The measure of a sustainable soil

Innovation Meeting tomorrow's challenge

In the first of a new series exploring the research into today's major issues that's tracking the path to tomorrow's innovations, *CPM* looks at the soil, and unearths some eye-opening new data.

By Tom Allen-Stevens

Agriculture's direct relationship with ecology and the climate should be a core consideration for an industry that seeks to be successfully sustainable. That's the view of Jonathan Halstead, head of Syngenta north-west Europe.

"At a time of seismic change for agriculture across the world, and specifically in the UK, the challenge for sustainability is how we, as an industry, can continue to marry the fundamental role of protecting food production, with evolving societal needs and demands," he states.

"Crop protection, both chemical and biological, is already a central component of integrated pest management (IPM). Now, utilising all the agronomic tools available, we can look beyond managing the crop alone — to take IPM to the next level. This will identify how every action can impact on wider aspects of the world in which we live."

Syngenta launched the Conservation Agriculture (CA) and Sustainable Farming Systems project which aims to provide an independent insight into the long-term implication and viability of different farming systems. Designed to run for five years, it's part of a pan-European study, with comparable initiatives in France and Spain.

Field-scale study

Here in the UK, the project started in 2017 with a field-scale study at the Game and Wildlife Conservation Trust (GWCT) farm at Loddington, Leics, in conjunction with NIAB. This was then extended to a second site in 2018, at East Lenham Farm in Kent.

The project aims to develop an understanding of a system based on the principles of CA — minimum soil disturbance, permanent soil cover, diversified crop associations and rotations. "But importantly, we've adopted a holistic approach," notes Belinda Bailey, Syngenta's sustainable farming manager for UK and Eire.

"Alongside key ecological and environmental assessments (see panels on p80 and p81) we're looking at yields, work rates, margins and cost of production. The aim is that adoption of more sustainable cropping systems can be quicker and more reliable for growers and the wider agricultural industry."

On the two farms — Loddington being a heavy-land site, while the soils in Kent are lighter — three different farming systems are being trialled across a standard arable rotation. In each of five fields (four in Kent) one area is ploughed and compared with a min-tilled and direct-drilled system.

Andy Barr has been direct drilling his 420ha in East Lenham for the past 11 years, but was keen to be involved in the project. "We've done farm comparisons before and we think we're doing the right thing, but the difference here is that this is a scientifically rigorous and independent trial," he notes.

"It'll be interesting to look at the economics, not just in each year but over the whole rotation. I know I get more worms and beetles through direct drilling, but it'll be useful to have the actual figures.

"Most of all, I'm keen to see the difference CA makes to overall greenhouse gas emissions. I've a pretty good idea on the reduction in diesel use, but that's a fraction of the overall effect, and none of the standard carbon calculation tools available give you an accurate assessment in my opinion. ▸

Alongside key ecological and environmental assessments Belinda Bailey has been assessing sustainable systems for yields, work rates, margins and cost of production.

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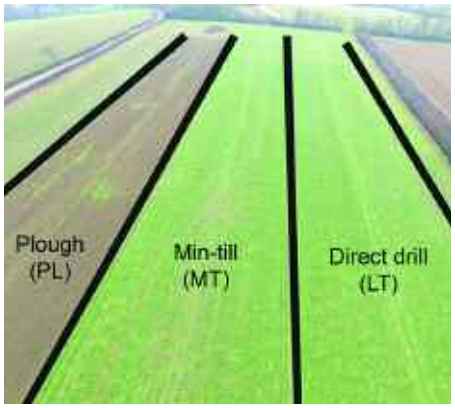


In each field 0.5ha is ploughed and compared with similar-sized min-tilled and direct-drilled areas.

▸ "Then, let's get the results out there — the more hard evidence we can learn about the best tillage methods, the better equipped we'll be to lobby government, not just to support change, but to recognise those who've already adopted CA."

Initial results are proving very promising, reports Belinda. "At both sites there have been noticeable reductions in fuel use (68%) and an increase in work rate (57%) for the sustainable systems, compared with ploughing. This has resulted in a reduction in cultivation costs of nearly 50%. Additional savings can also be made if you're ruthless in shedding surplus machinery that's not needed in the sustainable systems, reducing capital costs."

Yields from the conventional system have tended to be slightly higher across both sites, she notes. "But this has not always been the most profitable approach. Applying

Gas measurements bring 'startling' results on soil carbon dynamics

Jenny Bussell has been gathering data on gaseous soil emissions that hasn't existed in the UK before.

It's been during some of the heaviest rainfall events of the past two years that Dr Jenny Bussell has chosen to venture into the Syngenta trial plots at Loddington and take readings of gaseous emissions. Why?

"There's an interplay between emissions of CO_2 and nitrous oxide (N_2O)," she explains. "Temperature and rainfall have quite a bearing on how much of these gases are released by the soil, and we don't currently understand exactly what the impact of some of these heavy rainfall events are.

"We're gathering data that simply doesn't exist in the UK at the moment," she says. "So if we're going to make recommendations going forward, and more importantly if policy decisions are to be based on these dynamics, it will be crucial to gather good data and make sense of the results."

Jenny's been leading the work on measuring gaseous emissions from the soil and it's not just CO_2 she's measuring. Soils also release a small amount of methane and N_2O. The importance of these two gases is that they are 21 and 296 times more damaging respectively than CO_2 as greenhouse gas emissions.

"The aim with arable soils is not to eliminate gaseous emissions, but strike the right balance," Jenny explains. Carbon is stored in the soil in its organic matter, captured from the atmosphere mainly through photosynthesis and brought underground by roots. Organisms in the soil get to work on it, and it's this activity that creates the gaseous dynamics Jenny's looking to monitor.

"There's fast-cycling carbon, constantly being released and recaptured, and slower-cycling carbon. Ploughing is a very effective way to speed up the activity in a soil, which helps release nutrients, as well as CO_2. But too much ploughing results in a boom and bust where a soil loses the majority of its fast-cycling carbon," notes Jenny.

Building up organic matter, through applying manures, incorporating crop residues and cover crops are good routes to build soil carbon. But how that influences microbial activity and the dynamics of carbon transfer is currently unclear. "What we can say is that carbon in the soil is 'safe'. Once you release it, it's much harder to put it back," she points out.

Leaving soil undisturbed can do even more harm than cultivations, however. "A soil needs to breathe — pore spaces are essential for the soil microbial community to work effectively. A lack of these, such as in a compacted soil, leads to anaerobic conditions where you find a larger proportion of nitrifying bacteria. Rather than producing CO_2, their activity results in damaging N_2O emissions."

The first two years of the study have revealed very low methane emissions, while N_2O accounted for around 5-10% of the CO_2, equivalence released, with no discernible difference between tillage systems.

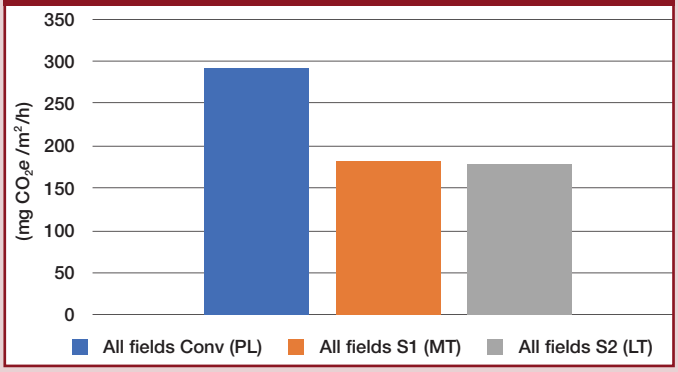
But the results on overall emissions are really quite startling, comments Belinda. "When you look at total CO_2 equivalence of the gaseous emissions across the three establishment systems, the minimum tillage and direct-drilled systems resulted in half the GHG emissions of the conventional, ploughed system." (see chart below).

She's confident that the project will unlock many of the secrets of the soil and provide some clear pointers for growers, however. "Questions yet to be resolved include how often and how much it's appropriate to cultivate a soil, and if you plough to reset in one year, how long it takes earthworm numbers and microbial activity to adjust.

"We'll learn more about the dynamics of gaseous emissions. But this work in particular is new, very exciting and what we've learned so far has shown that productive farming and sustainable soils can go hand-in-hand," she says.

A soil gas flux analyser was used which is a portable instrument with a bell-shaped chamber that can detect six different gases simultaneously.

The effect of cultivation regime on soil gas emissions



Source: Syngenta, 2019. Average emissions across all crops for the two sites in Kent and Loddington for ploughed (PL), min-tilled (MT) and direct-drilled (LT) comparisons. Assumes a CO_2 equivalent of 21x for methane and 296 for N_2O.

Initial results from the first two years of the project are proving very promising.

the cost savings in the sustainable systems showed that, in 2019, across both sites these were more profitable than the conventional. Through the length of the project we'll look at the resilience of these systems against fluctuations in grain prices."

David King, head of technical for Syngenta in the UK, highlights the results are also being integrated and replicated in part on the company's farm trials sites across the UK, including a dedicated blackgrass site at Barton in Cambs and a ryegrass site in Yorks.

"Providing solutions that can support conservation ag systems with confidence involves bringing together a complex mesh of inter-related factors. We know there's massive in-field variability and much of this happens beneath the soil surface," he says.

"Through our work developing hybrid barleys and seed treatments we've progressed our understanding of how we can develop systems that promote root growth, to capture carbon and that are more resilient to a changing climate.

Andy Barr is keen to put the results in front of government to help shape policy on conservation agriculture.

"But this is just the start. Our hybrid wheats, due to be commercialised in the coming years, have the potential to follow hybrid barley varieties, by making better use of available soil nitrogen. They could be useful tools should there be any further regulatory N restrictions. It will be exciting to follow how these tools are developed to ensure a sustainable yet practical future. Making better use of all resources is a core focus for solutions we're set to introduce over the coming years." ■

Birds count towards a more sustainable approach

A key aspect of the project has been to assess implications of establishment systems on farmland birds. Dr Alastair Leake is head of policy at GWCT and points out farmland birds sit towards the top of the wildlife food chain. "So their presence, or lack of it, tells us a lot about what's going on for the species underneath that may be harder to monitor," he explains.

"Many arable farmers have focused their attention on providing habitats at field margins. This is great, and there's no doubt a well managed margin provides many key birds with the food and shelter they need. But there's also much you can do in the centre of the field, and it doesn't have to impact on profitable farming," notes Alastair.

"Less soil disturbance leaves grain and weed seeds on the surface, and these are valuable food sources for birds. It's a better environment for soft-bodied insects — spiders can spin their webs more easily on a standing stubble — and these are a great food source for young chicks."

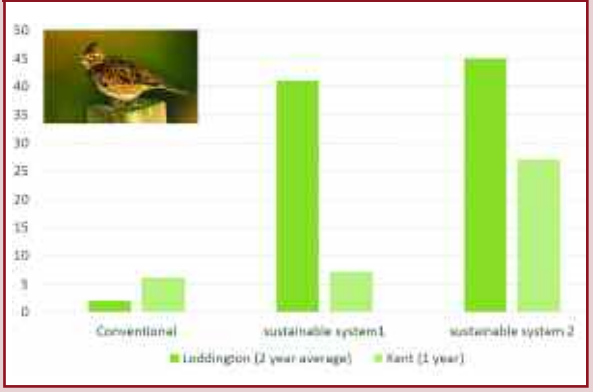
Looking at the results, Belinda notes it's not surprising that the two sustainable systems offering less soil disturbance, provide a better habitat for farmland birds (see chart below).

Another notable find is that the two sustainable systems resulted in an increase of earthworms of 32%.

"This project shows you don't have to take land out of production nor limit productivity to provide an environment in which wildlife can thrive, provided you farm in a more sustainable way," she concludes.

Alastair Leake points out the presence of farmland birds gives an indication on what's going on for other species that may be harder to monitor.

Skylark sightings in 2018-19 season



Source: Syngenta, 2019

Meeting tomorrow's challenge

Farming faces some major challenges. It's not just about the products and practices applied today, but exploring what will shape the farming of tomorrow.

In this series of articles, *CPM* has teamed up with Syngenta to investigate latest developments in sustainable farming, agronomic innovation and digital technology, with the aim to embrace tomorrow's opportunities.

Syngenta is uniquely placed to address the increasing challenges faced by UK farmers and the changing views of society. From the discoveries made at Jealott's Hill in Berks, the company's largest global site for new agrochemical R&D and product support, to its network of Innovation Centres, it has dedicated resources to bring applied science and sustainable solutions to UK growers. Through the company's collaborations with farmers, academia and environmental groups, it's on track to accelerate innovation in a changing world.

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