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SOUTHERN NSW RESEARCH RESULTS 2024

The residual effect of dual phosphorus placement on grain yield in southern NSW

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Key findings

- Responses to residual phosphorus (P) were evident during the fourth cropping season.
- Increase in grain yield is attributed to the higher P rates rather than placement depths.
- The dual P placement provided little evidence of yield advantage (only in 2 out of 44 datasets) when compared with the same total P rate with shallow placement.
- Shallow P was as effective or more effective than the dual P placement.
- Placing P deeper in the soil profile might not be a reliable way of improving crop performance and P use efficiency in southern NSW.

Keywords Phosphorus placement, deep banded P, shallow P, dual P, residual P, cumulative effect

Introduction

Deep banding of phosphorus (P) in the subsurface layer has been reported to increase grain yield of winter crops in the northern growing regions (southern and central Queensland), where rainfall is summer dominant and topsoils can remain dry for extended periods of time during the growing season (Bell et al. 2012; Singh et al. 2005). In southern growing regions (southern NSW, Victoria and South Australia), available P can be highly stratified at the soil surface but very low in lower soil layers. In contrast to the northern region however, rainfall is winter dominant, raising the question of whether winter crops in the southern region will also respond to deep P banding. In 2020 NSW DPI collaborated with the Grains Research and Development Corporation (GRDC) to develop a project (Maximising the uptake of phosphorus by crops to optimise profit in central and southern NSW, Victoria and South Australia; DPI2001-033RTX) to investigate the effectiveness of dual (deep and shallow) placed P on crop performance in the southern region.

This paper will report on findings from the experiments in southern NSW that tested the effectiveness of different combinations of dual placement of shallow (~5 cm) and deep (~20 cm) banded P. Both the effect of P placement on grain yield and the residual P effect on different crops over the last 4 seasons are presented.

Site details

Location	French Park, southern NSW
Soil type	Red kandosol
Design	• Experiment plots were arranged in a row-column design • Replications: 4

Sowing	• Species: Faba bean (cv. PBA Samira(ф)) • Seed rate: 228 kg/ha • Sowing date: 5 May 2023 • Spacing: 25 cm
Fertilisation	Urea at 30 kg/ha at sowing (to balance for mono-ammonium phosphate [MAP] applied in a particular treatment)
Rainfall	• Fallow rainfall: – November 2022 – March 2023: 348 mm – Long-term average: 195 mm • In-crop rainfall: – April–October 2023: 200 mm – Long-term average: 325 mm
Harvest date	20 November 2023

Treatments

The experiment was established in 2020 with a range of P rates and 2 placement strategies. Phosphorus was either applied as a dual placement strategy or shallow only:

- Dual P placement – a portion placed below each seed row (shallow band) combined with a portion banded at approximately 20 cm below the surface at 50 cm spacings (deep band).
- Shallow P only – all placed below each seed row.

These 2 strategies are described as dual P or shallow P, respectively.

The shallow banded P treatments had rates of 0, 10, 20 and 40 kg P/ha. Except for 0 kg P/ha, each shallow banded treatment also had 4 deep banded P rates such as 0, 20, 30 and 40 kg P/ha. A very high rate of shallow banded P (80 kg P/ha) was included to estimate P deficiency severity.

An additional treatment where P was supplemented with Granulock®Z (shown by '+' with P rates) was included to cover any possible deficiencies in zinc and sulfur. Another treatment had 30 kg P/ha applied annually (referred to as 30 P).

All treatments were disturbed to ~20 cm deep to account for any apparent ripping effect. An additional control 0/0 undisturbed (no ripping) was included.

Phosphorus was applied as MAP and balanced for nitrogen (N) for different placement depths.

In 2021, the site received a blanket application of 5 kg P/ha. In 2022, the original undisturbed 0/0 treatment (0 UD/0) was treated with a shallow band of P at the maximum rate used in the initial experiment year (i.e. 80 kg P/ha) to examine fresh versus residual P effects. The remaining plots were balanced for N only.

In 2023, only the 30 P treatment received 30 kg P/ha.

The crop sequence during the last 4 seasons was:

- wheat (2020)
- lentil (2021)
- wheat (2022)
- faba bean (2023).

Results

Growing conditions

The experiment was established at French Park, southern NSW in 2020. Soil pH at the site is 6.2 (pH_{Ca} 0–10 cm) with pH increasing with depth (pH_{Ca} 6.9 at 10–30 cm and exceeds 8.2 below 30 cm). The site has a Colwell P of 49 mg/kg at 0–10 cm but only 4 mg/kg at 10–30 cm.

In the 2023 season, summer fallow rainfall totalled 348 mm, which was almost double the long-term average (195 mm). At sowing, the site had a gravimetric water content of 556 mm (up to 150 cm deep). The site received only 200 mm of rainfall during the growing season (April–October), which is lower than the long-term average for the same period (325 mm), and had a dry finish.

There were no establishment issues. Recorded plant density was 41 plants/m^2.

In the 2023 season, faba bean growth responded to both fresh P i.e. 30 P treatment (Figure 1) as well as residual P applied in the 2020 season.

The plot on the left is a 0/0 control receiving no P over the last 4 seasons (2020–23). The plot on the right is the 30 P treatment that had 30 kg P/ha applied annually. Both treatments were disturbed to ~20 cm deep at 50 cm spacing at sowing in 2020 to account for ripping effects of other deep-placed P treatments in this experiment.

Figure 1 Faba bean (cv. PBA Samira$^{(\dagger)}$) response to different P management strategies during flowering at French Park, southern NSW in 2023.

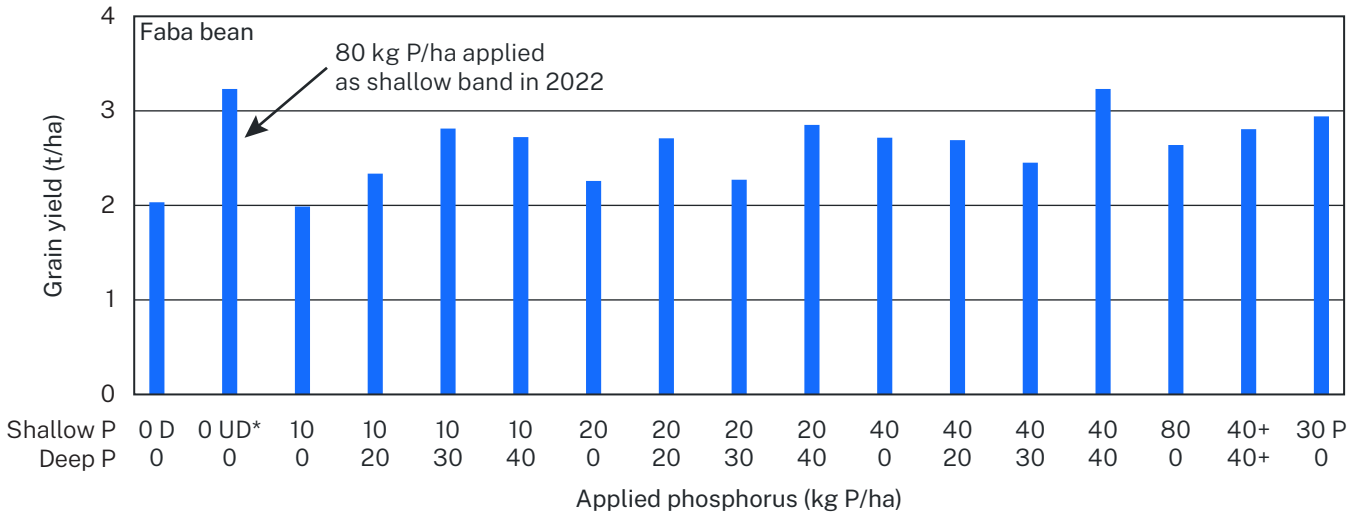
Grain yield in 2023

Faba bean yield was significantly (P<0.001) increased by P management (including rate and depth) strategies (Figure 2). Compared with the 0 D/0 (shallow/deep kg P/ha) control, applying 30 kg/ha shallow P annually (30 P treatment) increased the grain yield from 2 t/ha to 2.9 t/ha.

The effect of the residual P (either from the 2020 or 2022 seasons) on yield was significant in 2023. When compared with the 0 D/0 control, faba bean in 2023 treated with 80 kg P/ha in the 2020 and 2022 seasons yielded 30% and 59% higher, respectively.

The residual effect of deep banded P was evident only with low rates of shallow banded P. For example, with 10 kg P/ha shallow banded P, the residual from deep banding 30 kg P/ha and 40 kg P/ha resulted in a significantly higher yield than the 10/0 (shallow/deep kg P/ha) treatment. However, with higher rates of shallow banded P, i.e. 20 or 40 kg P/ha, these differences disappeared.

In some cases, the residual effect of dual banded P (40/40; shallow/deep kg P/ha) was significantly higher than its corresponding comparison of shallow banded P (80/0). However, this trend was not consistent for the 10/30 and 20/20 treatments when compared with its equivalent rates of shallow banded P (40/0; Figure 2).

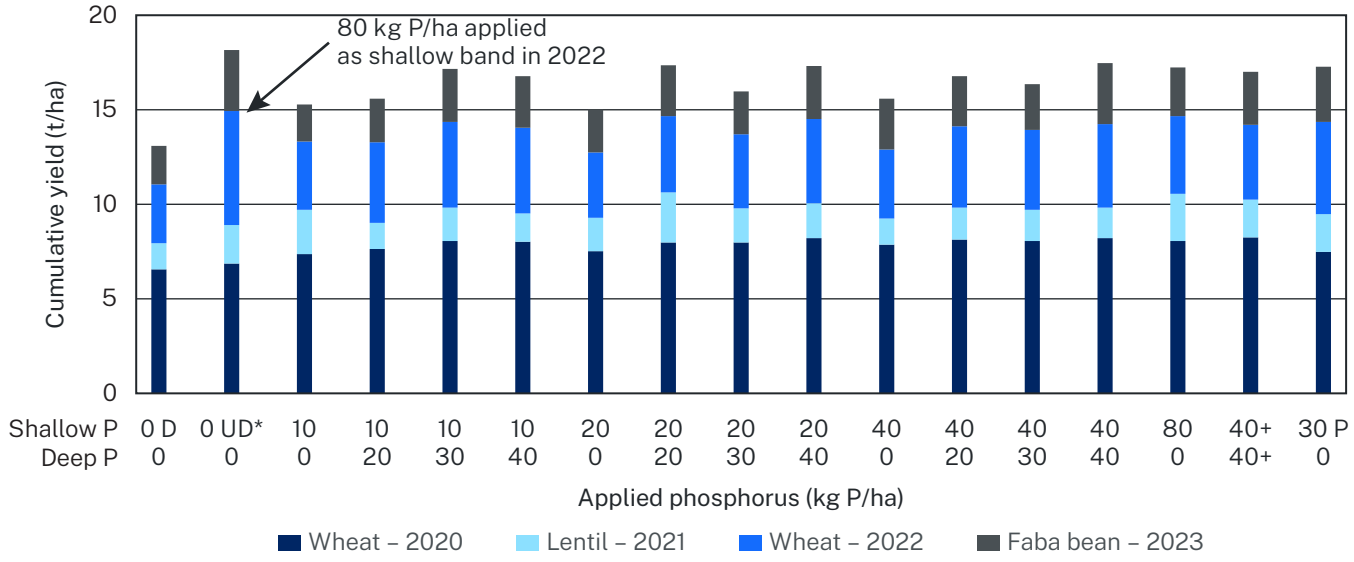


Treatment with '+' indicates P was supplemented with Granulock®Z fertiliser. All treatments except the 0 UD/0 (UD = undisturbed control) had been disturbed to ~20 cm deep at 50 cm spacing in 2020 as part of the deep P application.
Each data point is a mean value of n = 4. l.s.d. (*P* = 0.05) = 0.55 t/ha.
* UD: 0 UD/0 plots were treated with 80 kg P/ha as shallow bands in 2022 to compare with the residual effects of other treatments from 2020.

Figure 2 The residual effect of shallow and dual banded P (kg/ha) on faba bean (cv. PBA Samira(4)) grain yield during the fourth season (2023) after the initial application of P fertiliser in 2020 at French Park, southern NSW.

Cumulative yield response over 4 seasons

The effect of P management strategies on the cumulative grain yield of different crops was significant (*P*<0.001) over the last 4 seasons (Figure 3). Compared with 0 D/0 control, different P rates increased the cumulative grain yield by up to 39%. The cumulative residual effect of higher P rates (i.e. 40 kg P/ha or higher) resulted in more than 30% grain yield over the last 4 seasons. This cumulative yield response was rate-dependent, but was not affected by the placement depths (Figure 3).



Treatment with '+' indicates P was supplemented with Granulock®Z fertiliser. All treatments except the 0 UD/0 (UD = undisturbed control) had been disturbed to ~20 cm depth at 50 cm spacing in 2020 as part of the deep P application.

Each data point is a mean value of n = 4. l.s.d. (P = 0.05) = 1.7 t/ha.

* UD: 0 UD/0 plots were treated with 80 kg P/ha as shallow bands in 2022 to compare with the residual effects of other treatments from 2020.

Figure 3 The effect of shallow and dual banded P (kg/ha) on cumulative grain yield of different crops over the last 4 seasons (2020–23) after the initial application of P fertiliser in 2020 at French Park, southern NSW.

Summary

Despite having a high background Colwell P, in the fourth season (2023) this site was responsive to both fresh P applied annually as well as to the residual P. This suggests there could be an opportunity to improve farming productivity and profitability through P management. However, the phosphorus buffering index (PBI) should be considered along with the Colwell P to optimise P rates (Sandral et al. 2019).

In line with earlier findings from the northern growing regions (Sands et al. 2022) the residual effect of higher rates of deep banded P is carried through into the fourth season following the year of band placement. The relative yield responses to deep banded P observed in this experiment were much higher than the earlier reported values from the northern growing regions. However, this observed trend was evident only with low shallow P rates and disappeared with a higher or corresponding comparison of shallow P rates (Bell et al. 2012). This suggests that applying commercially acceptable higher rates of shallow banded P can overcome the subsoil P limitation in the southern growing regions.

In this experiment, there was little evidence of the yield advantage of dual banded P when compared with the same total P rate with shallow placement (i.e. 40/40 vs 80/0; shallow/deep kg P/ha), but this trend was not consistent across other treatments (i.e. 10/30 and 20/20 vs 40/0; shallow/deep kg P/ha). Even the cumulative yield response over the last 4 seasons did not demonstrate any yield advantage from dual banded P when compared with its corresponding comparison of shallow banded P.

Over the last 4 seasons the project has generated 44 experiment datasets comparing the effectiveness of dual banded P over shallow banded across southern NSW, Victoria and South Australia. About two-thirds (31 out of 44 datasets) showed a significant P response to grain yield. In all situations where P responses were observed, shallow P was as effective, or more so, than dual P placement. There was very limited evidence (only 2 out of 44 datasets) of dual banded P being more effective than shallow P.

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