Department of Employment, Economic Development and Innovation
Agri-Science Queensland

Southern Queensland farming systems

Improving phosphorus fertiliser management on southern Queensland grain farms

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Introduction

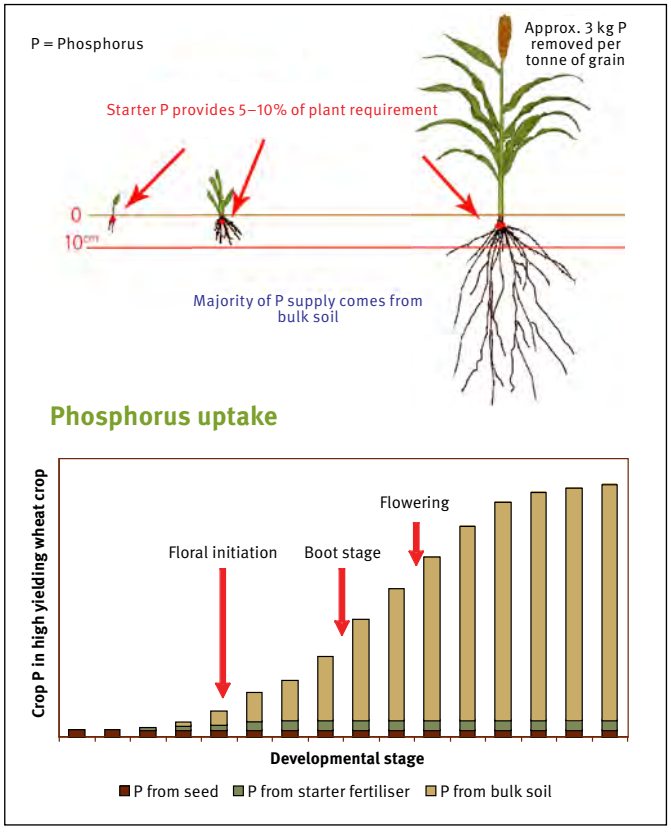
This project has focused on the main cropping soils of southern Queensland, where unpredictable responses to applied phosphorus fertiliser in grains and pulses are continuing to be recorded.

Some key messages that have come out of the project include the following:

- Our soil phosphorus reserves are declining, especially in the subsoil.
- Fifty per cent of phosphorus removed comes from below 10 cm.
- Phosphorus applied with seed only supplies approximately 10% of crop needs.
- Measuring BSES-P and Colwell P in the 10–30 cm layer gives growers and advisers a better understanding of how much phosphorus the plant can access.
- There is a measurable yield response to deeply applied phosphorus when subsoil reserves are low.

Where does the phosphorus come from?

Recent studies have shown that on the inner Darling Downs approximately 50% of the net phosphorus removal from soils (averaged over a string of typical seasons) comes from layers deeper than 10 cm, with most coming from the 10–30 cm layer. However, in commercial fields the 0–10 cm soil layer has not shown the same level of net phosphorus removal. This is due to the continual placement of phosphorus in this layer from both fertiliser and crop residue, along with the reduction in soil mixing resulting from a reduction in tillage operations. This stratification of phosphorus (enrichment of the topsoil but depletion of the subsoil) makes fertiliser management strategies difficult, as traditional soil tests may still indicate adequate phosphorus.



Typical phosphorus uptake

CSIRO
GRDC Grains Research & Development Corporation
Toward Tomorrow's Queensland
Queensland Government

Taking soil sample

How do plants use phosphorus?

Crop phosphorus requirements can be considered in two phases.

The initial requirement for a high phosphorus concentration around a small and relatively inefficient seedling root system is to ensure early vigour and the establishment of high yield potential.

The plant also needs a continuous, adequate supply of phosphorus to produce dry matter through the rest of the season.

Once the root system is much bigger and more efficient, it can either tap into easily accessible, moist topsoils that are relatively rich in nutrients, or (when these layers dry out) into deeper subsoil layers that retain moisture for longer but have generally lower stores of available nutrients like phosphorus.

This means that growers and advisers need to consider two things. Firstly, they need to understand the status of the phosphorus reserves in the top 10 cm, which will help with the crop's early growth. However, they also need to understand the status of the phosphorus reserves in the immediate subsoil to understand the soil's ability to supply the crop during the rest of the growing season.

Average phosphorus removal rates in the northern grains region of Australia (kilogram of phosphorus per tonne of grain)

Crop	Average removal rates
Wheat	3.2
Sorghum	2.9
Chickpea	3.2

Nutrient management initiative, DAQ00084 (Bell et al. 2008)

Phosphorus testing

We recommend testing both the 0–10 cm layer and the 10–30 cm layer, as this will provide the most useful information. When analysing these soil samples, growers and advisers will need to measure:

- **Colwell P**—a measure of the phosphorus stored in the most easily available forms for plant uptake
- **Phosphorus Buffer Index (PBI)**—an indicator of the rate of replenishment of these available pools
- **BSES-P**—an indicator of likely slow-release phosphorus reserves. The quantity of phosphorus in these forms can be substantial in some soils and almost non-existent in others.

This more intensive sampling is only required every 4–6 years (or once per rotation) as the presence of slow-release reserves will not change very quickly—especially in the deeper soil layers.

Applying phosphorus

If the soil is low in phosphorus, growers and advisers will need to determine the best phosphorus application strategy to meet crop demands.

The traditional starter phosphorus fertiliser techniques of banding phosphorus fertilisers in, or very near to, the seeding trench at planting will meet early crop demand.

However, we have rarely seen starter phosphorus fertilisers provide more that 1–2 kg of phosphorus per hectare to crop phosphorus uptake, which is only about 5–10% of crop phosphorus requirements.

That means that most phosphorus comes from the rest of the soil profile. Our work is continuing to investigate the most effective way of meeting this demand. Preliminary research has demonstrated growth and yield responses to supplying phosphorus in addition to starter fertilisers.

Responses have been as high as 20% yield increases in wheat and sorghum.

The best responses occur when the additional fertiliser is applied in multiple bands as deep as 20 cm.

If applying phosphorus into the lower soil layers is considered worthwhile, timing of application, the form and quantity of fertiliser used, and the band spacing all need to be considered.

However, in soils with relatively low PBI (< 150) the phosphorus applied will continue to be available to following crops for several years, depending on the amount. This potentially opens up the possibility of pre-planting applications—either when pre-plant nitrogen fertiliser is applied or even earlier in the fallow when soil moisture stores are low.

While almost all application options have high power requirements, one option that may fit well with current farming practices is applying high rates of phosphorus when deep planting chickpea. While care will obviously need to be taken to avoid effects on crop establishment, the residue from these deep bands will be a source of phosphorus for other crops in the rotation.

One thing growers do need to remember is that addressing a low–soil phosphorus problem requires a different approach to supplying phosphorus to a young seedling via an application of starter fertiliser.

To effectively meet crop demand, a large volume of phosphorus-enriched soil is crucial to maximise crop root system access to the applied fertiliser.

Single bands, especially when spaced wide apart (as for summer crops like sorghum), will not allow enough roots to access the applied fertiliser and will have only small effects on crop phosphorus uptake, reducing fertiliser efficiency.

The key will be multiple bands (probably applied over a number of years) in different positions and depths.

The high residual value of these fertilisers in low-PBI soils is an obvious key to success in this strategy.

Wheat crop

Summary

With declining soil phosphorus reserves (especially in the subsoil) becoming a major limitation to crop yields, appropriate fertiliser management strategies are critical to improving profitability.

By measuring phosphorus status in the subsoil, industry will be better equipped to understand the crop growth limitations posed by low soil phosphorus and improve fertiliser management strategies.

While at this stage there is no clear answer on the best method to apply phosphorus deeper into the profile or how much should be applied, further research is underway.

However, this project has demonstrated that starter fertilisers alone are not enough to overcome phosphorus limitations to yield in soils with low phosphorus reserves.

More information

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