Phosphorus response in the eastern wheat belt highlight challenges in applying critical soil phosphorus value interpretations

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Key messages

Summit Fertilizers field trials consistently find growth and yield responses to phosphorus, even at soil test concentrations above published critical levels.

There are real risks of crop growth penalties and sub-optimal grower returns if P is not applied at sowing. Additionally, driving increased crop yields with N may not be fully effective if levels of P (and other elements) are not adequate.

Summit data and growth response curves suggest P at 6 to 8kg per hectare will optimise growth, yield and returns in the eastern wheat belt.

Aims

Complementing broad scale soil test indicators of crop response to P with local knowledge and robust local trial data to improve productivity and profitability from fertiliser application.

Background

Summit Fertilizers have a long history of conducting fertiliser response trials in the eastern wheat belt. Over the past five years, these trials have strongly focussed on factorial combinations of nitrogen (N) and phosphorus (P) to validate nutrient recommendations and maximize grower returns from fertiliser applications.

Fertiliser recommendations are, now more than ever, reliant on analysis of soil samples for nutrient content and other physico-chemical properties. For P, this presently means predicting how a crop will respond to P application based almost exclusively on Colwell P test values, in combination with a complex of other factors including Phosphorus Buffering Index (PBI), pH and lime impacts, gravel content, water repellence, other root constraints, tillage, application method and, increasingly, crop rotation (Neuhaus, et al., 2015).

Phosphorus in WA agricultural soils has received much attention since historical application rates were high with the access to low cost superphosphate and strong early yield responses. However, coupled with increased environmental concern for use in water catchments and a desire for decreased resource input to maintain farm profitability, assessments have indicated that WA soils have accumulated a bank of phosphorus to levels above what will respond to P fertiliser application (Weaver & Wong, 2011).

While many trials have established the relationships between Colwell P values and crop growth response, variability is often observed and conditions local to the paddock where a recommendation is to be applied do not always replicate the broad scale or specific locality from which these trial data are derived. An example detailed here is the BFDC Interrogator (Watmuff, et al., 2013), compiled through the Making Better Fertiliser Decisions for Cropping Systems in Australia Project. In order to derive a valid calibration curve for P in wheat near Merredin [fulfilling requirements of number of trials, sufficient correlation and valid data in the critical part of the curve fit], a region with a radius of 75-100km must be selected and a number of representative soils must be filtered out (Figure 1). This produces a critical Colwell P value of 19mg/kg that should, to a level of confidence, produce 90% or greater of the P non-limited yield.

Is 19mg/kg representative of a soil P level that will optimise crop yield and grower returns without supplementary P application? We present a brief summary of four years' data from 2012-2015 trials on wheat in the eastern wheat belt area around Merredin to show how the conservative outcomes from the abovementioned assessments may indeed impact grower returns from crops in this region.

Method

A series of fully replicated, randomised trials have been established in the eastern agricultural zone between 2012 and 2015. They incorporated a factorial design of a minimum of four N and four P rates ranging from zero to in excess of adequate requirement for maximum wheat yield potential. Typically, N was applied at 0, 25, 50 and 75kg/ha and P at 0, 6, 12 and 18kg/ha, although these varied on occasions depending on site yield potential. Site selection included comprehensive soil tests of top and subsoils. Collection of harvest yield data and grain quality analysis allowed the assessment of gross margin returns attributable to fertiliser application.

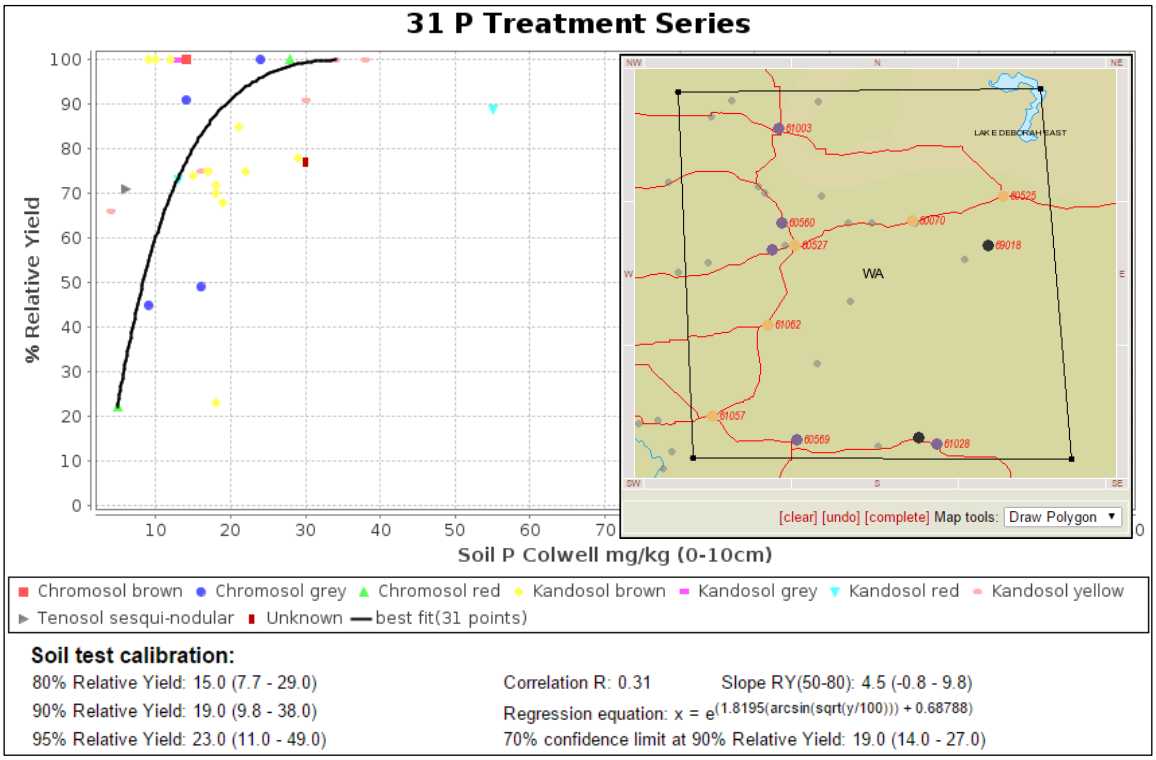

Figure 1. Calibration curve and critical Colwell P derived from BFDC Interrogator (https://www.bfdc.com.au)

Results

The BFDC Colwell P soil test value of 19mg/kg is derived from a combination of soil types. There is some question over how much adjustment should be made for soil type when assessing a P test level that will or will not produce a crop response to P fertiliser (Speirs, et al., 2013). For example, Moody (2007) defined a curvilinear relationship for how critical Colwell P changes with PBI (see Figure 2).

Compared to the Colwell P values for 90 % of maximum wheat yield across the range of soil PBI as described by Moody (2007), eastern wheat belt soils where trials were established had P levels equal to or greater than these critical concentrations. The expectation is that with soil P above the critical value, no yield response to applied P should be seen. However, roots still need to directly access this P, especially during early growth. Indeed, in the majority of cases in the trials, wheat yield did respond to P applied at seeding even at reasonable P soil test levels (Figure 2). Responses were observed across a range of good and poor-yielding seasons (Figure 3).

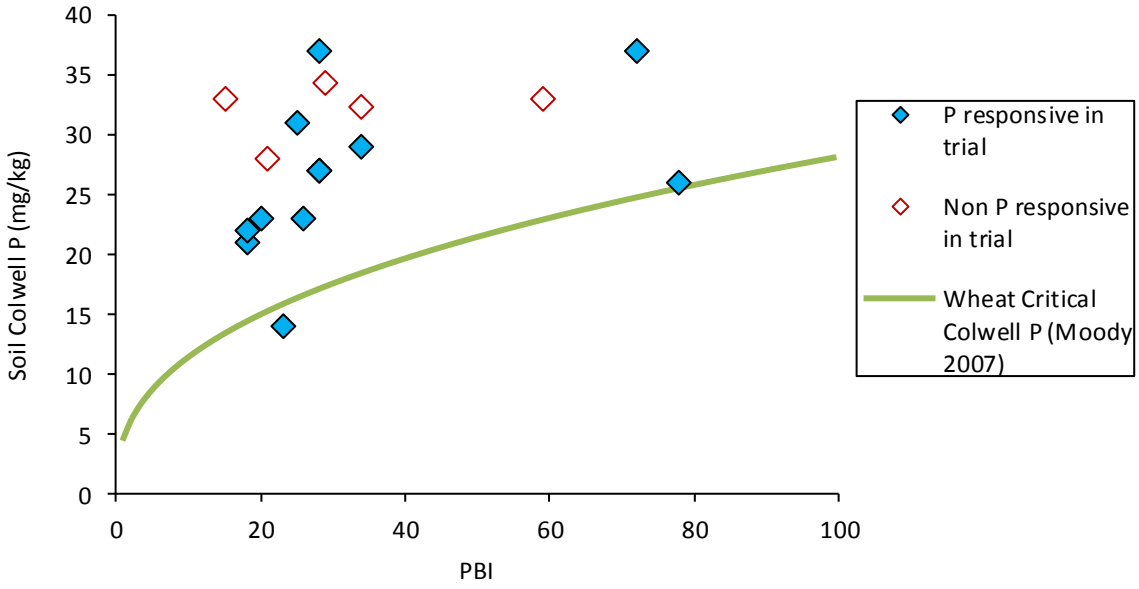

Figure 2. Soil Colwell P and responsiveness of wheat to P application in eastern wheat belt trials 2012 – 2015.

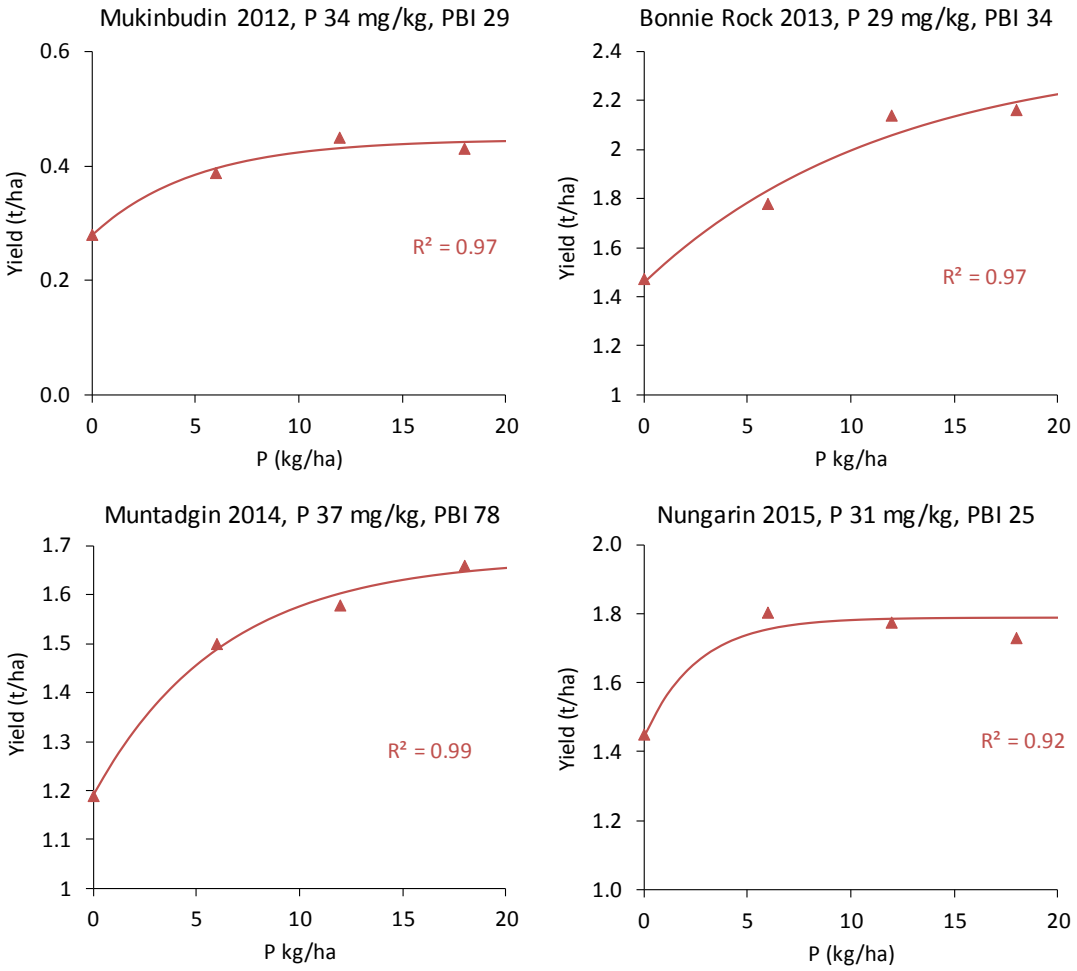

Figure 3. Examples of mean wheat yield response to P application in trials at a range of sites 2012-2015. Lines are fitted Mitscherlich functions.

A regular feature observed in the factorial NxP trials is the inability of P-deficient plants to respond to both simultaneous and subsequent applications of N. Figure 4 shows yields in a 2015 trial at Nungarin where there was no response to N without P applied. This effect is seen even at sites where soil test Colwell P is higher than the previously-mentioned critical values. If the crop is to be driven to optimum yield and protein content by either predetermined or opportunistic N applications, an adequate level of P nutrition is required. Growers can only be certain of this by the application of some P.

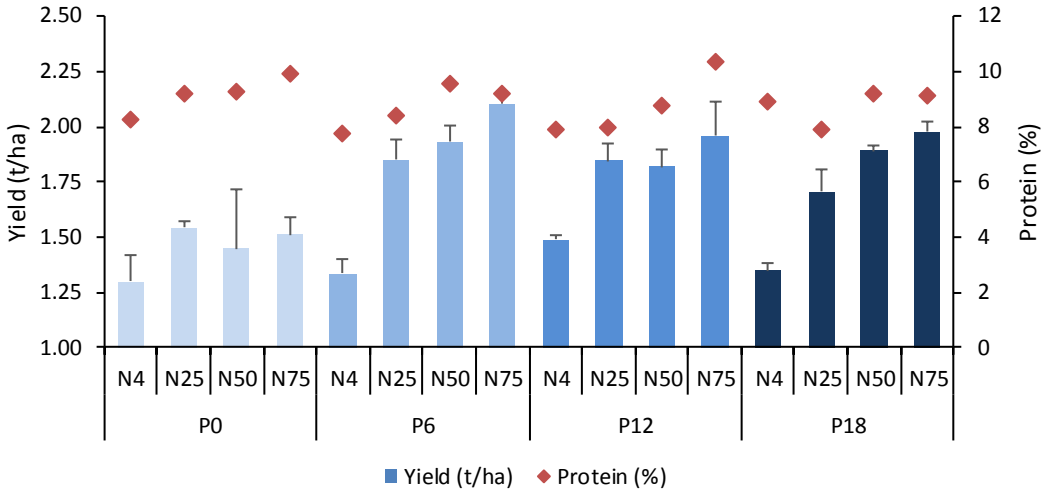

Figure 4. Yield and grain protein response to N application at different establishment P rates, Nungarin 2015. Colwell P 31mg/kg, PBI 25, pH topsoil 5.0, pH subsoil 4.7.

Phosphorus is quite immobile in most soils. Acidic soils exacerbate this. So, placing an effective amount of P fertiliser near a germinating seed makes a plant's task in intercepting and the uptake of adequate P to promote growth much easier. Total yield response of wheat to P does vary with sites and site conditions, but the most efficient P application rate in the study area trials has been 6 to 8kg/ha banded below the seed at establishment. At this rate, we see positive effects on P uptake, significant yield improvement and maximised return on fertiliser investment (Figure 5).

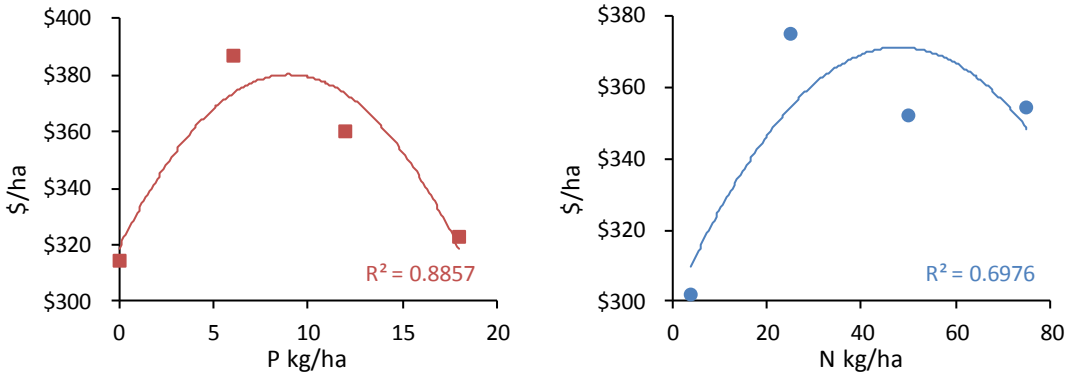

Figure 5. Mean gross margin net of cost of fertiliser applied to achieve different target N and P rates, Nungarin 2015. Lines are Excel-fitted polynomial trendlines.

Conclusion

Designation of soil test levels of nutrients as "critical" may be overstating the reality. Certainly, a significant number of Summit trials near Merredin in the eastern wheat belt have shown strong yield response and dollar return on P application where Colwell P is well above the BFDC Interrogator 19mg/kg critical value and P binding ability is low.

While soil test level indicators provide useful information to assist in making fertiliser recommendations, without a large effort in localised data generation from robust trials, viewing these values as absolute green or red lights, for example to P fertiliser application decisions, could result in sub-optimal crop growth and yield and, in turn, marked decreases in returns to growers.

Continued improvement of tools such as the BFDC interrogator should be sought by additions to the trial database to enable small scale focus to produce useful calibration curves. This will require ongoing establishment of robustly designed nutrition trials throughout the growing regions and collaboration between industry representatives.

Key words

Phosphorus, soil testing, Colwell P, nutrient response, wheat, critical values

Paper reviewed by

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References

Moody, P. W., 2007. Interpretation of a single-point P buffering index for adjusting critical levels of the Colwell P soil test. *Australian Journal of Soil Research,* Volume 45, pp. 55-62.

Neuhaus, A., Easton, J. & Walker, C., 2015. Phosphorus requirements for cereals: What role does crop rotation play?. *Building Productive, Diverse and Sustainable Landscapes. Proceedings of the 17th ASA Conference, 20 – 24 September 2015, Hobart, Australia.,* p. http://www.agronomy2015.com.au/papers/agronomy2015final00333.pdf.

Speirs, S. D., Scott, B. J., Moody, P. W. & Mason, S. D., 2013. Soil phosphorus tests II: a comparison of soil test-crop response relationships for different soil tests and wheat. *Crop & Pasture Science,* Volume 64, pp. 469-479.

Watmuff, G., Reuter, D. J. & Speirs, S. D., 2013. Methodologies for assembling and interrogating N, P, K and S soil test calibrations for Australian cereal, oilseed and pulse crops. *Crop & Pasture Science,* Volume 64, pp. 424-434.

Weaver, D. M. & Wong, M. T. F., 2011. Scope to improve phosphorus (P) management and balance efficiency of crop and pasture soils with contrasting P status and buffering indices. *Plant & Soil,* Volume 349, pp. 37-54.