TARGETED NUTRITION AT SOWING FACT SHEET

Grains Research & Development Corporation

2009

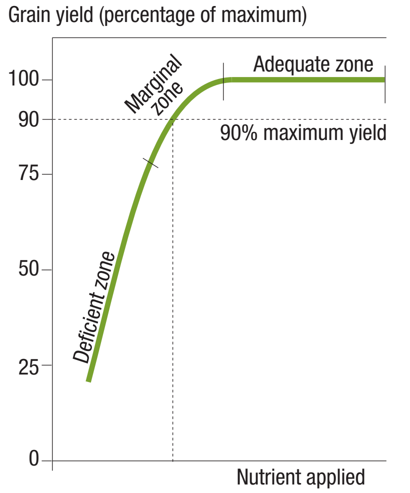
Profitable nutrient use starts with knowing the reserve

Maximising profit from fertiliser starts with targeting inputs to yield potential, the reserve of nutrients in the soil and forecast grain prices. Guesswork does not pay.

KEY POINTS

- Economic optimisation of nutrients at sowing protects profits and the environment.
- Every cropping situation has a unique set of circumstances that determines its response to fertiliser and therefore the return on money invested in nutrients.
- Profitable input supply is achieved by using soil tests and plant analysis, interpreted for appropriate target yields and with reference to fertiliser prices and grain values.
- Information on nutrient removal rates, paddock history and long-term soil health can assist.

FIGURE 1 EXAMPLE OF A NUTRIENT RESPONSE CURVE



SOURCE: Andrew Speirs, MS&A.

In deficient soils, yield potential can only be achieved by applying the correct amount of phosphorus (P) fertiliser close to the seed at sowing. In many districts P inputs have been applied for average years but grain yield has fallen below average. At the same time P prices have increased dramatically. This has led growers to question:

- how much P is stored in the soil?
- what P rates are really required?
- is granular P the best source? and
- where will investments in P return the greatest profits?

Phosphorus

Unlike nitrogen (N) and trace elements, sowing is the only time to apply P efficiently to a deficient soil, as most P is taken-up during early growth. P deficiency reduces seedling root growth, decreasing access to water and other nutrients, and making them susceptible to weed competition, pests and disease.

Phosphorus is needed most in the first six to eight weeks after sowing because it helps set-up yield potential by maximising tiller number and head size. P is readily translocated through the plant. (Crops absorb P throughout the growing season but yield potential cannot be recovered if there is an early deficiency.)

P is poorly mobile in the soil so needs to be applied close to the seed and is readily fixed in the organic and inorganic soil pools. Most crops only recover 20 to 30 per cent of fertiliser P in the year of application.

The greater the period between application and use, the less amount of P available in the year of application. P application rates can generally be reduced if there is an early break. This is because there will be increased mineralisation of P during the growing season.

In the northern region, where plants grow on stored soil moisture, crops are more reliant on deeper, native soil P.

Cereal crops need three to four kilograms of P for every tonne of grain produced.

Selecting phosphorus rates

When fertiliser is applied to a responsive crop, the largest increase in production per unit of fertiliser occurs with the first unit. As more fertiliser is applied, production gains become relatively smaller (Figure 1).

Soil type and fertiliser history largely determine the supply of phosphorus of a crop.

Every soil has a different phosphorus supply (assessed by soil tests), which is largely influenced by soil type and fertiliser history. Soil tests are valuable for calculating fertiliser rates. Most soil P is unavailable to plants, which is why soil test measurements of available P (such as Colwell-P, Olsen-P, resin and BSES-P) and the P fixing ability of the soil (measured by the P buffering index or PBI) are so important.

Nutrient budgets using previous fertiliser rates and crop yields can also be used to make fertiliser decisions.

Soil tests

The best way to target fertiliser is to collect soil samples for analysis in all paddocks once every three to four years to determine what nutrients will be available to the next crop.

A Colwell-P test costs less than $1/ha but the information gained could save or make thousands of dollars over the entire farm (see case studies).

While soil tests do not provide all the answers by themselves, they currently give the best quantitative measurements that are correlated to likely fertiliser responses and offer an underlying platform on which other less objective indicators of responsiveness can be stacked.

Soil tests are particularly valuable if crop history records are poor or if other factors have changed. For example, a failed crop, where hay has been cut or where weed growth has been prolific due to summer or autumn rainfall.

The accuracy of soil tests of available P has been improved by laboratories and advisers who include the PBI test in their interpretations.

Under development is the diffusive gradient in thin films (DGT) method of assessing plant available P for a range of soil types.

Preliminary trials in Western Australia, South Australia, Victoria, New South Wales and Queensland have shown the DGT method predicts wheat response to P more accurately than other soil tests (Colwell-P, Olsen-P and resin). However, the DGT test is unavailable commercially as further research on calibration is needed.

Collecting soil samples

Soil samples can be collected any time after harvest to measure plant-available P.

Before sampling, select a testing laboratory with evidence of accurate measurements such as proficiency certificates (www.aspac-australasia.com).

Plan sampling locations before driving into a paddock to ensure different soil types and management zones are sampled. Ideally, samples from better, average and poorer performing areas within the paddock should be tested separately so a complete picture of P status can be related to productivity.

Check if the selected laboratory has a preferred method for collecting samples. If not, three approaches can be used.

One approach is to select at least three global positioning system (GPS) referenced, or otherwise identified, sites six to eight samples in a five-metre radius around each point.

PHOTO: NICOLE BAXTER

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Another is to walk in a zigzag pattern across the whole paddock or management zone and collect 25 cores (or pogos) per sample to a depth of 10 centimetre. This depth is used because most yield response curves have been developed for a 0 to 10cm Colwell-P calibration.

The third approach is to select a monitoring transect (a straight line or zigzag) through a consistently yielding management zone.

If yield or other maps are available, target sampling to the soil and nutrient characteristics of the main soil types rather than mixing samples from the entire paddock.

Return to fixed sampling sites over time to monitor soil and nutrient changes and to match soil tests with plant tissue tests.

TABLE 1 PHOSPHORUS REMOVED (KG) IN ONE TONNE OF GRAIN PER HECTARE

Crop type	Phosphorus
Cereals (wheat and barley)	3 to 4
Cereal hay	2
Cereal straw	1
Pulses	6
Canola	7
Sorghum	4
Maize	3
Peanut	4
Sunflower	8

TABLE 2A AN EXAMPLE OF PHOSPHORUS REMOVAL PADDOCK A

Year	Crop type	Phosphorus removal	
		Crop yield (t/ha)	Phosphorus removed (kg/ha)
2008	Barley	1.5	3.6
2007	Wheat	1.2	3.6
2006	Wheat	0.2	0.6
2005	Lentils	1.0	6.0
2004	Barley	2.5	7.5
		Total removed	21.3

Source: Birchip Cropping Group

Nutrient budget

The nutrient removed in grain can vary depending on the crop, soil fertility and growing conditions.

On average, for every tonne of grain harvested 3 to 4 kilograms of P is removed (Table 1).

If soil tests within the past three to four years show adequate P and the aim is to maintain soil P at current levels P rates can be calculated as follows: **Phosphorus rate (kg P/ha) = yield of previous crop (t/ha) x phosphorus (kg/t of yield) + adjustment for fixation.**

In using the figures in Tables 2A and B the phosphorus budget equals 41.8 - 21.3 = 20.5kg/ha of phosphorus.

A replacement strategy for P is only suggested where there is a history of high P application and soil tests confirm high levels of available P.

A blanket cut in P across the farm might save upfront costs, but unless the cut is relevant for each area profit will suffer.

If soil P levels are low, limiting yields and profits, the best strategy would be to increase P inputs to obtain an adequate P level.

Over the long term, a replacement strategy may not be sustainable as it does not account for the P that goes missing each year through fixation by the soil.

TABLE 2B PHOSPHORUS SUPPLY PADDOCK A

Year	Phosphorus supply			
	Phosphorus fertiliser applied			Total phosphorus supply (kg/ha)
	Type	Rate (kg/ha)	NPKS percentage	
2008	Mono-ammonium phosphate	30	10:22:0:1.5	6.6
2007	Mono-ammonium phosphate	30	10:22:0:1.5	6.6
2006	Mono-ammonium phosphate	45	10:22:0:1.5	9.9
2005	Mono-ammonium phosphate	40	10:22:0:1.5	8.8
2004	Mono-ammonium phosphate	45	10:22:0:1.5	9.9
		Total supplied		41.8

N= nitrogen, P = phosphorus, K = potassium, S = Sulphur

Source: Birchip Cropping Group.

Example phosphorus budget = 41.8 - 21.3 = 20.5kg/ha of residual phosphorus.

If a P replacement strategy is used a ‘soil fixation’ component should be included in the budget. On some soils fixation might be as much as 50 per cent of applied P (extreme cases), while on others tie-up might be 10 per cent of applied P. For most soils, this is indicated by the PBI.

Ongoing monitoring with soil testing and plant analysis is necessary to ensure a replacement strategy is working.

If yield maps and management zones have been produced nutrient budgets and replacement strategies can be designed for these zones.

Test strips and plant analysis

If starter fertiliser is applied regularly, leaving a strip untreated with P each year could be useful to check the crop’s response to P, particularly if nitrogen is balanced using urea.

Plant analysis is useful to confirm the response and indicate if micronutrients are limiting crop growth before a deficiency becomes evident.

Even if strip trials appear no different during the growing season, do not assume a crop has not responded to fertiliser. Yield responses of 20 per cent are difficult to detect visually.

Sources of phosphorus other than granular fertiliser

Manures

Manure might seem cheaper by the tonne but available nutrients are released very slowly (only 50 per cent of P is available in year one) so larger quantities are needed to supply enough nutrients for plants to use in the first year.

In no-till systems, manures do not have a place because they need to be worked in.

When using manures, always ensure the manure being applied is analysed for available nutrients because the nutrient content varies greatly depending on source and storage.

The cost of transporting and applying manure could be greater than traditional fertiliser so add it to budget comparisons.

Fluid phosphorus

On most soils, although fluid P might initially increase dry matter production, it offers no agronomic advantage over granular P.

The exception is on alkaline calcareous soils (high in calcium carbonate) similar to those found on the Eyre Peninsula in SA.

On these soils:

- phosphorus added as granular fertiliser is rapidly fixed and made unavailable to plants;
- large pools of unavailable P may build up in the soil; and
- fluid fertilisers are more efficiently taken up by plants due to their greater availability in these soils.

However, fluid fertilisers may offer advantages in transport, storage and flexibility of application.

If in doubt about the usefulness of any new products, use test strips on-farm and assess economic (as well as agronomic) effectiveness before adopting.

TABLE 3 EXAMPLE CONTENT OF NUTRIENTS IN MANURE

	Single super	Mono-ammonium phosphate	Di-ammonium phosphate	Fresh manure		Manure more than one year old		Composted manure		Chicken manure (laying hens)	
				Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Water content				34%		26%		30%		35%	
Nitrogen (kg/t)	0	100	180	24	16	22	16	24	16	33	21
Phosphorus (kg/t)	86	219	200	7.5	5	9.5	7	10	7	20	13
Potassium (kg/t)	0	0	0	26	17	25	18	25	18	17	11

The nutrient content of manures varies significantly. Tests would allow accurate budgeting.

Source: Nutrient Management Handbook – An adviser's guide for the northern grains region, by Peter Wylie, formerly Horizon Rural Management and Chris Dowling, Back Paddock Company.

Return on investment

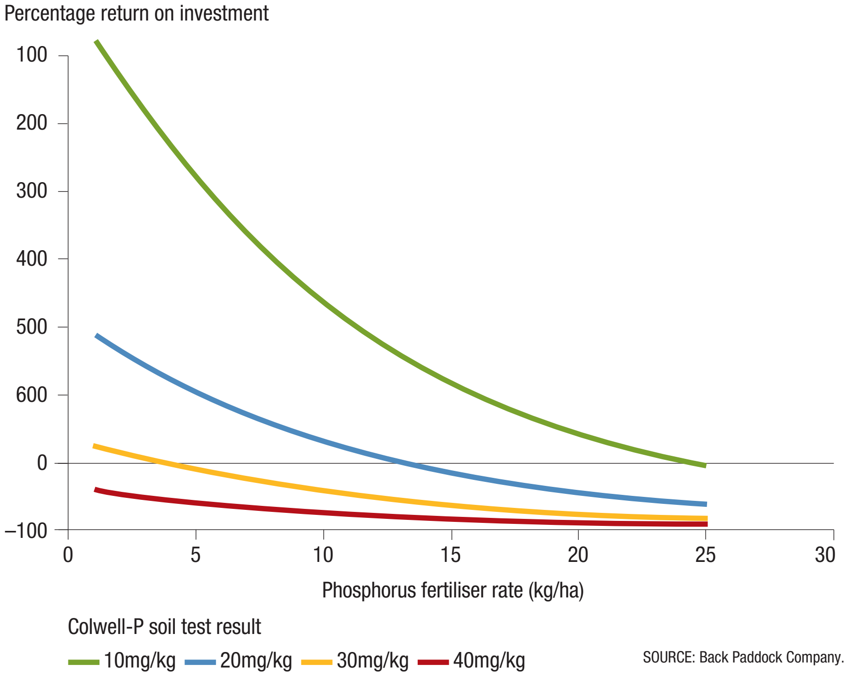
Arbitrarily selecting a fertiliser rate at sowing could improve or decrease the return on investment (ROI) depending on soil P level (Figure 2).

In Figure 2, the Y-axis shows the percentage return for each dollar invested in P fertiliser for a given scenario of grain price and P cost. While ROI for P investment varies with grain price and fertiliser P cost this variation tends to be small across wide ranges of prices and costs when compared to the effect of variation in soil P supply.

At any given soil P level (Colwell-P soil test result), the ROI decreases as more P is applied.

As higher rates of fertiliser P are applied, the limitation of P to production, relative to other nutrient limitations, decreases.

FIGURE 2 AN EXAMPLE OF HOW RETURN ON FERTILISER INVESTMENT VARIES WITH SOIL NUTRIENT SUPPLY



SOURCE: Back Paddock Company.

For the next dollar invested in P:

- 200 per cent ROI is where $3 is returned, $2 of which is profit
- 100 per cent ROI is where $2 is returned, $1 of which is profit
- 50 per cent ROI is where $1.50 is returned, $0.50 of which is profit
- 0 per cent ROI is where $1 is returned, none of which is profit
- -50 per cent ROI is where $0.50 is returned, with a loss of $0.50
- -100 per cent ROI is where $0 is returned, and all investment is lost.

Some soil-testing services only provide a single figure result which can make it difficult to determine the most profitable product and rate to apply for a range of yields and grain prices.

If possible, select a service that interprets results with reference to local soil test calibration data and econometrics (by looking at the ROI) so best and worst-case scenarios can be considered based on a range of yields and grain values.

The most limiting nutrient, in this case P, limits plant growth and production but as the fertiliser P rate is increased, deficiencies in other nutrients become important to address.

Targeted fertiliser yields a $36/ha benefit

Malcolm Sargent, Crystal Brook, South Australia, has a paddock with a long history of cropping with uniform fertiliser application.

From six years of yield maps, consistent differences between areas within the paddock (management zones) were apparent.

Soil tests showed the high-yielding zone had a 14 per cent higher plant-available water-holding capacity than the low-yielding zone.

Of interest was the impact different yields had on nutrient removal and soil phosphorus (P) levels.

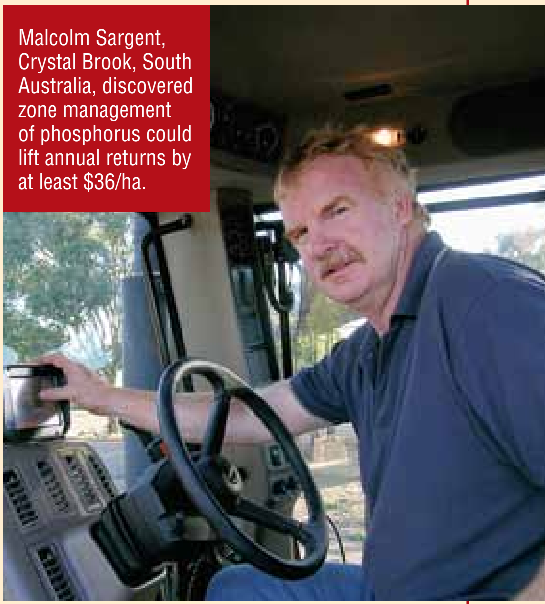
The high-yielding zone had a Colwell P level of 27 milligrams per kilogram, while the low-yielding zone had 57mg/kg, showing that P was accumulating where it had been applied at rates more than removal and tie-up by fixation.

Trials were conducted in both zones over four years and P was applied at 0, 7, 20 and 30kg/ha.

The crops grown were wheat, peas, wheat and barley in 2003, 2004, 2005 and 2006 respectively.

In the cereal-growing seasons there was no yield response to added P in the low-yielding, high-soil P zone. But in the high-yielding, lower-soil P zone there was a yield response in 2003 and 2005 but not in the drought of 2006.

Had Mr Sargent used the optimal P rate as determined by each year's results, the gross margin would have been on average $36/ha better than the traditional blanket P application of 11kg/ha.



Malcolm Sargent, Crystal Brook, South Australia, discovered zone management of phosphorus could lift annual returns by at least $36/ha.

PHOTO: PA IN PRACTICE

$18/ha advantage with precision fertiliser

PHOTO: PA IN PRACTICE

Dave Fulwood, Cunderdin, WA, estimates targeted fertiliser inputs are saving about $18/ha annually.

David Fulwood, Cunderdin, Western Australia, estimates using variable rate technology to target fertiliser inputs to production zones saves $18 a hectare a year over uniform application.

Yield maps collected since 1999 are used in conjunction with biomass imagery, supplied by a consultant, to define fertiliser zones for each paddock ($600 per paddock).

Each paddock has high, medium and low-input zones defined and these are used for starter fertiliser and top-dressed nitrogen applied as urea in June-July, but not for seed or lime application.

Soil tests are carried out in each zone every three years.

Yield potential and soil test results are used to define fertiliser rates for the 42 paddocks in-crop.

In 2007, he estimated targeted fertiliser saved $13/ha, or eight per cent, in costs but suggests the figure is now $18/ha due to increased fertiliser prices.

Tests eliminate guesswork

Grain grower Paddy Coleman says basing fertiliser rates on soil analysis results has helped take 25 per cent off his fertiliser bill.

In the past Mr Coleman made fertiliser decisions based on an average of what everyone else was doing for his northern NSW property that has an annual rainfall of 635 millimetres.

Today he takes a coordinated approach, working with an agronomist to check available nutrients with soil tests.

During 2008, soil tests revealed deficiencies in the 0 to 10 centimetre zone for nitrogen (N), P (Colwell-P results ranging from 3 to 12mg/kg) and sulphur, and only moderate N at depth.

In consultation with his agronomist Mr Coleman decided to apply 60 to 80kg/ha of mono-ammonium phosphate at planting and up to 60kg/ha of N split into a pre-plant and top-dressed application, depending on seasonal conditions.

After assessing the seasonal outlook Mr Coleman took a cautious 'run-down' approach and decided to limit his nutrient inputs by applying just three-quarters of the rates suggested.

Looking back, he is glad he reduced his 2008 fertiliser input as the crop still yielded 3.2 tonnes a hectare at 13.8 per cent protein, achieving Australian Prime Hard (APH).

But Mr Coleman recognises he cannot continue to reduce fertiliser inputs too much without compromising yield.

"Cutting fertiliser rates to raid what is stored in the soil is a bit like borrowing money; eventually you have to pay it back," he says.

PHOTO: LANDMARK

Paddy Colman's farm manager Jim Klowss and Landmark senior agronomist Sharon O'Keeffe collecting deep soil samples to check nutrient availability.

Nine per cent saving with targeted inputs

Mark Branson, Stockport, South Australia, analysed soil tests and discovered adequate levels of phosphorus (P) across all soil types but yield maps indicated in-paddock variation.

Ground truthing revealed soil water capacity had the biggest impact on yield so Mr Branson decided to use replacement P rates based on the previous year's crop yield, rather than apply 22kg/ha of P uniformly across paddocks.

Variable fertiliser maps are calculated on a crop-related replacement rate for removal in grain plus a blanket rate of 2kg/ha of P to account for P tied-up in the straw and soil.

The blanket rate is adjusted depending on whether he wants to build or reduce soil P.

For example, Mr Branson uses:

- 3.5kg/ha of P replaced for every 1t/ha of cereal grain removed plus 2kg/ha of P;
- 4.4kg/ha of P replaced for every 1t/ha of legume grain removed plus 2kg/ha of P; and
- 7.5kg/ha of P replaced for every 1t/ha of canola grain removed plus 2kg/ha of P.

On average, Mr Branson estimates that moving to a replacement fertiliser strategy is reducing P expenditure by about nine per cent.

Less P is applied in the year after low yields and more after high yields, allowing him to better match expenditure to cash flow.

Follow-up soil tests are showing no nutrient deficiencies.

PHOTO: EMMA LEONARD

Mark Branson from Stockport, South Australia, is using a replacement strategy and targeting rates according to yield variation across his paddocks.

Useful resources:

Useful resources:

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Phil Moody, QDERM	(07) 3896 9494, Email phil.moody@derm.qld.gov.au
Fluid Fertilisers web site	www.fluidfertilisers.com.au
Australian Soil and Plant Analysis Council (ASPAC)	www.aspac-australasia.com/index.php?option=com_labproficiency&Itemid=126
Precision Agriculture Fact Sheet	www.grdc.com.au/director/events/factsheet

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