ISSUE 15 | OCTOBER 2021

DIRECT DRILLER MAGAZINE

THE FUTURE OF YOUR SOILS

The results are in?

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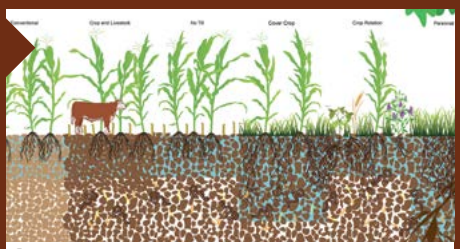

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DIRECT DRILLER MAGAZINE

Issue 15
October 2021

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THE REAL MEANING OF **KNOWLEDGE TRANSFER**

MIKE DONOVAN, EDITOR

If this issue of Direct Drilling says anything, it is that farmers are not afraid of change. Every one of the farmer focus articles describes how the contributor has made changes to many of the inputs under their control. It provides a vast amount of highly relevant and valuable information for all involved in arable farming, and in particular direct drilling. One gem that came from Clive Bailye is the observation that the drought resistance of cereal rye is far better than winter wheat. (pg 30) Arable farmers need to make time to read these and the other technical articles in their free paper copies (www.directdriller.com) or from the on-line issues. This is information which is shown to make a real difference in outcome, to both soil health and financial performance.

These experiments done by those who are curious as to what happens when things get altered are a huge contrast to the 'we do it this way' approach. The dictats of the War Ag conditioned farmers to do what they were told by advisors who came from institutions and, in the last few decades, increasingly from commercial suppliers. There was little appetite to argue and do it different. Brexit, which has coincided with the explosion of communication methods, has opened the door for wider research.

Change in UK farming includes post Brexit farm payments. The end of the greening rules has been welcomed, and these are the first of huge changes to Defra and Rural Payments.

The Sustainable Farming Incentive pilot scheme (www.gov.uk/guidance/sustainable-farming-incentive-pilot), required those interested to provide an 'expression of interest' in the window Mon 15 March to Sunday 11 April. Some 2,000 were accepted and have needed to complete their application by the end of Sept to start their pilot scheme in October. So far there has been muted response, perhaps partly the result of it being bang in the middle of harvest.

Pilot participants get £5,000. The scheme will support approaches to farming that deliver for the environment such as soil health, IPM, and hedgerows.

It looks as if it is a case of early birds catching worms. The Defra changes will in time involve dispensing a large budget, and knowledge of how it works and the application procedures are the next hurdle for farmers to clear.

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THE 3.5% RULE

The "3.5% rule" refers to the claim that no government or organisation has withstood a challenge of this percentage of their population or membership mobilised against it during a peak event. This rule is based on an insight that political scientist Mark Lichbach developed in his 1995 book "The Rebel's Dilemma". In it, he speculates that no government could withstand a challenge of 5% of the population; and that no rebellion could hope to mobilize more than 5% of the population anyway because of popular incentives to free ride on more risk-acceptant revolutionaries.

Given where we are with Red Tractor, I think this logic is worth highlighting to farmers. Who often feel they have no power. This figure for all of UK farming is 8400 farmers. Probably only 2200 if you look at Cereals and Oilseeds. Therefore, if we want change in farming, it can happen. Get 2199 of your colleagues to stand outside the AHDB in Stoneleigh or the Red Tractor offices in London or the NFU offices in Stratford-upon-Avon and make your presence felt.

The big question is, have that many farmers ever agreed on a single subject? The history of farming has been dominated by the opinions of the few. The NFU, CLA, RT, AHDB decide what farmers think and that becomes policy. The worrying thing is that none of those organisations elect people into positions of power in a very "democratic" way. That includes the way the NFU elect officials, as I was told once "the NFU are wise" in explanation to why a particular person could and would never get elected to the top position. Not exactly the "they will never get the votes" answer I was expecting. What is clear is that the few make the decisions on behalf of the many as with all systems of governance. But this is changing and given the 3.5% rule it can change whenever you want it too.

To this point, we now distribute this magazine to over 5000 farmers and it's read by more than 18,000 with our online and PDF readers. Thus, this magazine has surpassed that threshold. As has the attendance of Groundswell and have you noticed how much Regenerative Agriculture has become popular outside farming recently and in the media? This is the 3.5% rule in action. We as a group have got together, expressed our opinions and they have been listened to. Change is possible and you have more power than you think.

Written by Chris Fellows

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FEATURED FARMER
ED REYNOLDS

Farm Facts

- 327ha arable farm in west Cambridgeshire growing combinable crops on clay
- The land is 71% owned, 29% contract farming agreement
- 1 fulltime employee, 0.5 myself + casual staff at harvest

When I started farming there were two choices: conventional and organic. We were conventional. Organic just seemed out of the question, too bigger a leap on the heavy land we farm without livestock. I found neither of these provided me with that sense of fulfilment. I have always been an advocate for planting hedges, introducing trees, awareness of catchments and pollution – all things connected to working with the natural environment. However, I wanted to use (and appreciated) pesticides, when used in the right place at the right time. Farming in a way which delivers other benefits, not solely economic returns, has been what I was looking for.

There is nothing exceptional about our farm. We are a 327ha arable farm in west Cambridgeshire growing combinable crops on clay. There is, however, something remarkable going on underneath our feet. Every moment of every day, flora and fauna are interacting in ways too numerous for us to comprehend, for the benefit of our farm. And to encourage this, I have to do things differently.

I instinctively knew Regen Ag was an opportunity I wanted to grasp, from those first few 'alternative' talks and working demonstrations I had seen during early 2010's. I knew this because I began to grasp the concept that soil functions by itself, in cycles. This was revolutionary as I had come from a traditional, heavy cultivation regime, with little thought for the soil. A traditional focus is on the surface, how things look from above. Regen Ag presented an alternative: looking at the whole system. In 2016 I started to farm in a way that works with the natural systems, and attempted to use nature to help address some of the problems 'bag and can' farming had created. Turns out my first attempt was a failure as whilst I had the enthusiasm, I didn't prioritise information, in this case, about soil structure. And so on to the next year, this time armed with a soil consultant. We are now 5 years into a graduated transition, and the results, both anecdotal and empirical give me great confidence that we are on a better path. What is more, the fun has come back to farming.

2021 harvest:

1st Wheat direct drilled - 9.97t/ha

1st Wheat conventional tillage - 9.80t/ha

We run a 6 year rotation including W wheat, S barley, peas, oilseed rape, linseed and oats. We strive to grow multi species catch and cover crops, assuming we have a minimum 5-week gap between cash crops. I dig soil pits to check for problems during the summer and run a no-till establishment policy, with some exceptions based on soil structure data.

Our soil is Hanslope and Evesham series clay – 40% Clay, 37% Silt, 23% Sand. Although it is heavy soil, it has a high calcium content and has adapted to direct drilling better that I could have ever expected. The way in which it self-structures is remarkable, trafficability has improved and we do not get those sunken wheelings from harvest traffic during wet summers.

One big win for us as a 'smaller' farmer is to keep axle weights down. Regenerative Agriculture does not require much horsepower, we have been able to employ a 6t 150hp tractor for many operations and an 8ton 200hp tractor for crimper rolling / drilling. Lighter axle loads mean you are less likely to cause compaction, that leads to patchy crop establishment, weeds and problems down the line.

Residue management has been an area that we have grappled with. It took a while to understand that to establish a cashcrop in high residue situations, baling the straw has benefits. I have learnt to be pragmatic – you sometimes break one rule in order to achieve a successful cropping outcome. Ultimately, I hope that our worm populations and shredders will continue to build to a point where high C:N ration crop residue is pulled down and consumed, but we am not quite there yet. We have a disc drill and I am aware that hair-pinning will reduce my establishment % and may lead to residual herbicide washdown and damage.

In autumn 2019 I found direct drilling 2nd wheat seed into wheat stubble with chopped straw challenging. In some fields, the aggregation and structure was not yet there, meaning the moisture sat in the top 3 inches, causing smearing, compaction and anaerobic conditions. I saw blue mould and slugs attack the seed, leading to a stand of 112plant/m2 in February. The decision was made to keep the crop, and that year (2020) the direct drilled 2nd wheats only yielded 6.4t/ha. This decision was won over by the lack of weeds present, a great benefit of direct drilling and using a low disturbance opener.

Conversely, during spring 2021, spring oats establishment benefitted from chopped straw on the surface, along with a 5 way cover crop that was grazed by an over winter flock of ewe lambs. The straw acted like a mulch and prevented drying out and the opening of the slot during the dry April, just enough to allow germination, and the roots to find moisture. These milling oats went on to yield 6.0t/ha, 52kg/hl specific weight.

December '20

S Oats April '21

I have found that in this transition phase, mole draining and ditch maintenance has been key to our progression. A good mole may last for 10 years, and I hope that in time we may come to rely on mole draining less as our natural soil aggregation continues to improve.

Our first attempt at intercropping involved a crop of spring barley (50% seed rate) and peas (at 70% seed rate) in the same rows. The purpose of this was to try and address one of the 5 principles of Regen Ag – try to achieve diversity, to the benefit of soil microbes. This 5ha trial started well, but ended with the barley outcompeting the peas at GS39, coming to a 5.4t/ha spring barley yield and virtually no peas. This was not a complete failure as it achieved this yield on near zero N to the crop.

Artificial nitrogen fertiliser is an area we are trying to reduce, and rates for all crops are down 15% over 4 years. I have found this needs to be done carefully, as yields can be affected if done too fast or without a holistic view. I hope to partially move to foliar fertilisers to reduce this further in the short term, and who knows where intercropping can take us in the long term.

The adoption of this new way of farming has meant re-learning our trade and being open to new ideas. There have certainly been risks and pitfalls associated with the adoption of Regen Ag for us, but by taking a chance and managing the risks as best you can, so far the outcomes have been well worth it.

BLACKGRASS CONTROL ARE YOU USING ENOUGH DIHYDROGEN MONOXIDE?

Written by James Warne form Soil First Farming

Dihydrogen Monoxide or DHMO has been used for years to improve the distribution and performance of soil acting residual herbicides along with other uses such as a solvent, coolant, and used extensively as a fire retardant. It is critical for life, but deadly if too much is imbibed. You've probably heard of DHMO by its more common name – water.

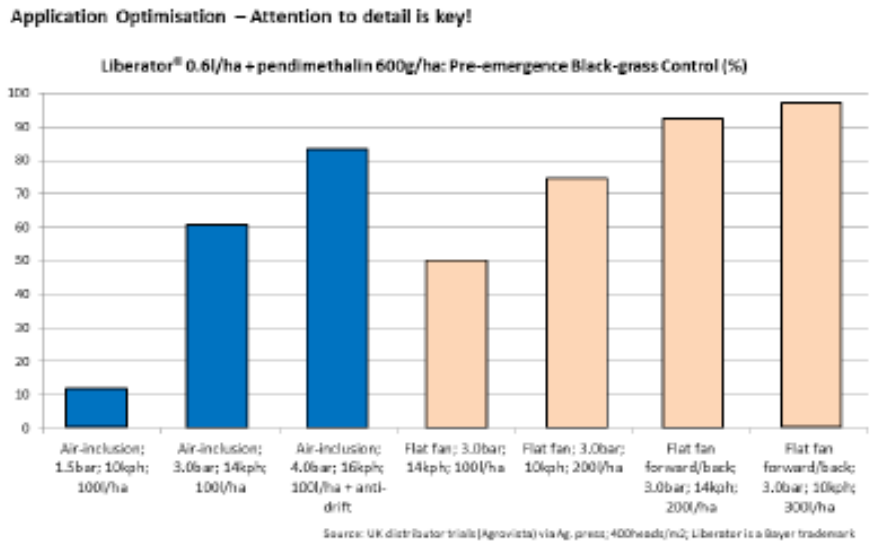
The slightly flippant tone of the opening paragraph belies a message of real importance when it comes to simple and practical advice on the use of soil residual chemistry. The real message is if you want greater efficacy from your herbicide spend, use more water.

This year has seen, in many areas, a massive seed return from the common grassweeds, brome, blackgrass, ryegrass etc. The last two autumns have also proved to be very tricky for crop establishment, both of which may combine into the perfect storm of earlier drilling and large seed banks ready to germinate.

Trial work (by Agrovista) reveals that pre-em herbicide efficacy can be improved by the addition of more water. At 100l/ha a programme (see graph below) using DFF/FFT/PDM mix achieved just 50% control of blackgrass, But the same programme with 300l/ha water achieved over 90% control. Can you afford to ignore this evidence?

DFF & FFT costs in the region of £20/ha at full rate, Pendimethalin is in the region of £20/ha. Prosulfocarb at recommended rate is circa £30/ha. An extra 200l/ha of water costs £0.4/ha. To nearly double your blackgrass control.

Of course, it's not quite that straightforward. The above trial was conducted using twin flange fan nozzles (forward and back), none of those expensive air induction or 'product' type nozzles. Spray pattern was fine, 3 bar pressure and a moderately low forward speed of 10km/h, (trial results below).



Just to be clear the graph above is showing that to achieve above 95% control of blackgrass use 300 litres of water, with forward & backward facing flat fans nozzles at a forward speed of 10 kph. Research by Stephen Moss et al has shown that in most situations a minimum of 95% control is required to reduce seed return.

Those of you who are BASE – UK members also have the privilege of being able to watch Chris Martin's excellent presentation of the correct choice of sprayer nozzle for different situations.

Those who are following a Conservation Agriculture strategy will hopefully have resisted the urge to do a little light surface cultivation and will now have all the weed seed on the surface. Excepting the fact that there will always be a little seed which germinates from depth, a legacy of historical cultivation. With the seed on the surface it is now in better place to be controlled with actives such as flufenacet (FFT) and pendimethalin (PDM). These two key actives provide the backbone of many pre-emergence herbicide stacks and are probably the most cost effective too. They are primarily taken up by the roots of the germinating grass weeds. Therefore the roots of the blackgrass plants have to come into contact with the herbicide to be taken up and be effective. If the weed seed is emerging from depth the germinating seed roots are very unlikely to encounter the active ingredient and can happily push its cotyledon through the layer of herbicide on the soil surface without harm.

Combine this strategy with spring cropping, wider rotations, more broad-leaved cropping etc and you should find that grass weeds become less problematic year-on-year.

AGROFORESTRY: LEARNING FROM FOUR PIONEERS

Written by Mike Abram

Interested in agroforestry, but don't know quite where to start? Four pioneers shared their expertise in an excellent knowledge exchange session at Groundswell.

More farmers and landowners than perhaps ever before are starting to consider agroforestry as a viable enterprise for farmland. Recent government announcements to treble annual tree planting in the UK by May 2024 as part of climate change mitigation and net zero targets is helping to set the agenda.

While that might be in the main for woodland creation, Defra has also recently approved an Environmental Land Management Test and Trials proposal from the Organic Research Centre and partners to explore how farmers can integrate agroforestry at scale.

That followed on from the Climate Change Committee, the UK's independent adviser on tackling climate change, recommending 10% of the UK's crop and livestock area should be agroforestry. The Woodland Trust suggests that would require an extra 39,000ha of agricultural land for agroforestry each year, which by 2050 could deliver 6 million t/ha CO2e in savings.

Currently only 3% of UK's farmed land is estimated to practice agroforestry, and that shows with technical advice and support only just starting to come on-stream. Early adopters, such as those on a panel at Groundswell, have had to rely on trial and error to make their schemes work, and were able to share some valuable experience on five topics during an hour-long session.

1. Selecting the right tree

Identifying tree crops with market demand was a key focus for Dartington Trust's 19ha Broadlears Field agroforestry project in Devon, said Harriet Bell, who helped establish the innovative land share agreement between five businesses.

"We found people who had specific demands, qualities and quantities, and we endeavoured to design a system that will deliver that outcome.

"The other thing we did was try to spread the risk with a variety of different trees. We tried something new in Szechuan pepper, which hadn't been grown here before, but in a small way compared with staples such as apple and elderflower which we knew

would grow well in Devon."

In a silvo-pastoral project also on the farm, understanding livestock behaviour and dietary needs were key considerations, she added.

For Cambridgeshire farmer Stephen Briggs an economic return within his 15-year tenancy was a pre-requisite for tree choice on his 52ha silvo-arable scheme, alongside the need at the time to maintain Basic Payment Scheme eligibility for his landlord. That led him to choose 13 varieties of apple from heritage to modern.

With no other fruit trees in the immediate area of his farm, it has meant lower pest and disease pressure, although selecting trees that will grow in your locality is important.

Other factors to consider were soil type, good planting stock and being able to buy it, he added. "That's going to be an increasing challenge with the government's tree planting targets – where is all the planting stock going to come from? You have to be thinking nearly two years ahead," he advised.

Climate change was another factor to reflect on both in terms of spreading risk of pest and disease pressure, as well as for future markets, he said. "People are starting to think about, with climate change what we might be able to grow in southern England, which we can't grow currently." Examples potentially were almonds, olives and Eucalyptus.

Your own farm could also be a market for produce from trees, said Ben Raskin, head of agroforestry for the Soil Association. "You could be growing your own fence posts or wood chip. There's lot of stuff you could grow to replace your own inputs."

Multi-purpose high-value trees from which you get more than one product could be important, said Prof Steven Newman, who assists with the development of large-scale agroforestry projects on farming estates. "Nut trees fall into that category, particularly walnut and hazel."

For example potential walnut markets included fresh walnuts, green nuts for pickling or for Greek / Cypriot sweet desserts, and timber, he explained. "There are at least 60 different products you can get from walnuts."

Be innovative, he advised. "Globally there has been a 20% increase in nut consumption over the past seven years. That's a massive shift. Nut milks have an incredible potential, while think about replacing carbon inefficient products."

Payback year for walnut was year seven, and year five for hazel. "After that you are into some quite significant gross margins, but it's not instant. The payback year depends on the cost of the tree, which is the dominant cost. Buying bigger orders reduces the cost per tree.

"The most profitable tree currently is cricket bat willow, which is a classic choice for a silvo-pastoral system. Nut trees, especially walnut, agroforestry can improve on this, providing an annual income, plus a final value from the tree when it has finished its productive life."

2. Planting and managing for survival

Planting trees into heavy clay was not easy, Mr Raskin said. On such a site he used a GPS-guided subsoiler to create a straight line and a slit to plant into, which made planting quicker and gave reasonable establishment.

"But in 2018, when we had the drought, the trench we created just split open so there was a 1m crack in the soil in which this poor little twig was sitting in and had nowhere to grow.

"So I think next time I'd plant about six inches to one side of the crack so you're not directly in it."

Planting date was also important – January-planted trees mostly survived while those in March mostly died – as was mulching, he said. "But I wouldn't use mulch mats – they create the perfect habitat for voles, whereas where we just used wood chip to mulch directly, we tended not to have problems."

Whether to use guards or fencing was a cost versus risk debate, he said. "It's the value of the tree and how many trees you have in the field. For example, in one field where we had a lot of expensive fruit and nut trees, and it was worth deer-fencing the whole lot.

"In another field, we just have single strand electric wire down each side of the row, with a little guard on each tree for hares and muntjac, and it's much cheaper. We feel we can lose quite a few trees before it's worth spending £30,000 on fencing.

"Straight lines are obviously easier to fence, whereas if you have clumps of trees, you're probably better off doing them differently or individual trees.

"In the end, how much can you risk losing that tree? If you're spent £0.50/tree and a £1 on a guard you can probably afford to lose quite a few, while if you've spent £25/tree and you're not going to get a return for 10 years you probably want it to survive."

Buy good quality posts, Mr Briggs said. "We bought on a budget, and after three years when they've rotten at the base you have to spend all over again."

It cost him approximately £5-7 to put a fruit tree in the ground, including mulch, tie, guard and posts.

In his arable system, he hadn't anticipated creating 4,500 roosting posts for pigeons, where two or three landing can break young saplings. "We solved that by putting a 10-foot bamboo cane with each tree, which the pigeons landed on."

Also think about what you're doing underneath the tree, what understory will grow well and how you're going to manage it, he said.

"I wish we had put a weather station in from day 1. We benchmarked a lot of things, but I know we have wind reduction and warmer climates in the field, but I haven't got the backup data on that."

3. Harvesting

Think carefully about labour for harvesting, Prof Newman said. While community labour might be an option for some, the lack of available labour for picking was driving a change towards mechanical harvesting. "All the large-scale systems we're designing for nut trees are mechanically harvested. That means changing the hazelnut varieties, so they are free husking and means when you shake the tree the nuts come down relatively swiftly.

"Similarly with walnuts when they fall to the ground they can be picked up," he explained.

It wasn't just harvesting labour to consider but also for summer or winter pruning, Mr Briggs added.

With apple trees in most systems you wouldn't get any yield for around five years, with yields peaking after about seven years. "You should be looking at least 5t/ha up to 20t/ha if you're managing quite intensively."

Another consideration was the impact of harvesting tree crops on the crop in between the trees, Ms Bell said. "When we were designing our silvo-arable system we were looked at when we would be taking a cut from our arable part of the field, and when we would need to be in with heavy machinery to harvest the trees and tried to design the whole system with that in mind.

"For example, with elderflower which is usually harvested in May or June, we put in a wider margin around those trees so we could still get in and harvest without it having a detrimental effect on the arable crop."

4. Marketing

Adding value when marketing produce was key because competing on price in a global market was unlikely because of high labour costs and standards in the UK, the panel explained.

"We were interested in adding value from the start," said Mr Briggs. "All our fruit is either sold as eating apples or juiced and sold through our farm shop. We wanted to generate a market, get some processing capacity and create a brand for that produce.

"By juicing our apples and putting it in a bottle, while there is a cost, you're pretty much quadrupling its value. You're turning something that was £280/t on the wholesale market into £1200/t."

But as with stock markets demand and value of products could change and with that future returns, the panel noted. For example, currently cider apples were generating a poor return, Mr Raskin said. "I wouldn't be considering cider at the moment – the value has dropped out of the market."

While spreadsheets were useful to model potential future risks, trees within typical agroforestry schemes were only 8-12% of the land area, Mr Briggs pointed out. "So around 90% of the area is going to be doing something different so you are spreading your risk."

Agroforestry had other benefits including sheltering livestock or raising the temperature between the rows in arable crops, Mr Raskin added.

Shading up to 27% of a potato crop didn't affect yield in Prof Newman recent research, while Ms Bell suggested agroforestry also helped manage the risk of unpredictable weather.

Storms during 2019 harvest on Mr Briggs's farm resulted in 20% loss of grain in open fields compared with 10% in agroforestry fields because of slowing down wind speeds, he said.

5. What options do you have as a tenant?

With nearly a third of the land area in the UK tenanted, the issue of whether agroforestry is deliverable as a tenant is no small matter.

At Dartington, a novel solution was used, Ms Bell said. "The Estate owns the land, we have a tenant with a FBT for the entirety of the field, and then we used licences to licence each of the tree growers for just the row of trees they were growing. Our tenant was paying the estate, and the people growing trees paid rent to him.

"Legally it was quite interesting as the tree growers in the first few years were investing quite heavily in getting trees to productivity, but then worried that when the trees became productive we would turf them out.

"So in the agreement we wrote that the cost of moving them on would increase during the first eight years as the trees established, and then once they started harvesting and getting their money back, the value of those trees would start to depreciate.

"And as the landowner we also underwrote the licence between our tenant and those businesses growing the trees so they had security if the tenant changed."

In Mr Briggs case his landlord was most concerned about letting the farm if Mr Briggs left, and whether it would damage field drainage. "We signed an agreement that we would take the trees with us if we left, so at worst I have a wood fuel business, and I found a piece of work that showed if drains are maintained trees don't cause any problems."

Farming with trees had allowed him to become more productive, he suggested. "I'm charged rent on a two dimensional – per hectare – basis, but I can make the farm bigger by farming it in a 3D way and make it more productive without affecting the rent at all."

DURHAM FARM TRIALS PUT SOLID SCIENCE INTO **BIOLOGICAL FARMING**

Detailed trials assessing a broad range of regenerative farming strategies on a progressive Durham farm are putting some solid science into efforts to improve arable sustainability by making the very most of above and below-ground biology.

Now into their third season, the Agrii Green Horizons trials with David Hankey on his family's 160ha Dunkirk Farm, Birtley overlooking Gateshead's Angel of the North are examining the impact of a wide variety of cover and OSR companion cropping approaches as well as in-field wildlife strips. In-depth assessments are being made of just about everything that can be measured to assess both their specific contributions and, more importantly, the benefits they bring to overall farm sustainability.

Spring barley profits from improved soil biology and structure

David Hankey (left) with Agrii specialist, Robert Bowes

To address a serious deterioration in the health and condition of the sandy loam soils which became starkly apparent in the wet winter of 2012, David made the decision to 'go regenerative' the following year. Since then he has done away with cultivations, broadened his rotation, developed his own cover and companion cropping regimes and given-up using insecticides entirely.

At the same time, he has been routinely applying around 25t/ha of compost and other manures to approximately half the acreage each year, more than replacing the value of the cereal straw – all of which is baled for the very valuable local market.

As well as dramatically reducing problems of surface erosion on the farm's exposed and sloping ground, this approach has transformed soil health and workability, boosted organic matter levels to 5-6%, lifted worm counts to as many as 30 per spadeful, and generated a wonderful surface tilth to aid crop establishment.

This has resulted in impressive 7.5t/ha-plus light land spring malting barley yields from little more than 120 kg/ha of nitrogen and oilseed rape doing 4t/ha from just 106 kg/ha, together with reductions around 80% in establishment diesel use.

"Taking the regenerative route has paid dividends from Day One," says Mr Hankey. "Our soils have become that much easier to work. They don't slump anymore and we seldom see water on the surface for more than a day. Putting life back into our soils has worked wonders for natural predators too. When we see aphids in our beans we no longer panic. Within a few days they're being decimated by ladybirds.

"We went into strip tillage with a contractor but invested in our own Claydon in 2015. It didn't take us long either to replace proprietary cover crop mixes with our own designs – the best of which we've christened Jeremy (Clarkson) for its combination of speed and power.

"Having tried a variety of no-till disc drills, we've finally settled on a Horsch Avatar multi-hopper model to give us greater flexibility to further develop our 'whole food web' regenerative ideas," he says. "The science Agrii and its partners are bringing to our efforts means we're able to do this with a very much better understanding of what's going on ecologically."

In the past year the Agrii team led by local specialist, Rob Bowes have been examining no less than eight cover crop mixes of three to 13 different species on a field scale after winter wheat and ahead of spring barley.

Costing from £26 to £86/ha, these have resulted in very different levels of soil nitrogen, phosphate and potash as well as overall organic carbon, active carbon (available for soil microbes), total microbial biomass and earthworm counts.

"The more diverse mixes have generally delivered greater nutrient and biological benefits," Mr Bowes reports. "While they have also tended to be more costly, this certainly hasn't always been the case. Two of our three-species mixes, for instance, varied in cost from £26 to £54/ha, with the cheapest one making a noticeably greater contribution to the main soil nutrients and organic carbon (Table).


Buckwheat gives rapid early cover from the companion crop

"Important in managing residues, fertiliser regimes and nutrient cycling, the mixes have also had very different carbon:nitrogen ratios," he adds. "In general, the bigger the above and below ground biomass, the higher the carbon content, the slower the cover will release its nutrients and the more nitrogen it will use to do so.

"We reckon a C:N ratio of around 30:1 offers the best balance between reasonably rapid residue breakdown and soil surface protection in most cases. Having said that, the best ratio for any particular situation will depend on the relative importance of the two priorities."

Like catch crops ahead of winter cereals, rapid residue breakdown that ties-up as little N as possible is likely to be preferrable in oilseed rape companion crops, favouring lower C:N ratio species like legumes.


Cover cropping and direct drilling have really improved the soils at Dunkirk Farm 2

This, and Dunkirk Farm's experience to date, is why the parallel companion cropping trials have primarily involved mixtures of buckwheat with vetch and berseem clover – plus phacelia and fenugreek to explore if these add anything in crop growth, nutrient contribution, soil structuring or CSFB confusion.

"As well as concealing the OSR from migrating adult flea beetles, our work confirms buckwheat is making a particular contribution to soil phosphate," notes Mr Bowes. "We also believe its early flowering is helping support the wasps that parasitise both flea beetle adults and larvae.

"We're finding the vetch that takes over as the dominant companion after the buckwheat dies back valuable in maintaining crop cover for pigeon deterrence, while the berseem clover is giving us great soil structuring. And, of course, both are contributing extra nitrogen in the spring and early summer.

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Clear improvements in drainage with a cover at Dunkirk Farm

"Our comprehensive soil and tissue testing indicates the companions are delivering around 50kg N/ha to the crop. At the same time, we have recorded noticeably higher levels of phosphorus, potassium and sulphur, as well as boron and molybdenum in OSR leaf tissue testing from our companion cropped areas (Figure); levels which were particularly elevated where we had a more diverse companion mix and replaced seedbed DAP with a specialist protected phosphate Agrii-Start fertiliser."

The visible differences in both crop health and grass weed control recorded in the Agrii trials at Dunkirk Farm have been especially impressive too.

What's more, adult flea beetle damage has been negligible in either of the two trial fields despite serious levels of grazing in the brassica component of adjacent cover crops. Which offers another valuable lesson in integrated farm-wide pest management.

The covers in the nearby field, sown a couple of weeks later than OSR and its companions on August 12, emerged into the peak of CSFB migration and clearly acted as a useful trap crop.

"This sequence of sowing is an inevitable consequence of our rape going in after winter barley and covers following winter wheat ahead of spring barley in our six-year rotation," Mr Hankey observes. "So, as the beetles arrive in September, we have reasonably well-established oilseed rape nicely sheltered by buckwheat on the one hand and fresh brassicas just coming through in neighbouring covers on the other.

"The scientists tell us flea beetles have a marked preference for younger plants, and this is crystal clear from the fact that our OSR volunteers are seldom touched. Getting companion and cover crops to work together in this way gives us what is basically a 'pop-up rainforest' harvesting sunlight and carbon while really make trap-cropping work."

Another element of wider IPM looking very positive in current Dunkirk Farm trialling is wildlife strips within crops to provide readily available food and cover for predators. Three metre strips of bee and pollen and nectar mixes have so far been sown into the centre of two fields of spring barley, with an average of 25 carabid beetles/trap collected in each of their three pitfall traps last summer.

"That's a healthy population for beetles the experts tell us we should only be finding within a few metres of our field margins," points out Mr Hankey. "What's more, we think they're going for slug eggs – carabid caviar perhaps? We're certainly not having to use nearly as many slug pellets these days."

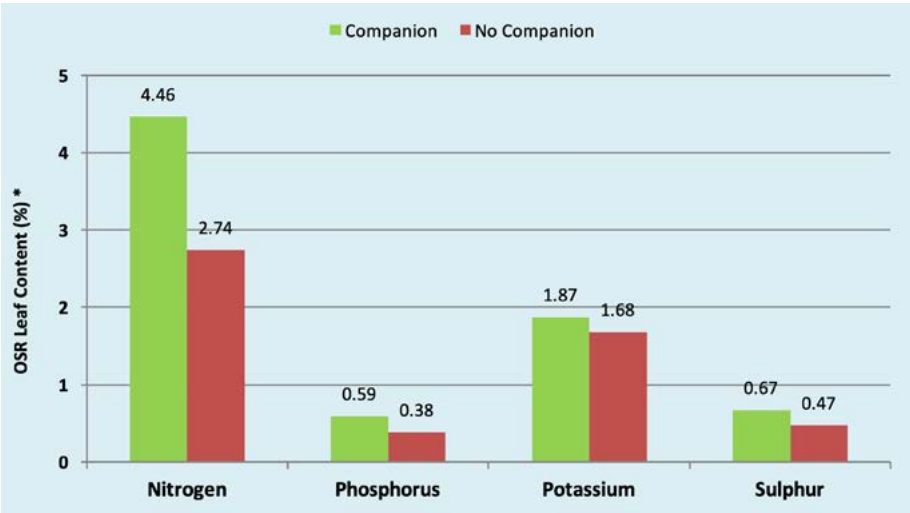
"There's a lot more our trial work here and on farms across the country is looking to understand about these and other aspects of biological crop management," concludes Mr Bowes. "As well as the best place to use covers and companions and the best species to include for particular circumstances, we need more intelligence on when and how best to establish and remove them; especially with soil types, at elevations and in other situations where farming conditions are more challenging than most.

Table: Dunkirk Cover Crop Trials 2020

Cover crop mix	Number of species	Cost (£/ha)	Nitrogen* (kg/ha)	Phosphate* (kg/ha)	Potash* (kg/ha)	Organic Carbon # (t/ha)	Earthworm Count
A	6	70.00	48.62	6.06	38.47	129.2	16
B	6	52.50	43.59	5.52	31.04	94.1	18
C	5	57.50	30.34	3.76	21.36	112.2	8
D	5	46.25	22.28	2.86	13.71	132.6	19
E	13	85.50	35.61	4.01	25.07	145.1	14
F	3	53.70	28.97	4.46	22.70	120.2	22
G	3	25.65	40.44	5.18	30.45	165.5	16
H	5	40.00	28.14	3.83	20.91	145.1	18
Fallow	0	0	0	0	0	104.3	4

** Tissue analysis just prior to spraying-off covers*
 # Soil analysis in early spring

Figure: Dunkirk Farm Companion Cropping Trials 2020



** Tissue analyses in early spring ahead of first fertiliser application*

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WHAT WE **CAN'T SEE**

Written by Chris Fellows

Farming is becoming as much about what we can't see as what we can. We as farmers already know that. Many of the articles in this magazine cover what can't be seen and the complexity of modern-day sustainable farming. Greenhouse gases in the air can't be seen, our crops and tramlines can. Soil carbon under the ground can't be seen, but soil on the road can. Soil microbiology can't be seen but cover crops can. The carbon footprint of an avocado can't be seen on its packaging, but our livestock can.

Farmers are becoming ever more berated for what can be seen. The public are being told that these visible elements are bad. Livestock are bad. The public don't even seem to argue that much with this hypothesis, because if agriculture is bad then it takes the spotlight off their own carbon footprint as they board their flights to Ibiza.

"look at all that damage being done" they say to their kids, as they drive them the mile to school while picking up a Costa in a disposable cup on the way. The blame game is a distraction for them, one that is very effective. It also damaging, as it stops people from making changes in their own lives that would make a difference to the planet. The truth is we all need to make changes, not just say we are doing the right thing or carry on taking private jets and then just saying you have bought an offset.

We as farmers know livestock aren't bad per se. CAFO's in the states certainly aren't the way livestock is going to be raised in a sustainable future, but livestock, in a rotation with crops, grass or other animals can be a very effective way to generate a closed loop farm that requires the minimum of inputs and creates the maximum of financial output. Read "Dirt to Soil" by Gabe Brown, if you want to understand closed loop farming better, he explains it far better than I could in a short paragraph. But what is clear, livestock are part of a closed loop farm, therefore the simple statement that a vegan lifestyle will save the planet is wrong in my eyes.

However, perception will only change if the public start to appreciate farming for what can't be seen. As these are our silver bullets, the truth behind the myths that are propagated in the media and online. This is the battle of perception we face. I toyed with whether to use the word battle, but the more I think about it, the more I think we are at war. If you look at the massive money institutions behind processed food and lab grown meat, it's a battle that we are doomed to lose unless some action is taken to educate consumers.

We need to define our bullets and start to repeat them enmasse.

Henry Dimbleby's National Food Strategy is our first bullet. He has said that processed food is the enemy of health. That ultra-processed food needs taxing, heavily. It causes long term health problems and just like cigarettes needs taxing at an appropriate level to the damage it is causing. The unhealthiest food on offer in a shop should not also be able to be the cheapest. The healthiest options should be the cheapest, preferably then priced by distance from where things are grown to the shop they are sold in. Meat substitutes are generally classed as ultra-processed food. Whereas there is not going to be a meat tax, which is good as sustainably grown meat is better for the diet of the general public (and their carbon footprint) than often the media portray.

Second bullet is being local. The UK has a very robust climate, day to day our weather is unpredictable, but year to year, we are in a better position than many countries to keep farming and even increase the list of products we grow as climate changes and the planet's climate changes. In June this year, researchers created a "shortlist" of five nations most likely to survive the apocalypse. The UK was ranked 3rd and Ireland 5th. The number one criterion was how much land is being used for farming compared to the population. Our climate, regardless of the changes we will see in the next 50 years will remain very suitable for

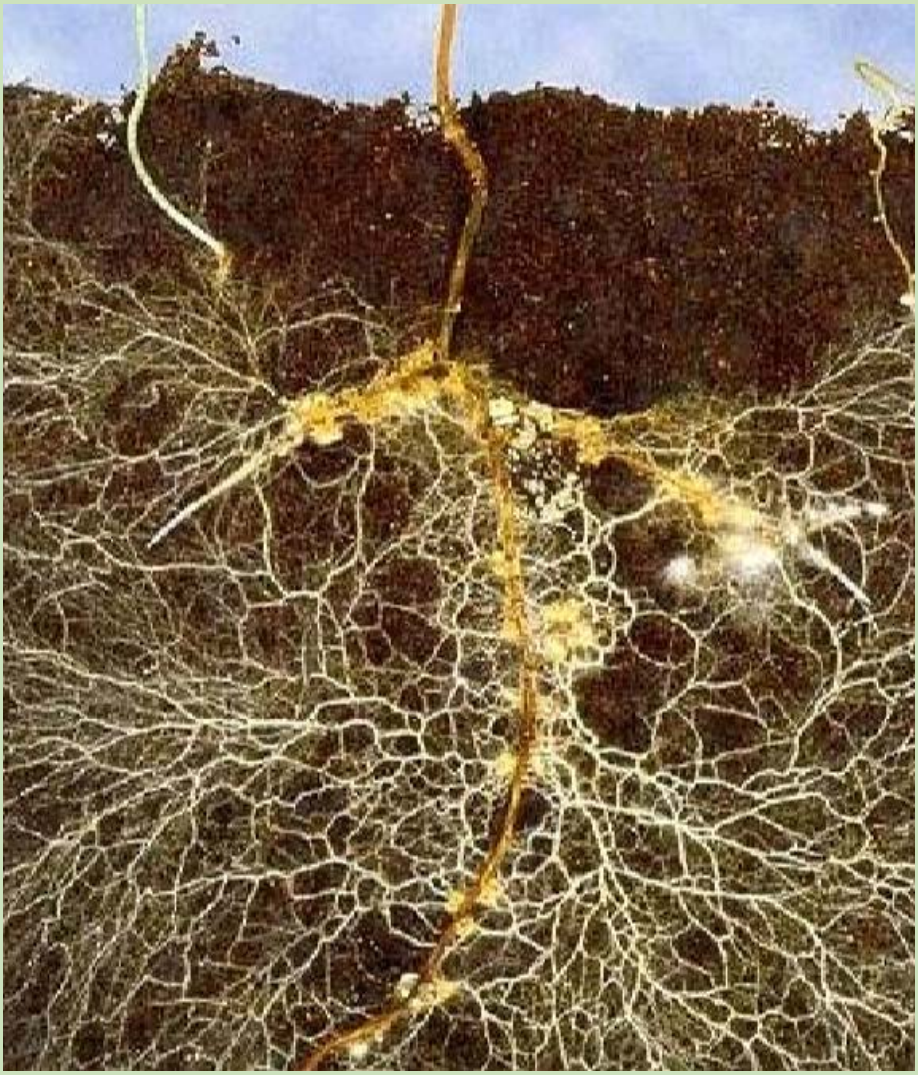
farming a lot of land.

Thus, we can and should grow more of our own food. Certainly, more than 60% of it. Looking at the national Food Strategy, we need to grow more fruit (and nuts) and reading about the agronomic benefits of including trees on your arable farms (detailed by Mike Abrams in this issue) then why not have more fruit trees. But this fruit ideally needs to be sold locally. While Waitrose is very open to the discussion around local food, I think the best way is direct to consumer. More farms need a little farm shop that the public can buy from. More of the public need to go onto farms and see how food is grown sustainably. More of the public need to understand this complexity in farming.

Third bullet. Education centres. We now have a few agricultural education centres around the UK. Agri-Epi, Agrimetrics, NIAB, Daylesford and FarmED to name just a few. We need to use these better to educate the public. Which won't be easy as the public don't think they need

Henry Dimbleby's National Food Strategy has suggested supermarkets can play a significant role in changing consumers trends (Photo: Paul Clarke)

educating, that's what the media and Facebook are for! An obvious target is to get more schools to visit these centres, but kids also love junk food. They won't change their diets on their own. We need to get more adults through the doors. I don't think that needs to be on the basis of learning about farming, we could just offer these spaces to businesses that need meeting and conference space. The people then that come in the door



can be influenced. But we should also all give up some of our time to organise events at these places. Get 50 people toegther and talk about how we farm. Assuming they all have families then just the readership of this magazine could influence over 2 million people from just doing one event each. I know talking to a group seems like a massive ask, but its easier and less daunting than you think. You really do understand you chosen subject and the public love the idea of regenerative agaiculture.

Fourth Bullet. We need to create Ag tech that makes farmers more profitable, not just the ag tech companies more profitable. I recently read that Agri-Epi feel the key driver for any agricultural business they support is GVA. I would have loved to have been able to tell them why I feel this is wrong. I guess I am, right now. GVA (Gross Value Added) is the measure of the value of goods and service a company produces. Yes, businesses need cashflow, yes they need to make money, but GVA is not king and should not be treated as such. The GVA of each business is what contributes to GDP on a national scale. At a governmental level GDP growth is good, so you could say their attitude to GVA and Ag Tech companies meets national needs. But GVA is not good in every situation. Just take the re-usable cup mantra that coffee shops promote. Using paper cups would drive higher GDP, but its not seen as good to do something so disposable. GVA that serves no purpose is not good. And this unfortunately is the history of farming. GVA has risen a lot in agriculture, but farmers have no reaped the benefit of this.

Going right back to the 1862 when Lincoln created the United States a Department of Agriculture. (see boxed information from the USDA at the end of the article). A statement that change would drive farming forward, change the way American's farm. It did, synthetic fertilisers, crop protection products all have enabled farmers to produce more. But I'd challenge whether any of it has made farming more financially sustainable or profitable. Farmers aren't better off, but agricultural companies are more profitable. Some of the world giants in financial terms have been built based on these changes. Ag Tech needs to start being measured in whether it makes farmers more profitable, not just give farmers the ability to grow more. GVA is not what I would be measured success as – sustainability is.

Fifth bullet, talk about complexity. The public has a view of farmers. A stereotype that we have all seen on many a TV show. It involves a flat cap or chewing straw and a character you find hard to understand. Clarkson's Farm is also guilty of this a bit. He is certainly demonstrating how hard farming can be, but he isn't demonstrating the finesse that goes on behind the scenes. Why a complex rotation is good for both a farmer's pocket only in the long term and not always in the short term. That bumper yields can be achieved at the expense of the soil health in the short term. But this isn't the right approach. That farmers look for complex rotations that will maximise revenues over 20 years. I think Clarkson's Farm was guilty of this mistake. He was advised

to cultivate land that hadn't been cultivated for years as it would get him a better yield that first year. He talked about the yield penalty. While it created some fun, it really isn't what we should promoting. Complexity is. That farming is incredibly complicated to do successfully (in fairness I think Mr Clarkson has highlighted this element rather well). When given the chance, make yourself sound like a rocket scientist.

Sixth bullet, food needs a documented carbon footprint. I've saved this to last. What currently can't be seen is the carbon footprint of food the consumers buy. Unless this is fixed, I don't think we can win this battle. The good news is that consumers want this information. They want to buy food grown carbon neutral. Carbon neutral beef exists, but we have the mantra that livestock is bad and we need to eat less meat forced on us. Having it on the packaging that a product is grown carbon neutral changes all that. Consumers can buy what they want and the added element is that they will pay more for carbon neutrally grown food. However, the bad news is that the supermarkets have zero interest in doing this. The cynic in me would say this is because they know the highest polluting foods have the most profit margin in them, but I am a cynic. Either way, I think it will require government intervention to do this, but doing it would change the face of food, eating and as that moves back, how we are rewarded for farming. The other problem is that the mills and processors don't seem to care either. At the moment, carbon neutral wheat is dumped in the same pile as all other wheats. Despite it having more value, the mills don't even care or ask farmers what their carbon footprint is or if they are carbon neutral. Once consumers require answers (and thus get an education on the food they buy) these questions will have to be asked downstream and the cream of UK farming will get paid better for what they grow. But you can tell this story.

You will note that you the reader can only help with a few of these bullets. When you are next asked about your farm, please talk more about what can't be seen than one can. This complexity will help educate whoever you are speaking to. It's a good habit for us all to get into. We can all be ambassadors for complexity.

LINCOLN'S **AGRICULTURAL LEGACY**

Written by Wayne D. Rasmussen and published with kind consent of the USDA National Agricultural Library

On May 15, 1862, Abraham Lincoln signed into law an act of Congress establishing "at the seat of Government of the United States a Department of Agriculture." Two and one-half years later, in what was to be his last annual message to the Congress, Lincoln said: "The Agricultural Department, under the supervision of its present energetic and faithful head, is rapidly commending itself to the great and vital interest it was created to advance. It is precisely the people's Department, in which they feel more directly concerned that in any other. I commend it to the continued attention and fostering care of Congress."

Lincoln's own background was the pioneer farming and rural life typical of the outer edge of America's westward-moving frontier.

His early years were spent on farms characterized by pioneer exploitation rather than by settled cultivation. The 300-acre tract in central Kentucky on which his log-hut birthplace stood was too poor to be called a farm. As a boy, he lived on a 30-acre farm. Because of hills and gullies only 14 acres could be cultivated.

In 1816, the Lincoln family moved to southern Indiana to 160 acres of marshy land. After 7 years, Lincoln's father had 10 acres of corn, 5 of wheat, and 2 of oats in cultivation. The young boy was hired out to do general farm work, to split rails, and to work on a ferry boat. In 1830, the family moved to land along the Sangamon River in Illinois. Soon afterward, Lincoln left the family and began life for himself.

This farm background, on what was then the western frontier, and his years as a country lawyer made Lincoln, during the 1850's, a representative of the frontier, the farmer, and small town democracy.

On September 30, 1859, Lincoln addressed the Wisconsin State Agricultural Society at its annual fair in Milwaukee. This was the only extended discussion of agriculture he ever made. He began by praising agricultural fairs as a means of bringing people together. However, the main purpose of the fair was to aid in improving agriculture.

Lincoln spoke of the desirability of substituting horse-drawn machines for hand power, and the potential usefulness of steam plows. He urged more intensive cultivation in order to increase production to the full capacity of the soil. This would require the better use of available labor. Lincoln contrasted "mud sill" and free labor, identifying "mud sill" laborers as slaves or hired laborers who were fixed in that situation. Free laborers, who had the opportunity to become landowners, were more productive than the "mud sill" workers.

Free labor could achieve its highest potential if workers were educated. As Lincoln put it: "...no other human occupation opens so wide a field for the profitable and agreeable combination of labor with cultivated thought, as agriculture."

His endorsement of education and his belief that farmers' interests were of primary importance indicated Lincoln's interest in agricultural reform. After saying

that farmers were neither better nor worse than other people, Lincoln continued: "But farmers, being the most numerous class, it follows that their interest is the largest interest. It also follows that that interest is most worthy of all to be cherished and cultivated -- that if there be inevitable conflict between that interest and any other, that other should yield."

When the Republican Party nominated Lincoln in 1860, two of the planks in the party platform were in accordance with ideas that had been advocated by westerners for many years. The first was the demand for a homestead measure. The second was advocacy of Federal aid for construction of a railroad to the Pacific Ocean. Two other proposals which had been advocated for many years -- grants of Federal land for founding of colleges to teach agriculture and engineering and the establishment of a federal Department of Agriculture -- were not mentioned in the platform. However, all four of the proposals were enacted into law in 1862.

The first of the measures to become law established the Department of Agriculture. In his first annual message to Congress on December 3, 1861, Lincoln said: "Agriculture, confessedly the largest interest of the nation, has not a department nor a bureau, but a clerkship only, assigned to it in the Government. While it is fortunate that this great interest is so independent in its nature as to not have demanded and extorted more from the Government, I respectfully ask Congress to consider whether something more can not be given voluntarily with general advantage.... While I make no suggestions as to details, I venture the opinion that an agricultural and statistical bureau might profitably be organized." Instead of a bureau, Congress established a Department to be headed by a Commissioner. The act was so broadly conceived that it has remained the basic authority for the Department to the present time.

The Homestead Act, approved by the President on May 20, 1862, provided for giving 160 acres of the public domain to any American or prospective citizen who was the head of a family or over 21 years of age. Title to the land was issued after the settler had resided on it for five years and made improvements on it. The settler could also gain title by residing on the claim for six months, improving the land, and paying $1.25 per acre. The Homestead Act did not achieve all that its proponents had hoped, but it stood as a symbol of American democracy and opportunity to native-born and immigrant alike.

The act granting western land and making payments for the construction of the Union Pacific-Central Pacific railroad was signed by Lincoln on July 1, 1862. The two sections of the railroad joined at Promontory Summit, thirty-two miles west of Brigham City, Utah, on May 10, 1869. This completed a rail connection between the Atlantic and the Pacific and opened new areas of the West to settlement.

The Morrill Land Grant College Act, donating public land to the States for colleges of agriculture and the mechanical arts, became law on July 2, 1862. Every State accepted the terms of the act and established one or more such institutions.

After President Lincoln signed the bill establishing the Department of Agriculture on May 15, 1862, he received much unsolicited advice, particularly in the columns of the farm press, on the appointment of the first Commissioner of Agriculture. Some urged the appointment of a distinguished scientist, others an outstanding "practical" man. A few periodical editors were certain that one of their number would be the best choice. However, Lincoln turned to Isaac Newton, a farmer who had served as chief of the agricultural section of the Patent Office since August 1861.

Newton was born in Burlington County, New Jersey. He grew up on a farm, and after completing his common-school education, became a farmer in Delaware County, Pennsylvania, near Philadelphia. Newton was a successful, progressive manager, whose farms were regarded as models. He also developed a pioneer dairy lunch in Philadelphia and a select butter trade as outlets for his farm products. Newton sent butter each week to the White House; and he and his family maintained a close friendship with the Lincolns. Subsequently, Lincoln gave him full support in managing the Department.

In his first annual report, Newton outlined objectives for the Department. These were: (1) Collecting, arranging, and publishing statistical and other useful agricultural information; (2) Introducing valuable plants and animals; (3) Answering inquiries of farmers regarding agriculture; (4) Testing agricultural implements; (5) Conducting chemical analyses of soils, grains, fruits, plants, vegetables, and manures; (6) Establishing a professorship of botany and entomology; and (7) Establishing an agricultural library and museum. These objectives were similar to the charges given the Department by the Congress in its legislation establishing the new agency.

Newton, during the nearly five years he served as Commissioner, made progress in achieving these objectives. The basis for a library existed in the book and journal collection of the Agricultural Division of the Patent Office. This collection, comprising about 1,000 volumes, was transferred to the new Department. Appropriations for library material began in 1864. The first librarian of record was Aaron Burt Grosh, a clergyman. Little is known of his library work. He is best remembered as one of the founders of the National Grange.

Although Lincoln's primary problem during his Presidency was preserving the Union, the agricultural legislation that he signed was to transform American farming.

By Wayne D. Rasmussen

Chief, Agricultural History Branch (retired 1986)

United States Department of Agriculture

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FARMER FOCUS
JOHN PAWSEY

I am currently bathing in post-harvest bliss. I haven't actually been through our results in detail yet but I am aware of the general highs and lows. With twelve months of observation of what has looked good and what could have looked better, I am hatching a plan for harvest 2022. September is my favourite month of the year; I get to have another go. The slate has been wiped and I have a new piece of white chalk.

So, the last twelve months?

Harvest 2021 gave us our first crop of oilseed rape on the farm since we converted our last piece of land to organic in 2007, and apart from annoying a group of organic oilseed rape growing Scottish farmers, claiming that I had grown the first crop of organic rape in the UK ever, it went far better than expected. Not so for my pioneering claim which suffered national protestation on social media, forcing me to limit my assertion to, "I have grown the first ever crop of organic oilseed rape in the village of Shimpling, Suffolk". I felt it best to name the county as there is a Shimpling in Norfolk where the residents share a single eyebrow and everyone is terribly closely related and you really don't want to piss them off.

To say that the whole crop was a success would be a lie as there were areas of pigeon damage on a former World War 2 runway where topsoil is non-existent and other areas where the companion crop of Berseem clover forgot that it was supposed to be frost intolerant and climbed out of the top of the crop. Fenugreek was also in the mix but didn't really make much of an appearance. In the bits of the field that we did have a decent crop it yielded around two tonnes to the hectare which has given me the courage to have another go. Last year's crop was planted in mid-August and had no inputs whereas our recent planting has had 7t/ha of dried digestate from British Sugar and has companions of Kora Buckwheat and Tabor Berseem clover. Ideally, I would like to cold press the crop on the farm and become a millionaire by Christmas 2022.

We had proper success with combining cover cropping with a non-inversion tillage trial. I took a sixteen hectare field and drilled a cover crop (brassicas and clovers) on one half and let the other regenerate with the diversity of weeds that we have managed to collect over the last twenty years with no herbicides, channelling the Newman Turner approach that,"The weed is your friend". The Newman side really went for it and produced a staggeringly impressive range of the thistle and dock family as well as a brilliant display of charlock. All was on show for my neighbours from the major A road that dissects the farm. To hide my blushes, the natural regeneration and cover crop were grazed by sheep over the winter and then lightly cultivated in a frost in early February and then sown with spring oats at the end of that month.

During the subsequent months the line between the two trials became increasingly impressive. Firstly, the apparent increased vigour from the cover crop side and the subsequent extra tonne in yield at harvest, but equally as magnificent the flocks of "Small brown jobs" on the Newman Turner side, feasting on the thistle seeds and the inevitable disappointing results in the combine tank. I'm not sure if you know this but historically young thistle shoots, stripped of their spines, were added to salads and the flower heads were used like artichokes? Yet another product, along with the organic oilseed rape oil, that could be sold in the virtual Shimpling Park farm shop furthering my ascent up the ladder of a well-known broadsheet's rich list.

That opportunity aside, buoyed by the evident weed suppression and fertility building, both factors contributing equally to the yield increase, we are repeating the trial on a much larger scale this year, fuelling our journey to divert our attention from the plough as a weed management tool.

It's definitely been a year for the thistle at Shimpling. Keith Banham from the Sandringham Estate did a loose trial a few years ago with subsoiling and thistle control with some positive results. Here, we have seen much reduced thistle numbers in our tramlines where we have subsoiled and so we are doing a bit more work on that to see if that is a thing.

I also grew my first crop of organic Chia this year. Using the past tense is inaccurate as at the time of writing it is still showing an impressive array of blue flowers and so I should say that I am "still growing" my first crop of organic Chia. Current thinking is that it's harvesting date will be in October and so the pressure washer has not yet visited the dusty panels of our combine. I'm seriously considering making the claim that I have grown the first ever crop of organic Chia in the UK. I'll probably test it out on Twitter first.

I have grown vetches on the farm organically in the early 2000s, but gave them up due to inconsistent yields and a price that I felt did not reflect the risk we were taking, but this year I was persuaded to grow a field of them for seed. Vetches are extremely hard on the combine cutter bar as they go as flat as a piece of paper two days before harvest and can be difficult to get the crop to flow evenly though the combine. You also have to empty the stone trap every ten meters. This year we had a Claas Convio Flex on demonstration (Google it or see a post I put up on Twitter) which I think will revolutionise cutting crops with a strong relationship with gravity. It was amazing. It could also open up some more niche opportunities for us, yet again increasing the product range of that imagined Shimpling Park farm shop.

Having said that I have not yet had an in-depth analysis of harvest yet, I am aware that it has not been a great year in term of grain output. Another wet winter, frosts continuing into late April and another drought at the beginning of spring is never going to be a recipe for bumper yields. Although we have got the boldest and brightest wheat, barley and oat grains that I have seen for many years, the berries are small which must be something to do with the unusual year.

There's nothing impressive about average, but that is the year that we have just had. It's been a year of consolidation of thought, more honing of what we do well and learning from what we do badly. Here's to harvest 2022!

GETTING PAID FOR CARBON - FARMERS' TOP 10 CONCERNS

Andrew Voysey, Head of Sales & Carbon, Soil Capital

Andrew Voysey

Seemingly at every turn, getting paid for carbon is the talk of the town. A flick through recent editions of Direct Driller is proof enough!

As the independent agronomy firm that launched Europe's first certified and multinational carbon payment programme for farmers, we at Soil Capital are certainly part of that momentum.

Our scheme was launched in France and Belgium last year. It targets mainly arable operations and in the first season we signed up around 150 farmers from the more than 800 that expressed interest.

As we expand further in those countries, as of this Summer, we have also now brought the programme to the UK. We're delighted to already be seeing British growers join the ranks of their European peers earning carbon payments each year.

But this market is still very new. Every day, we talk to farmers who are (quite rightly) full of questions about how it works. In this article, I address 10 of the most common concerns we hear.

1. There isn't enough agreement on how to quantify carbon

It is true that finding the right balance between modelling the impacts of farming practices and measuring soil carbon directly is a subject of ongoing effort. Scientists and technology developers are constantly bringing out new and improved approaches.

This evolution will continue for decades, and so it should. We engage with it closely, but it is not realistic for most farmers to be experts in all these approaches and pick winners.

You can be confident in a scheme if it can answer three questions on this topic.

1. Is the independent standard they use widely recognised, ideally internationally?
2. Is the quantification method they use already widely respected in the marketplace?
3. Have serious companies already bought carbon via the scheme?

As an example, our programme (called Soil Capital Carbon) has been validated by an independent auditor against a standard from ISO (International Standards Organization). We use the Cool Farm Tool, backed by over 100 of the largest global food and beverage companies, in conjunction with soil analysis at the beginning and end of the five year certificate generation period. And when we launched, a range of companies including Cargill had already pre-purchased more than €500,000 of certificates.

You should insist on such clarity from all schemes you examine.

2. I should wait because: the market is young

Quite right, the market is in its early stages of development. Those not comfortable with some level of risk will be sensitive to this.

But the devil is in the detail on the question of making a long-term commitment now. Is the scheme you are looking at clear about your rights to exit whatever contractual commitment they ask you to make? More importantly, are they clear about the consequences for you if you do so, such that you understand the cost of any flexibility they offer?

The challenge schemes face is that they have to balance farmer flexibility with buyer confidence.

There are different approaches. Some schemes will impose a "claw back" mechanism so that if you break the contract, some of your previous carbon revenues might be owed back.

Our decision has been that farmers should be able to exit Soil Capital Carbon at any point without a fee, claw back or legal restriction. We manage market expectations by operating a so-called "buffer" - simply put, 20% of certificates you generate each year are set aside and not sold for you until 10 years later. If you leave our programme, the only consequence is that you forgo those future earnings as those certificates have to be written off.

3. I should wait because: the carbon price will rise

Analysts certainly expect the price of carbon to rise in general over the next decade, with some views pointing to quite dramatic hikes over this period. As in all markets, I am sure there will be ups and downs on the way.

The real question is - once you are in a scheme, are you protected against drops in the carbon price and how do you benefit if it rises?

We have found it important to be crystal clear on this topic. In our case, we commit in our contracts to protect farmers from downside risk and expose you to upside opportunity. This means we insist that your carbon will only be sold if it can generate you at least £23 per tonne and that, however high the market price of carbon goes, you will always get a fixed percentage of 70%.

4. I should wait because: the supply chain will want carbon neutral crops

It is encouraging that farmers are seeing growing interest in carbon from the supply chain. However, I often hear the view that this means farmers shouldn't get trapped selling their carbon to someone else, if the buyers of their

crops will want it instead.

There are two important realities here. First, you sell your carbon on an annual basis. It isn't like selling mining rights for a lifetime! Companies are buying the claims related to the annual flow of carbon that you are either storing additionally in your soil or that you are no longer emitting. Provided the scheme has adequate flexibility to pivot to new buyers, you are positioned to adapt to changing market circumstances.

Second, if the supply chain is serious about carbon neutral crops, it will want credible, quantified and verified evidence that your crops are indeed carbon neutral. In other words, you will need to be using approaches like those developed by our programme and others. And if you are already monetising improvements in your carbon profile when the supply chain demands arrive, you are in a stronger negotiating position to insist that the supply chain compensates you fairly.

5. I should wait because: the Sustainable Farming Incentive will kick in

As is widely known, the Sustainable Farming Incentive (SFI) is in pilot mode today, with full details of how it will work in practice only to be confirmed once the few hundred farmers participating in the pilot have given feedback in the coming years.

Nevertheless, the Government has stated that it expects the SFI to be compatible with private sector initiatives that pay farmers for carbon.

The sorts of farming practices set to be incentivised by the SFI overlap strongly with those that will improve your carbon profile. Our experience as farm managers and advisors tells us that transitioning farming practices over 5 to 7 years is more prudent from a risk management and profitability perspective. It therefore makes sense to start now, generate carbon revenue from the private sector, and be well positioned to access SFI payments when they are fully rolled out in the years to come.

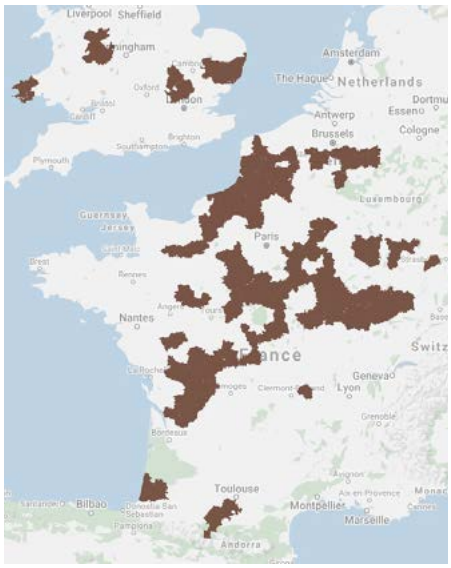
6. My farm isn't suitable because...

It's correct that the specifics of your farm matter - size, soil type, crops in your rotation, whether you are conventional or organic. Credible schemes should offer you honest advice based on the experience of real farmers.

For example, we know that farms with less than 100 hectares of arable land are likely to find the cost of our programme difficult to justify, so we advise smaller farms to look carefully at their potential earnings before making a decision. Some schemes, including our own, offer simulation tools for this purpose.

Some farmers seem to believe that carbon payment schemes are only suitable for organic systems. This is certainly not the case in our programme, where we are seeing very traditional, conventional operations, organic farms and everything in between finding opportunities to improve their carbon profile - whatever they produce.

You should find the scheme that



works best for your operation - because some may have constraints - rather than shoehorn your farm into a scheme even if the fit is not there.

7. Joining a scheme will force me into certain practices

Some will, yes. Most common is the requirement to commit to never plough. While a small proportion of farmers can make this commitment, this can obviously be an unacceptable constraint for most.

Our view has always been that carbon payment programmes should never prescribe to farmers how to farm. Local context always matters and nobody knows that context better than the farmer and their local advisors.

It is important to make it clear what practices will improve your carbon profile as these are the sort of practices that you will want to continuously improve for a scheme to make sense for you: replacing synthetic inputs with organic inputs, minimising soil disturbance, maximising ground cover with living plants, diversifying your rotation and integrating agroforestry are all changes that help improve the carbon profile.

In our view, good schemes should then provide detailed analytics, benchmarking, case studies and simulators to help you make the right decisions for your farm. But they certainly shouldn't prescribe practices.

8. I already store carbon - these schemes don't benefit me

Yes, be careful. If you have been direct drilling consistently for a number of years and increasing the organic matter you feed into your soil, you may well be storing carbon overall through your arable operations.

If a scheme requires you to show improvement only on your own historical practices to generate carbon revenue, this could create a perverse incentive for you to "reset" your carbon profile with the plough for a few years and then revert to your previous practices. We have already heard of such stories in Europe.

There are alternatives. For example if you join Soil Capital Carbon with practices that result in net sequestration of carbon which you initiated systematically within the last 20 years, we use an alternative baseline to your own historical practices. This is derived from analysis of common practice in your region and is typically a slightly emitting baseline. This means you can be rewarded for continuing to apply these good practices.

9. I don't want to give companies buying my carbon the right to pollute

This is something we hear often. And it's understandable - if farmers are bearing the risk of changing their practices to improve their carbon profile, why should another company benefit without doing anything to reduce its own emissions?

This is really a question about carbon offsetting. When it is companies in the same food supply chains as farmers buying the carbon, the dynamics are quite different.

My advice to farmers is to check with schemes what claims they are allowing companies with no supply chain relationship to the farmer to make, because all are not equal. A scheme can enable full carbon offsetting to companies - whereby they can use carbon credits generated by farmers to offset their own emissions - if that scheme uses a standard that is recognised by the International Carbon Reduction and Offset Alliance (ICROA).

In the UK today, there are no such schemes available because the relevant standards haven't been fully adapted for a UK context. Soil Capital Carbon, which generates carbon certificates against an ISO standard, therefore does not allow companies to offset their emissions if they have no supply chain relationship to you. Instead, they get what the leading NGO in this space calls a "results based claim" - the right to talk about their support for your carbon improvements, but without using that to formally offset their emissions.

10. I don't know how much I could really earn

I find myself instantly sceptical when a scheme presents carbon payments as the new "road to riches" for farmers. Often, this kind of marketing material doesn't reveal the assumptions made about soil types or pace and scale of practice change and should be treated with caution.

Schemes should present real case studies from farmers already in their programme, including the specificities of how they are achieving their earnings. Even better, schemes should provide simulation tools so that farmers can test the earnings potential of their specific circumstances and ambitions before they make a commitment.

When we work through this process with farmers we speak with, the right kind of response is that the earnings on offer from Soil Capital Carbon are modest but meaningful. Without doubt, for the right farm profile, the programme more than pays for itself. The incentive to generate new revenue is very often a welcome reward for the effort and risk of undertaking new practices.

But new revenues from carbon should be seen as the cherry on the cake of practice change. Even more significant are the cost savings and operational resilience that can be achieved as soil health is continuously improved.

There are plenty of other questions that we field from farmers about the carbon markets and our particular programme every day. You should be full of such questions and you should do your due diligence carefully.

But with the right perspective on how to navigate the offers that are emerging, this does not need to be overwhelming or paralysing. On the contrary, an exciting world of new opportunity is emerging and there are plenty of reasons why it makes sense to get involved sooner rather than later.

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FARMER FOCUS
CLIVE BAILYE

R & R...

Harvest 2021 was the second in succession where the combine saw no rapeseed through its 12m header. At least this time it was planned, as not an acre was planted following the 100% loss of our 2020 crop. This we redrilled with linseed after finding most of the stems were infected with CSFB larvae in the spring.

The 2020 loss underlined and reinforced the importance of our low stakes approach to growing this high-risk crop. At the point of redrilling the area with spring linseed less than £25/ha had been spent, with farm saved seed and herbicide being the only input to that point. I have spent as much on over winter cover crops in the past, and although OSR is not exactly the best of cover crops with its lack of mycorrhizal fungi association, at least it had been capturing important sunlight and water helping build organic matter from its August drilling date until its destruction in April.

Up until 2020 we had got away with things as far as CSFB was concerned, and we had been getting decent yields at low costs. I had seen growers further south and east lose crops to the beetle following the neonic ban but until that point crops in our area seemed to escape relatively unscathed. I had started to wonder if our more diverse farming system, which at that point had used no insecticide at all for 10 years, could be the reason. Had IPM built us higher beneficial populations that were keeping the beetles and other pests under control? Was improved soil health leading to improved plant health, making the crop less attractive to pest attack? It could have been a great story, but sadly the 2020 loss didn't have the hoped for happy ending.

Stopping growing OSR is an easy decision to make, but what to replace it with is a whole lot more complex. There is not exactly a great choice of consistently viable break crops, and importantly markets for them, suited to UK growing conditions. Our cropping is already quite diverse and depending upon markets and suitability of land break crops have included winter beans, spring beans. spring oats, spring linseed, lupins, millet and even peaola (a pea and spring OSR companion crop). All have their pros and cons, but all are far less consistent than the cereals. These break crops have yields which are far more weather dependant than agronomic genius, they suit our low input, low risk approach meaning that even in years where yield are disappointing the margins are rarely negative.

Our farm business has really focused hard on minimising fixed cost structure and a big part of that involves spreading labour and machinery over as long a season and as large an area as possible maximising use of available resources. The OSR crop was valuable in getting a good

Rye (right) vs Wheat (left) making use of limited moisture better

Near perfect establishment for 2022

chunk of drilling out the way early, easing workload peaks for crop protection and fertiliser application and most importantly of all providing us with a reasonable area of early combining before the main event that is wheat harvest.

We needed a replacement that shared some of these logistical characteristics and grain rye seemed to a good fit. We had been involved in some trail work for KWS a few years previously so had some experience of the crop and knew there was nothing particularly difficult about its establishment, agronomy or harvest. The market for grain rye was all that had really held us back from growing at scale in the past so when I learnt that £30 below feed wheat contracts were available we decided to give a couple of hundred acres a go.

Hybrid varieties bred for grain and better standing characteristics seem to have developed rapidly in the last few years. They can be drilled early, and harvest is early. Seed was expensive (especially for a farmer used to farm saving nearly all his seed!) but with nitrogen and crop protection costs significantly lower than wheat it's a reasonably cheap crop to grow. The lower Nitrogen requirement is particularly attractive as synthetic N is not beneficial to soil life or environment, anything we can do to reduce its use can only be a good thing, especially with nitrogen prices at present. 2020 is the first year we have sold our carbon sequestration via the brilliant Gentle Farming platform and the lower N use directly reflected in a lower carbon footprint that in turn gave us more ISO certified carbon certificates to sell.

Straw yields are high, at least double that of wheat so if trying to increase a soils organic matter content rapidly it's a great solution. What I found most remarkable was its use of water. The crop came through winter well and received its first split of nitrogen and growth regulator in late February. Then followed a very dry spell from mid-March, soils dried out quickly and wheat and barley crops were showing signs of drought stress. One of our rye fields had a lot of volunteer wheat in it, and the rye had developed more biomass so you would be more affected by the dry conditions. However inspection of the roots showed very clearly how much more efficiently the rye was using what water was available to it. The wheat roots were totally dry with no soil attached where as the rye roots were still surrounded with soil that was clearly still holding ample moisture, this could be a very valuable characteristic on our lighter soils where moisture often ultimately restricts our yields.

Rye yields were claimed to be above those of wheat, but in this first harvest here we found it has averaged about the same in a year where our yields have been in general very good. With the lower growing cost and lower sale prices considered I think the gross margin calculation will be similar or possibly slightly lower than our first wheats but similar to second wheat this season. If in future seasons we can access the higher than wheat yields that are claimed (and I think we would see these in a more moisture restricted season) then it could possibly equal or even better first wheat margins. Year one of a new crop is always a steep learning curve and I sure we have plenty of room to improve !

Happy as I have been with rye its not a break crop so doesn't really replace the losses of rapeseed to the rotation but as a crop that doesn't suffer from Take-all I plan to grow it continuously on a couple of blocks of land and have doubled the acreage this year. I hope we will see rapid increases in soil organic matter and will monitor this carefully.

With an area of winter barley harvested in late July and this most valuable of straw baled and removed quickly in ideal, dry conditions I just couldn't resist entering the OSR lottery again for harvest 2022. We had a tonne bag of farm saved seed kept back, now 2 years old that was quickly germination tested and direct drilled along with 30kgs / ha of placed DAP fertiliser using our Horsch Avatar drill on 250mm spacings. On the 10th of August in near ideal conditions we nudged 125mm on our 12/36m controlled traffic farming system to place rape seed directly between last seasons 250mm stubble rows and held our breath.

The results were as perfect as we could wish for and by September 1 we had a near perfect looking crop of OSR, free of CSFB and slug damage all at low stakes of under £10/ha spend. Will it make it to harvest 2022? Well, that's still in the hands of pigeon, slug, CSFB larvae, hail, or any of the other many things beyond our control that make this crop the arable farmers equivalent of keeping sheep. Oh, how I have not missed this crop! but I can sleep well knowing that if it does ultimately fail it will at least fail cheaply !

INSPIRATION, INNOVATION AND INSIGHT AT **GROUNDSWELL 2021**

We weren't quite sure how many people we could cram into the Groundswell site this year. We'd redesigned the layout, erected some large tents as lecture halls with double spaced seats to comply with covid restrictions and taken no end of advice from experts who all appeared to be making suggestions up on the spot. Then Boris pushed back 'freedom day' from the Monday of Groundswell week until some time in July. We thought what the hell, let's just do it. We decided on a 3500 attendee limit, which we hit just before it started and that proved to be just about perfect.

Written by John Cherry

I'd love to tell you about all the hundred or so talks that were delivered, but as it was only physically possible for any one person to attend, at most, ten sessions over the two days, that isn't going to happen. But we will eventually get them all up on the Groundswell YouTube channel https://www.youtube.com/c/GroundswellAgriculture . There is already some fascinating stuff on there: farmers telling their stories, soil experts explaining what goes on below ground, politicians sounding like they know what they are talking about, conversations about water, biodiversity, different strategies for building resilient farm businesses etc etc.

What was more evident this year was the sheer joy that everyone there found in being able to actually talk to fellow enthusiasts, after being shut down on our own patches for eighteen months. Farming can be a lonely business, especially if you are doing something which your neighbours think is bonkers, so it is really lovely to chat to old and new friends while queueing for a cup of coffee or over a pint in the Earthworm Arms.

One particular side-effect of the covid business was that we couldn't fly in any big name speakers from the USA or, indeed, anywhere abroad. This resulted in a pleasingly UK-centric event, albeit with a fairly fluid line-up as some speakers had to bow out at the last minute due to positive tests or whatever. It shows how much the atmosphere has changed since our first Groundswell six years ago, when we were advised that we'd better only put the show on every other year, otherwise we'd run out of speakers...we had 170 speakers this time and had to put several more on hold.

Meanwhile, out in the demo

field we had a dozen different companies showing off their drills and all reported a lot of interest from farmers. It won't surprise Direct Driller readers who will be well aware how big a saving there is to be made by avoiding tillage. Gary Markham's benchmarking figures underlined how desperate the situation is for many, if not most, intensive cultivating operations, especially as BPS starts to be phased out. Decent wheat prices this year may delay financial meltdown for some, but we've all got to find cheaper ways of establishing our crops.

The price of some of this tackle may seem eye-watering, but it was great to hear George Renner, in his double act with Adam Driver, talk about using his 20 year old Dale drill and 30 year old tractor pulling it to sow most of his crops. 'Work smarter, not harder' was his message.

There was, similarly, all sorts of tips available from all quarters about using Mother Nature as an ally rather than an enemy in our businesses. One of the funniest and most heart-warming sights was the exodus of delegates down to the cattle grazing field to take part in the dung-beetle safari, led by Sally-Ann Spence and Claire Whittle. Six years ago most farmers wouldn't have cared whether they had any sort of beetle on the farm, the mood has changed so much now that it seems we are all actively encouraging these little ecosystem engineers, not least because they improve landscape health and thus animal health and ultimately human health.

Another highlight for me was listening to Colin Tudge (the founder of the Oxford Real Farming Conference) talking about his book The Great Rethink which challenged a lot of commonly held views about the best way to get ourselves out of the mess humanity is finding itself in. Good farming, you'll be pleased to learn, is crucial to our salvation. I'm now reading the book...

There were indeed too many highlights to mention, the fascinating

compost ladies, the wild bee man, Professor Karl Ritz's pictures, Henry Driver's art etc etc...basically lots of hope for the future. The loveliest thing we find in putting this show on though, is the feedback that we get from the attendees and it's theirs (and your) enthusiasm that makes it all worthwhile.

We're already working on next year's event, plan your holidays around it: 22/23rd June 2022. If you have an idea for a speaking session please get in touch, likewise we are open to any ideas which would make the event better or more entertaining or more useful.

Re-Watch Groundswell on YouTube

In the meantime, you can catch up on sessions you missed via the Groundswell YouTube channel. Follow the QR Code below to get to the channel and give it a like to be notified when further videos are added.

Save the Date

Groundswell

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Session Applications are open from October to February - Please submit your ideas via the form on the website.

Exhibitor, Demo and Food Vendor Applications are now open, please enquire contact@groundswellag.com .

Tickets go on sale via the website in April 2022 www.groundswellag.com

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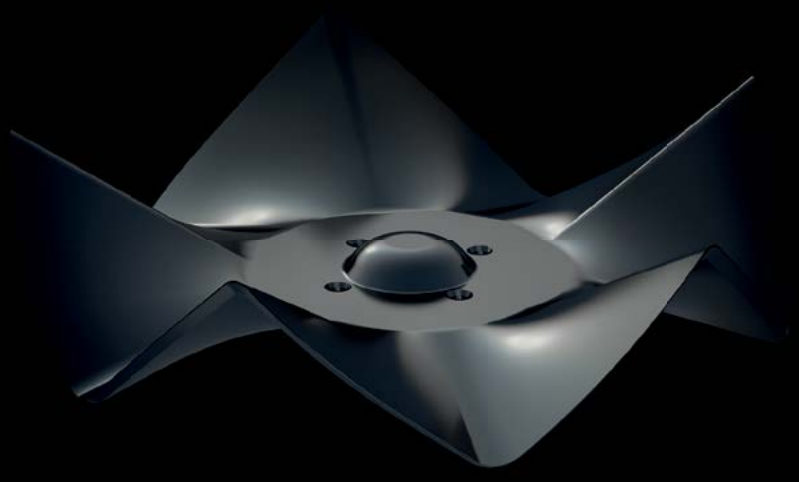

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DRILL MANUFACTURERS IN FOCUS...

INDEPENDENT CROP ESTABLISHMENT TRIALS YIELD EXCITING RESULTS

Harvesting oilseed rape on the Claydon farm in 2021

Suffolk farmer Jeff Claydon highlights the results of independent crop establishment trials and discusses the progress of harvest on the Claydon farm.

26 AUGUST 2021

In my last article for Direct Driller (Issue 14, July 2021) I promised to bring you some interesting information on the benefits of optimising crop establishment. Claydon have been assisting Agrii's R&D Blackgrass Centre in Cambridgeshire with independent research into different establishment systems and some of you will have visited Rookery Farm, Stow Longa during the summer to see the work taking place.

The trial site is on land owned by the Whitlock family, who have successfully used a Claydon drill to help them operate profitably for over a decade. Located on an old airfield near Huntingdon, it can be very wet and cold, providing ideal conditions for a range of grassweeds, from brome to blackgrass. Obtaining good, clean crops is a real challenge, but Martin Whitlock has proved that Claydon Opti-Till® is a major benefit in achieving that objective.

Agrii have carried out trials at Stow Longa since 2002, initially to investigate the effects of variables such as seedbed techniques, seed rates, drilling dates and varieties. However, in 2010 the researchers' remit was expanded to include factors such as cultural control methods and the impact of establishment techniques.

In May 2021, along with other members of the Claydon team, I went to see first-hand how establishment systems are evaluated. While we were there, Agrii Trials Manager Steve Corbett and Head of Agronomy Colin Lloyd emphasised the importance of operating a flexible farming system and a resilient method of establishment. They also stressed the critical role of soil health in achieving consistent crop performance and the need to make transitional changes between systems based on scientific evidence rather than 'gut feel'. This, they stressed, is especially important when considering a low- or zero-disturbance system.

Even then, clear benefits in favour of the Claydon Opti-Till® over conventional deep cultivation methods and a no-till approach were evident. These advantages continued through to harvest, so now we have the results of the Agrii team's work to assess the performance of different systems in a high grassweed situation.

Agrii evaluated a range of approaches, from no cultivations to the full Claydon Opti-Till® programme, including the use of the Claydon Straw Harrow, TerraStar light rotary cultivator and TerraBlade inter-row hoe in the spring to reduce blackgrass levels. The results are illuminating and with Agrii's permission I am delighted to share them with you.

On the very heavy, sticky site the researchers found some surprising results, which are shown in Table 1. Even though a full chemical control programme was used across all trials it was very apparent that the lower the level of stubble management carried out, the higher the weed pressures were in the crop. Where no stubble management was done the yield was over 2t/ha less than where the full Claydon Opti-Till® System was used. At current wheat prices, around £210 per tonne, that represents potential lost income of over £420/ha.

Very patchy no cultivation plot (left) yielded 2t/ha less than the full Claydon Opti-Till® plot (right) where the Straw Harrow, TerraStar and TerraBlade were deployed.

The Claydon Straw Harrow produces a fine 10mm-30mm tilth which encourages weeds and volunteers to germinate

Table 1: Agrii trial of Claydon Opti-Till® System at Stow Longa, 2020-2021

Only able to yield standard A share area due to high levels of grass weeds in other sections	Claydon Standard A share 20/10/2020 + TerraBlade Inter Row Hoe in Spring	Claydon Standard A share 2 0/10/2020 No Inter Row Hoe
TerraStar x1 then rolled 13/8/2020	8.4	6.33
TerraStar x 2 + Straw Rake 1st 13/8/2020 2nd 24/8/2020 + 2 more Straw Rakes 10-day intervals	9.02	8.4
TerraStar + Straw Rake 13/8/2020 + 2 more straw rakes 10 day intervals	8.41	7.38
Straw Rake 13/8/2020 + 2 more straw rakes 10 day intervals	8.35	6.49
No Cultivations	8.43	7.02
Cover Crop Claydon Drill Mustard & Phacelia 13/8/2020	No yields available from cover crop areas	
Claydon Twin Disc + Twin Tine 24/10/2020	Claydon Leading Tine + Twin Tine 24/10/2020	

The full benefit of the Claydon Opti-Till® System can be seen where the Straw Harrow and TerraStar were used. The increased tilth and better soil-to-seed contact which resulted also helped the Claydon TerraBlade to do an exceptional job in the spring, as can be seen clearly from the results.

They also show that the TerraBlade is exceptionally effective in reducing the number and yield-sapping effect of weeds between the band-sown rows. It produced an additional 1.4t/ha yield advantage (9.02 t/ha v 8.4 t/ha) through enhanced grassweed control, which underlines the value of this very effective, low-cost method of supporting existing ag-chem programmes.

Even where a full stubble management system was used, including two passes with the TerraStar, fuel use with the Opti-Till® System was still under 20 litres/ha, less than 20 per cent of a conventional crop establishment system, which helps to minimise carbon emissions.

We would like to thank Colin Lloyd, Steve Corbett and all the Agrii team for their input on this valuable work.

Oilseed rape returns

In the July issue of Direct Driller, I mentioned the excellent progress of oilseed rape being grown on the Claydon farm this season, a crop we had to stop growing for three years because of damage caused by cabbage stem flea beetle.

For the 2021 harvest we drilled four varieties, LG Aspire, an exceptional conventional rape, together with three hybrids, DK Exstar, DK Excited and DK Extremus, the latter two having TuYV resistance, a major consideration given its increasing prevalence. All were sown at the same time and received the same inputs.

This aerial view of the field taken on 28 April 2021 highlights the difference in development between LG Aspire each side and DK Extremus/ DK Exstar/ DK Excited in the centre.

The photograph shows how much stronger the hybrids looked compared with the conventional variety in April and throughout the season they showed greater vigour. In contrast, the conventional variety was slow growing and suffered from frost damage, reducing yield in those areas. Surprisingly, however, at harvest when we compared weighbridge yields from adjoining strips in the field, all had achieved virtually the same yields (Table 2).

Table 2: Comparison of yields from different oilseed rape varieties.

Variety	Yield (t/ha)
DK Extremus	4.376
DK Exstar	4.099
DK Excited	4.054
LG Aspire	4.038

Evidently, the LG Aspire came back in the race and ultimately performed extremely well, although we still feel that hybrids are stronger and will deliver better performance in adverse areas or conditions. All varieties suffered some damage from cabbage stem flea beetle, but with oilseed rape prices at high levels they will provide very good returns.

A stop-start harvest

This has been a stop-start harvest, with measurable rain for eight consecutive days from 15th to 23rd August. Fortunately, the preceding hot, dry weather allowed us to work very long hours and combine until early in the morning. From 8pm on Friday 13 until 10pm on Sunday 15th August we harvested 1150 tonnes of wheat from 300 acres, including all 250 acres of winter wheat where we wanted to drill this season's oilseed rape. We finished just as it started to rain on the Sunday evening.

The following day, 16th August, we started drilling DK Excited oilseed rape at a very low seed rate, just 2.7kg/ha, into the chopped straw and stubble with our 6m Claydon Drill. Although 5mm of rain stopped play on the Tuesday, we completed the balance by the close of play on Wednesday. The first cotyledons poked through the surface five days later and we applied 4kg/ha of Ironmax® Pro (De Sangosse) slug pellets to deter any slugs that were undoubtedly there due to the moist soil conditions.

Dealing with slugs and slug eggs effectively is key to success with the following crop of winter wheat, so after harvest I regularly check fields when the soil is damp to see what is about. If you clear away residue that hasn't been moved for several days both slugs and slug eggs will be evident.

In the early days of the Claydon System we had big problems with slugs if we simply ignored them and didn't do any stubble management, so that quickly became a cornerstone of post-harvest operations on the Claydon farm. We can't use slug pellets like we used to, and even though the new iron-type pellets are effective we don't want to rely on chemicals, so the aim is to take out as many slugs and slug eggs as possible using cultural and mechanical methods.

The cold, dry April made for a tough start to spring and delayed growth, but all our crops looked very promising from then on. We could have done with warmer, sunnier weather in June to help fulfil that early promise, but that was not forthcoming and restricted yield potential, so this harvest is merely average rather than spectacular as we had hoped.

The weather is forecast fine for the next few days, so hopefully we will be able to crack on with combining and stubble management to get back on track. I'll tell you how our wheat and spring oats performed in the next issue of Direct Driller, along with details of what impact, if any, cover crops had on spring oat yields.

Jeff examines a root of the previous oilseed rape crop, on which can be seen one of the slugs that were in evidence following a week of wet weather.

This field had received one pass with the farm's Claydon Straw Harrow immediately behind the combine to encourage weeds and volunteers to grow, then for a second time to take them out. Some small plants were still evident when this photograph was taken on 25 August and the plan was to go in with a Claydon TerraStar to create a little more tilth to expose the slugs and slug eggs to the warmer conditions which were due over the following days.

Tiny, pearl-like slug eggs are clearly visible on this rape stalk, so checking their numbers is vital in any direct drilling situation. The best time to do that is when the soil is damp, and slugs are near the surface. Running the Straw Harrow over the land when the weather is warm and sunny will ensure that they dehydrate and die.

The presence of large numbers of seagulls on the rape stubbles often highlights the presence of slugs.

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THE FUTURE OF EFFICIENT CROP ESTABLISHMENT

COMPARING INFILTRATION RATES IN SOILS MANAGED WITH CONVENTIONAL AND ALTERNATIVE FARMING METHODS: **A META-ANALYSIS**

Written by Andrea D. Basche and Marcia S. DeLonge, published: September 19, 2019. Republished under original Copyright.

There is a need to develop more resilient, multifunctional agricultural systems, particularly given risks posed by climate change to farm productivity and environmental outcomes [1–3]. Specifically, water-related risks from increased rainfall variability include soil erosion and water pollution, degradation of soil quality, and reductions to crop yields [4–6]. Although soils are vulnerable to water-related risks, they are also being recognized as a medium to mitigate such risk when managed to deliver a wide range of ecosystem benefits, beyond maximizing crop production [7,8]. Thus, designing agricultural systems that improve soils and soil water cycling is one strategy that could help reduce negative impacts of increasing rainfall variability [9–12]. To this point, global modelling analyses indicate that enhancing soil water storage at a large scale can benefit crop productivity and improve ecosystem services, such as by reducing runoff [13,14]. However, there is a need to identify how to secure such outcomes on the farm-scale, particularly across a range of management practices, environments, and climates.

Emerging interest in how soils can support climate adaptation has increased the urgency to understand the potential benefits of farms shifting from conventional to alternative agricultural practices. Presently, conventional cropping systems typically feature annual crops, leave the soil bare when a cash crop is not growing, have limited crop diversity, and include regular soil disturbance through tillage: within the United States, only approximately 3% of cropland acres are growing a cover crop and 25% are utilizing no-till practices [15–17]. Soil disturbance, a lack of soil cover and limited plant diversity can degrade soils, reducing their ability to withstand rainfall variability through affects such as disrupting aggregation, increasing bulk density, and limiting water holding capacity [18]. In contrast, management practices such as no-till and cover crops may improve soil properties related to water storage such as aggregate stability and bulk density, but they remain in the minority [19]. The limited adoption rates may be in part related to the fact that, in spite of decades of agronomic research surrounding such practices, we are only beginning to understand their potential value for improving key functions related to soil health and water cycling [18].

A growing body of research suggests that a range of alternative farming practices can contribute to biological, physical and chemical transformations in soil that in turn can increase water storage, improving resilience to droughts, floods, and extreme weather conditions [20,21]. For example, studies have shown that no-till, cover crops and crop rotations can in some cases improve soil carbon content, soil biological activity, and soil physical properties associated with water storage [22–27]. For example, no-till avoids disrupting soil aggregates and structure, and cover crops protect soils, particularly during extreme events. There is also evidence that practices such as introducing perennials and designing diversified landscapes, such as through crop rotations or integrating crop and livestock practices, can improve soils in similar ways, likely by providing vegetative protection of soils above- and below-ground, and including living roots throughout the year [28–31]. However, because there are a number of different soil water measurements, the effects of specific practices on soil water properties have not previously been well summarized quantitatively [20].

The primary goal of this analysis was to synthesize published field-experiments investigating impacts of agricultural practices on water infiltration rates and to gain insight into mechanisms impacting infiltration rates. We focused on soil infiltration rates because infiltration is a critical ecosystem function that can mitigate drought and flood risk by facilitating water entry into the soil and reducing water losses by runoff [29]. This is a particularly important ecosystem function given predicted climate changes, especially the trend toward increasing rainfall variability, leading to heavier intensity rainfall events and impacts in non-irrigated agricultural regions when there are longer periods without rainfall [4]. Infiltration rates are frequently measured in field experiments and are sensitive to changes in management. Infiltration rates are also closely related to other important characteristics of soils, including physical aspects such as aggregate stability, bulk density, plant available water, as well as chemical and biological aspects including soil carbon, and microbial biomass [20,26,27]. In this study, we considered a range of specific alternative practices that can be adopted on farms, including no-till, cover crops, crop rotations, introducing perennials, and livestock grazing on croplands, compared to more conventional controls (experiments with tillage, no cover crops, monocropping, annual crops, and no grazing). We hypothesized that the various alternative practices would increase infiltration rates, but that the relative impacts would vary, and that is the motivation behind including multiple practices in our analysis. We secondarily explored patterns of additional environmental and management factors (e.g. soil texture, climate indices, and the length of the experiment) that we hypothesized could be modulating observed effects.

Practice	Search key words	Control	Treatment	Experiments	Paired Comparisons
No-Till	"till"	Tillage (conventional or reduced)	No-till	52	207
Cover crop	"cover crop" OR "green manure" OR "catch crop"	No cover crop (e.g. bare soil when no cash crop)	Cover crop	23	81
Crop rotation	"rotation" AND "continuous"	Continuous cover cropping of one cash crop (Monoculture)	Same crop + at least 1 more crop, crown in rotation or as an intercrop	11	39
Perennial	"perennial" OR "agroforest"	Cultivated annual crop	Perennially-based system (perennial grass, managed forestry or agroforestry)	8	40
Crop and livestock	"graz' AND "livestock"	Conventionally harvested crops (including cultivated forage crops in pasture	The same crops with livestock grazing (of crop residues or forage)	7	24

Table 1. Criteria and results for literature searches for specific agricultural practice comparisons.

Methods

Study criteria

We evaluated the effects of various alternative farming practices that can be adopted in otherwise conventional farming systems [32–34]. We considered zero tillage (no-till) as compared to conventional tillage, cover cropping or green manure practices that keep soils covered compared to leaving them bare (cover crops), diversified farming

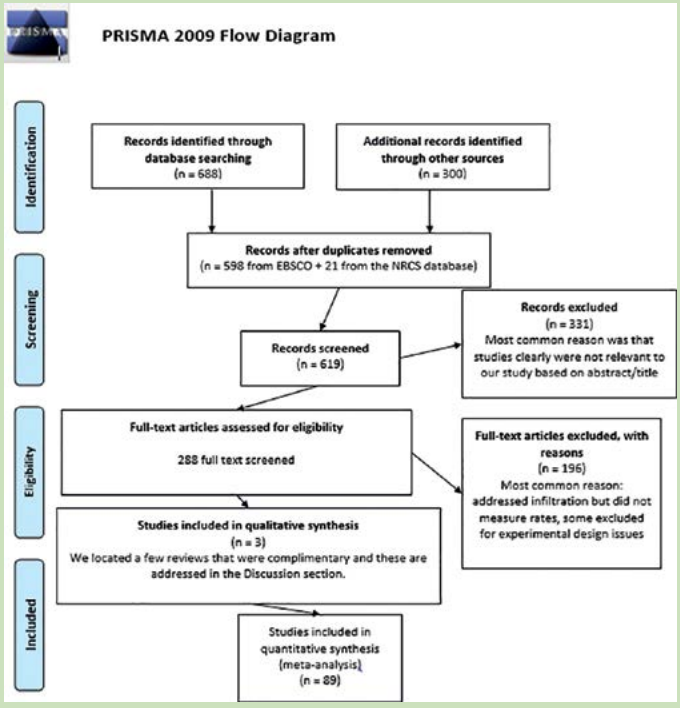

Fig 1. Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) Flow Chart describing the search protocol utilized to identify and select published research for this analysis.

(crop rotations, intercropping) as compared to monoculture cropping (crop rotations), agricultural systems with mainly perennial compared to annual crop systems (perennials), and grazing of croplands versus conventionally harvested or hayed fields (crop and livestock) (Figs 1 and 2 and Table 1). The main criteria for inclusion were field experiments that: 1. Measured and reported steady-state infiltration rates, defined as the volume of water entering the soil over a designated period; 2. Compared one of the alternative practices of interest relative to select conventional controls in a standardized way.

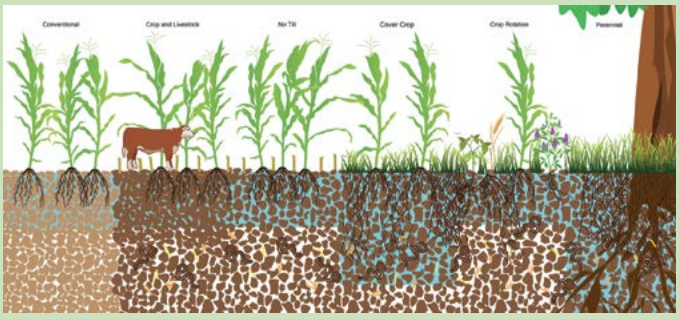

Fig 2. Conceptual figure of the alternative agricultural practices evaluated in this analysis and their impact on infiltration rates, including an example of a conventional practice control

Infiltration is a key component of the water cycle, influencing how much precipitation becomes available to plants as opposed to what is lost through other pathways such as runoff and evaporation. Conventional management is represented by tillage, a lack of crop rotation, no livestock, and non-continuous cover of plant roots. Alternative practices include the presence of livestock, crop residue, continuous plant roots and crop diversity. These alternatives could alter infiltration rates through a range of physical, chemical or biological processes, as shown in the illustration. Possible soil biological changes are represented through the addition of bacteria and fungi (represented as yellow and orange symbols). Possible soil physical changes are represented by differences in porosity, compaction and aggregation as represented in the size and distribution of soil aggregates. Possible soil chemical changes are represented in the addition of carbon represented in the soil coloration, which is lighter in the conventional management and darker in the alternatives. Depth of water movement represents a significant increase in the cover crop and perennial treatments as was found in this analysis. Artwork by Lana Koepke Johnson..

Literature search

The literature search was conducted using EBSCO Discovery ServiceTM (detailed in Basche and DeLonge [25]) and only included field experiments in English language peer-reviewed literature through 2015 (the earliest publication that met our criteria was from 1978). Keyword strings included "infiltration W1 rate" AND "crop*" for all searches, and additional keywords were used for individual practices (Table 1). These searches returned approximately 700 studies, of which 79 fit our criteria. We used the USDA-NRCS Soil Health Literature database [35] to find additional papers, leading to 10 more studies for a total of 89 (Table 1). Information about article rejection can be found in the PRISMA chart in Fig 1. Articles were rejected because they either did not compare controls to treatments appropriately, did not measure infiltration rate, or were otherwise not relevant to our analysis. For additional details, see the Supporting Information.

Management practices

Experiments within each practice were systematically included in the database only if they fit the below additional criteria.

No till: Papers identified from the additional search term "till*" were included if experiments clearly included a no-till treatment. We compared any tillage practices–reduced tillage as well as more physically disruptive tillage practices that are typically described as conventional tillage–to zero tillage as the alternative treatment (unlike some meta-analyses that have compared reduced to conventional tillage separately e.g. van Kessel et al. [36]). When papers included multiple different tillage practices that could have been counted as a control treatment, they were further classified as conventional or reduced tillage, based on reported equipment and/or method of plowing.

Cover crops: Papers identified from the additional search string of "cover crop*" OR "green manure" OR "catch crop*" were included when a control treatment with no cover crop was present (e.g. bare soil when the cash crop was not growing). Experiments were included when the cover crop was grown intentionally to protect the soil and was not harvested, and residues were mechanically terminated, chemically terminated, or left as a green manure (e.g. a crop grown specifically for fertility purposes).

Crop rotation: Papers identified from the additional search string of "rotation" AND "continuous" were included when there was a control treatment that represented the continuous (year after year) cropping of one cash crop. The experimental treatment needed to include the same crop as well as at least one additional crop, grown in rotation (as in McDaniel et al. [23]). We included two experiments where an additional crop was grown not in rotation but as an intercrop (i.e. two plant species grown simultaneously on the same field) and one experiment that met the rotation criteria but was different in that it also included grazing in the experiment treatment but not the control (Table A in S1 File). In all experiments, we recorded the number of crops in rotation for analysis.

Perennials: Papers identified from the additional search string of "perennial" OR "agroforest*" included experiments where a perennial treatment was compared to an annual cropping system. This practice represented more significant shifts in management practices that have been the subject of fewer studies, thus we included control practices that varied slightly (for example, they included monocultures with or without conventional tillage). Treatments included perennial grasses, agroforestry and managed forestry (Table A in S1 File). While these treatments have differences in species and management, they share the critical feature of continuous living cover through perennials. Given the limited number of total studies, we aggregated these into a single class (as in Basche and DeLonge 2017 [25]). Two of the eight experiments ultimately included in this practice also had livestock grazing as part of the treatment (compared to an annual crop system with no livestock; Table A in S1 File).

Crop and livestock: Papers identified from the additional search string of "graz*" AND "livestock" were included if there was a crop-only control and a treatment with a similar crop system that also included livestock grazing. This treatment was of interest as it is representative of one phase of integrated crop-livestock systems that has implications for diversifying cropland management. The identified studies included experiments with either annual crop or pasture-based systems, where control systems were harvested conventionally (i.e. with equipment) whereas treatments included livestock grazing and no conventional harvesting.

Database design

Data from experiments were extracted and categorized systematically. When experiments reported measurements from several years, years were included separately. When experiments included multiple measurements of infiltration rate within a year, measurements were averaged, as has been done in other meta-analysis evaluating soil properties that may be measured on a sub-annual basis [23]. This approach, which was used for 10 studies (and 11% of the response ratios in the database), allowed us to use as much data as possible to capture the influence of the treatments on infiltration rates over a longer timeframe.

We analyzed additional variables to examine how effects of management on infiltration rate are modulated by other factors of interest [23,37,38]. These variables included soil texture (percent sand, silt, clay), climate, study location, and study length. We also analyzed additional information within select practices, including tillage descriptions (within no-till), inclusion of cover crops (within no-till), the number of crops grown in an experiment (within crop rotations), and if crop residues were removed or maintained (within cover crops). Study length was defined as the number of years a treatment was in place, as reported by the authors, and we assumed that this duration explains differences between control and treatment conditions.

We supplemented our dataset using publicly available sources to explore broader patterns that could be influencing the effectiveness of management practices. When annual precipitation was not reported, we used the Global Historical Climatology Network (GHCN)-Daily database [39] (contains records from over 80,000 stations in 180 countries and territories). As an additional indicator of longer-term climate conditions for all study sites, we used locations to extract estimates for the aridity index, an integrated measure of temperature, precipitation and potential evapotranspiration (CGIAR-CSI Global-Aridity and Global-PET Database, resolution of 30 arc seconds [40,41]). In cases where soil textures were not reported in papers from the U.S. (which represented the largest number of studies, Table 1), we used data from the U.S. Department of Agriculture's Web Soil Survey [42].

Statistical analysis

Statistical analysis was conducted by calculating response ratios, representing a comparison of control treatments to experimental treatments, as is common in meta-analysis methodology43. Response ratios (LRR) represented the natural log of the infiltration rate measured in the

experimental treatment divided by the infiltration rate measured in the control treatment (Eq 1) [43]. A weighting factor (Wi) was included in the statistical model as is suggested by Phillibert et al. [44] based on the experimental and control replications (Reps) of each study (Eq 2) [45]. Natural log results were back transformed to a percent change to ease interpretation. Results were considered significant if the 95% confidence intervals did not cross zero.

$$LRR = \ln \frac{Experimental\ Infiltration\ Rate}{Control\ Infiltration\ Rate}$$

$$Wi = Experimental\ Reps \times Control\ Reps / Experimental\ Reps + Controls\ Reps$$

For statistical analyses, the five practices were analyzed separately because there were notable differences in experimental designs and control treatments. A linear mixed model (lme4 package in R) was used to calculate means and standard errors for the five practices. The statistical model also included a random effect of study to account for the factor of similar environments and locations in the cases where experimental designs allowed for multiple paired observations (e.g. a single study included multiple tillage practices or multiple cover crop treatments using different species) [46]. For the two practices that included the largest number of studies (no-till and cover crops) and could therefore be statistically evaluated in greater detail, additional fixed effects including mean annual precipitation, study length and soil texture, were analyzed with a similar linear mixed model [47]. Given the limited sample sizes for the other three practices (perennials, cropland grazing and crop rotations) additional fixed effects models could

Practice	Aridity Index		Annual Precipitation		% Sand		% Clay		Study Length	
	β	**n**	**β**	**n**	**β**	**n**	**β**	**n**	**β**	**n**
No-Till	0.028	207	0.000	207	0.001	188	-0.003	189	0.016	207
Cover Crop	-0.009	81	0.000	81	0.010	69	-0.015	72	0.015	81
Crop Rotation	1.228	39	0.001	39	0.004	32	-0.008	38	-0.005	39
Perennial	0.011	40	0.000	37	0.004	18	0.022	20	-0.007	40
Crop and livestock	0.430	24	0.000	24	0.005	20	0.008	20	0.010	24
(aridity index, annual precipitation, % sand content in soils, % clay content in soils, and length of study (treatment duration) (n = number of paired comparisons per practice, bold notes p<0.05). See "Model Selection and R Code" in the S1 File for additional information.										

Table 2. Regression coefficients (β) for continuous environmental and study variables included in the analysis.

not be robustly applied, but figures were developed to explore trends (Figs A-C in S1 File). Regression coefficients were calculated to determine the effect of continuous environmental variables (Table 2). Additional details, including sample R code, are provided in the Supporting Information.

A sensitivity analysis was performed for each of the practices using a Jacknife technique, where individual experiments were removed from the respective databases and overall means were recalculated, to determine how sensitive overall effects were to individual experiments44. This technique provides understanding of how the results would change if individual studies were not included in the database. We evaluated histograms for all practices to determine if there was evidence of publication bias (a preference for published studies with significant effects) [48].

Results

Database description

Through the methodical keyword-based literature search, we identified 89 studies eligible for inclusion in our database, representing 391 paired comparisons on six continents (Fig 3 and Fig D in the S1 File). Many experiments were in North America (31) or Asia (27), with most located in the United States (25) and India (20). More than half of the experiments and subsequent paired comparisons were no-till (207 paired comparisons from 52 studies), while the next largest practice was cover crops (81 paired comparisons from 23 studies). Sixty-three percent of the database (246/391 paired comparisons) demonstrated an increase in infiltration rate with any of the five alternative agricultural practices included in the analysis. Overall means for perennials and cover crops were significantly greater than zero (Fig 4).

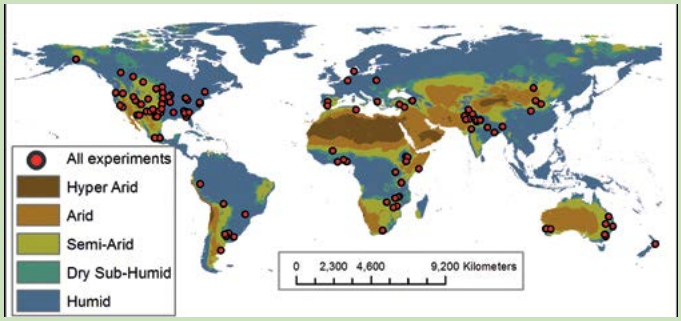

Fig 3. Map of experiment locations included in the analysis, with respect to their aridity regimes.

Aridity regimes were determined using the aridity index, an integrated measure of temperature, precipitation and potential evapotranspiration from the CGIAR-CSI Global-Aridity and Global-PET Database [40,41]. Maps were generated with ESRI ArcGIS version 10.4 (http://www.esri.com).

No-Till

The overall mean increase in infiltration rates in no-till versus tillage comparisons was not significantly different from zero (5.7%, confidence interval -13.3–24.7%) (Fig 4). Also, we did not find differences between experiments comparing reduced tillage to no-till versus conventional tillage to no-till. We found the effects of no-till to be complex, revealing

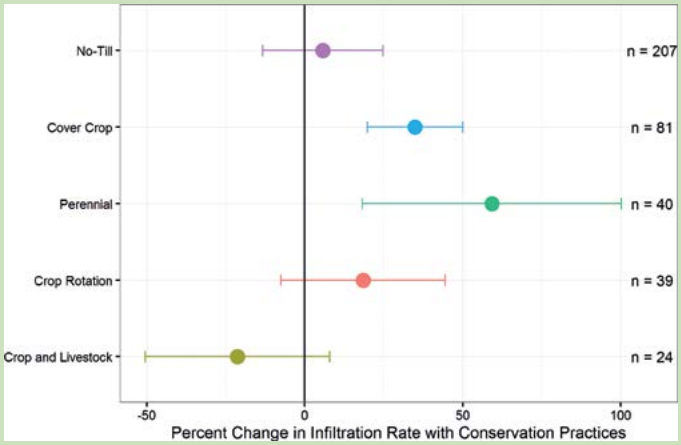

Fig 4. Percent change in infiltration rate with the five alternative agricultural practices included in the analysis compared to conventional controls (mean ± 95% confidence interval, n = number of paired comparisons per practice).

possible conditions and environments where no-till practices are more likely to increase infiltration rates (Fig 5). For example, in the subset of experiments reporting residue management details (11 with residue retained, 7 with residue removed), there were higher increases in infiltration rates in experiments that combined no-till with residue retention practices (41.5%, confidence interval -3.4–86.6%). Only 2 of 52 experiments reported data capturing the effect of no-till plus a cover crop (compared to tillage plus a cover crop) and results were inconclusive (16.2%, confidence interval -94.0–126.5%). Similarly, there was no significant difference when no-till experiments included more crop diversity (in both control and experimental treatments), such as having at least two crops in rotation or double cropping (0.0%, confidence interval -18.9–18.8%). With respect to environmental variables, we found an effect of precipitation, with significant improvements in

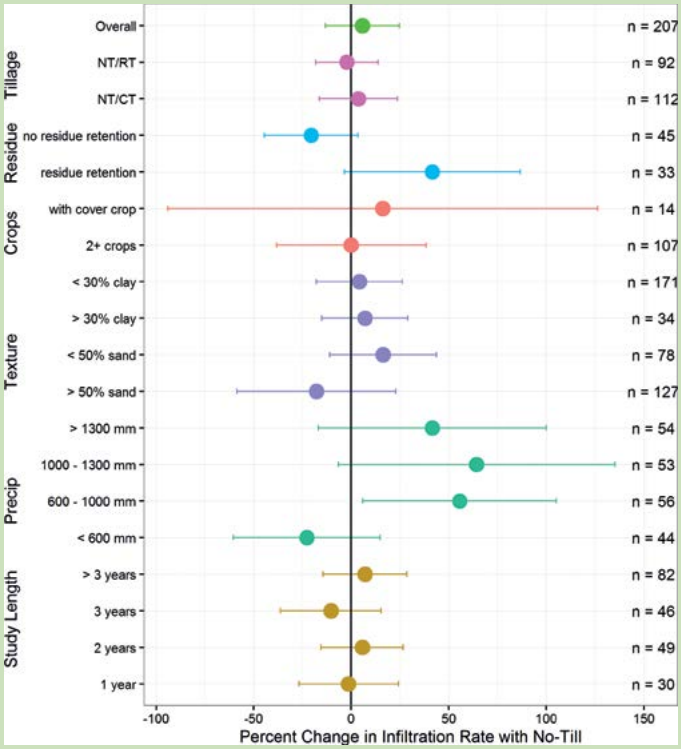

Fig 5. Response of infiltration rates to subsets of no-till experiments. Means and 95% confidence intervals were calculated using fixed effects for different subsets related to annual precipitation, study length, soil texture, tillage practice in controls, and crop and residue management (n = number of paired comparisons).

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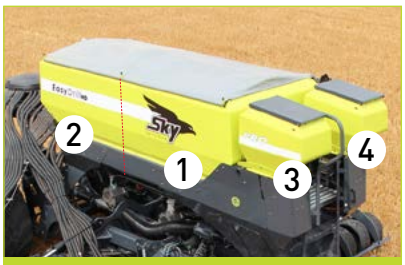

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regions with 600 to 1000-mm annual precipitation (55.6%, confidence interval 5.8–105.3%) (Fig 5). There were also greater numbers of results where no-till reduced infiltration rates located in more arid environments (i.e., lower aridity indices), but the effect was not statistically significant (Table 2 and Fig E in the S1 File). We did not detect any clear effects of soil texture, nor did we find differences due to study length (Table 2 and Figs F-G in the S1 File).

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Cover crops

The mean increase in infiltration rates for cover crop experiments (n = 81, 23 studies) was significantly above zero (34.8%, confidence interval 19.8–50.0%) and results demonstrated a few other important differences relative to patterns observed in no-till experiments. For example, there was a significant improvement in infiltration rates when cover crop experiments were in place for more than four years (30.0%, confidence interval 1.7–51.3%, representing 34 of the 71 comparisons) (Fig 6). Also, we did not detect differences when cover crop experiments were aggregated by annual rainfall or aridity index (Fig 6 and Table 2). There was evidence that the effects of cover crops on infiltration rate improvements were greater in coarsely textured soils with higher sand contents and less clay (Table 2 and Fig F in the S1 File). Similar to the no-till plus residue retention experiments, we found there to be a significant increase in infiltration rates when experiments combined cover crops with no-till (compared to no cover crops with no-till; 44.6%, confidence interval 11.6–77.5%) (Fig 6).

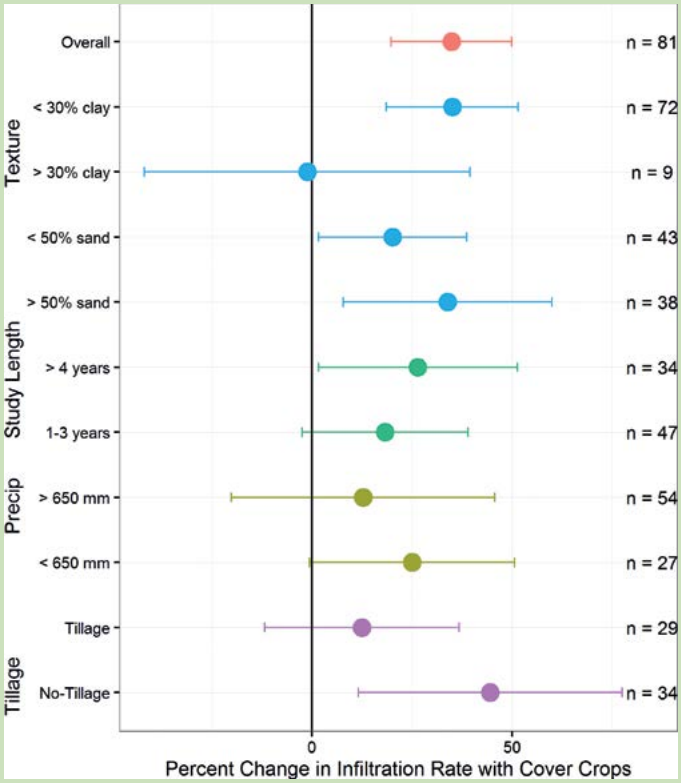

Fig 6. Response of infiltration rates to subsets of cover crop experiments. Means and 95% confidence intervals calculated using fixed effects for subsets related to annual precipitation, study length, soil texture, and tillage practice (n = number of paired comparisons).

Crop rotations

Impacts of crop rotations on infiltration rates were inconsistent, with an overall mean effect that was not significantly different from zero (18.5%, confidence interval -7.4–44.4%, n = 39 from 11 experiments) (Fig 4). Many experiments in our database compared monoculture to two crops in rotation, and only a few compared three or more crops in rotation. Further, in many experiments the control crop was monoculture maize (Fig A in the S1 File). The aridity index analysis revealed that most of the declines in infiltration rate among the crop rotation experiments fell within more arid regions (Table 2 and Fig E in the S1 File).

Perennials

Experiments comparing perennial treatments to annual crops showed the largest improvement in infiltration rates (59.2%, confidence interval 18.2–100.2%, n = 40 from 8 experiments) (Fig 4). These experiments included three types of perennial systems: agroforestry, perennial grasses, and managed forestry (Fig B in the S1 File); they were aggregated into a single group for this analysis because of the limited number of available studies (only eight total met the inclusion criteria) and because they share a key feature of continuous roots in the soil (Table A in the S1 File). Despite differences among and between these practices, the perennial practices showed a consistent pattern in that growing perennial rather than annual plants led to improved infiltration rates.

Crop and livestock (cropland grazing)

Experiments that fit our criteria for crop and livestock systems were more likely to contribute to a decline in infiltration rates overall (-21.3%, confidence interval -50.4–7.9%, n = 24 from 7 experiments) (Fig 4). However, individual studies within this practice suggested that pasture-based and diversified annual crop systems with livestock could lead to improved infiltration rates under some conditions (Fig C in the S1 File).

Publication bias and sensitivity analysis

We did not find evidence of publication bias in our overall analysis, as shown by histograms demonstrating that experimental results within each practice were not skewed toward very positive or very negative effects (Fig 7). Also, the Jacknife sensitivity analysis revealed robust results, with only minor shifts to overall means and confidence intervals when individual experiments were removed (Fig 8). Results were most robust for no-till and cover crops, which had the largest numbers of experiments. However, two practices–crop rotation and perennials–were somewhat sensitive to the removal of individual experiments. When two of the eight perennial experiments were separately removed, the 95% confidence intervals of response rates shifted to slightly cross zero (Fig 8). These experiments were the two with livestock, which suggests that in these environments the presence of livestock did not reduce infiltration

[49,50]. For the crop rotation studies, the removal of one experiment [51] led to a significantly different mean from zero.

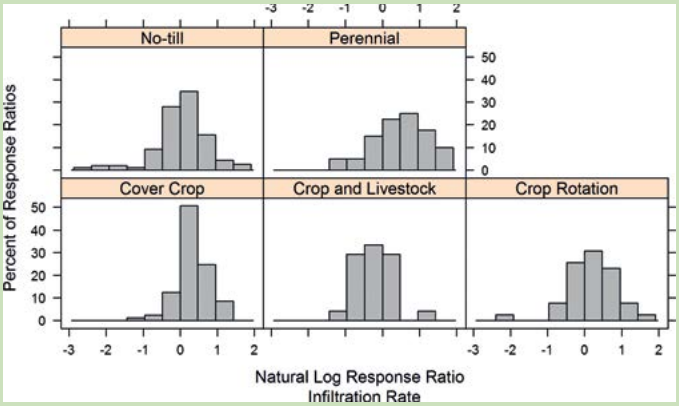

Fig 7. Publication bias analysis using histograms of response ratios. Histograms created using the methodology suggested by Rosenberg et al. (2000) [48]. Normal distributions indicate that publication bias was not likely a factor in study results (i.e. there was not a bias against publishing experiments that did not have significant effects).

Discussion

Alternative management impacts infiltration, likely through biological, chemical and physical processes

Overall we found that the largest infiltration rate changes were associated with practices that entail a continuous presence of roots and soil cover, suggested by the

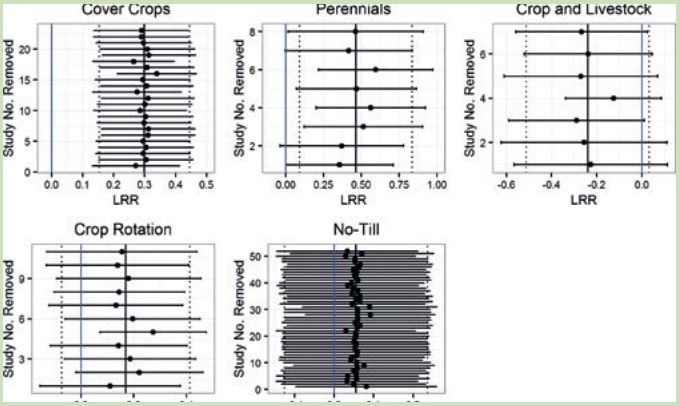

Fig 8. Sensitivity of results to individual studies using a Jacknife technique. Blue lines represent zero or no effect, and 95% confidence intervals that do not cross zero were considered significant. The solid black line represents the overall practice means and the dashed lines are overall 95% confidence interval before individual studies were removed to re-calculate the displayed means and confidence intervals.

positive improvements of perennial systems compared to annual crops and cover crops compared to no cover crops, as well as the negative trend associated with the crop and livestock systems compared to crop systems only. Determining the exact processes underpinning the observed results is outside the scope of meta-analysis. However, these results point to changes in soil hydrologic function which, in turn, is known to be associated to an intertwined set of biological, chemical and physical factors. For example, physical processes associated with root growth and decomposition

contribute to improved soil structure such as porosity and aggregation, which enhances water entry into the soil [52]. Recently, Basche and DeLonge [25] found that cover crops, perennial grasses and agroforestry practices led to significant improvements in two soil hydrological properties related to water infiltration (porosity and water retained at field capacity), which could help explain the effects from those practices in this analysis. The reduced infiltration rates that we found with respect to the crop and livestock studies could be related to the removal of vegetative cover or soil compaction from grazing, although the available studies for this practice were limited [53–55]. Overall, our results suggest that management has an important contribution to infiltration rates, and that these are likely related to soil physical changes.

Given established relationships between soil carbon and soil water properties [26,27], one factor that likely has a role in our findings is the impact of carbon accrual from the analyzed practices. For example, increases in soil carbon have been quantified by meta-analyses in response to cover crops, crop rotations, and other conservation practices [7,23,24]. Also, perennial systems typically store more soil carbon than annual croplands [56–58]. However, reviews evaluating the effect of no-till on carbon have found mixed results [22,59–62], similar to the complex no-till findings in the present analysis. Specifically, these reviews have found that no-till can lead to carbon accrual in some instances but may also lead to no net increase in carbon but rather a redistribution of carbon closer to the soil surface [59]. Further, it has recently been demonstrated that the relationship of soil carbon to soil available water may not be as strong as indicated by prior analyses [63].

Continuous cover of the soil combined with reduced soil disturbance is known to promote enhanced biological activity, with is also linked to physical soil structure. For example, management practices leading to a greater number of earthworms could contribute to soil aggregation and pore creation, increasing water entry [64,65]. A recent meta-analysis found that reduced tillage increased earthworm abundance and biomass by more than 100% compared to conventional inversion tillage [66], suggesting a potential biological mechanism that may help explain the success of no-till in improving infiltration rates under some circumstances. Cover crops have also been found to increase earthworm populations and recent work finds that they also significantly increased microbial biomass as well as mycorrhizae colonization across a range of experiments [67–69]. Increased biological indicators such as earthworms, microbial communities, microbial biomass and/or mycorrhiza colonization might also be expected in other practices that promote crop diversity and year-round growth, such as crop rotations and perennial systems, potentially facilitating higher infiltration rates through their effects on soil structure as well.

While increasing infiltration rates may mostly be considered important for reducing flooding risk, the previously discussed soil improvements can play a role in reducing the impacts of drought. A recent global meta-analysis found significant improvements from conservation tillage on soil hydrological properties such as aggregate stability, aggregate size, saturated hydraulic conductivity and available water capacity [70]. In particular, increasing available water holding capacity and soil organic matter are understood to increase the likelihood that water will be stored and/or utilized when drier conditions or drought arise [18]. Further, there is growing evidence that increases in soil organic matter and available water holding capacity are associated with increased yield stability, in particular through increased use of conservation agriculture systems [71,72]. Although tradeoffs may arise between alternative management and crop yields, the results of this work and prior work suggest that they can also improve the soil while increasing yield stability, important benefits to consider in the context of rainfall variability and climate change.

Comparing the efficacy of different management practices

Our results suggest similarities and distinctions between alternative management that are in many ways corroborated with past studies that have limited their scope to a narrower range of practices. For example, the overall finding that continuous soil cover can improve infiltration rate is corroborated by prior research focused on cover crops or agroforestry. A recent meta-analysis of eight experiments in Argentina found a similar effect of cover crops on infiltration rate, where infiltration was increased by an average of 36% due to the presence of cover crops compared to no cover controls [73]. Also, Ilstedt et al. [74] found that afforestation and agroforestry increased infiltration rates relative to annual crop systems by 100–400% across four experiments in tropical agroecosystems.

Somewhat contrary to conventional thinking around no-till, our global meta-analysis found that no-till did not consistently improve infiltration rates at this scale. In contrast to our findings, a recent qualitative review (mostly from studies within the United States, in both wetter and drier environments) found that no-till in most instances increased infiltration rates over conventional tillage [37]. Also, a review of experiments in the Argentine Pampas, a humid environment with well-drained soils, found that no-till doubled infiltration rates [38]. While our results did demonstrate a trend toward improvement, our database included very few cases where infiltration rates increased by at least a factor of two as a result of no-till, even in humid environments (16/207 paired comparisons; Table A in the S1 File). Also, we did not find a significant effect of no-till in the subset of no-till experiments including cover crops (Fig 5), contrary to our findings in for cover crops (where cover crops increased infiltration

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rates within the subset of cover crop studies with no-till, Fig 6). This inconsistency may be related to the limited number of no-till experiments reporting infiltration rates for combinations of factors, such as use of cover crops, which would have allowed more comprehensive analysis. We did, however, find that no-till experiments with residue retention were more likely to increase infiltration rates, suggesting the importance of combinations of practices to maximize benefits.

Crop rotations had an inconsistent effect on infiltration rates. We did observe a negative effect of crop rotations on infiltration rates in drier regions (Table 2; Fig E in the S1 File). However, the studies that met our criteria were largely from more arid regions, so the limited dataset may have inhibited analysis across a sufficiently wide range of aridity regimes in order to detect stronger overall effects. In a meta-analysis that similarly considered conventional management versus crop rotations but focused on soil carbon, McDaniel et al. [23] found that crop rotations generally increased carbon, but that greater increases were correlated with more precipitation. Thus, the study revealed a sensitivity of crop rotation impacts to climate, potentially related to small decreases in bulk density that may have affected soil hydrologic function [23]. Together, these findings suggest a need to closely monitor the impacts of crop rotations on several soil variables, especially in drier environments. This may be especially important for this practice, as there is already great deal of variability in the crop diversity and level of complexity of crop rotation practices.

Although limited experiments fit our criteria for crop and livestock systems, the overall result suggests that careful management of these complex systems may be necessary to maintain or increase infiltration rates. While the mean change in infiltration rates was negative across all studies, individual experiments suggested that a positive effect was possible under some circumstances and management practices. For example, Masri and Ryan [75] found infiltration rates increased when a diverse annual crop rotation included livestock as compared to when the systems included crops only. Franzluebbers et al. [76] reported increased infiltration rates in pasture-based systems with versus without livestock, but only when a lower grazing intensity was utilized. It is also important to note that cropland grazing typically represents only one component of a diversified farming system that may have different outcomes when assessed on a larger scale [77].

Uncertainty surrounding measurement timing and experiment duration

One variable potentially affecting our results could be related to a sensitivity to the timing of measurements in these experiments. This sensitivity may be particularly relevant for the no-till studies. For example, immediately after a tillage event, the infiltration rate in tilled fields could increase relative to no-till because of managed decreases in bulk density [37]. An experiment included in this analysis [78] found greater seasonal differences versus treatment differences when comparing tillage practices to no-till. Our database could not be categorized according to inter-season periods of measurement and management, as such analysis would have been complicated by inconsistent data availability and was beyond the scope of our study. As such, we were only able to evaluate overall trends based on available data and these limitations likely account for some uncertainty in our analysis.

Another related variable that could be introducing uncertainty is the lack of studies reporting effects following a wide range of treatment durations. In our analysis, we did not find experimental length to be a significant factor in our analysis across any of the practices (Table 2; Fig G in the S1 File). This finding therefore does not support the common convention that management practices need be in place for an extended period of time in order to demonstrate improvements to various soil properties. Instead, we found that even after a short period (as little as within the first few years) it was possible for infiltration rates to increase relative to conventional controls in some cases (for example, for some crop rotation and perennial experiments, Fig G in the S1 File). At the same time, longer experiments did not consistently lead to more significant changes. This finding could also be related to the interannual timing of measurements, as infiltration rate is a dynamic process subject to interseason and/or interannual variability. However, examining such effects was beyond the scope of this analysis, as the primary goal was to detect infiltration rate changes between different farming practices.

Uncertainty surrounding data limitations and research gaps

Overall, our results revealed the varying relative abundance of experiments evaluating different practices; no-till experiments comprised more than half of our database, while many fewer experiments evaluated practices such as perennials or crop and livestock systems. This observation aligns with recent findings indicating that more complex agroecological research receives relatively limited research funding [79,80]. While we did find several studies for each practice, our sensitivity analysis revealed that the limited number of experiments in some led to more sensitive results. Smaller sample sizes also limited our ability to explore influences of other environmental and management factors (e.g. we were able to comprehensively evaluate the effects of precipitation and soil texture only for no-till and cover crop practices).

Additional levels of analysis that also consider the combined and synergistic effects of multiple management practices would also be valuable. For example, it would be interesting to compare the combined effects of no-till, cover crops, and crop rotations (typically combined in conservation agriculture

systems) as compared to conventional agricultural systems. However, such analysis was beyond the scope of this study and would be challenging given the very limited number of experiments that combine practices and report results in a sufficiently similar way to directly compare controls and treatments. More complex, well-replicated, and long-term studies would be needed to enable a similar meta-analysis to the present study, but with this broader scope.

In general, a lack of detail on environmental and management factors was another important gap in our analysis. Gerstner et al. [81] and Eagle et al. [82] proposed criteria that field experiments should include to increase their utility for meta-analyses or synthesis reports, in the fields of agronomy and ecology. These criteria include environmental features, such as soil and climate characteristics, as well as reporting complete factorial results from experiments.

Conclusions

The overall trend quantified by this analysis is the potential for improvements to infiltration rates with various alternative agricultural management practices, with the greatest benefits observed in response to introducing perennials or cover crops. Our findings suggest the importance of the presence of continuous living plant roots and the positive soil transformations that accrue as a result. We found that no-till practices did not consistently increase infiltration rates but were more likely to do so in more humid environments or when combined with residue retention. Another important finding is that some practices have been substantially less studied than others, particularly ones that show some of the greatest promise for facilitating water infiltration such as the use of perennials.

Future work should explore greater opportunities for expanding practices such as perennial integration into agroecosystems to facilitate improvements to water infiltration. Further, more complex, long-term field experiments that evaluate alternative systems rather than individual practices would benefit our understanding of agroecosystem designs for optimal water outcomes. Additional research is also needed to better understand the potential synergies between optimal water outcomes and other ecological benefits at several scales, such as in relation to soil biology, nutrient cycling, and drought and flood impacts. Utilizing alternative practices that increase water infiltration rates offers the opportunity to mitigate effects of extreme weather that are expected to grow more frequent with climate change.

References and the S1 table of data can be found here:

IMPRESSIVE YIELDS FROM NEW VARIETIES DESPITE STOP-START HARVEST

Written by Keith Nicholson

Despite catchy August weather that has left many farmers with the usual harvest headaches there have been some notable performances from several new varieties being grown for the first time, including two new winter barley varieties, that have exceeded the current AHDB winter barley yield estimates of 6.8-7.2t/ha reported to date for 2021 harvested crops.

Tim Booth, Lincolnshire Farmer near Swinehead

Tim grew a crop of Lightning with a yield of just over 8.6t/ha, a new 2-row conventional winter feed barley from breeder Elsoms Seeds.

It's our first-time growing winter barley as historically, its been tricky to fit into our rotation. However, we changed things up last autumn, drilled 17ha and were rewarded with a fantastic looking crop that had no disease issues, all be-it in a low-pressure year for this area. Beyond 1 or 2 minor lodging problems due to heavy rains Lightning competed well producing a lot of tillers which smothered the ground very quickly helping to keep our blackgrass at bay. It's an early maturing type that proved excellent for an early harvest slot as we followed it with oilseed rape drilled on August 2nd.

Although not really tested it has 8s for Rhynchosporium and net blotch and 7s for mildew and brown rust, so the disease package looks potentially very solid" he confirms.

Tony Scarborough, farmer near Grantham

Tony grew a first-time crop of winter barley Bolton harvested on August 9th and achieved almost 8t/ha, again well above AHDB national yield estimates for this season.

We drilled on October 12th in decent weather. The variety established quickly, competing extremely well. It stood well during the spring, despite some heavy rain that temporarily yellowed the crop, and received a basic fungicide package at T1 with a more robust spray at T2 on May 12th. Bolton looks a good variety for a mixed farm, proving uncomplicated to grow and producing a significant quantity of good quality stiff straw. We grew two winter barleys this season, including Hawking from breeder KWS which did 6.78t/ha, although both varieties were drilled at the same time and received the same inputs package.

The final bushel weight of 63hL on the Bolton was slightly down on our farm average of 65hL, although that seems to be in line with AHDB reports of national averages of 60-64hL for winter barley this year" adds Tony.

John Wilson, Rankeilour Farms near Cupar in Fife

Reports on Bolton have also been positive further north where John drilled 17.6ha of the crop on 15th-16th of September.

Weather conditions at and post drilling were excellent, and the crop was at the 4-5 tiller stage going into winter. A low-pressure disease year was further aided by a cold snap in early spring so, despite not being fully tested, it did cope extremely well with the very heavy rain we caught in May. Harvested in early August the final yield was an impressive 10.56t/ha, ahead of our 5-year farm average. Specific weight was 68hL, again better than expected and excellent for a feed barley.

Although not really examined on its disease resistance this year Bolton was easy to grow, stood well and looks a straightforward robust variety

Whilst almost 90 percent of the UK's winter barley area had been cut by mid-August, winter wheat has seen its slowest start to a harvest since 2017 with late ripening and catchy weather the main explanations for delays. But, despite the unsettled weather, positive reports on early harvested wheat crops have started to filter through.

Tony Bell, farmer near Thirsk

For Tony a first-time crop of the Group 4 hard wheat Astound achieved a yield of almost 10t/ha supporting its credentials as a robust, low stress variety.

We drilled 18ha of Astound, split across 2 fields, with the larger field late sown on November 5th following a 'difficult to harvest' crop of maize. Despite heavy rain that submerged parts of the crop, it came through and established extremely well once the

land had dried, displaying excellent early vigour.

We went with Astound based on its high untreated yield and a relatively high treated yield and to achieve nearly 10t/ha following late drilling, just a modest fungicide package and the very challenging weather conditions it endured was a very positive result overall. Grain quality was excellent, and, in better growing conditions with earlier establishment, I feel that it's a variety capable of challenging the highest yielding winter wheats we've grown in recent years.

George Renner, farmer in Leicestershire

Further south George Renner achieved 9.2t/ha on a crop of Group 3 soft wheat Merit, a new variety to the recommended list that can be used for biscuit making, distilling and for export.

We eventually drilled during the 4th week of October, later than desired due to adverse weather and, despite not being in a particularly high risk septoria area, we took no chances applying a robust fungicide strategy. The crop stood well and coped well with the weather thrown at it and, whilst I was satisfied with 9.2t/ha, the potential for a much higher yield was lost during a 6 week dry spell in late April and May which was then followed by a dull June. It's uncomplicated to grow and with premiums available alongside good marketability I would certainly recommend it

Kit Papworth, farmer near North Walsham in north-east Norfolk

We grew 14ha of Merit as a seed crop this time to get a feel for it, late drilled in the second week of December following sugar beet. As with most late drilled crops it was slow to emerge before racing through its growth stages the following spring. Tillering nicely, the crop received a robust fungicide programme to combat significant late yellow rust and septoria outbreaks in late May and we were rewarded with a clean crop that should yield over 9t/ha.

Having budgeted the crop at 8.5t/ha it's a good overall result, however looking ahead to next year, on better fields and with an earlier drilling slot, I'd hope we'd be able to easily achieve 10t/ha as a commercial crop. Merit offers growers a range of marketing options, we're too far from a mill, so the attraction for us would be to grow for export, given our close proximity to the deep-water port of Great Yarmouth and Merit's UKS approval for soft milling export

PROPOSING A SOLUTION TO BOOST BIOLOGICAL PRODUCT ADOPTION

Could a Biologicals Pipeline Accelerator and Demonstrator be the conduit to improving the uptake of novel crop protection products within UK agriculture?

CHAP Innovation Network Lead, Dr Harry Langford and Research Associate, Dr Jemma Taylor, are part of a team that has developed a business case proposing just that.

Through CHAP's New Innovations Programme, which brings together skilled practitioners and technical specialists to define critical real-world challenges, potential ideas for overcoming areas of market failure are scoped. From this, business cases are formulated with a view to overcoming a shared sector challenge, in this case, the adoption of biological products.

Reporting on the business case, Dr Langford and Dr Taylor provide sector insight, share the proposed solution and draw in knowledge from industry advocates of biological plant protection

The why, the reason

Biological plant protection products are a distinct group within the crop protection market, set apart in that the active substances are derived from living organisms. This can encompass pest control by using non-toxic mechanisms such as pheromones in conjunction with traps, predatory macroorganisms, microorganisms as the active ingredient, or substances produced by plants, either naturally or through targeted modification.

They are recognised as having significant potential to deliver crop protection outcomes in a sustainable way, meaning they are ideally placed to deliver solutions in systems where traditional synthetic products can't or should not be used, such as in organic farming and regenerative agriculture. With the increasing interest in these alternative farming methods, biologicals have a bright future.

Biologicals can, and are already, being used across a wide range of crops grown worldwide, as they can help to improve quality and yield. They are used most effectively as part of an integrated pest management (IPM) system to complement other products and methods designed to keep the crop as healthy and productive as possible. Many biologicals can be applied using the same equipment as regular crop protection products, increasing their uptake and application by farmers. However, they do often have specified storage conditions and application times and rates, which users need to adhere to, to ensure efficacy.

The biologicals market can be segmented by type (macro-organisms, microbials and biochemicals), use (biofungicides, bioinsecticides, and bionematicides), or mode of application (foliar spray, soil application and seed treatment) to help apportion the marketplace and identify comparables. It is a growing global market due to a condensed regulatory timeline, reduced chemical residues and environment persistence, and compatibility with alternative farming methods such as organic and regenerative agriculture. Today the market is worth about $4.3bn, or £3.1bn.

In the UK, a growing number of established companies, SMEs and start-ups are investing in this market. This is encouraging, due to growing concerns around the efficacy of more traditional crop protection solutions due to resistance issues, synthetic product revocations and the decline in new products reaching the market, as well as ongoing environmental concerns.

Therefore, the acceleration of the biologicals market provides a significant opportunity to reduce the environmental impact of crop protection, improve IPM, and drive the development of a new sustainable skillset within farming. However, the challenges for biologicals can include variable effectiveness, unstable formulations and a different grower mindset to their useage. Consequently, small companies and research institutions can struggle to develop new biological products from discovery through to market launch.

We want to see what role CHAP could play in overcoming these challenges

Analysing the market

There are a number of public and private sector advisors and facilities that help support biological product development and testing. Challenges here include the fact that they can be shared with other sectors, underutilised or suffering from a lack of exposure, or they are not focused on the optimisation of biologicals at a farm scale within the context of IPM.

Understanding why these do not fulfil the market need in stimulating scale-up and commercialisation needs further investigation, but other factors could include a lack of capacity, high charges against a company's limited resources, or a lack of awareness of what facilities are available.

Others who are operating in this area are:

- Consultants who are specialist regulatory advisors, e.g. Enviresearch
- Research and scale-up facilities with specialist equipment, e.g. CPI and IBioIC, along with industrial biotechnology facilities
- Business advisors – public and private, e.g. Cambridge Consultants
- Public sector providers of grant funding, e.g. Innovate UK
- Venture capitalists and business angels, e.g. Yield Lab
- Associations promoting relevant applied research, e.g. AAB

There are already a number of public sector advisory and support organisations, and/or those who provide grants for this area.

With this in mind, there is an opportunity for CHAP to establish the core of a service which would provide advisors to help companies advance through the new product development pipeline, and direct them to resources and facilities that are available either within CHAP or elsewhere, to help them to progress. This would enable a complete pipeline provision:

- Small scale production facilities and equipment
- A network of field and farm trial sites optimised for biologicals

and IPM

- Advice on research and testing design
- Guidance on regulatory submissions and evidence
- Advice on further research and technology development
- Grant funding for future development
- Business and commercial training
- Overall advisor to progress pipeline
- Lab and testing equipment
- Consultants for regulatory advice
- Grant and loan funds for specific projects.

The case for change

During an assessment of the UK crop protection industry, CHAP identified three main areas of market failure:

- **Funding:** Risk for developers of new biological IPM products and systems, along with challenges demonstrating efficacy and best practice, leading to difficulties in securing funding to move products along the 'pipeline'.
- **Understanding:** Lack of clear information, both for SME product developers, in addressing development and demonstration challenges, both to move new IPM products and systems along the pipeline, and to help end users understand the product and system choice.
- **Tailoring:** Global, large market focus hinders the development of biological solutions tailored to local situations and smaller markets.

Alongside these market failures, several barriers were identified which slow or prohibit progress with the development, production and utilisation of biological crop protection products.

The market for biological control products may be on the rise, but challenges remain for the numerous SMEs developing them, especially the availability of independent facilities for scale-up of production. This is particularly true for certain product derivatives such as fungi, which require dry-mill biorefining. Beyond production, barriers to adoption include demonstrating biologicals' efficacy, and a more complex use strategy with many best used in association with other products or IPM strategies (but with little knowledge and information available to support users).

As a result, new biologicals often either stall and fail, or are purchased by larger companies during their early development, with limited benefit either to the original investors or to the UK economy. These barriers - coupled with the high cost to growers for biopesticides when compared to synthetic pesticides - restrict their adoption in more conventional broad-acre farming systems. This may ultimately limit the growth of the global biopesticides market.

As the new agriculture bill and ELMS regulations come into force in the UK, changes will be implemented to encourage more diverse, sustainable and environmentally benign farming systems. This will only add to the highly complex, multi-dimensional space of the crop protection 'environment', which is trying to interface between 'science', 'agricultural technologies', 'crop management practices', 'environmental impact', and an ever-growing public scrutiny of the environment and public health. This is concerning as it is already difficult for stakeholders in the sector to keep up-to-date with legislation and evolving products and solutions, and to therefore make good decisions about what products to use and where the business opportunities are.

The majority of UK farmers have a risk-averse view of pest management and undertake 'insurance' applications; in fact, pesticide applications on UK crop land rose 24% from 2000 to 2016. Setting up an effective IPM strategy is important when trying to deal with production risks, but with the multitude of traditional and new crop protection tools and technologies available, and the complexity and clarity of the information surrounding IPM programmes, this itself can be a major barrier to the correct and effective adoption of IPM.

To address this CHAP, in discussion with stakeholders from across the sector, created a problem statement to summarise the issues and opportunities for which a solution could then be developed.

Risk prevents truly disruptive crop protection solutions from being developed and delivered, particularly as part of an integrated system.

Manifold risks operate across the product development and regulatory

pipeline, in accessing and utilising real-time data to underpin user decision-making, and in designing systems-integratable solutions.

Solution - a collaborative way forward

To address this problem statement, CHAP proposes the development of a 'Biologicals Pipeline Accelerator and Demonstrator' in partnership with key stakeholders. This would increase the number of new biological products successfully reaching market, and improve the effective integration of biologicals into existing and novel IPM strategies, diversifying their use cases to include open field agriculture.

The Biologicals Pipeline consists of two parts:

- The 'Accelerator' - a brokering service to link SMEs to expertise and facilities along the development pipeline, with expertise in specific activities, such as scale-up of production, adjuvant/inert material specialists, biological and toxicological testing, regulatory compliance, product registration, investment and funding. This will provide a one-stop-shop for innovation in biologicals, from registration and compliance through to scale-up and financing.
- The 'Demonstrator' - a network of field and farm trial sites optimised for biologicals and IPM, providing two tiers of demonstration trials: efficacy trials of new products, singularly and in combination; and IPM optimisation trials to develop standard operating procedures for biological IPM solutions. This will allow product developers to determine and, if necessary, reduce the variability of their product's efficacy, as well as allowing application mode and delivery to be optimised within a commercial IPM setting. As such, the 'Demonstrator' will help to overcome technical limitations of biological products during the product-development pipeline, and showcase the efficacy of products within optimised IPM systems, helping to de-risk these products and systems for the end-user.

After demonstrating a successful service, the Biologicals Pipeline Accelerator and Demonstrator could expand further, via strategic capital infrastructure investment, to provide supporting equipment where strong market need is evidenced.

It is anticipated that primary users of the Pipeline will be SMEs at an early stage of biological product development, who are seeking to advance products through the pipeline towards the market, along with researchers in universities and research institutes at an early stage of biologicals source or product development. Contract researchers may also find it beneficial.

CHAP hopes that the Biologicals Pipeline Accelerator and Demonstrator will benefit farmers and anyone in the agricultural sector who uses the novel products that come out of the Pipeline, as well as benefiting wider society due to more sustainable food production and a resilient farming sector.

INDUSTRIAL HEMP
UNDERSTANDING THE OPPORTUNITY FOR UK FARMERS

This article was "Written by Camilla Hayselden-Ashby, Nuffield Scholar 2021

Hemp, Cannabis with a low level of the psychoactive compound THC (tetrahydrocannabinol), has seen a global upsurge in interest in the last decade. This has been driven by the growing popularity of CBD as a food supplement, demand for environmentally sustainable products and changes in legislation around cannabis growing. The global hemp market is projected to reach $15.26 billion by 2027.

This growth in the demand for the crop is generating interest among UK farmers. Although the area cultivated in the UK is small (820ha in 2020 according to the BHA), hemp has huge potential as a financially and environmentally sustainable break crop. This could not come at a better time as farmers look to diversify in the transition from BPS, and reduce their carbon footprint.

The UK has a long history of hemp cultivation starting from Roman times, and it was an economically significant crop until the start of the 20th Century. For much of this time, it was such an economically important crop for rope and sails in the shipbuilding trade that there were subsidies available to encourage farmers to grow it. Under Henry VIII it was even required that every farm grow a quarter of an acre of hemp for every 60ac cultivated.

Hemp has over 25,000 uses, with applications for all parts of the plant. These include food, construction, textiles and bioplastics.

It is also environmentally beneficial to grow. Hemp produces a lot of biomass in a short period of time, allowing it to sequester an estimated 15t of CO2 per hectare. This makes it an important tool in the race to Net Zero. Its deep root system (the taproot can go down to 2m) improves soil structure and brings up nutrients from lower in the soil profile. It has low input requirements and reduces herbicide requirements thanks to effective weed shading. Finally it takes up heavy metals in the soil, enabling its use in phytoremediation to deal with soil pollution.

Markets

There are three key parts of the hemp plant which can be harvested; seed, stem material and flower.

Flower

CBD, extracted from hemp flowers, has seen a boom in popularity in recent years and is taken for anxiety, inflammation and pain relief. This is a high-value output, but UK farmers will have to wait to take advantage as current industrial hemp licensing prohibits processing of flower and leaf material. As a result, the CBD oil sold in the UK is all imported. In the Channel Isles this restriction has been lifted, allowing farmers such as Jersey Hemp to tap into this growth market.

Seed

Hemp seed is the easiest market for cereal growers to switch to since it can be harvested using a combine harvester. Seed varieties are usually shorter at 1.5-2m (vs. 2-4m for other varieties). Finola is popular among UK growers because it has been bred to flower automatically 120 days after sowing, rather than being triggered by a change in day length; this allows an earlier harvest in mid-September.

Hemp seed is nutritionally dense with high levels of omega oils and protein. It is pressed for oil, made into hemp milk, sold as whole hemp hearts which can be added to cereal or smoothies, and processed into protein isolate used in vegan meat-alternatives.

Hemp oil can be extracted using cold press equipment similar to that used for oilseed rape. There are also several UK companies who produce hemp oil and seed products such as Good Hemp.

Stem

Hemp stem consists of long outer bast fibres and a woody core which is broken up into 'shiv'. These are separated through a process called 'retting' allowing the plant to break down slightly in the field followed by decortication which uses physical processes to separate the fibre and shiv. These products are used for construction, animal bedding, paper, kindling, bioplastics and textiles.

Building

Hemp is used to make 'hempcrete' a more sustainable alternative to concrete, made by mixing hemp shiv with lime. This results in a construction material used in walls with a timber frame or sprayed for insulation. As well as the carbon sequestered while the plant grows hempcrete buildings lock up additional carbon as they cure with total carbon

sequestration potential of up to 300kg of CO2 per m3 . Hempcrete provides good sound and heat insulation, is not flammable and is breathable.

Plastics

Hemp fibres can be combined with resins to produce biocomposites as a more sustainable alternative to traditional plastics. Hemp composites are used in a wide range of products. Car door panels are the most common, in fact the body of the original Ford Model T was made of hemp, but it is also used in packaging, sports equipment, furniture and musical equipment.

Textiles

Hemp fabrics are one of the most traditional uses of hemp fibre. They offer a natural, sustainable alternative to the polyester used in most of our clothing or cotton, production of which often uses large amounts of pesticides and water. It produces fabrics similar to linen but innovators are experimenting with blends and even using it to make an alternative to synthetic fake fur.

How to grow

Grows like a weed' is particularly apt when talking about hemp. It grows even on poor land and has low input requirements with no pesticides and little fertilizer.

However getting the best out of it requires some care, particularly at establishment.

Drilling

Hemp is a spring crop and is planted from April through to late-May. It grows best in well drained soils with good fertility and organic matter. Soil temperatures should be above 10ºC for planting and it is important to have some moisture for it to get going. As hemp is a small seed, establishing good seed-soil contact is essential. It is also quite particular about drilling depth with a target depth of 3-4 cm. It is possible to establish by direct drilling although most growers cultivate prior to drilling to ensure a fine seed bed. Seed rates should be around 30-50kg/ha.

Hemp needs Nitrogen at the start to get going. 60kg/ha should suffice although yield improvements are seen up to 150kg/ha.

In season

Seedlings take about 5-7 days to emerge and are quite vulnerable to birds and weed competition at this stage. However once the crop gets away it will easily outcompete most weeds as it grows so tall and dense that it will shade them out.

After this it is a bit of a case of 'shut the gate and wait'. Pests and disease are not usually too much of a problem. There is the potential for fungal disease of the flowers such as septoria or white mould but these have yet to present a significant issue for UK growers.

Harvest

Harvesting hemp can be challenging as its tough stems and long, strong fibres can wear down and wrap around machinery. While there is specialised harvesting equipment available this is not yet cost effective for the UK scale of growing. Most UK growers use conventional arable equipment or have built their own solutions to deal with the crop.

Harvest timing depends on end use.

Hemp seed is ready from mid-September. The seed can be cut using a conventional combine. It is important to set the cutter bar as high as possible to minimise the chance of the strong fibre wrapping around the machine. It is important to have immediate access to drying facilities to dry the crop to 9% moisture, particularly as it will normally be harvested quite green to minimise seed loss and fibre wrapping. Potential yields are 0.8-1.2t/ha.

If harvesting for fibre the optimal time to harvest for quality is at full flowering in July. The stems can be cut using a sickle mower, ideally at several heights to produce lengths of approximately 60cm which is preferred by fibre processors. This is then left in the field for several weeks to field ret, where the combination of microbes from the soil and moisture from dew break down the bonds between the hemp fibres. This is then baled and taken to be decorticated. Typical yields are 6-12t/ha.

There is potential for 'dual-cropping' where the straw left standing after seed harvest is cut, retted and baled. This is popular in Europe but is difficult to achieve at UK latitudes since the seed is harvested so late that it is often too wet to ret and bale the straw. An alternative approach is to leave the stalks standing over winter to 'stand ret' and then cut and bale in the spring. However this can negatively impact stem quality.

What are the challenges?

Despite the benefits hemp offers as a crop, there are a number of challenges facing UK growers.

Licensing

In the UK growing Industrial Hemp requires a license, administered by the Home Office Drugs and Firearms Licensing Department. Applications open in January and it is advisable to allow at least a month for processing (although it can take longer). As part of the license application you will have to supply a DBS (Criminal Record) check, state where you plan on growing it, which variety you plan to grow, the target end market and how you will destroy the flowers and leaves. Your selected variety must be one from the approved list of strains with THC levels of less than 0.2%. Growing locations can also pose a challenge as it is required that the crop is grown out of sight, away from roads, footpaths and houses.

Access to suitable varieties and agronomic knowledge

The relatively small area grown means that there is a lack of experience growing the crop and there have been few crop trials to test varieties and growing methods for the UK climate. In addition the current approved variety list is inherited from the EU variety list which means that most of the options included are suited to more southern latitudes. Breeding and trial work is needed to establish varieties suited to UK growing.

Processing facilities

There are only three decortication facilities in the UK which is a barrier to the fibre industry taking off as it means that growers have to transport bulky straw bales a long way for processing. For hemp growing for fibre to become more mainstream we need to establish regional processing capabilities such as mobile decorticators or regional processing hubs (as is seen in France). The global prohibition of hemp means that harvesting and processing equipment development is behind that seen in other mainstream crops although progress is being made rapidly as hemp gains popularity.

Market access

Most of the markets for hemp are still developing. This means that growers will need to put in more work to find a buyer for their crop or do their own processing.

Finding the solution to these challenges inspired me to apply for a Nuffield Scholarship. I will be using my 2021 Nuffield Scholarship, kindly supported by NFU Mutual Charitable Trust, to see how the UK's nascent hemp industry can learn from international best practice in countries such as Canada, the USA, China, France, Germany, Holland, Ukraine and Romania. Anyone with experience of or an interest in growing hemp in the UK or abroad is very welcome to get in touch at chayseldenashby@gmail.com.

Fact box

- The global hemp sector is projected to be worth $15.26 billion by 2027
- 820ha currently grown in the UK vs 150,000ha globally
- Uses in food, construction, biocomposites, textiles and pharmaceuticals
- Strong potential as a tool for carbon capture, sequesters CO2 at 15t/ha
- Drilled in April-May and harvested in July-September depending on end use
- Growing in the UK requires a Home Office licence
- Processing of flowers and leaves for CBD is prohibited

Hemp on our farm

I was inspired to start growing hemp on my family's farm in Kent after learning about the huge number of uses it has which convinced me that it would have a key role to play as a crop for a sustainable future. As I write I look forward to the harvest of our first trial crop in a few weeks time with excitement and not a little trepidation. We are growing a dual-use variety called Ferimon to be harvested primarily for seed.

For this year's crop we have experimented with growing with zero inputs to see what the baseline potential is. We have still managed to get a decent crop with 2.5m plants in the best parts. The field was drilled with a Claydon Hybrid following on from a cover crop of rape, mustard, radish and turnips which was grazed off with sheep.

We are also participating in an Innovative Farmers Field Lab to monitor the impact of growing hemp on soil health and biodiversity. For this we are taking soil samples, including organic matter analysis, and measuring insect numbers before and after the crop as well as in a control field for two growing seasons. My hope is that this will provide additional evidence for the government to relax hemp regulation so that more farmers can grow it.

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6 STEPS TO A SUCCESSFUL ON-FARM RESEARCH TRIAL

Written By Laura Barrera and first published on AgFuse.com

If you want to make smart, well-informed decisions on your operation, you need relevant, high-quality data to support those decisions, says Tim Laatsch. A great way to achieve this? On-farm research.

An Illinois-based farmer, Laatsch knows first-hand the importance of on-farm research. As the Director of Agronomy, North America for Koch Agronomic Services (Koch), he leads a team of agronomists responsible for developing and executing field research strategy.

Illinois farmer and Director of Agronomy, North America for Koch Agronomic Services, Tim Laatsch. Photo provided by Koch Agronomic Services.

Here he shares the steps to follow for conducting on-farm research and the best strategies for ensuring it's a successful endeavor.

1. Frame Your Research Question

The first step to getting started with on-farm research is to ask yourself why you're doing it, Laatsch says.

"If profitable decision-making is their goal, it's worth the time and effort to do the job the right way," he explains. "Because the decisions they make as an outcropping of the research could potentially impact their profitability for years to come."

The key is to keep it simple and only focus on one management change at a time, as one of the initial mistakes farmers make with on-farm research is trying to answer too many questions at once.

Laatsch highly recommends working with a qualified expert on this. In addition to helping you come up with the right question to ask, they can also provide guidance and support throughout the trial.

Once you've determined the one question you're trying to answer, then you need to come up with your hypothesis.

Laatsch recommends the following format:

- Start with a basic problem statement: "The problem is X…"
- Come up with a potential solution: "I believe that X…"
- Determine what you hope to achieve: "Will result in X…"

For example: "The problem is I apply two-thirds of my nitrogen prior to planting and I'm concerned I may be losing nitrogen and sacrificing yield opportunity. I believe that using a nitrification inhibitor will reduce nitrification loss, which will result in higher corn grain yields."

The last part of creating your hypothesis is to define the outcome. Laatsch says this part is most often neglected when framing the question.

"Not making an educated guess about the results before the research begins is a mistake that's made at times," he says. "What we should do is define on the front end our standard of success."

It needs to be more specific than just "higher yield" or "reduced fertilizer inputs." Laatsch suggests that you include your level of confidence in the treatment, and specify the number of environments it needs to be tested across, as there

may be some environments where you expect more or less change.

For example: "We will have the confidence to make a decision when the yield increase is X bushels per acre, with a minimum of 80% statistical confidence across three locations."

Statistical confidence is simply an outcropping of being able to measure the variation around the average, Laatsch says. In other words, what are the odds that the result is due to your treatment and not by chance or another factor?

So what should your confidence level be? Often 95% is used in university research and scientific literature, but for farmers, that probably sets the standard too high.

"There's a very good chance you will reject a viable technology [at 95%]," he says. "Maybe 80% would be a more reasonable starting point. I'll take a bet that 80% probability of a product will create more yield for me."

Again, working with an expert who is familiar with using statistics in on-farm research would be helpful in determining what the confidence level should be.

2. Design the Trial

The lack of statistical confidence is also why single side-by-side or field-by-field comparison research trials are flawed,

Laatsch says. That's because they don't account for in-field variability, so you can't run an analysis of variance on them.

Laatsch made this mistake with his own on-farm research. He was testing foliar fungicides, and since he was aerially applying them, it would have been difficult to do replications, so he stuck with side-by-sides. But at the end of the season, he couldn't readily determine whether those applications generated a positive ROI.

"There were places where it seemed like it performed well, other places where I couldn't tell the difference," he says. "I had no ability to measure the variation around the mean or to have any degree of actual calculated statistical confidence in the outcome. As a consequence, now I'm in the position where I can't make that decision."

That doesn't mean you can't do side-by-side plots. In fact, Laatsch recommends them because they're the simplest to implement. The key is to make sure you're including repetitions. In the example of the nitrification inhibitor trial, you'd include one strip with the nitrification inhibitor and one without it (i.e., your control) and repeat those throughout the field or across multiple fields.

To run an analysis of variance, you need at least 3 replications, preferably 4 to 6. That way if weather or some event takes out one of your replications, you're not down to two.

Examples from University of Nebraska-Lincoln showing a visual example of replicated treatments vs. a randomized complete block design.

One design option is a randomized complete block design. In this trial design, your treatment may be on the left in one replication, and then on the right in another, to help eliminate field biases. Modern GPS makes this design easier to implement because you can put in all your treatments and then fill the gaps on the way back, Laatsch says.

But the easiest and quickest way of setting these trials up is to split your planter or applicator. This eliminates randomization, but Laatsch says in most on-farm research that's probably fine. Having field-scale equipment already provides an inherent advantage because you can do larger plot sizes, reducing variability.

While a replicated trial within one field is probably sufficient to manage your decision-making risk, Laatsch encourages you to think about whether there are major differences in soil environments across your operation. If there are, consider repeating the trial within each of those environments to better understand whether the treatment you're testing is beneficial across the whole farm.

"The most powerful research designs have the greatest ability to impart statistical confidence, have fewer treatments, and only focus on one factor at a time," says Laatsch.

Again, this is another step where having a trusted partner is useful because they can guide the trial design and determine where to place it on the farm.

However you design your trial, don't forget to include buffers, Laatsch says, because excluding them can skew your results. For instance, including an outside row that receives open sunlight exposure could increase yield, creating

a favorable advantage. Instead, keep those outside edges out of the trial, and consider having harvest buffers within treatment cells to ensure you don't have overlapping edge effects between treatments.

3. Execute the Trial

With your hypothesis and trial design in place, the next step is executing the research. Laatsch's No. 1 piece of advice for doing this currently is to have that trusted partner on site. They can help with taking measurements, laying out treatments, and marking plot corners, so you can stay in the cab.

"It's very time efficient and improves accuracy if you have actual physical boots on the ground to help with trial implementation," he says.

But before you even head out into the field, you need to plan ahead. Laatsch says the last thing you want to do is get caught in the position of making design decisions on the fly because you're under pressure. You'll want to make sure the design, the repetitions and the treatments are all defined ahead of time.

He gives the example of a grower and retailer he knew who started a trial in the heat of planting season, on a Saturday evening. The trial was a total loss because they later discovered they had an old product label and applied the wrong rate.

"It's just an example of making sure you've got everything typed out, including product rate, before you go to the field," he says. "If you're trying to do that on a Saturday night, you may not be able to access resources that can answer questions."

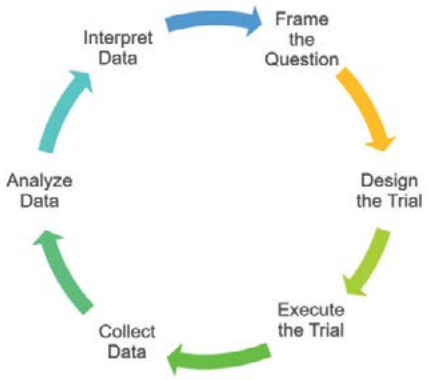
Documentation is critical to trial execution and redundancy is good. You don't want to rely strictly on digital or physical documents, so keeping both is a good idea in case one of them fails, especially when it comes to marking your plots.

Other factors to document include the conditions at the time, and you need to capture those in the moment. "If you don't write that stuff down, you will never remember it when you get back to the end of the season and you're trying to interpret your results," Laatsch says.

Finally — and as a farmer, Laatsch can attest this is the hardest part — you need to slow down.

"The pressure of spring planting can create all kinds of problems, in terms of temptations, to cut corners," he says. "You've got to slow down to get better."

The consequences of failing to do so can be detrimental to your farm's profitability. If you make a decision based on the results of a rushed and poorly executed trial, it can cost you money for years.



The critical steps to good decision making. Photo provided by Koch Agronomic Services

4. Collect Accurate Data

The next step is collecting data, which is determined by your research question.

"You really need to decide upfront what you're going to measure before you start the trial," Laatsch says.

There are two kinds of variables you need to measure in your research: independent and dependent.

Dependent variables rely on the treatment you're implementing — they're outcomes of what you're testing. Changes in plant nutrient concentration, plant growth rates, crop health, and grain yield, moisture or quality, are all examples of dependent variables.

Independent variables are factors not influenced by your treatment that could affect your results, such as weather, soil type, and growing degree days. These are important to measure because they can help explain why you got the result you did.

The proper equipment calibration of tools, like yield monitors, is key for accurate data collection. While Laatsch admits those technologies are getting better every day, "there's nothing like having a calibrated scale that you're actually weighing grain on in the field," for the most reliable result.

5. Analyze Your Results

It can be easy to look at the results on the surface and judge whether it was a success. But Laatsch implores farmers to take it a step further and look at the results' statistical confidence.

If this isn't something you're familiar with, he recommends working with someone who has that expertise. Look for someone who has an advanced degree in agronomy, as that normally signifies a formal training in statistics. You can also partner with a third-party service provider or reputable company who may have a research agronomist on staff that can help.

6. Study Up and Check Yourself

The best way to succeed with on-farm research is to do your own research. Laatsch says there are plenty of well-written guides to doing on-farm research that are just a Google search away.

"One way to prevent mistakes is to just study up on technique and become a student of the process," he says.

He adds that one of the best ways to set yourself up for success is to create a checklist for the entire process. As you move through the field and through the season, you'll have a way of ensuring you're following the protocols you've set out for your research.

"At the end of the day, you never want to make a bad decision based on weak or inadequate data," Laatsch says. "That's what's driving all of this. You've got to be cognizant of why you're doing this and the level of effort that is going to be required to get good data to support that decision."

For more information about on-farm research...

Laatsch gives greater detail about conducting on-farm research in a recent webinar hosted by The Fertilizer Institute. Watch the full recording via the QR Code.

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DRILL MANUFACTURERS IN FOCUS...

MORE STRINGS TO HIS BOW, MARTIN LOLE DISCUSSES HIS NEW IPASS DIRECT DRILL AND HOW IT COMPLIMENTS HIS EXISTING STRIP TILLAGE OFFERING.

Having a long history in designing and manufacturing agricultural equipment, from founding Spearhead when I was 30, going on to Mzuri Drills, and more recently the Razorback range, I am always striving to push the envelope in design and looking for innovative solutions for changing markets.

This passion is what led me to my latest development, the iPass direct drill which was launched earlier this year and demonstrated to the public for the first time at Groundswell and Cereals. I was pleased with the positive feedback we received, and whilst naturally the change in colour was questioned, it was important to me to send a clear message that this is a very different type of drill.

When designing the iPass to complement the existing Mzuri range, I focused on producing a machine that could offer high output seeding, in a simple, accurate format whilst allowing operators the freedom to choose between strip tillage, direct drilling, and more conventional seeding as and when their drilling campaigns required.

Before to this photo being taken, the wheat stubble was subsoiled with our new low disturbance subsoiler and raked with the Mzuri stubble rake. The iPass was then used to establish a cover crop mix into what is an ideal environment for good rooting, all whilst minimising surface disturbance.

Comprising of a leading spring-loaded disc, breaker leg and a clever parallel linkage assembly supporting the seeding coulter, adjustment of the drill couldn't be more simple.

The leading spring-loaded disc cuts through the previous crop residue and minimises surface disturbance followed by the auto-reset breaker leg that features replaceable point and wings to till the seeding zone and deliver fertiliser into the seedbed. This combination delivers a clean, residue free tilled zone and by simply adding or removing ram stops on the main lift ram, operators can easily adjust the extent and depth of cultivation.

The coulter assembly features a very simple adjustment lever to set the seeding depth in relation to the rear press wheel and once set, the seeding depth will remain consistent regardless of the depth setting for the breaker leg. This is a feature which is not commonly seen on drills in the current market, but it is one that I think is important when considering the accuracy needed for optimum establishment and when working with products such as pre-emergence herbicides.

The iPass is equally at home in a pre-tilled seedbed producing a very uniform finish. A 7000L pressurised tank complete with four metering units supply accurate seed and fertiliser rates at high speeds and gives the iPass an incredible output for larger acreages.

Once seed is delivered into the zone created by the front leg, V-shaped press wheels ensure perfect soil to seed contact and reconsolidation. The whole assembly has been designed to offer minimal disturbance whilst still achieving an optimum seeding environment, something that I am very excited about. Following the seeding assemblies, a double harrow evens the field surface and if there is a lot of crop residue present, a second pass of our Mzuri Rezult harrow or a set of paddle rolls can work exceptionally well.

Typical examples of crop establishment trials during this past month includes

establishing Oilseed Rape into Spring Barley, Winter Barley and Spring Wheat stubbles. We have established the OSR into multiple variations of pre-drilling field preparations, varying from direct drilling into untouched stubbles, drilling into stubbles that have been raked with the Mzuri Rezult, and finally into stubbles that have been subsoiled with our new low disturbance subsoiler and raked. From this we were able to see that the iPass was equally as happy drilling into all three scenarios and to conserve moisture, all fields were finished with a paddle roll.

Our trials involving pre-subsoiling stubbles followed by the iPass has been inspired from the growing popularity to couple low disturbance subsoiling with a one pass drill. It is a trend that we have seen developing, particularly where growers are looking for a quick, efficient and failproof system to establishment on a large scale and is why we have developed our new low disturbance subsoiler to compliment the range.

With a leg spacing of 500mm and a generous stagger of 750mm, the new subsoiler will cope in high residue situations and glide through ground, lifting the soil profile while minimising surface disturbance. 'Hammer-thru' Shearbolts rather than a hydraulic reset system maintains the wing at the right angle to get the correct amount of disturbance, with the minimal amount of pulling power. It is a recognised problem with auto-reset that if the leg drags backwards, it dramatically increases the horsepower requirements, therefore reducing the efficiency of the machine. The rear packer puts the field back down level, with rings concentrated closely to either side of the legs, again to get maximum efficiency from the packer.

In situations where a lot of surface straw is present, or where the combine has not done a very good job of spreading it evenly, I have found that using our Rezult Rake to even it before drilling is a useful tool, particularly in the fight against weeds. By mixing a little surface tilth with the straw it not only aids breakdown, but also encourages a flush of weeds and volunteers. All that is left is to go straight in with the drill and it makes for a quite superb system.

Going back to the iPass drill, on both my own farm and that of willing neighbouring land, I have found the system to work very well in both clay and sandy soils. The drill offers the flexibility to choose how much tilth to create and what depth to apply fertiliser. Everyone that has seen it comments on how easy it is to set up, by simply unfolding the wings and off you go. As I said before if you don't like the cultivation depth just change the ram stops, it couldn't be easier.

Each seeding coulter is mounted on an individual parallel linkage which ensures consistent seeding depth regardless of changes to the cultivation depth. Seeding depth is set by handle adjusters on each leg in relation to the individual v shaped packer wheels and cultivation depth is simply set by ram stops on the drills main lift rams.

The coulter and breaker leg assemblies are mounted in front of the axle to allow for good visibility from the cab but to also ensure that the tines are being presented with an even field.

Something that I also wanted to incorporate with a drill of this size was a means to adjust the draft when going up a steep hill or in hard going. The load transfer system incorporating weight transfer wheels to the front work in conjunction with the tractors lower link sensors and picks up on changes as you go along, lifting the drill up in tough going all while not changing seed depth.

It was also important to me to accommodate those operators who will be drilling anywhere from 12 – 15kph. To achieve accurate seed metering at high speeds, the 7000L tank is pressurised alongside four capable metering units (two for fertiliser and two for seed), to ensure accuracy isn't compromised in exchange for higher working speeds.

The output of this drill is truly phenomenal, and the simplicity and accuracy alongside even germination is what makes this a really special machine. The iPass is undoubtedly very happy as a one pass direct drill and is equally at home drilling into subsoiled ground – it ticks all the boxes. It also allows growers to achieve minimal disturbance to deliver on their soil health ambitions whilst avoiding problems commonly associated with disc drills, such as hair pinning, slotting and the requirement for ground to be in an almost perfect condition from the start.

Compared to our popular Mzuri Pro-Til, I absolutely believe that there is room for both drills depending on the customer's needs. By moving less soil than the Mzuri Pro-Til, the iPass can be six and eight metres wide and requires less power per working metre. Whereas if someone wants to work with a lot of dense residue and cover crops, strip tillage remains a solid choice. The Pro-Til is very efficient at working in high residue situations and achieves excellent light interception between crop rows. The iPass can strip till if required, but with both 250mm or 330mm row spacings available we are seeing exciting progress with drilling crops with the iPass slightly closer together, to a create a more conventionally drilled look.

The iPass will continue to be extensively trialled throughout the UK and interest is already gaining momentum for the first production run starting at the end of this year. In the meantime, for those growers looking for a smaller drill, or a purely strip tillage machine, the Mzuri Pro-Til remains the best choice on the market.

Watch the iPass in Action

PASTURE-FED CATTLE HELP PRESERVE ANCIENT MEADOWS

Encouraging greater biodiversity is one of the main drivers for farmers joining the Pasture-Fed Livestock Association, including some of the nation's Wildlife Trusts. Sara Gregson went to meet Joe Ryder of Gwent Wildlife Trust to find out more...

Traditional Hereford cattle and rare breed sheep are encouraging a rich diversity of wildflowers and wildlife across meadow sites owned and run by Gwent Wildlife Trust (GWT).

GWT has been protecting wildlife and working to educate, influence and empower people to understand and care about the wildlife where they live. Established more than 50 years ago, the Trust has 9,000 members and looks after 33 nature reserves across the county.

Pentwyn Farm, close to Monmouth and the River Wye, has one of the largest areas of flower-rich hay meadows remaining in Gwent. It was purchased by the Trust in 1991 and is designated a Site of Scientific Special Interest (SSSI). Running to a total of 11.5 hectares, it is also in a Welsh organic whole farm land management scheme.

In 2008, the Trust bought the neighbouring 40-hectare dairy farm and now manage the grass fields there in a way to encourage a richer biodiversity, linked to the Pentwyn Farm hay meadows.

"The cattle are an integral part of the grazing management," says GWT Conservation Grazing Officer, Joe Ryder. "We keep them for their positive impact – offering a natural solution to wildflower regeneration and bracken control. The animals are the grassland managers here – working 24 hours a day."

Joe buys organic, Pasture for Life steers, which have been reared purely on grass and forage, from local farmers at 12 months of age and keeps them for up to 36 months of age. There are usually ten to 18 in total on the farm at any one time.

The cattle are clearing bracken encroaching from the hedge-line – natural solutions to weed control

Joe Ryder with one of the Pasture for Life steers

The ancient hay meadows are shut up from early February until August, allowing all the flowers to set and drop seed. Wildflowers include early purple, green-winged and more than ten thousand common spotted orchids, along with knapweed, eyebright, milkworts, cat's ear, rough hawkbit and yellow rattle, that all thrive on the nutrient-poor, clay soils.

The hay is mown and made into small bales by a local contractor and used to feed the cattle during the winter out on the farm.

The cattle also graze the hay aftermath lightly for four weeks, treading the fallen seeds into the ground to ensure germination and flowering the following year. The 50 or so Hebridean and Hill Radnor sheep follow the cattle, grazing the swards down even tighter to allow the light in for plant regeneration.

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One of the ancient, biodiverse meadows in late summer

Bracken control

Bracken is an increasing problem, especially where it is encroaching from the hedges.

"It is very time consuming to cut bracken down by hand," says Joe. "But the animals seem to like wading through it, perhaps deriving some relief from the flies that bother them, breaking the tough stems with their hooves."

The welfare of the cattle is a top priority and the low stocking rate means there are rarely any veterinary problems. Joe does not use worming products that remain in the dung of the animals treated for fear of affecting dung beetles – which are an important component of meadow life.

A team of 20 volunteer livestock checkers visit the animals every day to count them and do a health check. They spend an hour with them and report back to Joe if there is anything of concern. This frees up time for Joe to work across the many other GWT sites.

Pasture for Life

Joe is a member of the Pasture-Fed Livestock Association and selling meat that is certified organic and Pasture for Life – meaning the animal has only ever eaten fresh and conserved grass and no grain, is important. He is grateful for the wealth of information and support from PFLA members, directly and through the organisation's website, forum and study groups.

The cattle are selected for seasonal meat boxes at Easter, in summer and autumn and at Christmas ,and sent to Broomhall abattoir in Gloucestershire. The carcasses are cut down and packaged into 10kg and 5kg boxes by local certified Pasture for Life butcher Simon Cutter at Model Farm Shop just outside Ross on Wye.

"Selling our meat directly to around 10% of our members is a great opportunity to invite them to visit the site and to talk to them about the role cattle have played in preserving the traditional meadows.

"We explain why we have them and how they are vital for helping maintain the wide range of wildflowers and wildlife. Without livestock the meadows are pointless – they would just be gardens.

"And they know the money they spend on the meat goes back into the Wildlife Trust and further supports our work here."

Wood pasture

Other ongoing projects at Pentwyn Farm include a 20-acre permanent wood pasture site, which has been developed at the bottom of the hill, close to the River Wye. Planted in 2005, cattle will be allowed to graze between the trees next year, which may provide useful shady grazing in July and August. It will be interesting to see what effect this has on biodiversity.

"The importance of grassland is now being more widely recognised and I believe it has a really interesting future," says Joe.

"We also want to improve access for the public, so they can also enjoy a rich and varied meadow-scape, teeming with wildflowers, insects, small mammals and birds, from swifts and swallows to red

PFLA Biodiversity Hub

The PFLA is contributing to the United Nations Decade on Ecosystem Restoration (2021-2030) by launching its own biodiversity project – a showcase of biodiversity successes, methods and data from farmers embracing a 100% pasture-fed livestock farming system. This is the first formal step towards a biodiversity action plan – which is inspirational but also evidence-based.

"Our focus in this project is on pasture, ruminants and soil," says PFLA President John Meadley. "This is our USP and out differentiator from other organisations who are also talking about biodiversity.

"Soil is the skin of the earth. Two thirds of its farmland is protected by pasture, our largest single solar panel. In the soil beneath it is the largest terrestrial store of carbon. It supports and is supported by biodiversity."

In the PFLA Biodiversity Hub at www.pastureforlife.org/biodivsersity there are case studies of real, inspirational certified Pasture Champions; simple can-do steps; tools and identification methods and links to helpful partners. The hub is developing and the project will be evolving and expansive.

Ruminants are the key to creating and maintaining biodiverse pastures

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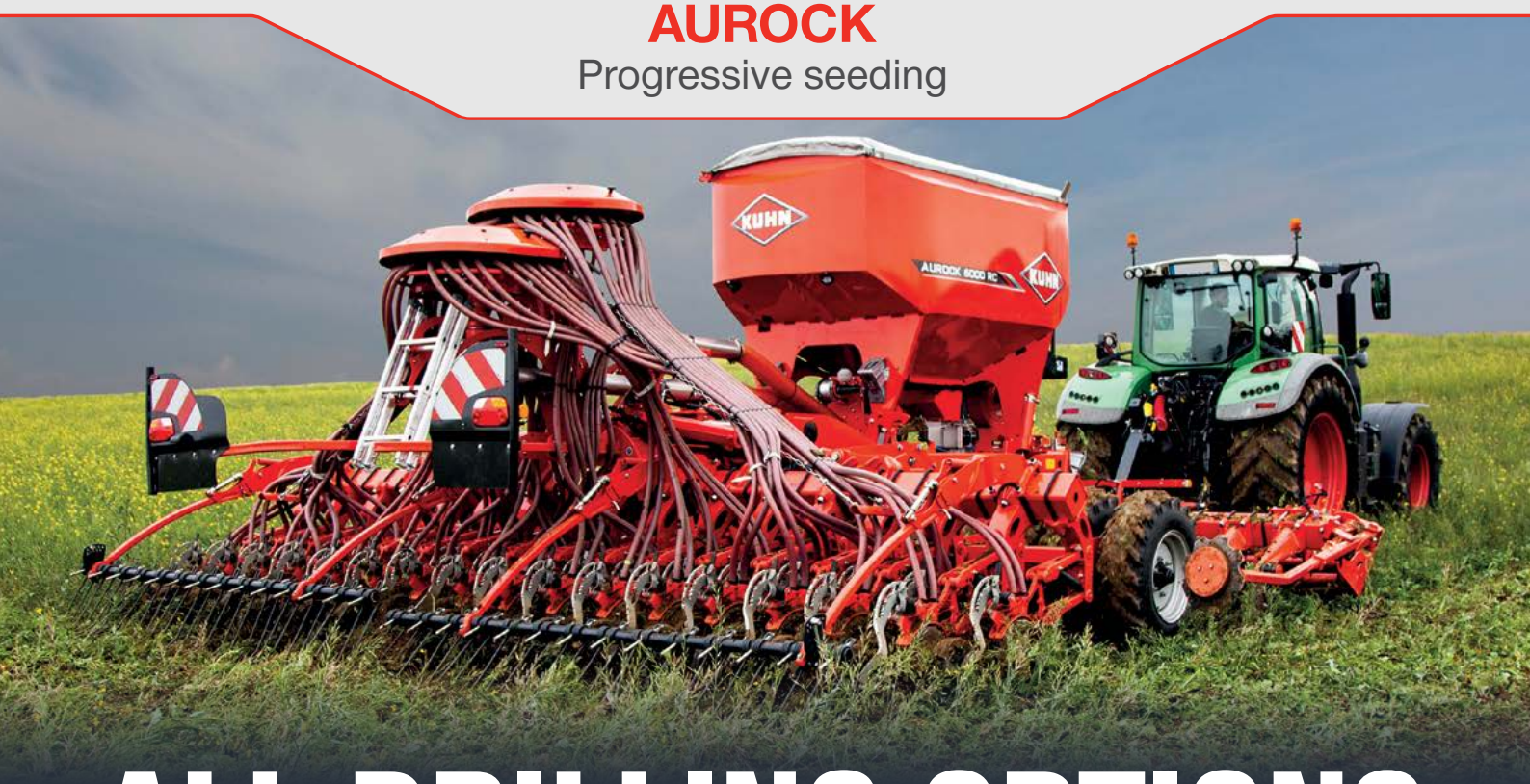

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FARMER FOCUS
DAVID WHITE

Harvest 2021 roundup at Hawk Mill, an East Anglian perspective.

Today, the 2nd September we finished harvest 2021. We tried on several occasions over the past week but the continued dull weather with early morning drizzle has prevented us from crossing the finish line, but today was going to be the day come rain or shine with spring beans and cover crop seed plots getting the chop. Queue the start of an Indian Summer!

Who knew on July 22nd when we started with the rape that harvest would drag on this long, somewhat different from last year when harvest barely stretched into August, finishing on the 7th.

I don't think we have had any notable highlights, with yields here and of my neighbours being average, but quality good. The benefit of Camgrain storage came into its own again as our quality has been captured at moistures that will cost me very little to have dried but would not have been low enough to store for any time at home and market without claims or rejections.

One highlight was my "Boats" (beans and oats mix) trial. I calculated the proportion of oats and beans in the sample to calculate the gross margin which was good for a break crop that had very few inputs and zero applied nitrogen. When looking at land use efficiency (LUE) it seems to stack up very well and has a very low carbon footprint. However, it took me nearly 2 days to separate the total field crop with my late 1950s dresser, a cost I didn't add into the GM and it highlighted that to do this on a bigger scale a better dresser setup is needed or the services of a mobile cleaning plant.

The combined crop did come to harvest together with the oats around 16% and beans 18%.

Lots to consider with bi-cropping, what are you trying to achieve, which is the main crop of the two, does that matter, seed rates of the two crops etc, etc, lots of trial possibilities here.

One thing I did prove was that adding oats to help weed control in the beans (Integrated Weed Control) that are then sprayed out does reduce the beans vigour and yield. However, my mono spring beans plot (.4ha) did produce a smaller GM than my "Boats" plot so something positive to take forward. Another observation, fewer Bruchid holes this year, is this due to having oats in the mix or a seasonal thing? There are two further questions to answer:

Could a crop like this become so popular that my central store would intake and handle it?

What/where is the driver to trial such crops as this nationally other than individual farmers?

Cereal crops this year produced a lot of straw, so much so that it's hampered my direct drilling practices. The pure volume even leaving a long stubble did not flow through the tine drill well. I think this was because after the very slow growth in April due to the many frosty nights we didn't apply much growth regulator then when it rained in May the crops overcompensated in growth. So, the baler guys have been here and very efficiently baled and cleared the fields when weather allowed. This again demonstrated the fact that combining is the first seedbed operation and you're not a good combine driver until you've driven a baler. Combine turning technique can make for a very tidy or untidy baling job! Removal of organic matter is not a problem if done occasionally and it will be replaced by the mixed species cover crops that have been planted and are growing albeit slowly as they need a proper rain! Yes although we have not had much decent combining weather we have not had much rain either, only 60% of the expected August average. East Anglia has also had the lowest number of August sunshine hours at 127.1 since 1968. How many of you will remember that year?

Waiting for the baler and chaser, if only for a few days, has demonstrated again that once the crop is cut the ground dries very quickly and the nicer conditions you have in the "five-minute fallow" window are valuable in a dry year.

I've sown a small area of OSR and companions which are nicely up in the row. I'm pleased to be part of a group of farmers hosting some CSFB monitoring traps for Colin Peters of NIAB to try and work out what the complete life cycle of this pest is and we will potentially be looking at what emerges where the 2021 rape crop was right through to the spring.

Cropping plans being made for the cereal crops. Big reduction of wheat area this year with spring barley and oats being the main cereals. My 3-way blend wheat seed sample was taken to the NIAB lab this week to be assessed for germination, vigour and disease levels so will hopefully be sown naked and I have found my local independent seed merchant is happy to sell me wheat seed without dressing too which is pleasing.

Lessons learnt or reinforced from the year.

Spring drilling, patience is the key to success but if the ground is still slotty when drilled a tickle with something a few days later can make a big difference to emergence. You do need a little tilth.

The benefit of having both disc and tine drills is invaluable.

Second wheat is the driver of increasing blackgrass numbers.

Second anything isn't a good idea, a diverse rotation is everything, look beyond a one year opportunity bonus driven by prices.

Don't underestimate the value of leaving seeds on the surface rather than mixing them in.

Crop residue management is everything.

COVER CROPS TO INCREASE SOIL MICROBIAL DIVERSITY AND MITIGATE DECLINE IN PERENNIAL AGRICULTURE. **A REVIEW**

Authored by Eric Vukicevich, Tom Lowery, Pat Bowen, José Ramon Úrbez-Torres & Miranda Hart

Published in Agronomy for Sustainable Development volume 36, Article number: 48 (2016)

Abstract

Commercial perennial agriculture is prone to declining productivity due to negative plant-soil feedback. An alternative to costly and environmentally harmful conventional treatment such as soil fumigation could be to manipulate soil microbial diversity through careful selection and management of cover crop mixtures. Although cover crops are already used in these systems for other reasons, their capacity to influence soil biota is unexploited. Here, we examine the role of plant diversity and identity on plant-soil feedbacks in the context of perennial agriculture. We identify key microorganisms involved in these feedbacks and explore plant-based strategies for mitigating decline of perennial crop plants. We conclude that (1) increasing plant diversity increases soil microbial diversity, minimizing the proliferation of soil-borne pathogens; (2) populations of beneficial microbes can be increased by increasing plant functional group richness, e.g., legumes, C4 grasses, C3 grasses, and non-leguminous forbs; (3) brassicas suppress fungal pathogens and promote disease-suppressive bacteria; (4) native plants may further promote beneficial soil microbiota; and (5) frequent tillage, herbicide use, and copper fungicides can harm populations of beneficial microbes and, in some cases, contribute to greater crop decline. Non-crop vegetation management is a viable and cost-effective means of minimizing crop decline in perennial monocultures but is in need of more direct experimental investigation in perennial agroecosystems.

Introduction

Perennial crops often experience reduced productivity over time due to the accumulation of soil-borne pests and pathogens (Hamel et al. 2005; Mazzola and Manici 2012; Úrbez-Torres et al. 2014). This is particularly problematic in woody perennial systems where crop rotation is not possible, and ultimately, replanting is necessary to restore production levels. However, addressing this problem from an ecological perspective may lead to more sustainable solutions or avoidance of decline altogether.

An ecological concept that is useful for understanding crop decline is plant-soil feedbacks. This concept describes the reciprocal effects of plants and their associated soil microbial communities (Bever 1994).

Negative soil feedback occurs when

plants promote soil microorganisms that are deleterious to their own growth, contributing to the maintenance of plant coexistence in natural systems through density-dependent regulation of dominant species (Bever et al. 2015). In perennial monocultures, however, negative feedback leads to crop decline and replant problems (Hamel et al. 2005; Mazzola and Manici 2012). That is, the deleterious soil microbial community also suppresses the growth of neighboring crop plants.

The negative effect of soil microbial communities in monocultures is not altogether surprising, given the negative relationship between biodiversity and the frequency of parasitism (Civitello et al. 2015).

In many systems, low levels of diversity will allow a parasite of the dominant host species to more easily find a suitable host. Increased diversity makes hosts more difficult to find and disease outbreaks less frequent and leads to the "dilution effect" associated with high species richness (Keesing et al. 2010). For plant-soil ecosystems in particular, it is well established that increased soil diversity decreases incidence of plant disease (Garbeva et al. 2004a; van Elsas et al. 2002) and improves plant productivity (van der Heijden et al. 1998, 2008).

Can growers capitalize on this dilution effect by increasing soil microbial diversity in perennial systems? While many mechanisms contribute to forming soil microbial communities, e.g., abiotic filters (Fierer and Jackson 2006; Lauber et al. 2008), there is an extensive body of literature documenting the ability of plants to "train" their associated microbial communities (Badri and Vivanco 2009; Fanin et al. 2014; Hartmann et al. 2009; Rovira 1969). While growers are limited in their ability to manipulate the diversity of crop plants in their cropping system, cover crop identity and diversity can be an efficient way to increase soil microbial diversity and suppress soil-borne pests that cause crop decline (Garbeva et al. 2004a). Cover crops are already a common feature in many perennial systems, but their potential impact on the biotic component of soils is often overlooked. For the purpose of this review, we define the term "cover crop" as managed vegetation grown between crop plant rows, including annual and perennial swards.

Here, we incorporate ecological knowledge of plant-soil feedbacks into the context of perennial agriculture to explore the use of cover crops to increase microbial diversity and manage crop decline. The specific aims of this review are to (1) synthesize our current understanding of how plant communities influence soil microbial communities into the context of cover crops; (2) highlight key beneficial soil microbes and their role in affecting crop decline; and (3) present plant-based strategies to mitigate decline of perennial crops through soil microbial diversity

Read the Review in full by clicking on the QR code.

PRODUCTS IN FOCUS...

BOURGAULT PUTS BRITISH FARMERS FIRST

British farmers will be primary beneficiaries of Bourgault Tillage Tools' (BTT) decision to open a new subsidiary company in the UK.

The Canadian company has become well established in the UK for many, initially working via distributors.

But its's new subsidiary – Bourgault Tillage Tools UK Ltd (BTTUK), based at Thorney, Cambridgeshire – will improve the company's offer to its loyal and expanding client base, says Ian Clayton-Bailey, managing director:

"We will be able to hold a much more comprehensive range of parts in the UK, which will enable us to offer customers a faster despatch of a wider range of parts.

"They will come from BTT's factory straight to our customers. That is essential to meet their demands during busy working seasons".

BTT's range of ground engaging parts and tools has already built an appreciative audience among British OEMs and farmers over the 30 years since the company was founded.

And the new UK company will also offer British farmers Forge de Niaux range of disc blades and Extreme® Carbide products.

Later this year it will introduce the company's new MAXLIFETM carbide technology, which infuses tungsten carbide onto wearing parts, giving them a greatly extended working life.

The company has built a significant global customer base thanks to its continual drive for innovation, having introduced a range of market-leading innovations over the years.

BTT celebrates its 30th anniversary this year, and is still owned by its founder Joseph Bourgault.

Over the years it has built an impressive business, which can boast some impressive numbers.

It now has some 500 dealers covering all the major farming areas of the planet, and has expanded its range from around a dozen parts to over 500.

And from a 10,000 square feet factory employing 16 people, it now runs a 76,000 square feet factory with 74 employees.

In a typical year it turns 200 tonnes of steel; 7.8 million feet of welding wire and 14,000 lbs of crushed carbide into the tillage, fertiliser and seeding tools to meet its customers' requirements.

The original Bourgault company was founded by his father Frank in 1969, initially to make a four-row multi-purpose cultivator, but soon expanding into air drills as well.

When the company found it increasing difficulty securing wearing parts that met its quality standards, it set up Bourgault Tillage Tools (BTT) in 1988.

Founded a parts producing division, it became a separate, wholly-owned, subsidiary in 1991.

As well as establishing a reputation for top quality, BTT quickly became recognised for innovative ideas and designs.

Among these was the Parallel Wing Cultivator Sweep, which offered users far greater working life than competitor's versions:

"As competitors' wings wore down so they narrowed,

which meant they did less work", says Patrick Yeager, Managing Director of Sales and Marketing.

"BTT's Parallel Wing Sweep overcame this problem and maintained the full width throughout its working life.

"The fact that they also offered significantly longer working life than those offered by competitors also attracted customers.

"In Canada the standard practice for changing worn sweeps was to use a blow torch to cut through the old bolts and then replace the worn parts with fresh ones".

The company's Speed-LocTM system changed that, says Joseph, enabling farmers to remove the worn part easily and knock a new part into place:

"It saves thousands of farmers many of hours down-time every year - and during the busiest season of the year".

A key part of that system is the range of adapters that the company offers which can be bolted to the bottom of any machine's cultivating legs, allowing any suitable BTT part to be fitted thereafter.

The company's product range has changed as the industry has developed, and its range of drilling boots are finding fresh customers as more farmers consider strip till and direct drilling techniques.

With direct drilling becoming widely adopted across Europe, the company's VOS (Versatile Opener System) is in great demand and is being widely used by OEMs and retro-fitted by farmers.

These feature a slim profile that cuts a neat slot in the ground to place the seed, while being able to 'band sow' a crop so that it covers 75% of the soil surface.

This maximises the amount of light and fertiliser it intercepts, while crowding and shading out weed competition.

One important aspect of its business is direct contact with its customers, which means it received any feedback on performance direct, says Ryan Olson, the company's General Manager:

"We have 60,000 farmers in our back yard who effectively field test our products and tell us which ideas work well and which do not".

BTT (UK) Ltd is exhibiting at several leading shows this autumn and winter, including:

Midland Machinery Show – 24th & 25th November, Newark Showground, Nottinghamshire.

CropTec – 24th & 25th November, East of England Showground, Peterborough.

LAMMA – NEC, Birmingham, 11th & 12th January 2022.

GROWERS DISMAYED AT THE UNLEVEL PLAYING FIELD OF GRAIN

Written By Steve Ridsdale

Combinable crop direct drillers have found ways to cut establishment costs, whilst at the same time aiming to increase the resilience and productive capacity of their soils. At the other end of the production cycle, comes our output in the form of crop sales. We want to be competitive producers and competitive sellers.

Combinable crop direct drillers have found ways to cut establishment costs, whilst at the same time aiming to increase the resilience and productive capacity of their soils. At the other end of the production cycle, comes our output in the form of crop sales. We want to be competitive producers and competitive sellers.

What would you think, if I told you it was easier for competitor imports to access our UK markets than it is for ourselves. That would be crazy, wouldn't it? Well, that's the exact situation we find ourselves in. Let me explain...

Most animal feed mills are members of an assurance scheme. It's called the Universal Feed Assurance Scheme (UFAS), and it's administered by the Agricultural Industries Confederation (AIC).

Imported combinable crops are not required by the AIC to have any farm level audited assurance when supplying to a UFAS accredited animal feed mill. This contrasts with AIC's insistence that UK and Eire growers adhere to farm level assurance protocols such as Red Tractor (RT) or Scottish Quality Crops (SQC), and so UK growers consequently face an extra layer of burden and cost to access their own home markets. It makes us less competitive in the marketplace.

How Do These Imports Become Assured?

These imports are used to feed RT assured livestock, so presumably RT and AIC are content with the imported grain safety, and consider it to be in no way harmful, or a food safety issue to our farmed livestock.

AIC welcome these imports into the feed chain by virtue of either pesticide residue testing, or a pesticide declaration confirming grains were only grown using EU licensed pesticides. The notable difference is that AIC have NO requirement for these imports to have any farm level assurance at all. Think about that when you're next paying your RT assurance invoice, writing down when you cleaned your grain bucket, or writing down the exact time and date you put some rat poison down.

These imports, having been grown in countries where growers have access to pesticides not licensed in the UK, pesticide testing is a reasonable safety check to undertake. One might, however, question the usefulness of sampling grain after it has been blended at central storage and then onboarded to a boat.

What Could An Equivalent System Of Assuring Grain Look Like For UK Producers?

Turning our attention to home grown grain, we only have access to UK approved pesticides, so it follows that pesticide residue testing is unnecessary, and that the pesticide declaration method is more appropriate.

Domestic legislation requires crop sprayers to be NSTS tested, and operators must have PA1/2 certificates of competence. Local authorities check we are compliant in having written HACCP procedural records for grain drying and storage, and are also at liberty to inspect our pesticide records. These legislative requirements provide a risk based assurance that UK grain has a safe pesticide adherence. Government are content with this high standard of legislative framework and the food

safety status this provides to our grain, and ultimately to the consumer. We have some of the highest standards in the world.

Our AIC approved TASCC merchants visit, and are welcomed at any time, 365 days a year, to take samples from our grain stores, check the hygiene procedures of our stores, inspect our machinery and visit our fields. If they're not happy, they won't purchase It's a self-policing system. In comparison, we should be mindful that AIC do not stipulate any on-farm checks of imports. Those imported grains are only entered into the assured food chain by the shipper, using the pesticide test or pesticide declaration methods.

It therefore follows, that a simple pesticide self-declaration on the grain passport provides UK grain with a much more comprehensive standard of assurance to that of imported grain, and so should be an accepted method for UK gain to enter a UK feed mill. This would give us equivalence to our competitors.

Farmers Are Angry

UK growers have not received any logical explanation as to why UK we can't have the same trading terms as imports. Rather, we're told that in order to have access to UK feed mill markets, we must continue with farm level assurance from schemes such as Red Tractor or Scottish Quality Crops.

A quick glance at the SQC website shows that AIC are one of 8 members in the ownership structure at SQC. Click over to the RT website, and we learn that the company guarantors of AFS (the parent of RT) include the NFU, AHDB, NFU Scotland and Ulster Farmers' Union. We also learn that AIC have representatives on the RT Crops Board.

NFU and AHDB

These associations must raise questions over conflicts of interest. We've seen our farming unions and AHDB support RT, and it's resulted in a situation whereby it's more difficult for UK producers to access the feed mill markets than it is for imports. Policies need rethinking, and it needs to happen quickly. Farmers are disappointed and perplexed.

Our representatives and statutory development board need to think carefully about who they are working for, or risk losing the support of the farmers who fund them. AHDB must work to ensure levy payers have, at a minimum, equal market access opportunities to competing imports, and our farming unions must help facilitate this. Questions need answering as to how anyone could have thought supporting the positioning of assurance companies, and the resultant market access anomaly, could ever have been a good idea.

Given that most other grain exporting countries did not have any farm level grain assurance schemes, it was an obvious and forseeable consequence that UK producers would be saddled with extra assurance cost burdens (in comparison to imports) for supply to our feed mills. Quire clearly, these policies were going to create a situation by which it would make market access more difficult for UK producers, and easier for competitors.

RT and AIC also have a responsibility here. They have responsibility to our home industry from whom they make a living, and they need to consider the position in which they have now placed our AHDB and NFU. Farmers have resigned their NFU membership over this issue, and with talk of a ballot on the future of our AHDB Cereals & Oilseeds sector, we want to be in a position where farmers can give whole hearted support to these organisations who are designed to help us.

We now need solutions. NFU and AHDB must no longer support a situation by which market access is more costly for UK growers. We must have, at a minimum, equivalent market access. Anything less is a failure by our NFU and AHDB.

Free Market Economy

Currently, feed mills and farmers are shackled to the AIC rules, and unable to choose different standards for themselves.

There should be nothing in the way of a free market economy. It's a huge disposition on the marketplace, and prevents the market trading naturally, commercially and in a free manner. Government decide upon our food safety regulations, not private self-appointed assurance companies who benefit from their own industry rules.

Double standards don't work, they're untenable. We need one common standard no more onerous than imports enjoy, with optional schemes to serve end users who require audited assurance.

Schemes such as RT and SQC can happily co-exist with the pesticide declaration method of assuring grain. There should be nothing stopping us having two voluntary standards for UK grain, working in tandem to serve different aspects of the marketplace.

A feed barley grower should be able to access feed mill markets using the pesticide declaration method. The farmer should have choice, and the mill should have choice.

A milling wheat or malting producer may choose to be RT assured. Some millers or biscuit manufacturers may insist on RT, others might not. It would be market led and premium led. The industry is grown up, it doesn't need to be told what standard it should trade, particularly when the UK and imported grain is then blended into the same product.

RT has often been criticised for failing to produce a price premium. RT would need to work harder to provide a premium over farmers' compliance costs. That's no bad thing. Innovation and excellence come from competition, competition that RT is currently lacking.

Our producers should be afforded a level playing field, and RT, AIC, NFU and our AHDB, should work to achieve this.

I'd urge growers to speak to their NFU representative or AHDB contact.

Our own industry leaders have got us into this crazy mess. Now it's time for them to work to repair the damage.

WHAT CAN YOU CONTROL IN **REGEN AGRICULTURE**

Written by Tom Carnell from Tramline TEC, formed in May 2021.

We were founded with the aim of providing solutions to problems in Agriculture, where the problems are normally caused by the need to control something. Why do we need to control something? So much of farming is without control. Weather, disease, pests, weeds, climate – all uncontrollable. This makes it even more important to control well the things that we can control.

Why is this relevant to Direct Drilling? It is even more important to be able to control what you can well when you add in cover and companion crops, beneficial insects, teas and coatings. When you control something well you can determine what effect it has had on the result. As an example, take adding a companion crop. If you do not place it well you will have no uniformity and therefore you will not know whether the companion crop worked or not – indeed you may draw the conclusion that it hasn't worked as you have not ended up with the result that you expected, and sthat result may have been down to the inaccurate placing of that companion crop rather than the crop itself.

What can we control? We can control pretty much anything with a control system be it liquid or solid. We can control liquid fertiliser, Liquid Teas, granular fertilisers, seeds, sludges, pellets, manure, compost, etc. The controls can be on the machine and off the machine.

Most implements on farm have controllers supplied as standard from the manufacturer. A lot of the time these controllers will not satisfy the needs of a modern farm. Retrofit controllers can be fitted to machines to give added benefits. These benefits can be:

- **ISOBUS.** This enables the machine control to be displayed on the tractors UT (on an ISOBUS compliant tractor). When the UT has task control and section control unlocked this will take control of the machine allowing the application of variable rate plans and individual row or section control of the machine. Multiple controllers can use the same UT. Additional UTS can be added to enable the separation of tasks – for example autosteer on one screen, tractor functions on another and the Implement on the third. Modern screens can "partition" and offer multiple displays on one screen. Its [possible to have multiple ISOBUS controllers on one UT – just because there is only one ISOBUS socket on the tractor doesn't mean only one ISOBUS implement can be connected.
- **Multiple channels.** Often the standard controller will only control the standard machine and be unable to add extra functions. For example, you have a seeder which has 3 hoppers and you wish then to add liquid fertiliser and slug pellets or Avadex. The standard controller will only control the 3 hoppers or channels. Retrofit controllers can control up to 8 channels and if they are ISOBUS can offer the ability to have 8 different variable rate plans.
- **Self-calibration**. More modern seeder controllers can be fitted with counting sensors which allow the seeder to calibrate itself and not have to be calibrated by the operator. The main advantage of these systems is the ability to apply seedrates in seeds per m2, removing the need for calculations using the thousand grain weight to get Kg/Ha rates.
- **Blockage and counting sensors**, or a mix of both can be added to most seeders on the market, giving confidence that every seed has been planted where it should be and opportunities for Blackgrass and other weeds to grow are removed.
- **Sharing of data** into the farm management system to show live data of where the machine is and how its performing and the ability to look at historic data to see why an area of a field yielded well. With the Precision Planting system its possible to look at this data down to a single seed level (singulated seed)
- **Precision placement of fertiliser**. Have you ever wondered what effect placing fertiliser in the furrow, to the side of the furrow or on top of the furrow has? We have controllers that will apply in all of these locations which combined with yield mapping will allow you to see what effect each of these variants has on your final crop.
- **Depth control.** This is interesting and also hard to get right. As we all know there are so many variables when you travel across a field in terms of soil type, compaction levels and moisture levels. Complex systems have loadcells on each row and row by row vary the pressure on the row to plant the seed into moisture. Simple systems allow the adjustment of whole machine row pressure from the cab.

Controls and control systems are not limited to tractors and implements. Grain dryer control systems can be dated with obsolete parts leading to costly breakdowns in the middle of a wet harvest. We can build new control systems or update existing control systems and add in Wi-Fi connectivity to provide operator alarms when there is a problem. Where there is no Wi-Fi we can add in point-to-point re-transmitters if Wi-Fi is close by or 4G routers when there is no Wi-Fi.

We can supply probes for grain stores that can be linked to a Wi-Fi network and will alarm if moisture, temperature or humidity values are exceeded. Weather stations can be added into these networks that can then be programmed to control fans in grain stores depending upon humidity and temperature of both the grain and the environment.

DEMYSTIFYING FARM CARBON OFFSETTING: THREE WATCH-OUTS FOR FARMERS

Written by Samuel Smith from Farm Carbon Toolkit (FCT)

There's a rise in farmers and landowners interested in getting paid for carbon sequestration. Yet in the UK, an absence of robust guidance, protocols and industry experience makes this space feel like the "wild west". Farmers are at risk of being misled, while NGOs and industry groups are struggling to form clear positions in what's a fast-moving and confusing landscape.

We help farmers to measure, understand and act on their greenhouse gas emissions (GHGs). It's our mission, as a farmer-led organisation, to help farmers become knowledgeable and empowered on this topic, building profitable and resilient businesses that also help to restore our fragile and deteriorating ecosystems. Reducing GHG emissions from farms is a priority and all farmers can begin now.

Therefore we take a close interest in the emerging opportunities for farmers and landowners to access payments for carbon sequestration and storage on their farms. Through our work, we are witnessing more carbon payment opportunities coming through supply chains, grant-funded projects, as well as future options within ELMs and in voluntary carbon offset markets.

With our deep understanding of GHG emissions in agriculture, combined with on-the-ground experience of measuring farm and soil carbon, we are helping to inform various schemes and start-ups. What we witness is mixed. Some schemes are well-designed and robust in their approach to supporting farmers and having impact. While some are less carefully designed, with limited transparency and a possibility of unintended consequences. Farmers, landowners and organisations have limited guidance on best practice and a lack of standards make comparison between schemes challenging.

Context: how a Net Zero paradigm is renewing interest in offsets

As climate breakdown becomes ever more visible, many people and organisations are scrambling to make major cuts in greenhouse gas emissions. In recent years, there has been a proliferation of "net zero" carbon commitments from some of the world's biggest companies and institutions. To meet these ambitious targets, organisations will need to use every tool at their disposal. This means not only reducing emissions as far as possible, but also investing in activities such as "nature-based solutions" to cover any residual emissions.

Achieving net-zero across society means a gigantic shift in business practice; reinventing business models and shifting the products and services available to citizens. Culturally, industries are in different places on what this means. Some industry leaders are recognising and preparing to implement radical changes, yet can often be working alongside others who are constrained by a tendency towards business-as-usual. What many companies have in common though, is a desire to buy offsets in the short-term to help achieve net zero faster – and many are now turning to farm carbon.

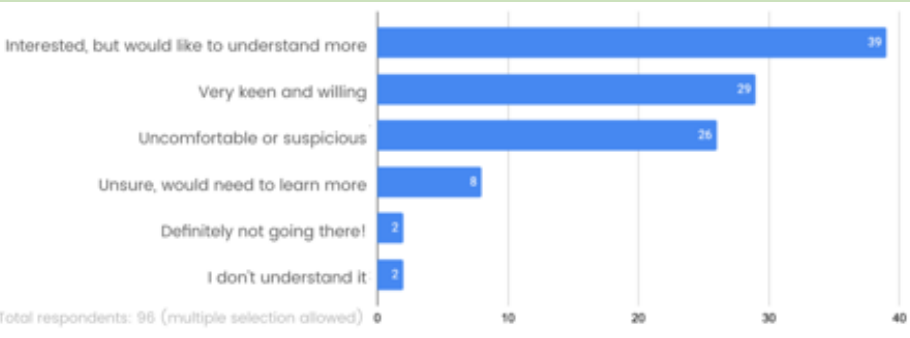
For example, Microsoft recently purchased $500,000 of soil carbon credits from Wilmot Cattle Company, who own an 11,000 acre farm in New South Wales. In the US, various brokers exist to pay farmers for carbon, many using an agreed protocol and a proposed Growing Climate Solutions Act may require the USDA to help

farmers access these carbon markets in the future.

Why Offset Schemes Require A Special Scrutiny

There are various ways in which farmers can be supported to shift towards more regenerative agricultural practices. For example, via government subsidies, philanthropic projects, landowner initiatives and through supply chains taking an "insetting" approach. The selling of carbon or biodiversity offsets is another route, coming with a greater need for accurate, trusted measurement and verification.

There is currently a lot of excitement around farm and soil carbon offsets in the UK and various new schemes are launching. A recent farmers' attitude survey we conducted suggested that 30% of farmers are "very keen and willing" to partake in offsetting schemes. Meanwhile, 27% of respondents were uncomfortable and suspicious about this topic.



FCT survey results from May 2021: farmers' attitudes towards selling carbon or biodiversity offsets

We urge farmers to recognise the risks that exist around these schemes and ask tough questions to any organisation seeking to "buy" your carbon. To support a more credible and robust environment for farm and soil carbon payments, we are part of a consortium of organisations working towards a UK Farm and Soil Carbon Code.

With carbon offsets – and any other mechanism to support change – there can be risks of driving unintended consequences, especially if we only focus on a narrow goal of carbon reduction. Instead, taking a "food systems" lens to the way we design projects can help us in building a healthier, more socially just food system.

3 Watch-Outs for Farmers Selling Carbon Offsets

To ensure farmers are empowered and clear on the terms in which their whole-farm or soil carbon credits are being sold, we believe farmers should demand the following from organisations seeking to pay them for carbon offsets:

1) What claims can you make in the future about your carbon footprint?

In a carbon offset, the sequestered carbon being sold is effectively taken off the farm or landowners carbon balance sheet and appears on the balance sheet of another business or individual: the "buyer". This means that the buyer has an exclusive claim to the carbon reductions or removals made by the farm.

What is often overlooked or missing in the marketing materials of offset intermediaries, is that the farm may no longer be able to make claims about any associated produce being "low carbon". While the farmer may be doing all sorts of positive practices, some or all of their sequestered carbon is on the balance book of the "buyer' of carbon credits. A farm claiming it is low-carbon could be misleading, amounting to double claiming, propagating a false view of our overall progress against climate change.

For illustration, if all farmers in the UK sold their sequestered carbon via offsets to private companies (that often operate beyond national borders), then the NFU's Net Zero farming ambition may become impossible to reach, as would the climate pledges of many food retailers and brands who have made Net Zero pledges covering their Scope 3 emissions.

This is a challenge and risk for farmers. Those selling direct-to-consumer may talk about their positive practices but may feel in a tricky position when explaining their carbon credentials, especially if their sequestered carbon has been purchased by an oil or airline company, who are some of the more prominent industry groups currently seeking offsets.

Farmers selling through their supply chains may also be in a weaker position. Retailers are increasingly wanting to buy low-carbon produce and cannot do this if the farm has sold much of it's sequestered carbon via a private offset. If the farm carbon offset sector follows the recommended principles around double-counting and double-claiming, then farmers may find themselves less desirable to customers.

2) Does the scheme have a transparent, robust methodology on permanence, additionality, measurement and verification?

The credibility of a high quality offset can be tested through its approach to:

1. Permanence:

In the ideal offset project, reversals of carbon emissions are physically impossible or extremely unlikely. Standard convention in offset markets has been to guarantee that carbon is kept out of the atmosphere for 100 years. Yet, this is not practical for soil carbon, which is considered as "short-lived" storage carrying a higher risk of reversal. In the USA, Nori manage permanence by offering short-term credits that expire after 10 years. In Europe, Soil Capital has a 5 year crediting period, in which farmers can earn and generate credits, followed by a 10 year retention period. Carbon Farmers of Australia must choose between 25 and 100 year permanence guarantee.

2. Additionality:

This is about whether the payment the farmer receives plays a decisive role in helping remove carbon from the atmosphere. Additionality is essential for the quality and credibility of the carbon offset market. Yet, especially in farming, its determination is subjective and deceptively difficult. Is this payment providing the make-or-break

difference?

3. Measurement, verification and scope:

This is a complex area. For example, what's included in the scope of the carbon footprint? Is the scheme considering the whole-farm's carbon balance, or is it based on a per-hectare field basis? For example, in the USA, White Oak Pastures received scrutiny last year as their claims about having carbon negative beef neglected their wider, whole-farm footprint and landuse.

For measurement and verification, what protocols and tools are being used to measure and verify the sequestration? Is the payment based on actual field measurements (and if so, to what depth, to what lab test, resolution and frequency), or are they computer models of how carbon stocks are expected to change with different practices? How much of a buffer is in place for uncertainty? Can we trust those models, given how nascent our understanding is around soil carbon sequestration? Are they based on the UK context?

3) Demand transparency and having a choice in "the buyer"

It's a common principle that organisations seeking to offset through farm and soil carbon should prioritise cutting their own emissions: minimising the need for offsets in the first place. As outlined in the Oxford Offsetting Principles, buyers of offsets should also publicly disclose their current emissions, accounting practices, reduction strategies and targets to reach net zero.

Furthermore, for the sake of the seller's reputation, we believe farmers and landowners should also have some say or agreement to who's buying the carbon offset. We believe geographically local carbon offsets are preferable, as it further assists with transparency and can provide an opportunity for the wider public to understand offsetting.

What next?

We are keen that farmers are incentivised and rewarded for farming sustainably. This may include payments for carbon reduction, building soil health and increasing sequestration. To this end, we're aware our Farm Carbon Calculator is beginning to be used as a helpful tool to help guide such payments.

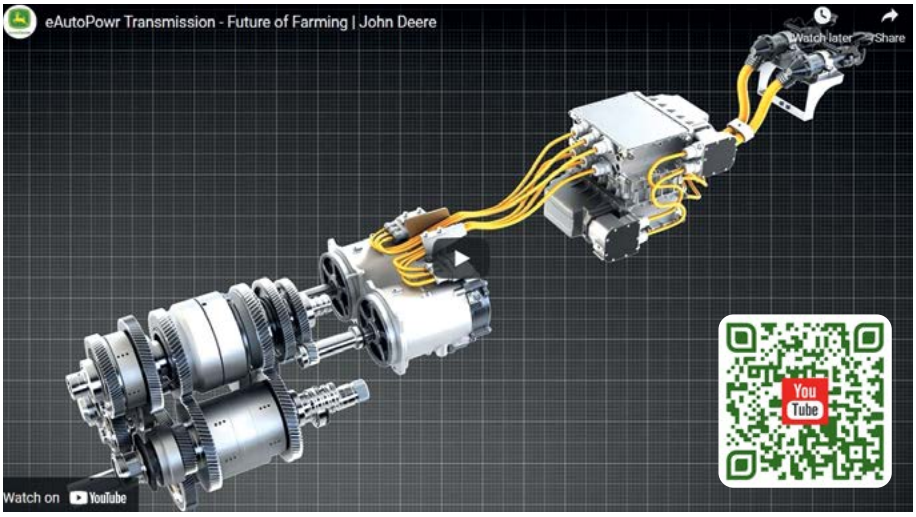
We will continue to draw on our practical, on-the-ground experience and expertise to contribute to projects in this space – always keen to support and advocate for robust and credible projects, schemes and marketplaces. Looking ahead, we have various innovations and services in the pipeline to support better, more accurate and meaningful carbon assessment. We're also keen to continue contributing to the science and understanding of GHG emissions in agriculture. There's lots to crack on with!

Farm Carbon Toolkit

DRILL MANUFACTURERS IN FOCUS...

JOHN DEERE - FUTURE OF FARMING

Changes in weather patterns are just one of many challenges farming is facing. John Deere is investing huge resources into solving these challenges. Three core technologies are shaping the future: Electrification, Automation to Autonomy and Artificial Intelligence.



Electrification

Electrification isn't just about using batteries as the power source. It's about using electrical drives to replace engines and hydraulics. Electric motors have huge torque at low speeds, they're more efficient, more reliable and lighter.

eAutoPowr transmission: eAutoPowr is the first continuously variable transmission with an electro-mechanical power split. Compared to conventional CVTs, the drive is more efficient and wear-free. Another special feature is the provision of up to 100kW of electrical power for external consumption. To demonstrate this, John Deere and Joskin have developed a slurry tanker with two electric drive axles. Thanks to this eight-wheel drive system, a much more efficient transmission of tractive power is possible. This can also reduce slurry incorporation costs by up to 25 per cent.

VoloDrone - The large drone developed jointly by John Deere and Volocopter has a diameter of 9.2 m and is powered by 18 rotors. It has a fully electric drive with replaceable lithium-ion batteries. One battery charge allows a flight time of up to 30 minutes, and the VoloDrone can be operated both remotely and automatically, on a pre-programmed route. The drone frame is equipped with a flexible standardised payload attachment system. This means that different devices can be mounted on the frame, depending on the application. For crop protection, the large drone is equipped with two liquid tanks, a pump and a spray bar. Thanks to the low flying height, very large area coverage of up to 6ha/hr can be achieved.

Autonomy through automation

The focus of automation is not to replace the operator. It's about using technology to create the best operator possible. The journey began with hands-free AutoTrac satellite guidance to steer the machine. Now we have Integrated Combine Adjust on our

S700 combines which makes real-time automatic adjustments to maintain the pre-set levels.

Autonomous electric tractor - John Deere's new autonomous tractor concept is a very compact electric drive unit with integrated attachment. The tractor has a total output of 500 kW and can be equipped with either wheels or tracks. Flexible ballasting from 5 to 15 tonnes is possible, depending on the application, to help reduce soil compaction. Thanks to the electric drive, there are no operating emissions and noise levels are extremely low. Further advantages include low wear and maintenance costs.

Semi-autonomous tractor - This tractor drives semi-autonomously and is equipped with an integrated crop sprayer. Using a built-in camera, it is possible to work in row crops – for example, applying plant protection products to fruit tree orchards. Filling the sprayer tank is fully automatic at the filling station, so the user is not exposed to pesticides. This is designed to reduce costs and increase productivity by over 30 per cent.

Autonomous sprayer - This novel autonomous sprayer is lighter than a conventional self-propelled sprayer and has a 560 litre spray tank. It can enter fields after rain without causing any soil compaction. The high ground clearance of 1.9 m and four-wheel steering make it extremely versatile, while the tracks minimise ground pressure and greatly extend the operating window.

Artificial Intelligence

Artificial Intelligence is changing the way we spray.

See & Spray - With See & Spray technology, high-resolution cameras capture 20 images per second. Based on the images and artificial intelligence, the system recognises the difference between cultivated plants and weeds so that individual plants can be specifically treated. With this new generation of weed control, the use of pesticides can be greatly reduced.

CommandCab - Whatever happens in the future, the farmer will always be in control. Our Command Cab shows how the journey from Automation to Autonomy is likely to evolve. The future vision of a driver's cab reveals new possibilities for artificial intelligence. With its joystick control, touchscreen display and networking of all machine components, it´s a completely new operating concept. By integrating real-time weather data, individual pre-settings and job management procedures, the cab becomes the command centre for agricultural operations.

AGRONOMIST IN FOCUS

DICK NEALE

FROM HUTCHINSONS

Catch and cover crop choices play significant part in positive transition to Sustainable Farming Initiative

When any new technique is employed its initial benchmark for success is a measure of the financial return it provides over the technique it replaces or enhances. In that respect cover crops have had a rocky start in their introduction to UK agriculture.

This is largely because the financial positives or negatives a cover crop brings in the initial stages of introduction are marginal with the potential for a negative financial impact often overriding the positive. However, measuring a catch or cover crops success or value based purely on one year's yield impact fails to recognise the significant improvements in soil structural health, biology, nutrient flow and water management their use imparts over time.

Increasingly research is demonstrating the importance of below ground biomass in the building of soil organic matter (SOM) with figures recording over 40% of root matter being retained as SOM while top growth contributes only 8% to SOM. Cash crops must not be forgotten in the process of building SOM but catch and cover crops play a vital role in filling the gaps in rotational cropping, in particular being present during the August to November period when UK soils are traditionally bare from post-harvest cultivation.

The value of catch and cover crops is immense when sown in August to intercept those longer days of sunlight energy and recharge the soils biological battery.

Cover cropping will help improve soil conditions

Choose a cover that works for your situation

Choice of cover is crucial to optimise performance, address identified issues on individual fields and match the farms management approach out of the cover period, be that grazing, rolling, spray and direct drilling or cultivation. Covers can be used to address carbon: nitrogen ratios within the soil which can impact the soils' ability to 'digest' high lignin residue like wheat straw, equally they can be used to slow the 'burn rate' of SOM in lighter soil fractions.

The focus is knowing what the state the soil is in and what it needs. Cover crops can be used to add significant diversity into rotations and are an ideal opportunity to get legumes into the cropping cycles and reduce reliance on applied artificial nitrogen. Following crops must be considered as there is significant risk of yield reduction where oats or rye are a high proportion of the cover crop mix prior to spring barley or wheat. Where cereals dominate the rotation ,utilising oats as the cover adds little in diversification terms.

Consistently successful cover crops are made up of multiple species. The species mix should be optimised to the targeted impact required whilst bringing diversity, nutrient fixation, storage and release. Ease of use like seed flow characteristics through air seeders and overall rates of use to fit with smaller air seeder hoppers is a further consideration along with reliability of species with the UK climate.

We have made sure Hutchinson's mixtures have been optimised for reliability and performance. Typically, our mixtures contain 8 species with the previous crop volunteers making it a 9 species population. Ratios in the mixtures are adjusted to optimise the area of performance, be that soil structural impact, nutrient release and fixation, water pumping or surface protection.

As details of the Sustainable Farming Initiative become clearer it leaves little doubt that cover crops, reduced cultivation practices and soil assessment and improvement will be central to accessing support funds in the future. Transition from one cultivation system to another takes time both for growers to gain confidence in the new approach and for soil to react and improve, now is an ideal time to make the change while support payments remain to help counter the risks and tweaks required for any system as it establishes itself on farm.

Multispecies cover crop

NEW MISCANTHUS FINANCE AND END-USER OFFTAKE AGREEMENTS ASSIST UK **DECARBONISATION**

In an industry first, farmers considering planting the carbon negative crop Miscanthus can now benefit from a finance package to cover virtually all upfront costs for crop establishment, as well as new direct, long-term offtake agreements with end-users, with 10–15-year index-linked annual returns.

The new opportunity has been launched to help support the growing need to decarbonise the UK economy with bio-based solutions, and if planting of perennial crops such as Miscanthus is accelerated quickly, to at least 30,000 hectares per year by 2035, this increase could sequester 2 MtCO2e by 2035 and over 6 MtCO2e by 20501.

Oxbury Bank is working in partnership with Miscanthus specialist, Terravesta, to deliver the new finance package, which is supporting farmers to plant and establish the crop. "One of the main barriers to entry for Miscanthus growing is the upfront cost of planting. Our finance package with Terravesta ensures a quick release of funds to help farmers to grow a sustainable business. The loan structure allows farmers to pay interest only for up to two years while the crop is establishing and then pay back the capital over an extended period of time when the crop is producing an economic return," says Nick Evans, managing director of Oxbury Bank.

"Agriculture is changing, and it's important that farmers have access to finance and capital for their low carbon initiatives and sustainable growth plans, like Miscanthus," says Mr Evans.

Under the new contract, Terravesta will supply its Performance Hybrids, planting equipment and agronomy throughout the crop's life, ensuring successful crop establishment by committing to a minimum number of plants emerging under its new planting promise.

"Our current rhizome-based variety Terravesta AthenaTM delivers higher yields than the commercially available Miscanthus giganteus, a calorific value increase of 8%, resulting in 180% increase in energy per hectare (megajoules) and significant ash content reduction, all of which benefits the end-user considerably," explains Alex Robinson Terravesta's chief operating officer.

"Terravesta Athena™ generally takes its first harvest in year two and reaches maturity faster than Miscanthus giganteus, and some of our growers are reporting a first harvest of eight tonnes per hectare, going onto a mature yield of between 10 -17 tonnes per hectare depending on the soil type.

"The beauty of this new package is that growers have a direct contract with renewable energy power plants, which enables Terravesta to provide a finance package and allows us to focus on crop establishment in the UK at a much greater scale to support our net zero targets," adds Mr Robinson.

To learn more visit:
www.terravesta.com/learnmore.

DOES GRAZING COVER CROPS NEGATIVELY IMPACT SOIL AND CROP YIELDS?

Separation of crop and livestock production can degrade soil and other natural resources while reducing economic returns. Additionally, the conversion of grassland to cropland has put a strain on forage for cattle. Grazing cover crops can be a potential option to re-integrate crops with livestock production and reverse the adverse effects of separating crops and livestock production. Grazing cover crops could still maintain the benefits from cover crops as roots and some stubble remain after grazing. Cover crop grazing has shown to improve economic returns (Franzluebbers and Stuedemann, 2007) while still capturing benefits from cover crops (Faé et al., 2009; Maughan et al., 2009); however, soil compaction risks can be a concern.

Written by Lindsey Anderson, Humberto Blanco, Mary Drewnoski and Jim MacDonald, Published in CropWatch from the University of Nebraska-Lincoln

While there are few studies evaluating cover crop grazing, most of the existing studies found any shallow soil compaction that did occur was not enough to influence yields. Tillage and soil wetness could influence the impact of cover crop grazing on soil compaction. A study under strip tillage in west central Nebraska found that grazing cover crops increased soil compaction in one of three years, but it is possible strip tillage may have alleviated potential compaction in the other two years (Blanco-Canqui, et al., 2020).

On the other hand, a study in Georgia found that compaction increased more when grazing under conventional tillage (disk plowing to 6-8 in.) compared to grazing under no-till (Franzluebbers and Stuedemann, 2008). This suggests conservation tillage, such as no till or strip till, could be more beneficial than conventional tillage when grazing cover crops. Another study in Georgia found cover crop grazing in the spring after an above-average rainfall increased soil compaction due to soil wetness and thus reduced cotton yields (Schomberg et al., 2014). Thus, soil wetness is also important to consider when cover crop grazing.

To further improve our understanding of how cover crop grazing may affect soil properties and crop yields, we conducted a study in 2019 and 2020 on a field-scale oat cover crop grazing experiment under an irrigated no-till corn-soybean rotation on silt loam soils in eastern Nebraska. Our results suggest that fall/winter cover crop grazing does not negatively impact soil or crop yields (Figure 1). These results are similar to other fall/winter cover crop grazing studies, but it should also be noted our study only had cover crop following the corn phase of the rotation, thus grazing only occurred every other year, possibly reducing any cumulative impacts of grazing.

Field Management

Our cover crop grazing experiment was established in 2015 at the Eastern Nebraska Research and Education Center near Mead, Nebraska. There were two study fields in this experiment, and each field was 52 acres under center pivot irrigation and no-till. The rotation was corn-soybean, and each field was cut in half and harvested as corn silage in one-half of the field and high moisture corn in the other half of the field. Corn silage was harvested around Sept. 1 and high moisture corn (about 32% moisture) harvested around Sept. 15, about 25 days before typical dry corn (about 15% moisture) harvest. A cover crop of Horsepower oat was drilled at 96 lbs per acre following corn harvest (Figure 2). Following cover crop planting, the fields received 40 lbs N per acre from ammonium nitrate. No cover crop was planted following soybean harvest.

Cattle Management

Cattle grazed from November to December at stocking rates ranging from 0.6 to 1.7 head per acre, with cattle initial weights ranging from 507 to

Parameters	Impact of cover crop grazing compared to non grazed cover crop
Soil Properties	
Penetration Resistance	no effect
Bulk Density	no effect
Wet Aggregate Stability	no effect
Dry Aggregate Stability	no effect
Cumulative Infiltration	no effect
Water Retention	no effect
Organic Matter	no effect
Particulate Organic Matter	no effect
Microbial Biomass	no effect
Crop Yields	no effect
Soybean	no effect
Corn Silage	no effect
High Moisture Corn	no effect

Figure 1. Summary table of soil and crop response to cover crop grazing compared to non-grazed cover crop. Penetration resistance and bulk density are soil compaction parameters. Wet and dry aggregate stability are indicators of water and wind erosion. Particulate organic matter is the fraction of organic matter readily accessible for soil microbes to use.

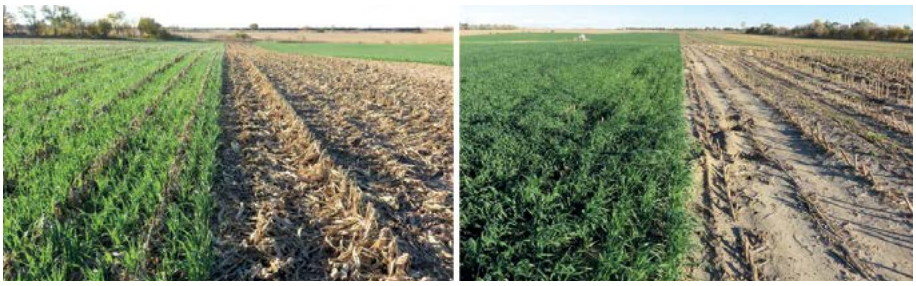


Figure 2. Oat cover crop biomass in October compared to the no cover crop control for high moisture corn (left) and corn silage (right). (Photos by Mary Drewnoski)

553 pounds throughout the study. The stocking rates were calculated based on a target grazing period of 70 days and accounted for cover crop biomass under corn silage and both cover crop biomass plus corn residue amount under high moisture corn. Forage allowance was about 25.6 pounds per steer per day in the first two years and about 39.0 pounds per steer per day in the last three years. Grazing only occurred in late fall/winter following the corn phase of the rotation with grazing durations ranged from 30 to 69 days over the five-year experiment. Based on the rotation, grazing occurred twice in one field and three times in the other field over a five-year period.

Did Cover Crop Grazing Damage Soils?

Cover crop grazing had no impact on soil compaction, wind or water erosion potential (expressed as wet and dry aggregate stability), water infiltration, water retention, organic matter, particulate organic matter (fraction of organic matter readily accessible to soil microbes), or microbial biomass compared to the non-grazed cover crop (Figure 1). These findings strongly suggest that cover crop grazing does not damage soils.

Why Might Grazing Not Impact Soils?

It is believed cover crop grazing had no impact on soil compaction in this experiment because:

1. Grazing only occurred after the corn phase of the corn-soybean rotation, which reduced the frequency of grazing (every other year grazing).
2. The experiment was located on soil with high soil organic matter (4.2% within 0 to 8 inches) and soil organic matter can prevent soil compaction.
3. Grazing occurred in late fall when the soil is less likely to be wet compared to spring, with spring having more rainfall.
4. Natural freeze-thaw and wetting-drying soil cycles can naturally break up any potential soil compaction.

Cover crop grazing removed about 47 to 87% of cover crop biomass due to cattle intake and trampling (Figure 3). However, much of the biomass removed was actually incorporated into the soil surface from trampling, retaining cover crop residue within the system. Additionally, cattle intake removes little nutrients from the system, as cattle excrete most of the nutrients consumed during grazing. For these reasons above, we believe cover crop grazing in this study may have had no negative impact on soil properties due to the addition of trampled cover crop aboveground biomass, cover crop root biomass and infrequency of grazing (every other year).

Did Cover Crop Grazing Impact Crop Yields?

Cover crop grazing had no impact on soybean or corn yields (Figure 1), which is similar to previous cover crop grazing experiments. Only two studies report yield decreases from cover crop grazing during wet soil conditions in spring (Schomberg et al. 2014) or increased soil water evaporation from summer cover crop grazing reducing residue cover (Franzluebbers and Stuedemann, 2007). Our study site was irrigated and grazed in fall/winter.

Should I Graze My Cover Crops?

- In this study, cover crop grazing had no impact on soil compaction, wind or water erosion potential, water infiltration, water retention, organic matter, particulate organic matter or microbial biomass compared to the non-grazed cover crop. Therefore, based on the conditions of this study, fall/winter cover crop grazing had no negative impacts on soil properties. Additionally, cover crop grazing had no impact on crop yields.
- In previous studies, cover crop grazing can have some impact on soil compaction, depending on tillage system and soil conditions at time of grazing. Based on what little research is available, it is suggested conservation tillage — such as no till or strip till — may prevent possible accumulated impacts of compaction, but conventional tillage should be avoided.
- Based on our experiment and others, cover crop grazing could be a strategy to re-integrate crop and livestock production without largely degrading soil properties or impacting crop yields.

Figure 3. Cattle grazing oat cover crop and corn residue in November following high moisture corn (left) and grazing cover crop following corn silage (right). Grazing reduced cover crop biomass by 47 to 87% under corn silage. Grazing reduced cover crop biomass by 64 to 87% and reduced corn residue by 18 to 23% under high moisture corn. (Photos by McKenna Brinton)

Acknowledgements

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For a full set of references follow the QR Code:

Institute of Agriculture and Natural Resources
CROPWATCH

PRACTICAL SOIL BIOLOGY

Written by Robert Patton from Plantworks UK

'It was a new day yesterday but by God it's an old day now'. The briefest of reflections on the COVID I could dream up, courtesy of Jethro Tull (worthy of pointing out to the younger audience not the chap that developed the seed drill).

While we struggle to find any positives from the last year, I would reflect on a discussion between a leading agronomist and a large Cambridgeshire farmer on the hugely popular Amazon Primes' Clarkson's Farm series. I was expecting to hear some critical comments about this, a program that I thoroughly enjoyed, for sure there were some lack of efficiencies on show at times, but to my surprise both men were both great fans. Not only because Jeremy showed the sheer level of graft that it takes to farm in the UK, and the complexity involved, but also because he showed a willingness to try new things, planting new crops, laying down greening areas, an innovative spirit that both men commented is prevalent on many farms as we move through a significant shift in farming knowledge and a change in practices.

Another light at the end of the dark spring was Groundswell. I could not have been the only person reflecting that it was like somebody had taken their finger off the hands of the clock and set it ticking again. This event continues to impressive, both in terms of scope and the growing numbers of audience attending. This year over 4000 farmers and interested parties wandered the various lecture tents and spoke with exhibitors. It is clear that in the quest for better management of our denuded soils, scientist and growers alike are challenging some of the ingrained practices developed since the mid-20th century. Noteworthy also was the presence of all the major agronomy companies each offering extended soil management programs, all focussing on different aspects and levels of biology in the soil. This in addition to the Groundswell Agronomy team also being on hand dispensing their own brand of knowledge transfer for the duration of the show.

More so than any other farming event Groundswell is planted firmly on the value of healthy, functioning soils, with a goal of promoting both a better understanding of their importance and how this, the greatest of all assets, can be managed sustainably.

A core theme of the over one hundred talks at the show was the value of soil biology, and its role in increasing a crops' efficiency of taking up nutrients and water. So where are we in the practical management of soils biology? Well understandably the first question posed by many is, 'How do I know the level of beneficial biology in my soils'? Soil organic matter remains the good proxy for biology soil health as it defines a measure of retained soil carbon through a balance of both organisms and vegetation in the soil and their natural decomposition.

At the organism level we have the worm counts, that all farmers are familiar with. Although studies have defined optimum worm counts, practically speaking a farmer needs to take a year-on-year measure of improvements. At the microbe level things become more difficult and yet here is where much of the breakdown of soil chemistry is taking place; as these microbes break bonds that lock nutrients in soils and convert soil nutrients to plant available forms.

Genetic tests, performed on soil samples, are available using primers for different micro organisms that can accurately quantify the biological background of certain species however these can be expensive and limited to laboratories and may be more of academic interest. General primers for common genetic markers are more generally used when reviewing fungi and bacteria in soils to offer an overall picture of populations, as can the measure of cellular / metabolic components. A tier below this level of detail are field testing kits, some reporting in less than a few hours, that define the general level of fungi and bacteria in the soils, often expressed as a ratio.

The soil is home for many organisms, good and bad and although these tests do not offer details of these, they do offer an overall datum of soil microbial life. There are no defined optimums for net bacterial and fungi levels or ratios in soils, although highly productive agricultural land generally tend towards a 1:1 ratio or err to a bias towards bacteria. These measurements are therefore useful when used as tools to measure improvements in soil life post soil management changes. The onus remains on the farmer to map their soils and to correlate soil structure, organic matter, and biology to yield, or in the modern world to profit, as a myopic maximum yield focus some would argue is the root of soil decline.

In relation to practical soil biology management there are simply two paths to travel. Changes to better and more harmonious (or balanced, possibly involving livestock) rotations and the use of biofertilisers - simply

products with living fungi or plant growth promoting rhizobacteria supplied on some form of carrier or suspension.

Changes in rotation and field amendments will depend on a road map of the current nature of the soil and where the goal is set. To define this path all farmers should understand how microbes' function with their target crops. Arguably the king of fungi is the mycorrhizal fungi; responsible for locking in one third of all soil carbon these fungi offer a common root system to crops and support greater nutrient uptake and drought tolerance. These fungi do not associate with all commercial crops, OSR, Sugar Beet and Brassicaceae not being hosts. Equally crops that require significant soil disturbance (cultivations), such as potatoes, break the fungal structures and reduces the effectiveness of this established hyphal network. Exploring means of intercropping to ensure the fungi always have an appropriate host or, where practical, using a cover crop with mycorrhizal fungi added after harvest, to redress the losses of the season are some options to consider.

Plant Growth Promoting Rhizobacteria are free living and are therefore less host dependant, although they replicate more readily in the presence of root exudates. Recent work has shown that specific consortia are required for different crops, these organisms act to fix nitrogen, unlock phosphorous and produce natural plant growth hormones.

Considered by many to be the most relevant of the biofertilisers, these are usually applied to soils as they warm up in the early stages of crop development. Recently reported 2019-20 trials in the UK provide replicated results showing uplift in yield following the use of biofertiliser in winter wheat. In addition, wheat trials have shown that by enhancing the soil microbiome with rhizobacteria farmers are able to reduce their nitrogen inputs by up to 25% and still maintain yield and quality.

So, back to the telly with Mr Clarkson and his team. You have made a truly great start! If we could, nudge you a little further in the direction of sensitive soil management in the ensuing series, you could really help move regenerative farming in the UK further forward; as well as making our Sunday evening viewing even more enlightening.

THE PLANT MICROBIOME: AN INTRODUCTION

Written by Joel Williams

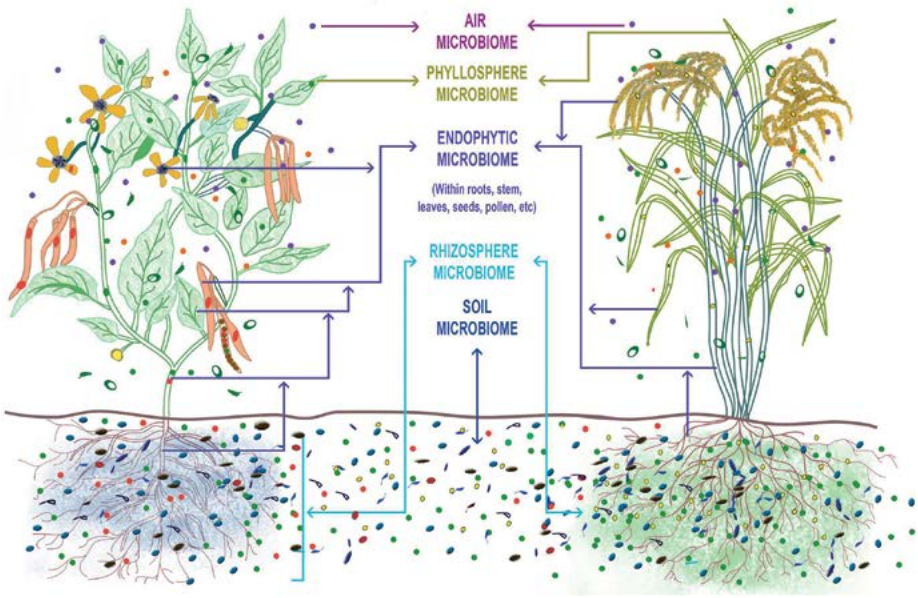
Soil Biology – two words that have become commonplace in the lexicon of the farming community in recent years, and rightly so. Biological interactions are of course as important as the physical and chemical interactions that make up the fascinating medium we call soil. Among all the groups of organisms that live in soil, there has been a particular growing focus on the microorganisms; interest in which gained significant traction as we began using more powerful tools to study them – genetic and molecular tools for example. As we began to unearth the world of the soil microbiota, we quickly realised just how vast and complex this underground universe really is – certainly much more so than previously thought. In dealing with this complexity, one branch of research has shifted attention away from the soil to study the microorganisms that are associated with plant tissues – enter the plant microbiome.

The plant microbiome – also known as the phytomicrobiome – refers to the groups of microorganisms that are intimately and directly associated either on or within various plant tissues. The number and diversity of organisms that make up the plant microbiome is a fraction of what is found in the bulk soil, hence the emerging focus on studying this less complex plant-associated ecosystem. Please note, I use the words 'less complex' very cautiously here – arguably, there is nothing 'less complex' about it at all apart from having less diversity and density of organisms.

I'm sure most readers will be familiar with the below ground community of microbes known as the rhizosphere but the above ground plant habitats are collectively known as the phyllosphere.

These microbial communities consist of bacteria, archaea, fungi, viruses, algae, and occasionally nematodes and protozoa (these latter two are much more common down below in the rhizosphere but less so above ground). Bacteria are by far the most commonly found microbe above ground in terms of both numbers and diversity. All of these microbes that associate with the plant are either acquired from the environment (soil and atmosphere) or they are inherited from the mother plant via the seed.

Within each of the plant associated habitats, some microbes live inside the plant tissues (endophytes) while others will remain outside of the plant, living on the surfaces (epiphytes). There is some overlap between the microbes that associate on various plant parts, but surprisingly, many of the species



are totally unique and distinct from each other, fulfilling very specific roles and functions within each of their micro-habitats. Let's briefly explore some of the different regions of the phytomicrobiome:

Root microbiome – often referred to as the rhizosphere, this is of course the microbes who associate with plant root systems. Arguably the most well studied of all plant microbiomes, the organisms in the rhizosphere play particularly important roles for nutrient acquisition, plant immunity and resilience during environmental stresses.

Shoot microbiome – the microbes that dwell in shoot tissues appear to be more closely related to the species found in the soil highlighting the soil as an important primary source of organisms which colonise the plant. The endophytes found in the shoot are highly mobile within the plant and are also commonly found in the seed – forming part of the seed microbiome for the next generation.

Leaf microbiome – the leaf microbiome has been shown to influence photosynthesis and transpiration hence playing a vital role in plant development, particularly under difficult climatic and weather conditions.

Flower microbiome – our understanding of the microbial communities that uniquely associate with flowers is far less when compared to other above ground plant habitats. This is particularly due to the fact that these attractive habitats receive more regular visitation by a diverse range of insects who facilitate transfer of other beneficial and pathogenic microbes; as well as inadvertently leaving a fingerprint of their own insect-associated microbiota. As you might guess, the organisms associated with flowers have been implicated in influencing plant reproductive

success – they have even been shown to use flower scents (volatile organic compounds) as a food source and additionally induce distinct changes in the expression of a plants floral scents.

Seed microbiome – like other parts of the plant, the seeds are also colonised with a diverse group of microbiota. At the end of reproductive development, the organisms on and within seeds act as a reservoir for the next generation and typically establish as endophytes in next years offspring. Functionally speaking, the seed microbiota release a range of metabolic substances that enhance germination and establishment as well as plant performance and productivity under stressful conditions. We will return to the seed microbiome in the next issue of Direct Driller and will expand on this article with a deeper dive specifically into the role of the seed microbiome.

Altogether, the plant microbiome directly and indirectly influences plant performance, productivity and can support low input production systems. Direct mechanisms that support plant growth include nutrient supply via solubilisation from soil reserves or biological nitrogen fixation, as well as production of plant growth promoting hormones. Indirectly, plants can also recruit specific microbes to help them overcome various biotic and abiotic stresses – such as activation of beneficial microbes who can suppress pathogens or improve drought resistance.

There is an increasingly prominent nudge towards reducing fertiliser and pesticide use in agriculture from both top-down (policy) and bottom-up (consumer driven). There is significant potential in the use of DIY or commercial microbial inoculants to support this transition, however, many challenges remain regarding improving product consistency in field conditions. Central to achieving this is the need for a deeper understanding of the ecological processes and mechanisms that underpin the plant microbiome assembly and function. Addressing these knowledge gaps will no doubt help provide the necessary tools to support agricultures transition toward ecological and productive sustainability.

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WHERE TO *Buy*

As a reader of the magazine, we are sure you appreciate good quality, nutrient dense food, but it isn't always that easy to know where to buy from. We are introducing this feature to highlight those farms who are selling direct and therefore maximising their profits, not just benefitting the wider supply chains. We would hope you all will support them by buying something during the next year. If you would like your farm shop and website featured in future issues, then please drop us an email to **info@directdriller.com**

Ardross Farm Shop *Fife*

Home delivery service available in North East Fife

The Pollock family warmly welcome you to their award winning farm shop nestled in the picturesque East Neuk of Fife. Looking over the beautiful Firth of Forth, Ardross Farm Shop reconnects you with fresh, local, inspiring food from the farm and the surrounding area along with an abundance of produce from Scotland's natural larder.

Arrive to a mouth watering display of freshly picked vegetables straight from our farm. Our cabbages are so fresh they squeak, our broccoli sparkles with the morning dew and our freshly dug carrots perfume the shop with a sweet earthy smell. Freshly baked local bread tempts you further inside where our fantastic team can tantalise you with an array of specially selected products for food lovers!

Using our own traditionally reared beef, fresh vegetables and other local products our kitchen is always busy and filled with the smells of homemade raspberry jam, steak pies and a variety of burgers. However it is not only our own produce that makes our selection so delicious.

Blessed with a wonderful selection of artisan products produced both locally and nationally we also stock fantastic free range eggs, rare breed bacon and local pork, world renowned venison, organic lamb and mutton, wild border game, delicious free range chickens, ready meals, British wines and beers, handmade chocolates, luxury jams and marmalades, divine puddings and ice creams to name a few. We are very proud of everything we stock and all of our products are tried and tasted by the family and many of our customers before they are included in our shop.

Follow up:

Address: Ardross Farm, Elie, Fife, KY9 1EU

Email: info@ardrossfarm.co.uk

Tel: 01333 331400

Court Farm *Rochester*

UK Wide Delivery

Specialising in traditional beef and lamb native breeds raised outdoors, Court Farm Butchery and Country Larder offers a wide range of fresh and tasty meat.

Because they butcher the whole bodies, they can supply you with just about any cut you could wish for – if you don't find what you're looking for in the shop email them and they will endeavour to get what you're looking for.

The Country Larder stocks a selection of preserves, sauces, speciality cheeses, Wessex Mill flour, Owlet apple juice and award-winning Simply ice cream from Ashford plus local fruit and veg from David Catt & Sons, and free-range eggs from Fairseat Farm.

In house they make their own pies, pasties, sausage rolls and pork scratchings plus a selection of cold deli meats. The Linghams have been farming at Court Farm for three generations. Court Farm Butchery & Country Larder is a well-known brand in North Kent since opening to the public in the 1990s.

Follow up:

Address: Pilgrims Rd, Upper Halling, Rochester ME2 1HR

Email: localfood@courtfarm.org

Tel: 01634 240547

COURT FARM
BUTCHERY
&
COUNTRY LARDER

FARMER FOCUS
CHRIS HOLLINGSWORTH

Harvest 2021 roundup at Hawk Mill, an East Anglian perspective.

In my first Farmer focus piece, I am writing to you about a new company which will revolutionise our farming businesses and one I have become personally involved in. It's a company called Farmdeals (you will have probably seen the adverts) and where better to start the journey than here at the Direct Driller magazine. The fastest growing farming publication on the planet and one of the very few farming journals where you get the real story not fake news.

Agriculture is the last major industry left without an online digital trading platform, well that was until Farmdeals was born. The Farming Forum has teamed up with a software company called Future Farm. They bring to the table experienced engineers who have the knowledge and ability to build the right digital platform for our industry, that with the experience of the marketing team at the Farming Forum then we have the right structure to create a very successful online digital ordering platform.

We can dramatically reduce the cost of every transaction and pass that on to our farmers.

We can do this because a digital ordering platform requires considerably less labour to run it than a traditional buying group. This will reduce our costs so we can pass this on to our farmers or members with lower prices.

There will be special offers, different payment terms, price updating. Deals where the price reduces as more product is sold and the savings are passed onto you. Where the price will drop depending on the how many farmers buy. We will encourage you all to do what we call 'milk round 'deals. An example of this is with fuel. We set up a 36,000-litre tanker delivery direct from the refinery to a particular area (minimum order for each farm would be 6000 litres). We can offer this at a 10% discount to conventional deliveries. This will incentivise you the farmer via your Facebook, Twitter or Whats app groups to build mini buying groups to trade with us, deals within Farmdeals.

All of this is designed to bring the manufacturer closer to the farmer, reduce the links in the chain between buyer and seller, optimise the price and give the farmer (whatever his size) more power in the marketplace.

This doesn't come as a long list of messages in your voicemail or endless emails to put in your delete box but instead in one easy to use app which you can view either on your mobile from the tractor seat or in the office on the laptop.The Farmdeals platform has been carefully designed to help you make the right choices. Yes, there will be some bumps in the road as the present cumbersome and expensive framework of buying and selling is slowly dismantled and yes there will be plenty of resistance from the trade.

Farmers are traditional and not everyone is going to take to online digital ordering straight away. Some will still want to chat to their supplier and will be unwilling to complete their transaction with a couple of clicks on their mobile phone from the tractor seat. But hey, Rome was not built in a day.

By now I am sure you are all thinking well good for you Chris so you are going to be making money out of your investment. Well true we are not going to do this for nothing but we all firmly believe, and this is written into the very heart and soul of the Farming Forum that we can start to disrupt agriculture's current trading system and we can all benefit from it.

Next time a salesman rings you on your mobile or worse still drives up to your farm just think who is paying for this? Between the manufacturer and you, how many middlemen are there all taking a margin out of the transaction?

Farmdeals will allow us to trade at a considerably lower cost and pass that onto you the farmer, and as we build our membership base, we will be able to command better prices for everyone. I use the word member because in effect we are an Agricultural Buying Group, but maybe not one you would recognise.

Currently there is no membership or joining fee, no levy on turnover and very small commission charges. What's the downside? Well, the personal service will be different. Queries, questions etc will be dealt with mainly by our help/chat lines. We will have staff available to help you, but you will be encouraged to use the online service first.

Check out the web site and you will see how many products we already have, look at our prices and see how competitive we are. Currently we have Fuel, Ad blue, Oils and Greases, Fertiliser, Crop Nutrition, Agchem, Animal feed, Vet Meds, Machinery parts with many more to follow.

So far, we have discussed the purchase side of Agriculture, well that's not all we are planning to do. We started on the purchase side, but we are now building a Selling Platform and that's where the story gets even more interesting. We want to build a much closer relationship between the farmer and the consumer.

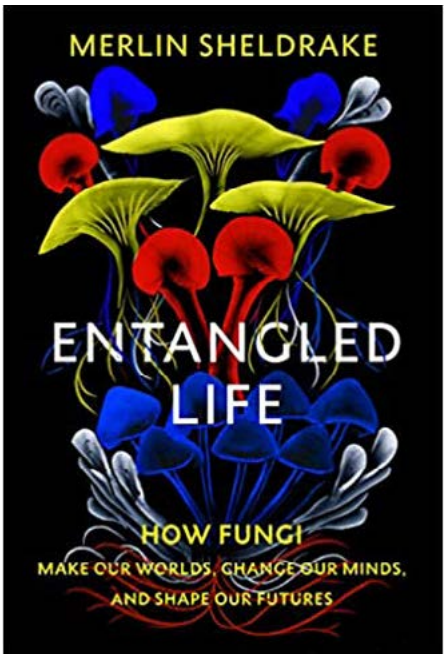
Very important and challenging in the fresh produce business but why not? If I was a livestock farmer producing high quality grass-fed beef, I would love to link up to a chain of restaurants who will buy direct from me and yes, they will pay a premium

Farming is never easy and no more so than in today's world. Farmdeals will help you to find new ways of reducing your costs of production and selling your produce at a better price.

So come and look at what we do and sign up as a member. We are only a click away.

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 more books you might find interesting, challenge the way you currently think and help you farm better.



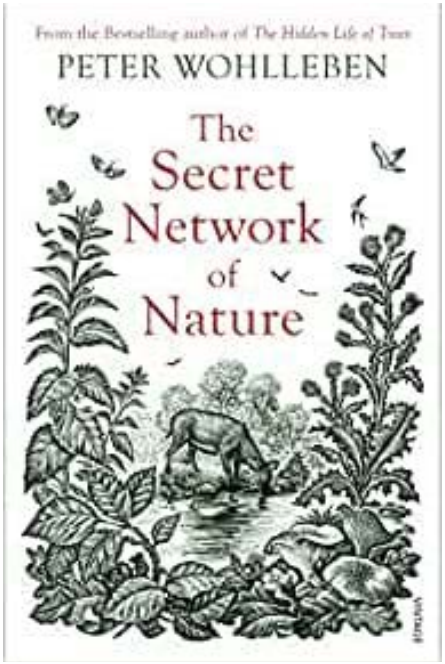
Entangled Life: How Fungi Make Our Worlds, Change Our Minds and Shape Our Futures

The more we learn about fungi, the less makes sense without them.

Neither plant nor animal, they are found throughout the earth, the air and our bodies. They can be microscopic, yet also account for the largest organisms ever recorded. They enabled the first life on land, can survive unprotected in space and thrive amidst nuclear radiation. In fact, nearly all life relies in some way on fungi.

These endlessly surprising organisms have no brain but can solve problems and manipulate animal behaviour with devastating precision. In giving us bread, alcohol and life-saving medicines, fungi have shaped human history, and their psychedelic properties have recently been shown to alleviate a number of mental illnesses. Their ability to digest plastic, explosives, pesticides and crude oil is being harnessed in break-through technologies, and the discovery that they connect plants in underground networks, the 'Wood Wide Web', is transforming the way we understand ecosystems. Yet over ninety percent of their species remain undocumented.

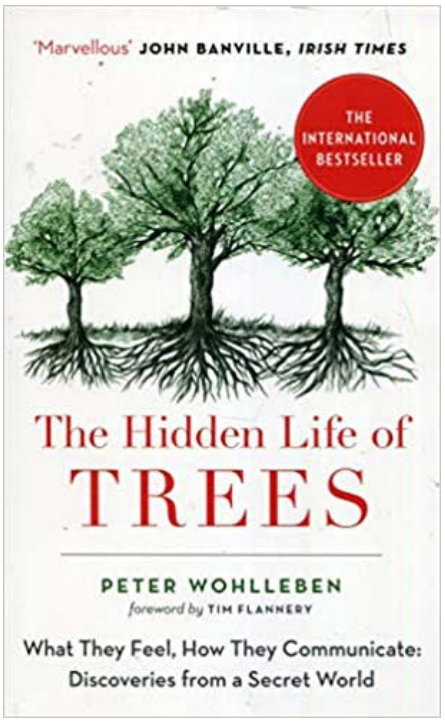
Entangled Life is a mind-altering journey into a spectacular and neglected world, and shows that fungi provide a key to understanding both the planet on which we live, and life itself.



The Secret Network of Nature: The Delicate Balance of All Living Things

The natural world is a web of intricate connections, many of which go unnoticed by humans. But it is these connections that maintain nature's finely balanced equilibrium.

Drawing on the latest scientific discoveries and decades of experience as a forester, Peter Wohlleben shows us how different animals, plants, rivers, rocks and weather systems cooperate, and what's at stake when these delicate systems are unbalanced.

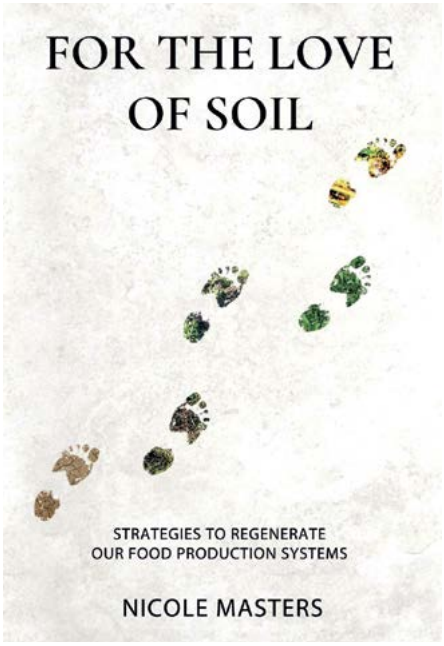


The Hidden Life of Trees: What They Feel, How They Communicate

Are trees social beings? How do trees live? Do they feel pain or have awareness of their surroundings?

In The Hidden Life of Trees Peter Wohlleben makes the case that the forest is a social network. He draws on groundbreaking scientific discoveries to describe how trees are like human families: tree parents live together with their children, communicate with them, support them as they grow, share nutrients with those who are sick or struggling, and even warn each other of impending dangers. Wohlleben also shares his deep love of woods and forests, explaining the amazing processes of life, death and regeneration he has observed in his woodland.

A walk in the woods will never be the same again.

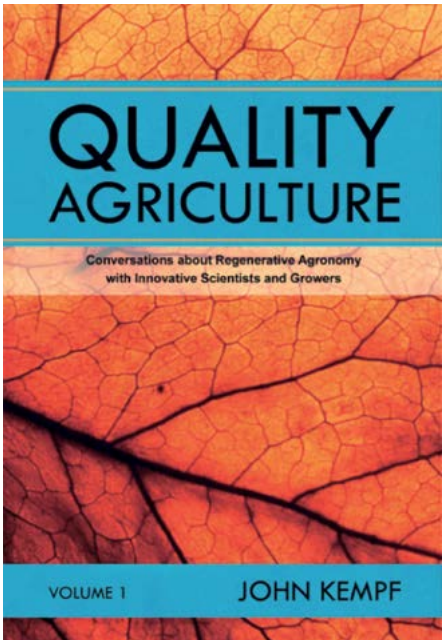


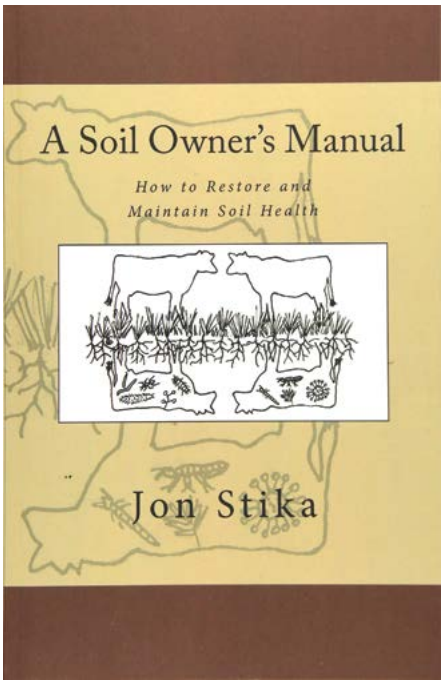
For the Love of Soil: Strategies to Regenerate Our Food Production Systems

Learn a roadmap to healthy soil and revitalised food systems for powerfully address these times of challenge. This book equips producers with knowledge, skills and insights to regenerate ecosystem health and grow farm/ranch profits. Learn how to:- Triage soil health and act to fast-track soil and plant health-Build healthy resilient soil systems-Develop a deeper understanding of microbial and mineral synergies-Read what weeds and diseases are communicating about soil and plant health-Create healthy, productive and profitable landscapes.Globally recognised soil advocate and agroecologist Nicole Masters delivers the solution to rewind the clock on this increasingly critical soil crisis in her first book, For the Love of Soil. She argues we can no longer treat soil like dirt. Instead, we must take a soil-first approach to regenerate landscapes, restore natural cycles, and bring vitality back to ecosystems. This book translates the often complex and technical know-how of soil into more digestible terms through case studies from regenerative farmers, growers, and ranchers in Australasia and North America. Along with sharing key soil health principles and restoration tools, For the Love of Soil provides land managers with an action plan to kickstart their soil resource's well-being, no matter the scale."For years many of us involved in regenerative agriculture have been touting the soil health - plant health - animal health – human health connection but no one has tied them all together like Nicole does in "For the love of Soil"! " Gabe Brown, Browns Ranch, Nourished by Nature. "William Gibson once said that "the future is here - it is just not evenly distributed." "Nicole modestly claims that the information in the book is not new thinking, but her resynthesis of the lessons she has learned and refined in collaboration with regenerative land-managers is new, and it is powerful." Says Abe Collins, cofounder of LandStream and founder of Collins Grazing. "She lucidly shares lessons learned from the deep-topsoil futures she and her farming and ranching partners manage for and achieve."The case studies, science and examples presented a compelling testament to the global, rapidly growing soil health movement. "These food producers are taking actions to imitate natural systems more closely," says Masters. "... they are rewarded with more efficient nutrient, carbon, and water cycles; improved plant and animal health, nutrient density, reduced stress, and ultimately, profitability."In spite of the challenges food producers face, Masters' book shows even incredibly degraded landscapes can be regenerated through mimicking natural systems and focusing on the soil first. "Our global agricultural production systems are frequently at war with ecosystem health and Mother Nature," notes Terry McCosker of Resource Consulting Services in Australia. "In this book, Nicole is declaring peace with nature and provides us with the science and guidelines to join the regenerative agriculture movement while increasing profits."Buy this book today to take your farm or ranch to the next level!

Quality Agriculture: Conversations about Regenerative Agronomy with Innovative Scientists and Growers

An increasing number of farmers and scientists believe the foundational ideas of mainstream agronomy are incomplete and unsound. Conventional crop production ignores biology in favor of chemical interventions, leading farmers to buy inputs they don't need. Fertilizer recommendations keep going up, pest pressure becomes more intense, pesticide applications are needed more often, and soil health continues to degrade. However, innovative growers and researchers are beginning to think differently about production agriculture systems. They have developed practices that regenerate soil and plant health and that deliver much better results than mainstream methods. Using these principles, growers are able to decrease fertilizer applications, reduce disease and insect pressure, hold more water in the soil, improve soil health, and grow crops that are more resilient to climatic extremes, increasing farm profitability immediately. As a leading agronomist and teacher, John Kempf has implemented regenerative agricultural systems on millions of acres across many different crop types and growing regions with his team at Advancing Eco Agriculture. In Quality Agriculture, John interviews a group of growers, consultants, and scientists who describe how to think and farm differently in order to produce exceptional results in the field. Their remarkable insights will challenge you, encourage you, and inspire gratitude and joy for the rewards of working with natural systems.





A Soil Owner's Manual: How to Restore and Maintain Soil Health

A Soil Owner's Manual: Restoring and Maintaining Soil Health, is about restoring the capacity of your soil to perform all the functions it was intended to perform. This book is not another fanciful guide on how to continuously manipulate and amend your soil to try and keep it productive. This book will change the way you think about and manage your soil. It may even change your life. If you are interested in solving the problem of dysfunctional soil and successfully addressing the symptoms of soil erosion, water runoff, nutrient deficiencies, compaction, soil crusting, weeds, insect pests, plant diseases, and water pollution, or simply wish to grow healthy vegetables in your family garden, then this book is for you. Soil health pioneer Jon Stika, describes in simple terms how you can bring your soil back to its full productive potential by understanding and applying the principles that built your soil in the first place. Understanding how the soil functions is critical to reducing the reliance on expensive inputs to maintain yields. Working with, instead of against, the processes that naturally govern the soil can increase profitability and restore the soil to health. Restoring soil health can proactively solve natural resource issues before regulations are imposed that will merely address the symptoms. This book will lead you through the basic biology and guiding principles that will allow you to assess and restore your soil. It is part of a movement currently underway in agriculture that is working to restore what has been lost. A Soil Owner's Manual: Restoring and Maintaining Soil Health will give you the opportunity to be part of this movement. Restoring soil health is restoring hope in the future of agriculture, from large farm fields and pastures, down to your own vegetable or flower garden.

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