Is there a preferred wheat or barley variety to grow in a P deficient soil?

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Key findings

- At low available soil P and moderate PBI levels relatively high P inputs are required to maximise yields.
- Replacement P programs should incorporate a measure of PBI in order to effectively balance available P across different soil types.
- Significant yield differences between varieties of wheat and barley could not be attributed to varying P uptake efficiencies.

Why do the trial?

Aim: To investigate responses to phosphorus (P) fertiliser of common wheat and barley varieties on a P deficient soil.

The imperative for efficient use of P in broad acre agriculture is an increasing issue due to the likelihood of increased fertiliser prices contributing to greater production costs in the future. Maximising yields on the basis of providing adequate P nutrition can be achieved by applying sufficient amounts of P fertiliser to soils where P is limited. Fertiliser applied to the crop contributes only 5-30% to the crops total P uptake and therefore the rest of the crop's P requirements needs to be supplied from existing soil P reserves. 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 that is taken up. 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 farmers due to the relatively low P levels driven by highly P fixing soils in the region. Previous experiments conducted at Minnipa and Mallala in 2012 and 2013 revealed small significant responses to P applications among various wheat and barley varieties, however no significant differences could be obtained for PUE potentially due to the relatively small yield response obtained (EPFS 2013 pg 129-131). Trials were repeated in 2014 at Condowie where very low P levels were measured in an attempt to generate greater yield responses to P and identify if there are any significant differences in PUE between varieties.

How was it done?

On 3rd June 2014, six varieties each of wheat and barley were sown at five rates of P: 0, 5, 10, 25 and 40 kg P/ha replicated three times. The varieties sown were selected from a range of current commercial varieties and some old varieties that have been reported to show differences in P responses (see table 2 for list of varieties used). The P was applied as triple superphosphate, drilled with the seed at sowing.

Soil samples were taken across the field site and analysed for available P (DGT and Colwell P) along with a buffering measure (PBI). Early crop growth was assessed by taking biomass samples at three times – 30th July, 14th August and 25th August. The biomass was estimated by measuring NDVI with a Greenseeker ™ and calibrating the readings with biomass cuts at each site. At the same time and at harvest, a soil sample was taken in-row from a selection of the 0 kg P/ha plots to measure available P with time.

The PUE is defined as the grain yield at 0 P relative to the maximum grain yield obtained which is calculated at the plateau of the response curve which is fitted through the yield response data. Phosphorus requirement was estimated as the rate that gave 90% of the overall yield response to P application. The economics of returns from obtained yield vs cost of applied P was calculated based on prices of $280/t for APW wheat and $270/t for Malt barley, and a fertiliser price of $750 (DAP) (PIRSA Gross margin guide 2015).

Results and discussion

Low levels of available P were present at the Condowie site as measured by either DGT P or Colwell P compared to their respective critical values (Table 1). The site had moderate phosphorus buffering index (PBI) value.

Table 1. Mean and spatial variation in available P values at Condowie. Ten cores were taken in 10 plots of each trial (wheat/barley) and measured separately. DGT P presented as μg P/L, critical value = 52 (47-56, 95% CI), Colwell P and critical Colwell P in mg P/kg. Data are shown as mean ± standard error of the mean.

	DGT P	Colwell P	PBI	Critical Colwell P
Wheat	17± 2.0	22± 2.0	97± 3.0	28
CV(%)	37	24	8	
Barley	17± 1.0	17± 1.0	85± 1.0	26
CV(%)	39	22	10	

Early biomass production of wheat and barley responded significantly to P fertiliser rate (Figure 1). There was a linear response to P with no evidence of a plateau in the response outlining a relative inefficiency of the P application potentially due to the late sowing date and cold temperatures experience soon after sowing. These factors would cause slow early growth rates and reduced diffusion of P from fertiliser granules.

Significant responses to P applications and among varieties were obtained for grain yield in both wheat and barley (Figure 2, Table 2). Despite overall larger responses to P compared to the 2012 and 2013 seasons there was no significant Variety x P interaction in either wheat or barley. In other words, for both wheat and barley the yield differences among the 6 varieties were too small to pick up significant differences in their responsiveness to P. Barley varieties tended to yield higher than wheat which in part can be attributed to the occurrence of yellow leaf spot at early development for susceptible wheat varieties (Scout, Correll) as the trial was sown into wheat stubble.

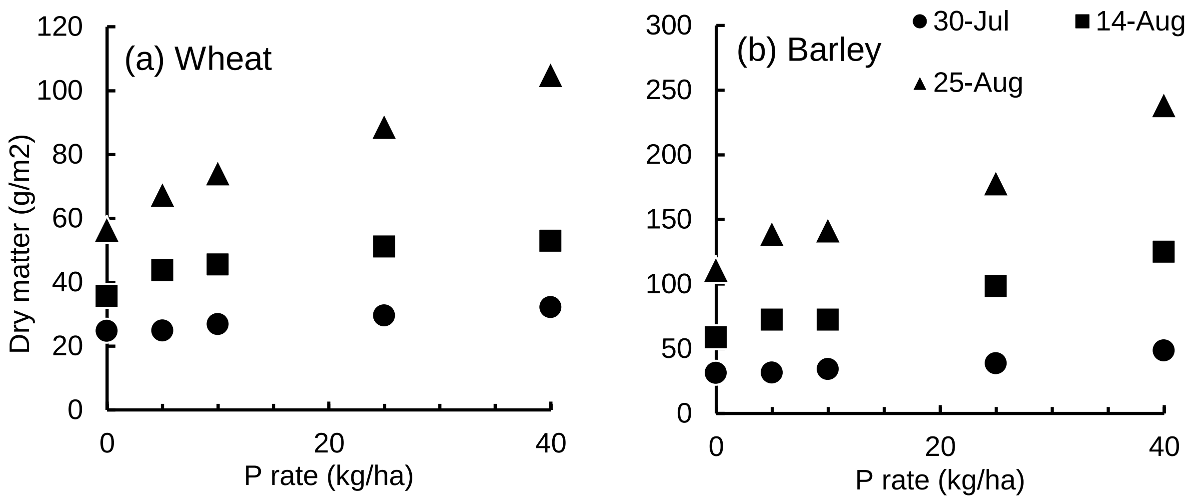

Figure 1. The responses in crop biomass to P of wheat and barley measured at three times during July and August.

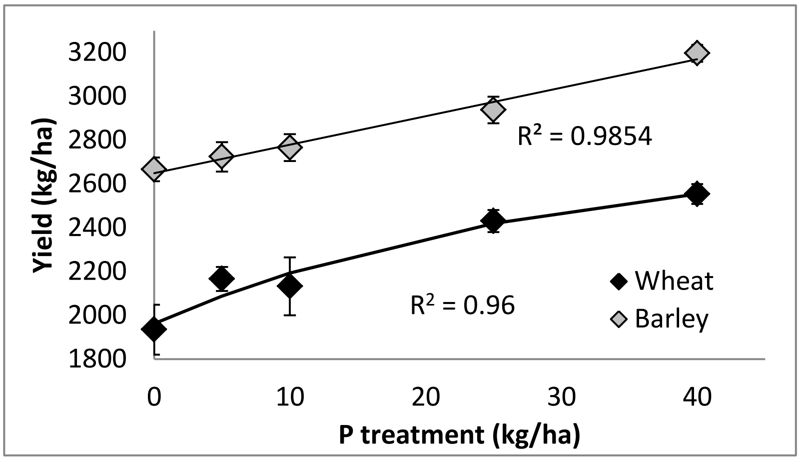

Figure 2. Mean wheat and barley grain yields across all varieties at each rate of P application. P < 0.001 (both wheat and barley), LSD = 202 and 115 kg/ha for wheat and barley respectively. Error bars represent standard error of replicates (18).

Table 2. Mean yields across all P rates for each variety at each field site.

Barley	Grain yield (kg/ha)	Wheat	Grain yield (kg/ha)
Variety		*Variety*	
Barque73	2962	Correll	2386
Commander	2962	Gladius	2294
Fleet	2939	Mace	2341
Galleon	2816	RAC875	2344
Hindmarsh	2853	Scout	1802
Yarra	2617	Wyalkatchem	2296
LSD (P=0.05)	254	LSD (P=0.05)	359
CV%	5	CV%	9

While highly significant grain yield responses to P were obtained the small response to P meant that yields at the low P rates were not significantly greater than the control for a number of the varieties. Significantly, greater yields were only achieved at 25 or 40 kg P/ha. Phosphorus deficiency could therefore be masked if trials on this soil type used rates below 25 kg P/ha and thereby give a false impression that P was not limiting.

There is a danger that current replacement P programs that attempt to match P removed off paddock in grain products are not flexible to varying fixation abilities of different soil types. Phosphorus rates required at Condowie were considerably higher than the replacement P rates required in 2014 based on average grain yields. Using the standard replacement rate of 3 kg P/tonne wheat grain, inputs for 2015 would be approximately 7-9 kg P/ha compared to predicted higher required rates based on outputs from 2014.

Despite required P rates at Condowie being calculated at the highest rate of P used (40 kg P/ha) or greater, the relatively flat linear response meant that the yields obtained in 2014 at these higher P rates (> 25 kg P/ha) were not necessarily the most economical with current grain and fertiliser prices (Table 3).

Table 3. Economic analysis based purely on fertiliser cost and yields obtained. Prices used can be found in the text. Economic optimal P rates for each category are highlighted in bold.

P treatment (kg/ha)	Fertiliser cost $/ha	Returns from yield ($/ha) wheat	Returns from yield ($/ha) barley	Net return ($/ha) wheat	Net return ($/ha) barley
0	0	542	720	542	**720**
5	19	607	735	**588**	717
10	38	597	747	560	709
25	94	681	793	**587**	699
40	150	715	863	565	713

The responses in yield to P were directly proportional to the responses in early biomass in both crops (Figure 3). This response appears to be different to N where high rates of N can promote vegetative growth without necessarily increasing yield.

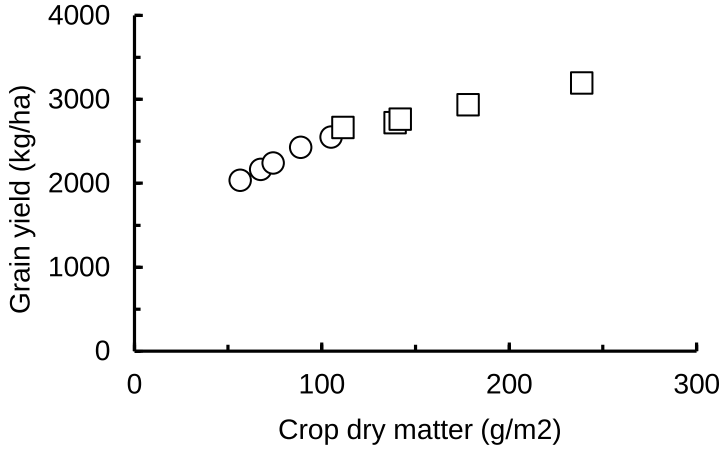

Figure 3. The relationship between crop biomass measured on 25th August and the grain yield of wheat (○) and barley (□).

Any difference in PUE between varieties has been difficult to observe due to natural field trial variability even though greater yield responses were obtained in 2014. Gains in yields through breeding new and improved varieties appear to outweigh any advantage of potentially growing P efficient varieties on P deficient soils. At current prices for fertiliser and grain it would be recommended to achieve maximum yields through sufficient P applications and growing appropriate varieties for the region as opposed to selecting potential high PUE varieties.

Summary / implications

Yield responses to P were associated with promotion of early crop biomass in both wheat and barley. Compared to N, there appears to be less risk of high P rates adversely affecting yields.

Despite large differences in yield among varieties, differences in responses to P have been small. At this stage variety selection should be based on yield rather than any differences in PUE to achieve the greatest return in investment from P.

Phosphorus nutrition levels should be continually monitored especially those on replacement P programs and soil types with moderate to high PBI levels. Unless the relative inefficiency of P applications and the capacity of some soils to fix P have been considered, replacement P inputs on these soil types could be driving down P levels. More efficient replacement P rates could be obtained if they are adjusted in accordance with PBI levels if they vary significantly within a paddock. We encourage the continued use of farmer strip trials (leave a strip of nil P fertiliser) in combination of with Colwell P and DGT results for on farm validation of the soil tests.

For paddocks with moderate to high PBI levels significant information could be obtained by incorporation of a P rich strip (e.g. 40 kg P/ha) next to the standard rate (10 kg p/ha) to ensure P deficiency is not masked by relative low fertiliser efficiency.

Acknowledgements

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