Is extension moving away from science? Reviewing recent phosphorus and lime responses from CSBP trials in Western Australia

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KEY MESSAGES

- A stronger collaboration between extension officers and field researchers within or among varies organisations is likely to improve the agricultural service in WA
- The so-called "critical" value(s) for Colwell P needs to be reviewed for WA conditions in order to lift crop productivity and farm profitability
- From a cash flow point of view, liming was usually less profitable than P applications in responsive P and pH situations, but, depending on the situation, both should be recommended if needed and applied if there are no financial barriers

AIMS

The soil phosphorus (P) status in WA is thought to be "excess" or "well in excess" (Weaver and Summers, 2013). The cost of P applications in the south-west of WA is estimated to be about $400 million per year" (Weaver and Summers, 2013). This is based on a "P fertility index", which operates on the Colwell P and the PBI (Moody, 2007) required to give 90% relative yield. In the case of wheat, this index has been derived from unknown and unpublished trial data for WA, thereby lacking scientific validation to establish the empirical evidence on which the extension can be based. In addition, concern can be raised about using the relative yield for calibrations instead of the absolute yield, because higher target yields drive nutritional demands, i.e. a 1 t/ha crop should have a lower critical value than a 5 t/ha crop. Furthermore, while it was reported that "the interpretation of the soil P status and fertiliser P requirement of soils is strongly associated with both the extractable soil test value (usually sampled for 0-10cm depth) and the P buffering capacity (PBC) of the soil (Watmuff et al., 2013)", other factors are missing. The NUlogic program, for example, uses the target yield (in absolute terms), soil gravel content, soil pH, PBI, nutrient interaction with soil N and soil K, the previous crop, and the economics (crop price, overhead costs, nutrient costs of fertiliser N, P and K, interest rate and loan duration). However, most of those additional factors are not considered for a good P recommendation if the "P fertility index" is used, even though these are important variables for WA growers. Bell et al. (2013) pointed out some of those weaknesses in missing metadata. They addressed the problem to some extent by giving a soil profile specific critical P concentration above 1 t/ha yield, thereby using relative yields within a defined range of absolute yields. Their overall critical P concentration was based on 1995-2011 trial data for WA, which did not allow them to query by soil texture, pH, PBI or gravel content, ranges from 18-26 mg/kg, depending on the confidence interval. A fresh look at some more recent and local trial data can provide some much needed scientific validation of the assumptions above.

On the other hand, soil acidity is identified to be "a major constraint to agricultural production" and it is believed that "the opportunity cost of lost agricultural production in the south-west of WA from soil acidity is estimated to be $498 million annually" (Gazey et al., 2013). Again, the cost of lost production is best evaluated and quantified from field trial data. The dynamics between soil P and soil acidity is a special case that also needs to be investigated in field trials and then be incorporated into the extension.

Even though the grower will make the decision, the question remains for funding bodies that are exploring research priorities: shall the $400 million per year on "excess" P applications be spent on lime applications to cover most of the $498 million opportunity costs per year? This paper focuses on

CSBP field trial data to discuss the claims of “excess” soil P supply and so-called uneconomical P applications as well as the production loss from soil acidity and so-called economical lime applications.

METHOD

Recent CSBP short- and long-term field trials have been analysed to establish yield responses to P, lime and P x lime. Each treatment in every field trial is randomised and replicated three times. Soil and plant tests have been taken to eliminate any other nutrient limitations as factors other than the treatment. An ANOVA has been carried out using GENSTAT to determine the statistical significance of effect of the treatments.

RESULTS

Trials in table 1 and 2 indicate that the “critical” Colwell P value can not be taken as a guide for every situation in WA, because there are many P responsive situations near or above the “critical” P value (6 out of the 11 field trials are highlighted in bold) in which growers would lose profit if they did not invest in P applications. The CSBP field trials also showed more profit gained from P applications than from lime applications, although this is dependent on the situation and can not be generalised. Lime tended to become economical after 2-3 years from applications in the trials reported here.

The Bindoon trial (photo 1, data in table 3) has a direct comparison on the productivity and profitability of P and lime. Fertiliser P was always more profitable in this trial than surface-applied lime. While lime increased productivity, the same P application was required to capitalise on the higher yield potential. Lime increased soil pH from 4.6 in 2010 to 5.1 in 2012, reduced extractable Al (mg/kg) from 5.6 to 2.5 and increased ECEC from 4.5 to 7.5 meq/100g. Continuous P applications of 36 kg/ha/year increased the topsoil Colwell P to 52 mg/kg in November 2013.

According to Moody (2007) and Bell et al. (2013), the last 2 years of the Bindoon trial would have reached a relative yield of > 90%, without any P applications. However, the measured relative yield was much lower. Even though the less acidic pH on the limed plots would make more soil P plant available while the Colwell P value would remain the same, the higher soil pH only slightly increased the relative yield from 23% to 32% and from 63% to 67% in 2012 and 2013 respectively. Limed plots did not reduce the yield response significantly due to a higher demand. A critical Colwell P approach would also make it difficult to generate a P recommendation, because it does not consider absolute yields. For instance, a yield of 5 t/ha with 18 kg/ha of applied fertiliser P in 2013 on the lower pH soils was achieved with 9 kg/ha of applied fertiliser P on the higher pH soils. However, maintaining P application rates of 18 and 36 kg/ha produced an extra 0.54 t/ha and 0.73 t/ha on the limed plots compared with the P rate of 9 kg/ha on the limed plots. The most profitable application rate in this trial was 36 kg/ha of P on the non-limed plots ($399/ha).

Canola grown after pasture was about twice as P responsive as wheat grown after canola. The strong P response is likely to be a combined effect of a relatively high PBI for WA conditions, high gravel content and high yield potential. Phosphorus is a macro-nutrient for plant growth and the low P availability on the Bindoon site would limit uptake via diffusion. Diffusion rates are slow compared with plant uptake rates thus creating depletion of P around the roots (Schachtman et al, 1998). It can be speculated that a higher concentration as well as a higher volume or amount of P, in a soil that has a reduced soil volume (by 45% gravel) of a measured Colwell P, would be required to sustain a fast enough P uptake for long enough to match the demand. Liming may not have made enough P available, but may have reduced root pruning due to aluminium toxicity to increase P uptake to some extent. However, P applications were more profitable in the short and medium term than surface applied lime. If there are no budget constraints then both, P and lime, should be applied to follow best management practices and to maintain the land value.

Table 1 (top): CSBP field trial results since 2008 for P responses on wheat, Table 2 (middle): lime responses on wheat and Table 3 (bottom): P x lime treatments on wheat, canola and pasture at Bindoon (soil test values for 2010: Colwell P= 35mg/kg, PBI=146, gravel content=45% and pH_{CaCl2}=4.6, soil texture= white gum 'pea' gravelly loam). ns = non-significant. Profit assumptions based on on-farm prices and costs, such as wheat = 260 $/t, pasture = 100 $/t, canola = 550 $/t, lime cost = 30 $/t, P cost = 3 $/kg.

Year	Location	Colwell P (mg/kg)	"Critical" Colwell P (mg/kg)	PBI	Gravel content (%)	$pHCaCl_2$	P applied (kg/ha)	$Yield_{max}$ (t/ha)	Yield response (t/ha)	Profit ($/ha)	Statistical significance
2013	Nungarin	18	35	179	0	7.8	5	0.60	0.09	8	ns
2012	**Beacon**	**19**	**18**	**31**	**0**	**4.6**	**12**	**1.03**	**0.25**	**27**	
2012	Burracoppin	16	21	45	0	4.8	12	0.73	0.14	-1	ns
2012	Lake King	44	16	25	0	5.0	9	1.39	0.09	-5	ns
2012	**Ravensthorpe**	**15**	**10**	**7**	**20**	**5.8**	**9**	**1.60**	**0.28**	**43**	
2012	**Wandering**	**29**	**31**	**124**	**25**	**6.0**	**16**	**3.02**	**0.54**	**87**	
2012	**Frankland**	**46**	**37**	**200**	**30**	**4.8**	**24**	**3.65**	**1.36**	**268**	
2012	Badgingarra	14	18	31	0	4.8	24	4.48	1.07	196	
2009	Moonyoonooka	9	15	21	0	5.1	24	3.04	1.38	273	
2009	**Narembeen**	**25**	**15**	**21**	**0**	**5.7**	**7**	**1.82**	**0.66**	**144**	
2008	**Frankland**	**40**	**33**	**155**	**30**	**4.9**	**32**	**6.40**	**1.39**	**252**	

Year of lime application	Location	Soil texture	OC (%)	Gravel content (%)	$pHCaCl_2$	Lime applied (kg/ha)	Yield response since application (t/ha)	Total Profit ($/ha)	Statistical significance In each year
2012	Gutha	red loamy sand	0.4	0	4.5	3000	0.38	9	ns
2011	Wongan Hills	yellow sand plain	0.9	0	4.7	2600	0.27	-8	ns
2011	Bolgart	deep grey sand	1.1	0	5.2	3000	0.59	63	ns
2008	Mukinbudin	wodgil sandy loam	0.8	0	4.4	4000	1.29	215	

Year	Location	Crop	P applied (kg/ha)	Yield (t/ha)	Yield response to P (t/ha)	Profit ($/ha)	Lime applied (kg/ha)	Yield response to lime (t/ha)	Profit ($/ha)	Yield response to 36 kg/ha P and 2 t/ha lime applied in 2010	Yield (t/ha)	Profit ($/ha)
2013	Bindoon	wheat	36	5.26	1.95	399	nil	0.52	135	1.90	5.73	386
2012	Bindoon	canola	36	2.88	2.21	1108	nil	0.36	198	2.17	3.20	1086
2011	Bindoon	pasture	36	4.90	1.90	82	nil	0.90	90	1.20	5.10	12
2010	Bindoon	pasture	36	2.44	0.54	-58	2000	0.07	-53	0.47	2.44	-121

Photo 1:2012 canola field trial in Bindoon showing response to 36 kg P/ha with 2 t/ha of lime applied in 2010.

CONCLUSION

Local trial results are crucial when evaluating the productivity and profitability of P and lime applications. It is clear from such an approach that knowledge gaps exist for many extension officers, leaving farmers confused at what to believe. P applications are still profitable and more widespread than indicated by Weaver and Summers (2013). Those P deficiencies will cause other nutrients, i.e. nitrogen, to be under-utilised if fertiliser P is not applied.

The trial work allows CSBP to develop a good understanding of interpreting soil and plant test values, and this is incorporated into the NUlogic fertiliser recommendation program. NUlogic does not use so-called “critical values” for P, but instead uses a crop sufficiency approach together with the economics of using fertilisers. It also takes account of N, P and K interactions. There is an opportunity for other agencies like DAFWA or GRDC to collaborate with CSBP on research projects, such as exploring the effect of gravel, soil pH or other factors on P requirements, and to benefit from sharing existing knowledge.

KEY WORDS
Extension, field trial, Colwell P, lime

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Paper reviewed by: Dr Leisa Armstrong (Edith Cowan University)