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Chickpea response to deep placement of phosphorus on a chromosol soil – Gilgandra 2017

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Key findings

- Applying phosphorus (P) as a starter fertiliser (MAP) resulted in a 90% increase in chickpea yield compared with nil starter, across all treatments, including the residual P treatments.
- There was a significant starter P by residual P rate effect, with yield responses to increasing triple superphosphate (TSP; P 20.1%) rates in the absence of starter fertiliser, but no increase when starter MAP was applied.
- Yields with no TSP, but with starter fertiliser were amongst the highest yielding in the experiment. TSP as residual P and starter P (~17 kg P/ha) at planting, maximised crop responses.
- These results highlight the effectiveness of in-furrow application of starter P on crop growth and efficiency of P uptake under conditions of limited moisture availability.
- In the absence of P uptake data, these findings suggest that MAP is an efficient source of available P, and when applied in the furrow in a dry season can provide strong yield benefits.

Introduction

Research looking at the benefits from deep placement P has focused on the black/grey self-mulching vertosol soils of the Northern Grains Region (NGR) of northern NSW and central/southern Queensland. This has been due to the growing awareness of nutrient rundown on these inherently fertile soils, and the stratified distribution of P within the soil profile. The region of nutrient rundown has typically been in the 10–30 cm layer, beneath where starter P fertiliser is placed at sowing and where residual plant matter is returned. As a consequence, P distribution has been stratified within the soil profile, with P more readily available in surface layers (0–10 cm) and less available further down the profile. Importantly, crops growing on these vertosol soils rely on subsoil moisture and nutrients for extended periods in the growing season, with the topsoil often dry. Unless immobile nutrients such as P are present in the subsoil, crop roots are unable to access nutrients required to meet yield potential. In dry seasons, when crops rely on stored water for growth, P is almost entirely obtained from the sub-surface layers (10–30 cm) for most of the growing season.

In the central west of NSW, with the adoption of no-till farming and associated intensification of cropping systems, there has been growing interest in the potential benefits from deep P placement on chromosol/dermosol soils. These soils, in contrast to the northern vertosols, tend to be of moderate fertility, have lower soil water holding capacity and crop production is more reliant on in-crop rainfall.

The aim of this experiment was to test whether placing immobile nutrients such as P deeper in the profile of chromosol soils will increase yields above the traditional approach of starter P placement in or near the seedling row. These experiments will contribute towards the Making Better Fertiliser Decisions for Crops (https://www.bfdc.com.au/interrogator/frontpage.vm) database that identified significant gaps in our knowledge of plant responses to P, particularly subsoil P requirements. Results presented from this experiment are a summary of data collected from the 2017 winter growing season of a chickpea crop grown over an ongoing residual P-response experiment near Gilgandra in central/west NSW.

Site details

Location	Gilgandra – 'Chippendale'
Co-operator	Kevin Kilby
Crop, variety	Chickpea, PBA HatTrick$^{\Phi}$
Previous crop, variety	Barley, Commander$^{\Phi}$
Soil type	Red/brown Chromosol pH_{Ca} 5.2 (0–10 cm) pH_{Ca} 5.5 (10–30 cm)
Starting P	Colwell: 21 mg/kg (0–10 cm), 7 mg/kg (10–30 cm) BSES: 61 mg/kg (0–10 cm), 16 mg/kg (10–30 cm)
Sowing date	25 May 2017
In-crop rainfall	131 mm (May to October)
Starter fertiliser	80 kg/ha Granulock Z
Residual fertiliser	Triple superphosphate to ~20 cm deep parallel to the sowing direction on 33 cm row spacings in April 2015.
Harvest date	7 November 2017

Treatments

Experiment treatments were as follows:

- Twelve tillage × P treatments (applied shallow or deep) with or without starter fertiliser in the furrow at sowing, by four replicates (Table 1).
- Two farmer reference (FR) or control treatments: plus or minus starter P fertiliser application with no deep ripping.
- Deep-placed residual P: TSP to a depth of ~20 cm, parallel to the sowing direction on 33 cm row spacings in April 2015.
- Shallow-placed residual P: TSP to ~5 cm deep into the seeding furrow in April 2015.
- Starter fertiliser P (MAP): applied at sowing into the furrow.
- Nil treatments balanced for nitrogen and sulfur using urea and gypsum.

Means were compared by conducting two separate analyses of variance (ANOVA) assessments, using either:

1. the 12 tillage/P treatments plus or minus deep/shallow P, or
2. responses to starter fertiliser P in soil that had been deep-ripped and with varying rates of deep/shallow P before the first crop season, in April 2015.

The initial analysis compared the FR treatments with the deep or shallow-ripped treatments to see if there was any interaction between tillage/P use and starter P response. The second explored the interaction between deep/shallow P rate and starter fertiliser P, specifically to see whether the starter fertiliser P use could overcome the need for deep/shallow P, or vice versa.

Table 1 Grain yield response to treatments

Treatment	Triple P (kg P/ha)	Starter P (MAP)[#]	Cultivation*	Grain yield (t/ha)
1	0	Nil	Nil – FR	0.28
1	0	Plus#	Nil – FR	0.70
2	0	Nil	Deep ripped*	0.39
2	0	Plus#	Deep ripped*	0.93
3	10	Nil	Deep ripped*	0.47
3	10	Plus#	Deep ripped*	0.70
4	20	Nil	Deep ripped*	0.42
4	20	Plus#	Deep ripped*	0.81
5	40	Nil	Deep ripped*	0.62
5	40	Plus#	Deep ripped*	0.85
6	80	Nil	Deep ripped*	0.64
6	80	Plus#	Deep ripped*	0.84
7	0	Nil	Nil – FR	0.28
7	0	Plus#	Nil – FR	0.70
8	0	Nil	Shallow^	0.21
8	0	Plus#	Shallow^	0.71
9	10	Nil	Shallow^	0.26
9	10	Plus#	Shallow^	0.80
10	20	Nil	Shallow^	0.31
10	20	Plus#	Shallow^	0.82
11	40	Nil	Shallow^	0.44
11	40	Plus#	Shallow^	0.58
12	80	Nil	Shallow^	0.53
12	80	Plus#	Shallow^	0.85
			l.s.d. ($P = 0.05$)	0.18

* Deep ripped to ~20 cm deep
^ Shallow placement ~5 cm into seeding furrow
[#] 80 kg/ha MAP.

Results

- There was a strong and consistent response to applied starter P across all treatments, with chickpea yield increases averaging 90% compared with the nil starter P (0.405 t/ha).
- There was a small, but significant yield increase from the deep residual P bands compared with the shallow TSP P bands. This response was small compared with that of starter P, with deep applications yielding ~29% higher than shallow applications (Table 1). There was no interaction between the original placement depth of TSP bands (deep or shallow) and either P rate or starter P use.
- There was a strong starter P × residual P rate interaction (Figure 1), which showed that in the absence of starter P, yields increased with high (40 kg P/ha and 80 kg P/ha) residual P rates relative to low rates (10 kg P/ha and 20 kg P/ha) or treatments without TSP bands. While the responses were large in relative terms (100% yield increase from 80 kg P/ha relative to zero P), they were exceeded by the response to starter P, with added starter P completely overriding any response to residual P.
- Both shallow TSP bands and MAP applications were placed at the same depth. The lack of response to shallow TSP bands compared with MAP in the same area of the profile suggests that banded TSP is an inefficient source of P. The close proximity of the starter P application to developing root

systems in a rapidly drying surface soil in 2017 could also have been a contributing factor. Chickpea biomass data was not analysed to test the effects of differing application strategies on crop P acquisition. Regardless, the data suggests much higher efficiency of MAP for chickpea crop use when P is applied as a starter rather than than P from the TSP applications.

- The strong linear relationship between yield and grain P content (Figure 2) indicates that any additional available P that the plant was able to access/uptake was converted into extra yield.

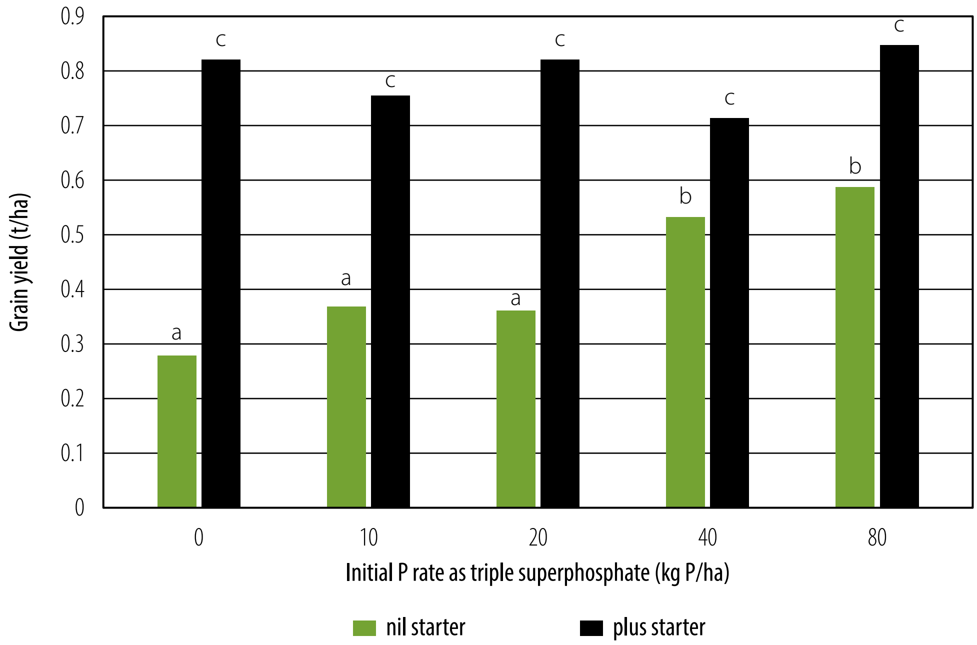

Figure 1 Yield response to residual P (TSP) and starter P fertilisers (minus vs plus). Bars with the same letter are not significantly different ($P = 0.05$). The residual P as TSP bands with data showing an average of shallow and deep applications. Starter applications were MAP applied in the seeding row at sowing.

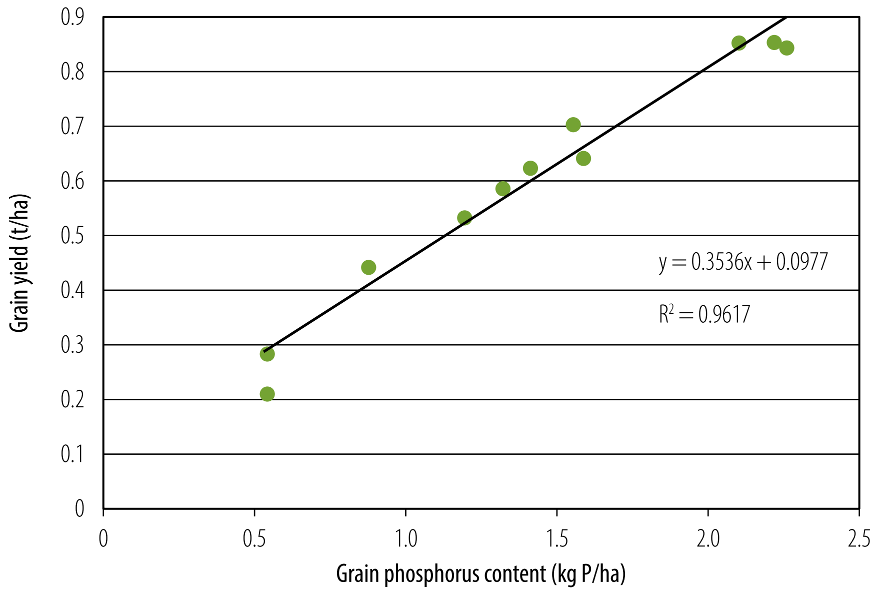

Figure 2 Chickpea grain P uptake (kg/ha) vs. yield (t/ha), Gilgandra 2017 (FR, 40 kg P/ha and 80 kg P/ha) plus and minus starter.

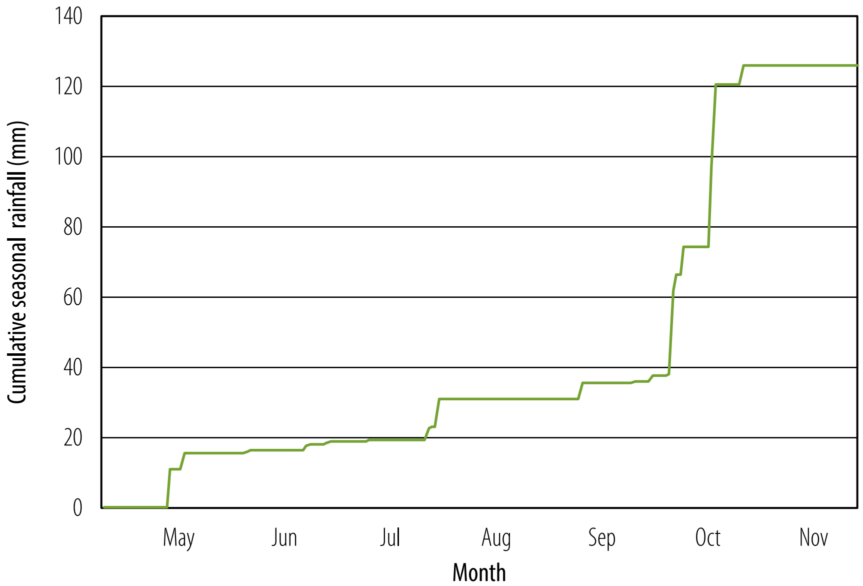

Figure 3 Cumulative in-crop rainfall, Gilgandra 2017.

Conclusions

The positive yield response to starter P applied at sowing in this season shows that the chickpea relied heavily on MAP as a source of P. This would most likely have been due to restricted root access in the rapidly drying subsoil from the dry growing season conditions experienced in 2017 (Figure 3) and the moderate water-holding capacity of the soil. The crop probably only had access to the deep bands of TSP for a limited period following rain in late May/early June. In dry years, placing P in the seeding row ensures the best chance of P uptake versus the uptake of high rates of (residual) TSP applied deeper in the soil profile, which plant roots might not be able to access.

Results showed large yield responses of ~90% to starter P, averaged across all treatments, increasing from 0.405 t/ha to 0.774 t/ha. Although there was a positive yield response to residual deep bands of TSP in the absence of starter P, this was overshadowed by the response to starter P applied in the furrow (Figure 1). Yield responses to starter P applied at ~17 kg P/ha, were larger than for those from the deep bands of TSP applied at rates of 40 kg P/ha and 80 kg P/ha.

There was a small, but significant, response to deep P placement in 2017 (22% chickpea yield increase compared with the FR). This is consistent with other experiments in the 'Regional testing guidelines for the Northern Grains Region' project (UQ00063), which show distributing available P sources deeper into the soil profile will improve crop P recovery. The reasons for the relatively minor yield increase compared with starter P responses cannot be clearly determined. The crop had limited access to the deep P bands due to the soil's low plant available water capacity and the infrequency with which these bands were wet to allow root activity (Figure 3). The P source in the deep bands was TSP, which was potentially less available than the starter P. Either factor could have contributed to the small response to deep P bands in this year. Any additional P the crop acquired appeared to be used to grow more grain (Figure 2), as shown by the linear relationship between grain P content and yield, whilst maintaining a constant concentration of P in the grain.

Despite the confounding results of P uptake with moisture availability, it is apparent that this site shows a poor residual response to banded TSP for yield. This is consistent with the other 'Regional testing guidelines for the Northern Grains Region' (UQ00063) sites that show that TSP is an inefficient P source for producing bioavailable P for crop uptake. A solution would be to supplement the P uptake from starter fertiliser with bioavailable P, distributed throughout the soil profile where water is available and roots are present to ensure uptake.

Results from Queensland field sites in the UQ00063 project and glasshouse experiments in the 'Deep placement of nutrients' project (UQ00078, Bell et al., 2018), suggest that TSP is not as effective as MAP at supplying P to crops in general. To test this, it is intended to reapply deep P as MAP in some of the Gilgandra treatments, to provide a contrasting deep P treatment to high residual rates of TSP in 2019.

References

Bell M, Lester D, Sands D, Graham R and Schwenke G (2018). The P story so far – an update on deep P research findings. GRDC Updates at Breeza and Allora, Feb–March 2018.

Acknowledgements

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