References

The importance of phosphorous to plants (2014). Retrieved May 5, 2014, from http://passel.unl.edu/pages/informationmodule.php?idinformationmodule=1130447043&topicorder=2&maxto=15

Fact Sheets Phosphorus - Western Australia (2014). Retrieved May 5, 2014 from http://soilquality.org.au/factsheets/phosphorus

D. Plénet, S. Etchebest, A. Mollier & S. Pellerin (2000). Growth analysis of maize field crops under phosphorus deficiency. Plant and Soil. Vol 223, Issue 1-2, pp 119-132

Matthias Wissuwa, Gloria Gamat & Abdelbagi M. Ismail (2005). Is root growth under phosphorus deficiency affected by source or sink limitations? Journal of Experimental Botany. Vol 56, Issue 417.

George Rehm, Michael Schmitt, John Lamb, Gyes Randall, and Lowell Busman (2002). Retrieved May 5 2014 from http://www.extension.umn.edu/agriculture/nutrient-management/phosphorus/understanding-phosphorus-fertilizers/

Daniela Montalvo, Fien Degryse, and Mike McLaughlin. Phosphorus chemistry around placement of granular and fluid fertilizers in acidic strong P-sorbing soils. Retrieved May 5, 2014 from http://www.adelaide.edu.au/fertiliser/docs/FluidForum2013_Final_version_presented.pdf

Rebecca Lines-Kelly (2002). Why phosphorus is important. Retrieved May 5, 2014 from http://www.dpi.nsw.gov.au/agriculture/resources/soils/improvement/phosphorous

The soils of Australia (2012). Retrieved May 5, 2014 from http://www.abs.gov.au/AUSSTATS/abs@.nsf/Previousproducts/1301.0Feature%2Article801966?opendocument&tabname=Summary&prodno=1301.0&issue=1966&num=&view=

Advanced Nutrients (2012). BANG P™ Field research

International Plant Nutrition Institute. Polyphosphate. Fact Sheet No. 2.

T. McBeath and Drs. E. Lombi, M. McLaughlin, R. Holloway, R. Smernik, E. Bunemann (2005). Determining The Yield Potential of APP In Varying Australian Soil Environments. Fluid Journal. Fall 2005, pp 1-2.

S. H. Chien, L. I. Prochnow, and H. Cantarella. Recent Developments of Fertilizer Production and Use to Improve Nutrient Efficiency and Minimize Environmental Impacts

George Rehm (2010). Poly or ortho; what's the difference? Retrieved on April 4, 2014 from http://agbuzz.ocm/?p=214

Phosphorous (P) basics (2014). Retrieved April 5, 2014 from http://www.spectrumanalytic.com/support/library/ff/P_Basics.htm

About Advanced Nutrients

Advanced Nutrients is a leader in the development of innovative, environmentally Enhanced Efficient Fertilisers, Bio-stimulants, Irrigation Line Cleaning & Water Conditioning products which cost less and deliver more.
For the last 23 years, smart agricultural, horticultural and livestock producers throughout Australia, Africa, Asia and the Middle East have been using our products to cut input costs, boost returns and reduce farming risks.

✆ 1800 244 009
service@advancednutrients.com.au

ADVANCED NUTRIENTS®

WHY 70% OF YOUR PHOSPHOROUS FERTILISER GOES TO WASTE,

AND HOW TO CHANGE THAT FOR GREATER CROP YIELDS AND INCREASED PROFIT

A whitepaper by Advanced Nutrients

ABSTRACT

Australia's farmers lose as much as 70% of the phosphorous they apply to their crops when they use normal granular varieties. This inflates growing costs and reduces yields.

Research suggests that bio-catalyst-invigorated liquid phosphorous offers growers an economic alternative that improves phosphorous penetration and plant uptake, lowering fertiliser wastage, reducing input costs and maximising return on investment.

ADVANCED NUTRIENTS®

www.advancednutrients.com.au

EXECUTIVE SUMMARY

Phosphorus deficiency limits the growth and productivity of plants in many parts of the world.

Since many soils are low in phosphorous, this nutrient is commonly added to improve crop yield and quality. But how can growers obtain the best results with the least amount of waste?

This paper examines the evidence and reveals how liquid phosphorous fertiliser supplemented with bio-catalyst acid may provide an edge over traditional granular phosphorous fertilisers.

Some of the key findings about phosphate fertilisers in this whitepaper:

- Phosphorous is crucial to germination and growth yet Australian soils are very phosphorous deficient
- Up to 70% of phosphorous fertiliser that growers add is not used by the crop
- Fertiliser is quickly fixed into unavailable forms that crops cannot use to fuel growth
- The composition of liquid fertilisers means the phosphorous remains available to the plant for longer and those enhanced with bio-catalyst additives have greater soil penetration and mobility
- Trials show that enhanced efficiency liquid fertilisers offer substantial economic returns for growers

Why phosphorous deficiency stifles crop growth

Phosphorus is a key constituent of the nucleic acid structure of all crops that controls the generation of protein. This makes phosphorus critical to the cell division that occurs at the growing tip of the plant.

Crops also require phosphorus to drive respiration. Respiration converts sugars produced during photosynthesis into energy during respiration. This is what drives plant growth. A lack of phosphorous restricts respiration and prevents the conversion of sugars into energy. And when energy is low, all plant processes suffer.

This is the underlying cause of the stunted growth typically seen with phosphorous deficiency.

For these reasons phosphorous is especially crucial to maximise early crop growth during the seedling stage.

Crops that are deficient in phosphorus exhibit stunted growth, and often their leaves have an abnormal dark-green or blue-green colour. Some part of the plant might have a purple colouration and there is reduced flowering and/or seed production because crop flowering and reproduction require a lot of energy. Fruits are small and acid tasting.

All plants can be affected, but crops such as carrots, lettuce, spinach, and apples are particularly susceptible.

In one long-run experiment with maize, field crops grown without the addition of phosphorous showed significantly reduced leaf growth (up to 60% less), especially during the first phases of the crop cycle.

As a result, crops reach maturity later. For farmers, late-maturing crops obviously impose greater growing costs.

The economics of enhanced efficiency liquid phosphorous

Field trials show that enhanced efficiency liquid phosphates offer a substantial return on investment when used as either a starter supplement, or a starter replacement.

One two-year study conducted under commercial farming conditions investigated the economic return from organically complexed polyphosphates when used as a starter supplement on irrigated cotton.

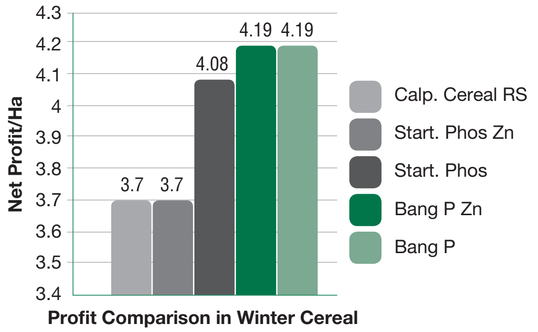
Test areas were of commercially significant size, and selected for naturally low phosphorous soil reserves and a history of response to the application of phosphorous fertiliser.

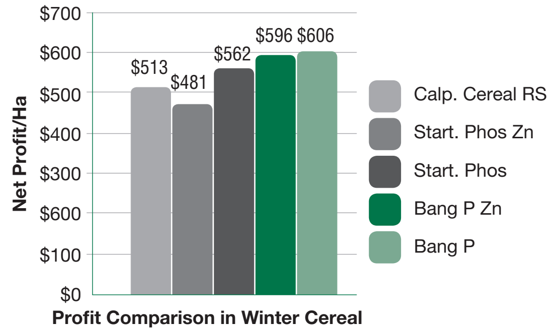
Pre-plant fertiliser containing nitrogen, potassium and sulphur was applied at rates consistent with normal commercial practice. Later, enhanced efficiency liquid phosphorous (in the form 13-19-0-0) was applied at a dilution rate of 10:1 by liquid injection at sowing.

Module weights increased 8% (an extra 0.8 bales per hectare) in the first year of the trial, and by 10% (an extra 1 bale per hectare) in the second. This increased grower net profits (after factoring the cost of the enhanced efficiency liquid phosphorous) by $296 and $455 per hectare respectively.

Enhanced efficiency liquid phosphorous trial on irrigated cotton

	Bales per hectare production increase	Per hectare cotton price	Enhanced efficiency liquid phosphorous cost	Liquid phosphorous profit per hectare
Year 1	0.8	$400	$24 per hectare	$296
Year 2	1.0	$500	$45 per hectare	$455





Enhanced efficiency liquid phosphates (in this case, BANG P™) delivered the highest gross margin of $606 per hectare and produced 4.19 tonnes per hectare.

CONTACT US TO TRIAL ENHANCED EFFICIENCY LIQUID PHOSPHATES

We hope you've found this whitepaper both interesting and useful.

If you'd like to learn even more about our enhanced efficiency phosphorous fertilisers, or explore the potential for a trial on your crops, so you can see for yourself how it measures up — both in terms of reduced inputs, and increased yields and profi ts — contact us at **service@advancednutrients.com.au** or call **1800 244 009**.

Banding improves phosphorous availability and uptake

One technique many growers use to overcome phosphorous fixation problems is banding — concentrating the placement of phosphorous fertiliser either close to the germinating seed, or to the root zone of the growing crop.

Because banding reduces the amount of phosphorous exposed to soil, it decreases the potential for fixation and tie-up. Plus when ammonium (which contains nitrogen) is included in the band, this can further boost root proliferation and establish a strong healthy root system at the crucial seedling stage.

It can also substantially reduce the amount of phosphorous farmers need to apply to grow strong, healthy crops.

Bio-catalyst-supplemented phosphate fertilisers

Another possibility for improving soil penetration, mobility and plant uptake of phosphorous is the use of carbon bio-catalyst additives or supplements.

These organic catalysts bind with the phosphate to reduce insoluble phosphate “tie-up” and increase long-term availability in soluble forms for sustained uptake throughout the growing cycle.

Studies indicate that bio-catalyst-supplemented liquid phosphate is up to three times as efficient at delivering nutrients to the root system — increasing available soil phosphate by 30% to a depth of 45 centimetres.

The liquid form enables deeper, wider soil penetration (especially compared to granular phosphates) so more phosphorous reaches more of the crop root system.

A University of Georgia study also showed that polymer-coated granular MAP delivered significantly greater maize yields than uncoated MAP when the uncoated MAP was broadcast, but not when it was banded. On the other hand, other studies have indicated no difference in performance between coated and uncoated granular fertilisers — the evidence of their effectiveness is mixed at best.

Australian soils are phosphorous deficient

Phosphorus deficiency is a major problem that limits crop productivity on 30–40% of the world’s arable land.

This is especially the case in Australia. The country’s arable land is dominated by ancient and highly weathered soils that have very low levels of natural phosphorus. In fact, Australian agricultural soils are among the most acutely phosphorus deficient in the world.

Native plants are adapted to these low phosphorous levels. However, traditional crops and pasture grasses are not. That means growers must apply phosphorus fertilisers to soil to achieve productive yields. As a result, Australian growers must use much more phosphorus than nitrogen and potassium than farmers in Europe and USA.

Most phosphorous fertiliser doesn’t reach the crop

These phosphorous-deficient soils contribute substantially to the fact that that Australian growers lose as much as 70% of the phosphate fertiliser they apply to the environment.

Truth is, phosphorous-use efficiency in the year fertiliser is applied is generally less than 30%. Studies show it can be as low as 5%.

Cold weather can cause a temporary phosphorous deficiency. And in light, sandy soils, some can be lost to erosion and run-off. However, in most soils, phosphorous is essentially immobile and moves no more than about one tenth of an inch in the soil.

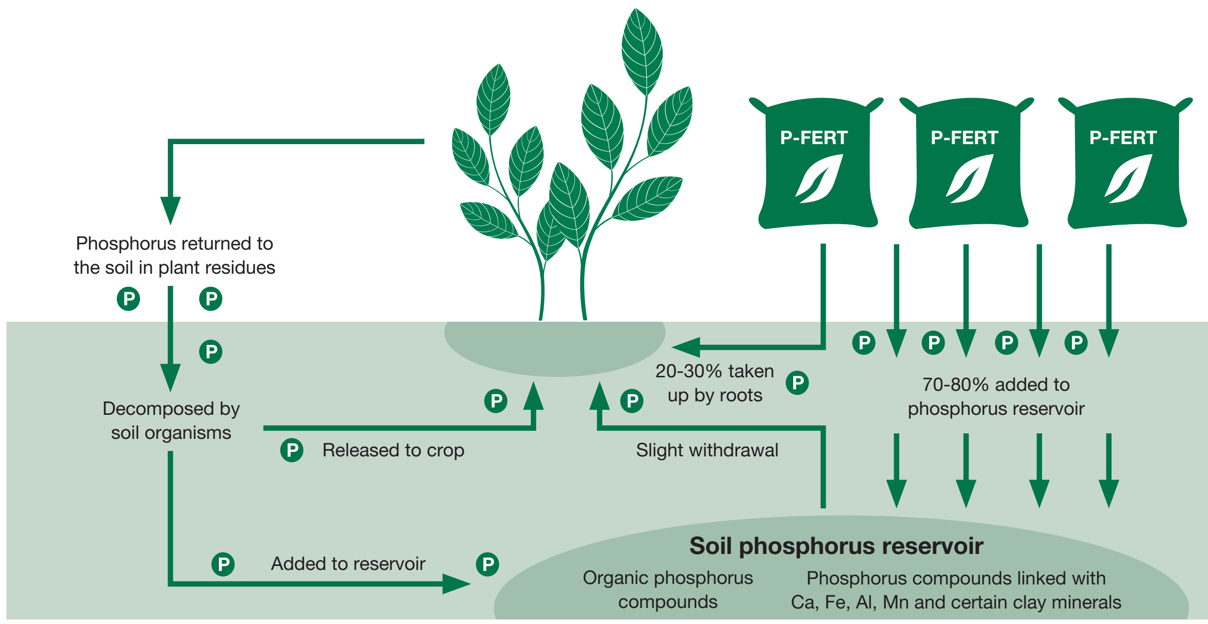
Instead, the key challenge is that plant roots must compete with the soil for the limited amount of water soluble phosphorus that is available.

Many soil types rapidly ‘tie up’ phosphorus, significantly limiting the amount available to crops.

This is because phosphorous reacts very rapidly with acidic and alkaline soils, as well as soils that are high in aluminium, iron or calcium. In particular, at low pH levels (< 5.0), the soil’s propensity to fix phosphorus in inorganic forms rises dramatically, decreasing its availability for crops.

High rainfall or soil moisture accelerates the process.

These processes lock the growth-stimulating phosphorous away from crops in stable (ie: long-lasting) insoluble compounds that the root system is unable to absorb.



Phosphate fertiliser options

So if growers must use phosphorous fertiliser as a supplement to overcome the natural phosphorous deficiency in Australian soils, what are the options?

Broadly, they fall into three categories.

1. Granular (usually orthophosphate) fertilisers.
2. Liquid (usually an orthophosphate/ polyphosphate combination) fertilisers.
3. Enhanced efficiency fertilisers (both liquid and granular)

The performance of granular fertilisers

Granular fertilisers include diammonium phosphate (DAP), monoammonium phosphate (MAP) and triple super-phosphate (TSP).

These fertilisers are exclusively made up of a phosphate form called orthophosphate.

Orthophosphates are the water soluble form which is absorbed by crops and fuel growth. In fact, crops can only absorb phosphorous in the orthophosphate form.

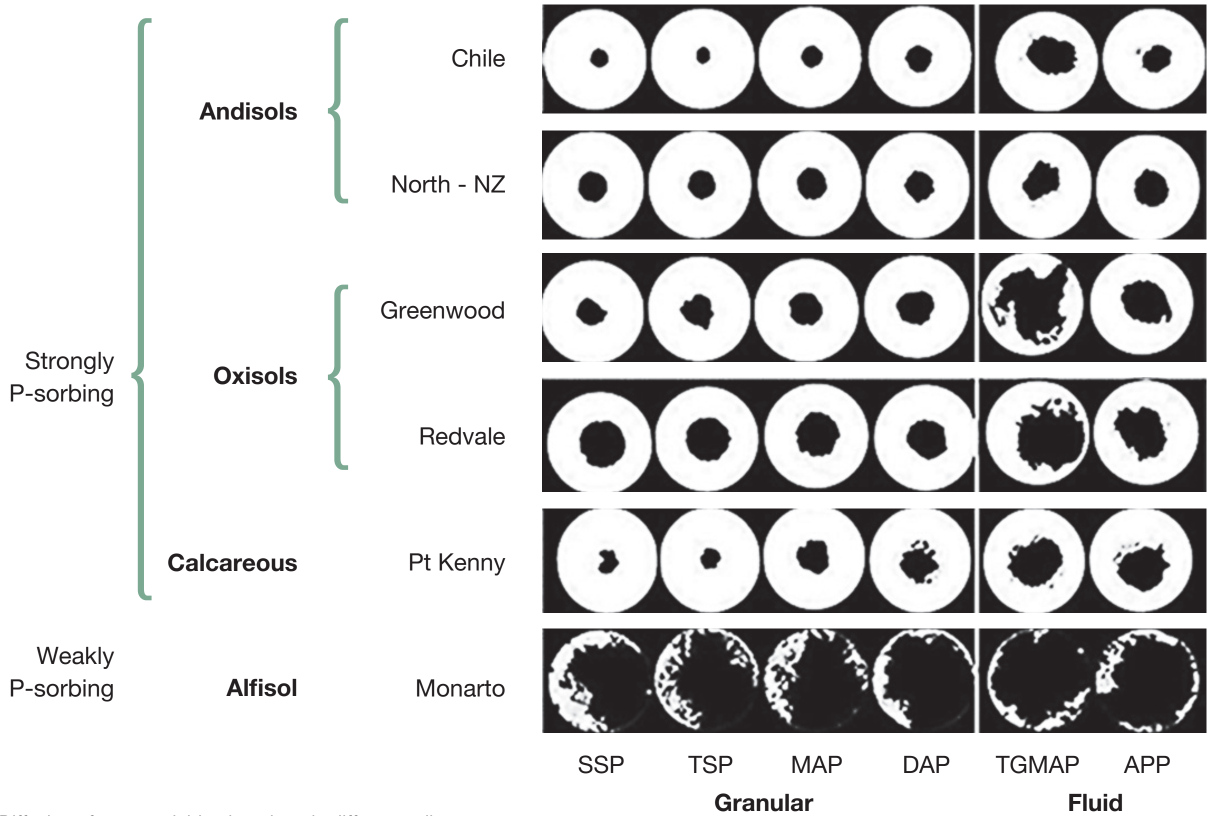
The challenge with these granular fertilisers is twofold.

First, the phosphorous in granular fertiliser is highly immobile. As trials repeatedly show, the ability of these fertilisers to diffuse through soils that are strongly sorbing of phosphorous is negligible: the phosphorous will likely travel no more than a tenth of an inch.

This means unless the orthophosphate is near the plant's root system the plant won't be able to absorb it and run all the processes that fuel growth.

Second, granular phosphate fertilisers precipitate (tie-up) into inorganic forms rapidly — especially in highly calcium soils. Studies indicate that soil moisture carries calcium molecules toward the fertiliser granule. Chemical processes fix the phosphorous in insoluble forms, limiting the size of the fertiliser reaction zone and reducing the amount of phosphorus available for the crop to absorb.

Previous work: Visualisation of P diffusion



Diffusion of water-soluble phosphate in different soils.

The performance of liquid fertilisers

Most liquid fertilisers are derived from ammonium polyphosphate (APP). In these fertilisers, half to three-quarters of the phosphorous exists in forms that are collectively called polyphosphate. The remainder is orthophosphate.

Polyphosphate and orthophosphate are both water-soluble, but the former must hydrolise (transform) into orthophosphate before the crop can absorb them.

This conversion occurs naturally (and often very rapidly) within the soil. Typically — if left unprotected (un-complexed) in the soil — half of the added polyphosphate turns into orthophosphate within one to three weeks.

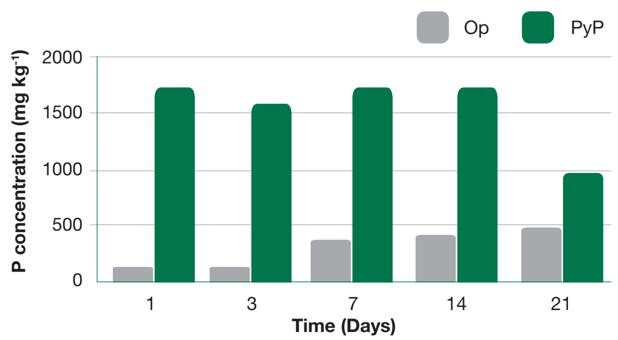
An Australian study shows that there is initially a small peak for orthophosphate — mostly the native orthophosphate in the APP. Gradually, the orthophosphate level grows as pyrophosphate (the dominant polyphosphate in APP) hydrolyses, and consequently the amount of pyrophosphate decreases. After 21 days, approximately half of the pyrophosphate remains while much more orthophosphate is available for the crop to absorb.

This combination of orthophosphate and polyphosphate enables plants to use phosphorous very effectively. The blend of short-term (orthophosphate) and extended-release (polyphosphate) phosphates steadily deliver soluble phosphates at a rate that doesn't exceed the crop's ability to absorb them. There is less chance for it to be wasted.

Research shows that liquid phosphorous fertilisers do not precipitate as rapidly (especially in the presence of calcareous soils), the size of the reaction zone is larger — increasing fertiliser availability and allowing greater root uptake.

A final advantage is that APP is a clear, crystal-free fluid. It mixes easily with many other nutrients and chemicals. And because each drop if fluid is exactly the same, it offers maximum precision in application. In particular, this makes APP an excellent carrier substance for any additional micronutrients that crops require.

NMR



NaOH Extraction

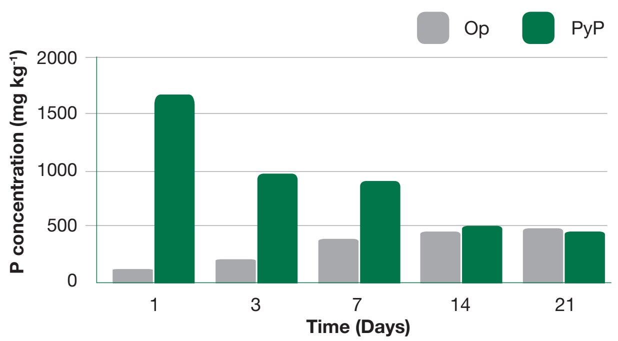


Table 1: Concentration of P as orthophosphate derived from hydrolysis of pyrophosphate (native P subtracted) and pyrophosphate (pyro-P) as determined by (A) NMR, and (B) 15 minute (1.10) 1 M NaOH extraction. (op = orthophosphate, PyP = pyrophosphate).