FERTILISER DEEP BANDING FACT SHEET

NORTHERN
AUGUST 2023

Deep banding immobile fertiliser nutrients in clay soils to support rain-fed cropping

Photo: D. Lester

Responses to deep bands of monoammonium phosphate applied six months before sowing of this sorghum crop near Wondalli, in southern Queensland.

KEY POINTS

- Removal of phosphorus (P) and potassium (K) from subsoils without replacement is increasingly limiting the ability of crops to use stored soil water
- Apart from starter fertiliser applications, enriching topsoil is generally ineffective as these layers are often dry for extended periods. Neither P nor K will leach into deeper soil layers in clay soils
- Aggressive tillage can re-distribute surface P and K into deeper profile layers, but this leaves the surface without stubble cover and can also lead to rapid P sorption and reduced plant P availability
- Deep fertiliser bands are effective, as they limit soil-fertiliser interactions and place P and K in soil layers that are wetter for longer. Placement of K with/near P bands can enhance crop K uptake
- Uptake of P and K from deep bands is limited by the volume of fertilised soil, drying of the soil around the band and the frequency with which bands are re-wet
- Residual benefits from deep P and K banding are substantial, although longevity does vary between nutrients. Crop K uptake >> P uptake, and rates of removal in grain differ between nutrients and species
- Choice of fertiliser form, blending of products, application rate, band spacing and application frequency will all affect deep banding responses

Background

Northern cropping systems are strongly reliant on soil moisture accumulated during a fallow, as in-season rainfall can be erratic and highly variable. Effective use of this stored soil water for crop production requires both water and nutrients to be available to the crop in the soil layers supporting growth at different stages in the growing season. Nutrients in shallow topsoils can be used inefficiently in rain-fed cropping if those layers remain dry for extended periods, which makes those nutrients inaccessible to plants (Figure 1).

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At these times, subsoil nutrient stores contribute to meeting demand. However, replenishing these subsoil reserves can be challenging. Mobile nutrients like nitrogen (N) can leach into deeper layers as soil profiles re-wet during fallows, but less mobile nutrients like P and K are held on soil particles and do not leach into deeper layers, even when topsoils are heavily fertilised. Subsoils therefore become increasingly depleted of P and K, and the cessation of soil mixing from conventional tillage further limits subsoil replenishment. Addressing this problem is critical for the profitability and sustainability of stored-moisture cropping systems on clay soils of northeast Australia.

Depleted subsoil P and K – where in the profile, and how low is 'low'?

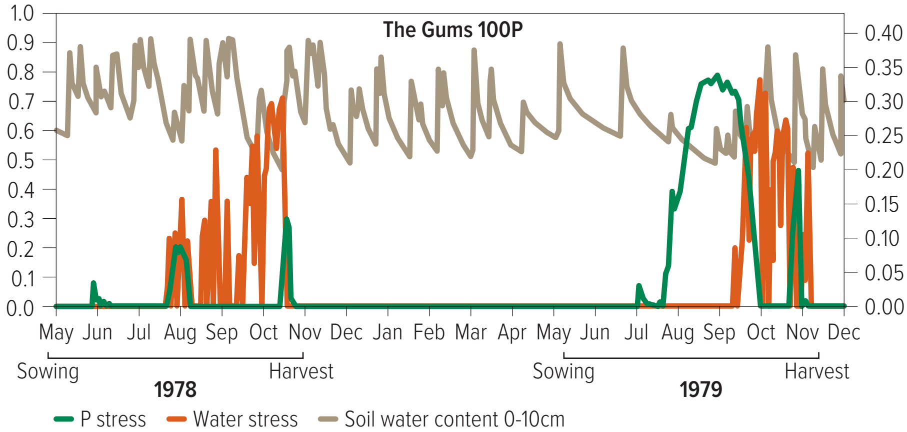
Uptake of P and K by plants is achieved by movement (diffusion) of these nutrients over very small distances from soil to roots along a concentration gradient. Uptake therefore tends to be greatest in layers with the greatest concentrations of plant roots – namely, the top 30 centimetres of the soil profile. The most severe subsoil P and K nutrient removal occurs in the 10 to 30cm layer, with only limited depletion below that as root density decreases. The 10 to 30cm layer is therefore the target of deep banding.

The frequency of responses to deep P and K applications increases as concentrations in the 10 to 30cm layer fall. The critical soil P concentrations are based on a combination of the Colwell and BSES P tests, while the critical soil K concentrations are based on exchangeable K modified by cation exchange capacity. The current best estimates of critical P and K concentrations in the 10 to 30cm layer are shown in Table 1 as guides for likely responsiveness to deep bands.

When should I apply?

Applications should be made early in a fallow, once there is enough accumulated moisture to prevent large clods from forming and leaving the rip line open. Stubble cover can be maintained if the tillage equipment has adequate trash handling capability.

Figure 1: Simulated water (orange) and P stress (green) in wheat grown in wet (1978) and dry (1979) seasonal conditions for a soil with high rates of P fertiliser incorporated in the top 10cm of soil. Fluctuations in soil water content of the 0-10cm fertilised soil layer are also shown (brown).



Source: Reproduced from Raymond et al. 2021

Table 1: Critical soil P and K concentrations in the 10-30cm soil layer. Concentrations below this mean deep banding responses are likely in Northern clay soils.

Critical soil P (mg P/kg)	
Colwell P 7mg P/kg	BSES P 50mg P/kg
Critical soil K (cmol(+)/kg)	
Cation exchange capacity	**Exchangeable K**
< 10 cmol (+)/kg	0.20 cmol (+)/kg
10–30 cmol (+)/kg	0.25 cmol (+)/kg
> 30 cmol (+)/kg	0.35 cmol (+)/kg

Photo 1: CT scan of barley roots showing a 'xerobranching' characteristic resulting from growing through an air-filled void, similar to that created by deep ripping in dry soils without subsequent reconsolidation.

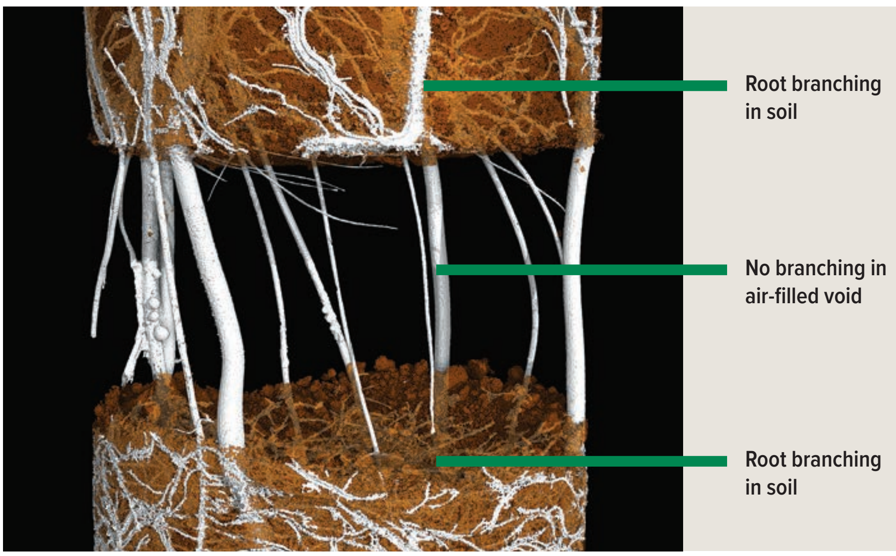


Photo: The image was generated using microCT imaging at The Hounsfield Facility, University of Nottingham.

The object is to disrupt subsoil compaction, minimise the loss of stored soil moisture and allow time for the rip line to reconsolidate around the fertiliser band. Successful crop nutrient recovery will depend on roots proliferating in and around the fertiliser band, but this will not occur if the fertiliser is sitting in an air-filled void created by the ripper tyne (Photo 1).

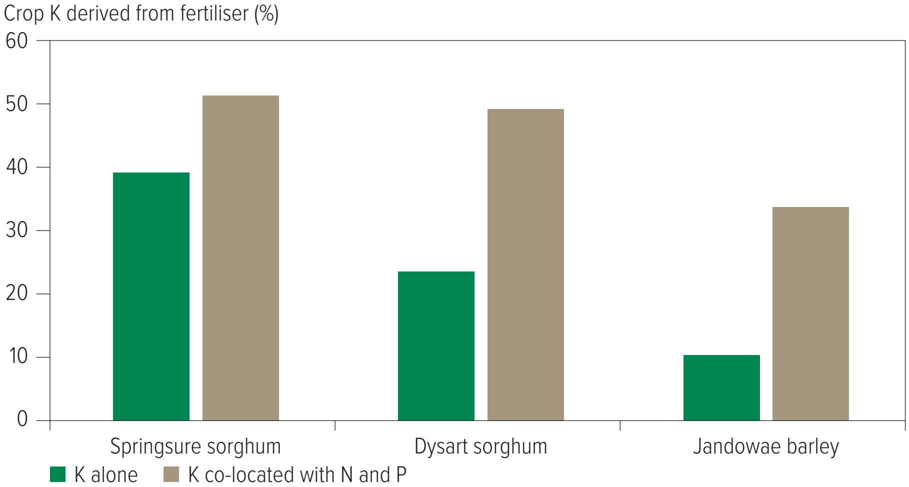
What products should I use?

The chemical reactions that occur in and around a concentrated fertiliser band will influence availability of P by precipitating fertiliser P into sparingly soluble forms. Fertilisers that generate very acidic band conditions (for example mono-calcium phosphate, also known as Triple Superphosphate) should be avoided for that reason, with ammonium phosphates the preferred P products. Although applying K in, or close to, the P band can improve plant K uptake due to the root proliferation response to the P (Figure 2), applying very high rates of K in this fashion can negate these benefits by causing precipitation of P and reduced plant P availability. The form of K is less important than P, as any salt effect caused by using muriate of potash (MOP) will be mitigated by the accumulation of soil water during the fallow.

What rate should I apply?

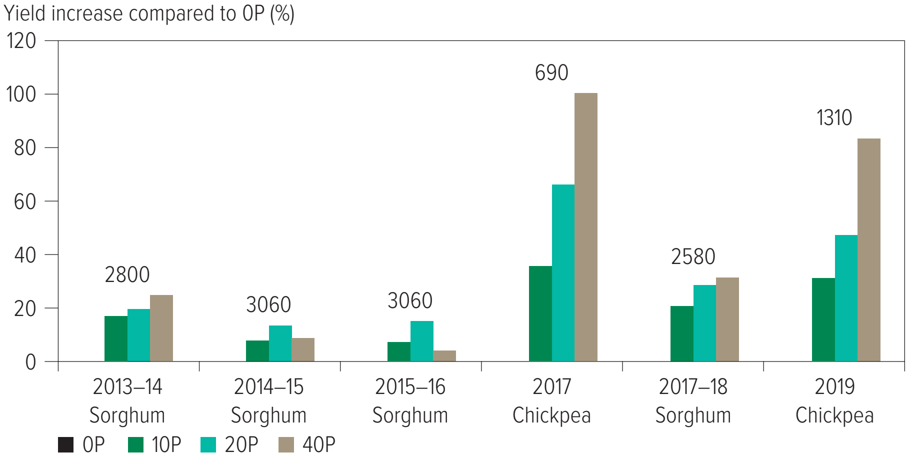
Given the cost of the ripping operation ($30 to $50/ha) and the strong residual value of applied P and K fertiliser

Figure 2: Percentages of crop K uptake derived from deep K bands with or without co-application of 20kg/ha (P) as monoammonium phosphate at three sites on Queensland Vertosols.



Source: UQ00063 data from M Bell and D Lester, unpublished

Figure 3: Percentage yield increase due to increasing rates of P applied in deep bands at the longest running site near Dysart. Grain yields of the 0P treatment (kg/ha) are shown for each crop. The P rate response in sorghum was limited by low nitrogen availability in 2014-15 and 2015-16.



Source: Adapted from Sands et al. 2020

Photo 2: The depth of band placement (inside yellow rings) affects the time taken to intercept a P band and determines the extent of root proliferation around it at a point in time. This example is for durum wheat.

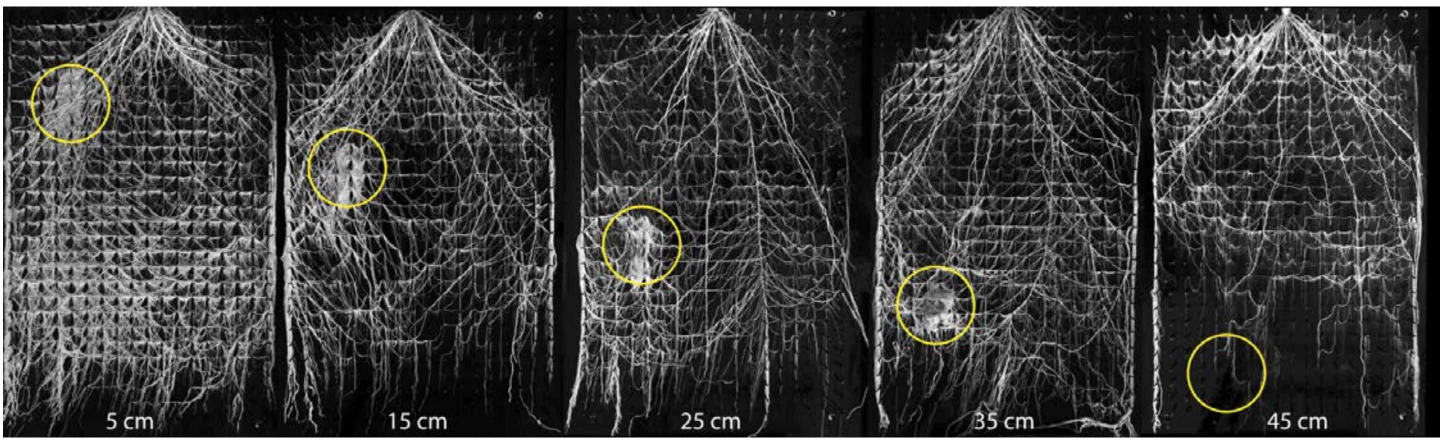


Photo: F van der Bom

Photo: D. Sands

Photo 3: Chickpea response to residual deep P and K bands at Dysart in the fourth crop after deep banding. The plants on the right represent the standard grower practice, while those on the left had received 40kg/ha (P) and 50kg/ha (K) in bands spaced 45cm apart over four years ago.

(Figure 3), rates should be such that benefits can be spread across multiple seasons before reapplications are needed. Higher P rates generally show longer residual benefits, but higher rates of K applied with P can be counter-productive due to negative effects on P availability and luxury uptake of K by the crop that is subsequently returned to topsoil layers in residues.

Typical P application rates range from 20 to 40kg/ha (100 to 200 kg/ha MAP equivalent), while those for K range from 50 to 100kg/ha (100 to 200kg/ha MOP equivalent).

What depth and band spacing should I use?

Band depth should be below the topsoil layer that is most vulnerable to drying, but still in a profile layer with high root density. We have targeted a depth of 20cm, in the middle of the depleted 10 to 30cm profile layer. This depth allows relatively rapid interception by crop roots (Photo 2), with plenty of time to proliferate roots around the band and still provide some opportunity for the band to re-wet in response to in-season rainfall.

Optimal band spacing is a trade-off between the volume of soil enriched with P and/or K (more bands enrich greater soil volumes), the equipment available and the stubble load. Collectively, research has shown that band spacings that are twice the row spacing of the narrowest crop rows in the rotation are very effective. These typically range from 40 to 50cm apart. Any wider and the risk of limited root interception increases, while closer band spacings enrich greater soil volumes but use lower in-band concentrations that expose more P for sorption reactions on soil surfaces. Bands can be applied parallel with intended crop rows, but applying at a slight angle across crop rows makes sure that any plant sown cannot miss accessing the nutrient.

When should I re-apply?

Research has shown that deep bands of P fertiliser provide strong economic responses and improve productivity over 3 to 5 crop seasons (Figure 3 and Photo 3), as long as other nutrients are not limiting yield increases (N, for example). Responses may last longer in some situations and soil types, but where low P and K occur simultaneously, uptake and transfer of deep K to the soil surface in crop residues usually

Photo: M. Bell

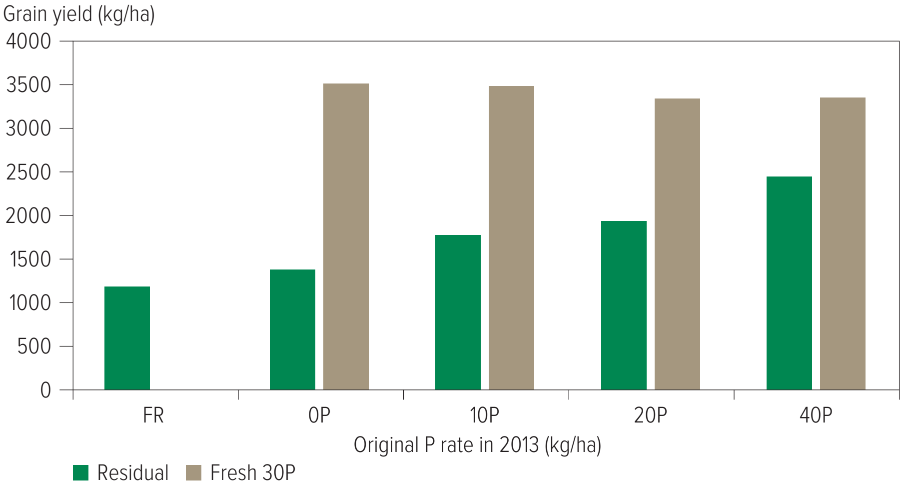
Photo 4: Faba bean response to freshly applied deep P and K bands near Jandowae in 2019. The plants in the foreground had been ripped but with no deep P and K applied, while those in the background received 30kg/ha (P) and 50kg/ha (K).

limits responses to deep K bands to three crop seasons. The K does not necessarily leave the paddock, it is just redeposited onto the soil surface with the returned crop stover.

Although strong residual responses to deep P bands may still be occurring (for example Photo 3), economic benefits from re-applications have still been recorded due to the fresh bands enriching greater soil volumes and allowing more crop P uptake (Figure 4 and Photo 4).

Once a deep banding program has commenced, soil testing to determine subsoil P and K status and likely fertiliser responsiveness become problematic due to uneven nutrient distributions across the paddock. Test strips can then be used to determine responsiveness to reapplication.

Figure 4: Effects of re-application of an additional 30kg/ha (P) before crop 5 (chickpeas) at the Dysart site. The farmer reference site (FR) was never deep ripped and represents local commercial practice.



Source: Adapted from Sands et al. 2020

USEFUL RESOURCES

GRDC Fact sheet: *Crop Nutrition: Phosphorus management* (Northern region) 2012 – grdc.com.au/GRDC-FS-PhosphorusManagement

GRDC Fact sheet: *Crop Nutrition: Soil testing for crop nutrition* (Northern region) 2014 – grdc.com.au/resources-and-publications/all-publications/factsheets/2014/01/grdc-fs-soiltestingn

GRDC Update Paper (2022): *P dynamics in vertosols – factors influencing fertiliser P availability over time and the implications for rate, application method and residual value* – grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2022/07/p-dynamics-in-vertosols-factors-influencing-fertiliser-p-availability-over-time-and-the-implications-for-rate-application-method-and-residual-value

GRDC Update Paper (2022): *Deep P and K – a call to action! Critical soil indicators, costs and benefits of deep P & K and timing* – grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2022/03/deep-p-and-k-a-call-to-action!-critical-soil-indicators,-costs-and-benefits-of-deep-p-and-k-and-timing.

GRDC Update Paper (2019): *Phosphorus and phosphorus stratification* – grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2019/02/phosphorus-and-phosphorus-stratification

GRDC Update Paper (2020): *Nutritional strategies to support productive farming systems* – grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2020/02/nutritional-strategies-to-support-productive-farming-systems

GRDC Update Paper (2020): *Fine tuning deep phosphorus and potassium management* – grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2020/11/fine-tuning-deep-phosphorus-and-potassium-management

FURTHER READING

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Lester D, Bell MJ, Weir D, Lush D (2022), **Rate or row spacing? What increases crop P uptake from deep placement in southern Queensland cropping soils?** Proceedings of the 20th Agronomy Australia Conference, Toowoomba Qld. www.agronomyaustraliaproceedings.org

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van der Bom F, Williams A, Borrell A, Raymond N, Bell MJ (2023), **Phosphorus management is key to effective deployment of root ideotypes in complex soil environments. Plant and Soil** https://doi.org/10.1007/s11104-023-06020-8

MORE INFORMATION

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UOQ1207-001RTX – Regional soil testing guidelines for the Northern Region.