Rate or row spacing? What increases crop P uptake from deep-placement in southern Queensland cropping soils?

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Abstract

Placing fertiliser phosphorus below 0.1m depth has reliably increased the grain yield of many crops. Growers are seeking to maximise this subsurface placement opportunity through decisions on how much to apply (rate) and where to apply it (band spacing). Higher rates have greater up-front cost, while narrower band spacing requires more tines in the ground and increased energy to insert them. Outcomes of two experiments evaluating both rate and band spacing effects suggest that application rate influences yield response more than row spacing.

Keywords

Phosphorus, subsurface, in-row concentration, NDVI, grain yield

Introduction

Recent research (Lester et al., 2018) shows that cereal and pulse crop yields can be reliably increased with subsurface (≈ 0.2m) or "deep-placed" phosphorus (P). However, this research used a constant 0.5 m fertiliser band spacings with granular MAP. Consequently, questions have arisen around the best approach to increase P uptake with deep placement?

Crop P uptake by roots is a diffusion driven process, meaning banded applications are likely to provide a better opportunity for fertiliser P recovery. The concentration gradient created in the band is a function of two factors: how much is applied (the rate) and where is it applied (the band spacing translating to lineal meters of row per ha). Exploratory placement experiments suggested 0.25 m bands were equivalent to 0.50 m bands, and both were better than the wider 1.00 m spacing that could be used to reduce application costs. These experiments however used a constant P rate (40 kg P/ha), so different band spacing were also characterised by different in-band nutrient concentrations.

This research aims to determine how different P fertiliser rates at different band spacing combinations alter crop response and fertiliser recovery, over a range of crop species with contrasting rooting characteristics:

a) Is phosphorus uptake increased when the band spacing is reduced from 0.5 to 0.25 m?

b) Is phosphorus uptake maintained when the band-spacing is increased from 0.5 m to 1.0 m to save application costs?

Methods

Two experiments at Jimbour West on the northern Darling Downs are reported here, exploring fertiliser P rate x band spacing interactions for deep placement (≈0.2m). Experiments at Field-W2 (W2) commenced in March 2015, and field-W5 (W5) commenced in March 2016. Both soils are grey Vertosols of the Cecilvale series (Isbell 2002). Selected chemical analysis for both sites are shown (Table 1).

Two experimental designs were used. In W2 an incomplete factorial of 5 P rates (0, 10, 20, 40 and 80 kg P/ha) x 3 band spacings (0.25, 0.50 and 1.00 m) plus an untreated control without soil disturbance was used. In W5, a complete factorial of the same 5 rates x 3 band spacings was used as main plots, with a split-plot of delivery type comparing granular vs fluid P forms. Granular fertiliser in both was

mono-ammonium phosphate (MAP 11N 22P) and urea (46N) balanced nitrogen across treatments. Both experiments used 6 replicates.

Table 1 – Soil test results for Jimbour West deep-Placed P rate x band spacing experiments

Depth	pH H2O	pH CaCl2	Col P (mg/kg)	BSES P (mg/kg)	PBI
			W2 field		
0.0-0.1 m	7.0	5.9	46	85	88
0.1-0.3 m	8.0	6.7	5	9	80
0.3-0.6 m	8.8	7.4	4	6	-
			W5 field		
0.0-0.1 m	7.4	6.6	18	30	73
0.1-0.3 m	7.9	6.7	4	12	73
0.3-0.6 m	8.4	7.5	6	-	88

Across the two sites six crops have been grown, four in W2 (Table 2) and two in W5 (Table 3). Growing season conditions for every crop has been challenging with below average rainfalls. Crop sowing has been at the discretion of the grower co-operator where the experiments were located.

Table 2 – Agronomic details for crops in W2.

Crop	Barley	Cotton	Barley	Sorghum
Date Sown	21-May-15	13-Oct-16	1-Aug-17	6-Nov-2018
Variety	Sheppard	748BRF3	Compass	Radicle Seeds “Brazen”
Row spacing m	0.375	1.5	0.375	0.75
Population	50 kg/ha (sown)	14 seeds/m	90 kg/ha (sown)	70 000 target
Starter product	Supreme-Z	MAP 2% Zn	Nil	Granulock Z
Starter rate	30 kg/ha (6.6 P)	30 kg/ha (6.6 P)	NA	30 kg/ha (6.6 P)
Maturity biomass date	21-Sep-15	16-Feb-17	NA	18-Feb-2019
Harvest date	23-Oct-15	31-Mar-17	15-Dec -17	24-Feb-2019
Fallow rainfall	NA	542	131	485
In-crop rainfall	104.5	97	101	94

Table 3 – Agronomic details for crops in W5.

Crop	Chickpea	Sorghum
Date Sown	20-May-17	9-Nov-2018
Variety	Seamer	Pioneer Seeds “A66”
Row spacing m	0.375	0.75
Population	60 kg/ha sown	70 000 target
Starter product	Granulock Z Extra	Granulock Z Extra
Starter rate	20 kg/ha (4.4 P)	30 kg/ha (6.6 P)
Maturity biomass date	20-Oct-17	14-Feb-2019
Harvest date	31-Oct-17	22-Feb-2019
Fallow rainfall	NA	527
In-crop rainfall	126	94

Dry matter samples at maturity have been collected from all crops (with varying sampling intensity) to characterise the crop responses. In general, cuts have been taken from most rate x row spacing combinations, but fewer samples were gathered for more moisture challenged crops such as the double crop barley following cotton in W2. Samples were dried and weighed prior to being homogenised and sent for chemical analysis. P uptake (kg P/ha) is calculated as dry matter (kg/ha) * P concentration (mg/kg). Grain (or seed) yields were machine harvested and corrected to constant moisture. For the cotton sowing, seed yield is reported.

Statistical analysis for dry matter, P uptake and yield was done in Genstat. The unbalanced procedure was used for W2, while ANOVA was used for W5 data. For ease of reporting the FR treatments are W2 are omitted with the P application rates shown.

Results

Above ground dry matter at maturity has been increased with increasing P rate in 3 of 6 sites years across the two sites (Table 4). Responses are approximately 10% greater than the 0P treatment, with the effect mainly detectable in the > 20 kg P application rates. In several years, distinct visual growth

responses were observed mainly in the stages up to flowering (photos not shown) however these effects are very challenging to precisely capture in a dry matter cut. Crops grown in 2017 and 2018-19 allowed drones to capture NDVI for assessment of relative influence that rate and band spacing. In general, the rate applied appeared to be a more dominant contributor to NDVI, with band spacing a lessor influence (Fig. 1).

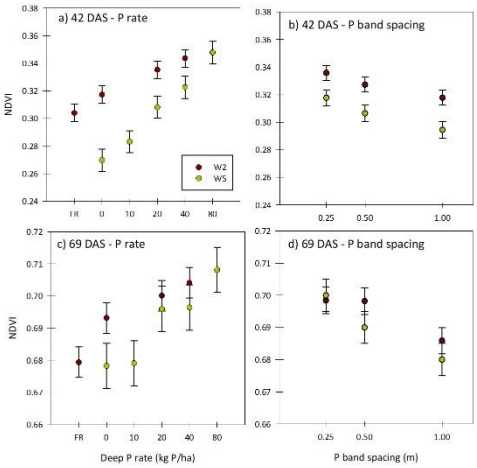

Figure 1. NDVI of sorghum at 42 and 69 DAS for W2 and W5 experiments in 2018-19

Maturity dry matter P uptakes were statistically significant for P rate for only 2 of the 6 trials (W2 in 2015 barley and W5 for 2018-19 sorghum), and one for P band spacing in W2 barley of 2015 (Table 5). In general, crop P uptake increased with increasing application rate, and decreasing as band spacing increased. The relative differences between the rate and band spacing effect also highlight the influence of each. Crop P uptake increases with rate were generally > 2kg P/ha whereas different band spacing produced changes of < 1.5 kg P/ha.

Table 4 – Mean maturity dry matter (kg/ha) for P rate and band spacings at W2 and W5 sites. Values for a particular crop/year with the same letter are not significantly different (P = 0.05)

Site	Crop	Year	P rate (kg P/ha)					P band spacing (m)		
			0	10	20	40	80	0.25	0.50	1.00
W2	B	2015	10848 a	11929 b	11617 b	12033 b	12244 b*	11763 a	11263 b	11287 b
W2	Ct	2016-17	3533	NA	NA	3520	NA	3413	3435	3679
W2	B	2017	NA	NA	NA	NA	NA	NA	NA	NA
W2	Sg	2018-19	11270	NA	11479	11851	NA	11078	12402	11120
W5	Ch	2017	3792 a	4125 b	4701 cd	4459 c	4750 d	4421	4416	4258
W5	Sg	2018-19	11142 a	11546 ab	11931 abc	12536 c	12092 bc	11890	11717	11941

* the 80 P rate at W2 is only at 1m band spacing

Table 5 – Mean P content in above ground dry matter at maturity (kg P/ha) for P rate and band spacings at W2 and W5 sites. Values for a particular crop/year with the same letter are not significantly different (P = 0.05) NA = not determined

Site	**Crop**	**Year**	**P rate (kg P/ha)**					**P band spacing (m)**		
			0	10	20	40	80	0.25	0.50	1.00
W2	B	2015	14.0 a	15.6 ab	16.4 bc	17.9 c	18.4 c*	17.0 a	15.9 ab	15.3 b
W2	Ct	2016-17	4.0	NA	NA	4.3	NA	3.9	4.3	4.7
W2	B	2017	NA	NA	NA	NA	NA	NA	NA	NA
W2	Sg	2018-19	13.0	NA	14.1	12.4	NA	13.7	13.3	12.5
W5	Ch	2017	3.8	4.1	4.8	5.5	6.4	4.8	5.00	5.0
W5	Sg	2018-19	10.2 a	11.3 bc	11.3 bc	11.1 ab	12.3 c	11.3	11.1	11.3

* the 80 P rate at W2 is only at 1m band spacing

Yield had a similar trend to DM P uptake - increased yield with increasing P application rate (Table 6). Responses generally has a step-wise increment from 0-10 kg P/ha as a baseline and plateauing across the 20,40, 80 kg P/ha application rates. There was no effect of band spacing on yield in any crop.

Table 6 – Mean grain yield (kg/ha) for P rate and band spacings at W2 and W5 sites. Values for a particular crop/year with the same letter are not significantly different (P = 0.05) NA = not determined

Site	Crop	Year	P rate (kg P/ha)					P band spacing (m)		
			0	10	20	40	80	0.25	0.50	1.00
W2	B	2015	4440 a	4482 a	4817 b	4694 b	4701 b*	4547	4649	4596
W2	Ct	2016-17	374	366	376	364	403*	377	367	375
W2	B	2017	752	732	731	746	728*	731	760	756
W2	Sg	2018-19	3083	3068	3048	3314	3466*	3118	3202	3138
W5	Ch	2017	1752 a	1937 b	2065 c	2155 cd	2266 d	2043	2007	2031
W5	Sg	2018-19	3927 a	3930 a	3896 a	4017 a	4339 b	4058	3957	4051

* the 80 P rate at W2 is only at 1m band spacing

While differences between means for dry matter, P uptake and yield where limited, the underlying relationships between crop P uptake and yield showed positive correlations for each crop at both (Fig. 2).

Conclusion

The P fertiliser rate placed at depth had a larger influence on plant growth than the band spacing that the P was placed in. Wider spacings have slight reductions in relative growth compared to narrower bands, but it appears, at least from the trial data to date with seasonal conditions that were challenging, that yields are more likely to be increased by the rate of deep-placed P than the band spacing of it. While no field research has been conducted to confirm, banding in the direction of sowing at no more than double the row spacing of the narrowest crop in the rotation also appears a pragmatic approach for growers.

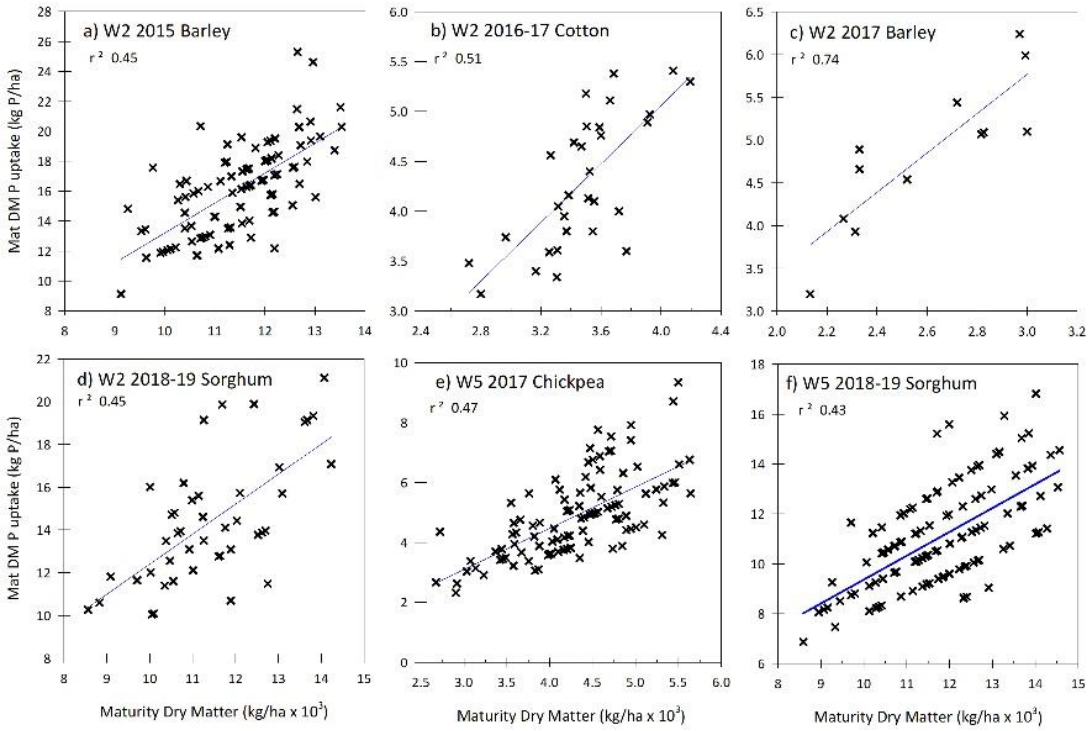

Figure 2. Maturity Dry matter vs P uptake for 6 site years across W2 and W5

References

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