PLACEMENT OF PHOSPHORUS FERTILISERS

Special consideration needs to be given to the placement of any P fertiliser due mainly to its immobile behaviour in soil.

To develop an effective phosphorus fertiliser placement strategy, a number of parameters need to be known.

- Available P in the 0-10 cm soil profile (use colwell P on most vertisols)
- Available P in the 0-30 cm profile (use colwell P on most vertisols)
- Phosphate reserves in the 0-10 cm profile (use BSES P and total P)
- Phosphate reserves in the 10-30 cm profile (use BSES P and total P)

Once we have these indicators of where the phosphorus reserves are then a strategy can be formulated.

DEEP PHOSPHORUS FERTILISER PLACEMENT

Background

"Only 1-2kg is taken up from the banded phosphorous fertiliser applied at planting (either in or below and beside the seeding row)." (Department of Agriculture, Fisheries and Forestry, 2012, Section: Phosphorous)

Due to rainfall patterns and the root architecture of most grain crops where the top 10 cm of soil is often dry or drier than below this depth, most of the moisture and nutrients are taken up from below 10 cm. Compounding this issue is almost all P fertilisers are applied no deeper than 10 cm. In addition, P from crop residues (at least half of which has been taken from below 10 cm) is deposited on the surface and in no till systems, is not incorporated at all, or at best where there is cultivation, is only incorporated in the top 10 cm also. Over the longer term factors like cracking and earth worm activity will play a role in redistributing nutrients, but in highly productive crop growing situations, nutrient relocation is outrunning these natural processes. In contrast to nitrogen and sulphur, P is immobile in the soil and surface application does not result in accumulation at depth. A study done at the Incitec Pivot long term fertiliser trial site at Rand shows that Colwell soil P levels accumulating 0-10 cm profile where P was applied at 0, 10, 20, 30, and 40 kg of P but with no significant increase below this depth (Laycock, 2014)

Seedlings and undeveloped root systems require higher concentrations of P in the soil both to ensure early vigour and to establish yield potential. Normally there is adequate moisture in the top soil to enable access to this higher level of fertility during seedling development. However as the season wears on, especially for crops grown mainly on stored moisture, the shallow soil where the more concentrated nutrients and nutrient cycling occurs, has dried out and the crop must extract its nutrient from where the moisture is, usually, the 10 – 30 cm profile. During the later crop growth stages the root system has become more mature and efficient and has developed such things as mycorrhizal colonisation that enhances its ability to extract P from deeper soil with a lower P concentration. This benefit is offset to an extent by the accelerating demands of the plant to supply P to an increasing biomass, flower and fill grain. Crop responsiveness to P fertilisers placed into this

area of the root zone where the plant is taking up the bulk of its P requirement during peak P demand growth stages depends on what concentration the soil P has been depleted down to.

Identifying a Responsive Site

As an indicator of responsiveness to P application, some critical P values have been developed for northern grain vertisols. The application of this as a guide will depend on other soil fertility factors/constraints (OM %, structure etc.) and the performance required from the production system which depends largely on the PAW – irrigation/rainfall. These values can be used as a criteria for justifying further investigation of the cost:benefit of P application in the form of trial areas to gain experience of the likely cost benefit of the particular areas in question.

Test	**Surface (0-10cm)**	**Subsoil (10-30cm)**
Colwell P	< 25 mg per kg = probably responsive. 25-40mg /kg = Maintain level with starter P >40mg/kg -= Response unlikely, replacement maybe unnecessary unless BSES is low	<10 mg/kg = Probably Responsive unless BSES is >100mg/kg 10-20 mg/kg= Probably unresponsive unless BSES <30mg/kg >20mg/kg = Should be more suitable for growing summer crop on stored moisture.
BSES P	< 100 mg/kg More important to replenish P removed from field >100 mg/kg maintaining P less important	< 100 mg/kg More important to replenish P removed from field >100 mg/kg maintaining P less important
TOTAL P (Estimated relative values)	<500 mg/kg more important to replenish P removed from field >600 mg/kg Maintaining P less important	<300 mg/kg more important to replenish P removed from field >400 mg/kg Maintaining P less important

Table 1. Critical P values.

Note. Table amended from Critical P values used to determine likely response or drivers of P availability in northern Vertosols by Bell et al. 2014.

PBI (phosphorus buffering index) should also be tested above and below 10 cm as an indicator of how the readily the available (soil solution) P pools are replenished from other reserves (sorbed P/BSES P) as the plant draws down on them. If PBI is under 300, then a Colwell P of 25 ppm or more is adequate. If the PBI is over 300, a higher colwell P would be required to ensure P nutrition is adequate through the season.

Implementation Strategy for Deep P Placement

- Where? (Placement): 50 cm spacing's, 15-20 cm depth. In alternate treatments, the rows can be offset such that there is no accumulation of residual P in retreated bands.
- When? (Timing): 1-4 months pre-planting, when soil moisture is low so that minimal losses occur. Or, opportunistically – when pupae busting post cotton picking or when deep sowing chickpeas.

- What? (Product selection): Generally, a granular product will be required to flow through most machinery. If no potassium is required then a high analysis product like MAP or DAP will probably represent best value. Some work has been done by Southern Farming systems in Victoria using chicken manure to ameliorate duplex soils. (Grains Research and Development Corporation. 2011)
- How much? (Application rate): to lift soil P by 1mg/kg in a colwell extract (PBI<140)2.5 kg of P are required per ha. (Laycock. 2014.) How much also depends on... How Often...
- How often? Once every 5 years is being suggested. If say an average of 10 kg of P is removed per year (4t/ha x2.5 kg of P per tonne), and 5 kg of this P is applied in the top 10cm, then we need to apply about 25 kg of P in the 15-30 cm profile once every 5 years. If P levels are very low, and responsiveness to deep P has been verified, then perhaps the initial application may need to take account of the deficit that is likely to have occurred over the past 5-30 years so that the levels can be built up to an acceptable concentration, after which a maintenance dose is required for the next period.

Placement with Seed:

Placing P fertiliser with the seed is the traditional method of fertilising most grain crops for obvious logistical reasons and application rates have reflected nutrient replacement requirements as well as crop response. This strategy needs to be revisited as starter fertilisers rarely contribute more than 1-2kg of P per ha to crop nutrition in the year of application. (Bell et al, 2010)

This means that if a Deep P fertiliser application strategy is able to be adopted, starter fertiliser need only be applied as means to ensure that seedling nutrition is adequate, ie where colwell P levels are < about 25 mg/kg. The minimum application rate with a granular product will need to account for the frequency of granule placement along the plant row so as not to space granules too far from each seedling such that the area of enriched P is out of reach. Application rates of between 10-50 kg of product per ha depending on row spacing should give adequate coverage. Based on granule sizing of 80 granules / gram (this will vary-check product used), one granule per 25 mm along a lineal row is equal to 5 kg per ha on 1 m spacing's or 20 kg per ha on 250mm spacing's and so on. Accuracy of the metering system of air seeders needs to be assessed to adjust this rate up or down. Liquid starter ferts are able to place a lower rate of P per ha and depending on dilution, can deliver a more continuous stream of enrichment (albeit at a lower concentration) along the plant row. For some growers liquid starters have a logistical ease of handling depending on their machinery set up. If the bulk of the P is able to be applied as a granular at depth, then the decision to use a liquid P fert at planting may become an easier one.

Foliar Applied P Fertilisation

Foliar application of P to supply mid season requirements where deeper soil reserves are inadequate will struggle to keep up with plant requirements. A minimum of 3 foliar applications would be required from late tillering through to flag leaf emergence. Due to the cost of these additional in crop passes and the lack of yield increase demonstrated in foliar P trials, it is unlikely that this is an effective strategy. Foliar application of P may be worth investigation if deep P placement was ineffective for example in hostile subsoil situations where high aluminium is fixing P.

Cost

The estimated cost of a pass at 20cm depth and a 50 cm spacing in a northern vertosol is $30-$40 per ha. Amortised over a 5 year period this figure comes back to $9 - $11 per ha per year. This does not account for the cost of the product applied. (Bell et al, 2014, March 4)

In principle, the cost of replenishing removed soil nutrients should already be factored into a properly formulated cost of production calculation. In reality, many grain producing areas may have a legacy of mined out nutrients that has effectively created a hidden deficit in the farm business. The initial replenishment may need to be accounted for as a capital expenditure. The amortised cost of the ongoing maintenance of deep soil P concentration (product +application) can be accounted for in Gross margin calculations. Some of this cost will perhaps be offset by reduced starter fert costs as P replacement is redistributed from shallow to deep.

Long Term Effectiveness

To some extent the P placed at depth will be brought back up to the surface again by the depositing of crop residues on the surface. Ongoing long term research into deep P placement systems may identify that once more of the P is available at depth, the O horizon may become increasingly self replenishing or even gradually accumulate P as the plant is able to access more P from depth and requires less from the top 10cm.

Efficiency of P uptake

Banding of P has advantages of disadvantages. In soils with a low PBI or where P is less prone to fixation then a more even distribution of P throughout the soil volume will improve access by exposing more root volume to available supply of P. In soils that are fixing P, banding or concentrating P may increase the efficiency of uptake by minimising the exposure of water soluble P to fixation and maximising the concentration gradient for easier root up take albeit to a reduced volume of roots. Due to mechanical constraints, we are limited to banding P at depth so as to minimise both soil disturbance and tractor draft.

Sustainability

Wikipedia states that as phosphorus is a scarce resource worldwide (only 50-100 years of Phosphorus fertiliser left) careful use of our P resource is therefore important. (Peak Phosphorus, para. 1). Use of recycled organic sources of P (manure, compost etc) is best applied on the surface for obvious logistical and mechanical reasons (machines are currently being developed to enable deep manure placement) and reserve the (generally) more expensive granular sources of P (from mined sources) for deep P placement. Routine application of (starter) P needs to stop and a focus on maintaining the critical minimum thresholds throughout the relevant soil profiles needs to be established as best practice.

FOR ADVICE ON IMPROVING SOIL HEALTH AND FERTILISER USE, DONT HESITATE TO

CALL JULIAN FROM FERTILE FARM ON 0417 138 015 Or email info@fertilefarm.com.au

SUMMARY:

What is being highlighted here is the need to encourage surface root feeding in our cropping systems. If we don't, then there will be an increasing requirement for this deep tillage/nutrient placement which will increase cost of production through increased fuel use and moisture lost. Encouraging surface root feeding comes back to holding more moisture in the top soil which - in a dryland situation - the main management tool is good ground cover. Bare fallow's with little ground cover that grow crops on deep stored soil moisture are going to be the worst offenders when it comes to using up precious deep nutrient reserves rather than the easier to replenish surface nutrients.

REFERENCES

Bell et al, (2014, March 4). *Changing nutrient management strategies in response to declining background fertility: The economics of deep Phosphorus use.* Retrieved from http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/03/Changing-nutrient-management-strategies-in-response-to-declining-background-fertility

Bell et al, (2014, March) GRDC Grains Research Update; Goondiwindi. *Economics and management of phosphorus & multiple nutrient decline: placement, costs and returns over time, and factors influencing response and risk*.

Bell et al. (2010). *Improving phosphorus fertiliser management on southern Queensland grain farms*. Retrieved from http://www.daff.qld.gov.au/__data/assets/pdf_file/0006/49821/SQFS-Phosphorus-Fertiliser-Mgmt-Report.pdf

Department of Agriculture, Fisheries and Forestry. (2012). *Wheat – nutrition*. Retrieved from http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/nutrition

Grains Research and Development Corporation. (2011). *Taming hostile subsoils with subsoil manuring.* Retrieved from http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2011/07/Taming-hostile-subsoils-with-subsoil-manuring

Laycock, J. (2014). *Economics and management of P nutrition and multiple nutrient decline.* Retrieved from http://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/02/Economics-and-management-of-P-nutrition-and-multiple-nutrient-decline

Wikipedia. (2014). Peak Phosphorus. Retrieved from http://en.wikipedia.org/wiki/Peak_phosphorus#Estimates_of_world_phosphate_reserves