HGCA

from theory to field

Mapping and managing the secrets of the soil

There are new ways to measure the potential of your soils as well as manage the vast amounts of data this generates. *CPM* rounds up the research that's been validating them.

By Tom Allen-Stevens

Even for growers who've placed their faith in precision-farming technology and reckon they're reaping the benefits, there may be two quandaries that remain. Firstly, it's prohibitively expensive to glean more than one soil sample per ha. But that's then used for sub-ha variations in fertiliser rate (albeit with input from other data sources, such as an N-Sensor, satellite or electrical conductivity scanner).

Secondly, once you've amassed the vast array of geo-referenced data on your yield and crop performance, how can you put it all together and produce something meaningful about the actual variation of potential within your fields?

A number of projects, funded both by HGCA and at a European level (see panel on p37), have been underway to shed more light on in-field variation, and the fruits of these are now tantalisingly close to commercial reality. There's new software and algorithms aimed at managing and making sense of historical yield maps growers are now amassing, points out Dr Shamal Mohammed of HGCA. Meanwhile an ingenious new sensor has been through exhaustive testing and holds promise of reliable, accurate data on how key properties of your soil vary.

"Once you truly know your soil's variability and what it means, you can start to understand and address its limiting factors," notes Shamal Mohammed. "If you can address these, then that lifts the lid on the whole concept of the yield plateau."

HGCA has focused its efforts on validating some of the new techniques that have developed, he explains. "Anyone can come up with a new tool. What we're interested in is the science behind it, and how it'll be used in practice. For example, it may now be possible to map precisely how different soil properties vary across a field. We want to know what that means in terms of input applications and business profitability, and whether that variability is enough to think about variable rate application strategy and invest in new technology."

Geo-referenced data

This has been the focus of one project in particular, that runs until Dec 2015. It forms part of the HGCA Soils Programme, but looks specifically at managing geo-referenced data, such as yield and other spatial datasets farmers have gathered. Led by Rothamsted Research, it brings in expertise from British Geological Survey and Soyl to develop a robust set of filters that should be used to clean the data, and incorporates a novel method to correct for 'flow delay'. This is the time lag between crop falling on the combine header table and registering with the

> *“Anyone can come up with a new tool. What we’re interested in is the science behind it, and how it’ll be used in practice.”*

sensor where yield is estimated — the recorded location of a measurement can be displaced by a few meters, he explains.

Data from a number of sources over several years have been cleaned up and combined, with advanced statistical methods used to identify consistently low and high-yielding areas.

“The first step has been to clean up the data and get it in a usable, compatible form — yield data can vary depending on how it’s gathered, for example. Next, to develop advanced statistical methods to divide the field into management zones. The aim here has been to identify consistently low and high-yielding areas, while accounting for the effects of annual variation, and so generate maps that highlight variation within the field. This then allows you to conduct a detailed analysis to identify yield-limiting factors in low-output zones and make decisions on variable-rate input applications.”

The result will be practical guidance for growers on how to analyse their various maps and make sound management decisions based on the information they hold, notes Shamal Mohammed.

But there’s now a new sensor to gather ▸

Once you truly know your soil’s variability, you can address its limiting factors and lift the lid on the whole concept of the yield plateau, notes Shamal Mohammed.

The new vis–NIR online sensor is the brainchild of Abdul Mouazen.

▸ data on growers' soils that could add a new layer of understanding about their variability. Developed and validated over the past 10 years, it's currently being tested for variable-rate applications through two major Europe-wide projects — FarmingTruth and FarmFUSE.

"The projects have been led by Cranfield University, and while HGCA is not directly involved, we're providing in-kind contributions, which involves sitting on a steering group and working with the research team on geostatistical analyses and modelling, for example," explains Shamal Mohammed.

The sensor is the brainchild of Dr Abdul Mouazen, who designed it in 2002 and patented it four years later. "It's an on-line visible and near infrared (vis–NIR) spectroscopy-based soil measurement device," he explains.

"Crop properties such as NDVI (Normalized Difference Vegetation Index) or Leaf Area Index are relatively easy to measure and tell you the growth above ground. The challenge has always been to measure the soil properties, such as major nutrients, pH, organic matter or cation exchange capacity (CEC)."

He reasoned that these could be measured with an NIR device that projects a light source onto a soil surface and then analyses what's reflected back. He attached the light probe onto a modified subsoiler so it scanned the soil about 150mm deep as it left the back of the subsoiler leg.

"Initially when first tested in the field in 2002, we were just measuring the moisture content. We didn't know it would work until we took it out into the field, but I was shocked at the first measurements we made — sometimes within a metre you'd get totally different readings. We've carried out a lot of work to validate and ground-truth the data, and it turns out the sensor is very successful at measuring moisture content."

And it doesn't end there — the sensor has been used to detect a whole range of soil properties, notes Abdul Mouazen. "For some, there's a very strong degree of correlation between the sensor readings and actual soil properties — this includes moisture content, clay content, total nitrogen and organic carbon. There's a medium correlation for phosphate and pH, and a moderate degree of accuracy for CEC, calcium and magnesium.

"We've had little success with potash or sodium content, and never been able to reliably measure the mineral N content of a soil. Even where there's a strong correlation, it's not 100% accurate, but it provides 1500-2000 readings/ha for each soil property — that's enough to provide a very detailed idea of how your soil varies."

So how's it then used? The aim of the FarmingTruth project has been to integrate the information on soil with other data. Satellite imagery, weather data, topography and yield maps were brought together

Trials overturn technology doubts

Darren Maskell never really got involved with precision farming, until the trials of the new sensor started on his farm four years ago.

Darren Maskell admits to being a precision-farming sceptic, but he's been won over by the trials taking place on his farm by Abdul Mouazen and his team. With 270ha of combinable crops and grass, he's based at Duck End Farm near Bedford.

"As for the soil type, you name it and we've got it — it goes from heavy clay to gravel and can change a lot within the same field," he says.

For the past four years, he's been hosting the trials testing the vis-NIR on-line sensor.

"Generally, the research team does most of the work, but I do the yield-mapping with the combine, for example.

"I've never really got involved with precision farming before and been quite sceptical of its benefits. But it actually tells you a lot you didn't see before — it picked up the site of an old muck heap that was cleared away ten years ago, for example."

As part of the trials, a uniform rate of fertiliser applications has been tested against commercial variable-rate application systems and application maps generated with the new sensor. "For the past two years, the difference has been noticeable — the crop's really evened up. I'm not sure what the financial benefit is, but the overall yield has definitely improved."

But he still reserves judgement on whether he'd invest in the technology. "A lot of it comes down to price. With wheat at £100/t, you'd have to be sure of a significant benefit, unless it was very keenly priced."

Much of the trials work is conducted by Robert Walker, who's worked on various projects with Cranfield University, and formerly at Silsoe. Like Darren Maskell, he initially had his doubts about the new sensor, until he put it to the test.

"Over the past 30 years, we've used all sorts of scanners and electromagnetic sensors in our precision-farming research, and the technology has certainly moved on. The online sensor is a definite step forward, without a doubt, and gives much more information about soil type and nutrients. Taking readings every second, it means we can establish accurate management zones," he comments.

Once Robert Walker (in cab) put the new sensor to the test, he could see it was a definite step forward.

with the soil sensor data to generate variable-rate application maps.

These were then put to the test against uniform application rates and commercially available variable-rate recommendations in replicated trials across two farms — one in Beds, UK, and the other in Denmark.

"We found the commercial packages were delivering a benefit on average of £25/ha over a uniform rate for N application. But including the on-line soil-sensor data through the integrated application maps boosted this benefit to £50/ha over two cropping seasons with oil seed rape and spring barely," reports Abdul Mouazen.

Although the project has now ended, the plan — subject to funding — is to develop the system on 16 sites across the UK. "We'll be working on arable and vegetable farms to confirm the profit reported in the last two seasons," he adds.

A new pan-European study is also underway to investigate further the potential of the new sensor and how it integrates with other geo-referenced data. FarmFUSE started in March last year and is a collaborative project, led by Cranfield University with partners in Greece, Germany and Turkey.

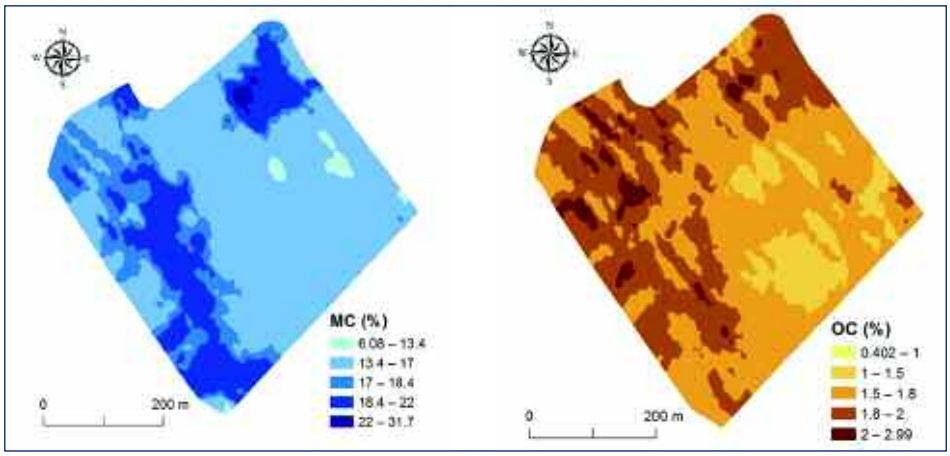
"We're bringing all the data together to create soil management zones. It's not just about creating those zones, but implementing them and carrying out cost/benefit analyses to evaluate the system."

A commercial service using the on-line vis-NIR sensor will be available within the next three years, he reckons, and it may even become an optional extra to add to a subsoiler, taking regular measurements as part of the cultivation routine.

For Shamal Mohammed, managing the data in a meaningful way is the priority for HGCA. "While we're currently assessing software packages that bring this data together and the role of management zones, there's also the area of telematics that'll bring an extra layer of data. And then there's the potential of the 'internet of things', which will allow remote management and monitoring of many other electronic devices. The government has highlighted agriculture as a priority area here, and HGCA will continue to ensure the technology is validated and the benefits are made clear for growers."

So will this squeeze out the agronomist? "I think the role of the agronomist will become very different over time — it'll be less muddy boots and more data interpretation. It's a great opportunity to harness the technology and use it in smarter ways to deliver real benefits on farm," he concludes. ■

Exhaustive testing has revealed the sensor can accurately map a range of soil properties from clay to total nitrogen content, pH and cation exchange capacity.



While the initial focus was on measuring moisture content (left), up to 2000 readings/ha can be taken for properties such as soil carbon content (right).

Research round-up

HGCA project 3785, Exploiting yield maps and soil management zones, runs from Sept 2012 to Dec 2015. 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.

FarmingTruth, Fusion of satellite and ground-based information on soil and crop for optimised crop production, ran from Sept 2012 to Feb 2014. Its aim was to use a new soil sensor to collect geo-referenced, high sampling resolution data on soil mineral content and other qualities, and then to integrate these with other data, such as satellite imagery and yield maps to develop algorithms to determine rules for variable-rate applications. Carried out by Cranfield University, its cost was €600,000 (£471,000), funded by the European Space Agency, with HGCA providing in-kind support. www.farmingtruth.com

FarmFUSE, Fusion of multi-source and multi-sensor information on soil and crop for optimised crop production system, runs from March 2013 to Feb 2016. Its aim is to fuse a set of data on soil and crop together with auxiliary data on topography, land use and weather to form management zones used for variable-rate fertilisation, seeding, tillage and irrigation, with data accessed via a web-based portal. The project is led by Cranfield University, with partners Rostock University, University of Thessaloniki, Uludag University and Design Optics and Mechanics. Its total cost is €800,000 (£629,000), funded by Defra, the General Secretariat for Research and Technology (Greece), the Federal Agency for Agriculture and Food (Germany), and the Scientific and Technological Research Council of Turkey, with HGCA providing in-kind support. *www.farmfuse.eu*

HGCA project 3728, Site-specific land management of cereal crops based on proximal soil sensing, ran from Nov 2010 to Nov 2013. Its aim was to bring together high resolution data gathered from a collection of sensors on soil and cereal crops to understand and establish new concepts and methodologies of variable-rate fertiliser applications. Led by Cranfield University, with partner Douglas Bomford Trust, its total cost is £75,500, with £37,500 funded by HGCA.