HGCA

from theory to field

P critical to maximise yield

Following the conclusion of an HGCA-funded project on soil phosphate levels, *CPM* reviews the results and asks what's next from this major tranche of industry-funded research.

By Tom Allen-Stevens

Have you ever suspected Defra's Fertiliser Manual, RB209, isn't feeding you quite the right information on phosphate (P) applications for your soil? Perhaps you're taking a P holiday, and wondering if it's actually costing you anything.

Results from ongoing HGCA research into phosphate management are providing answers to these and a host of other P-related issues. "One of the central questions we've been addressing is whether maintaining Index 2 is appropriate for combinable crop rotations," says James Holmes of HGCA.

"The simple answer is 'yes', but there are situations where you simply can't sustain that. The P-related projects are now delivering some really tangible things growers can do to address their on-farm P levels."

The Critical-P project (see panel on p51) came to an end in Sept 2013 and has hung some figures on the yield penalty growers will be suffering if their soils are at Index 0 or 1. "We know from the British Survey of Fertiliser Practice and AIC data that soil P levels are being run down, so does this mean we're falling off the edge of a cliff? The project concluded that the best chance of achieving optimum yield comes through maintaining Index 2. But in some situations, growers at Index 0 or 1 will struggle to build levels."

That's not to say those at Index 1 are doomed to perpetual P-derived penalties, however. "The Targeted-P project addresses the question of whether using novel fertilisers and fertiliser placement can help you farm at

"Growers who maintain soils at low levels will be losing crop potential"

Index 1. Preliminary results suggest you can, although we won't know the full conclusions until this project finishes in Sept 2015."

Bridging the gap is a further project, Cost-effective P, which started in Aug 2013 and will run for a further five years. "This continues the Critical-P work and will take forward the results of the Targeted-P project. For Critical-P, we established six very different sites where P levels have been monitored closely and we already have some valuable data. But by its nature, P research is long term. We can apply new thinking to these established sites and provide growers with robust, tangible, evidence-based advice going forward."

Stuart Knight notes that growers who maintain soils at P Index 0 or 1 may be losing significant crop potential unless they take other action to address the problem.

From the outset, Critical-P set out to challenge RB209 recommendations, maintains project lead Stuart Knight of NIAB TAG. "Current advice doesn't differ between soil types, but we've found that's an over-simplification."

There were two parts to the study — a review of existing knowledge by Rothamsted Research helped to identify gaps and guide a set of new experiments. "We quickly identified soils for which little or no data on critical P levels existed — deep clays, sandy loams and shallow soils over chalk and limestone.

"So we found six sites with low soil indices, growing mainly wheat, oilseed rape and spring barley, and applied various doses of P fertiliser in the first autumn to create a wide range of soil P levels in each field. For the next four years, we looked closely at soil and crop factors influencing the response to both soil P levels and fresh P fertiliser applications."

The soil index system gives an indication of readily extractable or plant-available P levels in the soil, which are usually determined either by an Olsen P or Resin P test. "Applied P can be locked up in soils and become part of the overall pool of phosphate, but some of this can become available to a crop over time," explains Stuart Knight. The 'Critical' P level is the level of available P at which crop yield is close to maximum, he adds. ►

One of the central questions the project addressed is whether maintaining Index 2 is appropriate for combinable crop rotations, says James Holmes.

Large applications of fresh P were needed to raise yields.

▸ "Soil structure, rooting and management influence a crop's ability to access available P. Well structured soils typically have a lower critical P, while poorly structured soils need more available P to achieve the maximum yield."

The key finding of the project was that most growers with a P index of 0 or 1 are suffering a substantial yield penalty compared with Index 2, he maintains. "We collected most data for winter wheat. Over 14 crop years of data, we found the average yield penalty at Index 1 was 0.6t/ha, with nearly all sites showing a penalty. But at Index 0, this increased to 1.7t/ha, with all sites showing a large increase.

"On OSR, penalties of around 0.25t/ha at Index 1 and 0.4t/ha at Index 0 were observed. These aren't insubstantial amounts, and growers who maintain soils at these levels will be losing crop potential unless they take other action to address the problem."

The research team found that critical P levels varied from year to year, and from site to site. "In most situations, Index 2 was appropriate, but there was quite a bit of seasonal variation as well as differences between sites — sometimes the optimum wheat yield was achieved at Index 1, and sometimes as high as Index 3."

Water-logging

One loam-over-clay site suffered badly from water-logging in 2012, he notes. "The Critical P level was high despite a low yielding wheat crop. But after drainage work was completed, the field produced a very high yield of spring barley in 2013 with little response to soil P level. It shows that you shouldn't neglect underlying problems, such as soil structure and conditions, when considering how to manage P most effectively."

During the last two years of the trials, the research team investigated the impact of annual fresh P fertiliser applications, applied as triple super phosphate (TSP), where indices were low. "We found we could increase wheat yields by an average of 1t/ha, at Index 0, resulting in a yield equivalent to that obtained at Index 1, and by an average of 0.6t/ha at Index 1, resulting in a yield equivalent to that at Index 2. But we couldn't bring yields at Index 0 up to the level obtained at Index 2, even with a dose of fresh P fertiliser that was much larger than usual."

When P fertiliser is applied, only some of this remains available once the soil has settled down, continues Stuart Knight. "In our experiments, on average about 17% remained available in the years after application, but it varied between sites from about 10-25%."

One of the biggest eye-openers of the project came from a site in the Cotswolds, he says. "This was a shallow soil over limestone with high extractable calcium levels where we couldn't actually maintain P Index 2 beyond the first year after applying our initial P fertiliser treatments. What's more, after allowing for crop offtake, three times as much P fertiliser was needed raise the soil Index by 1mg/kg on this soil compared with the deep clay.

"A lot of growers on these soil types have been saying they can't maintain Index 2. This is the first time we've been able to prove there's an issue that needs to be addressed."

Shallow soil over chalk may also require more phosphate fertiliser to raise the soil P level, he maintains. So are crops grown on these soil types destined never to reach their true potential through lack of available P? "Not necessarily," he counters. "Growers could look at other sources, such as manures and biosolids that may behave differently in the soil. Achieving Index 2 may be impossible for some growers, but that has what it needs. We're still watching them, learning from them and adapting our thinking.

"The wheat's five-year average yield is 10t/ha, but I wonder if we've hit a yield plateau. I want to be up to 12t/ha or more, and it's research like this that I think will help achieve that," he concludes.

P management evolves as trials progress

Growing continuous milling wheat for 58 years at Peldon in Essex, RobertDavidson was somewhat surprised when some of his land was identified as having a low soil P index. Various trials have taken place on the heavy clay farm for many years, so it was a natural choice as one of the sites for the Critical-P project.

"It's important to know on heavy land if your P levels are low. The nutrient is absolutely critical for a continuous wheat as early good root growth is essential," he says.

He's followed the progress of the trials closely ever since. "I was particularly keen to learn from work the research team did on raising P indices with fresh applications."

The farm had always taken a very traditional approach to P management. Testing was carried out every 3-4 years with samples taken in W-pattern across the field. TSP was then applied on the basis of a three-year rotation, putting on 125kg P_2O_5/ha.

"We've moved on quite a bit since then. Before the trials started in 2009, the farm was precision-mapped by Soyl for P and K. and we're variable-rate applying N, P and K every year to balance crop offtake."

In 2013, Agrii's Soilquest service was used for the next cycle of P and K tests and to set up soil management zones. "When we started, there were only four fields out of 130 where P was a bit low so we've managed to lift lower nutrient levels."

Diammonium phosphate (DAP) is used more commonly in the spring now. "It's a more readily available form, and useful for land being contract farmed, where there's less interest in long term indices."

Biosolids and compost are also applied. "These have transformed the clays — they warm up faster in the spring and the biosolids are a good source of P."

The trials are now continuing on the farm with the Cost-effective P project. "They've helped us focus on the P levels and making sure the crop

The trials on his farm have helped Robert Davidson refine his phosphate management.

Initial results from work investigating the effect of placing P in the rooting zone look promising

may not be their critical-P level."

Growers should also consider the payback period from raising soil P levels. "This will partly depend on the yield benefit, and partly on the amount of P fertiliser needed to achieve the increase. Excluding the Cotswold site, the payback period from applying a large dose of P fertiliser to raise soil P levels from mid Index 0 to 1, and maintain them, worked out at between 2-5 years. In most cases, it was 3-6 years for raising soil P levels from mid-Index 1 to 2, but for one site where yields didn't increase above Index 1 it wouldn't have paid," he reports.

Rooting zone

But what about P placement, where the nutrient is put close to the seed at drilling? "In theory, this has the effect of putting a high concentration of P in the rooting zone, so is potentially a more cost-effective method of ensuring a locally high-enough soil P level in situations where it's difficult or not cost-effective to achieve that level over the entire field. Targeted-P is investigating this, and initial results look promising.

"We'll also be studying it in more detail at a farm level in the Cost-effective P project — One of the factors we don't know at the moment is the long-term effect of the targeted-P approach."

So is it time to chuck out RB209? "It gives a good average for the majority of situations, and the soil index system is still a valid approach," points out Stuart Knight. "But we've moved our understanding — the Critical-P project has added finer subtleties to a blunt instrument that should help growers achieve optimum yields."

This is set to continue as the results from the other projects unfold, notes James Holmes. "One of the major challenges facing the industry is raising wheat yields sustainably from the current plateau of around 8t/ha. Better P management is bound to be one of the requirements for achieving this.

Effect of P index on wheat yield (no fresh P applied)

Soil type (site)	Mean yield at P index 2 (t/ha)	Yield increase (+) or decrease (-) vs Index 2 (t/ha)		
		Index 0	Index 1	Index 3+
Deep clay (Peldon, 4 crops)	9.73	-1.25	-0.41	+0.57
Chalky clay loam (Weston, 2 crops)	9.70	-2.37	+0.002	-0.05
Fine loam (Great Carlton, 2 crops)	8.50	-1.72	-0.70	-0.17
Sandy loam (Caythorpe, 3 crops)	5.87	-2.17	+0.98	+0.10
Silt loam over chalk (Cholsey, 3 crops)	9.72	-1.36	-1.00	+0.30
Mean 14 site years	**8.72**	**-1.70**	**-0.64**	**+0.22**

Effect of fresh P fertiliser on wheat yield

Site	Mean yield (t/ha) with fresh P			
	Index 0	Index 1	Index 2	Index 3+
Deep clay (Peldon, 2 crops)	9.51	10.34	9.77	10.79
Chalky clay loam (Weston, 1 crop)	7.18	10.71	9.90	(11.66)
Fine loam (Great Carlton, 1 crop)	8.27	8.61	8.45	8.22
Silt loam over chalk (Cholsey, 1 crop)	(10.69)	10.41	11.07	10.76
Grain yield response to fresh P (mean 5 site years)	**+1.06**	**+0.63**	**+0.36**	**+0.05**

() value based on only 1 plot

Source: HGCA

"There are fundamental measures growers can take to ensure soils are at Index 2 and that crops can access available P. But over the next few years, we'll continue to deliver results from the trials that will bring growers the level of detail and confidence they need to adapt practices to their own specific circumstances and get even more from their crops," he concludes.

Results of the Critical-P project have been summarised into an information sheet that will be available to levy payers shortly. A research review and the full project report will also be published. ■

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 (Critical-P), ran from April 2009 to Sept 2013. It aimed to identify critical soil P levels for cereal and oilseed crops on different soils. Led by NIAB TAG, with Rothamsted Research, its cost was £191,675, funded by HGCA.

HGCA project 3454, Improving the sustainability of phosphorous use in arable farming (Targeted-P), runs from Oct 2010 to Sept 2015. It aims to determine if using fertiliser placement and novel fertilisers can maintain soil at P index 1 (as opposed to 2) whilst consistently achieving optimum yield. 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 SRUC. Industry partners are HGCA, Potato Council, Speciality Fertiliser Products, Origin Fertilisers, Omex, Virotec, Severn Trent Water, Nutrient Recovery Technologies, Agrivert and M. Payne.

HGCA project 2160004, Cost-effective phosphorus management on UK arable farms (Cost-effective P), runs from Aug 2013 to Dec 2018. It aims to improve understanding of the factors affecting rates of change in soil P status, provide evidence on critical levels of soil P and determine the value of fresh P applications. Led by ADAS, with project partners Bangor University, NIAB TAG, Rothamsted Research, SOYL and Frontier, its total cost is £283,000, with £249,000 funded by HGCA.

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