The root to long-term improvement

HGCA

from theory to field

Established trial sites are forming the test bed for some new research into the long-term impact of soil management. *CPM* gets an update on progress.

By Tom Allen-Stevens

There are a thousand different ways to cultivate a field and establish a crop, and as many different types of soil across the UK. Add to that the weather at the time of working the field, and you're left with little more than gut feel that tells you whether you've chosen the combination that'll bring both the best results from that crop and long-term benefits for your soils.

Hanging some robust science on that gut feel has long been the Holy Grail for many researchers. But there's an inherent problem, points out Dr Shamal Mohammed of HGCA. "A two to three-year cultivation trial doesn't tell you much. You need a long-term trial to understand the impact of various cultivation systems."

So that's what the HGCA Soil Programme has set out to achieve. Now in its second year, a total of around £2.6M of funding, including more than £1M of co-funding, has been channelled into three projects (see panel on p33). One in particular — the Soils Platforms project — makes use of existing trials that have been underway for over a decade.

Long-term impact

"The sites in Cambs and near Dundee give us a really good opportunity to gain a better understanding of the long-term impact of various cultivation systems within two very different soil types and agro-climatic conditions," explains Shamal Mohammed.

"We're getting information not just on the economic differences of min-till, no-till and inversion approaches, but also the environmental and overall crop production impacts."

There's also the opportunity to look at soil resilience, he continues. "After the poor autumn of 2012, the project has gathered data to understand how various cultivation systems will bounce back."

The focus has been on defining parameters growers can use to gauge how the cultivation system they've adopted impacts on both the current crop and the production life cycle. "Researchers have looked in some detail at the soil physical analysis to determine what the crop-growth limiting factors are. They've measured penetration resistance, aggregate stability, water-holding capacity and bulk density, for example, to see how various systems perform."

The findings will form part of a soil strategy document that will give growers clearer guidance on how to identify problems such as compaction, and practical advice on how to mitigate and remediate them.

In Cambs, the long-term STAR (Sustainability Trial in Arable Rotations) project, supported by the Felix Thornley Cobbold Trust and the Chadacre Agricultural Trust, contributes to the Soils Platforms project and is managed by NIAB TAG. Meanwhile the two sites near Dundee are managed by the James

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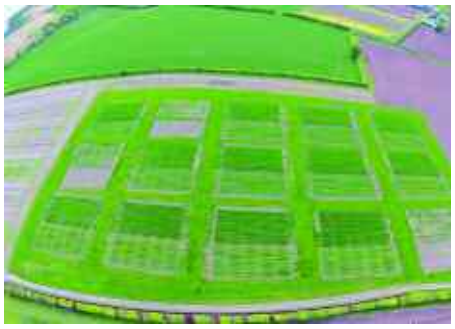
You need a long-term trial to understand the impact of various cultivation systems, points out Shamal Mohammed.

Hutton Institute, and funded largely by the Scottish Government, explains project lead Dr Blair McKenzie.

Limited root growth

“When we surveyed a range of commercial farms across Scotland a few years ago, we noticed significant numbers of soils would limit root growth because they’re too hard or too poorly aerated. These were sampled at seedbed depth just after harvest and they demonstrated just how vulnerable soils may be to change over time.”

So in the HGCA project, the research team is studying this more closely by performing multiple samplings over the year to see how resistant the seedbed is to the stresses of weather. “We complement this with simple resilience assays we hope could give farmers a new insight into the vulnerability of their soil,” he continues.



At the Mid-Pilmore site in Dundee, the effect of tillage treatments on different varieties of spring barley has been under investigation.

“At the Mid-Pilmore site in Dundee, ▸

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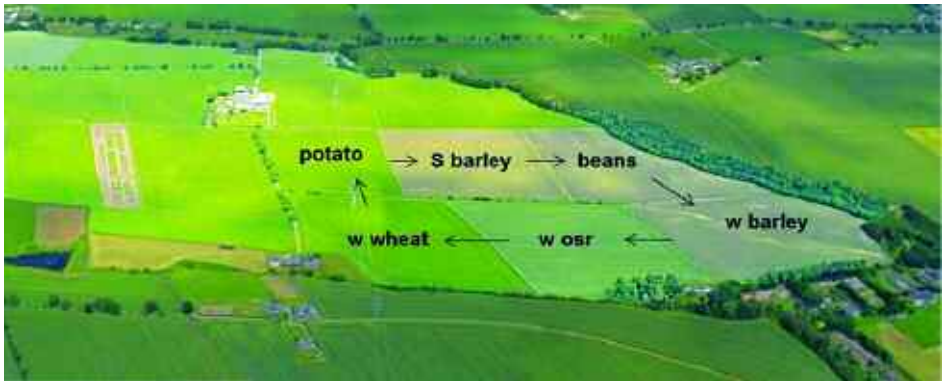

At the Balruddery site, each field in the six-year arable rotation is split with standard conventional practice on one side and the 'best' sustainable practice on the other.

▸ there's a series of replicated tillage treatments, and we've been investigating the effect of these on different varieties of spring barley."

There are five cultivation regimes:

- Zero tillage
- Min till – i.e. discing down to a depth of 80mm
- Conventional ploughing to a depth of 200-250mm
- Deep ploughing down to 400mm
- Conventional ploughing with extra traffic, to simulate extra compaction.

"Five miles away at the Balruddery site is the Centre for Sustainable Cropping (CSC), managed by Dr Cathy Hawes. Here there's a six-year arable rotation, including potatoes. Each field is split with standard conventional practice on one side, compared with the 'best' sustainable practice on the other."

Inputs minimised

The sustainable side receives large quantities of compost, for example, while herbicides and crop protection inputs are minimised. The cultivation regime is min till (apart from potatoes), while measures are put in place to reduce erosion, for example.

"We're using these long-term experiments as platforms over which we're overlaying elements of the soil project to understand the effects these different management systems have on the soil."

The work revolves around taking core soil samples at known timings — post establishment, just after winter and as harvest approaches. The samples are analysed closely and their physical properties assessed. While the James Hutton Institute is gathering soil physical data, NIAB is analysing what this means in terms of practical and financial considerations on the farm.

"We've looked at the water retention curve, for example — how much water a soil can store when saturated, at field capacity and at wilting point. That's related to the size and distribution of pores. For a known water status, we've also determined the strength of a soil, which gauges how easy it is for a root to penetrate."

Root assays have been undertaken to test the properties of the intact cores, continues Tracy Valentine of James Hutton Institute. "We've grown barley seedlings on loose soil to give us a base indicator which crops can root well, and the difficulty we have further north is that soils lay wet for much of the year, so roots rarely penetrate to depth if soil is not well managed"

And he's keen for research to deliver more clarity and definition on how soils can be quickly assessed. "It's not so much of a problem on your own land with soils you're familiar with. But as farms get bigger, and you take on more land, for example, you need a robust way to accurately assess soils that doesn't rely on decades of experience, so you can build a management strategy that's appropriate."

Sound soil based on sound science

Robert Ramsay has improved the workability of his soils and saved around 40% on fuel and tractor time.

Robert Ramsay reckons good soil management is about balancing its physics, chemistry and biology. "Get the physical and chemical elements right, and the biology will follow," he says.

With 700ha of combinable crops near Arbroath, north east of Dundee, he farms fairly light soils, varying from sands to medium loams, with very little clay. The crop rotation keeps potatoes seven years apart, with winter and spring barley, two wheats and two oilseed rape crops in between. "The key thing about our soils is that they don't self structure — if you damage them, you have to fix it."

So for the past three years, he's moved to controlled traffic farming (CTF). "It's a hybrid system," he explains. "All land preparation is done on 6m bout widths with tractors following the same 72in-wide wheelings. The combine has a 9m header and the grain trailer travels within those wheelings."

A modified Flatlift, with its four legs set to match the combine and trailer wheelings, is used shortly after harvest to lift out any compaction, and this is followed with a Lemken Krystall, going no deeper than 5cm, in front of the Väderstad Spirit drill — all following the same 6m track widths.

He checks fields after OSR harvest to identify any areas where compaction may be a problem. "You can tell from the roots — I'm looking for them to be the size of parsnips.

"But particularly on the heavier land, we're noticing far fewer problems now — the soil is so much more friable and easier to work. I reckon we're saving 40% on fuel and tractor time since moving to CTF. On the downside, we're learning about slugs."

With the physical side coming together, he's also focused on the chemistry. "In Scotland, that's all about pH. We've divided fields into management zones, based on previous cropping history and they're sampled on a 50m grid. The field is sampled for pH on a 50m grid and for phosphate and potash on a management zone basis. These zones are defined by cropping history, yield and soil type, with lime, P and K applied variably, according to soil need."

In the long term, he's looking to build carbon into his soils. "I firmly believe the land is a good place to sequester carbon, and it brings benefits in terms of soils that are easier to work. That comes down to ensuring you have ground into

and then compared these with seedlings grown on the intact cores. We found there was a 50% reduction in root growth on the intact cores, although this is highly variable."

Looser soil

Cultivation regimes that result in a high soil strength tend to result in shorter roots, she reports. "Looser soil leads to larger pores and you'd expect the roots to be longer — early data suggests that principle is holding up."

The measurements are based on cultivation systems that have reached a stable state, she notes. "When you change a cultivation system it takes a while for its properties to become established."

But the research team noted that some of the subsoil across the sites was generally in poor condition. "In a lot of cases, it would impede root growth, which is worth considering as machinery gets heavier, as this results in compaction going deeper."

Critically, the tighter the soil, the smaller the pores will be, which affects water retention. "Pores greater than 30µm in diameter are important for water flow. If there's a smaller proportion of these, you'll get poor drainage. Equally, it'll affect water availability, and the window between field capacity and wilting point will be very narrow."

At the Mid-Pilmore site, the response of different barley varieties has been under investigation, reports Adrian Newton of James Hutton Institute. "Initially we had 64 winter-sown varieties and 56 spring types as part of the wider project. We've narrowed that down to 10-20 varieties that offer the most interesting responses."

The Soils Platform project has offered the opportunity to study the rooting in more detail. "We've found there's very little difference between varieties where there's generally been good crop growth. But these tend to show up when the plants are stressed, such as in dry years. Rooting angle varies, for example, and we're beginning to find this results in differing abilities to manage marginal conditions."

Soil nutrient distribution has also been studied, continues Blair McKenzie. "A key measure has been soil carbon, which relates to the organic matter content of a soil. We've looked at the total amount of carbon stored, and the distribution within the soil profile."

Importantly, at the Mid-Pilmore site, there was no accumulation of soil carbon under no-till or min-till regimes. "Minimal tillage may help for fuel efficiency, but so far we've found it's not making a significant contribution to increasing carbon concentrations through the profile.

But the distribution of soil carbon within the profile does vary, he notes, with more even distribution through the top 30-40cm in a plough-based system than in one that is min till.

Increased carbon

"There are also increased concentrations of carbon under the more sustainable approach on the CSC site. It makes a difference to the strength of the soil, in that one with more carbon requires less force to shear the soil, which means less energy to cultivate it," explains Blair McKenzie.

"We've also been studying aggregation — the ability of a soil to form a good crumb structure. The more you disturb it, the less stable it becomes and this affects its propensity to slump and set hard or erode, which in turn affects plant-available water and penetration resistance. A good soil has a diverse range or pore and aggregate sizes, and we're developing an index that relates these to a soil's least-limiting water range."

"There's also a parallel project, funded by Potato Council, that's using the CSC site and the same range of soil physical measures to assess the impact of the potato crop. We're looking at what the cultivations actually do to a soil, and in particular the effect in subsequent years," notes Blair McKenzie.

"Because the work builds on these long-term, established studies, it should result in some useful, definitive guidance for farmers they can use to help them determine whether they're taking their soils in the right direction," he concludes. ■

Tracy Valentine found there was a 50% reduction in root growth on the intact cores.

Blair McKenzie and his team have been taking core soil samples at known timings.

Research round-up

HGCA project 3786, Platforms to test and demonstrate sustainable soil management: integration of major UK field experiments, runs from Oct 2012 to Sept 2016. Its aim is to use defined tillage experiments at three locations and in larger, farm-scale trials to assess soil properties and the performance of different cereal varieties in commercially relevant cultivation systems. Led by the James Hutton Institute, with partner NIAB TAG and the University of Aberdeen, its total cost is £643,754, funded by HGCA.

HGCA project 3787, Improvement of soil structure and crop yield by adding organic matter to soil, runs from Sept 2012 to Aug 2016. Its aim is to find the minimum addition of external sources of organic matter to bring about the maximum improvements in crop yield and soil and environmental quality. Led by Rothamsted Research, with partner Cranfield University, its total cost is £1,770,982, with £774,999 funded by HGCA, and Defra and DARD providing additional funding.

HGCA project 3785, Exploiting yield maps and soil management zones, runs from Sept 2012 to Aug 2016. Its main aim is to determine when it's cost effective for farmers to use yield maps and management zones to guide soil management decisions. The project is led by Rothamsted Research, with the British Geological Survey as a partner. Its total cost is £202,000, funded by HGCA.