Responses to phosphorus and potassium by winter crops in Southern Queensland

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Research Questions: *Does putting phosphorus (an immobile nutrient) in the soil at 15-20 cm deep increase grain yields? | How does starter phosphorus interact with deep-placed phosphorus? | For soil with low subsoil K, does applying potassium at 15-20 cm deep in the soil, either with or without phosphorus, increase grain yields?*

Key findings

1. Wheat at Condamine and late barley at Jimbour West both had yield increases with starter and deep-P independently.
2. Chickpea at both Roma sites had no effect of starter or deep-P on grain yield, with little in-crop rain restricting yield potential.
3. Potassium (K) had no yield effect on late barley at Jimbour West.

Background

As the length of time we have been cropping land increases, immobile nutrients such as phosphorus (P) are being taken up by plants from the soil in the 10-30 cm and lower layers, however crop residues are depositing P onto the surface. This is creating a stratified distribution of higher nutrient availability in the surface and lower availability below. Root activity in the soil surface can be limited through faster loss of soil moisture and limited in-crop rainfall. Potentially, deeper soil layers can support periods of root activity for longer as they are not as prone to evaporative moisture loss. This research is questioning if placing immobile nutrients deeper into the soil can increase grain yield.

What was done

Four continuing nutrition experiments were sown to winter crop in 2018 (Table 1). The two Mt Bindango sites west of Roma were deep-planted to chickpea in late May and early June. These were the third crops sown following wheat on the northern site and chickpea at the southern site in 2016; both were sown to wheat in 2017. The Condamine south site was sown to early wheat in late April. This was the fifth crop at the site following chickpea (2014), wheat (2015), chickpea (2016), and wheat (2017). At Jimbour West, the barley sown in July was also the fifth crop following barley (2014), mungbean (2014-15), sorghum (2015-16) and chickpea (2017). Full details on the experimental sites and treatment methodologies are in the *Queensland Grains Research 2017* book. Biomass was not cut at the Jimbour West experiment due to hail damage in October.

Table 1. Agronomic details for 2018 winter experiments.

Site	Mt Bindango Nth	Mt Bindango Sth	Condamine Sth	Jimbour West
Date sown	8 June 2018	30 May 2018	24 April 2018	13 July 2018
Variety	Chickpea (PBA-SeamerⓅ)	Chickpea (KyabraⓅ)	Wheat (SunMaxⓅ)	Barley (Spartacus CLⓅ)
Row spacing (m)	0.75	0.75	0.33	0.33
Planting rate (kg/ha)	60	60	48	55
Starter product	Starter-Z	Starter-Z	Starter-Z	Starter-Z
Starter rate (kg/ha)	35	35	20	37
Maturity biomass date	16 October 2018	16 October 2018	27 September 2018	NA
Harvest date	5 November 2018	6 November 2018	2 November 2018	20 November 2018
In-crop rainfall (mm)	81	84	135	187

Results

Phosphorus (P)

At Roma, P has had little influence on chickpea grain yields (Table 2) with late season rain the only substantial rainfall for the crop (Figure 1). Neither site had any significant yield impact from starter P application. There was a significant treatment effect at the northern site, but that appears to be related to either the tillage and/or basal nutrient applications (Figure 2a). With deep-P rate having no effect on yield, presumably it is some other component of the treatments responsible for the yield increase. This same influence was not observed at the southern site (Figure 2b).

Table 2. Statistical significance for starter or deep phosphorus treatments for winter trials in 2018.

Treatment	Mt Bindango Nth	Mt Bindango Sth	Condamine Sth	Jimbour West
Starter	NS	NS	**	**
Deep-P	*	NS	***	***
Starter.Deep-P	NS	NS	NS	NS

NS = not significant P(0.05); Significant results * P(0.05), ** P(0.01), *** P(0.001)

Significant dry matter increases with deep-P were measured at both the northern and southern sites (data not shown), suggesting P can influence the amount of biomass accumulated, however the mechanisms relating biomass production to grain yield for chickpea remain uncertain. In this season it may simply relate to exhaustion of available moisture in a very tough season (more biomass = more water use, possibly compromising yields).

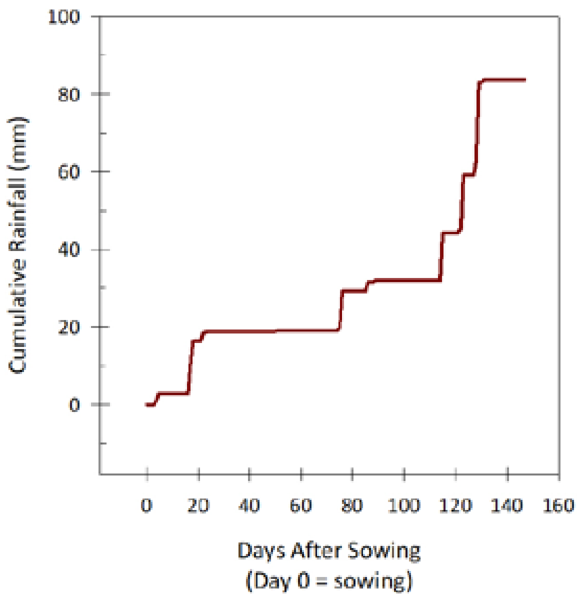

Figure 1. Cumulative rainfall at the Mt Bindango sites for 2018 winter growing season.

However, the conversion of biomass responses into yield responses was more consistent in Central Queensland in similar tough seasonal conditions (see Clermont trial report, page 45), suggesting there is more to this than a 'haying off' response.

For the cereal experiments, both starter and deep-P treatments were independently highly significant on grain yield (Table 2). Neither site has recorded an interaction between starter and deep-placed P. The grain yields for both experiments clearly demonstrate the potential contribution each can make to increasing yield with the plus starter treatments greater than the minus starter across the range of deep-placed P rates (Figures 3 and 4).

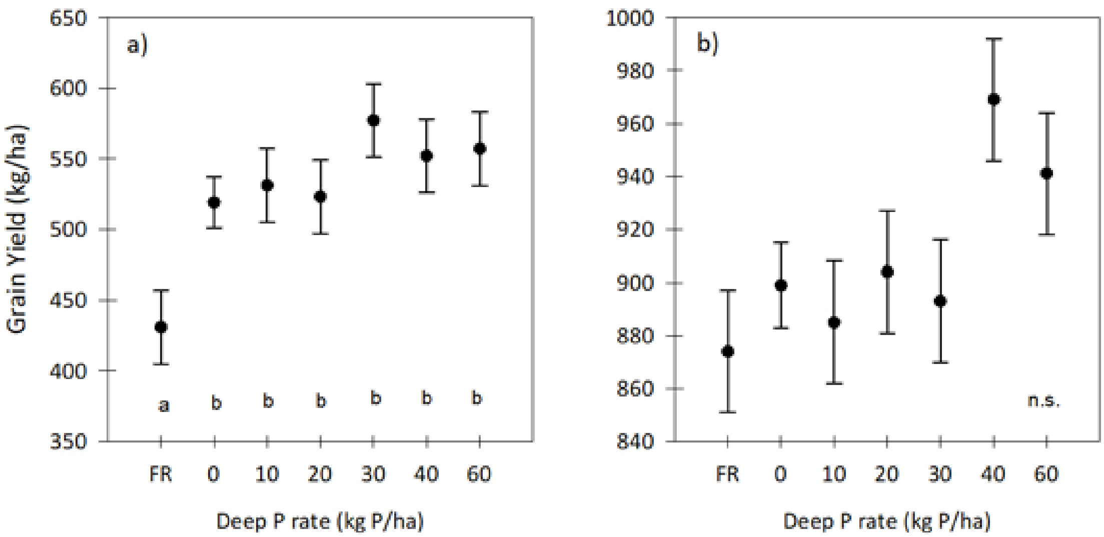

Figure 2. Mt Bindango 2018 chickpea yield for a) North and b) South sites for deep-placed phosphorus treatments (kg P/ha). Error bar are standard error for each mean. FR=farmer reference plots (no additional fertiliser beyond normal farming practice)..

Table 3. Mean wheat grain yield for deep-placed phosphorus treatments at Condamine South in 2018.

Treatment	FR	0	10	20	30	60
Yield (kg/ha)	1487 a	1603 ab	1701 abc	1754 bc	1894 cd	2099 d
Delta yield (kg/ha)	-	116	214	267	410	610
Relative yield (%)	-	7.8	14.4	18.0	27.4	41.1

Table 4. Mean barley grain yield for deep-placed phosphorus treatments at Jimbour West in 2018.

Treatment	FR	0	10	20	30	60
Yield (kg/ha)	1531 ab	1497 a	1569 ab	1705 bc	1783 c	1883 c
Delta yield (kg/ha)	-	-34	38	174	252	352
Relative yield (%)	-	-2	2	11	16	23

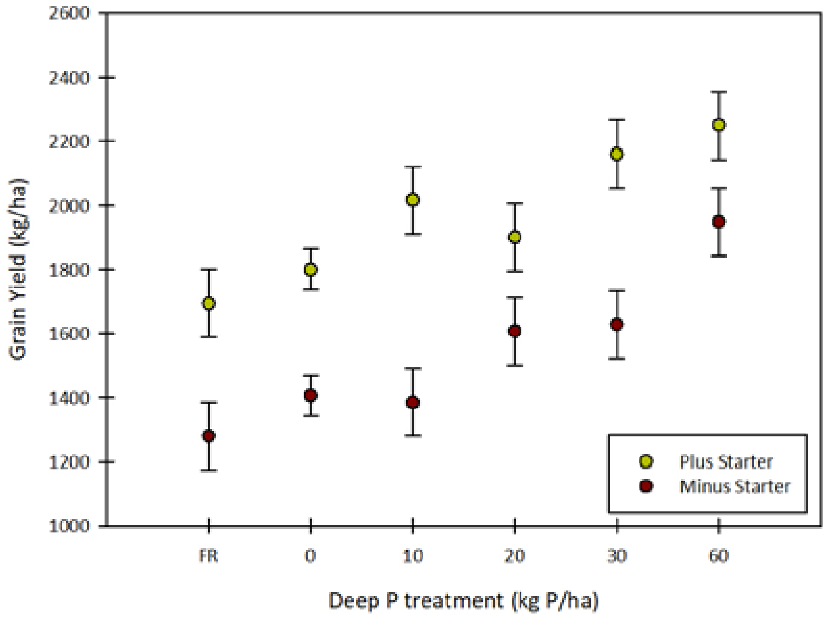

Figure 3. Condamine south 2018 wheat grain yield for deep-placed phosphorus treatments (kg P/ha) with or without starter application. Error bar are standard error for each mean.

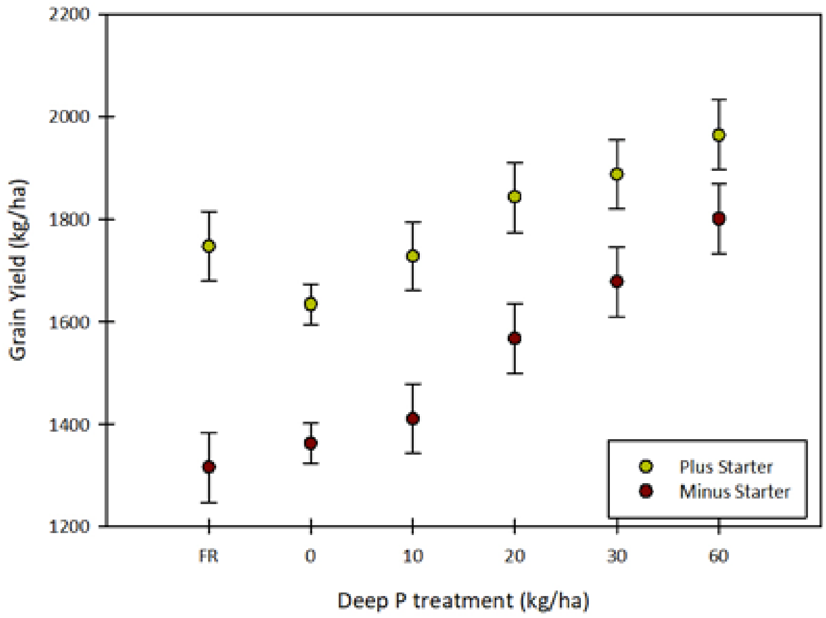

Figure 4. Jimbour West 2018 barley grain yield (kg/ha) for deep-placed phosphorus treatment (kg P/ha) with or without starter application. Error bar are standard error for each mean.

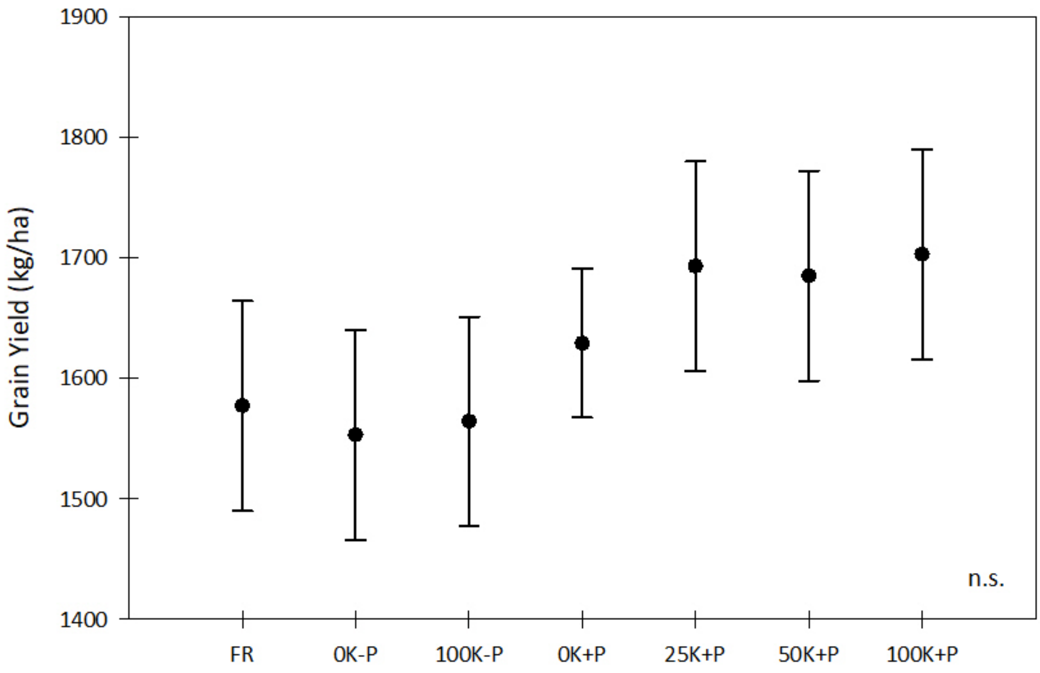

Figure 5. Jimbour West 2018 barley grain yield for deep phosphorus and potassium treatments.

At Condamine, starter application had a highly significant effect on yield. If we examine the starter effect in just the FR and 0P plots (no deep-P) it reveals a yield increase of 409 kg/ha (30%) to 1752±103 kg/ha from an average of 1343±103 kg/ha.

The effect of deep-placed P is examined using the mean result of both the minus and plus starter treatments (Table 3). As the rate of deep-placed P increases, the yield also improves. The net yield gain increases from 210 kg/ha at 10 kg P/ha to 610 kg/ha with 60 kg P. These translate to relative grain yield increases from 12 to 40%.

At the Jimbour West site, similar effects were recorded with the barley from both starter and deep-placed P (Figure 4). Averaged across the FR and 0P treatments, plus starter increased yield to 1687±66 kg/ha, a gain of 387 kg/ha (30%).

Deep-placed treatments increased grain yields with increasing rate (Table 4). At 20-60 kg P/ha deep yield increases of >11% were measured.

Potassium (K)

Grain yield was not significantly affected in the K experiment in 2018 (Figure 5) by either K or P treatment. Late sowing and reduced yield potential may have also decreased K demand by the crop.

Implications for growers

For winter cereal crops in 2018, the application of phosphorus as both starter application and deep-placing into the soil delivered substantial yield increases.

Challenging seasonal conditions for the Maranoa diminished chickpea performance so no new information was gathered about the relationships between P supply and chickpea yield.

This research has been conducted under controlled experimental conditions. Before commencing a large scale nutrient application program, growers are urged to appropriately soil test their fields to establish available nutrient levels for the surface and subsurface layers, and to quantify any other potential constraints to yield. They are then encouraged to evaluate the responses on their soils using an appropriate program of strip-trials and on-farm exploration to validate responses for themselves.

Acknowledgements

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