INVITED ARTICLE

BREAK CROP BENEFITS IN LOW P ENVIRONMENTS: IS PHOSPHORUS A FACTOR?

Sean Mason and Ashlea Doolette (University of Adelaide) and Stuart McColl (BCG)

TAKE HOME MESSAGES

- Wheat yields were highest when grown after chickpeas or lupins at both low and moderate phosphorus (P) sites.
- Benefits provided by the previous chickpea or lupin crops could not be attributed to an increase in residual P sources alone.

KEYWORDS

Break crop, Colwell P, DGT, P rate, P response, phosphoros, residual P.

BACKGROUND

In 2012, two phosphorus (P) responsive trials were established to assess the efficiency of different crop types under low P conditions (*BCG 2012 Season Research Results* pp.116-120). The findings from these trials showed that wheat, canola, chickpea and lupin crops were all responsive to applications of P at the low P site at Sunnyside, but were non-responsive at the moderate P site at Ballapur.

Further to this, at Sunnyside, each crop type revealed different efficiencies in terms of the external P requirements needed to achieve its maximum yield. Unexpectedly, crops that had previously been shown to solubilise sources of less available P (chickpea and lupin) were less efficient than canola and wheat.

Previous trials investigating the ways in which break crops benefit wheat yields have for the most part been performed at adequate P levels (due to sufficient applications of P). The use of the two sites, low P at Sunnyside and moderate P at Ballapur, provided an opportunity to: i) to examine whether residual P levels, following certain break crops, were enhanced under P deficient conditions; and ii) to determine whether any benefit from the break crop rotation to the succeeding wheat in the rotation is due to the presence of P. To that end, in 2013, both sites were sown to wheat. No further applications of P were applied to the trial in order to assess the residual benefits of each previous crop type and differing applications of P.

AIM

To determine the ways in which different crop types influence available soil P and the P requirements of subsequently sown cereals.

METHOD

Kord CL Plus wheat was sown over previous trials at Sunnyside (10km south west of Birchip) and Ballapur (23km west of Birchip) that had examined the interaction between P rates and different crop types in low P environments. The wheat was sown as close as practical to the previous season's stubble row of each crop type – canola, chickpeas, lupins and wheat. The trial was managed to maximise yield (i.e. weed and disease free). No P fertiliser was applied in 2013, but in 2012 six varying P rates (0, 3, 6, 12, 18 and 24kg/ha) were applied to each of the crop types at both sites.

Soil samples were collected one week after sowing, with ten cores taken from the top-soil (0-10cm) of each plot in furrow. Wheat grain yields were measured and gross margins calculated.

Locations:	Ballapur and Sunnyside	
Replicates:	Four	
Sowing date:	28 May	
Crop type:	Kord CL Plus wheat	
Seeding equipment:	BCG Gason parallelogram cone seeder (knife points, press wheels, 30cm row spacing)	
Fertiliser:	28 May	Urea (50kg/ha) IBS
	12 July	Urea (90kg/ha)
Herbicide:	28 May	TriflurX® (2L/ha) + Sakura® (118g/ha)
	9 July	Intervix® (600ml/ha) + Lontrel™ Advanced (125ml/ha) + MCPA LVE (350ml/ha) + Hasten™ (1%)
Harvest dates:	Sunnyside	25 November
	Ballapur	6 December

RESULTS AND INTERPRETATION

Soil test results

Soil chemical characteristics for each site can be found in *BCG 2012 Seasons Research Results* (pp. 118). Soil P test results (DGT, Colwell P) performed on samples taken immediately after sowing revealed that Sunnyside was still at deficiency levels, while Ballapur's were marginal to adequate P levels (Table 1). Significant ($P \leq 0.05$) increases in DGT P (both sites) and Colwell P (Sunnyside only) according to P application rates indicated there were residual benefits from a previous year's P application, despite the furrow shifting slightly. However, this increase, with the corresponding P rate, was more notable where canola, lupin and wheat had been grown (both soil tests). Erratic, but slight, increases were evident where chickpeas had been grown. At both sites, where low P rates were applied, significant differences in DGT values between crops were recorded. This could not be explained by any site variation observed from 2012 soil analysis.

At Sunnyside, both chickpeas and wheat had higher DGT values when no P was applied, while at Ballapur, chickpeas also had the highest DGT P value. Any differences were not related to P removed in the grain from the previous crop (data not shown).

Table 1. Soil test results (DGT in µg/L, Colwell P in mg/kg) from soil samples (0-10cm) taken near sowing from each rotation.

			P rate (kg/ha) 2012						
Site	Crop history	Soil test	0	3	6	12	18	24	2012
Sunnyside	canola/wheat	DGT	26	22	30	36	37	50	**33**
		Colwell P	16	14	17	22	21	29	**21**
	chickpea/wheat	DGT	35	31	37	39	40	38	**22**
		Colwell P	18	15	18	18	20	19	**18**
	lupin/wheat	DGT	27	33	25	29	37	35	**21**
		Colwell P	16	17	17	17	19	21	**18**
	wheat/wheat	DGT	37	36	39	39	48	64	**21**
		Colwell P	17	16	17	19	21	26	**21**
Stats	**DGT**	**Crop**	**P=0.006, LSD (0.05)=7.4**						
		P rate	**P=0.003, LSD (0.05)=9**						
		Crop. P rate	**NS**						
	Colwell P	**Crop**	**NS**						
		P rate	**P=<0.001, LSD (0.05)=3.4**						
		Crop. P rate	**NS**						
Ballapur	canola/wheat	DGT	63	75	84	82	85	87	**90**
		Colwell P	27	27	27	29	29	30	**21**
	chickpea/wheat	DGT	84	100	87	86	79	89	**85**
		Colwell P	23	27	27	24	25	28	**20**
	lupin/wheat	DGT	59	68	72	91	86	111	**71**
		Colwell P	21	23	23	27	28	28	**26**
	wheat/wheat	DGT	54	63	74	82	79	69	**118**
		Colwell P	22	24	28	27	27	25	**23**
Stats	**DGT**	**Crop**	**P=0.029, LSD (0.05)=11**						
		P rate	**P=0.019, LSD (0.05)=13.9**						
		Crop. P rate	**NS**						
	Colwell P	**Crop**	**NS**						
		P rate	**NS**						
		Crop. P rate	**NS**						

Yield results: Sunnyside

Overall, there was a significant ($P \leq 0.05$) linear yield response to residual P applications (R^2=0.8) in addition to a yield effect from the previous crop rotation (Table 2). At almost all P rates, the 2013 wheat yield following each previous crop was generally lowest for the continuous wheat rotation, followed by canola/wheat and was greatest for the lupin/wheat and chickpea/wheat rotations. No significant P response was obtained for each crop rotation individually, but there were linear trends of increased yield with P rate. This suggests the existence of a small residual value from the previous year's application of P, but not enough to maximise yields. This observation was supported by the relatively slight increases in soil test values with residual P rate. It should be noted that phosphorus does not move very far from the point of application and, given that the following wheat was sown adjacent to the previous year's crop row, the P application was less effective.

Table 2. Yield results from low P site at Sunnyside.

	2013 wheat yield (t/ha)				
P rate (kg/ha)	Wheat/ wheat	Canola/ wheat	Lupin/ wheat	Chickpea/ wheat	Mean of crops for P-rate
0	2.63	3.00	3.21	3.30	**3.04**
3	2.42	2.80	3.37	3.34	**2.98**
6	2.69	3.21	3.38	3.48	**3.19**
12	2.72	2.96	3.25	3.51	**3.11**
18	2.72	3.26	3.57	3.62	**3.29**
24	2.73	3.37	3.67	3.62	**3.35**
Mean (crop type yield)	**2.65**	**3.10**	**3.41**	**3.48**	
Sig. diff.					
Crop		P<0.001			
P-rate		P=0.049			
Crop x P rate		NS			
LSD (0.05)					
Crop		0.217			
P-rate		0.266			
Crop x P rate		11.9			
CV%					

Yield results: Ballapur

No significant P response was obtained overall or for each separate crop rotation (Table 3). There was, however, a significant difference (P≤0.05) in wheat yields following the different crop rotations. As with Sunnyside, wheat grown after lupins or chickpeas yielded higher at all P rates. Wheat grown after lupins had the best overall yields.

Table 3. Yield results from moderate P site at Ballapur.

	2013 wheat yield (t/ha)				
P rate (kg/ha)	Wheat/ wheat	Canola/ wheat	Lupin/ wheat	Chickpea/ wheat	Mean of crops for P-rate
0	1.69	1.65	2.00	1.85	1.8
3	1.67	1.70	1.96	1.84	1.79
6	1.69	1.66	1.93	1.78	1.77
12	1.71	1.69	2.02	1.91	1.83
18	1.79	1.70	1.99	1.88	1.84
24	1.70	1.73	1.99	1.93	1.84
Mean (crop type yield)	**1.71**	**1.69**	**1.98**	**1.87**	
Sig. diff.					
Crop		P<0.001			
P-rate		NS			
Crop x P rate		NS			
LSD (0.05)					
Crop		0.06			
P-rate		-			
Crop x P rate		-			
CV%		5.9			

Crop type and P economics

Combined gross margins over the two year crop sequence calculated simply on yield responses and P input costs revealed contrasting benefits from break crops (Tables 4 and 5). At Sunnyside, the most profitable crop rotation was chickpea/wheat followed by canola/wheat. The importance of diagnosing P deficiency was again highlighted by the best returns when P was applied at a rate of either 12kg/ha or 24kg/ha.

At Ballapur, the wheat-on-wheat rotation produced the most profitable gross margin followed by the chickpea/wheat rotation. Relatively lower canola and chickpea yields compared with wheat in year one at Ballapur influenced this result. High soil P levels at the beginning of the trial, and minimal crop responses to P, resulted in the most economical P rates being at the lower range (0 or 12kg/ha).

Table 4. Combined gross margins from the two year rotation at the P responsive site - Sunnyside.

	Gross margin ($/ha)			
P rate (kg/ha)	Wheat/wheat	Canola/wheat	Lupin/wheat	Chickpea/wheat
0	1081	1154	905	1260
12	1183	1208	985	1425
24	1149	1351	1186	1497

Table 5. Combined gross margins from the two year rotation at the P non-responsive site - Ballapur.

	Gross margin ($/ha)			
P rate (kg/ha)	Wheat/wheat	Canola/wheat	Lupin/wheat	Chickpea/wheat
0	933	733	577	814
12	894	736	621	807
24	859	678	542	757

Note* Gross margins calculated on the 2013 wheat price of $265/t (H1-H2). Grain prices for each crop type in 2012 were reported in the *BCG 2012 Season Research Results*.

It appears that the increase in yields associated with the wheat crop following either lupin or chickpea was not due to a P benefit. If there was a benefit, it was very small. Soil P values did not show a definitive increase in P after lupins or chickpeas, and wheat yield benefits after these crops also occurred at the non-responsive P site at Ballapur. Both lupins and chickpeas have the ability to fix nitrogen (N) from the atmosphere, which could provide extra N to the subsequent crop. Wheat yield benefits were evident even when lupin yields were low (just 0.15-0.17 t/ha in 2012).

At the time of writing this article, the crop P and N contents had not been collated. It is anticipated that P balances will be calculated once these values are available.

COMMERCIAL PRACTICE

Incorporating break crops into cropping rotations benefits the subsequent cereal phase. These two trials support previous work that suggests this. Knowledge about soil constraints that may reduce the yields of certain break crops is important.

Results from 2012 and 2013 suggest that break crops can offer a viable alternative to cereals as long as the P status is correctly evaluated.

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