Reassessing the value of phosphorous replacement strategies on fixing soils

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Key findings

- Economic gains can be made by applying higher than typical replacement P rates on soils with the ability to fix applications of P.
- Highest gross margins are obtained by growing the most suitable variety for your region assuming P nutrition is corrected.

Why do the trial?

The aim of this project is to quantify the economic benefit to farmers of:

- applying high application rates of phosphorus (P) on moderate buffering soils (phosphorus buffering index PBI) across a range of sites with different yield potentials.
- comparing three-four common wheat and barley varieties to assess their Phosphorus Use Efficiency (PUE).

Phosphorus deficiency still occurs in several regions across SA with major yield limitations occurring due to inadequate applications of P. Low soil P test values are commonly associated with soils that have moderate to high P buffering indices (> PBI 100) implying that replacement P programs may not be sufficiently accounting for the low fertiliser recoveries, thereby generating inadequate P replacement rates. In some cases, application rates > 40 kg P/ha might be required to maximise yields, a fertiliser rate that under some circumstances might not be the most economic if yields are low. Identifying these sites and assessing under which circumstances (yield potential, fertiliser prices) high rates of P are economically-viable will add vital information to the grains industry.

Wheat and barley varieties may vary in their responsiveness to P either by having root traits that increase access to soil P or by more efficient use of the P taken up by the crop. In combination with different yield potentials external P requirements and phosphorus use efficiency (PUE) could vary. Identifying varieties that have greater PUE in deficient soil is of great interest to many farmers in S.A. due to the relatively low P levels driven by moderate to high P fixing soils in several regions.

How was it done?

Plot size	1.8 m x 5.0 m	**Fertiliser**	P as MAP (10:22) @ 0, 5, 10, 20, 30 and 50 kg P/ha. Urea was used to balance N inputs so each treatment had an application of 22 kg N/ha applied at sowing.
Seeding date	2nd June 2015		

The trial location was at Pinery on a red calcareous (~10% $CaCO_3$) soil. Four wheat (Cobra, Corack, Mace and Trojan) and four barley varieties (Commander, Compass, Fathom and La Trobe) were sown at each P treatment, and replicated 4 times. Soil sampling (0-10 cm) occurred soon after sowing to obtain P availability measures across the trial (Table 1). Growth responses of each variety to applied P was assessed at the start of stem elongation, GS30 (data not shown) by NDVI and at maturity. Response of each variety to applied P was expressed as phosphorus use efficiency (PUE %) which = Yield (control, 0P)/Yield (maximum) x 100. Optimal P rates required to maximise yields were also calculated together with gross margins (GM), calculated by subtracting fertiliser cost off the income made in grain yield at each P rate. Prices used were as follows (PIRSA Gross Margin guide 2016) – wheat $260/t, barley $260/t and MAP $700/t.

Table 1. Soil test results for Pinery, 2015.

Crop		PBI	Colwell P (mg/kg)	DGT P (μg/L)
Barley	mean	135	28	17
Wheat	mean	135	31	14
Barley	minimum	128	23	11
	maximum	143	45	26
Wheat	minimum	129	21	8
	maximum	140	49	28

Interpretation: Critical Colwell P (mg/kg) for this site is 32 mg/kg based on PBI value. Colwell P values for both the barley and wheat trials were slightly deficient. DGT values indicate moderate deficiency with values well below the critical value of 52 μg/L.

Results and discussion

Grain yield

Wheat and barley yield penalties occurred when P was not applied at this site. Significant responses to P applications occurred for both wheat and barley (Table 2 and 3). There were also significant differences between the yields of wheat and barley varieties but no interaction between variety and P rate. This means that any differences in terms of PUE between the varieties was too small to assess.

In wheat, Corack and Mace performed well as did Compass, Fathom and La Trobe all yielded better than Commander. Optimal P rates were high for all wheat varieties (>50 kg P/ha) and greater than the highest P rate applied in this trial. For barley optimal P rates ranged from 22 to 50 kg P/ha. This high P requirement was caused by the high P fixing ability of this soil type and potentially later sowing time. The later sowing time may have caused the poor relatively performance of Trojan which is a longer maturing variety compared to the other wheat varieties sown.

Table 2. Wheat grain yield (t/ha), PUE (%) and optimal P (kg P/ha) for all varieties trialed at Pinery, 2015.

Variety	Yield (Control) t/ha	Maximum yield t/ha	PUE %	Optimal P kg/ha
Cobra	2.19	2.99	73	>50
Corack	2.66	3.58	74	>50
Mace	2.45	3.35	73	>50
Trojan	2.50	2.81	89	>50
Mean	*2.45*	*3.29*	*74*	*>50*

Treatment	P value	Least significant difference (LSD)
Variety	< 0.001	0.14 (t/ha)
P rate	< 0.001	0.17 (t/ha)
Variety x P rate	ns > 0.05	

Table 3. Barley grain yield (t/ha), PUE (%) and optimal P (kg P/ha) for all varieties trialed at Pinery, 2015.

Variety	Yield (Control) t/ha	Maximum yield t/ha	PUE %	Optimal P kg/ha
Commander	2.40	3.20	75	22
Compass	2.82	3.88	73	50
Fathom	2.78	3.68	76	46
La Trobe	2.94	3.95	74	44
Mean	*2.73*	*3.69*	*74*	*46*

Treatment	P value	Least significant difference (LSD)
Variety	< 0.001	0.182 (t/ha)
P rate	< 0.001	0.223 (t/ha)
Variety x P rate	ns > 0.05	

Gross margins (GM)

The calculated GM for each variety revealed that yield increases between varieties was the main driver of increased GM and was relatively independent of optimal P rates (Figure 1 and 2). Corack returned the greatest GM out of the wheat varieties trialed, while it was hard to differentiate between Compass, Fathom and La Trobe barley varieties. In general, the economic P rate where GM was maximised was lower than the P rate required to maximise yields overall. This indicates that on this soil type due to the lower efficiency of applied P, yield increments towards the higher part of the response curve are not great enough to generate income greater than the cost of extra P applied.

The GM curves also highlights the importance of determining economic P rates as considerable reductions in GM can occur with too low or too high P application rates. Economic P rates determined from this trial are considerably greater than P replacement rates based on 3 to 4 t/ha yields which would be 9-12 kg P/ha. To test if higher P rates are economical in your specific soil type, the authors suggest using P rich strips which consist of a P rate at least double typical replacement.

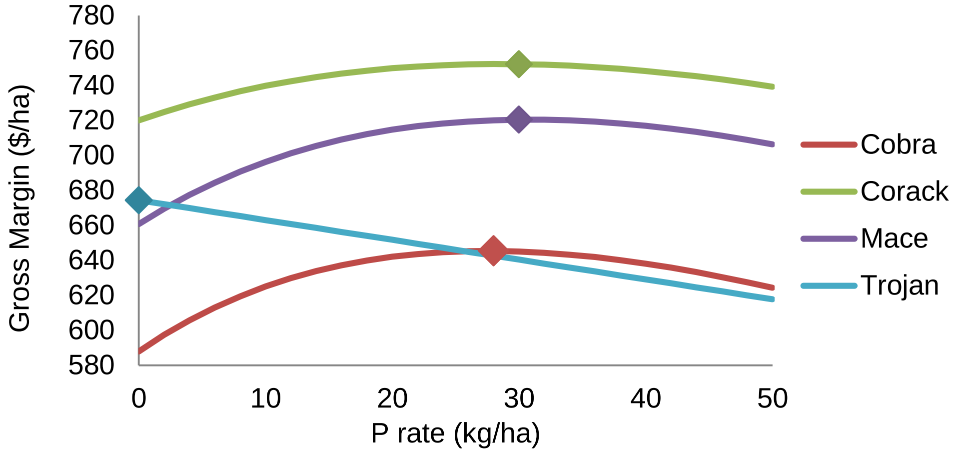

Figure 1. Gross margin curves for different P application rates in wheat. Data points on the curves indicate maximum GM at the associated P rate.

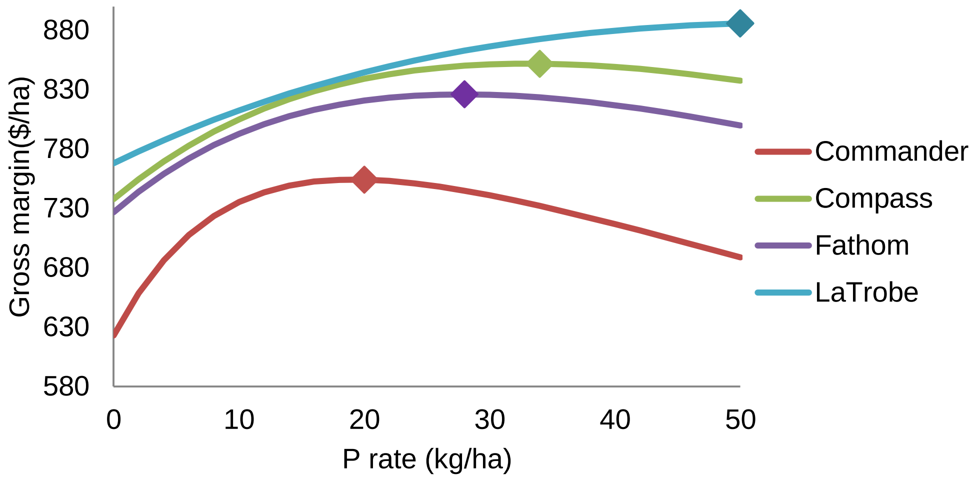

Figure 2. Gross margin curves for different P application rates in barley. Data points on the curves indicate maximum GM at the associated P rate.

Summary / implications

- Benefits in yield through choosing the most appropriate variety for a particular region outweighs any potential savings through choosing a variety based on higher PUE.
- Overcoming P deficiency on prone soil types (moderate – high PBI) with high P rates will not be the most economical management option but defining economic P rates is important as they are considerably higher than typical replacement rates.
- The use of farmer strip type trials where P rates are adjusted accordingly. That is P rich strips which consist a P rate at least double typical replacement rates to determine if high P rates are economical in your specific soil type.

Acknowledgements

The authors thank SAGIT for the financial assistance that supports this research (project code UA1201).