tillers won't like being called normal! Seeing this trend, it was very interesting to compare this to data that has just been published in the No-Till Farmer magazine from the 2017 Census of Agriculture in the US. This carried the conclusion

"Growers are moving away from Intensive tillage in favour of no-till, min-till and cover crops."

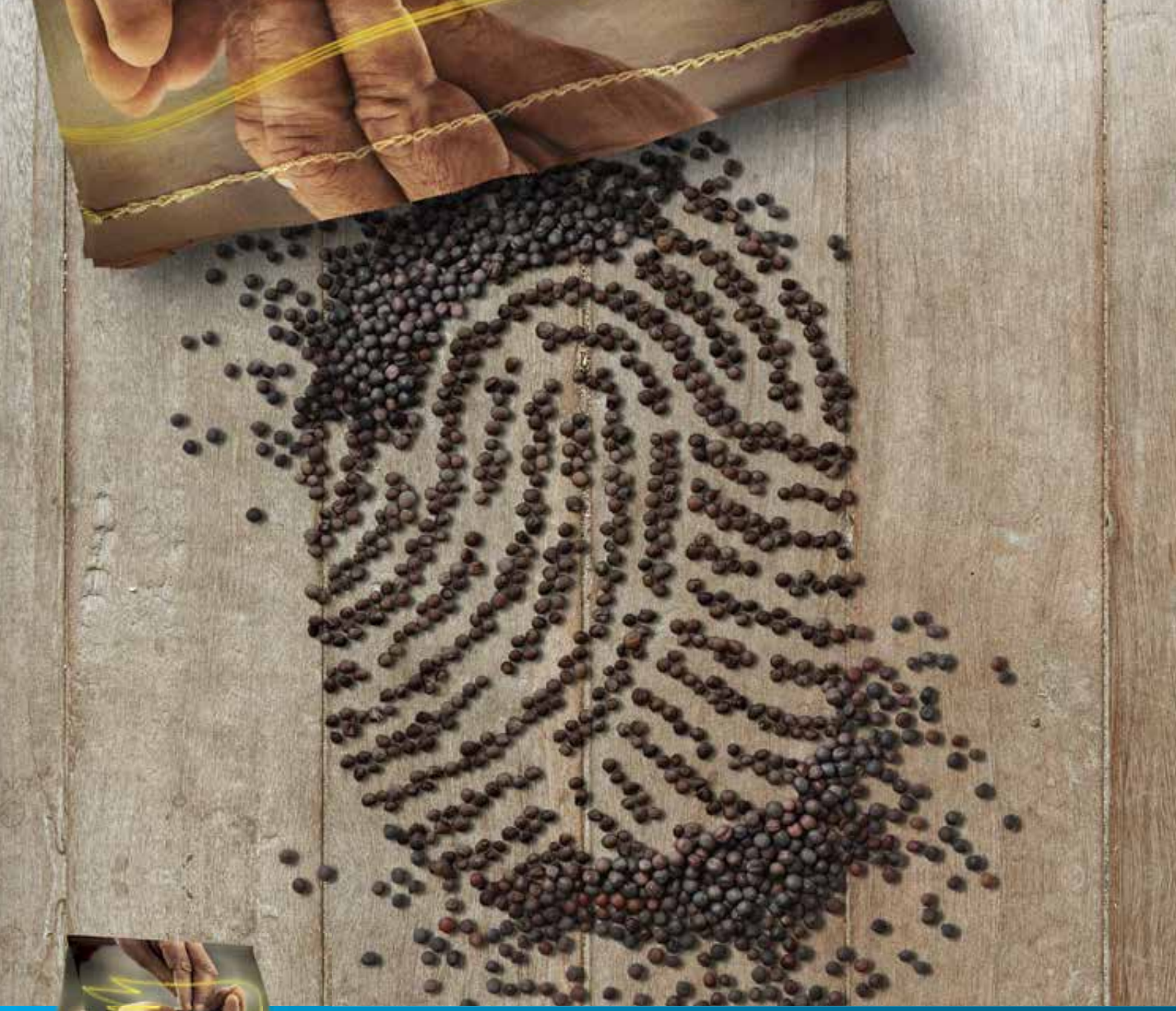
The number behind this certainly show we are still well behind the curve in the UK in terms of adoption.

US Tillage Practices 2017

No-Tillage	104M Acres	37%
Reduced Tillage	97M Acres	35%
Intensive Tillage	80M Acres	28%

These figures do vary considerably by state though as you would imagine with the size of the US and the climatic changes across the country. There are a number of states like Nebraska, Montana, Maryland, Dakota, Tennessee are all well over 40% and in some over 50% of acres are no-tilled. However, conservation tillage numbers are lower than this, but growing at a faster rate.

Given the information we are receiving from the government at the moment, with regards to climate and natural capital, it is likely the appetite for no-till practices will become a lot more palatable to farmers in the UK who will be pushed towards new methods of establishment. Therefore, we expect to see the UK numbers grow considerably over the next 10 years. If you are considering going no-till at the moment, we would love to hear from you about why you are considering a new method of establishment.



DK EXPEDIENT THE FASTEST DEVELOPER

VIGOROUS ESTABLISHMENT

DOUBLE PHOMA RESISTANCE

POD SHATTER RESISTANCE

PRODUCT CHARACTERISTICS

GROSS OUTPUT%	103 %
OIL CONTENT%	45.3 %
EARLINESS AT REGROWTH	EARLY
EARLINESS AT FLOWERING	1 2 3 4 5 6 7 **8** 9
EARLINESS AT MATURITY	1 2 3 4 5 **6** 7 8 9
PLANT HEIGHT	1 2 3 4 5 **6** 7 8 9
LODGING RESISTANCE	1 2 3 4 5 6 7 **8** 9
STEM STIFFNESS	1 2 3 4 5 6 7 **8** 9
POD SHATTERING RESISTANCE	YES
PHOMA RESISTANCE	1 2 3 4 5 6 7 **8** 9
LIGHT LEAF SPOT RESISTANCE	1 2 3 4 **5** 6 7 8 9

AHDB Recommended List 2018/19 Table 16 – Varieties not added to the RL.
https://cereals.ahdb.org.uk/varieties/ahdb-recommended-lists.aspx

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FEATURED FARMER

JAKE FREESTONE

Farm Manager at Overbury Farms

The Farm

Overbury Farms is an integrated part of Overbury Enterprises which has been in the same family for over 250 years. It is a mixed farm that produces a range of crops including wheat, barley, oilseed rape (OSR), pease, linseed and soya beans. We also let out certain areas of our farm to specialist growers who produce crops such as onions and peas. The farm also has a flock of 1,200 sheep and home-bred Texel Cross Mules. The ewes are a mixture of Mules, Aberfields and Lleyn crossed Romneys. All lamb is LEAF marque certified which is an environmental assurance system that recognises sustainably farmed produce. Produce and livestock are sold to high street supermarkets as well as local markets and food outlets. OSR is sold on to Unilever and our barley is harvested and sold to Molson Coors.

Watch a video by scanning the QR Code opposite (recorded at an intercropping event) of Jake introducing the farm and talking about the importance of no till and cover cropping.

Scan me

Sustainability In Practice:

Building soil fertility and reducing weeds through carefully planned rotations, no till, intercropping and cover crops

The 6 year rotation at Overbury includes winter and spring barley, OSR, winter wheat, peas, linseed and soya beans. We have reintegrated livestock and now graze ley mixtures with home bred Texel, Abermax and SufTex lambs. This has the benefit of breaking weed lifecycles and also allowing the restorative periods in the rotation.

The system has been no till since 2013 (on some trial blocks, most of the farm came in from July 2015), which has had a very noticeable impact on soil quality, infiltration and biology - evidenced by some giant worms that we have found here lately! On most occasions we leave some straw and use mollasses and humates to help break it down. I don't use seed treatments as the effect on mychorrhizzae is compromising the essential life in the soil, and instead have farm-saved untreated seed (seed is tested for fusarium mainly and if clean enough it's not dressed). If the soil is going to be uncovered for more than 5 weeks, I will put in a cover crop.

In monoculture there is no room for genetic variation. A field of wheat is full of genetically identical plants and everything is vulnerable to the same pests and diseases. In a crop mixture you can guarantee that something will grow regardless of what conditions come your way. But it is not so much what happens above ground as below. Speaking to fellow Nuffield Scholar Andy Howard, I was inspired to give companion cropping a try...

Our most common species mixture (or 'plant team') is OSR, vetch and buckwheat. We have 4 hoppers on the Cross Slot drill (one also for slug pellets) and drill it at the same depth in the autumn - seed rates of approx. 7kg buckwheat, 2.5kg OSR and 13.5kg vetch per hectare (ha). As we found we were attracting a lot of pheasants in the crop, we are now using a mixture of 2.5kg/ha OSR, 2kg/ha burseem clover and 10kg/ha vetch. Each species has different functions in the mixture. The vetch is deep rooting and breaks compaction to open up the soil for the OSR and also provides residual nitrogen; the buckwheat is good for creating a cover to smother weeds, making phosphate more available and distracting pests as well as providing a structural function to stop the crop going

flat.

In these mixtures we use no pre-emergence herbicide as we rely on the competition effect to smother broadleaf weeds. Astrocurb is the only broadleaf herbicide we use to kill off the buckwheat and vetch and stop them growing over. Frost will take out buckwheat at less than 5˚C.

A simple cost benefit analysis shows that despite the higher costs of seed, we are saving approximately £35/ha on inputs with the intercrop versus a monocrop of OSR.

Cost	Benefit
Extra seed = £30/ha	Herbicide saving = £35
	Fertiliser saving £25
	Insecticide saving = £5
	Net benefit = £35/ha

We also undersow a mixture of red clover, perennial ryegrass (PRG), plantain and chicory into spring barley. This year we had a yield of 6 tonnes / ha with no herbicide. I deliberately chose those fields that have a brome problem to help get on top of it. This then goes into a 2 year ley for sheep.

Another mixture we are trying is kale undersown with white clover for fattening lambs. Once grazed we then direct drill winter wheat into the white clover. I am interested to continue experimenting with this - an understory of white clover for the whole rotation would be good.

One example of this experimentation was a recent cover crop of rye, vetch, phacelia, and buckwheat drilled into soya ahead of soya beans which were planted the following spring. The cover crop provided a valuable habitat for pollinators in November when there is not much else available.

I am pleased to say that blackgrass is now a diminishing issue - it's now just a spot of leisurely hand rouging on a Sunday afternoon! I think this is a combination of 5 years no till, spring cropping and having a cover at all times (if the soil is going to be bare for more than 5 weeks I put a cover in). We also try to drill later but I am cautious not to push it back too far in a no till system - although the soils are drier.

There are barriers to farming in this way - there are some machinery requirements; we need to consider the rotation effects and limit the 'green bridges.' Finding markets for crops such as buckwheat is also a challenge, as is important to get spring crops to contribute enough to gross margins...

But I think the biggest barriers are in our minds! Have to stop worrying what the neighbours will think and take the plunge and try something new...

Motivations:

Overbury Farms became a member of LEAF in 2003 due our core belief that intensive farming also needs to be environmentally sustainable. We then gained LEAF Marque status in 2007 and we proudly became a LEAF Demonstration Farm in 2012. This allows us to promote Integrated Farm Management (IFM) and show our strategies to achieve sustainable farming with the agricultural supply chain as well as the local community through farm visits. LEAF membership has helped us implement many strategies in order to enhance yields while being conscious of the environment.

In 2013 I was awarded a Nuffield Farming Scholarship to study the possibilities of growing 20 t/ha of wheat in a sustainable farming system while following IFM - 'Breaking the Wheat Yield Plateau in the UK.' Through this project I visited several countries including Canada, Mexico and the United States to understand the limiting factors of high yielding wheat crops and what the main mitigation strategies were that were in place. Differing climates produces a range of challenges when faced with growing high yielding wheat crops and this project allowed me to witness these problems first hand and to bring solutions back to the UK with the potential to use them on British wheat crops.

One of the big eye openers for me was to realise that we are in fact abusing the soil by overcultivation. I came to the conclusion that we need more diversity to enable us to overcome some of these challenges. Increased soil management, more diverse rotations and livestock integration are all key to increasing wheat yields.

Farmer Tips

- Always keep soil covered.
- Consider what your objectives are with mixtures before selecting them i.e. weed suppression, increasing protein, combating pests and diseases...?
- The biggest barrier is in your mind!

Farm Facts

FARM SIZE: 1,538 hectares

MANPOWER: 6 full time staff

FARM TYPE: Mixed

NUMBER OF LIVESTOCK: 1,200 sheep

TENURE: Owner occupied

REGION: South West England

RAINFALL: 843 mm

ALTITUDE: 229 m - Bredon Hill Summit

SOIL: Brash

APPROACH: Integrated Farming

KEY FARMING PRACTICES:

No Till
Trap crops
Mixed farming
Companion crops
Cover crops
Diversified rotation
Intercropping

HOW TO IMPROVE YIELD AND QUALITY AFTER APPLYING YOUR NORMAL INPUTS?

Written by George Hepburn from QLF Agronomy

I have worked with farmers on their inputs for the last 15 years. I worked with Soil Fertility Services for 12 years as a Soil Fertility Advisor, advising many farmers on soil health and nutrition. For the last two years I have worked for QLF Agronomy (based in the US), advising farmers on the virtues of using carbon in biological and conventional farming contexts to feed the microbes and fungi which has shown significant yield, quality and fertility improvements. I am FACTs qualified and I have Certificate in Nutrition Farming from NTS. I have seen biological farming go from muck and mystery to main stream agriculture but there is still much more for us to understand about the soil and more importantly the life within it. Whilst working with quality proven carbon-based products for the past few years I have seen the results of extensive trials and farm use to improve the crops in the US, UK and EU. I believe that future of farming is biological not chemical and over the next 10 years using carbon with inputs will become a standard procedure as the environmental factors alone, such as improved efficiencies and efficacies of fertiliser and fungicide, better conversion of residue to OM and improved breakdown of chemical residues (e.g. glyphosate) are going to push farmers and policy makers down this route. At the moment there is not enough trial work done in this area by the big agronomy companies, although it is increasing as more farmers and agronomists are switching on to the benefits of a biological system.

You have probably heard that there are more organisms in a teaspoon of active soil than there are people on the planet, there is a very complicated world of interactions going on beneath our feet, which even the top soil scientists admit we know little about. We do, however, know the difference that soil biology makes when it starts working for you. Soil structure improves, water is held when needed and released when not, availability of nutrients improves, it can handle traffic much better and it smells like rich dark chocolate!

One Teaspoon of Healthy Soil

- 75,000 Bacterial Species
- Metres of Fungal Hyphae
- Thousands of Protozoa
- Hundreds of Nematodes
- A Few Micro-Arthropods
- Billions of Living Creatures!!

Farmers working on direct drilling systems often notice very quickly how their soil does improve (in a soil sense of time) but many still do not look after the life in the soil enough to get the best out of it.

You can now buy different strains of bacillus bacteria and mycorrhizal fungi and apply them directly to your soil, I have sold these products to farmers and they have worked sometimes but not consistently, and this is the problem there are so many variables you don't know which ones are affecting your soil life.

Soil Composition by volume

20-30% **Air**
20-30% **Water**
5% **Organic**
45% **Mineral**

I am now of the opinion that if you look after the soil, and feed it with the right foods then the soil life will follow without applying any of the actual bugs. There are certain situations that I can understand applying them for example after potatoes when large amounts of chemicals have been applied alongside a major cultivation program, but most of the time what you actually have to do to get these microbes working for you is quite simple.

Ideally you are looking for the target ratio of 45% mineral, 5% OM, 25% air and 25% water. This is the home that the microbes need to not only live but to thrive in. Microbes will respond to feeding by an increase in number, but you will never get to the optimum levels unless they have the correct surroundings. Air and water in the right ratio is key for stimulating the biology. The best way to check this is with a spade and your senses. Dig in a number of places across the field and feel at how well the spade goes in, how far the roots go down, the smell, number of earthworms (and other visible soil life) and how well residue is breaking down. If you want a point of reference go to an old hedge and dig underneath it. This is the potential of your soil.

Science can help too. Calcium and Magnesium help to define the structure of your soil. High magnesium levels can make the soil quite tight and sticky, not allowing air in and holding on to water. High calcium levels can mean the soil is too open and can't hold on to water or nutrients. Neither of these situations are good for the soil microbes. This is where an in-depth soil test can be useful looking at the exchangeable nutrients and certain key ratios like Ca:Mg, which can guide you down a soil remediation route.

When you have the correct soil structure; which I am seeing more frequently as increasing numbers of farmers do less and less tillage, the next job is to feed the soil or more importantly the microbes and fungi. FYM, compost,

lime, cover crops, green manures and digestate are good 'fertilisers' as they are all giving the soil life a job to do, but to help them to achieve this they need some energy. Plants do with this by exuding simple sugars, fatty acids and enzymes out through the roots to feed the microbes and we can mimic this by applying similar substances to the soil.

Using a carbon-based (read sugar) product like L-CFB BOOST™ as part of your system can make a big difference, not only are there various types of sugar (sucrose, fructose, glucose and more) which is ideal for feeding the bacteria there is also a more complex food added for both microbes the fungi. Using this type of product alongside your regular applications means that every time you go through the crop you are looking after and feeding these microbes and helping them to perform their role.

Do be aware that there are many types of these carbon products getting on the market going from raw beet molasses through to humic acids. Some of these are not suitable for this type of application and a lack of consistent trial data over the years puts a question mark over their benefits. Make sure you ask for independent and farm trial data and look for a good track record of results and ideally farmers that are using it that you can actually talk to.

Getting your soil microbes working for you can mean reduced inputs of fertiliser and fungicides, OM levels building, less run off and erosion, better water holding capacity, improved rooting, better residue breakdown and increased nutrient cycling. All you have to do is give them a stable home and feed them with a quality product little and often.

Bacteria

Bacteria is the crucial workforce of soils. They are the final stage of breaking down nutrients and releasing them to the root zone for the plant.

Actinomycetes

Actinomycetes were once classified as fungi, and act similarly in the soil. However, some actinomycetes are predators and will harm the plant while others living in the soil can act as antibiotics for the plant.

Fungi

Like bacteria, fungi also lives in the rootzone and helps make nutrients available to plants. For example, mycorrhizae is a fungi that facilitate water and nutrient uptake by the roots and plants to provide sugars, amino acids and other nutrients.

Protozoa

Protozoa are larger microbes that love to consume and be surrounded by bacteria. In fact, nutrients that are eaten by bacteria are released when protozoa in turn eat the bacteria.

Nematodes

Nematodes are microscopic worms that live around or inside the plant. Some nematodes are predators while others are beneficial, eating pathogenic nematodes and secreting nutrients to the plant.

QLF Agronomy

IS **ORGANIC NO-TILL** POSSIBLE?

Written by Jerry Alford from the Soil Association

There has recently been a lot of interest in the potential of organic no-till and it has been described by some as the holy grail of organic arable farming. It is also something that is of interest to non-organic farms because of the potential to reduce inputs, particularly on less profitable break crops.

Organic arable farming systems have always been built around the use of cover crops, diverse rotations and animals. Building fertility during the rotation for high value crops and also using these covercrops and grass leys as part of weed control strategies. These regenerative phases have always been used to counter the effects of the exploitative phases where crops and tillage remove soil nutrients. Organic regulations (EU Regulations 834/2007, 889/2008 and 1235/2008) prohibit the use of artificial chemicals and fertilisers and support the minimisation of the use of non-renewable resources and off-farm inputs. Put simply, the requirement is for circular economy principles to be followed as far as possible. Many organic farms include grazing livestock enterprises and as with non-organic mixed farms, soil health will benefit. In stockless organic arable systems, clover is grown as part of the rotation and is regularly topped and mulched to build soil fertility.

It is difficult to compare an organic arable farm with a non-organic arable farm because rotations, inputs and even crops may vary. Most organic rotations include legumes because of the fertility value, but very few grow oil seed rape because of its high nutrient demand and pest risk, to both it and following crops. The inclusion of fertility building phases in the rotation is also very different, although this is becoming more widespread in non-organic systems. Cover crops over winter as green manures are also often part of the rotation. Organic farms can use composts, manures and digestate, subject to certain restrictions, but there are no synthetic nitrogen products approved.

The biggest problem organic farmers face is weeds, particularly grass weeds. Blackgrass can be a problem but the diverse rotations including ploughing, spring cropping and low fertiliser use does seem to reduce its effects in organic systems. In non-blackgrass areas, other weed grasses like annual meadow grass and bromes can reduce yields if allowed to develop. Perennial grass weeds like couch are also a problem although an Innovative Farmers trial has shown positive effects by using buckwheat which has an allelopathic effect as well as a shading effect when the weeds are at their weakest after harvest. Ploughing has become the main weed control mechanism for many organic farmers, with seedbed preparation and cultivations being part of the weed control strategy. However, many organic farmers have looked at using min-till or non-inversion techniques through their rotations to reduce the need to plough. Most would plough 3 times during a 5-6year rotation but finding a way to grow organic crops using a no-till system during the rotation would be a good next step.

Grass weeds

The benefits and potential of Conservation Agriculture are plain, but an organic farmer is restricted by the need to generate fertility on farm, the decision not to use chemicals and their customers choosing to buy organically certified products. The Soil Association agrees with the principles of conservation agriculture and in the long term would hope to get to a situation where tillage in organic could be reduced still further and conservation agriculture could take place with reduced or zero herbicide use. Knowing what the issue is the easy bit, finding the answer is the challenge.

So how do we get there?

If we are going to go no-till organically we need to control weeds and cover crops without chemicals. There are already three practices used worldwide, which have been tried in the UK by organic farmers, with varying degrees of success. None have been tried organically into long-term no-till situations.

The most well-known is the crimper roller. Developed by the Rodale institute in America, the ribbed roller crushes the stem of plants. The rolled plants then act as a weed controlling and moisture retaining mulch which also returns nutrients and organic matter into the soil. To work properly the crop being rolled must be an annual and at anthesis (early flowering). In America the most common crop crimped is rye which is at the correct stage when Soya and Maize are being drilled. In the UK the correct growth stage comes too late for UK cropping. The allelopathic effects of the rye may also make it unsuitable for small seeds

Roller Crimper

like wheat. In an organic rotation, there is the potential to grow rye as a cover crop and then crimp and drill vetches during the fertility building phase. This second cover can then be crimped and will supply nitrogen to an autumn drilled cereal. This avoids the need to plough out a grass ley which itself can become a source of weeds.

The second technique is to drill a crop in the winter into a frost susceptible cover crop such as buck wheat, berseem clover, phacelia and mustard. This will provide a mulch to the next crop as well as nutrient recycling. Smaller seeded plants may not work in this situation because they are less competitive as seedlings, but it has been used for beans. There is a potential problem if there is a mild winter because any cover crop plants which produce seed could create a weed problem in later crops so some form of management may be necessary. Grazing with livestock could be an option because cereal and OSR plants will regrow after grazing. As part of an Innovative Farmers trial on alternatives to glyphosate a group of farmers used rollers on cover crops during a frost to investigate whether they would be an option and did show some success, which would allow late winter drilling where ground conditions allow.

A third option is to use a permanent understorey and drill into this. Similar to pasture cropping which drills into permanent pasture this form of bi-cropping would use a clover understorey to provide both cover and fertility to the growing crop. This technique has been used in non-organic situations where the clover is either grazed hard or sprayed with glyphosate at low rate and crops drilled into this. Clover needs soil temperatures of above 10 degrees to grow and so is not very competitive against a winter/early spring sown crop but could be an issue at harvest if the crop is not competitive. It is important to choose a smaller leaved and low growing variety of clover. Nitrogen will be released when the clover is cut and so some method of topping or crimping between rows would release nitrogen to the crop. After harvest the clover could be mulched, cut for silage or grazed prior to the field being redrilled in the autumn/winter. In theory any crop which is competitive could be drilled into this permanent cover which will self-seed and spread to maintain a competitive mulch. Possible problems come during later years if the clover grows too quickly or competes for moisture with the germinating crop plants.

Innovative Farmers are setting up a trial looking at this using white clover as a cover. To be held on long-term no-till farms and an organic farm, the plan is to plant a white clover cover crop in the summer after harvest and drill a spring crop for 2020 harvest. This can then be continued into 2021 and there is the possibly to also look at techniques to manage nitrogen release from the clover. If this proves effective it could be possible to have a rotation including cash crops every year with a permanent cover crop in the understorey.

Trying to fit these techniques into either organic or non-organic systems in the UK is tricky. Our maritime climate suits grass and weed growth, particularly during the summer and the current variable weather patterns lead to late weed flushes. If we had European type weather patterns with dry summers and hard winter frosts, it would be easier to do. As a result, we need to look at what cover crops and cash crop rotations fit best into the UK climate and farming systems. This research must also look at profitability and costs of systems as much as at inputs and this research needs to be done at both farm and regional level to move away from a one size fits all scenario. Both organic and non-organic farms would benefit from sharing this knowledge and applying those practices which they can borrow from each other or which can be adapted to fit.

Please contract the Soil Association on 0300 330 0100 for more information or advice.

FARMER FOCUS
SIMON COWELL

An Alternative System of Crop Nutrition

Back in 1894, Julius Hensel wrote Bread From Stones which proposed the idea that all the minerals plants need are present in rocks. He used the annual flooding of farmland beside the River Nile as an example, where the soil's fertility was maintained for thousands of years by sediment washed down from mountains to the South. Hensel compared this to the soil of many other civilisations which gradually lost its ability to grow crops and so, after a few hundred years, became deserts. He thought that there was no need for animal manure to maintain fertility, and only a light dusting of ground rock dust was needed.

Edward H Faulkner wrote an equally controversial book Plowman's Folly in 1943, a great read for all No-Tillers. As well as arguing for minimal soil disturbance, he thought that all mineral nutrients originally came from the base material that topsoil is made of. He suggested that it is the same all over the world, whether the underlying base is limestone, granite, sand, clay, chalk or anything else, and that there was no need to apply fertilisers such as Phosphate or Potash.

Even in Faulkner's time, little was known about soil biology and so he and Hensel had to guess how the minerals were being made available to plants. Hensel thought that the Carbon Dioxide released from plant roots was acidic enough to dissolve rock dust, while Faulkner believed that acids were produced during the process of breaking down organic matter such as dead roots and crop residues. We now know that turning limestone, sand, clay etc into fertile topsoil is a biological process in which many types of bacteria use acidic compounds to break down the base material. This process releases mineral nutrients which are then made available to growing plants.

About twenty years ago someone told me about a simple phenomenon which formed the basis of everything I have done in farming ever since. If you test and measure for available nutrients in both a given area of soil and in a quantity of farm yard manure, (and the manure is then applied to that area), when the soil is tested again after a few weeks, the total nutrients available will be substantially higher than the sum of the two original tests. In other words, the manure stimulates the soil biology to release otherwise unavailable soil nutrients.

I did some total soil mineral nutrient tests using very strong acids which evidenced tons of tied up P, K and Mg, and hundreds of kilograms of B, Mn, Cu and Zn in the top four inches. Some crop roots go down to six feet meaning the amount of existing nutrients in the top four inches can be multiplied 10 or 15 times; therefore, I have an unlimited supply of soil based mineral nutrients in my soil. Not having any manure available, the soil biology needed to be stimulated by other means. Biological Stimulants are widely available nowadays, but back then it was a matter of spraying on molasses. This idea has quickly advanced into more complex mixtures of humic and fulvic acids, soil conditioners and other soil goodies and now forms the basis of my policy of not applying any Phosphate or Potash fertilisers. Due to continuous no-till, my crops now have unheard of levels of mycorrhizal root colonisation, at 80% on wheat rather than the typical value of 30%, which increases each plant's root rhizosphere by a thousand times. The plants full nutrient requirements are being met by these fungi, (and in the correct ratios), rather than having to accept what ever is in solution in the water they take up.

As always with these things, it is worth referring to what can happen in non-farmed environments. Although a lawn is not natural, keeping the grass short the only human interference; however, I don't think anyone has ever claimed that removing cuttings makes any difference to how much it grows compared to mulching them down. If it rains, the lawn needs cutting, and there is nothing you can do about it, whether the nutrients are recycled or not. Trees are another great example, in many gardens and parks, fallen leaves are picked up, year in year out. This means that the nutrients are not being recycled as they would in a forest, so every Spring the trees must work with soil biology to extract fresh minerals from the ground to grow new leaves. In the extreme, there are thousands and thousands of perfectly healthy trees growing out of pavements in towns and cities. How can they keep on growing for hundreds of years without recycling nutrients in their leaves when their roots don't have much access to air or rainfall?

It seems to me that all higher successional plants growing in the absence of recycled nutrients or fertilisers are perfectly capable of extracting all they need from the infinite store underground. I am sure this all seems impossible to mainstream farmers and advisers who test for soluble nutrients and convert percentages into "indices" which are then assumed to represent a level of stored nutrients. Fertiliser is then applied to make up for what has been removed by their harvested crops. In my opinion this system is wrong and I have now come to the conclusion that I do not want my indices above 1; I want all my nutrients tied up in the organic matter or clay where they can't leach away but are easily available to the crops.

It is quite normal to question yourself when doing something different, and I too have gone through periods when I have wondered if a little phosphate fertiliser, even as a starter, might help. However, when combining wheat crops a few weeks ago which were yielding over 10 tonnes/hectare, I did allow myself a little congratulatory smile because I really was proving that the soil can provide all a crop needs.

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HOW TO FARM SUSTAINABLY

Just after Groundswell in June, the Sustainable Food Trust held an event at Fir Farm titled "Farming and Climate Change: Towards net Zero Carbon Emissions." Climate change and the ability of farming to be #TheSolution has been in the farming media a lot recently and there were a number of mainstream journalists at the event who where hopefully getting a lot of exposure to farming ability to be part of solving climate change around the world.

Opening the speaking was Charles Massy on regenerative farming. This certainly set a tone for the meeting and his thoughts were not universally appreciated by this audience. However, this was a very different audience than you see at Groundswell and so getting the message across about sustainability, climate change and soil health to a different audience can only be good. If you heard Charles speak at Groundswell you will know how passionate he is about creating balance in any environment. His book is well worth reading and is referenced in the "what to read" section later in this issue.

The event was inspired by Minette Batters pledge to make farming net-zero by 2040, 10 years ahead of the government 2050 deadline. Minette herself spoke at the event. Much talk was given to livestock and pasture fed approaches to sustainability. Certainly, introducing pasture fed livestock into your rotations has been shown to be very beneficial for your soils. There was however no time given to grazing cereals, which also has potential to benefit farmers and soils. However we certainly don't need a "Cereals Grazed Livestock Association" to join as well as pasture fed, so we aren't sure who will promote it.

All about carbon

While the title of the event was about carbon neutral farming, one of the most interesting sections (not necessarily for arable farmers) was from Professor Myles Allen of Oxford University. The government and NFU pledge relate to both Nitrous Oxide and Methane as well as CO2.

To stop the effect of climate warming by CO2 we have to simply stop producing more C02. So we need to reduce net output to zero. Tricky on a number of fronts, as we exhale it and we have a habit of driving, flying and avid consumerism. Crops, grass, hedges and trees do like to consume CO2 though in vast amounts. So farmers have a distinct advantage here.

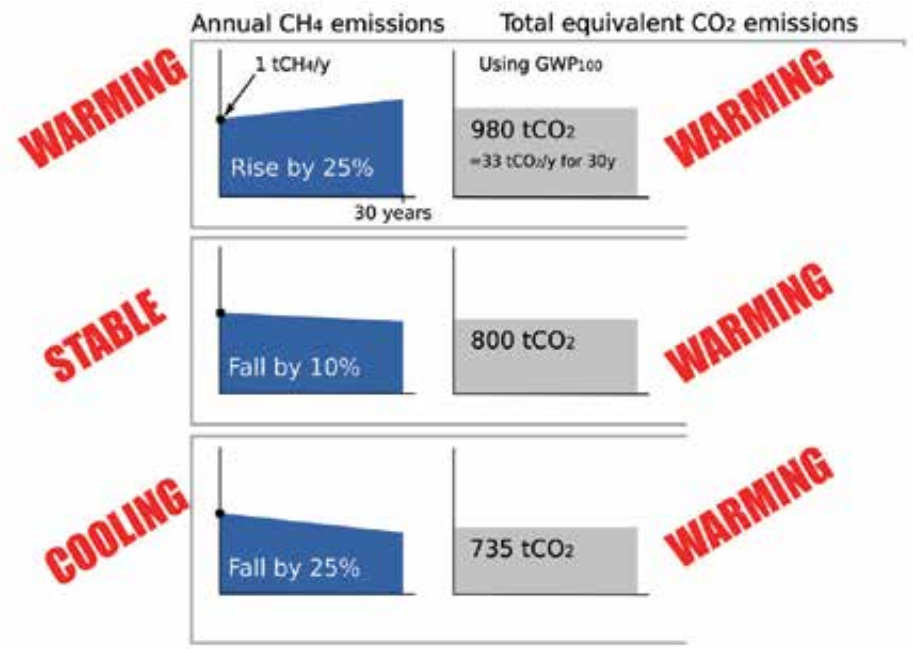

Figure 1 -
From Climate metrics for ruminant livestock, Oxford Martin Programme on Climate Pollutants briefing:https://www.oxfordmartin.ox.ac.uk/publications/view/2714
Nominally "equivalent" emissions of CO2 and methane have very different impacts on temperature

But methane is the interesting one. To halt its effect on global warming, you don't need to reduce methane emissions to zero. In fact a 10% reduction will do. Figure 1 shows the situation based on how a 25% increase, a 10% decease and a 25% decrease in both CO2 and Methane would effect the way they warm or cool the environment.

This is great news for any livestock farmers, as the solutions to reduce methane production already exist. We already have feed additives than can reduce production. You have methane collection systems. You can then burn collected methane for energy production or even run your tractors on methane. While the costs of these are still high, they do exist and the effective "net zero" for methane is actually 90% of today's production and can easily be achieved by the NFUs goal of 2040. Therefore if you are a livestock farmer your path to reaching net zero by 2040 doesn't seem that complicated. That said, this move will still have a massive effect on the price on meat from UK production.

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Ironically, this is the exact opposite of the picture presented by the national media, where meat is taking a bashing at the moment.

Not so great for combinable crops farmers though who feed the vegan community in the UK. If you have time, please do watch the video of Professor Allen's presentation by clicking on the QR Code below and going to 16 minutes in.

The summary here does not do it justice and shows how livestock farming can also be part of the solution to global climate change.

Scan to see a live preview

What was missing?

The event was brilliant, any opportunity that allows you to learn is always a good use of a day. There was massive disagreement in the audience when it was suggested glyphosate should be banned. Members of the public who were attending stood up and stated that glyphosate in food was causing harm. So regardless of what we think as farmers or know from research we have read, "glyphosate" which seems to be the word the public uses for all crop protection products, is "bad". The fact that glyphosate allows farmers to massively reduce the amount of fossil fuels they burn needs to be stressed to the public. It is a lot easier to be a sustainable farmer with glyphosate than without.

As you can imagine, we were hoping to hear lots about direct drilling, no-till farming, cover crops and everything else you read in this magazine. This was however in the great part missing. This was mostly because of the livestock and organic basis of the event. You would think these reduced tillage practices become almost essential for a conventional farmer who want to grow crops sustainably in 2040. There was also very little talk about reduction of synthetic fertilizers. A quote from an attendee at lunchtime pretty much summed it up:

"When is someone going to break the news to the average NFU member, that Minette's pledge means they are going to have to stop ploughing and stop using synthetic fertilizers"

There is a lot to agree with in this statement and why the target of 2040? Gail Bradbrook of the Extinction rebellion movement also spoke at the event. Gail has asked that 2025 should be the deadline for net-zero emissions in terms of climate change. It's a good question really for agriculture. If we just stopped using fert and stopped ploughing next year, this is certainly achievable. The major problems are of course that yields would be reduced and therefore we would have to buy in more food from abroad. So, while UK farmers will be doing our bit, I think consumer trends would mean that the average carbon footprint of a shopping basket would go up if we took this approach as a country. Secondly, we are not convinced that consumers want the price increase that would inevitably come with this production method. Thirdly, to be sustainable farms also have to be profitable and the above situation does not seem financially sustainable at the moment. However, maybe that's going to change.

Carbon Farming

Along with Dieter Helm's views on Natural capital that you can read about later in this issue. The concept of carbon farming was mentioned. Carbon currently sells for £17 a ton on the bond market. We are not totally sure where this carbon is bought from, but you can buy carbon credits to offset your carbon footprint. Elton John did just this recently to offset Prince Harry's flight by private jet. So there is a market for it. Therefore if you farm in a carbon negative way, with limited inputs and low fuel usage and therefore have a balance of carbon in terms of your own footprint you can sell this (in theory). So if you can be 1000 tons of carbon in credit you can sell this for £17k a year. Sounds like a nice way for a farm to supplement its income and will be interesting to see how this market evolves. We would think that given this potential income stream, Direct Driller's readers could create a very large pool of carbon to sell together to the market. Of course, you need to know your own carbon footprint and you would need to do the maths on whether reducing inputs (and therefore yield) would give you a saleable carbon footprint that outweighs the loss of yield it would cause. The future in this respect is going to be interesting.

Professor Allen

We will let you know when the Sustainable Food Trust hold their next event as it is well worth a day of your time to understand more about our industry and how it is going to change over the next 30 years to go from a net emitter of green house gases to becoming a net sequestrator of green house gases. This is a massive opportunity for farming.

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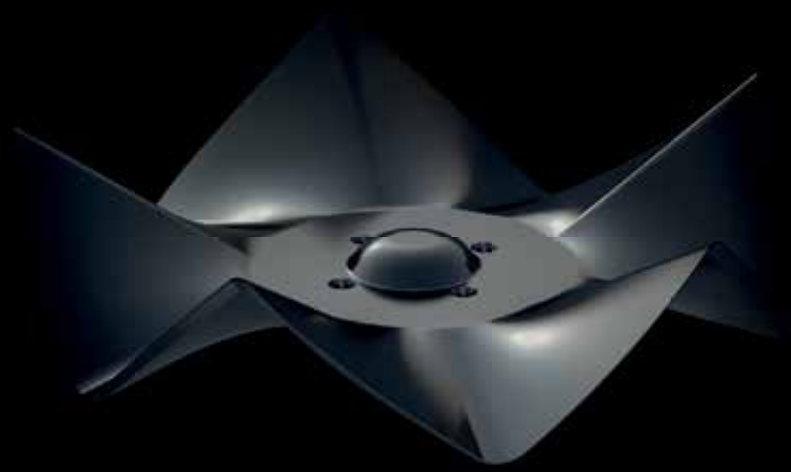

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SOIL FARMER OF THE YEAR COMPETITION **2019**

Written by Becky Willson, Farm Carbon Cutting Toolkit

The Soil Farmer of the Year competition aims to find, promote and champion farmers who are passionate about safeguarding their soils and building resilient businesses. The competition is now in its fourth year and attracts amazing farmers who are running a range of different enterprises and management systems, but are all connected by a focus on soil management and a drive to make the system more sustainable.

One of the highlights of the competition is the opportunity to dig a little deeper into the finalist's soil management strategies at farm walks which take place in early July on the top three farms. These events are always brilliant, not just because of the interesting things that are taking place on the farm, but also because of the honesty and openness of the farmers to answer questions and explain their management and how their system has evolved.

The winners were announced in early June and we were incredibly lucky this year to be offered a space on the main stage at Groundswell to present the awards and allow our top three farmers to share their experiences with the delegates attending the show. This was a great opportunity for our winners to meet each other and discuss ideas, and the session was chaired by Joel Williams. All of the farmers gave a short presentation on their management system and some of the challenges that they had faced along the way.

Our winner this year was Julian Gold, an arable farmer from Oxfordshire, and on a sunny evening (when combining was in the forefront of people's minds), we all gathered to hear more about Julian's award winning management. Julian runs a predominantly arable farm, with a flock of sheep that graze cover crops and areas of permanent pasture. The fundamental management principle on this farm is managing carbon; by growing high yielding crops there is a lot of carbon pumped back into the soil and by reducing tillage, once that carbon is in the soil it doesn't escape. Julian explained his key philosophy on the farm, "I am not a farmer, I am a facilitator of photosynthesis and everything flows from that."

The key theme of the walk was focussed on the practicalities of residue management, specifically the management of barley straw and whether all of the issues that Julian has experienced was worth it. He is managing his system by returning all crop residues to the soil which is following his carbon principles, however practically it is causing some issues with crop establishment. By growing big photosynthetic crops, they are pumping carbon through the plant roots and into the soil which is great, and then by leaving the straw on the surface, it is acting as a soil biology primer. However dealing with the straw can present a challenge. The high carbon to nitrogen ratio of the straw will ensure that the biology have to work to breakdown the material, and Julian is convinced that the biology in his soil is now used to assimilating the straw. The nitrogen strategy on the farm currently is to apply it little and often however over the next few years, cutting back on nitrogen is a key management aim.

The farm occupies 800 ha and is mostly owner occupied. Julian runs a 6 year rotation, which is rape, wheat, spring barley, spring or winter beans, wheat and winter barley. There is flexibility between whether he grows winter or spring beans, and there is a guaranteed cover crop before spring barley after winter wheat, and if spring beans are grown after the spring barley. The farm runs a controlled traffic system which Julian started in 2012 which is based on 10m, which means that 20% of the field is ever driven on and 80% is not touched. No deep tillage is done and the carbon and root systems are protected. Julian was keen to recommend that everyone could try using a controlled traffic system at harvest, to minimise the potential damage by grain trailers and the combine.

Crops and residue management

The first field that we visited was a field of oil seed rape. This field had previously grown winter barley, and had a lot of chopped straw on the surface. The crop had established fine apart from an area where combining had carried on too long into the evening and straw chop quality was bad. A big issue with high volumes of straw residues is maintaining soil to seed contact as the soil surface layer is very fluffy and hard to consolidate. Another issue the farm struggles with is the battlement effect left behind when direct drilling with the tine drill. The undisturbed areas of soil support the rolls and make it difficult to consolidate the seed trench.

After the rape we went to look at a field of barley, which had had a cover crop before which had been grazed by sheep. The cover crop had a high biomass, as (similar to the cereals) Julian is keen to maximise photosynthesis even in the cover crop and provide a variety of rooting depths and species. Julian also explained how he creates the right mindset for soil friendly farming by imagining a fictional scenario "that way back in time as life was evolving on the planet, an intelligent soil ecosystem evolved first and needed a food source so created plants to grow and harvest sunshine and carbon dioxide to feed the soil community. The farmers function is to tend the food producing slaves and in return is allowed to take the seeds as payment!" Julian explained that "when you have this focus on farming for the soil it is a win-win scenario because the grain yields become better and more robust over time."

Julian has been growing cover crops since 2014, starting off with vetches and black oats, and now including high biomass mixes. They are mob stocked with 50% of the cover trampled and the field is never turned brown with bare soil. The field is then sprayed off and drilled. Until the point that it is sprayed off, something is growing, providing soil cover. This year, on this field, however grazing with the sheep was challenging, as they couldn't take advantage of the good weather early in the season to drill as the sheep were still grazing it, but Julian is still keen on the value of the sheep in the rotation, explaining "everything is an integrated holistic system, and you have to take some things on the chin to achieve the end

goal."

The walk also took in a different field of oilseed rape which had been drilled with the Moore disc drill, and looked at some pollinator strips that are planted in the middle of a field of barley as part of a research project looking at management systems for sustainability. While the main benefits of the strips is crop protection and improvement of biodiversity, it will be interesting to see whether there is a soil health benefit from them being planted.

Future plans

Julian is trialling a few acres where he is undersowing clover and medic. Now that the soil organic matter levels have built up, the next plan is to start to reduce Nitrogen levels and improve nitrogen use efficiency which will reduce nitrous oxide emissions, with the ultimate aim of running a farming system which has lower inputs and positive economic and environmental benefits.

Cheshire Dairy man is runner-up

Our second place winner was Will Blackburn who farms in Cheshire. He runs a dairy enterprise with 300 milking cows and grows a range of arable crops. His light sandy soils make holding onto nutrients and water a challenge, and this has seen him adapt his management system to focus on building organic matter within the soil.

Will started drilling with a Moore drill 10 years ago for drilling grass into wheat stubbles. The farm was still growing potatoes, which prevented a complete switch over. He explains "when we were growing potatoes, it took 3 or 4 years of grass to get the soil back in good health. When potatoes were making good money that was ok, however when they weren't making good returns, it didn't make sense. You realise when you stop growing them how much they are damaging the system." Since the move away from potatoes the focus is to develop a fantastic surface to the soil which will build a humus layer (and resilience).

Will is also grateful to the cows and grass being on the farm, which has made the switch that much easier as the soil biology was already good. The soil on the farm is changing, the stones are disappearing which he puts down to good levels of worm activity, the worms are constantly active and digesting the soil, taking soil up which pushes the stones further down the soil profile. As well as the light land that is surrounding the home farm, Will has some heavier land away which is being managed in a similar way. Traditionally after 3 years of ploughing these fields would need a lot of working back down to get a good seed bed for the next crop, however with this system, that isn't the case.

The first field that we visited was a grass field. Here Will explained more about the soils on his farm and how he manages them. The soils on this farm are good at leaching potash, so the aim is to get carbon into the soil and keep in there to make best use of it (and not lose it). Although this is a simple message, by following it and looking after the soils by not cultivating it is possible to achieve. The light sandy soils are great for turning cows out early, but in periods of dry weather they can suffer. The system

being developed here is predominantly looking to provide the resilience in drought conditions. The grass seed in this field was disc drilled in. Will explains, "By not disturbing the soil, when the conditions go dry you maintain the soil capillaries and old root channels which allow water to percolate, and the soil can perform its natural function."

Although grass is fantastic for soil health and soil biology, Will is also keen on having a break from grass within the rotation and is seeing the benefits. It also provides an opportunity to get on top of the grass pests including leatherjackets. Grass management and efficient forage utilisation is something that Will has recently started to focus on in greater depth. Will maintains the grass in its vegetative state though grazing management. As well as providing high quality forage to the cows, he sees a soil benefit from this too as the grass is continuing to produce new roots until the seed head appears. By managing grass to keep it producing roots the soil biology is being fed and carbon is being cycled efficiently.

Lighter Machinery and Gradual Change

Will measures his grass once a week to calculate his available forage and complete a grass budget. Measuring grass covers and calculating his feed wedge has allowed him to improve his pasture utilisation and plan ahead. He explains, "the efficient use of grass means that we can use less concentrates, producing milk more efficiently." The leys on the farm are predominantly high sugar grasses and clover. Will has had fantastic results from high sugar grasses and finds them great for milk production as well as being carbon efficient.

Will isn't a fan of intervening mechanically with machinery including the use of subsoiling or slitting as the

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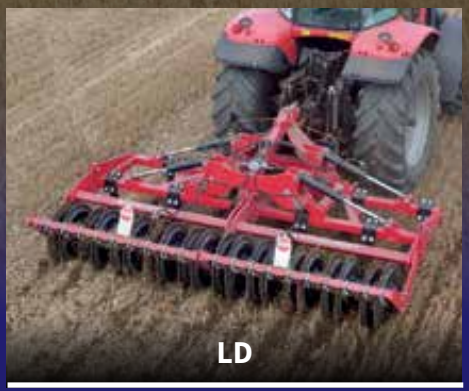

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aim is not to interfere unless there is a massive issue. He explains, "if we can get roots, pore spaces and channels built up then the soil is more resistant to compaction, the soil starts to bounce and become resilient, however if you are tilling it, instead of bouncing back it goes down and stays down."

Will started off with a Moore disc drill but struggled on the heavy land as there were issues with drying out and the slots opening up which led to poor establishment. He moved over to a 750a and finds that it does what it needs to do and fits the system, although he admits its quite extravagant for the number of hours that it does! However Will is completely honest that not everything has worked

"if you look at the past with everything I've done conventionally versus no till, I've had failures with both but my failures in no till have cost me less. There can always be crop establishment risks whichever system you are running. Through not cultivating though I've really seen the impact, as on fields where I've previously ploughed and the fields have been uneven and full of clods, I now have a flat field."

Future aspiration for Will include honing the grassland management system, and building organic matter levels even more. He is also interested in reducing fertiliser levels.

Lincs Farm gains Soil Farmer Award

Our final walk was with Paul Davey who farms 1100 acres in Lincolnshire. Spanning a mix of soil types including clay, chalk, medium and wold series, he grows a range of arable crops, runs a sheep flock of 200 ewes and a regional distribution business for local produce. The business has evolved to its current form through a range of different practices and growing of different crops including potatoes, vining peas, and onions. The broad rotation on the farm is 2 years of ryegrass, a legume break, wheat, an oilseed break, wheat, spring barley and then back to ryegrass. This longer rotation and cropping blocks of land has allowed him to reduce overheads. The inclusion of livestock on this predominantly arable farm has been a key part of the strategy to be more resilient, sustainable and regenerative.

The evening started with a presentation which explained the history of the farm and how they had decided to change the way they did things. He explains "What we've done hasn't been a licence to print money, it's been about trying to manage a ship in choppy seas. A key challenge has always been getting the equipment around the geography of the farm and get a margin at the end. So, we've always been on the lookout for changes to the system, but that involves finding a starting point."

Within the logistical confines of the farmed area, Paul's strategy is moving to lighter machinery and making gradual changes in terms of managing tillage and compaction. Having recently dug some soil pits and looked at rooting depths and soil structure, he has concluded that roots from the crop are capable of taking out compaction when you are travelling with lighter machinery. He has seen the impact of working with heavier machinery, as he remarks "two or three years later, you can see a wave across the field where the kit had been travelling." He is comfortable with the use of extremely shallow cultivation to sort out any compaction that the roots can't deal with. He is also keen on ensuring that tyre pressures are right for field conditions wherever possible (given the balance between travelling in the fields and between then on the roads).

Attentions were then drawn to the stripper header which is being used for the 6th season here on the farm. It is used for combining the ryegrass and allows the crop to be combined at the same rate as cereals, which allows for flexibility in tight weather windows, and it's also perfect for linseed. Paul is experimenting with it to drill directly into standing stubble, maximising the soil armour. Paul comments "a key question for the future is how we manage crop

residues and how to keep the carbon to nitrogen ratio high enough to deal with a large amount of residues."

Grasses are the building blocks of the system that is run at Girsby Grange, and Paul is a passionate advocate of the benefits that grass brings. "Regardless of how you manage it, whether it is through growing grass for seed or grazed share farming agreements, it provides a massive benefit and up to 40 tonnes of organic matter per hectare over a three-year period. It's an extremely valuable crop, with a big mass of rooting which brings life back to the soil, nothing works like roots do."

After visiting a field of grass grown for seed, the walk finished up in a field of beans, where a soil pit was dug. The soil looked very well structured with good levels of soil aggregation. The previous week, this field had experienced 125ml of rain in 48 hours, but there was no evidence of any ill effects. This field will be zero tilled into wheat once the beans are harvested.

Paul is farming to improve the long term sustainability of his farm and a key part of that is farming for the rotation. He comments "it's about taking a long term view, being flexible and brave and taking the risk. When you scratch the surface you can see the costs of our actions. Most farming practices seem to be fixing a problem by creating a different one, with this system of farming, there seems to be genuine solutions."

Three fantastic walks with three inspirational farmers that provided lots of ideas and knowledge for all who attended.

If you are interested in applying for the competition this year or nominating someone that you feel deserves to be recognised, the competition will open on World Soils Day (December 5th) and more information can be found at www.farmcarbontoolkit.org.uk.

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Managing 300ha in South Staffordshire on sandy/clay loam soils, I first became aware of how important soil was in the mid-90s. Presently, nothing in my mind is more important than our soil. It provides the population with food, air and clean water through plants and trees, that keep us nourished and sustained in life. Additionally, I noticed how crop yields had plateaued, whilst I was having to apply more nitrogen in order to get the same results. I knew something had to change; it is believed that 1kg of unused nitrogen can destroy 100kg of carbon in the soil. I knew that I had to replace the carbon that had been depleted over the last 60 years; the question was, how I was going to do it.

It began for me in 2010 in using a strip till drill, which worked really well. I never had a yield drop, only an increase; this was also a fantastic way for me to start and get my head around moving much less soil, which brought the change to a no-till drill.

In 2015 in the form of a 750a, never had I seen a drill position seed so accurately before, but the drill did lack some features which I felt it needed. I wanted to be able to place fertiliser / biology down next to the seed; this is vital to get the best out of the biology brew, which is aimed to fix nitrogen and release phosphate and also fight off fungal infection, of which I have had some fantastic results.

The options needed were another hopper for companion cropping or applying slug pellets. This was achieved by blowing the seed into the venturi. Also I wanted to be able to apply mycorrhizal fungi when sowing grass on a short term ley, (which I make into haylage for horse feed). This is a fantastic way to build fungi as the crop is down for 4-5 years and in addition it also controls grass weeds. Furthermore, I also wanted to be able to broadcast at the rear of the drill to give me even more options, such as applying Avadex or Boron granules.

The next change to consider was rotation, as now I not only grow what is profitable, but also what is best for the individual field. Since I am now farming for regeneration of soil for future generations, I feel that this is an important issue; to leave the soil in a regenerative cycle moving forward for generations to come and repair some of the damage done in the past. I still have OSR in the rotation, but on a 6-year rotation, as I feel this is still a good break crop for the farm that is profitable.

I haven't used insecticides for 5 years and don't really have a problem with csfb (I hope I have not jinxed myself by saying that). With dd crops I always get a higher brix reading (I recommend everybody to purchase a refractometer) which means that the crops grown just don't show up on aphids' radar but I am still out checking on a regular basis. I feel once you get off the insecticide hamster wheel then all the predators come back and begin to do the job for which they were intended. Nature to me has all the answers; we may not have discovered them yet, but they are there. I may also grow W Wheat, W/S barley W/S oats, W/S Beans, Lupins and Grass.

Autumn herbicides are no longer used, as all crops are drilled on the green into cover, this also reduces/eliminates the need for slug pellets. The rotation is also split w/s cropping in order to allow growing a cover crop through the mid-tier scheme which allows me to be able to put carbon back into the soil through photosynthesis and also keep biology alive within the soil whilst also getting paid for the privilege.

Cover crops are then destroyed either by grazing or rolling on a frost, but it does need to be – 4o C when

rolling in my experience in order to get the shatter effect, which breaks the crop down into manageable pieces enabling worms to incorporate it into the soil. I am always trying to cut down on the need for glyphosate and this is one way that has definitely worked. The other approach for the future will be some trials with a crimper roller, as I firmly believe and have found, that as long as you keep the soil covered then weeds have no need to germinate hence, we have not the need for herbicides. People often said to me that as I disturb less soil, I would reduce my weed bank in time. I now believe this is not relevant; I want and need my seed bank as an indicator of what is actually happening within the soil, so if I do not keep the soil covered, the soil will take care of itself and produce plants to protect it. I no longer have problems with brome grass these days (hope I haven't jinxed myself by exclaiming that!) as my soil health has got a lot better I may get the odd plant which is just a reminder of what I am trying to achieve to keep me on track and not lose my focus on where I am heading.

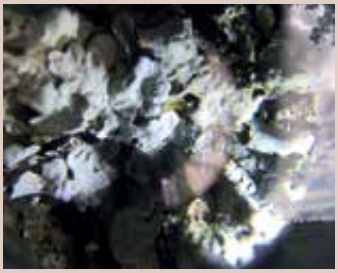
Cutting down on fungicides has also been one of my aims as some can be damaging to fungi within the soil and take yield if they are not needed. I have managed to grow wheat and barley without fungicides with a healthy soil and have brewed up microbes to eat fungi attacks such as fusarium. I like to rely on biology first and keep fungicides as a backup when needed. We still have such a lot to learn from biology and I still feel nature has all the answers especially once we stop relying on synthetic fertilisers, but this system does have its challenges and as I always say when I am giving a talk, one of the most important parts of this system is becoming a farmer again and actually getting out into crops/soil and understanding what is really going on. Regenerative farming has reignited my passion for agriculture, as I totally believe we are what we eat and a healthy soil provides healthy food which results in healthy people.

This season I haven't applied any T0 fungicides to my wheat. Instead I have corrected any nutritional imbalances using Aviva fertiliser products. I am able to have a mixture of nutrients made up to suit my plant requirements. This is achieved from tissue analysis, brix, potassium and phosphorus readings.

The nutrient mix varies from year to year, since weather conditions always vary, in turn causing the biology to behave differently within the soil. When the biology is not able to give the plant what it needs, I intervene. By growing healthy plants from healthy soils I have found I can farm without fungicides, but always like to have them as a backup. I did use some, (a fungicide at T1) on some of my wheat, because at the time of making the decision the weather looked unsettled (good old weather forecast) but the untreated did well and with the weather settled, I used brewed biology and orange oil as a T2.

Notice from the photos the untreated areas did have severe rust which was a nice way to prove that the treatment had done the job, also giving me even more confidence moving forward, which concluded with a biological T3. I feel going forward as farmers, fungicides' efficacy will continue to reduce and biology will take the lead as it is far more environmentally friendly, which is what our customers will demand going forward but also what I want as a land manager. Soil is our past, present and our future, so as a world community, we must take good care of it if we want to thrive as a species. I wish every person on the planet were compelled to read "Dirt the Erosion of Civilisations", by David Montgomery. Soil degeneration has happened before and in my mind, it is the fool that doesn't learn from past mistakes.

Recently I have also started to monitor air quality on the farm by looking at which species of lichens are growing around the farm and using them as bio-indicators. As the pictures show, I have moved away from the nitrogen loving species to the more intermediate types (flavoparmelia and parmelia). Once again I am reassured that nature and I are regenerating farming in the right direction.



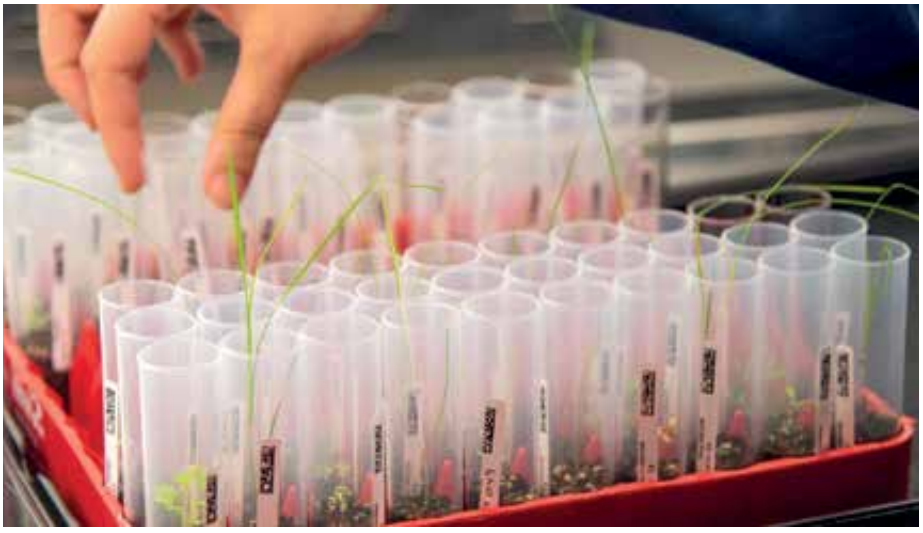
HERBICIDE RESISTANCE TARGETED BY NEW OXFORD TECH FIRM **MOA TECHNOLOGY**

Weed resistance is becoming a major issue for crop production. The International Survey of Herbicide Resistant Weeds collates information from researchers worldwide on the spread of weed resistance. Today resistance is present in more than 250 weed species infesting nearly 100 crops and affecting 23 of the 26 known herbicide modes of action. Looking at the highest selling herbicides globally many have resistance issues. Glyphosate is the most prominent as it is such an important product and used so widely, and often, but resistance issues affect most herbicides to some degree – which is why discovery of new modes of action is so critical *Written by Direct Driller editor, Mike Donovan.*

Frequent application of a herbicide or herbicides with the same mode of action exerts selection pressure on weed populations. If surviving weeds are fit enough to reproduce and establish a population then resistance arises. The root of the problem is the difficulty in finding new herbicide modes of action.

Herbicides accounted for more than 40% of the global market for crop and non-crop pesticides worth $64 billion in 2018 Selective herbicides, such as 2,4-D and MCPA invented in the 1940s started the move away from various forms of hand and mechanical weeding, yet still continue in many developing countries. It is increasingly difficult to find enough labour at the right time and at affordable wages to manually control weeds. Problems are exacerbated by the movement of people away from the countryside to work in cities. Often it falls to women and children to do the back-breaking work of hoeing, slashing or pulling weeds. Having cleared a field, the job has to be repeated in just a short space of time as new flushes of weeds emerge. In many developing countries, herbicides free women, in particular, to feed, educate and care for their children. Hand weeding one hectare of maize can take 250 person-hours of work, while it can take just two hours for one person to apply herbicide from a knapsack sprayer to the same crop area. With weed control taking a fraction of the time needed previously, herbicides allow smallholders to supplement their income from additional employment.

From the 1960s, non-selective herbicides (paraquat from the 1960s and glyphosate from the 1970s), enabled the adoption of no-till (direct drilling; zero tillage) and other reduced cultivation systems for crop production to be established. If weeds are removed by herbicides before planting, then there is no need to plough to bury weeds. No-till systems can increase yields when crops are appropriately established and have many environmental and economic benefits.



The benefits of no-till systems, include 1. reduced labour; 2. reduction in soil erosion; 3. water conservation; 4. reduced fuel and energy used; 5. reduced greenhouse gas emissions; 6. greater biodiversity. Combating climate change is especially topical. Ploughing aerates the soil excessively, causing the oxidation of organic matter. Not only does this destroy good soil structure (built-up after rotational pasture, for example), but it releases large amounts of carbon dioxide. Spraying a herbicide to burn down weeds before planting in a no-till system can reduce emissions of CO2 by more than 80%.

Fundamental research at Oxford University

Research scientists have developed new methods of developing the next generation of herbicides. The research is a new spin-off from the university in the shape of MoA Technology, launched to confront the global herbicide resistance issue. The company has secured a £6.3 million Series A funding round. MoA Technology will use the funding to develop its unique crop protection discovery platforms.

The research is out of Oxford University's Plant Sciences Department from ground-breaking research by co-founders Professor Liam Dolan FRS, and Dr Clement Champion. The company has developed its own discovery platform and is focused on the next generation of sustainable herbicides which have new modes of action from both natural and synthetic chemistry. MoA Technology has

developed three proprietary platforms: MoA Galaxy, MoA Target and MoA Select. Each platform is powerful in its own right, but when used in combination, offer the opportunity to revolutionise the herbicide discovery process and critically identify new, effective and environmentally-sustainable herbicides. The platforms are based upon a unique combination of genetics, trait analysis and data analytics.

The funding round into MoA was co-led by Oxford Sciences Innovation, the world's largest university venture fund, and Parkwalk Advisors, the largest EIS growth fund manager focused on university spinouts. Oxford University Innovation, the University's innovation arm, assisted in spinning the company out in 2018.

Liam Dolan, Sherardian Professor of Botany at the Department of Plant Sciences, Oxford University, said: "In recent years industry has moved from high throughput screening to lower throughput in-vivo plant screening but neither method has been successful in uncovering marketable herbicides that have new modes of action. We have redesigned the discovery process in its entirety. Not only do we focus on identifying new potential modes of action at the outset, our platform combines in-vivo screening with a high throughput capability that we believe is a first in this industry. Early results are extremely promising".

Hadyn Parry, Chairman at MoA Technology, added: "Weeds are now a greater threat to crop yields than at any time in recent decades. New solutions are urgently needed. Raising £6m at this stage in the company's development is a real testament to the strength of the company's prospects."

Why is herbicide discovery difficult?

MoA suggests four reasons why so few new herbicides have been developed in recent years. The first is that the creation of glyshosate tolerant crops has meant a lack of incentive to produce genuine weed killers. Second, as agri-chem companies like Bayer and Monsanto merge, so there are fewer companies searching for new formulations. Third, the dramatic escalation of R&D costs has reduced company research as the returns are difficult to assess. Lastly, regulatory hurdles have become ever more stringent.

In addition, in the past, leads were selected from whole-plant screens on the basis of their symptomology by expert herbicide biologists. The move to HTS in vitro screens effectively pre-screened the input into whole plant tests, lessening the probability of observing novel symptomology.

Serendipity has also played a role. Chance observations from Nature have sometimes provided the inspiration or starting points for very successful crop protection active ingredients. This may prove fruitful in future utilising new technologies to identify novel modes of action with potentially attractive commercial profiles of activity, physico-chemical, toxicological and eco-toxicological properties; and to identify the essential parts of often highly complex molecules.

The MoA system

MoA Technology has three innovative herbicide discovery platforms based on an in vivo plant model designed to pinpoint and elucidate new modes of action, essential to developing safe

DIRECT DRILLER editor Mike Donovan asks Hadyn Parry, CEO at MoA

1. Will these chemicals be paired with hybrid varieties of crop, in the same way as we have Roundup Ready crops?

HP: It may become an option but that is not our focus and we have no work in that area. Our focus is to find new modes of action that give farmers a new generation of herbicides

2. Herbicides which terminate cover crops are of great importance to an increasing number of farmers taking on the challenge of improving soil condition. Do you envisage developing glyphosate substitutes which will do the job?

HP: Potentially yes. Firstly we are looking for new modes of action as referenced above. It is very much our goal to develop both non selective and selective herbicides that are cost efficient, safe and environmentally benign. But whilst we are excited by the output from Galaxy Target and Select we are not at a point where we can declare we have a new product candidate in the field phase. Currently we are in lab and Glasshouse.

3. Some farmers tell me that the age of using almost no pesticides is coming due to legislation which of course many consider to be draconian and unfair. Is this something MoA Technology would refute? Do you see a new era and generation of products which can get through the product testing and safety issues okay?

HP: I think herbicides have been a major factor in agricultural production and are indispensable in modern agriculture. Regulatory processes should be science and evidence based. While once can fear that perception issues will override science I think overall that evidence wins out so I am a believer in a strong regulatory system that is fit for purpose and gives the consumer confidence in the products we use.

It is extraordinary in some ways that, if you look at the herbicides that are in the global top ten highest sellers, there are products that were first launched in the 1940's, 50's and 60's! So while some see product withdrawal (due to more stringent regulation) to be draconian the other side of that is a lack of innovation.

Yes I do think we will see a new generation of products coming through – as noted above there has been a real lack of innovation in this space and we aim to play our part in addressing that.

and effective active ingredients to control weeds.

The platforms need only sub-microgram test samples, ideal for screening chemical libraries not previously screened by conventional methods requiring high quantities, or those from which traditional high-throughput screening failed to detect hits. Each molecule tested generates a data-rich 'fingerprint'. Artificial intelligence systems pick out hits with novel modes of action.

Used together in sequence, MoA platforms can quickly and cost-effectively find streams of herbicidally active chemicals structurally unrelated to the original hits and having the newly defined mode of action.

Bringing a new herbicide to market

This can take over 10 years. There are many stages involved which can be condensed into three main phases:

- Lab phase – discover new compounds and modes of action
- Greenhouse phase – test on weeds, test within crops
- Field phase – testing outdoors in any different environments
- The regulatory side of safety, environmental profile, application rates and options, operator safety are all ongoing throughout out the process
- Safety and environmental factors have been at the forefront of regulatory improvements over the years. Any product coming to market must go through the appropriate regulatory approval process in each country.

MoA TARGET™ can identify the precise target protein, associated with a new mode of action. The platform uses an in vivo plant-based genomic patented process.

Knowledge of the target protein is important for two reasons: First, if the protein is found only in plants this predicts that the mode of action should be safe to humans and the environment. Second, this knowledge also assists in the discovery of more

effective analogues for this mode of action.

Overall, the information from MoA TARGET™guides researchers to novel, safer, more sustainable and effective herbicide active ingredients.

MoA GALAXY™ allows the simultaneous discovery of new herbicidally active chemicals and a prediction of the novelty of their modes of action. Using ground-breaking research into plant biology, MoA Technology developed MoA GALAXY™, a unique, proprietary, in vivo HTS platform for finding new herbicides. The wide range of herbicidal activity data produced is digitised and exploited by artificial intelligence. This provides high quality predictive information on both herbicidal activity and mode of action at a scale, speed and cost previously unavailable.

Comparing symptomology 'fingerprints' of known herbicides and test molecules, MoA GALAXY™ rapidly identifies known modes of action, and reveals new ones. Data visualisation creates a 'star map' showing clusters of known modes of action with 'lone stars' as outliers indicating new ones. Hence, MoA GALAXY™ ! Unlike in vitro screens, MoA GALAXY™ in vivo screens whether a molecule crosses the cell membrane to have its herbicidal effect. This makes for high quality hits and provides a strong indication of their whole-plant activity.

Features of Galaxy

- High content imaging coupled with artificial intelligence leading to novel herbicidal starting points with unprecedented level of insights at the earliest stage of discovery
- Fast turnaround: with the ability to test tens of thousands of samples per month for both herbicidal activity and corresponding mode of action
- Very small amounts of test chemical required, which allows the use of dilute liquid solutions

MoA SELECT™ can discover other herbicidal active molecules utilising knowledge from MoA Galaxy™ and MoA Target™. Knowing the original lead's mode of action and its associated target protein, MoA SELECT™ points to other chemistries with the same mode of action. These may be analogues or totally unrelated. At this stage, promising leads can be progressed for glasshouse and field testing. MoA SELECT™can also provide both new and structurally unrelated, diverse starting points for further traditional lead optimisation. This allows broad patent coverage of the new area of chemistry to be quickly and efficiently established.

Headquarters: MoA Technology Ltd., Innovation Building, Roosevelt Drive, Oxford, OX3 7FZ, UK

Novag

Next Generation Farming

Cross out the past
and let the worms work for you

Some direct drills from around the world may have been a good idea when they were invented. But times have changed – so keep up with the future.
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COVER CROP **CROSSROADS**

By Phil Jarvis, head of farming at the GWCT Allerton Project, as based on information found on Agricology (www.agricology.co.uk).

Life is all about choices, some turn out well and others can fire a whole load of challenges your way. The same is true as we develop our agricultural businesses from dipping a toe in the water to a new enterprise, or financially committing time, money and energy to turn opportunity into something more tangible.

Over the last 5 or so years, many growers have either read about, dabbled with, or fully integrated cover crops into their arable and livestock businesses. We're all aware of the soil health benefits of organic matter, storing nutrients, reducing erosion and helping structuring soil. However, cover crops do present challenges which can trip up or turn growers away from such an agroecological approach.

I'm going to concentrate on my thought processes at Loddington...

Firstly, cover crops are part of my drive to improve the resilience of the soils during wet and dry periods of weather. They are part of a system in which I am trying to disturb the soil as little as possible, keep as much of my soil as possible armoured against the wind, rain and sun, and it's based on an ever-expanding rotation. With such a philosophy, on my heavy Leicestershire soils, drainage is key. If you are going to pursue reduced cultivations, you have to make sure your land drains well. This is certainly an area I need to improve upon.

Soil needs its mineral and water components, but air allows the soil to breathe and its fauna and flora to flourish. There are many other factors which influence this holistic picture and they all meet together like the 'hustle and bustle' of a busy crossroad. So from one direction comes my rotation and cultivation strategy, from another route come my fertiliser and plant protection options. The course I eventually end up having to travel upon is one that will have to be financially viable; no matter how attractive the ideology sounds.

My options...

So at this congested junction sits cover, catch, and companion cropping. Much of the other paths are not new to me, but continuous cover is gathering momentum and maximising the benefits, whilst minimising the negatives is paramount.

I have to choose crops that will not encourage too many pest and diseases (encouraging none is virtually impossible!). I want to establish them with as little compaction as possible so I choose to put them in with a seeder unit attached to my low disturbance sub-soiler and not roll them afterwards, relying on the subsoiler's packer. Oats, phacelia with only a smattering of oil radish works well. Vetches can be expensive and air seeder fans are often not robust enough to blow them through the air seeder distribution head.

I can grow crops which are not frost-tolerant (buckwheat and mustard) that might negate my need to spray them off, but my un-friendly blackgrass community continues to vie for my attention and the sprayer beckons. Topping, ploughing and grazing are all alternatives. Some of these destruction methods require lots of diesel and horsepower and can undo much of the structuring work I'm aiming for. Sheep would be my four-legged animal of choice, if glyphosate is not part of your system.

My Sumo seeder unit and subsoiler

Sheep can be useful converters of biomass

My chllenges...

Establishing the following crop raises another conundrum... Many growers like to spray crops off early in the year, allowing the biomass to collapse which ultimately leads to better drilling conditions. I struggle to consistently find a weather window in early January but they are about! Doing this keeps the soil cover but I think it reduces any allelopathy effect on following crops.

The drilling operation is performed by my 4m Dale Eco-drill and, depending on conditions, I usually roll. I always start the first day of spring drilling mid-morning

Phil Jarvis has worked at the Allerton Project for 25 years, arriving as a working farm manager in 1992. He is currently Head of Farming at the project and also has roles on the NFU Environment Forum and National Crops Board. His interest in agriculture stemmed from working as harvest help on a farm in Norfolk whilst still at school. Since then he has been fruit picking in New Zealand, spent time on a maize and tobacco farm in Zimbabwe and a mixed contracting business in West Sussex. He has appeared in the Guinness book of records for having a voracious appetite for strawberries! And made the Farmers Weekly final in the 'Farming Champion' category. He writes: "A sustainable rural landscape that embraces food production, environmental rejuvenation and supports those that work in the countryside should be important to all of us. We're heading into a period where our climate and politics are going to become increasingly volatile."

Drilling into cover crops with Dale Eco-drill

when the dew has abated, otherwise it can be a frustrating few hours getting the drill and the operator to deal with fresh, wet, cover crops. It always goes better on day two - whatever time I venture out of the farmhouse.

My biggest challenges are blackgrass and slugs, so growing cover crops before spring crops is good, and reducing the brassica content helps fight the pesky molluscs. I'm told carabid beetles have an appetite for field slugs, so I'm investigating beetle habitat next.

So there are a lot of choices to be made at this crossroads, my only bit of advice is take one of the pathways and don't let indecision get you down. If it goes wrong, learn from it and move on, if it goes right.... get down the pub and tell everyone about it!

Visit www.agricology.co.uk to view other blogs, videos, podcasts, research projects and resources on growing and managing cover crops. Agricology is an independent collaboration of over 20 of the UKs leading farming organisations and provides a platform for farmers and researchers to share knowledge and experience on agroecological farming practices; online and in the field.

Subscribe to the newsletter or follow on social media @agricology to share your questions and experiences with the Agricology community.

AGRICOLOGY
SUSTAINABLE PRACTICAL FARMING

FARM FACTS

FARM SIZE: 330 hectares
MANPOWER: 3 FT
FARM TYPE: Mixed
TENURE: Owner occupied
RAINFALL: 660mm
ALTITUDE: 150 - 197m
SOIL: Denchworth & Hanslope clay
APPROACH: Integrated Farming
KEY FARMING PRACTICES:

No Till
Soil monitoring
Minimum Tillage
Mixed farming
Agroforestry
Cover crops
Direct drilling
Diversified rotation
Habitat creation
Leys

The Farm

The Allerton project has been researching farm ecosystems and the effects of different farming methods on wildlife and the environment for over 20 years. As a commercial operation the farm produces a range of crops including winter wheat, oilseed rape, winter oats, spring oats and spring beans. The arable activities of the farm have been managed in collaboration with a neighbouring farm since 2001 when we adopted minimum tillage. 30 hectares of permanent pasture is grazed by a flock of 280 mule ewes, a small flock of Leicester Longwools and, through a grazing agreement with a neighbouring farm, a South Devon suckler herd. There are 20 hectares of woodland, as well as numerous streams and ponds, within the farm boundaries.

REMOTE WEATHER DATA? MAKE USE OF A 'HIDDEN' NETWORK...

We're all becoming more and more familiar with the 'internet of things' – the burgeoning range of sensor-laden devices that collect, exchange and analyse information through the internet.

Domestically, IoT (as it's commonly referred to) is big business, with well-known brands such as Alexa, Nest, Ring, Hive and even children's toys taking advantage of IoT to provide services and features that only a few years ago would have bordered on science fiction.

Agriculture, despite or perhaps because of its recognition as one of the least-digitised industries, hasn't escaped the IoT influence. Everyone from start-ups to established multinationals has scrambled to take advantage of the new-found availability of low-cost sensors (to collect data), advances in artificial intelligence (to analyse the data) and of course the ubiquitous algorithm. Through IoT, agritech is becoming big business in its own right.

But of course, IoT devices demand constant connectivity. In a domestic or urban setting, that's rarely a problem. Figures from the UK's Office for National Statistics reveal that 90% of British homes enjoy an internet connection, while Ofcom reports that 4G coverage in urban areas is around 97%.

It's one crucial aspect that is often overlooked in making the transition to agriculture. "Too often there's the assumption that the countryside – the farmer's place of work – has access to the same quality mobile phone signal as towns and cities," says Martin Ducroquet, the co-founder of Sencrop, a provider of smart, affordable on-farm weather stations, which transmit super-localised, from-the-field weather data to the cloud every 15 minutes.

"Anyone who works in the field on a regular basis will know that's not the case," he laughs. "The official line from Ofcom is that less than two-thirds of rural areas have access to a 4G signal, while even fixed broadband often remains dismally slow in rural England. Data transmission is awkward and unreliable.

"What's more, connecting with a mobile network requires some kind of a subscription for a SIM card. If you can't connect your IoT devices to wi-fi, then you need individual cards and monthly subscriptions for each and every IoT device you intend to operate."

Working to perfect their innovative ag-weather station, which can record windspeed, rainfall, temperature, humidity, and leaf wetness, Martin and his co-founder, Michael Bruniaux, decided the SIM card route to connectivity was a dead-end.

"From the beginning, we made one of Sencrop's central features its ability to connect, peer-to-peer, with other stations in the vicinity. It's a collaborative approach. At Sencrop, in conjunction with our 10,000 users, we are building the largest on-farm weather network in the UK and Europe.

"With weather data, it's a case of 'the more, the merrier'. The more data points we have to analyse, the more accurate we can be in the advice that's provided to users through the app and interface.

"We wanted to pitch the units at a price point which would encourage farmers to buy more than one unit, to be able to take advantage of this ultra-localised technology. But if multiple stations meant multiple SIM cards to manage and pay for, we felt that would be a disincentive to realising the system's full potential.

"Moreover, we thought that users would – perhaps rightly – be wary of a system that was reliant on mobile phone signal, when many of those users would know from experience how patchy and unreliable a rural mobile signal can be.

"We thought there had to be a better way to provide connectivity," he says, "and that was when we set our sights on Sigfox."

Sigfox is a low-powered, long-range radio network – but few people have heard of it. Described as a 0G network, and superficially similar to a mobile phone signal, the network relies on a series of base stations. But because of its long range, it requires fewer masts. There are more than 1,000 Sigfox base stations in the UK, compared to between 30,000 and 40,000 mobile phone masts – yet Sigfox achieves nationwide coverage of 95%.

Created specifically to deal with the IoT boom, Sigfox now boasts more than 6 million connected devices – from urban streetlights to water meters. The figure's expected

to keep rising as more IoT developers opt for what looks likely to become an industry standard: trials with satellite coverage begin later this year.

The technology communicates in a part of the radio spectrum reserved for 'Industrial, Scientific and Medical' devices, using a wide-reaching signal that isn't blocked by solid objects and can even reach underground. Sigfox masts 'listen' for messages from enabled devices, without needing to establish a network – features which reduce both energy consumption and the complexity of the connected device.

"Sigfox communication is simple, energy efficient and low-cost," notes Martin, "three attributes which suited us and our development devices perfectly."

Simplicity means fewer complex parts in the device, Martin points out, reducing cost of production while allowing easy setup and configuration. "It's what allows us to turn out a professional-quality ag-weather station with 24/7 accessibility for £399."

Meanwhile, lower energy consumption causes less drain on batteries. "Ours last for more than three years," Martin points out, "despite transmitting data every 15 minutes. And the low cost of accessing the Sigfox network means we can price our service subscription, which includes customer support, at less than the cost of a yearly SIM card, including the comprehensive app that brings together real-time data, forecasting and disease alerts."

The company launched its three-strong model range in the UK earlier this year, following successful demonstrations at CropTec and LAMMA. Long-term, the company hopes the UK will be as enthusiastic about building a weather network as our European neighbours – more than 8,000 units are already in use on farms through France, Germany, Belgium and the Netherlands.

"Users commonly cite the reliability and affordability of the Sencrop units, but that's simply a knock-on effect of being able to use the Sigfox network with an affordable product that brings value," notes Martin. "A SIM-card based unit would be more expensive to buy and run, there would probably be gaps in the data feed, and users' choice of site would be more limited."

FARMER FOCUS
TOM SEWELL

Priorities... but who's to say which ones are right and which are wrong?!

Since penning my last article for the team at Direct Driller I've been thinking what fresh and interesting things to write about for my next contribution.

It seems that increasingly in recent years many aspects of farming, and life in general, have become very "black and white" as to what is right and wrong. We are told to "reduce our carbon footprint"!! Many reading this will have reduced cultivation, planted cover crops, applied manures in many different forms and chopped their straw rather than baling. The really go-ahead farmers are using stripper headers and disc drills to reduce costs and seriously increase output. Diesel use per hectare is paired to the bone and this should be commended. But what is right and wrong? By criticising someone who perhaps bales straw, cultivates or does something that we deem different to our ideal, we often miss out on really understanding the background to their decision and the practical, political, financial and "hassle-factor" reasons for their choices.

As William Cowper wrote in his poem The Task,

"Variety is the very spice of life that gives it all its flavour".

Perhaps we should all celebrate the fact that every farm, every farmer and every business involved in agriculture is different to yours, and mine. What's a priority for one is very low on another's list.

This was made very clear in a sudden and dramatic fashion to my wife and I earlier this summer. A very close friend or ours for the past 12 years contracted cancer and died on the 8th June. She was 42 years old, a single mum and leaves a 13 year old son. Life can be hard and unfair sometimes! Why is this relevant? I hear you ask!

Well this happened just before the Cereals Show and the annual round of shows, variety trials etc. Now those of you who know me well will know that I'm pretty passionate about farming and love nothing more than a good "tyre-kicking" day out! But this sudden tragic loss suddenly rearranged my priorities both on the farm, within the family and towards others I know and love.

Some of you may know that as a farming family we never work on Sundays, even during harvest! It quite often gets a raised eyebrow expression and the response "I wish I could do that but....."

There are a number of reasons for this decision (which I might go into in the future), but we also buy the biggest machinery (within budget!) to allow us to cover the ground and take any contracting opportunities that come our way within a 6 day week. It's a choice we have made and is a high priority to us. For others it's not a priority and other things will trump this. Isn't variety just great?!

I'm sitting writing this on September 1st. Harvest is all completed, Oilseed Rape all sown, rolled twice and slug pellets applied. All of our catch crops after Oilseed Rape and cover crops (after wheat before spring barley) have been sown and are emerging nicely.

As we don't have a weigh bridge I can't give you exact harvest yields so will use words rather than numbers to express our harvest results!

Winter Barley – dry, better than expected yield and lots of straw! (Which we chopped because I thought the straw price was too cheap!)

Oilseed Rape – varied from "absolutely abysmal" to "much better than expected" All cut dry and sold at levels higher than the past 2 years.

Winter Wheat – The star of the show this year with more in the shed than we expected, most was cut dry but protein lower than I'd like.

Spring Beans – The less said the better! But every year I have that "what was I thinking planting beans?" thought process. Dad always reminds me "they're good for the rotation" Thanks Dad!

So with harvest complete thoughts now turn to cleaning and maintaining machinery, hedge cutting and tree trimming and those winter projects that need completing. I can see the sense in adding a tined drill option to the armoury particularly for use in establishing cover crops into thick chopped wheat straw and for planting Winter Beans and Oilseed Rape. I'm also looking at future staffing options as the business continues to grow and will spend time off-farm on some personal development training. One thing that I've learned over the past few months is to make the most of every day and every opportunity, to be kind and help others. You never know when your time is up!

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CROP PROTECTION PRODUCTS

THE MODERN FARMERS' TOOLKIT, PART 2

Contributed by Ralph Early, Independent Food Scientist and Food Ethicist

Ralph Early discusses the historical and current use of crop protection products in this second of a two-part article (Page 61 Direct Driller Magazine Issue 6), and focuses on the use of herbicides and insecticides.

The first part of this two-part article explored something of the history and use of agricultural pesticides and focused on two important classes: herbicides and insecticides. Attention is given here to other pesticides of importance to farmers, as well as issues of significance associated with their use: principally environmental sustainability and human health.

We have seen that in the production of agricultural food materials herbicides are ubiquitous in the management and control of undesirable plant species that compete with crops and that insecticides are important to both crop and farmed animal protection. Other biotic threats of importance to agricultural food production are various fungal species which can be problematic in crop production, nematodes which threaten plants and animals, and common rodents.

In the production of food materials destined for use in primary processing and food manufacture, farmers seek to gain advantage over the variety of pests that threaten crops and animals. Failure to do so can result in product losses and reductions in yield, quality and profit as well as, in certain instances, food safety hazards. Yet though farmers must seek constantly to control the circumstances in which they produce agricultural foodstuffs through the management of pests, they must also remain cognizant of the possible negative impacts that measures may have on the environment broadly, and specifically local ecology and biodiversity, as well as the capacity to sustain food production resources for future use.

In many respects human survival has always represented a battle with nature, but as the agricultural pesticide industry developed through the 20th century and became an integral part of the mid-century Green Revolution, this notion came to emphasize and underpin modern farmers' raison d'etre, particularly in Europe and North America. However, with the benefit of hindsight we are now beginning to understand that while synthetic pesticides offer immediate benefits for farmers and consumers they also bring longer-term concerns about negative effects on ecosystems and wild biodiversity. Enlightened farmers, like environmentalists, will therefore find wisdom in the words of Schumacher1 who stated,

"Modern man does not experience himself as a part of nature but as an outside force destined to dominate and conquer it. He even talks of a battle with nature, forgetting that, if he won the battle, he would find himself on the losing side."

Consequently, as a result of growing concerns, agricultural pesticides are now squarely in the spotlight,

from environmental, legal and moral perspectives, and approaches to agricultural food production in which pesticide use is reduced and even eliminated are gaining ground: some of which will be considered here in order to complete this snap-shot of the topic.

Fungicides

Fungi are ubiquitous in most ecosystems and are generally familiar as edible macro-fungi such as meadow mushrooms (Agaricus campestris) which produce large fruiting structures. They represent a kingdom of eukaryotic organisms which includes many species beneficial to human endeavour, for instance bakers' yeast (Saccharomyces cerevisiae) used in the production of bread and Penicillium roqueforti, the mould used in the production of blue cheeses. Fungi are also represented by the numerous organisms responsible for creating the mycorrhizae essential to the production and maintenance of healthy soils and the growth of many plant species Indeed, fungi are nature's biodegraders involved in the breakdown

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and recycling of organic matter including, significantly, the decomposition of lignin, the structural polymer of vascular plants.

The significance of fungi to agricultural crop production lies in their capacity to damage crops, causing reduced yields and crop failure as well as, in some cases, the production of mycotoxins harmful to both humans and animals3. Some fungi of the genus Fusarium are prolific cereal pathogens affecting e.g. wheat and maize. They are capable of producing hepatoxic and nephrotoxic fumonisins, and protein inhibiting trichothecenes. Various Aspergillus and Penicillium species infect crops such as maize and peanuts producing carcinogenic and nephrotoxic ochratoxins, while organisms from the same genuses can produce the genotoxic mycotoxin, patulin, often associated with apples. The organism Claviceps purpurea infects rye, as well as wheat and barley, and is noted for its mycotoxin, ergot, an alkaloid and the cause of ergotism, consequences of which are convulsions and gangrene. Alongside fungi, and often mistaken as a fungal infection of crops, the organism Phytophthora infestans, an oomycete or water mould, is a disease of tomatoes and potatoes, and was the cause of the late blight that brought the Irish potato famine in 1845-49.

Matthews records the utility of fungicides in temperate and tropical crop production, describing their history and reviewing systemic fungicides. He explains that different fungicides have different modes of action, but all function to interfere with metabolic processes in target organisms, whether as multi-site inhibitors or a single-site inhibitors affecting e.g. the activity of specific enzymes.

Numerous proprietary fungicides are available to farmers and selection can be a minefield, which is why many farmers rely on specialist agronomists for advice. Some fungicides such as products containing fuberidazole ($C_{11}H_8N_2O$) are used as seed treatments while others are applied to crops during growth, for instance products containing the active agent difenoconazole ($C_{19}H_{17}Cl_2N_3O_3$) are used for disease control in fruits, vegetables, cereals and other field crops. Products containing the agents fenamidone ($C_{17}H_{17}N_3OS$) and propamocarb ($C_9H_{20}H_2O_2$) are used to treat late blight in potatoes, with the former effective against foliar infection while the latter controls soil, root and leaf disease. Fenamidone-based fungicides are also used on e.g. grapes, tomatoes, tobacco and ornamental plants.

Nematicides

Nematodes – commonly termed roundworms – inhabit virtually all ecosystems. The exact number of species is unknown but estimates suggest around 40,000 with authors frequently describing and classifying new ones. Nematodes vary in size. Some are microscopic, typically 0.1 mm in length, with some species a few millimetres long and up to 1m in the case of several parasitic species. Nematodes vary between 5µm and 100µm in diameter. Of the numerous species, Caenorhabditis elegans, a soil organism, is the most extensively described and serves as a model in research.

From the perspective of agricultural food production, nematodes may be categorized as beneficial or harmful,

i.e. as pests which require control. Beneficial predatory nematodes can be used as a form of biological control in the protection of crops from attack by cutworms, or caterpillars of the large yellow underwing moth (Noctua pronuba), the heart and dart moth (Agrotis exclamationis) and the turnip moth (Agrotis segetum), all of which can present problems for growers of potatoes and root vegetables, lettuce and cereals.

In Britain the potato cyst nematode (PCN) represents a particular problem for farmers. The twelve species of PCN belong to the genus Globodera and frequent the roots of the Solanaceae family, e.g. potatoes and tomatoes. As natives of the Andes, PCNs are not present in British fields until introduced, following which they can become a nuisance. AHDB5 states that PCNs are the most important potato pests in Britain capable of causing substantial yield losses, with two species, Globodera rostochiensis and Globodera pallida of concern. However, G. pallida is now more widespread due to a prolonged hatching period and selection pressure provided by the cultivation of potato varieties resistant to G. rostochiensis.

Control of nematodes by synthetic pesticides commonly employed the carbamate insecticide, aldicarb ($C_7H_{14}N_2O_2S$), which functions as a cholinesterase inhibitor. But it is extremely toxic and environmentally persistent, having been implicated in the collapse of ecosystems and the irreversible poisoning of farmland. It is also considered to be carcinogenic to humans. Consequently, biological methods of nematode control in crop production are of particular interest as an alternative to synthetics. Matthews4 describes use of the bacterium, Pasteuria nisizawae, a cyst nematode parasite, as a means of such control. He also reports the use of biopesticides derived from fungi such as Paecilomyces lilacinus, which is one of a number of nematophagous fungi producing toxins able to immobilize nematodes.

A variety of parasitic nematode species affect farmed animals e.g. cattle, sheep and pigs, some of which are a threat to humans, such as the large roundworm, Ascaris suum, which causes ascariasis in pigs. Roundworm treatments include piperazine ($C_4H_{10}N_2$), anthelmintics, such as benzimidazoles ($C_7H_6N_2$) and ivermectin, a preparation derived from avermectins, naturally occurring compounds derived from fermentations produced by the soil actinomycete, Streptomyces avermitilis.

Rodents

Rodents as pests in agriculture are also familiar to those who work in the food industry. One of the key methods of control in agriculture is the pest-proofing of buildings and produce storage facilities in order to prevent structural damage and, importantly, the contamination of products with urine and faeces as well as cross-contamination with spoilage and pathogenic microorganisms. The common mouse (Mus musculus) and brown rat (Rattus norvegicus) are associated with farms and together carry a range of rodent-borne diseases, such as Salmonellosis, Trichinellosis, Leptospirosis and Weil's disease (a more serious form of leptospirosis).

Anticoagulant, coumarin-based poisons have long been used to poison rodents in domestic and industrial situations, including farms. Warfarin, a first generation anti-coagulant, has commonly been used and disrupts vitamin-K metabolism involved in the synthesis of various proteins including some necessary to blood clotting6. A number of more toxic, second generation anticoagulants are now available, including difenacoum, brodifacoum and flocoumafen, all based on 4-hydroxycoumarin. The use of rodenticides on farms is tightly controlled under the UK Rodenticide Stewardship Regime.

Looking To The Future

As a tactical instrument of control, agricultural pesticides offer benefits to farmers and society in the management of pests in crop and animal production. However, increasing concerns about long-term strategic use and their negative effects on the environment, ecosystem stability and human health are causing environmentalists, public health authorities and policy makers to review rationales for continued use. It is clear that industrial agriculture, of which synthetic pesticides are an integral part, is not sustainable. The need to develop global food systems which are both Ecological by Design and Ethical by Design7 & 8 is now understood by many authorities and the part that pesticides might play in such systems will be rigorously scrutinized. Indeed, for many years approaches to reducing and eliminating pesticides have been explored, principally because of environmental concerns but now also because of concerns about human health.

Organic farming methods are well documented as an approach to food production that limits the use of pesticides, although some traditionally used compounds, such as copper sulphate, are extremely toxic. Agroecology, as detailed by Rosset and Altieri9, may gain ground world-wide as a form of agricultural food production that excludes synthetic pesticides and various governments are exploring its potential. Integrated pest management (IPM) as an approach to pest control in crop production has been under development since the 19th century10. It aims at reducing the use of pesticides through a combination of biological, cultural, mechanical and chemical pest control methods, thereby minimizing negative effects on wild biodiversity. However, concerns are raised that although pesticide use is permitted within IPM the prophylactic use of e.g. neonicotinoids challenges the spirit and practice of the technique11.

Precision agriculture using a range of technologies including satellite imaging and remote sensors feeding data to artificial intelligence (AI) systems controlling drones or UAVs (unmanned aerial vehicles) and robotic tractors are taking agricultural food production in new directions. Bongiovanni and Lowenberg-Deboer12 suggest that precision agriculture can contribute to long-term sustainability by enabling the targeted application of off-farm inputs such as pesticides, thereby reducing use. Interestingly, the rationale for precision agriculture appears to challenge agro-chemical industry assertions that agriculture based on the intensive use of chemical inputs can be sustainable. This may explain why some corporations are investing in precision farming technologies as they may sense that for moral and environmental reasons the sun is setting on the market for synthetic agricultural pesticides. Precision agriculture then offers a strategic opportunity to maintain control over food systems. Indeed, environmental advocacy groups assert that genetically modified (GM) crops were originally developed

with just such intentions: being a strategic means of sustaining the market for pesticides whose patents were expiring and, at the same time, exercising commercial control over food systems.

A quarter of a century ago GM crops were promoted as an ethically sound technology aimed at reducing pesticide use. A utilitarian ethical justification claimed that glyphosate tolerant crops would limit to one the number of pesticides applied to a crop as well as reducing quantities used. Environmental groups opposed GM crops on deontological ethical grounds expressing concerns, for example, about the eventual occurrence of glyphosate resistant weeds. In the event such weeds have become a problem in the USA where GM crops have been extensively grown. To address the problem new GM crops have been developed which tolerate glyphosate and dicamba (3,6-dichloro-2-methoxybenzoic acid), the latter being effective against resistant weeds. However, dicamba is controversial as it drifts onto non-target crops, trees and other plants causing severe environmental and economic damage. Lawsuits associated with dicamba are consequently being filed in the USA and linked to GM crop production, some American food companies are being sued over glyphosate found in food products, with claims made that residues may be harmful to human health.

Conclusion

We may think of food as simply a matter of energy replenishment, nutrition and hedonic pleasure. But it is inescapably also a political issue concerning not least the means by which farmers produce raw materials for transformation into saleable food products. Feeding a growing global population is frequently cited as the key challenge of the 21st century, with the prospect of world population reaching some 10 billion by 2050. This is not however the key challenge. Biodiversity loss and global climate change are rationally the priority issues for our time and both are impacted negatively by the world's industrial food system which, significantly, is the food system commanded by global corporations to feed mainly urban populations. Indeed, if the problems of biodiversity loss and global climate change are not resolved quickly, the question of feeding an expanded world population remains purely academic.

Agricultural pesticide use is now intrinsic to the industrial food system and in many ways has become synonymous with it, as has the use of synthetic fertilizers. The work of organizations such as the Stockholm Resilience Centre (www.stockholmresilience.org) illustrates the need to reduce significantly synthetic pesticide use globally. In resonance with the Schumacher quote, it is becoming increasingly clear that we must learn to develop ways of farming with nature and not against it. So, in this respect, it is in the interests of pesticide manufacturers to transition from old-school 20th century pest control solutions and explore the development of products that are consistent with sustainable food production and, at the same time, the protection and proliferation of wild biodiversity. Potential will likely be found in the development of biological pesticides, e.g. based on micro-organisms and derivatives, possibly using GM technology, and macro-organisms such as arachnids, insects and nematodes, that allow pest control without being ecologically catastrophic. Indeed, we can be sure that the political dimensions associated with agriculture and food production will demand this as social and political concerns about mankind's effects on the planet increase and take centre stage in national and international policy making.

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DRILL MANUFACTURERS IN FOCUS...

COST PER TONNE OF PRODUCTION MUST BE THE KEY DRIVER

The 2019 harvest yielded excellent results on the Claydon farm, resulting in a cost per tonne of production which provided a good margin, says direct strip seeding pioneer Jeff Claydon, who designed the Claydon Opti-Till® System.

In Issue 6 of Direct Driller magazine I discussed the importance of healthy soils and how to achieve them. This time, I want to reflect on the 2019 harvest and look ahead to autumn drilling, our goal now being to ensure that next year's crops get off to the best possible start.

Here in the East of England we have been very fortunate with the weather and at the time of writing this (20 August) we are over half-way through harvest, which has been relatively straight forward. However, I realise that has not been the case in many other areas of the country and sympathise with those affected.

Last year, despite the three-month drought, we enjoyed good yields, with milling wheats averaging over 8.5t/ha and £190/t. Yields are significantly higher this year, with oilseed rape averaging over 4.5t/ha despite coming under extreme pressure from Cabbage Stem Flea Beetle (CSFB) and milling wheats over 10t/ha.

Jeff Claydon stands next to 1350 tonnes of KWS Siskin winter wheat in the Claydon farm's grain store, 800 tonnes of KWS Zyatt having already left the farm destined for central storage.

I am delighted that so that many of our customers have taken the time to call our office to report that they have done even better, equalling or improving on our performance, in some cases with average yields of over 12 t/ha. They deserve to be congratulated. The downside this year is oversupply and wheat is currently trading at around £130/t. At that level many farms which continue to use a traditional, high-cost establishment system will be making a significant loss on every tonne produced.

FOCUS ON COST PER TONNE

With added pressure caused by fears over possible tariffs and the uncertainties surrounding Brexit every farming business must aim to produce crops at the lowest cost per tonne. However, it would be disastrous simply to cut costs only for yields to fall, as that would negate any benefit.

Milling wheats averaged over 10t/ha this year and met full specification.

For example, some might look to cut out a fungicide, or reduce the rate, but that would be a dangerous tactic as every single one that we used last season paid off, even when no signs of disease were evident. We also found substantial benefits to milling wheat proteins where higher rates of nitrogen were used. Assuming it is possible to accurately measure yields, I would certainly recommend that every farm has at least one tramline dedicated to experimenting with different rates of nitrogen and fungicides.

Going forward, the key must be to operate a system which is proven, enables crops to be produced with equal or better yields, and generates a healthy, sustainable profit margin. Those who purchase a direct drill solely to cut costs and expect instant results without investing time to understand how it works and how to get the best from it, will inevitably be disappointed. Before investing, it is vital to understand the fundamental differences between the various types and makes of direct drill, with harvest results providing the acid test of their capabilities.

On our own and contract farms we naturally use the Claydon Opti-Till® System, a holistic approach to crop establishment which has been independently proven, over 16 years, to consistently produce high-yielding crops at very much lower cost than where either conventional plough-based or min-till systems are used, providing maximum profitability.

A good harvest represents the culmination of making the right choices throughout the season and we must address each field individually, understand any issues it might have and tailor our approach accordingly. Correct establishment is crucial to getting the best results from autumn and spring sown crops and is a subject that I have covered in previous issues of Direct Driller magazine.

A GOOD YEAR FOR STUBBLE MANAGEMENT

The damp weather during harvest has made compaction a major issue on many

This 15m Claydon Straw Harrow is used immediately after harvest to encourage volunteers and weed seeds to germinate, allowing them to be controlled cheaply and effectively before the next crops is drilled.

farms this year and in some cases the damage inevitably inflicted by combines, grain trailers, balers and other harvest machinery will be difficult to repair by cultivations alone. Trying to do so will over-work soils and exacerbate the situation, making them more prone to weather risk, erosion and slumping, resulting in poor crop performance.

Compaction can take years to repair and can adversely affect crops established using low-disturbance drills, which will be reflected in yields next harvest. Depending on the depth of the compaction, investigation should be done to ascertain the extent of the problem and appropriate remedial action taken. If compaction is found below the working depth of the leading tine on the Claydon Hybrid drill then subsoiling should be considered, particularly if you are new to the Claydon Opti-Till® System. Once it has been used then the drill's leading tine usually works deep enough to eliminate any shallow compaction, providing excellent rooting for the new crop, which is key for plant development and to optimise yields.

Generally, this is not an issue with the Claydon Opti-Till® System because the patented leading tines on the Hybrid drill remove surface compaction as part of the drilling process, levelling the surface and ensuring that the seeding zone provides just the right growing conditions for the new crop to germinate quickly and grow away unhindered. In turn, this means less competition from volunteers and weeds, so inputs are used more efficiently and fully benefit the crop.

If your soils are in excellent condition and worm counts are at high levels, then the crops will also be right. As soils become healthier and more productive weeds and volunteers will naturally take advantage of the improved growing conditions. The reason that they sometimes appear to be less of a factor with low-disturbance or zero-disturbance establishment systems is simply that soils are in far from ideal condition because of compaction or because they can become anaerobic, with significant adverse effects on the crop.

We all must play the cards that Mother Nature has dealt us, but the secret is to play those right cards at the right time and in the right order. Rather than following a prescriptive approach to farming, just because 'that's the way it has always been done' we tailor our approach to the season, the key being to have a good rotation and avoid over-cultivating the soils.

The damp weather in August may have delayed combining on occasions, but it has provided ideal conditions for an effective stubble management programme. It is essential to encourage volunteers and weed seeds to germinate quickly so that they can be removed before the next crop is drilled, because it is much more efficient and cost-effective to deal with them at that stage rather than in the growing crop.

Soil conditions this year are the opposite of those in 2018. Instead of containing zero moisture, soils are very moist, so we have adapted our approach accordingly. Slugs love wet conditions and wet trash, so a few can quickly become many if not dealt with effectively.

Immediately after oilseed rape had been combined, we used our 15m Straw Harrow to create a shallow surface tilth and followed that with the TerraStar light rotary cultivator to create a little more soil movement. This resulted in a carpet of OSR volunteers which were left in the hope that they would retain any remaining Cabbage Stem Flea Beetles and discourage them from migrating into next year's crop, which was drilled on 9 August and five hours later received 15mm of rain, so it got away well.

When the new crop reaches the four-leaf stage and is better able to withstand CSFB attack, we will take out the OSR catch crop with the TerraStar and then clean up any volunteers with full-rate glyphosate before drilling winter cereals. It will be important not to let the volunteer OSR become too dense and give grassweeds the opportunity to flourish, but should that happen, or slugs begin to proliferate, we will hit them again with the Straw harrow or TerraStar.

The loss of neonicotinoid seed treatments and some products to control grassweeds creates a fear that the aphid vectors of Barley Yellow Dwarf Virus (BYDV) will increase significantly. This can be reduced considerably by using the Opti-Till® system to manage stubbles and take away the green bridge effect. You can also delay drilling, but to do that with any degree of certainty you must be able to get the crop in the ground quickly, which means not having too many operations before sowing.

A key benefit of the Claydon System is that its high output potential provides much greater flexibility, so you can choose when to drill rather than having to press on regardless. That is very important because we don't want the hassle and weather risk which plough-based or min-till systems create due to the need to prepare seedbeds well in advance of drilling.

We do that by implementing Opti-Till's effective stubble management programme, followed by a robust application of glyphosate to tidy up any stragglers that might be left. The aim is to create a 3cm deep stale seedbed, certainly no more than 5cm, especially when working with clay soils which need to dry before following operations, so we only use the Straw harrow and TerraStar when conditions are right.

When drilling with the Claydon Hybrid we recommend 50hp-60hp per metre of drill width, not to go deep but to comfortably maintain an operating speed of 10 – 12 km/h, giving very high outputs and ultimate flexibility.

In my next article I will review the performance of our autumn-drilled crops and look ahead to what we have planned for the spring.

To learn more about the Claydon Opti-Till® System and techniques to improve your farm's performance contact your local Claydon dealer and arrange a visit to the Claydon farm. For further details go to www.claydondrill.com or call the Claydon office on 01440 820327.

PRODUCTS IN FOCUS...

COULD HYBRID RYE BE THE NEW CROP DIRECT DRILLERS HAVE BEEN LOOKING FOR?

From Scotland to East Anglia, growers are finding success with hybrid rye, what is it about the crop that captured their interest?

Frustrated by the performance of winter barley and no longer able to grow oilseed rape, Colin Mitchell, farm manager at Meikleour Estate in Perthshire, was searching for a new crop to extend the rotation.

Although not the complete answer, hybrid rye is proving to be a rewarding discovery. "Farmers in Scotland need an alternative to wheat," he says. "It is becoming harder to keep clean of foliar diseases that limit yield, and this is making it expensive to grow. The obvious choices aren't that attractive."

The Meikleour Estate covers about 800 hectares and its fertile loam soils support a diverse range of crops including potatoes, energy beet and carrots. Cereals perform as a disease break for higher value crops but must still pay their way. Oilseed rape too is no longer a practical option due to severe clubroot problems and a desire to reduce disease risk from sclerotinia in high value root crops.

As with many other farmers in Scotland, Mr Mitchell's interest in hybrid rye was aroused after he was approached by a neighbour in need of feed stock for an anaerobic digester, but it has since earned its place for other reasons.

"We took a conservative approach; our 25 ha was modest in comparison with what some others were putting in. For many, it was the most profitable crop on their farms, and it can be, but you must properly account for the potash removed. This can be as much as 285kg/ha with a 50t/ha (AD) crop," says Mr Mitchell.

This brief experience was enough to capture his interest and he began to investigate other possible markets for the crop.

"It grew well, and I was impressed with it, but because we want the straw to cover the carrots, we decided we'd rather grow it for grain. We use about 50t/ha of straw, which equates to about 4000 Hesston bales a year, to protect the carrots against frost. Hybrid rye produces about 25% more straw than winter wheat so there is obvious appeal."

Variety choice is considerable but a call to Scottish Agronomy ensured he chose the right variety for his farm situation.

"Rye is susceptible to ergot, but the development of PollenPlus varieties, bred and marketed by KWS, has done much to remove this risk. Scottish Agronomy has long-term trials data on a range of varieties at two sites in Scotland so we knew straight away which variety to grow, what seed and nitrogen rates to use and how much growth regulator would be needed."

Growing rye for grain however, meant first finding a buyer for it. "A favourable amino acid profile means it is particularly well suited to pigs so that was our first thought, unfortunately it wasn't to be. Eventually, we found a market for human consumption through a local merchant."

David Lord

As his confidence with the crop has grown, so has the sown area and in 2018-19 covered 110ha.

"In 2016 the crop yielded an average 7.7t/ha though this was on some of the farm's least productive soils. The best-performing field managed 8.3t/ha. This made us start to take it seriously as the best crop we've ever had in that field previously was spring oats which managed about 6t/ha. In 2017 it achieved the same average but then in 2018 it gave 8t/ha with the best field at 10.48t/ha."

This compares with a three-year wheat average yield for the same period of 8.3t/ha. In the drought of 2018 wheat at Meikleour managed just 7.54t/ha and cost roughly £100/ha more in variable costs.

"It appears to be the one crop where real progress is being made year-on-year to improve agronomic characteristics, such as disease and lodging resistance. This year I'm growing KWS Edmondo and have entered a field in the ADAS YEN competition."

"For us, it yields on a par with first wheats, but is cheaper to grow because it needs less nitrogen fertiliser and fungicide. It has already replaced some winter barley and I'm starting to think it could replace second wheat too."

Eastern promise

Another grower frustrated by the poor performance of everyday cereals was Essex grower David Lord. After deciding to call time on winter malting barley and encouraged by a neighbour he decided to give hybrid rye a go. It's now four years later and the crop area has expanded to 40 hectares as demand for the grain has increased.

It was the low water requirement – at 300 litres per tonne of grain produced its moisture needs are typically 25% lower than that of wheat or barley – and early maturity that appealed in the first instance.

KWS Bono in ear

"I was looking for a crop to fit the light land rotation of potatoes, wheat, peas/onions, and wheat. Rye had good drought tolerance and the straw is useful for the cattle enterprise though we are careful to follow it with potatoes to replace the phosphate taken off (with the straw) and control the volunteers.

"We budget for yields of about 8.5t/ha, but it often exceeds this. In good years it does 10t/ha or more and as our contract sees us paid the same as feed wheat it often produces a better gross margin because it is cheaper to grow," he says.

It has since become an established crop and his 350-400 tonnes annual production is sold locally to a specialist food ingredients business.

"It does better than wheat on the same ground and is earlier to mature, but later than oilseed rape, so helps ensure a smooth harvest," he says.

Ergot is the curse of rye, but since moving to a fully hybrid variety this has become less of a concern.

"We moved to KWS Bono a few years ago partly for the higher yield potential, but also because the higher quantities of pollen these PollenPlus varieties produce means there is a far lower risk of ergot infection occurring," he says.

"It's not completely risk-free, but with milling wheat on the farm too we need to be proactive and PollenPlus varieties have helped greatly."

Sowing is much the same as any other cereal and Mr Lord will either drill it conventionally after cultivations or direct into stubble depending on the workload at the time, the field and weed burden to be considered.

"It's certainly easy to grow. We sow it in early October, normally apply two fungicides as mildew and brown rust are the main disease pressures, and a single application of Chlormequat to keep it from lodging. About 150kg N/ha is applied in two splits and that's it," he says.

New market opportunities

Just as the arable sector faces its own problems brought on by the loss of certain active ingredients and the need to find a more sustainable rotation, the pig sector has its own challenges.

The need to reduce antibiotic use is common to all livestock enterprises, but the high health status of many pig herds makes it more achievable in the short term. Methods that promote gut health have been identified as central to improving overall herd health and thereby reducing the reliance on medication. Rye has a role to play here as its coarse structure has been found to result in less ulceration in the hind gut compared with pigs fed with a conventional ration based principally on wheat and barley.

Colin Mitchell

A second issue is the need to promote general welfare across all production systems with the intention of eliminating tail biting among finishing pigs and reducing the incidence of aggressive behaviour among all pigs. Here rye too can contribute. Its denser structure promotes satiety – the sense of feeling fuller for longer – thereby leading to a feeding regime that sees pigs little and often. This leads to less boredom and less time to exert negative behaviour.

Environmental pressures are also forcing a change in production methods with the need to reduce ammonia emissions promoting interest in other feed sources and the viability of lower protein rations. Rye's lower nitrogen and water requirement means a crop with a smaller carbon score which has not gone unnoticed by feed manufacturers.

UK pig producers wondering how rye will perform in practice need only look to their continental counterparts for positive experience. In Denmark, Germany, Russia, Poland and Spain, rye is an established component of the ration.

REALISING THE BENEFITS OF SOIL HEALTH ON ARABLE

Why is it that grass margins are usually in much better heart than the cropped land? Is there something magical about grass? Field margins in many ways set the bar for soil health on your farm.

But is that as good as it can get? And do we need to go down to grass to achieve it?

"I believe the answer is no" writes Niels Corfield, crop advisor.

Crop Land

Grass Margin

We can go beyond the grass fallow and achieve good results in a short time frame. Because ultimately when cropping, we have more tools at our disposal. However, we have to employ those tools extensively, and thoroughly, if we're going to actually see these results on our farms, in any reasonable period.

What are the tools that we have available to us? It's just going no till, right? Well, basically, it's the application of all the soil health principles. Mimicking the conditions we find under grass.

That said, the acid test is in the soil condition. The good news is that you can actually see soil health. But what does healthy soil look like? Must it be lab tested? No, simply put, aggregation (crumb structure) is that measure.

With that said what are the primary rationales for adopting soil health practices? Why should we, as farmers, advisors & land managers care? Are there any production benefits?

Improved soil health basically equates to better crumb structure that's looser, easier to work and more absorbent. Certainly, the longer a ley is down for the better aggregated the soil becomes.

So before we get into the detail, I want to put this in a global perspective. Ultimately, with 4 degrees of locked-in warming, coming down the line, business as usual is not an option. The warming we are dealing with now, as well as that coming means, for example, we can't rely on rainfall to germinate spring crops, we need to do it with stored soil moisture (another reason not to till). Only improved soil health (crumb structure) can deliver this - so your disk drill can place the seed easily into a porous and moist seedbed.

When it comes to carbon sequestration, soil health practices, of which conservation agriculture (CA) is one example, is the only framework that can deliver the numbers we need to be hitting, under commercial conditions.

That said, if we are really going to be able to make the case for soil-based production, we have to be demonstrating significant soil carbon results. Recent data from Brown's Ranch recorded 96 tons per acre of carbon in the upper 48" of soil, as compared to 10-35 tons for farms in the region. While there is much controversy around carbon auditing, and it probably isn't a tool for day-to-day decision-making, these results represent a pretty high bar, and also an indication of what is possible.

Soil Health Principles

Select your management practices based on the soil health principles. Those that score highest should be preferred (where practical).

1. Living Root- for as Lomg-/as Often as Possible.
   - Root exudates feed organisms - they build soil
2. Cover Soil- with residues or Living Plants,
   - No bare soil in nature- protected from elements
3. Minimise Disturbance/ Compaction - Tillage
   - Preserves aggregate structure
4. Diversity- Rotations/ Plantings,
   - Diversity above ground feeds diversity below
5. Feed soils- w/Organic Matter (Betweeb Cropping)
   - Organisms need energy to stay active
6. Incorparate Animals- Ideally Adaptive Grazed
   - A grazed cover crop is better than an ungrazed one
7. Minimise Use of Chemicals/ Synthetics
   - undoes all your previous good work.

Cover Crops

Over-winter cover crops (OWCCs) are the bread-and-butter of CA, they perform a vital role: preserving soil structure, holding onto nutrients, protecting soils etc. And in warm autumns they may actually do some soil building but generally speaking with soil/air temperatures being low and day lengths short, microbial activity is low, and root exudation is minimal. Also when temperatures are low, little or no N-fixation occurs, calling into question the rationale for buying those

High Diversity

Low Diversity

expensive legume seeds. Beyond these shortcomings, there's limited species choice and slow growth.

Does this mean we shouldn't bother with them? No. They still play a vital role in protecting soil & preserving structure. Though that said, where planted too late, or too thinly, OWCCs may not actually give sufficient cover either.

But is there a way we can go further with our cover crops and get more pronounced results? Certainly.

Spring sown or full season cover crop mixes open up the floodgates for diversity. And with it being in season, there's plenty of warmth in the soil for optimal microbial activity (soil building), including nitrogen fixation by free living nitrogen fixing organisms, eg azotobacter. The diversity of plants means more specialist organisms should be being well fed through exudates.

But what about the cost of fancy mixes like these? Well, source seed from the feed merchant. A good starting point is bird seed mix. These tend to have at least the 8 species that are suggested as a minimum - getting that diversity lever up to where it wants to be. Just to reiterate the ideal is to have eight or more species from three or more of the functional groups: warm season/ cool season, grasses/broadleaves. The warm season plants are also the C4 plants, eg sunflower, millet, meaning more solar energy capture. Add to this any farm saved seed available. As well as this, include a tall straw cereal, like rye or population wheat - these may well be on the pricier end, so why not grow a strip or two of these as straights for combining for future mixes.

Finally, all of these plants should be annuals as we then have more options for termination, including: rolling and trampling - so long as the planting is fully mature. It's probably also worth leaving out any short-season inclusions, like: mustard, radish and even buckwheat, since they will shed viable seed long before this termination point, possibly volunteering in subsequent crops. At the end of the season obviously you will always have the option to spray off.

There's certainly question marks around margin for in-season covers, probably the best return this would be to graze these covers, using low utilisation, ultra-high stock density (UHD) systems. By terminating in this fashion (along with rolling) and with having low utilisation there will be large pulses of root exudates produced during these grazing events. It's exudates that contribute most directly to aggregation and soil organic matter. Ultimately the payback for root exudation is a steady supply of nutrients in a plant available form, that are free.

Diversity and Cash Crops

Are we limited to soil building under cover crops? No, techniques like: band sowing, strip cropping, inter row planting/undersowing, crop mixtures, intercropping and relay cropping, are all indicated. Simply shifting from a monocrop to a bicrop doubles the diversity.

Of these probably the most straightforward is strip cropping. The narrower the strips the better, to ensure the greatest interaction between the crop's roots.

Furthermore, the wider the spacing for the main crop the more a second planting is indicated. It would possible to undersow with a winter wheat (potentially bicropped with a legume) - making this more of a relay crop than an undersowing, and removing at least one spray pass.

Basically, do whatever it takes to get diversity into your cash cropping, and to maintain a living root in the ground through more of the year.

Advice for getting started

On small acreages or one field (potentially, close to home), modify your operation to incorporate some of the following (ideally with a commitment for three years minimum):

Cover Crops

Plant a cover crop, properly, with high seed rate, early sowed, and with starter fertiliser.

Where cover cropping already, try a diverse mix, 8 species or more, cheap/ farm saved seed.

If you're on the diverse over winter thing, then try it in season, ideally UHD grazed. Drill a cash crop into cover crop residues.

Cash Crops

Diversify the rotation, try a novel crop - maybe a seed crop

Strip cropping: could be a header width, or just a drill width (that you then stripper header).

Plant an intercrop, a two way mix, with that are co combined.

Niels Corfield is an independent advisor and educator specialising in soil health and regenerative agriculture. Check out his events page at the back of the magazine for upcoming courses or follow the QR Code to book places.

Scan me

FARMER FOCUS
NEIL WHITE

I farm 155Ha owned at Greenknowe and around 100Ha contract farmed in Berwickshire, Scotland just 6 miles from the border at Coldstream. The land is clay and sandy loam, deep, very variable but the best of products to run an arable business on, any limiting factor is probably me! I do all the farm work myself except for the corn carting, high clearance spraying and baling. My son, Harry (age 13) and I have been flying DJI drones since 2014 and he posts the video's on our Youtube channel 'Everything is Greenknowe' and pictures on Instagram under the same name.

YouTube Channel- 'Everything is Greenknowe'

The last of the livestock left in 2000 but 75% of all straw is still removed, as the local livestock farmers wouldn't let me live with the guilt if I chopped it all. The organic matter tests carried out in the last 2 years show a 3 to 4.4% OM in my soils. I think this is helped by my long rotation, with grass being replaced with oilseed rape and beans and the addition of hen muck on stubble prior to rape drilling. The current rotation is WOSR, WW, SB, SO (Or Spring beans), WW, SB, WB.

All this added up to what I thought was a good place but I had always wanted to do more with less. In Scotland we usually have very short weather windows to combine and sow crops, an example this year when the phrases "your rape is at 14% that's good" and "if it's not raining I'll be cutting", were spoken loudly without an eyelid batted. This year I am not alone in cutting wheat at a lower moisture than my rape. Even in a "normal" year I was beginning to struggle to get all the winter crops in the ground with my plough based system and like many I questioned taking the great tilth presented after harvest and ploughing it down then try to recreate it with metal, diesel and man hours while risking it getting soaked or baked. I had even considered buying an old MF 30 or 40 just to sow the wheat directly after my beans but that felt like going back rather than forward. I had a contractor sow my rape with a subsoiler and broadcast method and this worked well most years but if I was to own the kit myself it had to do more than just sow rape.

I started in 2014 to look online for information on direct drilling and spent hours reading the farming forum comments and watching Youtube videos of people's experiences, from that the Mzuri name came up. I had demoed other drills but most were a version of a combination drill rather than the options available now so I looked in more detail at the strip till concept. I think we all do our own version of min till, i.e. we all think we do the minimum amount of tillage necessary to achieve the desired results. I felt the Mzuri's leading leg and consolidating wheel were necessary on my heavier soils to create the correct conditions rather than a slot or smear. After a visit from Mzuri's Ben, who had a look round and a chat (he really was checking out the

condition of my soil), we decided a demo was worthwhile and after wheel kicking at Cereals 2014 the autumn date was set. The wheat went in perfectly as the Youtube video shows, and myself and a few neighbours dug and scraped the soil and decided, why wouldn't it work? It did, and very well, the subsequent wheat crop more than matched any other wheat I had that year, so far so good. I would have liked to have said "just leave the drill here" but to justify a new drill to sow a small percentage of my crops was difficult. Mzuri told me of someone who had a drill and farmed locally, so myself and a friend visited Patrick Fraser who runs a mounted 3T version and his wheat and rape looked well established and his feedback both pros and cons were very helpful. I began to look for a second hand 3 meter Protil and I found a trailed one online, with Mzuri's endorsement I went ahead and bought a single hopper drill in immaculate condition and at a good price (even for a Scotsman) due to its single hopper. The 3 meter drill does come with an estimation of the horsepower required, at 180 it is steep, but even on my tougher soils it was realistic even at the start when the soils were tight and I would hope to require less as time goes by. Having said all that I did upgrade my tractor from a Valtra 183D to a Valtra 234D clad in Scottish rugby star Doddie Weir's own MND tartan designed by my wife's company no less. The tractor does feature on my Youtube channel 'Everything is Greenknowe' with the drill before anyone points out its more than a 180, but nobody buys a smaller tractor than they trade in, do they?

The first crop I put in with the drill was spring beans, again with Mzuri's help in setting up, something they did FOC, above and beyond my expectation. The initial day was daunting as it was different to anything I had ever done before but the beans were through and rowed up very evenly a few weeks later, to my relief. Next I did spring oats, grown for Quaker, sown straight into over wintered stubble and again they came up and away very evenly but my first mistake was soon to come. Being a bit thrifty I had a dispute/discussion with my agronomist about the need to spray what looked like a clean stubble prior to sowing spring malting barley. After sowing, the cold wet Scottish spring stalled the barley long enough for every weed known to man to appear and confirm my agronomists concerns, first lesson learned, start with a clean slate. Don't worry he constantly reminds me!

I now use a hired straw rake on my rape stubble mostly for slug and slug egg destruction as I find it halves numbers prior to wheat sowing and I try and glyphosate my stubbles as I don't spray off crops prior to harvest. I do try to resist any other form of 'recreational' tillage as I strive to stop the part of my brain which is conditioned to think loose, brown, power harrowed soil and green rows are a sign of a successful crop. My strip tilling has now progressed to almost all of my crops with 30% of winter barley, 95% of wheat, all the rape, oats and beans put in with the Mzuri system with fantastic results. I have kept my 15 year old plough and the combi drill for the few barleys, but they won't be replaced. I do still feel when I leave a field after sowing that it hasn't really taken enough time and effort and it will never work, but it does.

This year's harvest has produced some great crops, some of the best wheats I have ever grown, great OSR crops (sorry South of England) and the spring beans and oats are on Youtube and look excellent so far! I have sown 9 different crops with the drill to date with the standard equipment and I hope to try cover crops in the future if I get into the AECS scheme I have applied for. I have now traded in my single hopper 3T and have a new 3 meter dual hopper Mzuri with the new upgrades on the fan, disc and low disturbance single coulters which will all be useful, and I look forward to fertiliser placement which can only be a good thing. I would like to put beans down the front leg, cereals down the coulter and a clover out the pelleter as a cover crop but only with the help of a scheme payment.

I was recently lucky enough to be asked to take part in a Q & A at Cereals in the Conservation Tillage tent, hosted by Clive Bailye, a premier league of very experienced direct drillers and then me. I had so many of my own questions for the panel as they had many years of experience and each their own approach. I do a very simple version but we were all focused on improving soil health, margins and building a resilience in our soils and business in our own different ways. I was asked if I saw myself moving to direct drilling from striptill in the future but I stuck to my original thought, we are all doing the minimum tillage for our needs and strip tillage on my ground is, I feel, the minimum required. Of course like the British weather all that can change.

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7 WAYS TO MEASURE **SOIL HEALTH IMPROVEMENTS**

Written By Laura Barrera and first published on Agfuse.com

While soil health may be harder to quantify than benefits like biomass production or input savings, there are ways of measuring how cover crops are making a difference in your soil.

While there are numerous reasons for using cover crops, a primary one is improving soil health. In fact, it's the one benefit most farmers using cover crops have experienced: In the most recent US Cover Crop Survey Annual Report, of those who rated the statement, "Using cover crops has improved soil health on my farm," 86% agreed or strongly agreed.

The report notes that it's interesting and heartening that "soil health reflects an embrace of a long-term, hard-to-quantify benefit of cover crops, and that for the past two surveys, it has achieved the top spot by garnering 86% of the responses."

1 - Reduced erosion

Protecting soil from wind and water erosion is a common reason growers begin using cover crops.

The easiest way to monitor this benefit is simply by looking for signs that less erosion is occuring. Diane Stott, National Soil Health Specialist for the USDA NRCS's Soil Health Division, says you can visibly notice less erosion by seeing how little runoff there is from a field after a rain or strong wings. If you have tile drainage, it should be relatively clear after a rain.

But to quantify a reduction in erosion, Stott says you place use stakes with measurement marks at the edge of your fields, preferably with one stake in a nearby field that's not in cover crops for comparison. Over time, you can check those measurements on the stakes to see how little soil you're losing, if any, compared to the fields that are bare.

Stott notes that it doesn't take much for a significant amount of soil to be lost. In fact, if a field loses as little as ¼ of an inch of soil per acre, that's 10 tons of topsoil gone.

"I have seen fields where people who have been in cover crops for a number of years, compared to their neighbours who have not, and it's frightening the amount of difference there is in the level of soil between the two," Stott says.

2 - Less compaction

Another soil health benefit you should see after using cover crops is less compaction and deeper root penetration, especially if you're seeding species like daikon radishes, which are known for growing a deep taproot.

To measure soil compaction, you'll need either a penetrometer, a soil probe or a steel rod, Stott says. If you're looking for more precise measurements of your soil compaction, you'll want to use a penetrometer. Which measures the soil's compaction in pounds per square inch (psi).

In a Penn State Extension article written by soil scientist Sjeord Duiker, he recommends using the penetrometer when the whole profile is at field capacity, which is approximately 24 hours after a soaking rain. Spring is the best time of year for this, he says, because the whole profile will have been thoroughly moistened during the winter. He notes that if the soil is too wet or too dry, compaction could be under- or overestimated, respectively.

Some other things to consider when using the penetrometer are the tip options. In a YouTube video by University of Wisconsin Integrated Pest and Crop Management, soil scientist Francisco Arriaga explains that there is a ½-inch tip and ¾-inch tip. The ½-inch tip

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is generally used on soils that are harder, while the larger tip would be used for soils that are looser and have better structure.

To take a soil compaction reading, Arriaga recommends first taking a reading in a fencerow or somewhere with the same soil type hasn't had any traffic on it, which would give you a good comparison of the soil's natural compaction. Push it in the soil and watch the gauge to see how much pressure is required to get through. The easier it is to push, the better your soil structure is.

You can return to the same spots in the field year after year to perform this test and see how the cover crops are alleviating soil compaction. Stott says that if you're seeding a cover crop mix that contains 30-40% radishes, you should see a difference after just one year.

She also notes that covers are best at alleviating plow pans and compaction that was formed by equipment, livestock or tillage. Cover crops may not be able to alleviate diagnostic compacted layers that are natural in the soil.

3 - More earthworms

Earthworms are another indication of

Taking a soil penetrometer reading in the same spot of a field before and after using cover crops can give you an idea of how covers are relieving soil compaction. Photo from Wikimedia Commons.

good soil health that you can measure, as they "need moist soils that have sufficient residue or organic matter for food," writes Christina Currell, a water quantity educator for Michigan State University Extension.

You can do earthworm counts to see if your populations are increasing by digging out a square foot of soil one foot deep, and counting the number of worms found, Currell says. To count for deep-burrowing worms, you could also level out the bottom of the hole and slowly pour a solution of 2 tablespoons of mustard powder dissolved in 2 litres of water, which will cause them to come to the surface within 5 minutes.

Currell points out that if earthworm counts are taken when the soil is dry, your number is likely to be lower, and populations are typically higher in areas with high organic matter. You should try to do your counts in a spot that's a good representation of the field. She recommends doing the test several times during the growing season and to get an average count.

Stott notes that if you're located in a northern area, you shouldn't be too worried if you don't see too many earthworms.

"Understand that, especially in the northern states, earthworms are not indigenous," she explains. "Most of them have been seeded. Anything that's from a glaciated area, the earthworms are not native. So don't worry if you don't see any earthworms, it does not mean your soil is bad."

Instead, she suggests looking for other beneficial species and see if you notice an increase in populations as you continue cover cropping.

4 - Faster Water Infiltration

As cover crops help lower your erosion and compaction, while also increasing earthworm populations, your soil's water infiltration rate should improve as well.

To measure your infiltration rate, Stott recommends taking a No. 10 coffee can with both ends cut out and placing it in the soil. Pour two inches of water into the can and time how long it takes for the water to seep into the soil.

The longer you use cover crops, the faster your water infiltration rate should be.

5 - Higher organic matter

Along with infiltrating water faster, cover crops should also help your soil's water-holding capacity, as it increases the soil's organic matter. According to the NRCS, organic matter holds 18-20 times its

weight in water, which means 1% of organic matter in the top 6 inches of soil holds approximately 27,000 gallons of water per acre.

Measuring organic matter just requires a soil test, but Stott warns that it's going to take longer for growers to see a significant change in their organic matter percentages.

That doesn't mean that soil organic matter isn't increasing — just that it takes a while for the tests to detect those changes. Stott says you're not going to see a significant change in your soil test values until there's been at least a 0.3% change in the soil.

If you're in the Midwest, it'll probably take 3-5 years to see your organic matter levels increase on your soil test results, she says, and if you're in a drier region you may not see any significant changes for 5-10 years.

Because of how long it takes to see a change, Stott recommends taking a soil test before you start using cover crops to get a baseline number, but don't test it again for another 5 years.

In the meantime, look for qualitative changes to your soil for verification that your organic matter and soil health are improving.

6 - Better soil stability

One qualitative measure you can take to see how your soil health is improving is the Slake Test, also known as the Soil Stability Test.

The Slake Test can help you see how stable your soils are currently and how much their aggregation improves as you continue cover cropping. Photo by Jason Johnson, Iowa NRCS.

The Slake Test, measures the stability of soil when exposed to rapid wetting, adding that soil stability serves as a "qualitative indicator of soil biological activity, energy flow and nutrient cycling."

To perform the Slake Test, you'll need two glass jars, wire mesh that can be hooked onto the glass jars, and a chunk of soil from your fields, as well as some soil from another area that can serve as a comparison. The NRCS says this can be from a grassland, fencerow, or no-tilled field, if you're not no-tilling.

The Slake Test: This compares how soils hold together when wetted. The soil samples are held in a wire cage which is in the top part of a vertical jar of water. The jar stands for some hours and the test is to see how quickly the soil disapates in the water. The faster this happens, the less stable the soil. Low stability soils get lost through field drains and erode from the surface run off. For a visual on how the Slake Test is done, scan the QR Code below with soil scientist Ray Archuleta using it.

Your soils should darken the longer you use cover crops and increase soil organic matter. The dark area of this northern Minnesota soil is from carbon sequestration, due to being in permanent grass cover. Photo by USDA ARS.

Another simpler qualitative measurement similar to the Slake Test is to spray the soil aggregates found clinging to roots. Stott says to place the aggregates in a dish and spray water on them. You'll see if the aggregates hold together or if they fall apart.

Scan to see a live preview

You can continue performing these measurements over time to see how much your soil structure improves from cover crops.

7 - Visual Changes

Finally, one of the easiest tools for observing how your soil health is improving is the shovel.

Stott recommends digging 1-2 feet deep in your soil to examine the color of it, how deep roots go and how soil aggregates are clinging to the plant roots. The color of your soil should be getting darker, she says, and you should see more soil aggregates near the soil surface.

"They'll start seeing a marked increase in that nice crumbly feel in their soil," she explains, noting that this can occur as soon as the first season after using cover crops for growers in more humid regions"

If possible, it's a good idea to do this before you start cover cropping, she says. She also recommends digging in a fencerow that you can compare to your field, so you get an idea of the condition of your soils and how close or different they are from their natural state.

"You can learn so much that way and it's a lot cheaper than sending things to the laboratory," Stott says.

To better track how these changes progress, take videos and photos so you have a way to compare how much your soil health improves.

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DRILL MANUFACTURERS IN FOCUS...

NO-TILL FARMING: BOOSTED SOIL HEALTH, CUT COSTS... IT'S THE FUTURE

Worcestershire-based Weaving Machinery – manufacturers and suppliers of farming equipment – have called on UK farmers to investigate and consider implementing no-till systems as part of a campaign for better soil health, highlighting not just the conservation benefits of low disturbance farming, but also the cost savings and greater control across the farm. No-till farming has seen a steady increase over recent years in the UK, despite historically slower rates of adoption compared to other parts of the world.

According to the UN Food and Agriculture Organisation (FAO), food production must increase by 70% by 2050, in order to meet the needs of the projected population of 9 billion. This will naturally require a rethink in terms of optimising productivity but also demands a greater need for sustainability. More and more farmers are already aware of this sea-change, and the industry is experiencing a shift towards no-till as a means to achieve better soil health and sustainable production... all while cutting costs and saving time.

"The shift has been massive," says Simon Weaving, Sales Director at Weaving Machinery. "Five years ago, farming was all about completely mixing the soil profile. Today, it's more about lifting the soil profile, rather than mixing. Farmers are beginning to understand the very real benefits they can see when incorporating a no-till system."

The drive for better soil health

The UN recently stated that the world's soil reserves has only an estimated 60 harvests left before complete degradation, with around a third of the world's soil already at that point.

Michael Gove, the former environment secretary, also warned that the UK is only a few decades away from "the fundamental eradication of soil fertility", adding that "countries can withstand coups d'état, wars and conflict, even leaving the EU, but no country can withstand the loss of its soil and fertility." The British government has also signalled possible incentives for farmers who promote better soil health following Brexit, though these are not set in stone.

While the importance of soil health is widely understood, why the slow rate of adoption? Part of this is the UK's strong sense of tradition in farming, but a significant barrier to entry has been the cost. With many farms under increasing financial pressure, few are willing to invest and risk trialling a new method of farming, even if the benefits are clear.

For Weaving's part, accessibility and affordability has always been one of their leading mission statements: "I completely understand that farmers may be wary of leaping straight into direct drilling or low disturbance farming," says Simon. "Our drills are designed to work on conventional systems as well, for complete flexibility. Ultimately, no-till is the direction the industry is heading, and it's a change that will directly benefit both this country's soil health and, importantly, the financial security of UK farmers."

The benefits of no-till farming

No-till requires more planning but advocates are quick to praise the huge benefits they've seen on farm. These include a cut in costs for machinery, labour, fertiliser, and chemicals. In turn, this leads to a marked increase in insects, birds and wildlife, as well as fewer floods and more resilient crops during droughts.

At face value, the cost savings might prove the biggest incentive for interested farmers. Savings include less money spent on diesel, parts that wear far slower, less manpower required in the field, and less horsepower (and therefore fuel consumption) during the crop cycle. These costs may be relatively small

when taken individually, but quickly add up.

In the long-term, no-till also increases worm numbers and boosts organic matter. Unlike conventional systems, no-till keeps everything underneath the surface, giving it a chance to build up. This also leads to another significant benefit for many farmers: a solid defence against blackgrass.

In brief...

key benefits of no-till farming

- Better soil health and reduction in erosion
- Increased worm numbers and boosted organic matter
- Reduction in time and manpower required in the field
- Improved management of weeds, including blackgrass
- Lower diesel costs – on average, when using a 6 metre drill, farmers can expect to use 2 - 3 litres of diesel per hectare, about half of normal consumption.
- Lower wearing costs – approximately £2 per hectare.
- Lower horsepower requirement– most GD customers are running 6 metre drills on around 200HP.

Fighting Blackgrass

Blackgrass is a grass weed that grows in any condition, particularly thriving in very wet weather, that grows in the crop and smothers it. A persistent threat, blackgrass has the potential to halve – or more – cereal yields. Simon Weaving identifies customers who saw their yields fall by as much as 4t/ha.

Blackgrass seeds can lie dormant for years before activation, which can then be exacerbated by cultivating and mixing the soil profile. While by no means an all-purpose solution, no-till means the seed hits the floor and stays there – making spraying much more cost-efficient, effective, and long-lasting.

"We made this decision because we just had to tackle blackgrass," says one Weaving customer who adopted a no-till system. "This system was affordable and a viable route to go down. No-till has lots to recommend it in terms of preserving soil health, but to be honest ours was largely a practical decision. This is the right thing to do for our farm."

The next step

As more farmers begin to consider whether no-till can work for them, what are the next steps? Simon Weaving advises to take stock of your current situation. "First, look at your soil health," he says. "Is it at the levels it should be? If the soil is in poor health, you might not want to jump straight into direct drilling. You can use a machine like our LD top spoiler to slice into and lift up the soil. This gets air underneath before putting it back down with minimal disturbance before drilling."

"All farmers should be seriously looking at no-till as an option for their farm," adds Simon. "Year on year, we're seeing more farms trial whether no-till can work for them, to achieve better soil health, reduce costs, or implement better weed control. We've worked to deliver machinery that has the power and functionality for farms of all sizes and systems, to improve soil health – all while keeping yields strong."

Find out if no-till could benefit your farm. Contact Weaving Machinery to learn more about their newest drills and other robust and reasonably priced farm machinery at https://www.weavingmachinery.net

About Weaving

Weaving is a family run company founded in 1983. Its aim from the very beginning was to offer farmers the best quality farm machinery at affordable prices.

The company distributes farm machinery throughout the whole of the UK. The newest GD Drill, as with all Weaving products, is made totally on site. From design, fabrication, construction and spraying, everything is done in-house, all at the Evesham headquarters

Low Disturbance Farming – the ideal kit

Simon Weaving outlines what an ideal collection on no-till equipment would look like:

- Top-Soiler – moving the soil and ensuring airflow.
- Short Disc – for working in stubble and chitting weed seeds.
- GD Drill – for seed placement that leaves the soil undisturbed, directly into the residue of the of the previous crop.

Alternatively, instead of a direct drill:

- Sabre Tine – In addition to Weaving's GD Drill, they offer the Sabre Tine, with four rows of tines in a large staggered configuration to avoid trash blockages, and an adjustable angle for different sowing depths and seed types.

COVER CROP STRATEGY **GETTING IT RIGHT FOR SUCCESS.**

Written by James Warne of Soil First Farming

A cover crop can be anything that is not intended to be harvested. It is simply there to provide soil cover, light interception, push roots in the soil and carbon sequestration.

If you are following a true Conservation Agriculture (CA) system, cover cropping is an essential part of the system. The three principles of Conservation Agriculture are;

1, Minimum soil disturbance

2, Soil Cover

3, Diversity

The clue to cover crops is in the name, for them to work for you they need to firstly cover the soil, 100% of the soil, simple. While cover is the simplest measurement, they also intercept light and use photosynthesis to capture carbon and store it in the soil. Cover crops help us fulfil all three of the CA principles. Roots help to stabilise soil, and create structure by feeding biology, reducing the need for cultivation; providing soil cover when no cash crop is growing which protects the soil from the damaging compacting effects of rainfall and warming by the sun; and providing diversity in species and rotation.

Getting to know the feel of their soil is an important element of learning.

Roots can help stabilise structureless soil and provide the ultimate cultivation.

A lot of CA promotion in the UK and abroad focuses on growing large biomass cover crops with multiple species, sometimes up to 15 different species in the cover crop. While this looks amazing and certainly does bring benefits, and is the eventual goal with cover crops there are downsides to this strategy particularly in the early years of CA adoption particularly with relation to cost.

A more complex 8-way mixture, looks impressive but probably unrealistic in the early years of CA.

It is easy to forget many of these amazing cover crops are being grown on soils that have been in CA system for many years and therefore have greater tilth and structure which provide better seed:soil contact to drill into and reliable establishment. There will certainly be better nutrient cycling, nutrient availability and greater water holding capacity and this is all due to the soil having more carbon stored within it. The Carbon to nitrogen ratio of the soil is also more likely to be in balance meaning the cover crop can access the nitrogen it requires.

At Soil First Farming we believe in the early years it's much better to stick to a simpler strategy and to build on this success year on year with increasing complexity of cover crop mix as you gain confidence in the system.

In the initial years stick to monocultures or mixtures with a maximum of three species. The soil is in 'cultivation cold turkey' at this point and it's very easy for the soil to become compacted by trafficking at harvest, excessive precipitation and gravity. Therefore to stabilise the soil as quickly as possible you need roots, lots of roots. Focus on growing something cheap at a high seed rate to ensure not only soil cover but lots of roots per square metre. Preferably something with a reasonable taproot and some finer fibrous roots. Mustard is perfect for this. Crops in store can also provide a good starting point, such as OSR, Linseed, and be very cost effective.

A monoculture cover of mustard, very cost effective and plenty of roots per square meter.

It is very easy to lose confidence in the system in the early years especially when experience is low, the risk of cash or cover crop failure is high and

there is little self-belief. To ward against this is it easy to think that if you spend a lot of money on a cover crop mix that you must be doing the right thing. Confidence then takes a crash as only two or three species of the expensive mix actually establish and the cover crop looks very thin and you realise it was an expensive mistake. In our experience it is much better to sow a simple crop and get it established in good time.

Many people get hung up on cover crop species and not wanting to grow brassicas or legumes because they have them as cash crops in the rotation already. We have been told not to grow these too close in rotation due to the potential build-up of soil borne pathogens such as club-root (a nutrition issue in reality) and rhizoctonia. But generally we don't seem so concerned about growing cereals close in rotation. All of the in-field evidence suggests that using legumes and brassicas in cover crops does not increase the incidence of these pathogens providing they are not grown as a cover crop immediately prior to planting the same species as a cash crop. The only detrimental incidence I have seen is where BYDV incidence was high in crop of winter barley grown after spring barley volunteers were used as a cover and destroyed on the day of drilling the winter barley.

For over-wintered cover crops legumes are essential to balance out the large carbon input from straw and lignified cover crop residues. Too often we see situation where the following cash crop is struggling due to imbalanced soil carbon to nitrogen ratios, a big part of the feared yield dip. There is a desire to spend the budget on the seed and then forget nutrition. In order for cover crops to fulfil they part in the system we need them work hard, but to work hard they need nutrition. Chopped straw and other crop residues can quickly push the C:N too far in excess of carbon which then reduces the nitrogen available for the growing cover crop.

Most cover crops are destroyed before the crop has completed its full life cycle, we believe this is also detrimental for some pathogens which reduces the likelihood of pathogen build-up. As the soil biology begins to build we also see

A more suitable cover crop with 3-4 species

trash degrade quicker, large earthworm populations in particular can cover and digest chopped straw residues within a few months with ease. This reduces the chances of a green bridge effect of pathogen transfer. Some growers are also reporting that fusarium levels are much lower than the fusarium risk assessment would suggest. Again we believe this is attributable to increased straw digestion by greater soil biological activity.

In our brave new world of Boris's bold optimism it is important not to let the failures outweigh the successes. We must have a mindset of positive thinking and believe in the system for success.

FARMER FOCUS
ADAM DRIVER

"Driver Farms is a family run 1200ha contract farming business based in Suffolk farming hanslope series clay. They practice a regenerative agriculture system based on zero and min till. All agronomy is carried out in house. They are also five years into running a 12m CTF system'

I have just been to look at a field of our no till rape. Not much rape on this one. Flea beetle is probably the automatic thought for many when OSR fails, it's a great way to divert any blame from your own management. Roared through with a tillage train and got rid of any modicum of moisture? Flea beetle. No tilled into a stripper headered field of spring barley that you know needs mole draining and has a history of bad slugs? Flea beetle did it mate, not my fault they took our chemicals away.

It is my fault. Probably shouldn't have planted it in first place and moled as planned, probably should have been more vigilant on slugs, probably drilled it too deep. At least we have learnt something and can now improve for next year. Happily, the rest of the OSR looks good with its companion crops of buckwheat and berseem clover into both stripper headered and chopped spring barley, disc and tine drilled respectively. We have not used any insecticides, but this was never really on the cards anyway as it seems resistance to pyrethroids has built hugely and the impact on beneficial's is too much. However, they haven't really been much of an issue. We aren't in a flea beetle hotspot but have done everything in our power to try and combat them. Very high/stripped stubble, early drilling, no till, companion crops, a farm system now based around trying to build ecosystems. So far so good, but let's wait and see what it's like in the spring. The bad field will be moled this week (1st Sept), follow by a dose of chicken muck, followed by a shallow cultivation in which we will broadcast a cover crop.

Osr berseem and buckwheat into stripped spring barley

Last October we planted wheat into stripper header harvested spring oats. We used a couple of different demo drills which were both great (Sly Boss, Horsch Avatar). It looked a wonderful mess for a long time, neighbours seemed to be looking at it a lot. I loved the thatch of soil armour it provided and the wildlife seemed to thrive. It ended up yielding very similar to the standard shallow cultivation we would usually do, there was also less blackgrass (but still too much) on what is a bad block. The headlands were worse however, but again this was my fault. Usually I drill headlands last, however I should have done them first and avoided running straw down in all directions. Lesson learnt and I did the headland first to good results when drilling the OSR into similar conditions. On the back of the original demos we bought the Horsch Avatar, sharing it with another similar sized farm. It complements our tine coulter Horsch Sprinter fantastically. The Sly is excellent and I thoroughly recommend it, but it wasn't being made in the 12m wide version we wanted to fit in with our CTF system.

Osr berseem and buckwheat drilled into row with Horsch sprinter on 2 inch Dutch points into chopped spring barley.

We have planted a lot of cover crops this year, broadcast from the back of a cultivator. We have seen big yield differences between pure no till and shallow cultivated land in spring crops. Most of our land is owned by other people so we cannot afford the risk of no till in the spring yet. This seems like a good compromise for the time being as the system evolves, we learn more and the soils improve. It's all very well trying to no till some of this clay in the spring, but not if it could cause us to lose business. Although our aforementioned co-owner of the avatar drill claimed he could see "Plumes of carbon" rising from our cultivator from 3 miles away...

Cover crops comprise of phacelia, buckwheat, linseed, sunflower and some clover. I saw someone talking about this sort of mix on social media or a magazine and copied it. Cost is about £24/ha and the components have all been used in various other mixes in the past, they are the ones that were always the most useful. The aim is to balance C:N ratios and not have too much residue to deal with come spring. I am loathed to use any brassica in a cover crop, they seem to breed slugs horrendously, mustard especially seems to cause more problems on our

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Winter wheat planted into stripped spring oats

clay soils. I also heard an interesting theory that involved beneficial nematodes that are predatory to slugs. What do spud farmers use for PCN? Biofumigant brassicas, work that one out.

This whole web of nature that we are trying to work with becomes ever more complicated to me by the day. Modern agriculture is essentially based around putting the correct active ingredient on to kill a pest, weed or disease at the perfect timing and making sure you put fertiliser on in some nice even splits, again at the correct time. There is an idea of 'integrated farm management' that is regularly read about these days, but to me this is still based around chemical answers and mainly involves threshold, not chucking chemical on just in case and trying to stop chemicals getting banned. Which is good stuff but just a start.

Regenerative agriculture is an exciting next step where the farm system is no longer built around synthetic chemicals and fertiliser, instead they are a useful and important addition within the system. In place we are building our own defences by trying to harness nature and all its power (which as we know always beats chemical answers eventually anyway). There are to be an exciting evolution happening amongst farmers who have started to really change the way that profitable high yielding farming can be done. I am not one of these yet, but I am happily copying and learning as much as I can from these guys if I think they will work on our farm. Twitter is a great tool for this kind of lurking and learning, especially if you can avoid arguing and debating. I struggle with that though!

There is a lot of doom and gloom in farming at the moment. You open a magazine and another industry leader is writing about how unfair it is another chemical has been banned or how the consumers don't value us. It's both negative and defensive but an understandable reaction in difficult times. What I have found since getting into this regenerative ag thing about 5 years ago was how positive everyone involved is about the farming and the future. The atmosphere at Groundswell was a myriad of thought. The lectures so full of information and methods that you simply do not hear about at more conventional events like Cereals. The trend seems to be growing, the more of us starting to tread this path the more we will learn. This farmer to farmer knowledge exchange is key for us going forward.

What's next? We often hear the phrase that fixed costs are variable and variable costs are fixed. Our fixed costs are in a good place according to benchmarking we do. I do believe there is still room for improvement, but in reality this kind of cost saving is fairly black and white, it's instantly obvious where costs can and should be saved. This is basic business and should be addressed quickly if there are issues. With this sorted, and a smooth office system running it leaves us time for the most important thing we do, growing our crops and developing the system. The variable input costs are much harder to start cost cutting on. It is such a fine line between a certain product producing a positive margin over input cost and these details are often difficult to quantify on a farm scale. Again, looking at benchmarking we are low input compared to many. My father and I do our own agronomy here so the buck falls with us which gives us the confidence to cut back when needed. This isn't without excellent information we get from NIAB and CMI. However, this is just cost saving in a conventional agronomy system and this can be done through buying well and knowing what you are doing agronomically. What I am trying to learn more about is how we start using biology and nutrition to help with crop protection. I believe we are just scratching the surface of this. The added benefit is moving towards this kind of system will also help massively with aforementioned 'IFM' taking the pressure off the active ingredients and allowing them to be used less but more effectively. I have been running around with a brix refractometer and taking tissue leaf samples, but I will be honest and say I am only just starting to get a vague understanding of this and how it can affect our fungicide programs or issues with insects. Brewing up beneficial biology is an exciting prospect for next year and I have a tank set up ready to do it. I have learnt about this sort of thing by visiting BASE UK members farms with a group called Agricecology.

Despite the uncertainty surround our industry, I believe exciting times are ahead. A sharp and open mind with a working calculator will be important tools going forward and as always, a willingness to take some risks.

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SOIL HEALTH: LET'S GET PHYSICAL (CHEMICAL AND BIOLOGICAL)

If you want to know how healthy you are, there are a myriad of tests and tools to help you 'quantify' your body condition – blood pressure, body mass index and cholesterol level, for example. Now there is a move to develop ways to quantify the health of your soil, too.

In 2016, AHDB and BBRO funded the five-year Soil Biology and Soil Health Partnership. With its focus on soil health, one goal is to produce a toolkit to assist with its measurement and management.

One of the first tasks was to review what could be measured and how practical it was to measure it. A broad range of indicators (physical, chemical and biological) has been assessed by the research team, including:

- Common indicators: pH, routine nutrients, bulk density and penetrometer resistance
- Less common indicators: visual evaluation of soil structure (VESS), soil organic matter/loss on ignition (LOI), respiration and earthworms
- New indicators: total nitrogen, microbial biomass carbon, potentially mineralisable nitrogen (PMN), DNA measures (e.g. of pathogens), nematodes and microarthropods

With so many soil attributes available for measurement, a simple way to bring the most relevant ones together was essential – enter the 'soil health scorecard'. The team has identified threshold values associated with each attribute. When the results from the various field measurements are entered into the scorecard (currently an Excel spreadsheet), a traffic-light system flags up whether anything requires investigation (red), monitoring (yellow) or, if things are good, where no action is needed (green).

To test the approach, a network of seven experimental sites has been established. The sites represent a range of soil management histories, soil types, soil organic matter additions, pH levels, drainage statuses/structures, climatic conditions and rotations (including grass leys, cereals, sugar beet and potato production).

A research case study, available on the AHDB website, has been developed for one of these sites. Located at Harper Adams University, it is a fascinating and unique long-term experimental site. Established in 1991, on a sandy-loam soil ('Wick' soil series), the site provides an extreme test for the prototype scorecard. It has a long history of repeat organic material additions (at recommended rates) in a predominantly arable rotation (cereals and potatoes). In fact, cumulative organic matter inputs range from 0 t/ha to 129 t/ha. Prior to the latest round of funding, the site had received support from a variety of sources: most recently, via the WRAP digestate and compost in agriculture (DC-Agri) field experiment (wrap.org.uk/content/digestate-and-compost-agriculture-dc-agri).

Five organic material treatments have been applied (Table 1). These include annual applications of cattle farmyard manure (FYM), cattle slurry, green compost, green/food compost and food-based digestate. There is also a control treatment, which has received manufactured fertiliser only. Fertiliser was also applied across treatments to ensure that nutrient supply did not limit crop growth.

Initial measurements of topsoil physical, chemical and biological properties were made in October 2017 and a soil health scorecard was produced (Table 2).

In terms of soil organic matter (SOM), the thresholds set were based on those considered typical for the soil type and climate. Unsurprisingly, the control – which received no applications of organic matter – had a relatively low SOM content. The light-textured soils responded well to the application of organic materials, particularly bulky materials, such as FYM and green compost.

Key nutrients were also measured – extractable phosphorus (P), potassium (K) and magnesium (Mg). Thresholds were based on values taken from AHDB Nutrient management guide (RB209). Levels of nutrients were relatively low in the control. Levels were higher across the organic matter treatments. The soils at this site are inherently high in extractable P, and management strategies would need to consider this across all treatments, especially the FYM treatment.

Visual Evaluation of Soil Structure (VESS) scores from the topsoil (top 30 cm) were also good at the site. VESS is a straightforward and quick way to test soil structure in three simple steps – soil removal, soil assessment and soil scoring. The soil quality score produced can help highlight where soil structure needs to be improved. Ideally, each distinct soil layer should be assessed separately, and management focused on the worst performing, 'limiting' layer. A score of 1 or 2 is good, a score of 3 is moderate and shows the soil requires monitoring, and a score of 4 and 5 indicates that management action is required.

Further information on VESS can be found, at: sruc.ac.uk/info/120625/visual_evaluation_of_soil_structure

Counts of the number of earthworms (total number of adults and juveniles) showed that all treatments were associated with an active population – more than eight per pit is an 'active' population for arable or ley/arable soils.

The application of bulky organic materials was also shown to improve topsoil bulk density (at 5–10 cm depth), from 1.4 g/cm3 on the control treatment to 1.3 g/cm3, where either FYM or green compost had been applied.

The plan is to repeat the sampling process for three more years of arable cropping (winter wheat, potatoes and spring cereal). The impact of additional organic material applications on a wider range of soil quality indicators will also be investigated.

Other long-term sites in the network are also using the approach to determine the effect of crop rotation, pH, tillage and drainage status on soil health.

The main strength of the scorecard is that it breaks down the challenge of improving soil health into manageable pieces. It can focus attention and guide management interventions to improve the overall health status of the soil.

During the remainder of the partnership, the soil health scorecard will be refined and tested across the experimental sites, and in consultation with the project's eight farmer research innovation groups.

A set of indicators, which can be used to measure soil health in the field directly or indirectly (i.e. through sending samples away for analysis), will be developed by the project. Critically, the research will also improve understanding of the relationship between each component of soil health and crop yield.

One of the most exciting areas of activity is the development of more robust indicators, benchmarks and thresholds for biological properties. The 2018 annual report includes details of innovative developments in molecular biology that are yielding ways to measure the soil biological community, including the presence and distribution of soilborne pathogens.

Information on the project can be accessed via ahdb.org.uk/greatsoils

Treatment	Applications to autum 2017	Organic matter loading (t/ha)
Control	None	0
Cattle FYM	23 Years	129
Cattle Slurry	23 Years	53
Green Compost	13 Years	62
Green/ Food Compost	7 Years	27
Food-based digestate	9 Years	7

Table 1: Organic Materia' treatments applied at the Harper Adams University trial site

Above: VESS assessment of the long-term farmyard manure (left) and control treatments (right)

Above: These earthworm populations were sampled from medium soils that received regular organic matter inputs (manures and crop residues). The effect of tillage system – conventional (left) and zero till (right) – on the number of large deep-burrowing earthworm species is clear to see

Eight farmer research innovation groups have been established across the UK to review the soil health scorecard approach

Attribute*	Control	FYM (23 Yrs)	Slurry (23 Yrs)	Green Compost (13 Yrs)	Green/Food Compost (6 Yrs)	Food- Based digestate (9 Yrs)
SOM (%)**	3.0	4.1	3.6	4.0	3.7	3.4
pH**	6.4	7.0	6.4	7.0	6.2	6.5
Ext. P (mg/l)	56	73	53	60	59	65
Ext. K (mg/l)	80	311	194	187	140	167
Ext. Mg (mg/l)	44	87	75	63	66	48
VESS Score	2	2	2	1	2	22
Earthworms (Number/pit)	11	13	9	11	9	13

Table 2: Example soil health scorecard for the Harper Adams University trial site
*** Attributes that showed a statistically significant difference between treatments (P < 0.05)*

No action needed *Monitor* *Investigate*

Case Study: Farmer learnings from the scorecard approach

George Renner farms with his parents on a 300 ha arable farm in Rutland on predominantly limestone brash soils. Their rotation is based around first wheats, with peas, oilseed rape, linseed and rye as break crops. George has been involved in the East Midlands farmer research innovation group, testing the soil health scorecard.

George says, "We have been direct drilling for 19 years with a John Dale Zero-Till drill and returning all crop residues to the soil by chopping and spreading with the combine. We use lightweight 100 hp tractors to help minimise soil compaction issues."

He continues, "I am interested in soil health because I see it as the key to cost-effective crop production. Heathy soils give crops the best chance of being heathy, with lower plant protection input costs. I think well-structured soils enable crops to have better nutrient usage efficiencies, potentially maintaining yields lower soil nutrient indices."

Through trying out the scorecard approach, George has found that it "helps me look at soils in a more rigorous manner than just heading out with a spade, and it gives me tools to keep a record of what I have found year-on-year. It also goes into far deeper analysis than I would do on my own, with the likes of the FERA Big Soil Community project involvement."

Their farm business is planning to introduce some 2-year legume fallows, as part of their Countryside Stewardship scheme. They are interested to see what effects this has for soil structure and health, and how they can further translate this into cash crop benefits for the farm.

LIVESTOCK – USING GRASS LEYS TO BOOST SOIL ORGANIC MATTER AND SOLVE THE **BLACK-GRASS CONUNDRUM?**

AHDB Animal Scientist, Siwan Howatson, takes a closer look at the potential to incorporate livestock into the arable rotation through establishing a grass ley, while improving soil organic matter and increasing soil resilience.

Soil organic matter (SOM) is an essential element because it provides the soil with the resilience it needs to sustain a crop, through supplying nutrients and the right environment for growing crops by enhancing the physical, chemical and biological properties of the soil. Continuous arable cropping with little or no inputs of organic materials has led to a reduction in SOM on many arable soils. In some instances, arable land has SOM values below 1%, while an average of 4% is desirable.

Is grass the answer?

Incorporating temporary grass leys into arable rotations has the potential to enhance SOM levels.

Improving SOM leads to increased moisture retention, better nutrient turnover and reduced risk of soil erosion. Grazing livestock on these temporary leys can also provide an extra advantage through the animal returns to the soil through manure, which is a good source of organic matter for the soil.

AHDB research shows that adding amendments, such as farmyard manure or slurry achieves a yield benefit over and above the nutrient content of what you apply, with benefits seen after just two years.

Leys should be treated as an arable crop, with good soil structure and nutrient supply to ensure yields are maximised. The target for commercial grazing systems in the UK and Ireland is to use 10 t Dry Matter per hectare.

There are many options for managing your grass leys, including grazing and silage production, and the type of ley should be chosen for its end purpose. See the table, which includes guidance on which type of grasses and clovers to use for your situation.

Managing your grass ley

A newly sown grass ley takes about 11 months to fully establish. During this time, it is important that the sward is encouraged to tiller as much as possible and is protected from any damage. An established perennial ryegrass sward typically contains 5,000–7,000 tillers/m2.

The tillering process in new swards is strongly aided by grazing because it removes existing leaf and encourages a new generation of tillers to emerge

at the base of the sward. Avoid using the new ley for cutting silage in the first six months, as this will not encourage tillering.

Graze the new reseed as soon as it is not possible to pull the plants out of the ground by hand. This is usually at the two-leaf stage or when the grass has produced about 2,200–2,500 kg DM/ha.

Use sheep or youngstock for the first grazing, to minimise any potential soil compaction, particularly in wet conditions. Aim to graze autumn reseeds at about 6–8 cm down to 4 cm before the first winter to encourage tillering.

The need for multiple harvests, through cuts or grazing, means it is crucial to focus on utilisation, because this has an important impact on the cost of production. Utilisation can vary from less than 50% to more than 80% in well-managed systems. Improved utilisation is linked to investment in infrastructure (e.g fencing systems for grazed swards or machinery for cutting systems) and allocation of labour.

Black-grass bonus

If you are considering introducing a grass ley into your rotation, there is the opportunity for the cultural control of black-grass.

It is important to remember that black-grass has low palatability for livestock, so the amount in the grass ley should be minimised. If the preceding arable crop had a high

black-grass burden, ploughing is recommended to bury the seed below the germination depth. Delayed drilling of the ley in the autumn, until after the peak black-grass germination period, or drilling in the spring, will further reduce the number of black-grass seeds germinating in the grass ley.

In either case, cultivations should be used to prepare a sterile seedbed, which can be managed with further cultivation and glyphosate. Minimising soil disturbance when drilling the ley will minimise any black-grass germination.

There are no herbicide options for controlling black-grass in the ley if it is to be used for grazing or conserved herbage. Cutting or grazing a grass ley within an arable rotation is recommended for black-grass control to minimise seed return, and allows a rapid decline in the weed in the seed bank, and a reduction in the resistance pressure to current herbicides.

When returning the grass ley to arable production, some viable black-grass seed will still be in the soil. Soil disturbance will stimulate this seed to germinate. Consequently, spraying off the grass sward with glyphosate and direct drilling is likely to result in the lowest black-grass population in the first crop following the grass.

Cost considerations

As with all crops, understanding production costs is crucial to ensuring the enterprise is profitable. Calculating the cost of the ley is a three-stage process: firstly, working out costs on an area basis, including establishment, inputs, machinery and rents; secondly, estimating your yield and, thirdly, working out the costs for pence per kilogram of dry matter. Worked examples of this can be found in the AHDB Livestock and Arable Rotation guide.

Harder to quantify are the benefits to soil health through organic matter increases, grazing benefits and improvements in black-grass control for following crops. In the right situation, a grass ley may well be a good option to consider for your system and soils.

More information on grazing techniques, including measuring grass and infrastructure, such as electric fencing, can be found in the AHDB Better Returns Programme (BRP) manuals. You can read more on introducing livestock into arable rotation in our new guide, available at: cereals.ahdb.org.uk/livestock

DO YOU KNOW YOURS?

Cost of production? Cash only net margin? Machinery depreciation per hectare? Holly Shaw, AHDB's Knowledge Exchange Manager for Benchmarking in East Anglia looks into the detail.

Holly Shaw - Farmbench

AHDB's Farmbench online benchmarking tool hopes to take the mystery out of physical and financial performance of multiple farm enterprises. The updated tool now incorporates cross-sector recording, including combinable, potatoes, sugar beet, dairy, beef, lamb and forage. With many people looking to reduce costs but not to the detriment of their soils and environment, Farmbench can highlight the areas that may need review.

David Lord who farms in Clacton-on-Sea, Essex, benefited from several years benchmarking to help confirm his decision to move to a Cross Slot no-till drill. David has recorded his figures since 2014, originally as part of the Colchester Monitor Farm Arable Business Group. Being able to analyse both the variable and fixed costs of the business, in particular the machinery and depreciation, made the move to direct drilling an easy sell on the business front. Over five years of recording with AHDB, David has reduced his cost of production per tonne by £24. The focus of reducing fixed costs was high priority for the business, and Farmbench helped highlight where these savings could be made. A 40% decrease on fuel consumption, is one area that has brought the cost of production down.

Discussing the figures inputted to Farmbench with other members of the business group, helped identify which were on-farm issues and issues that were typical of that growing year. This process was started off the back of the Colchester Monitor Farm benchmarking group and latterly through joining a group in South Suffolk. The detailed reports, showing the costs associated with all the combinable enterprises on farm, presented alongside others within the group and regional averages allowed greater scrutiny of the areas of high cost.

David said, "We needed to look at reducing costs with a system that didn't compromise soil quality and enabled us to reduce weeds. The ability to discuss the figures with knowledgeable peers not associated with your business gave an outside opinion, which is often needed when deciding to make big changes."

He continued, "analysis of your business by a third party often brings new suggestions for achieving your goal. More often than not, someone has already had a similar experience or knows of someone who has already achieved what you are hoping to. We, as a group, choose to meet twice a year – once in the winter to look solely at the figures and then again in June at one of the groups' farm. This year, I hosted the summer meeting, which helps put into context the reason why the figures are what they are.

Farmbench Summer Meeting

Using Farmbench was a straightforward process, simply entering data we already had in the farm office, but entering it in a way it can be used to compare against others, which is so useful."

The programme allows you to allocate costs across all of the enterprises on farm, either by total figure or on a percentage basis. Farmbench can be used individually to analyse specific crop performance, or to help make decisions on cropping, inputs and marketing. As part of a discussion group, farmers who are part of national groups use the tool to enable them to draw comparisons between their businesses. The strategic dairy and beef programmes, progressive beef and sheep, are currently using the programme to add benchmarking to their 3-year projects.

The Farmbench programme benefits from both a regional technical team covering all the sectors and a dedicated helpline to assist with user issues and registration. To register with Farmbench, visit: ahdb.org.uk/farmbench

Lord & Hunt Farm Details

- 650ha of which 565ha is combinable cropping
- Family owned and run business
- Typical cropping includes winter wheat, oilseed rape, spring barley, winter beans, spring oats, peas and rye
- Farming conventionally on clays - silty clay loams
- The farm is in Entry and Higher Level Stewardship
- Farm diversifications include: wind farm, fishing lake, solar PV, camping, caravans, self catering cottages, B&B and Christmas turkeys.
- Farm formerly mixed, with dairy and beef - these enterprises ended in 1999.

NO-TILL KNOWLEDGE, NETWORKING ON TAP AT 28TH ANNUAL NNTC

A variety of powerful, educational speakers will be on hand when the 28th annual National No-Tillage Conference convenes Jan. 7-10, 2020 in St. Louis, Missouri, USA.

Behind the theme "Banking More No-Till Dollars," headliner speakers at this 4-day event at the newly redeveloped Union Station Hotel include:

- Roberto Pieretti, long-time no-tiller and farm consultant from Argentina
- David Johnson, research scientist and molecular biologist, New Mexico State Univ.
- Robert Saik, ag futurist and consultant, Alberta, Canada
- Jason Mauck, relay cropping/ interseeding, Gaston, Ind.
- Steve Groff, cover crop expert, Holtwood, Pa.

In addition, two exclusive pre-conference workshops (additional cost) will cover soil biology, and no-tilling hemp as a specialty crop. There will be 23 focused classroom sessions for intensive learning, and more than 70 roundtable discussions allowing attendees to discuss specific no-till challenges with their peers and find solutions.

A welcome reception, several meals and a dessert/networking session will enhance the networking opportunities. A revamped spouse's program with enhanced opportunities for learning through the Women for the Land program (American Farmland Trust and NRCS) will make NNTC an even more attractive event for farm and family members.

To learn more about NNTC, go to www.notillconference.com. The full printed program should be available online in early October.

28th Annual NATIONAL NO-TILLAGE CONFERENCE
January 7-10, 2020 • St. Louis, MO

DRILL MANUFACTURERS IN FOCUS...

DALE DRILLS

WHY TINES?

This summer has been yet another busy one for us, with drill building in full swing. It has, as always, been punctuated with exhibitions including Cereals and Groundswell. A great opportunity for us to discuss our machines with potentially new customers, we always make the most of the shows and try and speak with everyone who visits our stands. These discussions are often varied and always interesting, however there are certain common questions we are asked, the most frequent being:

So why tines and not discs?'

It is clear that both openers have their advantages and obviously as a tine drill manufacturer, we are biased. That said, our preference for tines is considered and the following is our reasoning behind this choice.

We believe the three main differences between tines and discs are: Disturbance, Weight, Cost.

Disturbance

It goes without saying that narrower tines working to a shallower depth will reduce disturbance. Disturbance of a tine can also be reduced by reducing the forward angle of the point. Taken to the extreme, a backward facing point would have very low disturbance, but clearly would be more inclined to smear the soil and would create compaction within the bottom of the seed row. The leading edge of a disc could be argued to be the same as a backward facing tine.

The additional disturbance of a tine is said to be not desirable due to the potential for weeds, such as blackgrass, to be more likely to germinate. If weeds such as blackgrass are a problem, agronomists are likely to encourage delayed autumn sowing and a large herbicide stack. Delaying drilling in the autumn normally means sowing into wetter soils, where narrow, forward facing tines (such as the Eco Tine) avoid smearing and ensure seed is properly covered over. The covering of the seed being essential in preventing loss of vigour from residual herbicides being sprayed onto the seeds.

Our Eco Tine is designed to create the optimum amount of soil disturbance, placing seed into fine tilth which can be consolidated around it, ensuring good seed to soil contact, whilst preventing smearing of the soil. All of this is achieved using a 12mm wide tine with a forward facing angle drilling down to approx. 10mm below seeding depth.

Weight

The action of pulling a forward facing tine through the ground creates a downward force, holding the tines in the soil. On the other hand the leading edge of a disc is always having to be 'pushed' down into the ground. As a result significantly less weight is required to gain and maintain penetration with a tine opener compared to a disc. Not needing to be as heavy is a significant plus, particularly in no till situations where compaction of the soil should be avoided at all costs.

Not requiring excessive coulter weight allows for wider working machines and comparatively smaller tractors can be used to pull them. This reduces the amount of soil trafficked and the overall weight put over the soil, significantly reducing soil compaction.

Wider and lighter seed drills are best suited to delayed autumn drilling as they offer higher output to ensure drilling is completed in potentially tighter 'weather windows' later in the autumn, whilst also avoiding excessive weight on potentially wet soils susceptible to compaction.

Cost

With no moving parts a tine coulter does not require a bearing, making it a cheaper and more simple option. The Eco Tine is constructed from Boron Steel and is tipped with Tungsten Carbide which combine to offer an average life of 500ac/m of drill (a 6m Eco will drill approx. 3000ac on one set of tines, although this can vary depending on factors such as soil type, etc.).

Less frequent replacement of wearing parts along with a more simple process to replace them, ensure tines offer further savings.

Dale Drills will be exhibiting at the Midland Machinery Show & Croptec in November.

What if you could simply create the perfect seed bed?

At Dale Drills we're as passionate about your soil as you are. As farmers we know just how vital good soil structure is to the health of your crop – locking in vital nutrients to create optimum conditions for sowing and growing.

Capable of drilling in direct, min-till and conventional seedbeds our versatile range of lightweight seed drills have been made with exactly that in mind – promoting low impact cultivation that encourages minimal disturbance. Renowned for excellent contour following, accurate seed placement and a low power requirement, why not see how our drills can help your business fulfil its full potential?

daledrills.com info@daledrills.com 01652 653 326

DALE DRILLS

THE FUTURE OF EFFICIENT CROP ESTABLISHMENT

SOLID PROGRESS MADE IN PERENNIAL WHEAT RESEARCH

A wheat crop from plants which yield year after year has huge attractions for both the farmer and the environment. There's no yearly crop establishment. Plants develop strength and get deep rooting. Carbon capture is enhanced. Creating a commercially viable perennial wheat has been a fundamental challenge that has been taken up by The Land Institute in Salina Kansas, which is focussing entirely on creating perennial varieties of annual crops. *Written by Mike Donovan, editor*

Founded in 1976 by geneticist Wes Jackson, the Land Institute's work is led by a team of plant breeders and ecologists in multiple partnerships worldwide, and is focused on developing perennial grains, pulses and oilseed bearing plants to be grown in ecologically intensified, diverse crop mixtures known as perennial polycultures. The Institute's goal is to create an agriculture system that mimics natural systems in order to produce ample food and reduce or eliminate the negative impacts of industrial agriculture.

Wes Jackson, the plant geneticist who created the Land Institute

As an undergraduate Wes Jackson noticed the inherent robustness of the native prairie compared with the fragility and the increasing chemical dependency of the annual monocultures that constitute the American breadbasket. Every acre planted is an uphill battle against the natural order, which favours diverse perennial polycultures — deep-rooted, enduring plants that form synergistic communities that define the essence of resiliency as demonstrated by the Dust Bowl experience — when an extended drought hit the lower Midwest in the 1930s, turning tens of thousands of acres of native prairie that had been ploughed up to plant wheat into massive, deadly clouds of dust. Meanwhile, the undisturbed prairie, with its deep roots and highly evolved survival traits, remained intact.

Roots develop into a thick and deep mass

Jackson's fundamental premise is that humankind took a wrong turn when it began ploughing up the land and planting homogeneous annual crops. As he told Modern Farmer, "... there was a dualism that developed — wild nature, with virtually no soil erosion, and then us with the plough... Now we have not only soil erosion but chemical contamination of the land and water with fertilisers and pesticides and so on."

Perennial crop solutions

Perennial crops are robust; they protect soil from erosion and improve soil structure. They increase ecosystem nutrient retention, carbon sequestration, and water infiltration, and can contribute to climate change adaptation and mitigation. Overall, they help ensure food and water security over the long term.

The crop in the field

Perennial grains, legumes and oilseed varieties represent a paradigm shift in modern agriculture and hold great potential for truly sustainable production systems.

The Land Institute is using two approaches to breed perennial grain, pulse, and oilseed crops:

1. Domestication of wild perennial plants
2. Perennialization of existing annual crops.

Domesticating wild perennials

Farmers have been domesticating wild perennial plants for the last 10,000 years. This is the approach that resulted in many of our current crops.

Domestication starts with identification of perennial species that have one or more desirable attributes such as high and consistent seed yield, synchronous flowering and seed maturation, and seed retention, also called non-shattering (a feature of non-shattering plants that hold onto their seeds like an ear of corn rather than disperse them over the landscape like a dandelion).

Large, diverse populations of the crop are grown out at The Land Institute, and plant breeders select the best individuals for the traits of interest. These individual plants are then cross-pollinated, and the resulting seeds are planted to produce the next improved breeding population.

The Land Institute established the

perennial wheat program in 2001 with the goal of developing perennial wheat that is economically viable for farmers and replaces the global food calories of annual wheat.

Annual wheat is grown on more acres than any other grain crop, at 548 million acres worldwide, followed by maize at 445 million and rice at 399. Wheat accounts for 20 per cent of human food calories and more protein calories than any other grain.

The programme at The Land Institute creates perennial wheat hybrids made from crossing annual wheat species with wheatgrass species (especially intermediate wheatgrass, which is the same species being domesticated as Kernza®). The annual types include bread wheat and durum wheat used for making pasta. Many successful hybrids have been achieved between wheat and wheatgrass. They are being used to understand the genetic contribution of the annual and perennial parents. Other research partners around the world have made similar crosses between annual and perennial wheat.

Twenty of the most promising crosses are being grown in nine different countries to see how particular genetic types vary in performance when grown under a broad range of environmental conditions. The best performers have a grain yield grain about 50-70% that of annual wheat cultivars.

Perenniality (the ability of the plant to regrow after grain harvest and to survive harsh winters and/or summers) is also highly variable depending on environmental conditions. Some of the perennial wheat plants in Kansas have lived for more than six years. In other locations, stands of perennial wheat have persisted for many more years.

Their breeding program continues to seek improvements on a number of plant traits including perenniality and yield. Although we see steady improvement every year, we expect it could take another 10-20 years to develop an economically viable perennial wheat variety.

With a goal as bold as "changing the way the world grows its food," all partners are critical to success. They provide insight, data, operations support, connectivity, and an expanded community of brainpower and technical capacity. The Institute currently has research partners in 41 different locations around the world, but none in the UK. Global partnerships spread researchers' knowledge and botanical germplasm across six continents with diverse climates and soil types.

Partners are helping to fully develop Natural Systems Agriculture, and plant breeding is a numbers game. The more experimental lines evaluated, the better the odds of developing superior, high-yielding perennial crop varieties. The Institute is dedicated to ensuring worldwide

Harvesting Kernza (intermediate wheatgrass) in August 2010 from a demonstration field near The Land Institute.

food security without compromising ecosystems.

In 1983, using Wes Jackson's vision to develop perennial grain crops as inspiration and guidance, plant breeders at the Rodale Institute selected a Eurasian forage grass called intermediate wheatgrass (scientific name Thinopyrum intermedium), a grass species related to wheat, as a promising perennial grain candidate. Beginning in 1988, researchers with the USDA and Rodale Institute undertook two cycles of selection for improved fertility, seed size, and other traits in New York state.

The Land Institute's breeding programme for intermediate wheatgrass began in 2003, guided by Dr. Lee DeHaan. Multiple rounds of selecting and inter-mating the best plants based on their yield, seed size, disease resistance, and other traits have been performed, resulting in improved populations of intermediate wheatgrass that are currently being evaluated and further selected by collaborators in diverse environments.

Experiments are also underway to pair Kernza® with legumes in inter-cropped arrangements that achieve greater ecological intensification, and to utilise Kernza® as a dual purpose forage and grain crop in diverse farming operations.

The breeding programme is currently focused on selecting for a number of traits including yield, shatter resistance, free threshing ability, seed size, and grain quality.

In the next 10 years, the Institute's aim is to have a crop with seed size that is 50% of annual bread wheat seed size. Our long-term goals include developing a semi-dwarf variety and improving bread baking quality.

Ultimately, we hope to develop a variety with yield similar to annual wheat and to see Kernza widely grown throughout the northern United States and in several other countries around the world. If that vision becomes a reality, you might see perennial grain in common staples found on grocery store shelves.

Plant breeders report increasing success

At the 2018 Prairie Festival scientists from the Land Institute explained the advances they were making in the development of perennial wheat and other crops. Lead scientist Dr Shuwen Wang explained that the process in the past year had created 297 new cross-bred, 570 embryos created and 9,176 single flower heads compared. He told the audience that research was being carried out in eight separate countries ranging from equatorial to temperate. The 2017/18 results were better than previous years, with some tests being done on wheatgrass which has an additional 14 chromosomesto regular wheatgrass.

The crossing work started in 2011 when the first set of crosses was made and this has now created more than 500 plants which are available for testing and breeding.

This year they were very pleased to have produced five rows of uniform plants which shows it is possible to get close to stability, and the seeds generated are being sent to the overseas research stations for further evaluation and experimentation. Some will be crossed with annual cultivars and will also be involved in gene stacking.

Dr Wang said there were agronomic difficulties in these experiments. The toughest of these is weed control. Plant numbers remain small and the susceptibility of each of them to chemicals is different. When the numbers of individual plants of each cross are so few the opportunity to try out different herbicides is small. He said that weeds in these test circumstances "grow like crazy".

A similar problem occurs with fertilising. There's no handbook to suggest the stages when the plant needs fertiliser, or indeed the compounds that are most effective.

Research has shown that the

Perennial sunflowers in a field trial

The location of research partners extends across all continents

perennial plants do better in mild seasons and have a tougher time in both high and low temperatures.

Kernza® Grain Goes to Market

The Land Institute developed the registered trademark for Kernza®

Kernza grain sample

grain to help identify intermediate wheatgrass grain that is certified as a perennial using the most advanced types of T. intermedium seed. The goal is to develop varieties that are economical for farmers to produce at large scale.

The aim is to create a recognisable and protected brand - they say "When you buy Kernza® perennial grain, you can be certain that you're eating product grown on a perennial field that is building soil health, helping retain clean water, sequestering carbon, and enhancing wildlife habitat."

Patagonia Provisions was the first company to develop a commercial retail product for the mainstream marketplace. The company took the risk of product development and market entry for their product called, appropriately, Long Root Ale. A number of restaurants have taken up Kernza® as an ingredient, using the perennial growth as a marketing tool. Hopworks Urban Brewery in Portland, and Vancouver, brews Long Root Ale for Patagonia Provisions and has it on tap, in addition to the ale in four-pack cans being sold in Whole Foods in California. Bang! Brewing in St. Paul has a Kernza® beer available, as does Blue Skye Brewery in their home town of Salina.

Innovative Dumpling & Strand produces Kernza® pasta which they retail through Twin Cities-area farmers' markets. There are a few other small-scale retail food outlets scattered around the country, but to our knowledge, those are the most reliable sources right now.

Additionally, Cascadian Farm is excited to incorporate Kernza® into some of its foods, with expectations for products made with Kernza® available in retail markets by late 2019. Cascadian Farm has agreed to purchase an initial amount of the perennial grain which allows us to arrange with farmers to plant on commercial-scale fields versus the test sized plots currently being grown.

General Mills (parent company of Cascadian Farm) approved a $500,000 charitable contribution to the Forever Green Initiative at the University of Minnesota in partnership with The Land Institute, to support advanced research to measure the potential of Kernza to significantly reduce greenhouse gas emissions associated with food production, determine best management practices for sustainable production, and increase Kernza yields through breeding.

The hope is that increased demand for Kernza® products translates into more growers and acreage dedicated to Kernza® perennial grain, resulting in more Kernza® in production and on shelves, which in turn encourages more research and development into Kernza® and other perennial grains.

Patagonia's and General Mills' early commitments to create a market for Kernza® are significant milestones. Yet the transformation to an agriculture and a food system based upon perennial grain crops is a complex and long-term endeavour. Other perennial grains, oil-seeds, and legumes require agro-ecological research beyond that which market forces alone can provide at this critical juncture.

The Institute says "We have been leading this research effort for forty years and we welcome your support of our work to help sustain the next vital stage of this agricultural revolution."

Kernza® grain is the first perennial crop from The Land Institute's work to be introduced into the agriculture and food markets, but our researchers are currently working on others, including perennial wheat, perennial rice, perennial sorghum, and wild sunflower, with more to come.

Followup: The Land Institute, 2440 E Water Well Rd, Salina, Kansas 67401
https://landinstitute.org/

info@landinstitute.org

Scan me

THE LAND INSTITUTE

GROUNDSWELL 2019 REVIEW

It seems a long time ago now, but Groundswell 2019 came and went with heaps of ideas and enthusiasm from speakers and attendees. It really is a joy of a show to put on, there are so many interesting people who all want to be involved in the sea-change that is happening in agriculture at the moment.

We had a terrific variety of speakers this year, from the headline attractions like Allan Savory and Charles Massy, who both gave a couple of concise and devasting accounts of what is wrong with so much mainstream agriculture around the world and how we can improve things, to the myriad lectures and discussions about methods for making your farm and operation work better and in tune with nature.

Shorthorn calf

I particularly enjoyed Frederic Thomas's talk about dealing with weeds in no-till. He was asked where he thought his farming would be in ten years time. His reply was that when he started no-tilling, he thought that this was the answer to all his problems. He has since realised that

'going no-till' was merely opening the door to a magical kingdom beyond, where all sorts of ways of farming were possible...and so where-ever we are going to be in ten years, it's going to be quite different from where we are now.

Jay Fuhrer spoke to packed barns on a similar theme. His three tenets of no-till expand every time I hear him speak, as more ideas flood in to help us regenerate our soils and make farming them so much easier and more profitable. He also was part of our 'first principles' thread of lectures which were designed to help farmers who are thinking of 'going no-till', to get a firm understanding of what you need to do to make it work.

As most people are aware, it isn't just a case of buying a no-till drill and selling all your cultivating kit and Bob's your uncle. However, if you are going to buy a no-till drill, then there they all were, demonstrating away. And a lot of drills were sold, so the message is filtering through.

One of the interesting side-effects we've noticed over the years is the number of attendees coming who are not farmers, but are really excited about what is going on. We had some really interesting fringe discussions with delegates who had ideas for helping UK agriculture make this transition...there are so many ways that regenerative farming results in 'public goods', like carbon sequestration, improved water

Frederic THomas Q&A

Allan Savory addresses a full Conference Barn

Simon Cowell in the Seminar Barn

Paul Cherry, Minister Robert Goodwill and Jay Fuhrer

Sly demo

Mob grazing

cycling, air quality and drought and flood prevention, all of which could earn farmers extra cash. I was particularly intrigued by the idea of Green Bonds which would effectively be financed by Insurance Companies (who would benefit from much smaller payouts due to less flooding)

Soil test tubes

and which would pay farmers who could stall water on their land through better infiltration: in effect a privatised form of subsidy.

Compost turning

We had other speakers, like William Kendall and Nick Barnard, who surprised a lot of people by introducing them to ideas about marketing produce which they didn't think were relevant to their businesses, but, of course, they are. In a similar vein, Isabella Tree and Charles Burrell gave a fascinating account of their rewilding experiment at Knepp, complete with financial information and they largely won over an initially sceptical audience with their story.

Unfortunately, we didn't record all the talks, but a lot of them are available on the Groundswellag YouTube channel to watch at your leisure. We pulled up the drawbridge this year and stopped selling tickets as we exceded our capacity, we didn't want fights to break out with delegates struggling to get into talks. Next year we are again swivelling the venue around and we are going to have a bigger and better demonstration field with more and bigger tents for talks etc. We hope to see you there.

John Cherry

PRODUCTS IN FOCUS...

LOW INPUTS AND HIGH YIELDS ACHIEVED BY UNLOCKING CROP POTENTIAL WITH BIO-STIMULANTS

Increased yields and performance reported

Combining drilling with the timely application of biological crop stimulants has resulted in encouraging yield responses and improved quality performance, independent trials and first-time user tramline trials indicate.

AminoA products are natural bio-stimulants, obtained through enzymatic hydrolysis. Containing essential amino-acids that plants synthesise throughout their growth cycle, they can contribute positively to yield and quality if the plant is not already producing optimal levels of amino-acids itself.

The latest replicated trials with a single use, autumn application of AminoA has provided yield responses of 0.5t/ha, matching other single application trials in 2018 at T1 and T2 timings. Other independent trials gave 10.3% more yielding in OSR crops. But how does this relate to experiences on farm, with the paying customer?

Farming some 1659ha ranging from Kelso, Scotland, to Cambridge, Triton Farms director Simon Chaplin believes the use of AminoA FLO from AminoA Bio-stimulants has been crucial in increasing yields and profitability.

Mr Chaplin first trialled AminoA back in November 2017 to boost rooting development on late drilled crops. Applying the product in February as the crop is emerging from the ground, Mr Chaplin has found AminoA FLO to stimulate greater root development, seeing crops on his Abington Park Farm in Cambridgeshire at even 7th wheat, looking more like 1st wheat.

"Our philosophy is very much about extending the profitable part of our rotation, and seeing our 4th, 5th 6th and even 7th wheat looking like 1st wheat, is making a difference," explains Mr Chaplin.

The results are showing at the weighbridge too, as the second harvest since using AminoA products reflects. "2018 yields on the weighbridge at Abington were our best-ever until now, with some 750 tonnes more across the farm," Mr Chaplin adds.

With 2019 harvests still coming in across Triton Farms, indications are that this record will again be broken. Trials over 36 x 0.5ha plots have shown 0.47 t/ha yield increase when 2 litres of AminoA FLO was applied at early flowering to winter wheat, with 0.31 t/ha when 1 litre was applied flowering. This is following a full season's programme, and results would have been even more dramatic had it not been for previous treatments.

Over the two farms near Kelso in Scotland, Mr Chaplin has seen 5.1 t/ha over 320 acres of OSR at the weighbridge, in some places this would have been at least 6 t/ha. Winter wheat averaged at least 11.5 t/ha over 650 acres, with some parts being in the upper 12 t/ha, all 1st wheats.

Key to the success across all Triton Farms has been the low input costs. At Abington Park Farms, fungicide costs have averaged at just £22/ha and herbicides at £32/ha on wheats, with Mr Chaplin planning to reduce further for the next crop. His agronomist confirmed no visible diseases, despite these low input costs.

Similar yield responses have been reported elsewhere in the country. Tramline trials on an 800-acre farm in Northumberland have seen a yield response of 8% on OSR, with wheat results to follow. A Doncaster farmer claims AminoA has given him a 1 t/ha yield increase in spring oats.

One Leicestershire farmer using AminoA FLO for the first time on his 200ha farm growing wheat, OSR and fodder beat amongst others, reports good yield responses and plans to use the product again next year, having seen enough positive evidence.

In Peterborough, farm manager James Robinson explains, "As with others, we have seen good yields all round, but we have seen some changes compared to other local fields.

"Our OSR certainly stayed greener and for longer on the fields where we applied AminoA. Likewise, despite the very dry spring, when AminoA was applied to spring barley it greened up very quickly and produced a good yield," he adds.

Mr Robinson enjoyed an average yield of 9t/ha on the spring barley, proving to be the thickest crop he had seen.

Richard Philips, managing director of AminoA Bio-stimulants says, ''Our products are deliberately designed to have broad spectrum activity, as they contain every essential amino-acid that plants synthesise throughout their growth cycle."

He adds, "Repeated use of our products, in combination with other agrochemicals, will enhance their effectiveness and produce a yield response in the crop, as these results are proving."

Unlock the potential of your crops.

AminoA Biostimulants a complete range of L-isomer amino-acid products. Suitable for use in all crops

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AMINOA BIOSTIMULANT EFFECTS

- Increase root development
- Improve leaf and bud development
- Stimulate blossom, formation and growth of fruit
- Increase resistance to stress by cold, heat, drought, and agrochemical phytotoxicity
- Facilitate and increase nutrient absorption by roots and leaves
- Stimulate early and more uniform fruit ripening
- Stimulate mobilisation of Calcium (Ca) in fruit
- Extend fruit preservation after harvest
- Increase Iron (Fe) and Potassium (K) in the plant

IMPROVE PROFITS BY

- Increasing yields (trials have been conducted in many different crops and countries to support the efficacy of our products:
  - Winter Wheat yield increases 6-18%
  - Oilseed Rape 250-1000kg ha
  - Potatoes >8000 kg ha)
- Improving quality
- Manipulating harvest date
- Improving the efficacy of inputs (Fertiliser, agrochemicals, trace elements)

ENVIRONMENTALLY FRIENDLY

AminoA Biostimulants are safe to handle, are a food source for soil microorganisms and leave no pesticide residues.

FLO AminoA

AminoA FLO is an easy to use liquid natural amino acid complex with in-built spreading and anti-foam technology to provide optimum plant cover and uptake.

AminoA FLO has been formulated to use in tank mixtures with other agrochemicals and fertilisers

AminoA FLO should be applied at 2.5 litres ha in minimum of 100 litres water or at 1 litre in fungicidal tank mixtures.

GRO AminoA

OF&G ORGANIC

AminoA GRO is a liquid natural amino acid complex formulated to be suitable for use in all organic production systems

To find out how are our products can improve your crop performance email **enquiries@aminoa.co.uk** or call **01633894300** to speak to our technical team.
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DRILL MANUFACTURERS IN FOCUS...

PROOF OF THE PUDDING

Last year our Ryetec Ma/Ag autumn demo season kicked off in earnest on the 31st of August in Fife, we drilled into flailed down cover crop including oil radish some winter oats at 110kg/ha, we also drilled Winter Wheat on the same day @ 160kg/ha into an identical cover crop. The control was half the same field or next door field drilled after conventional min till cultivations had taken place. This was the Oats just gone in and the second picture, the field in the following spring 20.4.19.

The story went on, both crops were entered in a local crop competition and the Oats achieved 3rd equal place with the wheat 5th out of 22 entries and were some of the cleanest crops on the farm, we and the customer (he had ordered a drill by this point!) were understandably very pleased with this unexpected bonus however at harvest we have even better news with the Oats direct drilled achieving a full 1.2 ton/ha higher yield than the min tilled crop and the Wheat cut only a few days ago at 0.5t/ha

Whilst we would not expect generally yields to be better with direct drilling than conventional methods, when convention assumes that yields will be lower, it's nice when not only establishment costs are lower, but thanks to low disturbance drilling, less weed infestation also gives a saving on weed control and when the crop out performs in the yield stakes then it really is a great result, onwards and upwards, and the customer should have his new Ma/Ag 6 metre drill next week !

For more information, contact Ryetec, 01944 728186

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for Minimal Disturbance

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Proving itself across the UK with;

Choice of press wheels

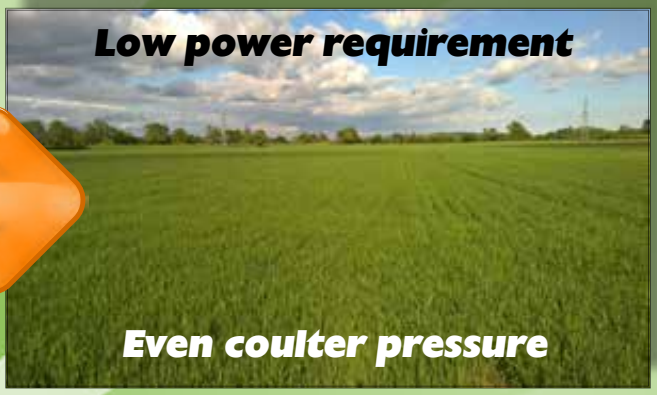
Individually floating coulters

Perfect seed to soil contact

Uniform seed depth control

Straight opening discs

Perfect weight distribution



Low power requirement

Even coulter pressure

Simple & robust

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No blocking with trash

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RYETEC

BRIDGEWAY AMINO ACID TRAMLINE TRIALS AT TWB FARMS – **THE RESULTS**

When it comes to conducting farm scale field trials and putting manufacturer claims to the test, Clive Bailye has ran his fair share over the years. So when biostimulant Bridgeway was reported to have delivered a 2.2 tonne yield benefit in winter wheat from 3 applications in 2018, Clive felt compelled to try it on the farm - could such benefits be replicated? In this latest feature, we (Interagro) share the results hot off the combine, warts and all, and get Clive's take on what happened.

In 2018 Hutchinsons agronomist Sally Morris conducted a commercial field scale trial with plant based biostimulant Bridgeway in a stressed crop of feed wheat, variety Relay. The crop was stressed at T1 due to waterlogging, T2 co-incided with some very hot and prolonged dry days, and at T3 the crop was drought stressed. Bridgeway applied at T1, T2 and T3 went on to deliver a yield benefit of 2.2 tonnes per hectare. Reading about these results in the Spring of 2019, Clive decided to put these impressive Bridgeway results to the test on his farm, on his soils.

Flag leaf length measurements – cm – average of 20 random leaves

Field	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Average	Bridgeway increase
Workshop	22.5	21.8	21.2	20.6	21.2	20.8	20.0	20.2	19.8	19.8	19.2	18.5	19.2	17.1	15.8	15.2	15.0	15.6	15.2	14.0	18.6	
Workshop	20.6	21.5	19.5	19.1	19.6	19.5	18.7	18.6	18.4	19.1	17.7	18.0	18.6	18.5	17.5	17.8	17.0	16.0	15.2	13.7	18.2	-0.4
Churchill	23.7	18.5	18.4	17.2	16.8	16.0	16.0	15.8	15.8	15.2	15.7	15.0	14.9	14.0	14.0	13.5	13.2	13.0	12.0	12.0	15.3	
Churchill	19.8	18.2	18.5	18.1	18.2	16.8	16.2	16.6	17.4	16.0	16.2	16.2	16.0	15.0	15.0	15.3	14.5	14.6	14.5	14.0	16.4	+1.1
Mere Oak	21.0	21.5	19.4	18.5	19.2	17.9	17.0	18.6	18.0	16.9	18.4	17.0	16.4	16.1	15.3	16.4	14.0	15.2	13.4	14.4	17.2	
Mere Oak	21.8	22.5	21.6	22.5	21.3	20.1	21.4	20.2	19.5	19.1	17.4	17.8	17.8	18.9	18.1	18.1	18.2	17.2	16.2	14.4	19.1	+1.9
Bank	22.6	20.0	21.4	20.0	18.8	17.8	17.9	18.8	17.1	17.5	17.4	17.2	16.4	16.1	15.0	16.1	16.4	14.9	15.1	12.6	17.5	
Bank	23.1	21.2	19.5	20.2	19.5	18.8	18.6	17.8	18.2	17.8	17.4	17.0	16.8	16.6	17.0	16.0	15.6	14.8	14.2	14.2	17.7	+0.2
Claverdon	19.4	19.8	19.0	18.4	18.0	18.0	17.8	17.6	17.6	17.4	17.2	17.6	17.0	16.0	15.6	15.6	14.6	14.6	14.0	13.0	16.9	
Claverdon	22.2	18.4	18.6	18.4	18.5	17.5	18.0	18.3	17.8	17.0	17.2	16.4	15.6	15.6	15.0	14.8	14.0	15.0	14.5	14.2	16.9	0

Untreated areas still received full CPP programme. Bridgeway was an additional treatment applied at 2 L/ha. Leaf samples taken on 6th June, analyzed on the 7th June.

Bridgeway flag leaf sampling 6th June

The plan – to test Bridgeway at 2 L/ha at various application timings in winter wheat, from T0 to T3, on not just one field but six different fields, each in 4 ha blocks. The trials were reported live on The Farming Forum in-season and measurements were taken from the fields approximately two weeks after each application to see if Bridgeway was having any impact on components of yield.

On May 14th tissue samples were taken from T0 and T1 untreated and treated tramlines. Visually no differences could be seen by the naked eye or satellite NDVI images. Brix readings (a measure of sugars) seemed to indicate a consistent increase inline with the dose applied.

Bridgeway Brix testing 14th May

Field	Treatment	Timings	Sample 1	Sample 2	Result % Brix	Increase in Sugar %	% Increase
Mere Oak	Untreated		24.7	24.7	24.7		
Mere Oak	Bridgeway	T0 + T1 + T2	26.0	26.2	26.1	+1.4 %	+ 5.7 %
Workshop	Untreated		26.9	26.5	26.7		
Workshop	Bridgeway	T0 only	27.5	27.3	27.4	+ 0.7 %	+ 2.6 %
Churchill	Untreated		23.7	24.6	24.15		
Churchill	Bridgeway	T1 + T2	25.2	24.6	24.9	+ 0.75 %	+ 3.1 %
Bank	Untreated		25.6	28.1	26.85		
Bank	Bridgeway	T0+T1+T2+T3	32.8	31.6	32.2	+ 5.35 %	+ 19.9 %

Untreated areas still received full CPP programme. Bridgeway was an additional treatment applied at 2 L/ha. Timings in RED have not been applied yet.
Leaf samples taken on 14th May, analyzed on the 15th May using a Milwaukee Digital Brix Refractometer MA871

Bridgeway Brix testing 14th May

Ear length measurements – cm – average of 20 random ears

Field	Bridgeway timings	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Average	Bridgeway increase
Workshop		9.5	7.3	9.0	8.1	9.4	9.5	9.0	10.0	9.3	7.5	8.4	8.3	8.4	9.0	8.2	8.1	7.7	7.3	6.8	7.5	8.415	
Workshop	T0	10.5	9.5	8.2	8.7	9.0	8.3	7.7	9.0	9.5	8.1	9.5	9.7	9.8	8.2	10.0	7.7	9.5	9.7	8.7	9.8	**9.055**	+0.640 cm
Simmons		8.8	8.6	8.5	9.0	8.3	8.7	8.5	8.2	8.5	8.3	7.8	8.0	9.2	8.8	8.2	7.3	7.5	9.5	9.5	9.6	8.540	
Simmons	T0 + T1	9.3	9.1	7.8	8.5	9.1	10.0	10.0	8.9	10.0	9.5	8.5	8.0	9.4	9.0	9.0	9.3	9.0	7.8	8.0	8.5	**8.935**	+0.395 cm
Mere Oak		8.0	8.0	8.0	8.0	7.5	7.3	8.5	9.2	8.6	8.5	8.3	8.5	7.7	8.0	8.4	8.6	9.5	9.8	7.8	9.2	8.370	
Mere Oak	T0 + T1 + T2	11.0	10.0	9.0	9.5	9.0	8.8	9.8	9.2	9.0	8.2	8.5	8.0	8.2	8.8	8.5	8.3	8.0	7.8	9.5	9.0	**8.905**	+0.535 cm
Churchill		8.2	9.8	9.0	10.0	8.7	8.8	9.5	8.2	6.6	7.5	8.2	9.2	9.0	7.5	8.0	6.2	8.0	8.5	8.5	7.0	8.320	
Churchill	T1 + T2	8.3	8.5	8.7	8.7	9.5	9.7	9.2	9.0	9.0	7.7	9.0	8.0	8.2	9.5	8.0	8.3	8.8	9.5	9.2	9.5	**8.815**	+0.495 cm
Claverdon		8.7	8.5	9.5	7.0	7.5	9.6	7.5	8.0	8.0	8.0	9.5	9.7	7.5	9.0	9.5	9.5	6.5	9.6	10.0	9.7	8.640	
Claverdon	T2 + T3	10.8	7.5	8.8	8.0	8.0	9.5	9.4	7.7	8.3	7.7	7.2	8.0	9.5	8.0	9.0	10.3	8.3	8.5	10.3	9.5	**8.715**	+0.075 cm
Bank		9.5	9.5	8.2	8.5	9.5	9.5	9.6	8.2	9.4	8.2	9.0	8.5	7.5	9.2	9.5	9.2	7.2	8.5	8.6	8.6	8.795	
Bank	T0 + T1 + T2 + T3	9.5	7.7	9.5	8.0	9.6	9.1	7.8	9.9	8.0	8.3	8.6	8.6	8.0	9.5	9.0	8.7	9.3	8.2	9.3	9.0	**8.780**	-0.015 cm

Bridgeway ear sampling 18th July

On June 6th flag leafs were randomly sampled and measured for leaf length. There was an indication that possibly T0 + T1 Bridgeway applications had increased leaf length, though this was not assessed for statistical validity – only to gain a possible indication on what might be happening. To the naked eye no visual differences could be seen in the fields, except Mere Oak where there looked to be more biomass in the treated plots. This was reflected in the leaf length measurements.

Test	Crop	Application timing	Untreated Yield	Treated Yield	Yield Benefit	Untreated Protein	Treated Protein	Protein Benefit
Field 1	Feed wheat	T0	9.45	9.50	+0.05	10.00	10.10	+0.10
Field 2	Feed wheat	T0 + T1	10.44	10.92	+0.48	9.87	9.81	-0.06
Field 3	Feed wheat	T0 + T1 + T2	12.15	12.10	-0.05	9.84	10.10	+0.26
Field 4	Feed wheat	T1 + T2	11.11	11.15	+0.04	10.00	10.15	+0.15
Field 5	Milling wheat	T2 + T3	7.30	8.20	+0.90	15.12	15.10	-0.02
Field 6	Milling wheat	T0 + T1 + T2 + T3	9.10	9.35	+0.25	14.56	14.45	-0.11

Bridgeway flag leaf sampling 6th June

On 18th July the last measurements were taken prior to harvest. Ears were randomly sampled from untreated and treated tramlines in every field. In all fields, there was an indication that Bridgeway had increased ear length in all but 1 field – again we were looking for indications only.

Bridgeway ear sampling 18th July

At harvest, yield was mapped and calibrated using the farm's weighbridge and grain samples were tested for protein levels.

The Bridgeway treated yields did not return the 2 tonne yield benefit that had been recorded in 2018 but certainly delivered a yield improvement.

A post mortum on the results, taking into account some of the early field measures, suggests Bridgeway is having a positive effect on the crop, and as to why we are seeing large yield benefits in one field versus small or no benefits in another, we put down to Liebigs Law of the minimum – the agricultural principle that yield is limited by the scarcest resource i.e. something else is likely to have restricted the yield gain.

Taking the cost of the Bridgeway programme used in each of the fields and grain prices into account, two fields delivered a valuable margin over input cost per hectare – field two (T0 + T1) delivered a margin benefit of £24.80/ha and field five delieverd a benefit of £135.50/ha.

Grain prices used to calculate margins:

Feed wheat - £135 per tonne

Milling wheat - £160 per tonne + milling bonus of £35 for over 14% protein

Milling wheat - £160 per tonne + milling bonus of £45 for over 15% protein

The early effects of the Bridgeway application were very encouraging. After T0 a significant increase in Brix levels were noted, this corresponding with a dry period post T0 which caused significant plant stress. Through the remaining season T1-harvest we saw no more plant stress so later applications demonstrated a less clear differences in assessments but still seemed to generally show improvement where more product was used.

It seems that the Bridgeway helps the plant most through stressed conditions but is of less value when growth conditions are good. On our lighter soils this "insurance" could prove very valuable in a droughty season. I would like to replicate the trial again next year and see if this "anti-stress" effect is consistent before committing to runtime application as part of my regular crop protection programme.

Margin over input costs per hectare (MOIC / Ha)

Test	Crop	MOIC / Ha
Field 1	Feed wheat	-£13.25
Field 2	Feed wheat	£24.80
Field 3	Feed wheat	-£66.75
Field 4	Feed wheat	-£34.60
Field 5	Milling wheat	£135.50
Field 6	Milling wheat	-£31.25

BASE-UK was established in 2012 and is independent of all businesses or organisations. We provide a forum for members to share information, experience and ideas on conservation agriculture, which would include topics such as minimum tillage, direct drilling, cover cropping, integration of livestock and many other techniques offering more sustainable agriculture by working in harmony with soils and the wider environment as well as inviting industry experts to speak to members.

We have had a busy Spring and Summer with many members holding farm walks, a trip to Rothamsted Research Centre, Agrovista's Lamport Project site and stands at Cereals and Groundswell. Cereals, whilst very soggy was successful in raising awareness of the group to a wider audience and as ever, it was great to be at Groundswell where we had many members visit the stand as well as new members signing up.

This year, BASE-UK membership has experienced strong growth and it is encouraging to see so many more people taking conservation agriculture seriously and wanting to share their knowledge.

We look forward to welcoming you to the following upcoming events:

SAVE THE DATES:

- 27th November 2019 – Member visit to Agrovista's Lamport Project.
- 27th and 28th November 2019 – we will be at Croptec at the East of England Showground alongside the Direct Driller.
- 4th to 6th December 2019 - BASE-UK Members visit to Frederic Thomas, in France.
- 11th and 12th February 2020 - AGM Conference 2020 - to be held at The Park Inn by Radisson in York.

A couple of BASE-UK members are going to No-Till on the Plains in Wichita, Kansas USA on 27th to 29th January 2020. For more information see www.notill.org/upcoming-events

For more information about membership or events and activities, please go to our website: **www.base-uk.co.uk** or contact **rebecca@base-uk.co.uk**

FARMER FOCUS
ANDY HOWARD

A Big Harvest, so let's spend big?

Majority of the harvest is in at the time of writing in the South of the country and it seems to have been a good one. So, I expect that the phones of the machinery dealer salesmen are red hot with farmers eager to spend their cash to avoid the tax man taking his slice. Is this a good strategy? All those people who have had the pleasure (or maybe misfortune) to hear me speak at meetings this last year may remember a graph I showed showing the total Canadian agriculture output since 1926 in Dollars and the proportion of this output that ends up as farm profits. The graph showed the Canadian output increasing over that period but the farmers profits decreasing year on year as a proportion of the total, where in 2016 Canadian farmers only ended up with $7 billion dollars out of the $60 billion of output they produced.

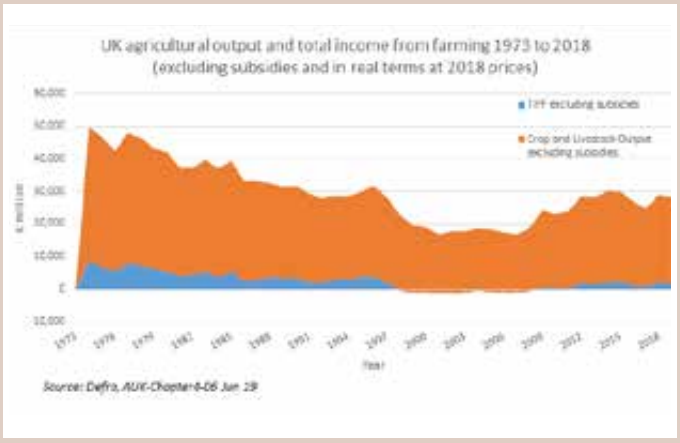


Figure 1: My showing of this graph triggered the AHDB to do a similar graph for the UK (Source AHDB)

TIFF is the Total Income From Farming which in general terms is farm profits.

Figure2: shows this profit as a percentage of total agricultural output (excluding subsidies) (Source AHDB)

The key point for me personally is that when I was born, 40 years ago, 20% of the total output ended up as farm profits, in 2018 it is 5%. It is a sobering figure and the question I ask is "where is the other 95% going?" I suggest a few places would be machinery companies, ag-chem companies, fertiliser companies, landlords to name a few. Second question is how can I get some of that income from our output in my pocket and so lead to higher profits? A simplistic answer is to spend less on machinery, ag-chem and fertiliser inputs.

It is the Canadian graph that I use to highlight in my talks why we are reducing our inputs year on year, there is good money to be made in farming, but it is not farmers who make much of it. The merchants may tell you that to be profitable you need multiple fungicide applications and large doses of fertilisers otherwise your crops will perform poorly, do you? I don't here on the farm, this year we used 14-18 kg/N per ton (depending on variety) to produce good wheat yields. The UK record Wheat Crop used about 19kg/N per ton which isn't bad, but I would suggest most farms would be between 20-30 kg/N per ton. We on average spent about £40 per ha on fungicides on our wheat too, not many would be able to beat that.

I'm not trying to show off just highlight what is possible and I think we can improve further. We will all have to improve our Nitrogen efficiency and reduce pesticide use due to the three R's (Run-off, Regulation and Resistance). The water companies will only continue to pay the £200/ha cost of cleaning water off farmland for so long before they get fed up and demand that the polluter pays. My worry is that a lot of articles you read in the agricultural

The picture above shows how the beans dominated on the wet headland and above on the drier ground the oats faired just as well as the beans. For me on our highly variable fields this feature of intercropping helps even up our output from the field.

(Clover planted on the left)

press are promoting the opposite and a high input system, this as the graphs above show is unsustainable.

At home all the trials have been harvested but as yet the results have not been finalized. From the combine cab I would say the Linseed/ Oats and the Spring Bean/ Oat trials have been successful. The Peas/ SOSR and Lentil/Linseed intercrops were a failure in terms of the secondary crops but a success in terms of the main cash crop as they yielded well.

An interesting observation from our bean/oat intercrop this year is how the two component crops varied over different soil types and conditions.

For the coming year I have a few ideas for trials. One is already in the ground; this is Micro-clover planted into second-year grass seed aftermath to achieve a living mulch.

We have tried to establish clover into spring oats with mixed success, the main issues with planting clover into oats is slugs, residual herbicides from previous wheat and the oats shading over too quickly. My theory by planting in the grass seed aftermath is: there has not been any residual herbicide and the grass will be grazed and so not be competitive, we'll see. Firstly, we need some rain!! Hopefully the clover will remain in the bottom of the Spring beans and subsequent crops.

The second trial is going to be a Winter Wheat companion crop trial. The main drivers are aphid confusion, Nitrogen scavenging, increase Grain protein and yield improvement. I am sure there will be other trials in the spring, I will keep you posted.

THE FUTURE BELONGS TO **SMALL SELF-DRIVING VEHICLES**

A small Dutch company called Precision Makers have not only converted John Deere Tractors in self-driving machines, but have now also done one without a cab. John Deere were so impressed that they have partnered on collaborations with them which has started with autonomous mowers that can be used in the golf world as well. There is clearly a lot to come from this company over the next few years.

Self Driving Tractors - The X-pert package

The X-pert package from Precision Makers makes it possible for your existing machines to work autonomously. The X-pert package is a state-of-the-art robot package that combines reliability with precision. The package is available for all tractors and mowers.

With the aid of the most advanced software and GPS systems, it is possible to work with the precision of an expert, with an accuracy down to the nearest millimetre. You can program a tractor or mower with an X-pert package to do every possible work task.

Get started in less than 5 minutes

Precision Makers uses Teach & Playback technology for the X-pert package. To record a work task, you carry it out as usual and the machine saves all the actions, such as driving, steering, accelerating and even raising and lowering the mower and turning on the sprayer. After that, you can play back the recorded route as often as you wish. The unmanned machine precisely repeats all the actions. X-pert's memory is large enough to save hundreds of actions. The system is operated via an operating terminal on the armrest: available in different languages, with a touchscreeen and 3D display of the route.

Safety first

The machine has various safety systems. The system checks itself and the machine stops if an obstacle is detected in front of the tractor, which the operating system will inform you of via a text message.

Greenbot - A versatile all-rounder

Greenbot is the first self-driving machine that has been specially developed for all professionals in the agricultural and horticultural sectors that perform work tasks that are regularly repeated. This can vary from work for fruit farming, horticulture and arable farming to work in the municipal sector. Greenbot can also be used at the waterfront or on roadsides.

At the front, it has a Cat I lifting device that can lift up to 750 kg. The Cat II lifting device at the rear can lift up to 1,500 kg. Greenbot is available in two widths: 1.3 metres or 1.8 metres. The ground clearance is 35 centimetres, but this can be increased by using larger tyres. Greenbot has a reliable Perkins/FPT engine. The four steered wheels ensure maximum manoeuvrability.

The Greenbot can perform many different tasks all by itself. The machine can mow, sow, plough or fertilize 24 hours a day. The software is user-friendly, safe and reliable. Greenbot can work fully autonomously via 'Teach & Playback'. For some jobs, Greenbot is able to plan its own route and tasks fully independently.

Conclusion

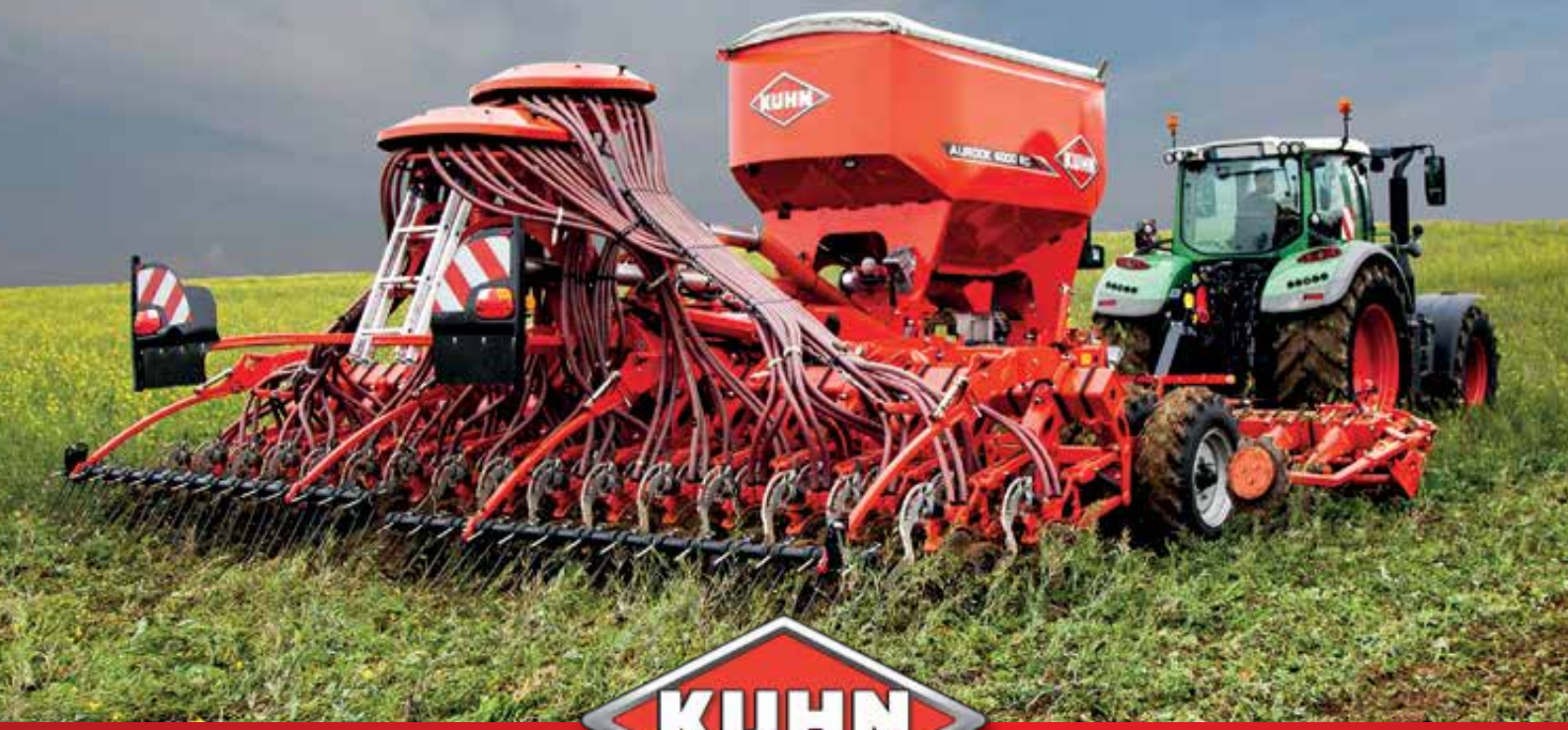
Some further advances in automation, based on repetition of activities is an interesting approach. Marien van Breugel of Precision makers predicts

"We believe that we will all get small self-propelled tractors for specific activities. We discovered that during the development of the X-pert conversion kits. Every tool requires specific programming, not forgetting its own safety system. You could not attached a seed drill on the the back, followed by a plough or a sprayer and expect it to work. And if the farmer then buys a new or a different machine, you need to check once again how everything interacts and anticipates. Combining all this into a single programme is not possible, which is why you get a small self-propelled vehicle for each cultivation method, each with its own specialism. That is where we are heading: small, autonomous self-propelled vehicles"

Scan to see a live preview

AUROCK

Extend your drilling options



KUHN

DUAL METERING

- Added versatility for progressive farming practices
- Drill two different varieties or crops simultaneously
- Sow alternate rows
- Manage drilling depth independently in dual cropping situation

KUHN's new AUROCK 6000 pneumatic triple disc seed drill is designed with the versatility to sow into cover crops, minimum tillage or direct drilling conditions.

- Two rows of opener discs with options to suit different drilling conditions
- Centre pivot design aligns seed coulters with opener discs
- Parallelogram-mounted double disc seeding unit for optimum ground following
- An integrated cutter roller can be fitted to allow operation in all types of cover crop
- Two 6m models available:
  AUROCK R – single metering, 3,500 litre hopper;
  AUROCK RC – dual metering, 5,000 litre hopper.
- Low power requirement (180hp for 6m drill)

forage harvesting I livestock husbandry I arable I landscape maintenance

be strong, be **KUHN**

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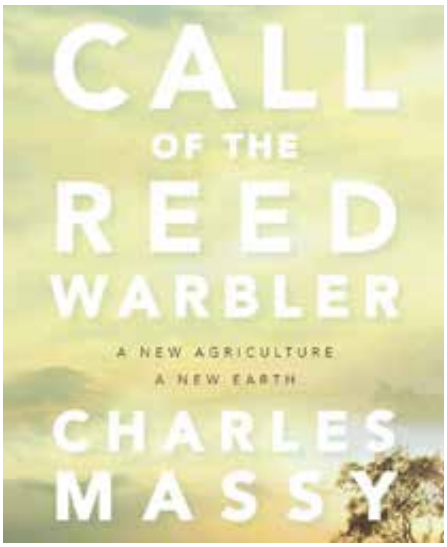
www.kuhn.co.uk

WHAT DO YOU **READ**?

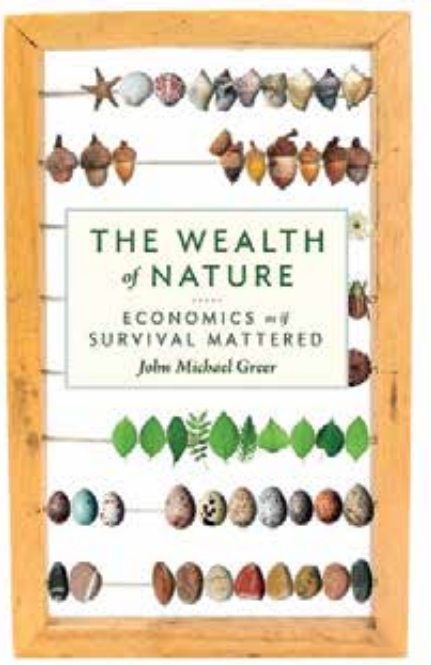
If you are like us, then you don't know where to start when it comes to other reading apart from farming magazines. However, there is so much information out there that can help us understand our businesses, farm better and understand the position of non-farmers. We have listed a few books you might find interesting and challenge you way you currently think.

Call of the Reed Warbler: A New Agriculture, a New Earth



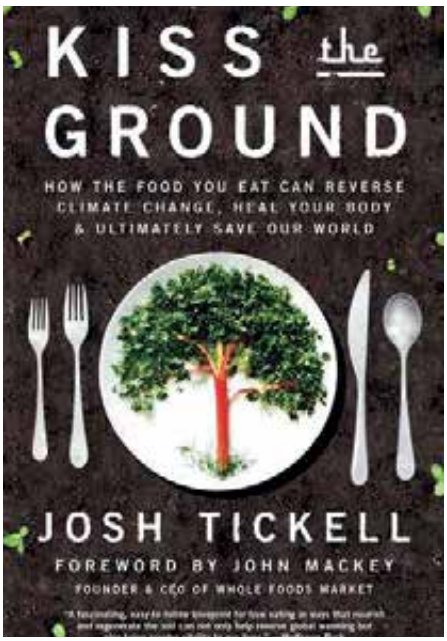
Is it too late to regenerate the earth? Call of the Reed Warbler shows the way forward for the future of our food supply, our Australian landscape and our planet. This ground-breaking book will change the way we think of, farm and grow food. Author and radical farmer Charles Massy explores transformative and regenerative agriculture and the vital connection between our soil and our health. It is a story of how a grassroots revolution – a true underground insurgency – can save the planet, help turn climate change around, and build healthy people and healthy communities, pivoting significantly on our relationship with growing and consuming food. Using his personal experience as a touchstone – from an unknowing, chemical-using farmer with dead soils to a radical ecologist farmer carefully regenerating a 2000-hectare property to a state of natural health – Massy tells the real story behind industrial agriculture and the global profit-obsessed corporations driving it. He shows – through evocative stories – how innovative farmers are finding a new way and interweaves his own local landscape, its seasons and biological richness. At stake is not only a revolution in human health and our communities but the very survival of the planet. For farmer, backyard gardener, food buyer, health worker, policy maker and public leader alike, Call of the Reed Warbler offers a tangible path forward for the future of our food supply, our Australian landscape and our earth. It comprises a powerful and moving paean of hope.

The Wealth of Nature: Economics as if Survival Mattered



The Wealth of Nature proposes a new model of economics based on the integral value of ecology. Building on the foundations of E. F. Schumacher's revolutionary "economics as if people mattered," this book examines the true cost of confusing money with wealth. By analyzing the mistakes of contemporary economics, it shows how an economy centered on natural capital—the raw materials that support human life—can move our society toward a more productive relationship with the planet that sustains us all.

Kiss the Ground: How the Food You Eat Can Reverse Climate Change, Heal Your Body & Ultimately Save Our World

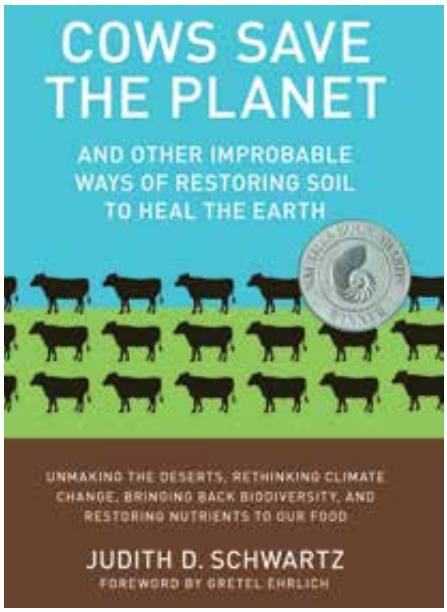


Discover the hidden power soil has to reverse climate change, and how a regenerative farming diet not only delivers us better health and wellness, but also rebuilds our most precious resource—the very ground that feeds us.

Josh Tickell, one of America's most celebrated documentary filmmakers and director of Fuel, has dedicated most of his life to saving the environment. Now, in Kiss the Ground, he explains an incredible truth: by changing our diets to a soil-nourishing, regenerative agriculture diet, we can reverse global warming, harvest healthy, abundant food, and eliminate the poisonous substances that are harming our children, pets, bodies, and ultimately our planet.

Through fascinating and accessible interviews with celebrity chefs, ranchers, farmers, and top scientists, this remarkable book, soon to be a full-length documentary film narrated by Woody Harrelson, will teach you how to become an agent in humanity's single most important and time sensitive mission. Reverse climate change and effectively save the world—all through the choices you make in how and what to eat.

Cows Save the Planet: And Other Improbable Ways of R Restoring Soil to Heal the Earth

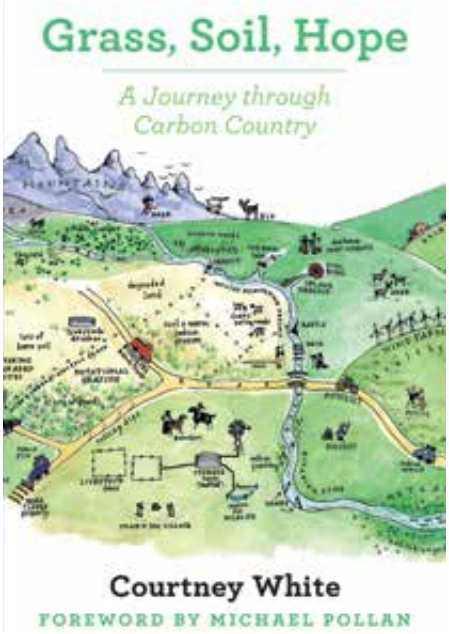


In Cows Save the Planet, journalist Judith D. Schwartz looks at soil as a crucible for our many overlapping environmental, economic, and social crises. Schwartz reveals that for many of these problems—climate change, desertification, biodiversity loss, droughts, floods, wildfires, rural poverty, malnutrition, and obesity—there are positive, alternative scenarios to the degradation and devastation we face. In each case, our ability to turn these crises into opportunities depends on how we treat the soil.

Drawing on the work of thinkers and doers, renegade scientists and institutional whistleblowers from around the world, Schwartz challenges much of the conventional thinking about global warming and other problems. For example, land can suffer from undergrazing as well as overgrazing, since certain landscapes, such as grasslands, require the disturbance from livestock to thrive. Regarding climate, when we focus on carbon dioxide, we neglect the central role of water in soil—"green water"—in temperature regulation. And much of the carbon dioxide that burdens the atmosphere is not the result of fuel emissions, but from agriculture; returning carbon to the soil not only reduces carbon dioxide levels but also enhances soil fertility.

Cows Save the Planet is at once a primer on soil's pivotal role in our ecology and economy, a call to action, and an antidote to the despair that environmental news so often leaves us with.

Grass, Soil, Hope: A Journey Through Carbon Country



This book tackles an increasingly crucial question: What can we do about the seemingly intractable challenges confronting all of humanity today, including climate change, global hunger, water scarcity, environmental stress, and economic instability?

The quick answers are: Build topsoil. Fix creeks. Eat meat from pasture-raised animals.

Scientists maintain that a mere 2 percent increase in the carbon content of the planet's soils could offset 100 percent of all greenhouse gas emissions going into the atmosphere. But how could this be accomplished? What would it cost? Is it even possible?

Yes, says author Courtney White, it is not only possible, but essential for the long-term health and sustainability of our environment and our economy.

Right now, the only possibility of large-scale removal of greenhouse gases from the atmosphere is through plant photosynthesis and related land-based carbon sequestration activities. These include a range of already existing, low-tech, and proven practices: composting, no-till farming, climate-friendly livestock practices, conserving natural habitat, restoring degraded watersheds and rangelands, increasing biodiversity, and producing local food.

In Grass, Soil, Hope, the author shows how all these practical strategies can be bundled together into an economic and ecological whole, with the aim of reducing atmospheric CO2 while producing substantial co-benefits for all living things. Soil is a huge natural sink for carbon dioxide. If we can draw increasing amounts carbon out of the atmosphere and store it safely in the soil then we can significantly address all the multiple challenges that now appear so intractable.

NET ZERO CARBON: HOW TO MAKE SUSTAINABLE FARMING PAY

by Marianne Landzettel and published by the Sustainable Food Trust

"Money drives change…you can't be in the red if you want to be green." This was the short and simple message of investor and philanthropist Robert Appleby from ADM Capital, delivered in the closing session of the Sustainable Food Trust's conference Farming and Climate Change: Towards Net Zero Emissions. The need for change in agriculture is obvious: the carbon footprint of industrial agriculture is huge because it is dependent on fossil fuels – from fertiliser production to running big machinery. Because the UK government has set a legally binding target of net zero carbon by 2050 a lot of changes will have to be implemented. Climate-adapted farming and agroecological agriculture are definitely part of the solution – the question is: will sustainable farming be financially viable? If it isn't, farmers simply cannot and will not adopt the practices that are vital for the reduction of greenhouse gas (GHG) emissions.

Marianne Landzettel

Former Secretary of State for Environment, Food and Rural Affairs, Michael Gove, seized on the opportunity that Brexit has thrown up: once Britain leaves the UK, British farmers will no longer receive subsidy payments under the Common Agricultural Policy (CAP) and that gives us in the UK, the chance to redefine who in future will receive payments and for what. With the headline 'public money for public goods', Michael Gove has indicated the path forward. "That is a huge policy change," said Tony Juniper, Chair of Natural England, at the conference. Together with a host of other organisations, Natural England is helping to shape the notion of what will be considered 'public goods'. Nature is a public good, argues Juniper, nature is natural capital; economic values and price tags can be attached to nature's assets – from clean air and water to carbon and biodiversity.

Dieter Helm is the Chair of the Natural Capital Committee and Professor of Economic Policy at Oxford. Looking at production, assessing costs and benefits, is what he does. Helm, too, sees tremendous opportunities in a new agricultural policy which (to him) could amount to a revolution: Britain could go from "a broken system", fuelled by the wrong incentives, to one that delivers biodiversity, carbon sequestration, healthy food and income for farmers.

"Natural capital is the ultimate public good," Helm stated at the conference. At present farmers receive about £3 billion in subsidies through the EU and CAP. Helm is not optimistic that any UK government will in the long run pay the same amount to farmers for delivering 'public goods'. It is easy to see that there will be stiff competition for limited Treasury funds – farmers would be up against the NHS, schools, the elderly… But if the system were set up and designed correctly it could provide the money

needed to deliver public goods, says Helm. In his book Green and Prosperous Land, he lays out what he calls a "blueprint for rescuing the British countryside".

What would it take? First of all, Helm argues, we would need to take all costs of production into account. Agricultural run-off pollutes water sources and water companies have to spend a lot of money on cleaning it up, costs that are passed onto the consumer. The production of fertiliser is very energy intensive and causes GHG emissions. There are economic, environmental and health costs embedded in the use of herbicides and pesticides. And we need to think globally and include the cost of imported goods. Food prices need to go up, Helm asserts in Green and Prosperous Land. "It is us, consumers, who buy these pollution-inducing agricultural products and are therefore really the polluters, who should pay for the damage our consumption habits cause. It is ultimately our fault, not that of the farmers, who respond rationally to the incentives they face. Cheap food cannot be an objective without regard to the consequences." Higher food prices, of course, would have a negative impact on food security for people and families on low incomes – so this is a contentious issue. Everyone should have a right to access good quality, healthy food at an affordable price.

Advances in technology are making it easier to measure pollution, says Helm, but there needs to be stringent controls, and the payment of costs and fines has to be enforced. It is critical that the UK enshrines the 'polluter pays' principle into UK law in order to address the damage. If farmers had to pay to use agrichemicals, the additional cost would be a strong incentive to reduce inputs or go organic. Farmers would also have to give up some privileges – like red diesel which is currently subsidised. It doesn't make sense to reward farmers for carbon sequestration and at the same time incentivise them to use more fuel because it's cheap.

For Helm, it's not only about taking all environmental cost into account and making polluters pay, but about a 'net gain'. He further states in his book "There should be compensation, offsetting any damage. But the net gain principle goes further: it states that we should be risk-averse and err on the side of overcompensation. It incorporates the precautionary principle, especially where renewable natural capital is involved and when we don't know precisely where the safe limits lie."

Dieter Helm, Chair of the Natural Capital Committee and Professor of Economic Policy at Oxford

In his presentation at the conference, Helm focussed on agriculture, but his 'blueprint' goes beyond this: he looks at river systems, coastlines and marshland, the uplands, towns and cities. The same principles should apply everywhere. When environmental costs are incurred, they must be offset with a net environmental gain: if houses need to be built and land is paved over, there must be compensation elsewhere. And Helm defines pollution in the widest possible sense: "Imagine if GlaxoSmithKline were liable for the environmental damage caused by its products. Imagine if Unilever were responsible for the disposal of all its beauty and personal hygiene products…They would have a direct incentive to minimise the risks."

Dieter Helms's logic is impeccable, his enthusiasm for far reaching changes is infectious. It can be done, he says. The Government's 25 year Environment Plan sets out the goals – and they need to be enshrined into law. The Agricultural Bill could be a framework for incentivising environmentally sensitive agriculture practices. Planning orders can guarantee the principle of net environmental gain. Credible new institutions could coordinate and enforce the plans. "It's a one in 50-year chance," says Helm who is not naïve enough to think that achieving such goals is anything short of an enormous challenge. A lot of money is at stake, and there are many vested interests. It will take time, a lot of work and new trading arrangements with the EU and the rest of the world, Helm says. But even for the optimistic economist there is a caveat: a hard Brexit – the probability of which has just increased with the election of Boris Johnson as prime minister – resulting in massive tariffs would scupper the chances for a green and prosperous Britain.

The economic model Helm proposes simply would not work in the event of a hard Brexit. Under any circumstances, the stars would have to align perfectly and in record time to push through the legislation needed. In the current political climate, it is hard to see how tackling it would become a priority. The best hope might be that 'the polluter pays' principle becomes more widely accepted and we all begin to pay more attention as to who pollutes. Making them pay might be difficult, but we can reduce their profits. Making the right choices as consumers might be a good start.

VISITING NOVAG IN FRANCE

Following on from seeing Novag for the first time at Groundswell and meeting the team including Antoine and Ramzi, we were invited to visit the factory, just east of La Rochelle in France to see how they are planning for the future.

While Novag are new to the UK this year, they have been selling drills for over 7 years now. They have already sold machines in France, Germany, Russia, Bulgaria, Switzerland, Estonia, Latvia, Lithuania, Canada, Slovakia and Czech Republic. They started production in a smaller unit in Celle-sur-Belles and have more recently moved to a purpose-built factory outside Fressines. This move allowed them to build something completely tailored to their requirements and needs to allow them to build up to 50 drills a year. Which is their short-term aim.

Even from the outside, it is an impressive approach to the factory (apart from the tilled fields belonging to the farmer next door!). The new build factory and offices certainly set out their stall to become one of the bigger no-till drill manufacturers in Europe. If you visit the factory, you will come away very impressed.

Inside the clean bay setup has clearly had a lot of thought behind it and makes clear the high quality, precision engineered attitude Novag have . Ramzi, who studied engineering and was at Groundswell this year, has designed the factory layout to allow multiple operations to happen at the same time. With easy access to parts and enough bays to be building 5 or 6 drills simultaneously, each with plenty of space to work around them for multiple staff. Overhead hoists span the whole building to make light work of the bigger jobs and have made staff over 4 times as productive from when they were at the old production unit. The parts storage and logistics was equally impressive, everything was organised, from discs to hoses to electronic screens and cables. If you needed a part, you could have delivered almost anywhere in the world within 24hrs as Novag is located next to one of the major distribution units in France. Their commitment to customer service to be able to supply any part at any time seems to be at the heart of building the community of Novag drill users across Europe.

Antoine gives Novag the same farmer led development that we have seen with many UK drill manufacturers. On his farm, not far from Paris, they are able to test new drills and develop new innovations. Antoine worked on farms in Canada, Australia and New Zealand before taking over the farm and founding Novag with Ramzi. Their passion to develop drills to work in conditions throughout Europe, from softer southern Russian and German soils to harder environments in France and other parts of Europe, means the range of soils we have the UK should present no problems for their different solutions. This farmer led approach, coupled with the R&D and engineering skills of Ramzi means that the drill is constantly evolving and when second-hand machines are brought back into the factory, they are upgraded with the

Two 3m drills and one 6m drill being built for customers.

new technology and all the wearing parts are changed. The ground breaking Massey institute opener design has been refined and evolved through Novag's now extensive and unparalleled experience since its invention near 40 years ago in New Zealand. As a farmer, even when you buy a second-hand machine from Novag, you are getting the highest quality and technologically advanced machine they can produce at any given time.

Novag will be at Agritechnica again in November 2019 in Hall 11. If you haven't yet met Ramzi, Antoine and the rest of the team, you can visit them at the show.

PLANT TEAMS IN THE FIELD
INTERCROPPING IN PRACTICE IN THE UK AND SWEDEN

Katie Bliss from Agricology (www.agricology.co.uk) shares insights from farmer and researcher experiments with intercropping in the UK and Sweden.

Intercropping has been shown to be beneficial for pest, disease and weed management, preventing lodging, improving water quality, soil fertility and biodiversity as well as increasing resilience to climatic and agronomic shocks. Much of the innovation is happening in farmer's fields and on-farm trials are an important step towards enhancing understanding of the benefits and challenges of working with different plant teams in a variety of contexts.

The theory

Plants in monoculture have similar traits and compete for the same resources. Plants in species mixtures can have divergent and sometimes complimentary traits. Beneficial interactions between crop species include facilitation (e.g. suppression of weeds), resource sharing (e.g. mycorrhizal associations) and complementarity (e.g. differing crop architecture above and below ground reducing competition for resources

Factors to consider

When deciding on a plant team combination it is important to consider the key objectives and the traits of the intercrop components to find a mixture that fits your needs. For example, which crop is the priority, what is the end-use? Is there a production challenge that you are aiming to address such as weed or pest pressure? Alongside this, it is important to determine the best seed rates and ratios, taking into account the competitiveness of the different crop species in the intercrop, and how varietal choice could be maximised e.g. to optimise maturation dates.

Intercropping in practice

In the UK researchers are working with a group of farmers and sharing experiences of different plant teams online and in the field as part of the DIVERSify project (www.plant-teams.eu) and the Innovative Farmers Field Lab 'Intercropping in Arable Systems' (tiny.cc/IntercroppingIF). The main mixtures can be grouped as cereal – legume mixtures and oilseeds plus companions. In 2017/18 four farmers trialled plant teams on their farms as part of DIVERSify; including Carlin peas and spring triticale, wheat and beans on two different organic farms, and spring oil seed rape and beans. This year two of the farmers have been continuing trials. Here are some insights into some of the plant teams tested over the last couple of years and key findings from the trials.

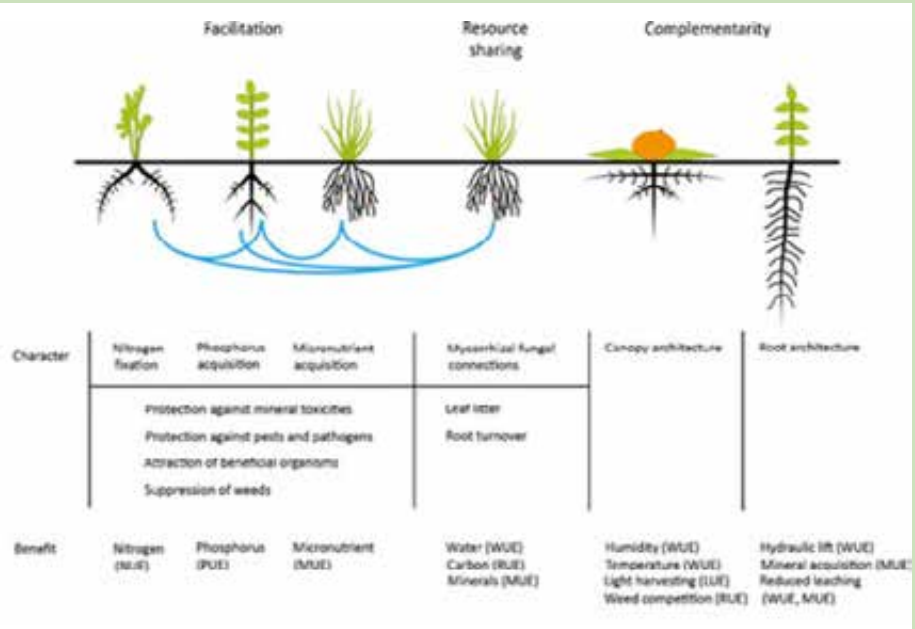


Fig 1: Facilitation, resource sharing and complementarity (Brooker et al, 2015)

James Hares, Winter Wheat and Beans at Roundhill Farm, Wiltshire

Motivations: Weed control (particularly wild oats) and increase protein of a mixed livestock feed

With a heavy wild oat problem, James hoped that intercropping beans with wheat would allow the wheat to dominate the wild oats and outcompete them in his organic system. In 2017, James established two 1 ha strips – one an intercrop of beans (Tundra at 175kg/ha) and wheat (Mulika at 125kg/ha) and one of monoculture beans. Both were drilled with a Weaving Sabre Tine drill, the intercrop in two passes. James observed a huge difference in the size of the weeds in the monoculture vs the intercrop and analysis showed that there was an average of 74% less dry matter weed biomass in the intercrop that the monoculture! The vast majority of these weeds were wild oats.

Although the bean yields were low due to the weed pressure in both fields, there was a slightly higher bean yield in the monoculture (0.59 t/ha) than in the intercrop (0.48t/ha beans; 1.43t/ha wheat) suggesting that the wheat may be competing with the beans. Nevertheless, the combined yield of

the intercrop was higher than the monocrop, and as the intercrop was harvested and used as a mixed feed for his own livestock, James felt that the lower bean yield was compensated for by the weed suppression benefits and additional feed value of the wheat.

Based on this success James decided to repeat the trials again in 2019 (with a much smaller area of monoculture). He lowered the wheat seed rate to 100kg/ha and increased the beans to 200kg/ha in both the intercrop and monoculture. The weed biomass results replicated the previous year, with 73% less dry weed biomass in intercrop v monocrop (again mainly wild oat although more black grass, charlock and poppies than in the previous year). Unfortunately, the weed burden in the monoculture was so high that he had to mow the crop before the wild oats could go to seed and it was not taken to harvest.

James noticed that the wild oats in the intercrop (top) had much less biomass than those in monoculture

Mark Leam, Carlin Peas and Triticale at Green Acres Farm, Shropshire

Motivations: Provide scaffolding for the pea crop and improve ease of harvest

Mark is growing Carlin peas for Hodmedod's 'British grains and pulses' however due to their high level of biomass they tend to lodge and can make harvest challenging. In 2017/18 he trialled pairing the Carlin peas with different seed rates of triticale to determine which level provided optimal support for the crop. He obtained the highest yield of peas at the 20% seed rate (2.29 t/ha) but all of the intercropped strips had a higher pea yield than the monoculture peas (which yielded 1.91 t/ha). However, the highest triticale rate of 30% was Mark's favourite when it came to harvest as the standing ability of the crop was much improved, as you can see in the images below, and it was much more pleasant to combine.

In 2018/19, Mark split his field to try an increased triticale rate of 40% in comparison to a 20% rate. He reports a very challenging year for organic pea production due to the high weed burden but that the intercropping did aid in weed competition as well as providing a good level of scaffolding as per the year before. However, he felt that the 40% triticale was providing more competition than he would like with the peas.

Comparison between 20% triticale (2.29 t/ha) and 30% triticale (2.34 t/ha) intercropped with Carlin peas

Andy Howard, Linseed and Oats at Bockhanger Farms, Kent

Motivations: Oats to facilitate better linseed establishment via reduction of pest and disease pressure

Andy has been innovating with a number of plant teams over the last 3 years since completing his Nuffield Scholarship on 'Intercropping and companion cropping in arable systems' which is available on Agricology.

Having observed better linseed establishment in areas of the field with wild oats in 2018, Andy wondered if the oats act as a temporary nurse crop to help reduce flax flea beetle attack and aid linseed establishment. He therefore drilled a crop of linseed (700 seeds / m2) with a nurse crop of oats (at 0 / 70 and 140 seeds / m2). The oats were killed off with herbicide once the linseed was established.

Assessments in April 2018 showed an average of 13% higher linseed plant survival with oats at 70 seeds/m2 when compared to no oats, and 17% higher plant survival with 140 seeds / m2 oats. (285 plants /m2 with no oats 323.5/m2 with 70 seeds/m2 oats and 333.72 plants in 140 seeds / m2 oats).

Flax flea beetle caught in water trap; shot-holing of linseed

Pest damage scores (PDS) were assessed, based on percentage shot-holing by flax flea beetle. There was a trend of lower PDS on the linseed intercropped with oats (average PDS of 1.71 with oats at 70 seeds per m2 and 1.79 with 140 plants / m2 versus an average of 2 in linseed monoculture). This year Andy is also trying out 3 other plant teams; beans and oats (with the PGRO), OSR-peas-linseed (OSR has failed) and lentils and linseed.

Innovations in Sweden

Alongside DIVERSify and Innovative Farmers, another Horizon 2020 funded project, DiverIMPACTS (www.diverimpacts.net), is facilitating a growing network to share experiences of crop diversification from across Europe. This includes many different case studies which include looking at diversifying rotations and intercropping and their integration across value chains. Hodmedod's (UK) and Nordisk Ravara (Sweden) are businesses supporting farmers to diversify their rotations and produce locally grown pulses – including lentils, peas and beans. These crops can be challenging to produce but have clear benefits for the rotation. Challenges include suffering from lodging (and consequent impact on harvestability and quality) as well as weeds, pests and diseases. Many farmers are exploring the potential for intercrops to address some of these issues, and the businesses buying their products are keen to support them in finding solutions. In June, I and a group of farmers, Hodmedod's staff, and researchers travelled to Sweden to visit farmers innovating with intercropping and to share experiences. Here is an insight into what we saw and learnt:

Per Modig, Lentils and oats, Fagraslätt farm, Sweden

Motivations: Oats to provide scaffolding to lentils and aid weed suppression

Lentils have been traditionally grown in some parts of Sweden and are on the increase again. Lentils are low growing and lodge easily. In the gravel soils of Southern Sweden this can mean harvesting small stones which are difficult to clean out. They are also sensitive to weed competition, particularly if there is poor/delayed establishment. In response to this, many of the farmers we visited are intercropping with oats - to hold the lentils off the floor, whilst also supressing weeds.

Per Modig had teamed oats with red lentils and green puy lentils as he found them easier to separate than other cereals. He had drilled lentils (90kg/ha) with oats (40kg/ha) and compared weed biomass and crop yield to a monoculture strip. Although the oats could increase the moisture content of the lentils, Per felt this was outweighed by benefits for scaffolding and weed suppression. His expected harvest was around 1-1.5 t/ha of lentils and about the same for the oats. His on-farm separation set up, which also served other farmers in the Nordisk Ravara network, included a series of cleaners including a spiral separator which was particularly effective at separating similar sized seeds.

Red lentil and pea trials at Per Modig's farm. Spiral separator forms part of Per's seed cleaning and separation business

Per Modig's trials are part of a trial at the Swedish Agricultural University, Alnarp, comparing different varieties of the traditional puy lentil (Gotlands Lins – a traditional Green puy lentil grown widely in Gotland until 1945, and Amnesia a modern French variety) intercropped with oats, and the effect of any additional harrowing. They were drilled with lentils at 100% RD and oats 20% RD. Previous research carried out at SLU Alnarp had found an increase in protein in oats intercropped with lentils – this could either be due to translocation of nitrogen (N) from the dying lentil roots, or (and more likely) due to there being a greater availability of N with their being less intraspecific competition with other oats.

Raj Chongtham Iman, Peas and oats, SLU Alnarp, Sweden

Motivations: To increase resilience to in field heterogeneity and climatic shocks

As part of another H2020 research project Remix (www.remix-intercrops.eu) we visited another trial which looked at the impact of intercropping oats and peas to help manage in-field heterogeneity and resilience to stresses – including drought and flooding, and nutrient availability.

Peas and oats were a common mixture grown by the group in Sweden. The UK farmers were a little concerned about how to separate a crop of peas and oats as split peas can be difficult to clean, but the Swedish farmers explained that they used screens with long slots for oats as well as a spiral separator and have not found it to be a problem.

Grey peas 190kg/ha and oats 150kg/ha drilled with system chameleon. Peas suffered from a dry spring and insects

A similar mixture of camelina and lentils was being trialled. Camelina was found to be great for supressing weeds and also forced the lentils to senesce a little earlier.

In summary...

These examples are just a brief snapshot of a huge amount of innovation happening in the field, but demonstrate some of the potential benefits of intercropping for weed suppression, scaffolding and pest control. The effectiveness of different plant teams seems to vary significantly from farm to farm and from year to year, so the best way to learn what can work for you is to try on a small area of your own farm. In selecting your plant team, be clear about what your objectives are, what the intended use is, and which crop is your priority.

Visit www.agricology.co.uk to find more practical information on intercropping from farms and research trials. Agricology is an independent collaboration of over 20 of the UKs leading farming organisations and provides a platform for farmers and researchers to share knowledge and experience on agroecological farming practices; online and in the field. Subscribe to the newsletter or follow on social media @agricology to share your questions and experiences with the Agricology community.

UPCOMING EVENTS

9th October 2019	Soil Health & Regenerative Agriculture for Livestock Farms www.eventbrite.co.uk/o/niels-corfield-courses-amp-workshops-16591076222
21st October 2019	YEN Deadline for returning Oilseed Yield Entry Forms and completed Entry Packs
23rd October 2019	Improving Soil Health on Horticulture Operations www.eventbrite.co.uk/o/niels-corfield-courses-amp-workshops-16591076222
31st October 2019	YEN Deadline for returning Cereal Yield Entry Forms and completed Entry Packs
1st November 2019	Soil Health & Regenerative Agriculture for Livestock Farms www.eventbrite.co.uk/o/niels-corfield-courses-amp-workshops-16591076222
14th November 2019	East of England Farming Conference 2019
27th-29th November 2019	Nuffield Farming Annual Conference 2019
27th/28th November 2019	CropTec 2019 - https://www.croptecshow.com/
29th November 2019	Improving Soil Health on Horticulture Operations - www.eventbrite.co.uk/o/niels-corfield-courses-amp-workshops-16591076222
December 2019	BASE-UK Members visit to Frederic Thomas, in France - first week in December
3rd/4th December 2019	Agronomists' Conference - https://ahdb.org.uk/events/agronomists-conference
5th December	Soil Security Programme - https://www.agricology.co.uk/join/events?page=1
7th - 9th January 2020	Oxford Farming Conferance
7th - 10th January 2020	28th Nationbal No-Till Conference
7th/8th January 2020	LAMMA
8th/9th January 2020	Oxford Real Farming Conferance
11th/12th February 2020	Base UK AGM Conference 2020
24th/25th June 2020	Groundswell 2020 - Weston, SG4 7AL

SUMO

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