Reviving subsoil fertility

Potassium deficiency in young mungbeans. INSET: Deep placement of fertiliser is a practical option that does not alter surface cover or produce a cloddy surface.

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Decisions about phosphorus (P) fertiliser use on pulses like chickpeas and mungbeans are shrouded in uncertainty, partly because so little research has been done to determine the extent of P responses in these species.

A common misconception has been that these pulses show little response to P fertiliser, mainly because neither species has an obligate P requirement in early growth to set final grain number, unlike grains such as wheat, barley and sorghum. However, recent experience suggests both species do respond to P and, in some cases, the response is very strong.

Requirements for P mirror crop growth, with demand greatest when growth rates are high. Both chickpeas and mungbeans require some starter P (in low P soils) to help the crop root system establish and to grow vigorously as it uses moisture and nutrients in the subsoil. Deficiency can occur if there are insufficient nutrients available deeper in the profile.

Perhaps the greatest response to P and K in our environments occurs when these nutrients are either already present or placed as fertiliser in the subsoil (10–30 cm layer). These deeper nutrients are well placed to meet the demands for growth, as they are in moist soil for longer and are in profile layers where there are lots of crop roots. Deeper placement is particularly important for chickpeas, which are often planted below the top 10 cm layer, which typically has the highest immobile nutrient concentrations. As the coarse taproot system develops, only P from deeper in the profile can be accessed.

Changes in farming practices over recent decades have seen the nutrient profile of agricultural soils alter, particularly for immobile nutrients like P and K. While subsoil reserves are depleted, topsoil concentrations can be retained or even increase due to inputs from crop residue and surface applied fertiliser. These shallow nutrient stores are not available to plants when topsoils are dry, and we no longer till to redistribute those nutrients into the subsoil. Therefore, nutrients removed from subsoils require replacement, and the idea of deep placement of fertiliser bands has been investigated at a number of trial sites since 2006–07. While not specifically targeting pulse crops, chickpeas and mungbeans have featured in the crop rotations.

In each trial the reference treatments consisted of normal practice (e.g. starter fertiliser at the normal farm rate), a nil treatment (no P or K applied, but with deep tillage), a starter P treatment and a starter P treatment with either extra P (or K) applied deep (15–20 cm) during the preceding fallow. The nil and starter P treatments provided benchmarks for the effects of P, and also the effects of soil disturbance when compared to the farmer normal practice.

Deep placement of phosphorus, typically at a rate of 40 kg P/ha, was applied as TSP or MAP at depths of 15–20 cm (with extra N applied to compensate for the N in MAP), with bands 50–100 cm apart. Deep placement of potassium was also in bands and at the same depth and spacings, using a typical application rate of 100 kg K/ha applied as muriate of potash. In sites where both P and K were low, trials looked at adding each nutrient alone or as a combination of P and K to simultaneously overcome both constraints. Rates were deliberately high to ensure residual effects could be followed in subsequent crop years.

While the number of pulse trials is small, especially from 2013 winter due to a combination of both dry conditions and frost, there have been some consistent trends emerging.

- Chickpeas seem to be fairly consistently responding to P placed deep in the soil profile. Responses were significant in three of the four trial sites, with a trend for an increase in the fourth site. Some of the higher yielding crops accumulated 20–30 kg P/ha in the crop biomass, with up to 40% of that coming from the applied P. Yield responses typically averaged an increase of 20%.
- Mungbeans crops also demonstrated a trend for benefits from deep P at all sites. However, while relative benefits ranged from 10% to an impressive 60% yield increase, depending on soil P status, the benefits were only statistically significant in one of the three trials. There also seemed to be greater responses to starter P than in chickpeas, although more work is needed to confirm this.
- At a number of sites there were interactions between P and K (see the case studies below). At the Capella site the primary limitation was P (generating a 20% yield increase), with a trend for a small additive effect of K. However at Gindie the primary limitation was K (generating a 27% yield increase), with a strong additive effect of P after the K demand was met, making a total of 51% yield increase.
- Similar P and K effects were seen in a mungbean trial near Warwick, but while both P and K effects were significant there was no evidence of additivity. This can occur where the better root development that occurs when P deficiency is corrected allows the crop to then scavenge more effectively for K. This is the equivalent to squeezing a little more blood from the stone, as it does nothing to replenish soil K reserves!

The implications of these findings from a farming systems perspective are significant. Many farmers are concerned over the suggested return to deep tillage—even if

Deeper soil tests needed

Minimum tillage and long-term export of nutrients have resulted in depletion of P, K and sulphur (S) reserves at depth across the northern region. Research to date suggests that analysis of the 10–30 cm soil layer, along with the traditional top 10 cm layer, is critical for assessing P and K status of soils. Sulfur is more mobile in the soil and so testing as deep as 60 cm is needed to assess the status of this nutrient.

There is currently no information on the critical soil concentrations of these nutrients in the subsoil for any crop. Research is underway to fill these gaps in our knowledge through trials across the region, from the Central Highlands in Queensland through to the southern Liverpool Plains in New South Wales, with additional sites in the western areas of southern Queensland and central and northern NSW.

The focus of this research is to determine the critical soil concentrations required for yield responses in sorghum, wheat, mungbean and chickpea to applied P, K and S.

Chickpea response to deep placed fertiliser—control in foreground, PK response in background.

only at infrequent intervals. However, the management of immobile nutrients may require the use of such tillage if we are to replenish nutrients exported from farms across the region. The recommended frequency of this management strategy will be considered as the research project continues to collect data about the residual effect of fertiliser placed at depth. Early results indicate that the benefits of deep placement of fertiliser may be reasonably long-lasting and so the frequency required may be tied more to the application rate than any other factor.

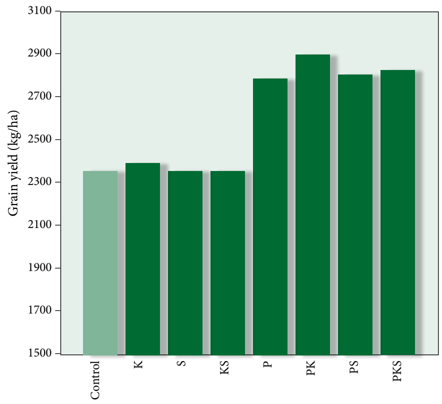
Case studies—CQ fertiliser deep placement trials

Two trials were conducted on sites near Capella and Gindie in Central Queensland, with support from the International Plant Nutrition Institute (IPNI) and Canpotex. Soil tests indicated that the soils at both sites were depleted in P, K and S.

In winter 2011, treatments of these nutrients, alone and in combination, were banded 50 cm apart at depth during a fallow at both sites. Crops of chickpea (2012) followed by wheat (2013) at Capella and sorghum (2011–12) followed by chickpea (2013) at Gindie have so far been monitored for yield responses.

At Capella, deep placement of P gave rise to a 20% increase in yield above the control (deep tillage only), an additional 500 kg/ha of grain. Along with this main response

Chickpea at Capella 2012 (first crop after treatments)

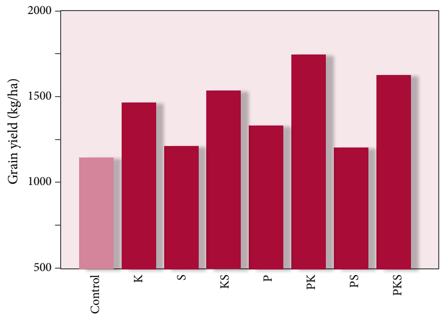


there was also a slight trend for an additional benefit of K once P adequate, such that the combined effects of deep tillage and (P + K) fertiliser yielded 900 kg grain/ha more than the farmer reference. Effects in the following wheat crop were limited by a lack of water (there was no in-crop rain in 2013) that restricted the development of secondary roots and tillers (a key part of wheat P responses), but trends for higher yields with P and K (13% increase) were still evident.

The additional crop production (2012 chickpea @$550/t and 2013 wheat at $275) was calculated to be worth $310/ha for P only, or $380/ha for P+K. Compared to commercial practice (no deep tillage) in 2012, the combined effects of deep tillage and P lifted the combined benefit to $600/ha after two crop seasons.

At Gindie the sorghum crop only responded to P (again a 20% yield increase), but the chickpea crop responded to the

Chickpea at Gindie 2013 (second crop after treatments)



residual of the applications of both P and K, and there was a strong additive effect of the two fertilisers that delivered a 51% yield increase. The primary limitation in this season seemed to be K (27% response), and only once K was supplied could the additional response to P be observed. These yield increases represented additional grain production of 340 kg/ha and 530 kg/ha respectively, with the combined value of additional crop production (assessed as 2012 sorghum @$200/t; 2013 chickpea at $375) worth $160/ha for P only, or $320/ha for P+K.

Interestingly, the dry seasonal conditions in 2013 seemed to enhance the response to residual deep P and K in chickpea (where development of secondary roots and tillers is not a key driver of extra yield) at Gindie, versus the opposite effect in wheat at Capella.

The question remains about how long the residual benefit of deep placement of fertiliser will continue.

Soil test data from case study sites

Site	Depth (cm)	pH	Colwell P	BSES P	SO4-S	Exch K	CEC	DTPA Zn	Org C%
Gindi	0–10	7.2	13	10	3	0.17	35.3	0.2	0.6
	10–30	7.8	<5	5	2	0.07	38.4	0.1	0.5
Capella	0–10	8.1	10	14	3	0.46	73.7	0.25	0.7
	10–30	8.3	<5	9	2	0.16	74.6	0.1	0.65

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