

PHOSPHORUS—NEW SOUTH WALES

Key points

- Phosphorus (P) is one of the most critical and limiting nutrients in agriculture in NSW.
- Phosphorous cycling in soils is complex.
- Only 5–30% of phosphorus applied as fertiliser is taken up by the plant in the year of application.
- Phosphorus fertiliser is best applied at seeding.

Background

Phosphorus is essential for plant growth, but few Australian soils have enough phosphorus for sustained crop and pasture production. Complex soil processes influence the availability of phosphorus applied to the soil, with many soils able to adsorb or 'fix' phosphorus, making it less available to plants. A soil's ability to fix phosphorus must be measured when determining requirements for crops and pastures.

Deficiency symptoms

Phosphorus deficiency is difficult to identify visually. Stunted growth, leaf distortion, chlorotic areas and delayed maturity are all indicators (figure 1). A purple or reddish colour is often seen in deficient plants, especially when temperatures are low, but deficiency can also cause the crop to look darker green at some growth stages. Deficient cereal crops are often poorly tillered. Deficient areas are first visible on lower parts of the plant but the whole plant tends to be affected.



Figure 1: Stunted growth and yellowing of leaf tips in phosphorus-deficient wheat (right.) Photo: Snowball and Robson, 1988.

Measuring soil phosphorus levels

Most phosphorus is tightly held by soil minerals and weakly available to plants, so testing for available phosphorus is

more useful than total phosphorus. The most common test for available phosphorus in NSW is the **Colwell phosphorus test**. The amount of Colwell phosphorus needed for crop growth depends on the soil's texture, clay mineralogy and pH, which determine its 'fixing' ability. On some soil types the Colwell P test has not proved to be reliable, particularly on calcareous soils. The new DGT test appears to work well on this soil type and so will probably become the preferred soil test on at least calcareous soils.

Measuring soil's ability to fix phosphorus

Knowing the soil's ability to fix phosphorus is vital in determining the rates of fertiliser application, as a high fixing soil will require significantly more phosphorus fertiliser. The most common test used in Australia to estimate a soil's potential to fix phosphorus is the **Phosphorus Buffering Index (PBI)**. This test is used with other soil and crop traits to optimise fertiliser recommendations.

Fate of applied fertiliser

Phosphorus fertiliser is mostly applied in a water-soluble form, which reacts rapidly in the soil (principally with iron, aluminium and calcium) to form less soluble, more stable compounds. This means there is competition between soil and plant roots for the water-soluble phosphorus. Only 5–30% of the applied phosphorus is taken up by the crop in the year of application. In acid soils (pH < 5.0), the soil's ability to fix phosphorus rises dramatically. Phosphorus is lost from the soil with soil erosion.

Phosphorus in the soil and plant availability

Phosphorus generally stays close to where it is placed in the soil, with little lost to leaching. It is present as undissolved fertiliser, adsorbed by clay minerals, or as a component of soil organic matter. In a high fixing soil, phosphorus associated with soil organic matter may be the most plant available form, so increasing soil organic matter levels may be part of an effective strategy to boost available phosphorus.

Role of vesicular arbuscular mycorrhizae

Some crops enhance their phosphorus uptake through a symbiotic relationship with fungi that grow within the plant roots. These fungi, known as vesicular arbuscular mycorrhizae (VAM), greatly increase the effective root surface area and the uptake of phosphorus. High levels of VAM in paddocks can reduce the need for phosphorus fertiliser in crops that form associations with them. Chickpea, faba bean, linseed and safflower crops promote the build up of VAM in the soil. Winter cereals and field peas also support VAM, but to a lesser degree. VAM levels are reduced by cultivation and some crop rotations, including canola and lupins. Some agronomic models include consideration of the VAM status of a paddock based on the paddock's crop rotation history, but most do not consider this effect.

Phosphorus removal

Different crops remove different amounts of phosphorus from soil at harvest. Canola removes more than twice the amount of phosphorus per tonne of crop harvested compared to cereal crops such as wheat and barley. However the higher yields of cereal crops mean that they usually demand more phosphorus overall.

Fertiliser strategy and placement of phosphorus

Phosphorus budgets usually aim to meet current crop needs and slowly raise the level of available phosphorus over a period of years. A long term regime of applying phosphorus fertiliser, combined with liming to maintain pH above 5, reduces soil's capacity to fix phosphorus,

which makes subsequent fertiliser applications more effective.

The optimum time for applying phosphorus fertiliser is at seeding. There are significant yield penalties in applying phosphorus more than 10 days after germination. Placing concentrated phosphorus too close to seeds can reduce germination and establishment. Banding phosphorus in the top 10 cm of high fixing soils has had variable results in trials—lupins responded, wheat and canola did not. When the effects of disturbance on soil moisture were accounted for, some strong biomass and yield responses to deep banding has been shown in a range of grain and forage species (Bell et al. 2005) (figure 2).

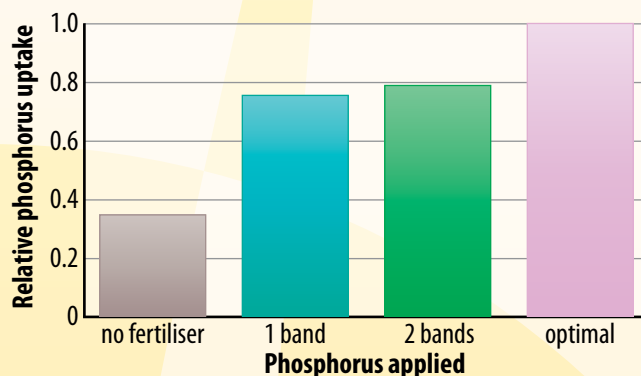


Figure 2: Effectiveness of banding to supply nutrients for uptake by maize where the same quantity of phosphorus was supplied in 1 or 2 bands (Bell et al. 2005).

Phosphorus fertiliser applied to the topsoil does not replenish subsoil reserves. Recent research in the northern cropping region suggests yield penalties of up to 20% where subsoils are phosphorus deficient, and ongoing yield benefits for up to five seasons following deep fertiliser banding.

Further reading and references

- Bell M, Singh J, Norrish, S and Moody P (2005) 'Nutrient stratification and implications for fertiliser placement', Goondiwindi Grains Research Update.
- Snowball K and Robson AD (1988) Symptoms of nutrient deficiencies in subterranean clover and wheat, The University of Western Australia, Crawley.
- The GRDC maintains useful resources including decision support tools CliMate, CropMate VarietyChooser and MyCrop ([online](#))
- The New South Wales Department of Primary Industries maintains useful information on soil fertility and its management in NSW ([online](#))

Authors: Richard Quinlan (Planfarm Agricultural Consultancy), Andrew Wherrett (Department of Agriculture and Food, Western Australia)

Revised for NSW: Stephanie Alt (NSW Department of Primary Industries), 2013



Department of
Primary Industries



Soil Biology Initiative II
Supported by the GRDC

The National Soil Quality Monitoring Program is being funded by the Grains Research and Development Corporation, as part of the second Soil Biology Initiative.



Grains Research &
Development Corporation
Your GRDC working with you

The participating organisations accept no liability whatsoever by reason of negligence or otherwise arising from the use or release of this information or any part of it.