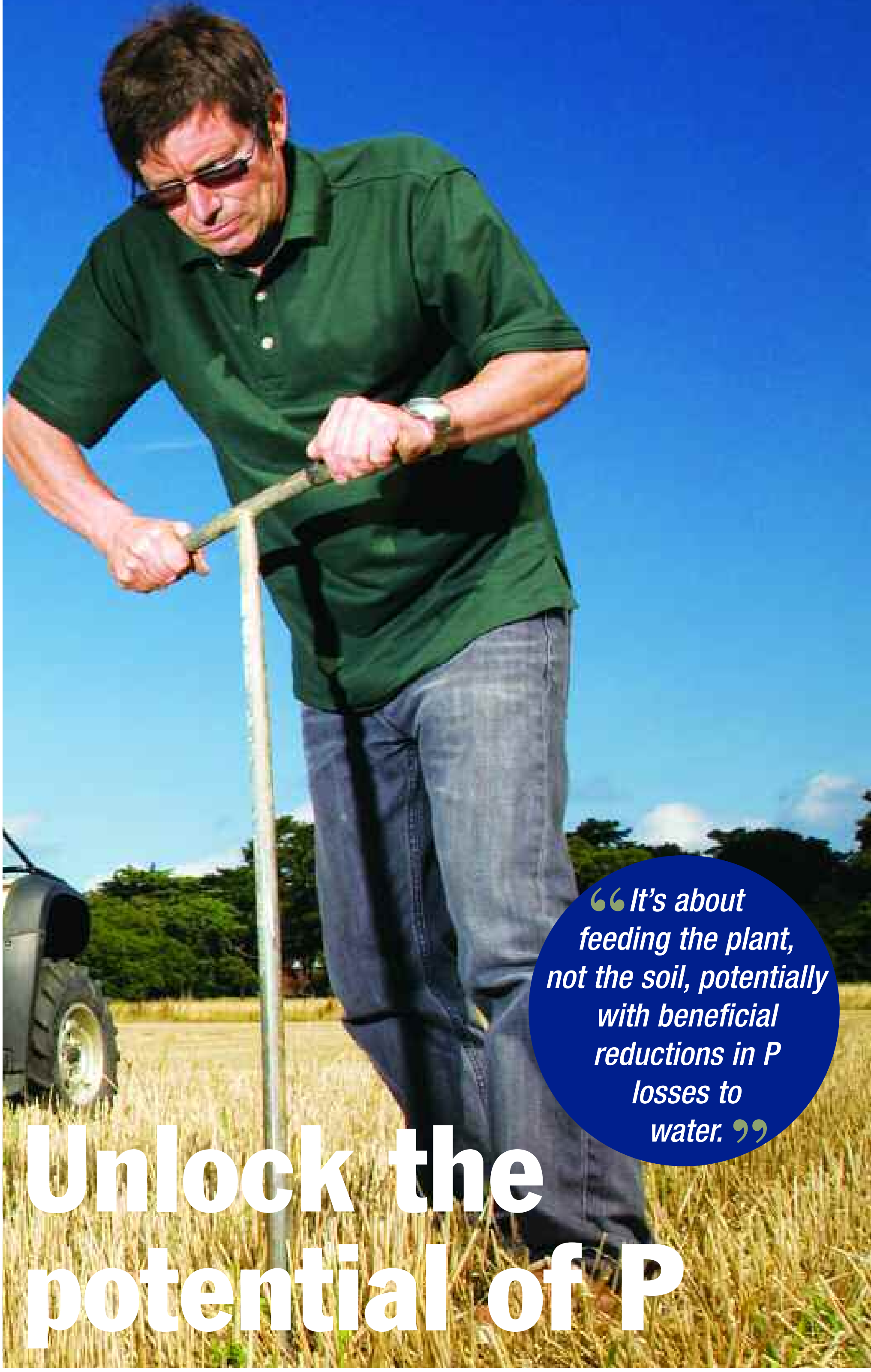
HGCA

from theory to field

Unlock the potential of P



Two HGCA-funded research projects are underway that aim for a more efficient use of phosphate. *CPM* gets an insight into their aims and progress to date.

By Tom Allen-Stevens

> *"It's about feeding the plant, not the soil, potentially with beneficial reductions in P losses to water."*

For many growers, phosphate is one of those great unknowns of farming. Few can actually pinpoint how much they have in their soil, and how it varies across the farm, the amount their crops need and when, and just how much is being lost to the wider environment. Meanwhile, it accounts for an increasingly uncomfortable chunk of the fertiliser bill.

Part of the difficulty is that growers are largely relying on historic data, according to James Holmes of HGCA. "Standard practice is to maintain arable soils at index 2 for phosphate. Yet this advice is based on trials many of which were carried out 30-40 years ago, over a fairly limited range of soil types. So a review is long overdue."

Two new HGCA-funded projects (see panel) are now underway that are set to deliver just the sort of answers growers are after, he reports. "The first addresses the fundamental aspects. Do we need to maintain soils at P index 2, or are there situations where it's appropriate to maintain a different level? We need this data over a wider range of soil types.

"The second body of research, a joint industry LINK-funded project, tackles the practical side. How can we target P to address the specific requirements of the crop? It also evaluates some of the many different formulations that are now commercially available."

Both are long-term projects — four and a half and five years respectively — with the first not due to complete until the end of 2013. "Phosphate work needs to be long-term as it takes time for changes to take effect and to assess exactly what they are," explains James Holmes.

However, initial results from research teams are now indicating there's vast potential to improve the way P is utilised. Nathan Morris is with NIAB TAG, that leads the critical soil phosphate research, working with Rothamsted Research.

"It's already clear that maintaining soil P indices at below the required level, risks a substantial yield penalty and increased yield variation. That could translate into £30-60/ha of lost income, after taking fertiliser costs into account," he reports.

The first stage of the project reviewed previous research. "We looked at work that had taken place, mainly at Rothamsted, from 1969-2008, which broadly confirmed that to get optimum yield, it's best to aim for index 2. But it also indicated there were seasonal effects, and that soil conditions had a particular impact.

"The data was also restricted to sandy clay loams and silty clay loams. So is index 2 equally appropriate for shallow soils and heavy clays, for example?"

The index system is based on extractable (Olsen) P levels, he explains. "There are four pools of phosphate in soils. Olsen P measures two of these that the plant can take up — the immediately ▸

Maintaining a P index of 2 may not be best for all soils, says Nathan Morris.

▸ available soil solution P and readily available surface-adsorbed P. When P fertiliser is added to the soil, some of the P will initially be locked up in low availability pools, but this can become available over time.

Structure benefits

"Soil structure, rooting and management can influence a crop's ability to access available P — there's a tendency in well structured soils for the critical level of Olsen P to be lower. Conversely, poorly structured soils have a higher critical P and a lower nitrogen efficiency, so these tend to need more N as well as P."

So the second part of the project has been to investigate these dynamics over a range of soil types. "We've got six sites, ranging from deep clays to fine sandy loams, and including shallow soils over limestone at Cirencester and over chalk in South Oxon."

Sites with a low initial Olsen P were chosen with the aim of establishing a range of phosphate levels on the same site. This was achieved by raising the indices in selected plots in the first year, so the yield response to Olsen P could be determined in subsequent years. Harvest results from two seasons have been analysed to date.

"For winter wheat across the sites so far, we've recorded a yield penalty (compared with Index 2) of about 0.75t/ha at index 1 and 1.5t/ha at Index 0, with much greater variation in yield also at lower indices," reports Nathan Morris. "With oilseed rape, there's a similar tendency for increased variation at below Index 2, with a yield hit of around 0.2-0.4t/ha."

But the results are far from straightforward at this early stage and there's still some work to be done before the team can define response curves across the range of soil types. "One complication we've had is the amount of P we had to apply to achieve the higher indices. It's a large amount to work into the soil that then takes time to stabilise. So in some cases, we've had a response to even higher Olsen P levels, but further years of data are required to determine if this is representative."

Now the sites have stabilised, the data can be augmented over the next two seasons and definitive results fed back to growers. "We're also looking at the response to fresh P fertiliser applications to determine whether optimum yields can still be achieved where soil Olsen P levels are maintained at below the critical level. Once complete, growers will have access to improved information on how to manage and maintain soil P," concludes Nathan Morris.

It's these applications themselves that are coming under scrutiny in the LINK-funded Targeted-P work, that aims to improve the sustainability of phosphorus use in arable farming. Paul Withers of Bangor University, the project's technical lead, works with partners ADAS, Southampton and Newcastle Universities, and SAC.

"Growers currently apply highly soluble inorganic fertilisers sourced via an energy-intensive manufacturing process from depleting rock-phosphate reserves but using this expensive resource to maintain high levels of P in the soil may not be the most efficient and sustainable way to manage arable crop P requirements. Excessive use of P can also cause eutrophication in surface waters. So we're taking a different approach and investigating more innovative ways of getting P into the plant."

There are three aspects to the research, he explains:

- Understanding what the plant needs
- Investigation of novel fertilisers and methods of application, including those from recycled sources
- Improving a plant's acquisition of soil P.

Targeted approach

"To build up and maintain a soil at index 2 involves quite high amounts of applied phosphate. The targeted P approach we're working towards involves using less applied P, but achieving the same results. We think growers can farm profitably at P index 1, rather than index 2, through having a better understanding of soil-root-crop interactions. Essentially, it's about feeding the plant, not the soil, potentially with beneficial reductions in P losses to water."

A key part of the project is to investigate novel fertilisers. "One example is AVAIL. One of the problems associated with applied P is that it's bound up by iron and aluminium ions in the soil. The theory behind AVAIL is that the compound prevents this lock-up."

Another, Struvite, comes from waste water, he continues. "It's the concentrated waste from effluent and a big problem for water companies. The Ostara process extracts the phosphate into an ammonium

Paul Withers is investigating more innovative ways of getting P into the plant.

Research round-up

HGCA project 3554, Identification of critical soil phosphate (P) levels for cereal and oilseed rape crops on a range of soil types, runs for 54 months from April 2009. The project partners are NIAB TAG and Rothamsted Research.

HGCA project 3454, Improving the sustainability of phosphorous use in arable farming (Targeted-P), runs from Oct 2010 to Sept 2015. Its aim to evaluate the impact of maintaining a lower background of soil P, supplemented with targeted fertiliser applications. Total cost is £1,544,330 of which HGCA is contributing £215,000. The project is co-funded by Defra, the Scottish Government and BBSRC through the Sustainable Arable LINK programme. The scientific partners are ADAS, Universities of Bangor, Southampton and Newcastle, and SAC. Industry partners are HGCA, Potato Council, Speciality Fertiliser Products, Origin Fertilisers, Omex, Virotec, Severn Trent Water, Nutrient Recovery Technologies, Agrivert and M. Payne.
For more information visit www.hgca.com.

Targeting phosphate efficiency

Putting new thinking into practice is par for the course for many who return to the family farm after a stint in the wider agricultural industry. For Ian Matts, who's also Yara's agronomic coordinator, there was a yearning to put to the test his conviction that there's a better way to nurture a young crop than simply feeding the soil.

"I was aware of the HGCA-funded research that suggested maintaining a P index of 2 wasn't necessarily correct for all soils. I know from my role at Yara that the amount of phosphate measured in the soil is just one of a number of factors that will influence the amount that's available to a crop, and that there's real potential to target inputs better. At Brixworth we were able to implement this."

Ian Matts maintains soil P at index 1, with additional applications made direct to the crop.

Brixworth Farming Company is a joint-venture arrangement of five farms north of Northampton, covering a total of 2000ha and run by Ian's father, Charles Matts. The soils range from drought-susceptible ironstone to heavy clays.

"The P index varies across the farm," explains Ian Matts. "In some places, where manure has been applied in the past, indices are high, whereas the lighter soils tend to have a lower P index. But that's not the whole story — to determine the P index, phosphate is measured in just the top 15cm of soil, but in some cases there's as much, if not more at 60cm and 90cm depths."

The traditional approach was to variably apply TSP biennially after harvest, aiming to maintain an index of 2. "But phosphate applied to the soil can become locked up and therefore unavailable to the crop you're about to establish, let alone the following crop," he notes. "We're now continuing to variably apply P, although now aiming for an index of 1."

In addition they're feeding the crop direct, and this year, are trying a targeted approach with oilseed rape. It was established with a Sumo Trio fitted with Stocks seeders, dropping seed in at 500mm row spacings. Between the Trio's leading subsoiler legs and discs, fertiliser was placed in bands, provided by a Chafer tank. "We applied 75 l/ha of 18-27-0 in a concentrated band, covering roughly one-third of the field."

Fertiliser was placed in bands between the Trio's leading subsoiler legs and discs.

The seed comes in after the discs before the roller, and slug pellets were applied in the same pass. "The theory is that it helps the crop get away in the autumn — rapeseed is small, so the seedling depends on soil nutrient reserves in the early stages. If you're banding seed, it makes sense to band the fertiliser too."

The wheat received a foliar dressing of Magphos K at GS30. "It's a product with good tankmix-ability and provides some foliar phosphate early in the season to improve rooting, as well as helping the crop to explore the soil for more."

Although the OSR crop looked good in the autumn, areas that didn't receive the autumn dressing are now no different to those that did, notes Ian Matts. "It's too early to assess how effective the change in approach has been. But it's brought minimum disruption to our operational efficiency, and hopefully over time the results will show that we can target our inputs more effectively."

magnesium phosphate (5 N:28 P_2O_5 :17 MgO) compound and turns it into prilled fertiliser. It's a potentially very useful slow-release source of P, so we're taking a closer look."

Other slow-release compounds include Bauxsol, a by-product of the aluminium mining industry which, when combined with TSP, has the potential to slow down the rates of P released. "Growers currently only have manufacturers' claims about these products, and trials that may not have been carried out to rigorous scientific standards. Our trials are independent and we want to understand the science behind their claimed efficacy," maintains Paul Withers.

However, the project has only just started. "In pot experiments in the lab, we're firstly looking closely at Struvite, its solubility and the mechanisms that bring it into the plant. Initial results suggest it has really good potential to supply P at a regular rate. But the real revelation in the first year of field trials was a yield of 7t/ha of spring barley with no applied P at all on a soil at P Index 1. There was little response to applied P, except during early growth when placement of TSP and AVAIL performed best in a dry spell."

This highlights the final part of the team's work that involves unlocking the secrets behind how plants acquire P. "We want to find out how we can capture the vast source of P in the soil that's currently unavailable. It comes down to root architecture, the exudates plant roots produce, and how these interact with soil microbial activity. A greater understanding of the science means we can move away from reliance on chemical additions to the soil by enhancing the natural biological movement of nutrients."

The team is carrying out mathematical modelling work to understand different rooting patterns, P movement from soil to roots to crop, and where P should be placed to ensure better efficiency of uptake. "It's very exciting as this is an area where there's huge potential to reduce the amount of P you apply, ensure better utilisation and improve a plant's ability to survive a dry spell."

Initial results show that placing P strategically can significantly improve rooting, compared with soil-applied P, he notes. Further field trials will evaluate seed dressing and foliar P applications in addition to the novel fertiliser types and placement techniques.

Excessive use of P can also cause eutrophication in surface waters.

"Just the environmental implications of using fertiliser more efficiently are immense," enthuses Paul Withers. "Eutrophication costs millions of pounds each year, so much can be saved through improving application — the P in run-off from fertiliser applied incorrectly can be very high. Targeting our applications more effectively will not just be a cost-saving for agriculture — P is a finite and dwindling resource, and reserves must be protected for future food security. So it'll be real progress for everyone." ■