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Crop response to deep placement of phosphorus in a chromosol – Gilgandra 2018

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Key findings

- There was a significant yield response to starter fertiliser at Gilgandra in 2018.
- No significant yield response to deep phosphorus was recorded when starter fertiliser was applied.
- Environmental conditions experienced at Gilgandra in 2018 limited crop yield and potentially limited crop access to deep phosphorus.

Introduction

Research investigating the benefits from deep phosphorus (P) placement has previously focused on the black–grey self-mulching vertosol soils of the northern grains region (NGR) of NSW and central and southern Queensland (QLD) (Bell et al., 2018). This is due, in part, to the growing awareness of nutrient rundown within these inherently fertile soils and the stratified distribution of P that occurs within the profile.

This 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 to the soil. Phosphorus can be stratified within the soil profile, with P more available in surface layers (0–10 cm) and less available further down the profile. Crops growing on these vertosol soils rely on subsoil (10–30 cm) moisture and nutrients for extended periods in the growing season when the topsoil is often dry. Unless immobile nutrients such as P are present in this subsoil, crop roots are unable to access the nutrients required to meet the yield potential. In dry seasons, when crops rely on stored water for growth, P is almost entirely obtained from the sub-surface layers.

With no-till farming and intensified cropping systems being adopted in the central west, there has been growing interest in the potential benefits of deep P placement. In contrast to vertosols in the north, soils in the central west tend to have moderate fertility, lower soil water holding capacity and are more reliant on in-crop rainfall.

The aim of this experiment was to examine if placing immobile nutrients such as P deeper in a chromosol soil profile will increase yields above the traditional approach of starter P placed in or near the seeding row, close to the soil surface. Results presented in this report are a summary of data collected from the 2018 season from an ongoing residual deep-P experiment at Gilgandra, NSW.

Site details

Location	Chippendale, Gilgandra, NSW (31°59'18.18"S, 148°68"77.77'E).
Soil type and nutrition	Red–brown chromosol, pH_{Ca} 5.2 (0–10 cm) Starting P (Colwell), 21 mg/kg (0–10 cm), 7 mg/kg (10–30 cm) Starting nitrogen (N) (nitrate), 66 mg/kg (0–10 cm), 9 mg/kg (10–30 cm) Starting N (ammonium), 16 mg/kg (0–10 cm), 4 mg/kg (10–30 cm)

Rain	Yearly rainfall 2018: 408 mm Yearly long-term average (LTA) rainfall: 560 mm (Bureau of Meteorology) Starting soil moisture: ~130 mm (0–120 cm) In-crop rainfall: 158 mm, a reduction from the LTA for in-crop rainfall of 215 mm
Sowing	At Gilgandra, Commander[⁽ᵖ⁾] barley and HatTrick[⁽ᵖ⁾] chickpeas crops were grown at the experiment site in 2016 and 2017, respectively. Spitfire[⁽ᵖ⁾] wheat was sown for a target population of 120 plants/m^2 on 29 June 2018. Plots were 9×2 metres 5 rows at 33 cm row spacings.
Harvest date	27 November 2018

Treatments

- Twelve treatments in a fully factorial experiment.
- Four replicates.
- A farmer reference (FR) treatment: an untreated control for baseline data where there was no additional nutrient input or soil disturbance.
- Deep P applied in April 2015 ~20 cm deep parallel to the sowing direction as triple superphosphate (TSP, monocalcium phosphate [$Ca(H_2PO_4)_2$ H_2O]) on 33 cm spacings.
- Starter fertiliser (P): applied as monoammonium phosphate, MAP ($NH_4H_2PO_4$) at sowing with the seed.
- Treatments were balanced for N and sulfur (S) using urea and gypsum.
- Each treatment received an additional 30 kg N/ha side banded as urea (46% N) at sowing (Table 1).

Means were compared by analysis of variance (ANOVA) assessments using least significant difference.

Table 1 Deep P treatments at Gilgandra.

Treatment	Phosphorus, triple superphosphate (kg P/ha)	Starter fertiliser#	Cultivation
1 minus	0	Minus	Farmer reference (no deep P, no deep ripping)
1 plus	0	Plus	Farmer reference (no deep P, no deep ripping)
2 minus	0	Minus	Deep ripped*
2 plus	0	Plus	Deep ripped*
3 minus	10	Minus	Deep ripped*
3 plus	10	Plus	Deep ripped*
4 minus	20	Minus	Deep ripped*
4 plus	20	Plus	Deep ripped*
5 minus	40	Minus	Deep ripped*
5 plus	40	Plus	Deep ripped*
6 minus	80	Minus	Deep ripped*
6 plus	80	Plus	Deep ripped*

* Deep-ripped to 20 cm deep
\# Starter fertiliser Plus = 60 kg/ha Granulock®Z

Results

Grain yield

The use of starter fertiliser resulted in a significant, 114% (0.47 to 1.01 t/ha), increase in yield across all treatments.

The highest yield was deep P applied at 80 kg P/ha (1.12 t/ha) together with starter fertiliser. Where deep P was applied without starter fertiliser, a significant increase in yield was not recorded compared with the FR treatment (Figure 1).

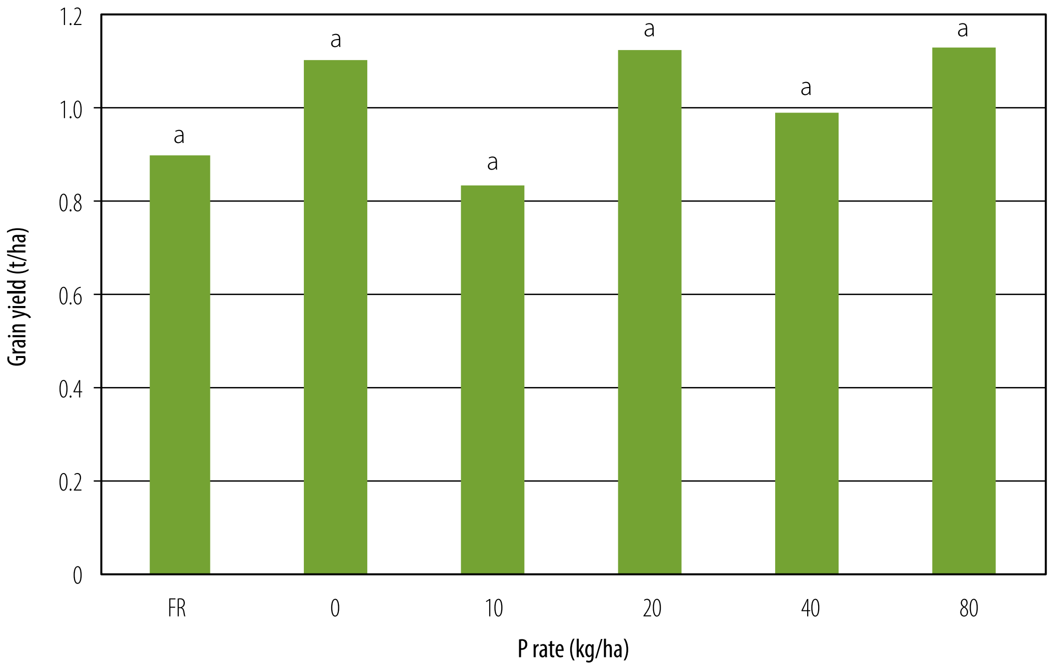

Figure 1 Yield response to deep P/tillage treatments plus starter fertiliser. Bars with the same letter are not significantly different (*P*<0.05).

Deep P applied at 80 kg P/ha (without starter fertiliser) gave the highest yield at 0.72 t/ha (Figure 2). Significant increases in yield were also recorded for the FR treatments where deep P was applied at 40 kg P/ha and 80 kg P/ha.

Crop P content

Crop tissue and grain analysis (ICP test) was only conducted on plants from the FR and 80 kg P/ha deep-P treatments. Within the FR treatments, crop P content significantly increased when starter fertiliser was applied (Table 2). The highest crop P content (10.9 kg/ha) was measured from the treatment where deep P was applied at 80 kg P/ha with starter fertiliser. Crop P content from this treatment was not significantly higher than the crop P content from the FR treatment where starter fertiliser was applied.

Table 2 Crop P content of crops from the FR and 80 kg P/ha deep-P treatments.

Treatment	Crop P content (kg/ha), minus starter fertiliser	Crop P content (kg/ha), plus starter fertiliser
Farmer reference	4.0^{a}	9.3^{cd}
80 kg P/ha deep P	7.5^{bc}	10.9^{de}

Numbers with the same letter are not significantly different (*P*<0.05)

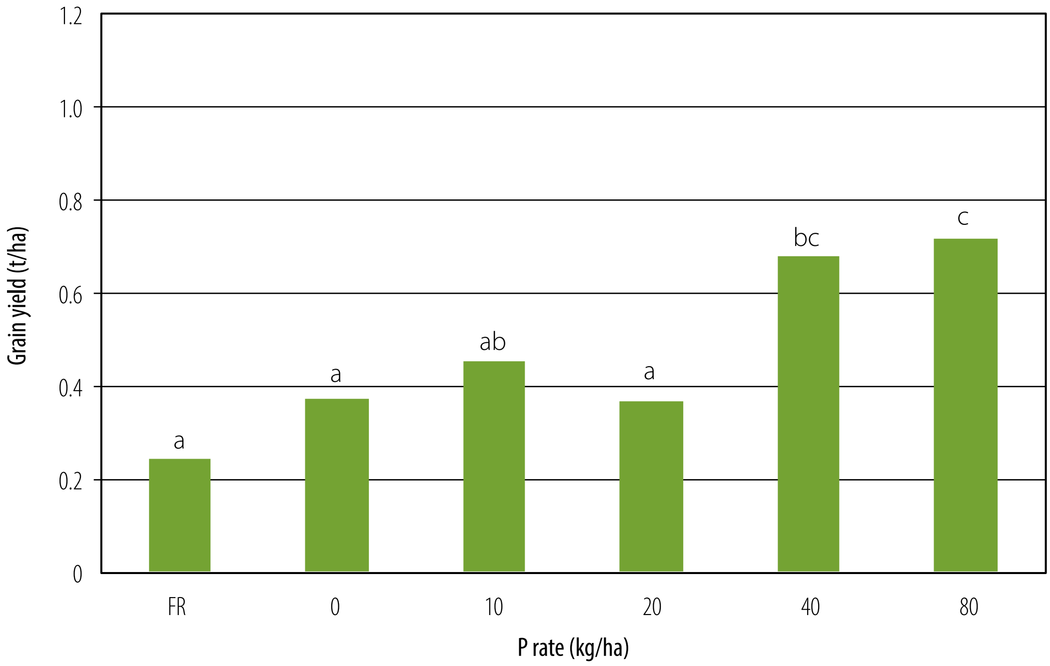

Figure 2 Yield response to deep P/tillage treatments without starter fertiliser. Bars with the same letter are not significantly different (*P*<0.05).

Summary

In 2018 Gilgandra experienced drought conditions with only ~120 mm of in-crop rainfall. These harsh conditions meant limited plant growth and resulted in yields ranging from 0.2 t/ha to1.1 t/ha. In 2018 the state's wheat crop averaged 1.0 t/ha reflecting these drought conditions, with many crops failing, if sown at all.

Yields recorded at Gilgandra in 2018 were limited, however, some trends emerged. Across all treatments, a large yield response to starter fertiliser was recorded. This response indicated that the plants relied heavily on starter P applied with the seed. Root access to deep P might have been restricted due to low in-crop rainfall. Although there was a general trend of increasing yields with increasing deep P rates (plus starter fertiliser), significant responses were not recorded compared with the baseline FR treatment. The highest yield in 2018 was where deep P was applied at 80 kg P/ha (1.13 t/ha).

Significant yield increases occurred where deep P was applied at 40 kg P/ha and 80 kg P/ha without starter fertiliser. Yields increased where starter fertiliser was added, but where no deep P was applied, compared with the FR treatments. The treatments with starter fertiliser out-yielded the deep P only treatments compared with the control (Figure 2).

A significant response to deep ripping was not recorded at Gilgandra in 2018.

Grain yields did not appear to be limited by N as indicated by an average grain protein concentration across all treatments of ~16% (data not shown), which was above the industry minimum of 14% for APH1 wheat in 2017–2018. Nutrient analysis of grain and tissue was limited to the FR and 80 kg P/ha deep-P treatments. Within the FR treatment, crop P content significantly increased where starter fertiliser was applied (Table 1), again indicating that this source of P was used efficiently. Within the 80 kg P/ha deep-P treatments, a significant increase in P content was also recorded with added starter fertiliser. The highest crop P content was measured from this treatment.

Conclusions

The yields obtained at Gilgandra in 2018 reflected the 2018 drought conditions. Where deep P was applied with starter fertiliser, no significant increases in yield were recorded. Limited in-crop rainfall and stored soil moisture restricted crop growth and could have restricted the plants' access to the deep-placed P. Results also indicated that deep-banded TSP might not be as efficient a source of P as other forms such as MAP. Deep-P experiments at alternative sites in northern NSW and southern QLD have resulted in regular responses to deep-banded MAP compared with deep-banded TSP in previous seasons (Bell et al., 2018). Similar observations have been recorded in glasshouse studies (UQ00078). In early 2019, a new deep-P treatment was established where MAP was applied at a rate of 40 kg P/ha. This new treatment will allow for yield comparisons where P is not limited and will provide a differing deep-P treatment to TSP.

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.

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