Unearthing soil's secrets

An ambitious soil research programme is underway that uses new methodology, based on existing long-term experiments, to gain a deeper understanding of crop and soil interactions. *CPM* finds out what it aims to achieve.

By Tom Allen-Stevens

Growers have grappled with it since the dawn of farming itself, yet still it's believed to be one of agriculture's least understood, and often misused resources. How exactly does the soil support a wheat plant? What should you feed it, and how do you make the most of its variability?

HGCA's Soil Programme, launched at Cereals 2012, aims to answer these and other questions about farming's essential foundation for agricultural production. Representing a total investment of over £2.6M, with more than £1M of co-funding secured, it's the biggest HGCA R&D project underway at present and has ambitious aims, according to research and KT manager Dr Shamal Mohammed.

"The intention is to give growers the practical information needed to increase productivity, but with a lower environmental impact — it's the Holy Grail of producing more with less," he states.

The call for research projects drew in 25 applications, of which nine were short-listed and three were offered grant funding (see panel on page 6). "We've focused on new research projects that'll bring growers fresh information on soil management. But a four-year study on its own isn't long enough to build credible data on the impact of changes to a soil, so the projects are based on long-term experimental work," he explains.

The sustainable soil management project, for example, is drawing on work undertaken at three sites for as long as 10 years by the James Hutton Institute and NIAB TAG. "These sites have looked at the long-term effect on crops of different cultivation systems and rotations. The new work is studying the effect on rooting and soil profiles more closely, as well as investigating the potential for carbon storage."

Lessons learned from Rothamsted Research's Broadbalk experiment, agriculture's longest ever unbroken study, are being brought into a new project that investigates the role of organic matter. "We're looking for the right recipe to feed soil organisms that'll improve soil structure and aid a crop's resilience to drought. It's about the quality, rather than quantity, of different manure types."

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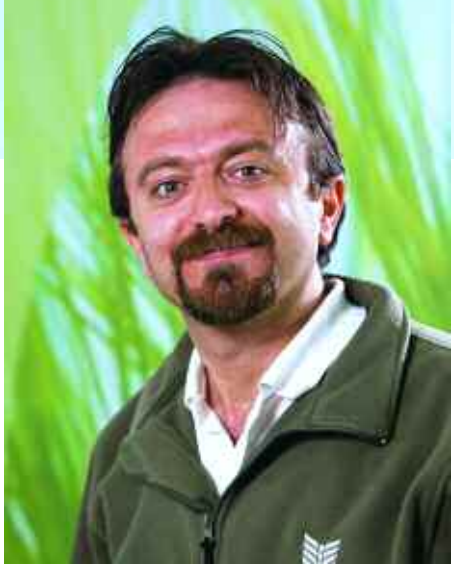
Few areas of agriculture have generated more data on soils in recent years than precision farming. "We want to use this wealth of historical data to understand how to create useful soil management zones," explains Shamal Mohammed. "The project applies new geostatistical analysis to these data sets — you're not just dealing with a value, but a value with a defined location attached to it."

When it comes to gathering data on the effect of cultivations and rotations, this is the year when real differences have shown, according to Ron Stobart of NIAB TAG. The research centre has two long-term projects



The projects will bring fresh information but are based on long-term experimental work, says Shamal Mohammed.

studying farming systems — the STAR (Sustainability Trial in Arable Rotations) project, that has been underway for eight years in Suffolk, and the New Farming Systems (NFS) study, running for five years in Norfolk.

"The differences in the STAR project this year have been phenomenal," he reports. Various rotations and cultivation practices have been on trial, but all plots on the site returned to winter wheat this year. "The shallow-tilled plots look poorest, while there's barely a crop visible in the shallow, continuous wheat plots."

A major outcome of both the STAR and NFS projects has been to compare the financial performance of different systems over a number of years, with NFS looking more closely at energy use. "With this new project we're joining these platforms together with James Hutton Institute's Soil Disturbance Experiment near Dundee, that's been running for 10 years and their new Centre for Sustainable Cropping. But we're looking to gather the sort of detailed data we've never had before."

The study revolves around taking a series of intact soil profile cores across the sites, which are then closely assessed. "We're analysing the physical properties — structure and porosity — as well as moisture and nutrient content. These properties are measured accurately, with both field-based and lab-based tools, to gain a real understanding of how roots move through the soil and exploit available resources."

Cores are taken in the topsoil, at the depth of cultivation and immediately below, three times a year — post-establishment, just after winter and as harvest approaches — to explore how the integrity of the profile is maintained. The interactions of soils on different varieties, under a range of cultivations and rotational practice, are also being analysed.

"We're also looking at shock resilience — stressing the soil to see how it recovers. And we're investigating carbon storage — a number of studies suggests it's stored in different places throughout the profile, depending on the cultivation regime," adds Ron Stobart.

Yield and gross margin expertise from NIAB TAG complements the expertise in soil science, crop-soil interactions and rooting at the James Hutton Institute, he says. This'll build a detailed picture for the grower on both the physical and financial performance of a crop's interaction with its farming system. "The aspiration is to get to a stage where you can use a few targeted soil measurements to get an accurate idea of the soil's status and yield potential."

Observations from the Hoosfield barley experiment, run alongside Broadbalk wheat at Rothamsted, has prompted renewed interest in soil organic matter (SOM), according to the institute's Prof Andy Whitmore.

"At the turn of the century, colleagues Johnny Johnston and Paul Poulton started to add farmyard manure to plots that hadn't received any in the long-term experiments. What they found was that these plots soon started to behave in a very similar way to those that ▶

Cores are taken in the topsoil, at various depths and times of year, to explore how the integrity of the profile is maintained.

Ron Stobart is hoping to gather the sort of detailed data from trial sites that soil scientists have never had before.

Manure measures help moisture need

The recent heat wave has been a hectic time for the Elveden Estate near Thetford in Norfolk. Vegetables and potatoes dominate cropping across the 4000ha of mainly Breckland sands, which means keeping up with irrigation has been top priority for farm manager Andrew Francis.

"Access to moisture is our biggest limiting factor," he confirms. It's for this reason that rye, rather than wheat, is the main combinable crop, for example, in the farm's six-year rotation.

It also means there's a firm focus on the health of the farm's soils, and organic matter is a key issue. "We've got records going back 35 years and can identify trends across the 360 fields of the farm on all sorts of soil quality and nutritional issues. The organic matter averages 1.75%, which doesn't sound like much, but that's high for these soils — the cropping and the soil type means part of its benefit will only ever be short lived".

So manure is spread regularly on the farm, usually twice across the rotation in front of potatoes and onions. "We use cattle and pig manures, litter from the nearby racing stables and green-bin waste compost.

"The pig and cattle manures are the best. The green-bin waste is too processed, while you get the impression the racing-stable litter hasn't spent enough time with the animal and doesn't have enough manure content — you have to be careful that it doesn't actually rob N from the soil after application. But pig and cattle manures have an additional quality that goes beyond their pure nutritional value — an 'X' factor that brings an added zing to the crop."

Livestock FYM has an 'X' factor that brings an added zing to the crop, says Andrew Francis.

Exactly what that 'X' factor is may be what Andrew Francis will learn from the HGCA-funded manure trials — these are taking place on some of the fields of the Elveden Estate.

"It'll be interesting to see how the different sources of manure perform. I'm also keen to see what happens when you get a run of applications four years on the trot — do you get anything in the short term that you don't achieve when applying twice across a six-year rotation?"

But he's also wary that results from any trials will have to be interpreted according to individual circumstances. "You can't generalise about organic matter — a 0.5% difference is huge on Breckland sands, for example, but it's nothing on a Lincs silt. The research is bound to bring out some valuable information, but it must be related to an individual's own situations — there's no one size fits all in organic matter," says Andrew Francis.

▸ had received FYM for 150 years. Nutritional differences were discounted, so clearly the FYM was doing something else — but what exactly?"

The benefits were considerable — the FYM-treated plots were yielding an extra 1t/ha each of grain and straw for the same nutritional inputs as those plots that were receiving just mineral nutrients, with the turnaround noticed in as little as two years. "This led us to the reasoning that you can actively improve your soil and your productivity through adding SOM."

SOM essentially serves a number of purposes, he explains. "It physically helps hold the soil together, keeping pores open and reducing erosion loss. Turnover of SOM also drives the supply of native nitrogen in the soil.

"However, there's a third, underappreciated role — it's an energy source for worms, fungi and other organisms that work the soil and keep it in good condition. But what are the essential ingredients, and how do you deliver these cost effectively, without the side effects, such as nitrate leaching or nitrous oxide emissions?"

Farm-scale plots

That's what the new project is studying. A series of seven large farm-scale plots have been set up in conjunction with Produce World on commercial units. A range of different manures is being tested — FYM, anaerobic digestate, straw, compost, and certain mixtures of these — and differences to the crop and soil closely analysed. "We're including the cost of transport and spreading, and any environmental implications in our assessments so that growers get a really accurate idea of the true costs and potential benefits," notes Andy Whitmore.

So will it help farmers produce more? "In a high-input, high-output system it's difficult to discern just what difference increasing the SOM will make. But if regulation moves farming towards a system of lower inputs, the current arable system won't be able to cope," he warns.

"That's because you rely more on the basic soil functions to maintain productivity when you pull back on inputs. A soil that has a functioning, dynamic ecosystem will perform well because there's a faster turnover of organic matter and nutrients. One with a lower SOM content lacks that inherent processing potential, so is sluggish by comparison."

But the performance of a soil can vary, across a farm and even within the same field — growers could be capturing more data on that variance than perhaps they appreciate, notes Shamal Mohammed.

"Growers may have 10 years' worth of yield maps, and other spatially variable data about their fields that can tell them a great deal about their soils and best management practise," he says.

The third project in the soil programme looks at using some of this data to help growers develop soil management zones. With the help of SOYL as a commercial partner, the research team at Rothamsted and the British Geological Survey are aiming to produce clear guidance on how to exploit yield maps and complementary soil data.

"Soil management zones are already in commercial use," points out Shamal Mohammed. "But this project is more about refining the statistical, analytical methods for creating these, with the aim of producing reliable tools that'll be freely available to growers."

At the very least, it'll help growers use spatially variable data to focus soil sampling, he says. But it's hoped algorithms can be developed that'll intelligently analyse the data, relating a yield map to a soil map, picking out true changes and differences from what may be just errors or anomalies. "This sort of work has never been done before, but there's a wealth of experience on the research teams and a huge amount of data at our disposal."

All of the projects have only just started, he notes, but growers will be kept informed of progress and findings through HGCA events and updates. "Some of the outcomes will be published in academic papers, while much will be filtered through to update technical updates and industry advice.

"We're also linking together with similar work undertaken by HDC and Potato Council with the aim of producing a cross-sector strategy document that'll bring a step-change in how soils can be managed," concludes Shamal Mohammed. ■

A range of different manures is being tested in farm-scale trials to analyse differences to the crop and soil, says Andy Whitmore.

The desktop study will use existing spatially variable data to refine the statistical, analytical methods for creating soil management zones.

Manures can bring an extra 1t/ha each of grain and straw, but what are the essential ingredients that deliver these?

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, with Defra, DARD, Produce World and Cereal Growers in the Waitrose Agronomy group 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.