Soil Health Focus - November | 2021

Incitec Pivot Fertilisers

Nutrient Advantage®

MAKING SENSIBLE PHOSPHORUS DECISIONS.

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Very high phosphorus (P) fertiliser prices mean it is a good time to review your application rates to ensure P is sensibly allocated between and within paddocks. In some instances, there will be an opportunity to reduce rates and decrease fertiliser costs, however, in the wrong circumstance this strategy could lead to significant yield penalties.

To help you make sound P rate decisions this document provides information to assist with seven key questions:

1. How do I know what the critical P level for my paddock is?
2. What to consider with low starter P rates?
3. Does crop rotation have an influence on P response?
4. How much P is removed in grain?
5. How do I calculate rates of P for capital application?
6. Can I mine my soil-P reserves?
7. How can I use variable rate technology to refine P rates?

How do I know what the critical P level for my paddock is?

Soil testing plays a key role in managing P inputs. A soil test will tell you if your paddock is above or below the critical P value required to achieve a target level of maximum grain yield. Critical values vary by crop type, location, and soil type and responses can be influenced by other soil characteristics.

Table 1 shows the published critical concentrations for the Colwell-P test. Values are shown to achieve 90 and 95% of maximum grain yield. In a reliable, high-rainfall zone an appropriate target Colwell-P would be the critical concentration associated with 95% of maximum grain yield. This is because the risk of lost yield from inadequate P may greatly exceed the risk of low yield and no return from the P fertiliser investment in the year of application. By contrast, in low-yielding and unreliable rainfall zones, a lower critical value may be more appropriate, minimising the cost of P fertiliser when the likelihood of profit from the investment is low (Bell et al, 2013).

Key message

Understand the critical P value for your soil types on your property and use soil testing to inform your fertiliser decisions.

What to consider with low starter P rates?

In furrow distribution of starter P is influenced by the rate of application, fertiliser diffusion and row spacing. At very low rates of P (< 5 kg P/ha) plant access by roots may be limited. Diffusion is the process that allows P in fertiliser to move away from the applied fertiliser granule. In acid soils, P moves only two centimetres from the fertiliser granule (Montalvo, 2014). If MAP is applied at a rate of 40 kg/ha on 25 cm spacing, there are about 40 granules per metre of row. Given the granule number in the row and the limited P movement, only 80% of the plants would have initial access to the fertiliser. Reducing the application rate to 20 kg/ha (4.6 kg/P) potentially reduces P availability to 40%. Wider row spacing increases the number of fertiliser granules per metre of row.

Key message

Even a low rate of P can be beneficial, but granule distribution, which is a consequence of rate and row spacing, is an important consideration.

Species	Soil Type	Location	90%	95%
Wheat	Red chromosol	NSW, Qld, Vic	30	38
Wheat	Brown Chromosol	SA	17	19
Wheat	Dermosol	NSW	27	35
Wheat	Calcarosol calcic	SA, Vic	24	29
Wheat	Red Kandosol	NSW	24	30
Wheat	Tenosol	SA, Tas	16	20
Wheat	Brown sodosol	NSW, Vic, SA	27	32
Wheat	Black vertosol	NSW, Qld	25	33
Wheat	Brown vertosol	NSW, SA	24	32
Wheat	Grey vertosol	Vic, NSW, Qld	18	21
Canola	All soils	National	20	25
Feed barley	All soils	National	20	25
Narrow-leaf lupin	All soils	National	22	26
Field pea	All soils	National	27	34

Table 1. Colwell P (mg /kg soil) 0-10 cm values for 90 and 95% of maximum grain yield for various crop and soil type combinations. Source: Better Fertiliser Decisions for Cropping database (Sandral et al, 2020).

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Does crop rotation have an influence on P response?

Consistently higher yields have been observed for cereal crops sown on pulse or brassica stubbles (Angus et al, 2011). This is due to the influence of a disease break (root and foliar), residual moisture, residual nitrogen and soil biology. As a result, higher rates of P are likely to be needed after a rotation crop.

Incitec Pivot Fertilisers ran a series of trials from 2012 to 2014 at Dookie investigating this rotation effect (Figure 1). IPF found that wheat after canola was more responsive to increasing P rates (ie: a greater change in yield) than the wheat on wheat and canola on wheat rotation.

This is supported by the Better Fertiliser Decisions for Cropping (BFDC) database which shows the critical Colwell-P level (95% relative yield) in wheat following cereal is 34 mg/kg (critical range 29–40). However, for wheat following canola the critical Colwell-P level is higher (49 mg/kg) but the critical range (range 17–140) is much wider. Even though from a smaller data set, the wide range indicates the recommendation is less reliable than from wheat on cereal.

Key message

Ensure that P rates are maintained or increased following a break crop for the best response.

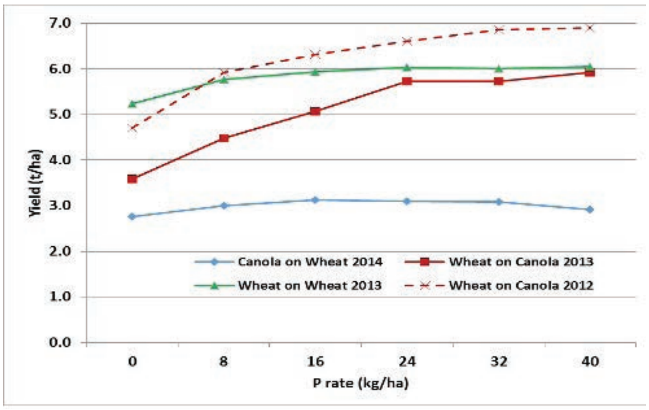

Figure 1. Effect of crop rotation and P rate on yield in wheat (2012 and 2013) and in canola (2014). Note: The wheat on canola trial in 2013 was conducted in a neighbouring paddock. All other trials were run within the one paddock over consecutive years. Colwell P across sites >48 mg/kg (considered optimum).

How much P is removed in grain?

The major loss of P from cropping systems is through nutrient removal in grain. Maintaining soil P levels over time requires enough P to be applied each year to replace grain-P removal – i.e. the replacement strategy.

A grain test will tell you the grain nutrient concentration. Grain-P concentration is variable, so it is best to take grain samples from each production zone in the paddock. You can then calculate nutrient removal using the yields from those same zones.

Phosphorus concentrations in wheat, barley and canola have been shown to vary significantly. With some of the variability due to the balance of available P (e.g. increasing P rates increases grain P concentration) and crop yields (e.g. increasing yields can dilute grain P concentrations).

Norton (2009) analysed wheat grain samples from NVT trials across south eastern Australia in 2008 and 2009. He reported that mean P concentration ranged from 2.3–3.6 kgP/t grain. These results align with an IPF grain survey in 2019 that showed a variation range of 2.3–4 kgP/t grain (corrected to 12% moisture).

Similarly, barley grain samples taken by IPF in 2016 and 2019 found that removal values ranged from 2.0–3.3 kgP/t grain (corrected to 12% moisture).

Norton (2014) reported mean canola P concentrations from 54 NVT trial sites across southern Australia ranged from 3.6–7.2 kgP/t grain (corrected to 8% moisture).

Key message

Knowing grain-P concentrations and removal can be useful in monitoring paddock P status, calculating P removal as part of a maintenance strategy and is an adjunct to soil testing.

How do I calculate rates of P for capital application?

Measuring soil-P is a critical step in calculating the fertiliser rates required. Where the Colwell-P levels of the soil are below the critical values and likely to be limiting crop growth it is recommended that capital rates of P are applied.

Capital P is the amount of P required above and beyond the replacement P, which aims to increase the soil P reserves for plant growth. The rates of capital P are calculated using the measured and critical soil Colwell-P values which inform the Target P level as well as the soil's Current P status and Phosphorus Buffering Index (PBI) which determines the P build up factor required (table 2). The equation is:

Capital P (kg/ha) = (Target P – Current P) x P build up factor*

* see table 2

Key message

A soil Colwell-P test and a soil PBI will enable capital P rates to be calculated.

PBI Value	PBI Class	P build up factor (kg/ha P required to increase Colwell-P by 1 mg/kg)
0-15	Extremely low	1.8
15-35	Very, very low	2.0
36-70	Very low	2.3
71-140	Low	2.6
141-280	Moderate	2.8
281-840	High	3.2
>840	Very high	>3.6

Table 2. P build up factor required to increase Colwell-P in the soil by one unit is determined by the Phosphorus Buffering Index (PBI) of the soil.

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Can I mine my soil-P reserves?

In contrast to the capital P discussion, where the Colwell-P levels in the soil are above the critical values there is the potential to reduce P fertiliser use, and effectively mine the P reserves in the soil. However, even with high soil-P levels some starter P fertiliser is required to ensure crop establishment and yields.

Several studies have shown that a mining phase results in a decrease in soil-P levels which are relatively slow, with Colwell-P levels in one study declining by 8 mg/kg over a five-year period (Coad et al, 2014). The decline in soil P reserves will be significantly higher in low buffering sandy soils compared to heavier clay soils which have a greater capacity to store P and buffer changes in P concentrations. It is essential that on-going monitoring of both soil-P levels (2–4 years) and crop yields is used to monitor the impact of a low P strategy on farm productivity. Relationship responses are more difficult to predict in highly calcareous soils because of the way the Colwell (bicarbonate) reagent reacts in these soils. Diffuse Gradient in Thin-films (DGT) method may better predict P responses in these soil types.

Key message

Mining the soil-P reserves is only a short-term strategy where soils are above their critical P levels and some starter fertiliser is still required.

How can I use variable rate technology to refine P rates?

The final question to ask is how can I refine my P fertiliser strategies to ensure the greatest return from my fertiliser investment? Building on the fertiliser recommendations above, this is about understanding and managing the variability across the paddock and farm. Increasingly, farm machinery has the capacity for VR application of fertiliser, and the question is how to start using the technology.

Grid soil mapping is one method used to measure and map the variability in soils, including soil P levels. Figure 2 is an example of how much Colwell-P can vary across a paddock. In this paddock uniform fertiliser application can result in over- and under-fertilisation in different areas of the paddock, reducing fertiliser use efficiency. Measuring the variability in Colwell-P across the paddock allows the fertiliser strategy to vary across the paddock from capital to maintenance to mining rates based on soil P status and PBI.

For the example in Figure 3 using a critical Colwell P of 25 (90% maximum yield) for a wheat crop on very low PBI soils, approximately one-third of the paddock requires a capital rate of P, about a one-third has a Colwell-P above 40 mg/kg and could potentially be mined with a starter rate of P for a couple of years, leaving the balance to receive a maintenance rate.

In addition to measuring the variation in Colwell-P in the soil to refine the fertiliser strategy, there is also the potential for yield data to be used to tweak the phosphorus maintenance strategy within a paddock. P removal is highly driven by crop yield and using variable P application rates allows fertiliser use to be weighted towards the higher yielding parts of the paddock. This strategy should maintain more even soil P levels across the paddock over time. However, it assumes that lower yields were not caused by P deficiencies and requires on-going monitoring not only of yields, but also grain-P levels and soil testing to ensure that a robust strategy is meeting crop and soil requirements.

Key message

Paddock variation of soil-P levels is significant. Grid sampling identifies and forms the basis of a P map that can be actioned by a variable rate application map.

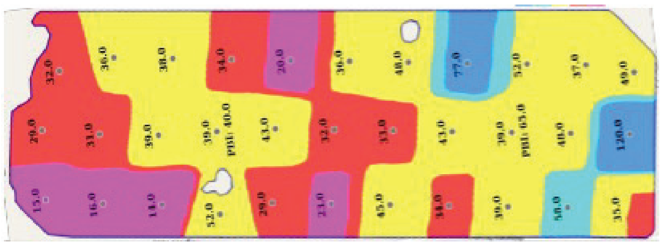


Figure 2: Example of Colwell-P variation measured across a paddock using a two-hectare grid, with Colwell P ranging from 14-120 mg/kg. Map provided by Precision Agriculture P/L.

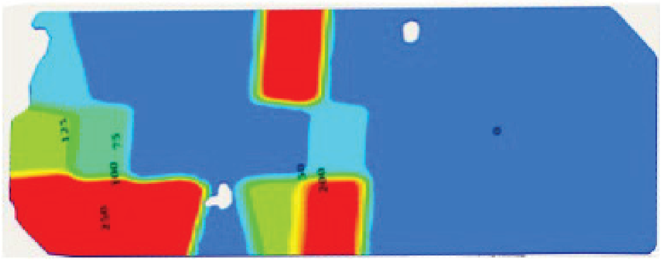
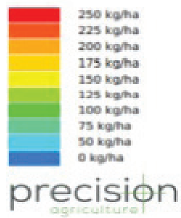


Figure 3: Variable rate Single Super (kg/ha) capital application to achieve a target Colwell-P of 33 mg/kg. Map provided by Precision Agriculture P/L.



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