

CROP NUTRITION FACT SHEET

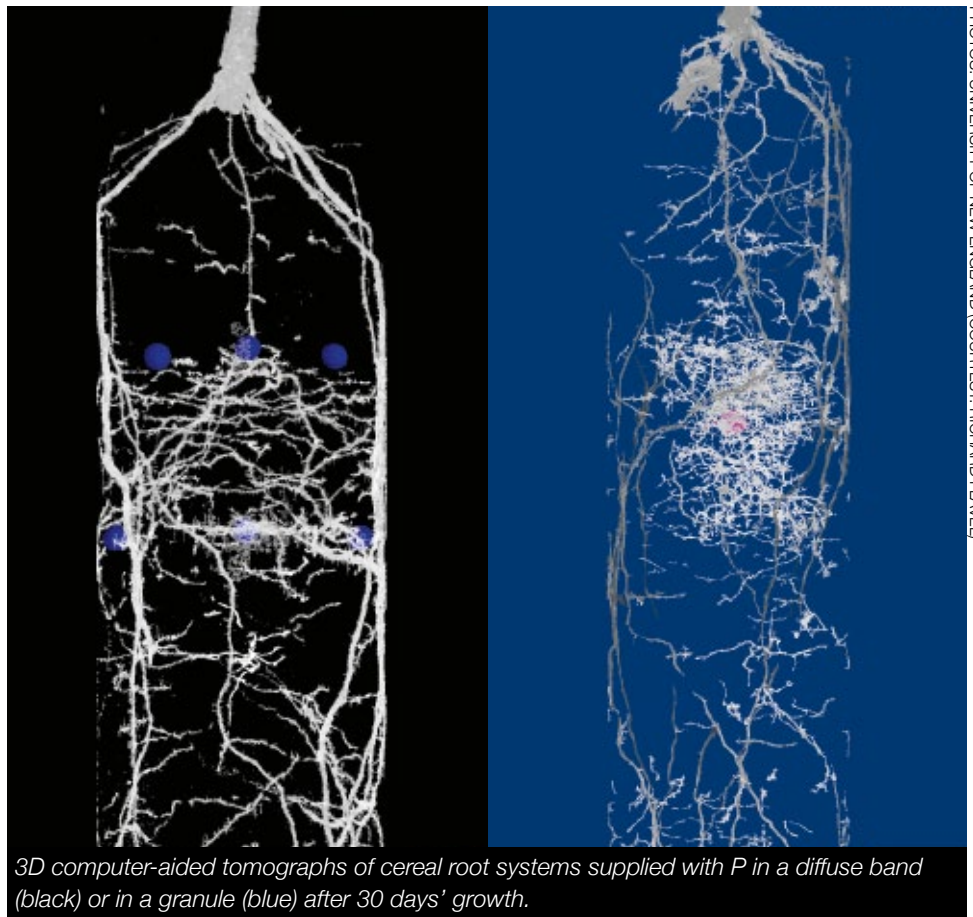
NORTHERN REGION

PHOSPHORUS MANAGEMENT

Addressing low subsoil phosphorus (P) levels by soil testing and deep placement of P can bring yield increases across multiple cropping seasons.

KEY POINTS

- Phosphorus (P) reserves have been run down over several decades of cropping.
- Adding fertiliser to the topsoil in systems that rely on stored moisture does not always place nutrients where crop needs them.
- Testing subsoil (10 to 30 centimetres) P levels using both Colwell-P and BSES-P soil tests is important in developing a fertiliser strategy.
- Applying P at depth (15 to 20cm deep on 50cm bands) can improve yields over a number of cropping seasons (if other nutrients are not limiting).
- Addressing low P levels will usually increase potential crop yields, so match the application of other essential nutrients, particularly nitrogen (N), to this adjusted yield potential.



3D computer-aided tomographs of cereal root systems supplied with P in a diffuse band (black) or in a granule (blue) after 30 days' growth.

Reserves of mineral nutrients such as phosphorus (P) have been run down over several decades of cropping with negative P budgets (removing more P than is put back in by fertilisers or crop residues).

This trend has accelerated as direct drill cropping has improved yields and crop frequency, removing even more P from the soil.

Consequently, limited P is now constraining yields in parts of the northern grains region, particularly in the vertosols (black and grey cracking clays).

High native fertility has been depleted, and the move to zero/minimum tillage has reduced the opportunities to incorporate P and other immobile nutrients into the soil.

Also, soil testing regimes used today were developed when soils were potentially more fertile in the subsoil and when conventional tillage re-incorporated crop residues.

Because the way we farm has changed, these testing strategies may no longer accurately predict soil fertility status, and they need to be revisited.

Note the following points.

- P is largely immobile in the soil, particularly in clay soils, so P applied to the topsoil (0 to 10cm) layer will not penetrate into the subsoil.
- P is being removed from the deeper subsoil layers (10 to 30cm) to meet crop demand, especially during dry periods when crop roots cannot access dry topsoil layers and the plant relies almost exclusively on stored subsoil water.



PHOTO: SARAH CLARRY

High native fertility in the black and grey cracking clays of the northern grains region has been depleted by years of continuous cropping, and incorporating phosphorus and other immobile nutrients at depth in zero/minimum tillage systems is a challenge.

- Crops must be able to access P (and potassium (K), another essential but immobile nutrient) from the subsoil. This supply is especially important in the post-seedling stage.
- P (and K) levels need to be adequate down to 30 to 40cm to drought-proof cropping systems in northern regions, which have a greater reliance on stored soil moisture rather than in-crop rainfall.

Test the subsoil

It is important to assess the P status of the subsoil periodically. Test the 10 to 30cm layer using BSES-P as well as Colwell-P soil tests.

Take the opportunity to test for K at the same time.

Such testing will build a more complete

picture of a soil's fertility and the values from the deeper layers can be used to refine your fertiliser strategy.

P and K fertility in the subsoil changes more slowly than in the top 10cm, where starter fertiliser is applied and where nutrients are deposited via crop residues.

Subsoil tests are an extra expense, however, they generally only need to be done once every four to six years.

Analysing grain for nutrient content provides additional information when monitoring soil fertility by accounting for the amount of nutrient removed with each harvest.

Crop needs

Different plants remove varying quantities of P from the soil and have different requirements for P at different growth stages. This needs to be taken into account when considering crop rotations.

Wheat, barley and sorghum have a critical requirement for a high soil P concentration around young seedlings in their first 30 days. This is when grain numbers are established and yield potential is determined.

Canola, lupins, chickpeas and maize do not have the same critical early requirement for P. They will establish more vigorously if they have it, but yield potential will not suffer if they do not.

In all species, however, P acquired during early growth is only a fraction of the crop's requirement through to harvest.

Soil tests explained

Colwell-P

The Colwell-P test uses a bicarbonate (alkaline) extraction process to assess the level of readily available soil P. It was the original test for P response in wheat in northern New South Wales. It is used with the phosphorus buffering index (PBI) to indicate the sufficiency and accessibility of P in the soil.

BSES-P

The BSES-P test was developed for the sugar industry but is now an important tool in the grains industry. BSES-P uses a dilute acid extraction to assess the size of slower-release soil P reserves.

These reserves do not provide enough P within a season to meet yield requirements, but they partially replenish plant-available P.

Because the P measured by BSES-P releases only slowly, changes in the test value of subsoil layers may take years. Therefore this test needs to be done only every four to six years, and is most important in the subsoil layers.

PBI

The 'buffering capacity' of a soil refers to its ability to maintain P concentration in solution as the plant roots absorb the P. The phosphorus buffering index (PBI) indicates the availability of soil P. The higher the value, the more difficult it is for a plant to access P from the soil solution. Generally, a PBI value of less than 300 (a range that would include most northern vertosols) indicates that soil P, as assessed by Colwell-P, is readily available.

Colwell-P and PBI values are needed in both 0 to 10cm and 10 to 30cm soil tests. BSES-P is optional in the 0 to 10cm layer but essential in the 10 to 30cm layer.



PHOTO: TIM COGDON

Comprehensive soil testing that includes the subsoil (10 to 30cm) will build a more complete picture of a soil's fertility, and the values from the deeper layers can be used to refine your fertiliser strategy. Because these values change very slowly, subsoil tests are necessary only once every four to six years.

The extent to which crops rely on starter P varies with species and season, but is typically less than 10 per cent of overall demand.

The rest must be supplied from the soil profile (residual P from crop residues and previous fertiliser applications in the zero to 10cm layer, and soil P reserves in layers below that).

Studies have shown starter P fertiliser applied at rates of 20 kilograms per hectare over a number of crops does not increase soil P below 10cm.

In dry seasons in particular, when crops rely mainly on stored subsoil water for growth, P is acquired almost exclusively from sub-surface layers (10 to 30cm) for much of the growing season.

However, this is not to discount the importance of subsoil P in more normal seasons. The key issue is the amount of soil with P that is accessible by plant roots.

The volume of soil accessed by roots increases as the crop grows, but the greatest density of roots is in the top 30cm of the profile. This is where P supplies are most important.

If Colwell-P testing shows that easily available P is low, as is often the case in subsoils, slowly available (BSES-P) becomes increasingly important as a reserve to supply some P to the soil solution.

While the rates of release of BSES-P are low, the important factor is that this release

is occurring over a large soil volume.

Older crops with large and expanding subsoil root systems are able to tap into this trickle supply of P to meet plants' needs.

The key to BSES-P meeting crop demand lies in the ability of the root system to access a sufficiently large soil volume containing these reserves.

Target the most responsive crop

The target soil nutrient levels in paddocks should be guided by the needs of the most responsive crop, that is, the crop that is going to return the greatest profit as a result of its access to P. The excellent residual value of P fertiliser in the northern vertosols means subsequent crops will be able to capture any unused P.

For example, wheat is more responsive to P than sorghum or maize, which in turn are more responsive than peanuts.

Wheat yield may be restricted if available P is less than 35 milligrams per kilogram (Colwell-P) in ferrosol soils with a higher PBI (phosphorus buffering index), while maize would be unaffected by P levels above 25mg/kg and peanuts above 15mg/kg on the same soils.

In contrast, yields of wheat grown on low PBI vertosols would be unaffected above 23 to 25mg P/kg Colwell-P.

The need for deep P

The maximum amount of starter P that can be applied with the seed depends on crop row spacing. In wide-row crops such as sorghum it is as little as 4 to 6kg/ha.

However, a crop will need much more than that throughout the growing season. For example, a five tonne per hectare sorghum crop will accumulate between 40 and 50kg P/ha and ultimately remove about half of that in grain.

In the north, P is accumulating in the top 10cm of soil as growers now band P with the seed, but at 10 to 30cm the soil reserves are declining at a worrying rate. To overcome this, P needs to be applied deeper to meet seasonal yield potential.

To achieve this in zero-till systems is a challenge. However, while P in most northern soils is largely immobile, PBI values are generally low, so fertiliser P remains available for plant uptake over extended periods. It is not 'locked up'



Above: The difference in soil disturbance between 50cm (background) and 100cm band spacings (foreground). Although soil disturbance is greater, applying P in bands 25 to 50cm apart has been consistently shown to produce stronger yield responses across soil types and crops than bands 100cm apart.



An example of soil disturbance with 50cm bands of P applied 20cm deep in the profile. While the site appears rough, subsequent rainfall allowed a good seedbed to ensure crop establishment.

TABLE 1 Phosphorus removed (kg) in one tonne of grain per hectare

Crop type	Phosphorus
Cereals (wheat and barley)	2-4.5
Cereal hay	2
Cereal straw	1
Chickpeas	2.5-5
Canola	7
Sorghum	1.5-4
Maize	2.5-4
Peanuts	3-5
Sunflowers	5-9

Different plant species remove different amounts of P. Around half the net P removed will come from the subsoil, the majority from the 10 to 30cm layer. The proportion from deeper in the profile is likely to be greater in drier environments in more western and northern areas.

as often occurs in other regions with different soils.

In some locations in the northern grains region, benefits are still being recorded six cropping seasons after deep application.

These excellent residual effects mean P can be applied at rates sufficient to meet crop requirements over multiple cropping seasons, keeping tillage to a minimum.

Use narrow bands

Apply P at depths of 15 to 20cm and in bands 50cm apart, or closer if possible.

If the bands are any wider than 50cm there will not be enough plant roots to reach the high P zones and meet crop demand.

Applying P in bands 25 to 50cm apart produces stronger yield responses than bands 100cm apart.

This has been shown consistently across soil types and crops, including wheat (sown



PHOTO: MIKE BELL

Response to deep P placement in mungbeans in Warwick. The crop on the right had normal starter P, while the crop on the left is benefiting from deep placement of P.

on 30cm row spacing) and sorghum (sown on 100cm row spacing).

Aim for enriched soil

Increasing the volume of enriched soil is more effective than just increasing P rates. The key is placing bands in different positions each cropping season.

The strategy of lower rates applied more frequently will eventually enrich enough of the soil volume to overcome P limitations, due to the excellent residual value of deep-placed P.

Soil disturbance

Deep application of P in narrow bands represents significant soil disturbance in a zero or minimum-tillage system, so apply strategically when stubble levels and soil moisture stores are low, to limit moisture loss.

This also allows time and fallow rainfall to reduce any roughness and ensure good establishment in the next crop phase.

Alternatively, make deep P applications on an opportunistic basis, such as when deep-sowing chickpeas, or when using tillage after a cotton crop.

Some variability in crops sown soon after deep placement of fertiliser can be expected, but this effect seems to even out in subsequent seasons.

Nutrient combinations

Yield response to deep placement of P in subsequent crops may be constrained

if other nutrients are limiting, so the right combination of nutrients is important to get the best return on your fertiliser investment.

As deep placement of P should be done only occasionally, take the opportunity to address any other nutrient deficiencies at the same time, especially for immobile nutrients such as potassium (K).

Assess the K and sulfur (S) status of the subsoil and, if levels are low, both K and S can be included along with P in the same application.

Trials in northern grain crops have often demonstrated stronger responses to combined nutrients placed deeply than to individual nutrients alone.

Soil test results will indicate if there is likely to be a response to a fertiliser nutrient, and the approximate amount of nutrient required to achieve a target yield.

These values are not definitive. Both will vary with target yield and soil/environmental conditions.

Applications of more mobile nutrients such as nitrogen (N) and S can continue to be made to target individual crops and yield targets, as is commonly practiced.

Matching nitrogen

Most growers use a N budgeting approach to match fertiliser N input to the water-limited yield potential.

Applying combinations of nutrients including P, K and S will raise crop yield

potential for low fertility fields, which will mean an increased demand for N.

At some research sites following deep placement, consistent increases in crop growth were observed in subsequent cropping seasons.

At others, yield was more unpredictable. In these cases, N levels were often not adequate enough to allow the new water-limited yield potential to be realised.

In soils that are responsive – that is, those that are low in subsoil P – an adequate application of P generally produces about a 20 per cent yield increase. However, if targeting such an increase, remember to apply 20 per cent more N.

USEFUL RESOURCES

Making Better Fertiliser Decisions for Cropping Systems in Australia

www.bfdc.com.au

MORE INFORMATION:

Mike Bell, QAAFI

07 4160 0730
m.bell4@uq.edu.au

Chris Guppy, UNE

02 6773 3567
cguppy@une.edu.au

David Lester, DAFF

07 4639 8886
david.lester@daff.qld.gov.au

Phil Moody, DSITIA

07 3170 5706
phil.moody@derm.qld.gov.au

GRDC PROJECT CODES

DAQ00148, DAN00165



Undertaken as part of the GRDC's **More Profit from Crop Nutrition** initiative.

Acknowledgments: Mike Bell, Chris Guppy, David Lester, Phil Moody, Enli Wang.

DISCLAIMER

Any recommendations, suggestions or opinions contained in this publication do not necessarily represent the policy or views of the Grains Research and Development Corporation. No person should act on the basis of the contents of this publication without first obtaining specific, independent, professional advice.

The Corporation and contributors to this Fact Sheet may identify products by proprietary or trade names to help readers identify particular types of products.

We do not endorse or recommend the products of any manufacturer referred to. Other products may perform as well as or better than those specifically referred to.

The GRDC will not be liable for any loss, damage, cost or expense incurred or arising by reason of any person using or relying on the information in this publication.

CAUTION: RESEARCH ON UNREGISTERED PESTICIDE USE

Any research with unregistered pesticides or of unregistered products reported in this document does not constitute a recommendation for that particular use by the authors or the authors' organisations.

All pesticide applications must accord with the currently registered label for that particular pesticide, crop, pest and region.

Copyright © All material published in this Fact Sheet is copyright protected and may not be reproduced in any form without written permission from the GRDC.

PRODUCED BY WWW.CORETEXT.COM.AU