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Phosphorus Nutrition for Winter Crops

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CONTENTS

Front: Comparatively small grain yield increases pay for the cost of additional phosphorus fertiliser and provide a handsome return on the investment. Measuring such a small grain yield increase can be difficult at harvest, especially on a paddock basis with the yield variations that commonly occur.

MAIN POINTS

- Adequate P nutrition is the basis of soil fertility and crop management.
- Good profits are common when adequate rates of phosphorus fertiliser are sown with crops.
- Best responses to phosphate fertiliser application are only achieved when other major crop management inputs and decisions are optimised.
- Use a combination of guides, including paddock history, soil testing, geographic regions and target yield, to optimise the rate to apply.
- For best responses band phosphorus fertiliser near or with the seed.

Phosphorus (P) is an essential nutrient for all winter crops. Most soils in NSW will respond to added P. Applying P fertiliser to winter crops, where it is needed, is an investment that brings good financial returns. Economic responses to applying P fertiliser depend entirely on soil P level, soil moisture, the prevailing cost of P fertiliser and gross returns for grain. Conversely, the yield penalty for not using enough P fertiliser can be severe.

Adequate P fertiliser is the basic building block of crop nutrition and management. No amount of P fertiliser, however, will correct poor management decisions. Attention must be given to well-planned rotations, timely operations, variety selection, pests, soil moisture and nitrogen management for best returns on P inputs. P supply is a key determinant of grain yield, whereas the quality of that grain is determined by the supply of other nutrients, especially nitrogen, and water.

P management requires special attention in the overall management package for sustainable crop production.

THE NEED

P is essential for healthy plant growth and cell division. Good P nutrition results in:

- improved seedling vigour
- better root development which allows for better uptake of soil moisture and nutrients leading to more robust plants
- more grains per head resulting in higher grain yields.

Supply of P is crucial in the first few weeks of a crop's life. It is mobile within the plant so that P absorbed during early growth is redirected to fill grains.

Despite extensive use of P fertiliser for more than five decades many paddocks are still deficient in available plant P, or there has been only a relatively minor buildup of soil P in this time. Because of this P fertiliser must be added to crops grown on deficient soils to achieve profitable yields.

Many soils with a high natural P level after an extensive cropping history are now reaching the stage where P fertiliser is necessary to maintain or increase yields.

DEFICIENCY SYMPTOMS

Leaf and root growth, vigour and tillering in cereals are much retarded before leaf symptoms appear.

P deficient canola and oats can show purpling on the leaves and growth is retarded.

Pulses are stunted, pale in colour, and have poor root development with small nodules.

FACTORS AFFECTING CROP RESPONSE TO PHOSPHORUS

Soil moisture management has the greatest influence on whether crops respond profitably to P fertiliser. During fallow management timely early weed control and preserving soil cover are key elements in optimising soil moisture

Phosphorus application has the effect of advancing crop maturity, bringing crops into head, flowering and grain-fill earlier. In some situations there can be up to a week's difference.

conservation. Adequate P at sowing enables crops to access this stored moisture, and it contributes to high water use efficiency.

The amount of P available to plants from the soil pool changes over time. The percentage of clay present, soil pH, organic matter content, presence and amount of aluminium, calcium and iron oxides, and the overall amount of P in the soil all change how much P is available for plant growth. As a result P levels vary across paddocks and within seasons.

Soil physical characteristics

Soil texture

Generally, P levels tend to be medium to high on heavier textured soils. The red-brown loams and lighter textured soils commonly have low to medium P levels. Lighter, acidic, coarse textured soils usually respond better to applied P than heavier textured soils.

Soil aeration and strength

These two factors greatly influence oxygen supply in the soil needed for root growth. Compaction or waterlogging or both restrict P uptake. Waterlogging favours iron oxide formation. The iron oxide locks onto available P, making it less available to plants. Poor soil aeration can also restrict root biological activity, e.g. lower levels of mycorrhiza, resulting in reduced P uptake in some crops such as cereals.

Soil chemistry

Soil pH

Soil pH affects how much and the way in which P is fixed in the soil to become less available to plants. Soils with pH 7 ($CaCl_2$) or greater can have P tied up as calcium phosphates.

Those soils with a pH of less than 5 ($CaCl_2$) have a lot of the P pool tied up as iron or aluminium phosphates or both. Liming acidic soils to a more neutral pH may help minimise P fixation.

Soil P buffer capacity

The ability of the soil to release P and make it available to plants is called the soil P buffer capacity. How much P is available to the plant varies with a soil's buffering capacity. Heavier textured (more clay) soils tend to have higher buffering capacity and so have a larger 'bank' of fixed or 'locked up' P than lighter soils. Soil P buffer capacity also varies in response to seasonal conditions, and is stronger in wet seasons.

Interactions with other nutrients

Available P is critical for the effective utilisation of all the other plant nutrients, particularly nitrogen and zinc, given that there is enough soil moisture for growth.

Soil biology

Crop residues

When incorporated into the soil in large amounts, crop residues increase microbial action, which can immobilise available P for a short time.

Mycorrhiza

The symbiotic relationship between some soil fungi and plant roots, which is know as Vesicular-Arbuscular-Mycorrhiza (VAM), can help some crops take up nutrients such as P and zinc from the soil and fertiliser more effectively.

Crops such as chickpea, faba bean, linseed, safflower and many summer crops have a high VAM host dependency and promote its buildup. Winter cereals and field pea are less dependent but do allow VAM to increase. Canola and lupins do not host VAM and, along with extended fallow periods, result in reduced VAM levels.

Crops like canola and lupins, which do not host VAM, must have enough P applied at sowing, particularly where soil P levels are low to medium. Similarly, in low VAM situations i.e. following canola and lupin crops or a fallow period, VAM dependent crops like chickpea, faba bean, safflower and many summer crops must have enough P applied.

Careful VAM population management in good organic farming systems may enable better use of soil P.

Crop factors

Root development and distribution

In most soils the amount of P in the top 10 cm is a good indication of the soil's ability to supply P to the crop. As roots tend to concentrate in this surface zone, they can gain ready access to the soil P for early plant growth.

P promotes root development, enabling plants to use subsoil moisture resulting in improved water use efficiency. Cereal roots can grow to a depth of a metre or more to access moisture and nutrients, especially nitrogen. When soil moisture is low, soil P becomes less accessible.

Investigations in northwest NSW show that in some cracking clay soils (Vertosols) with low to medium surface P the higher levels of the nutrient at depth contribute to crop P nutrition.

Fertiliser factors

Bag or batch labels show the nutrient analysis of the fertiliser. Water and citric acid soluble portions are regarded as plant available P in a fertiliser. For example, a common analysis of single superphosphate is:

- water soluble P 7.2 per cent
- citric acid soluble P 1.4 per cent
- citric acid insoluble 0.2 per cent.

The total P content is 8.8 per cent. However, the citric acid insoluble P should be considered as presently unavailable for plant uptake and so the total P available in this case is 8.6 per cent. The citric acid insoluble P does make a contribution to the total soil P pool and could become available to plants later.

Crops only take up a small proportion of available fertiliser P but it is important to apply P at sowing to ensure it is readily available during crop emergence and establishment.

USEFUL GUIDES TO APPLICATION RATES FOR CROPS

A number of guides are available to determine how much P to apply, and it is best to use these in combination rather than rely on any one technique. Response to fertiliser P application often varies greatly between seasons and between paddocks.

Responses to applied P tend to be better in the average to drier seasons, when crop roots are unable to fully explore the available soil P. Applying higher rates of P fertiliser can increase the availability of plant nutrients, particularly nitrogen, ensuring a quicker crop canopy cover and excellent grain yield responses. Aim to fertilise for an above average season. This ensures crops yield to their full potential in such seasons, which are often the most profitable years.

Paddock history

Previous crop yields combined with an understanding of soil type, native trees present and pasture balance can be used to help determine likely soil P levels in a particular paddock.

Soil type and native trees present. Soils and native trees are good guides to natural soil P levels. Lower P soils are commonly light coloured, e.g. red sandy loam and clay loam, and carry such trees as bimbil and narrow leaf box, cypress pine, iron bark, mallee, wattle or wilga. Medium P soils are often brown or grey, of medium clay, and carry such trees as belah, bimbil box, boree, kurrajong, myall, rosewood, white box, wilga or yarran. Higher P soils are often medium clays, with black and grey box, river red gum or yellow box timber present.

Previous pasture composition. On lower P soils pastures tend to remain stable. Clover growth is poor and annual grasses tend to dominate. Medium P soils vary widely between dominant clover or legumes and excess grasses so that pastures are not stable over the long term. Grasses commonly dominate on higher P soils soon after the cropping phase, as concentrations of soil nitrogen increase under the legume pasture phase.

Previous crop yields. Records of fertiliser applications and grain yield and protein are a great help in assessing paddock potential performance.

Many paddocks have a long cropping history for over five decades and there has been a net depletion of soil P. In recent seasons, average crop yields have significantly improved with further extraction of soil P occurring resulting in increased reliance on applied P to meet crop demand.

Visual yield responses in the previous crop where P fertiliser was not applied at all or applied at a higher rate than normal can be one of the best guides to whether P needs to be applied to the next crop. This is not foolproof, however, and it is possible for profitable yields to be harvested even though it is difficult to see a visual response.

Soil testing

Soil testing is a proven tool for soils with pH ($CaCl_2$) between 5 and 7. A chemical extractant

Table 1. Wheat yields correlated to different soil tests.

Soil phosphorus level	Soil test Milligrams per kilogram (mg/kg) of P[1]		Phosphorous rate[2] kg per ha		
	Colwell	Bray No 1 & Olsen	Rainfall zone Lower	Medium	Higher
Very low	1–10	1–6	15	20	25
Low	11–20	7–12	10–14	15–19	18–24
Medium	21–35	13–20	5–9	10–14	11–17
High	>35	>20	0–4	5–9	6–10

[1] samples to 10 cm depth

[2] based on fertiliser P cost of $2.20 per kg of P and wheat priced at $150 per tonne on-farm.

is used to estimate levels of available P in the soil that plants can use. Tests used by accredited laboratories are as follows:

Colwell test – sodium bicarbonate, 1:100 soil to extractant ratio. The sample is shaken for 16 hours so takes a long time to conduct. This test is also referred to as the Modified Olsen test and is commonly used by Hi-Fert Pty Ltd, and Incitec Pivot Ltd.

Olsen test – also sodium bicarbonate, 1:20 soil to extractant ratio. The sample is shaken for ½ an hour. This test is used by Pivot Ltd.

Bray No1 test – hydrochloric acid with ammonium fluoride, 1:7 soil to extractant ratio. The sample is shaken for 1 minute. The Bray No. 1 is a very useful test for acid to neutral soils but very unreliable for alkaline soils. It is one of the tests used by NSW Agriculture.

Fertiliser companies provide soil testing and interpretation services. Relationships between the tests vary greatly.

Interpreting soil P levels depends on accurately correlating soil test methods with wheat yield. Table 1 is a guide to rates.

Be careful in interpreting test results on alkaline soils above pH 7 ($CaCl_2$) and on acid soils with pH below 5 ($CaCl_2$). Tests are unreliable outside these limits. Variations in soil texture also influence the reliability of test results.

Soils with pH below 4.8 ($CaCl_2$) can have toxic levels of aluminium leading to P immobilisation. Therefore there can be benefits by liming to reduce the ‘lock up’ (short to medium term unavailability) of P in acid soils.

Soil sampling

It is absolutely essential to take soil samples correctly using a consistent method. Select areas with uniform soil colour and texture within paddocks. Walk in a zigzag pattern across the uniform area putting 20 to 25 ten cm deep samples in a clean bucket. After sampling, thoroughly mix them all then take about a kilogram for your soil sample. Put this sample in a clean plastic bag and store it in a cool place until delivered to the local agent for testing.

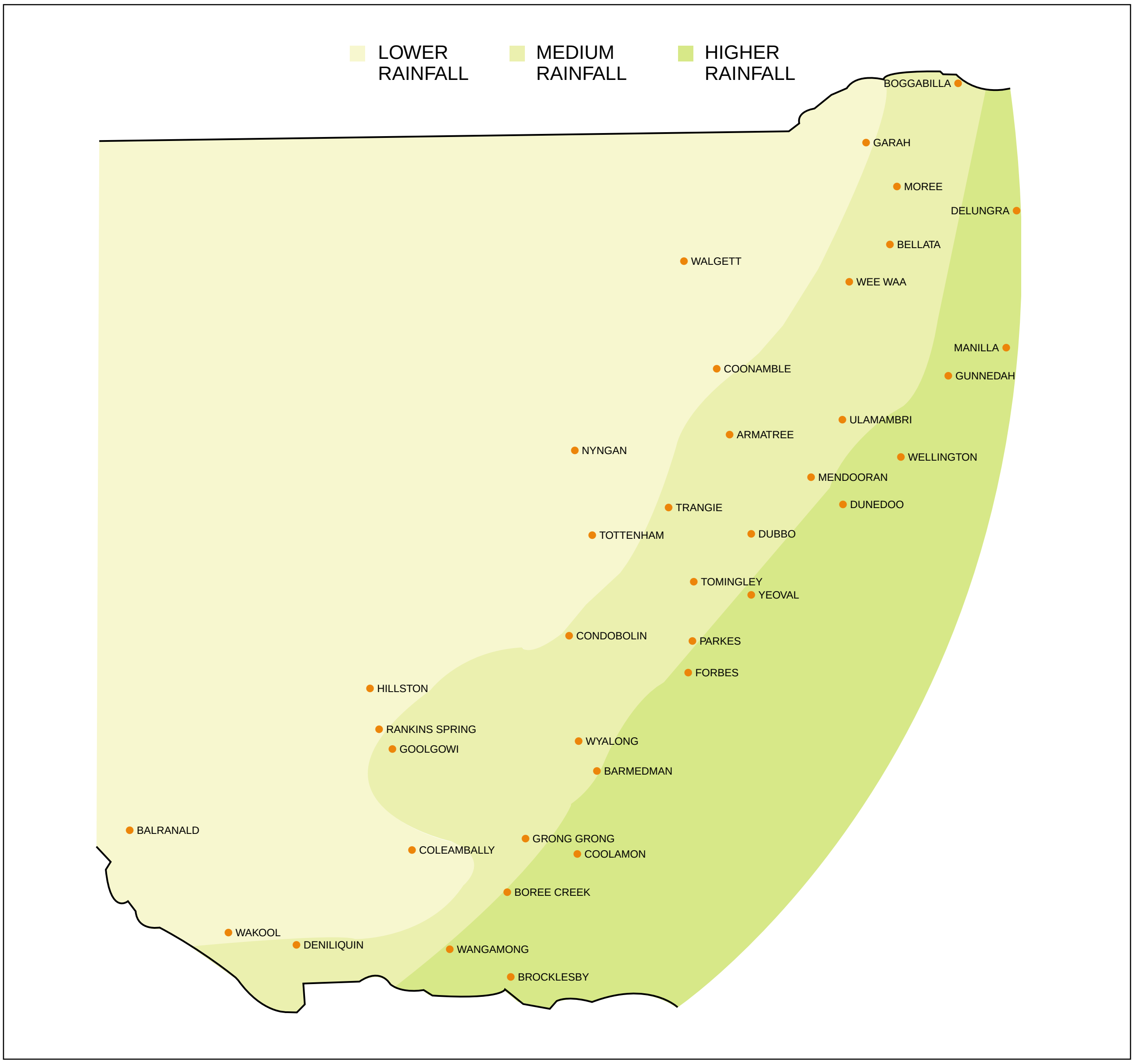
Don’t take samples in extreme weather conditions, e.g. in drought or soon after waterlogging or within 3 months of liming or 2 months of applying P fertiliser. Late summer to early autumn is the best time to sample, after a useful rain when the soil is moist so it is easier to use sampling tools.

Which paddocks to test

Regular soil testing of individual paddocks is the only way to monitor changes in pH and soil P levels. Always take samples from the same

Early response to P fertiliser — 15 kg P/ha on the left compared to nil on the right.

Map. Rainfall zones for determining P nutrition of winter crops.



general area within paddocks and use the same test method every time.

A good practice is to routinely test paddocks as you start a cropping sequence. This will give a guide to changes in soil P levels. Keep all your records so trends in soil P levels and other soil measures, e.g. pH and organic carbon can be traced over time.

Geographic zones

A useful guide is to divide NSW into zones on the basis of expected seasonal conditions for winter crops, as producers in lower rainfall areas expect to harvest lower yields compared with those in the higher rainfall zones. Lower yields result in less P removal in the harvested grain from the paddock over time.

General recommendations based on these criteria have proven to be reliable over the past three decades and continue to be used.

After estimating if the soil in a paddock falls into a low, medium or high P category using the paddock history guidelines in combination with a soil test, use the map (above) to locate your property.

Table 2 (over page) is a guide to the rate of P fertiliser in kg per ha to apply.

Target yield

This is one of the more reliable tools in estimating crop P requirements. Applied realistically, this method can help reduce the

Table 2. Rate of fertiliser to apply in lower, medium and higher rainfall zones.

Soil phosphorus level	Rainfall zone Lower	Medium	Higher
Low	10–15	15–20	20–25
Medium	5–9	10–14	15–19
High	0–4	5–9	10–14

Table 3. Likely P requirements for target yields.

Soil phosphorus level	Phosphorus requirement kg of P per tonne of grain yield per ha		
	Canola	Pulses	Wheat
Low	10	5.0	5.5
Medium	8.0	4.0	4.0
High	6.0	3.0	3.0

variability that results from using other indicators like paddock history, soil testing and the geographic zones detailed above.

While there are many methods to arrive at target yields, most are based on an estimate of likely available soil moisture at sowing plus growing season rainfall. When calculating P requirement soil P status is taken into account. It is accepted that on medium to high P status soils, more of the crop's requirements are being supplied from the soil P pool. Table 3 indicates the likely P requirement.

Example

For a paddock in the medium available soil P category with a target wheat yield of 3 t/ha, P fertiliser should be applied at the rate of 12 kg/ha.

WHEAT NUTRITION EXPERIMENTS

Intensive research has been done to help grain producers better determine optimum P fertiliser rates to apply to wheat. This research started over 40 years ago and is continuing. NSW Agriculture has conducted about 800 wheat nutrition experiments in this time.

Some observations

In many experiments, wheat responded to increased P with improved yield, which commonly leveled off at higher fertiliser rates. However, this leveling off did not occur in all trials and in all areas.

In many trials there was an economic response over nil fertiliser but in others this did not occur, demonstrating the need to consider the many interacting factors before deciding on how much fertiliser to apply. Measured responses were less common in the lower rainfall areas, pointing to the need for caution in applying relatively high P fertiliser rates there.

Low soil test figures commonly indicate the need for applying enough P to optimise yield. Unfortunately, the opposite does not always hold true so that just because a soil test figure is high does not mean there is no likelihood of an economic response. There are situations, particularly on acidic soils with a pH below 5 ($CaCl_2$), where P often tests medium to high but plants are unable to source this P and excellent responses are obtained provided the fertiliser is banded with the seed.

MEASURING THE PROFIT

Commonly, returns on dollars invested for the first 10 to 12 kg/ha of applied P is very high. In many trials over a wide area, yield responses of around 0.45 t/ha were measured. Economically, this shows a return of $67.50 (based on wheat valued at $150 a tonne on-farm) on an investment of, say, $22/ha for ten kilograms of P, or a 207 per cent return after paying for the fertiliser. There are very few on-farm investments that provide such a high rate of return.

The most important economic question is how much extra is still profitable? The best approach to measuring a profitable yield increase is to

Sowing adequate rates of phosphorus fertiliser with crops is commonly very profitable. (20 kg P/ha on left vs nil on right)

look at the yield at one level of application and compare the marginal cost of applying additional P to the extra yield and grain return.

Example

On a per hectare basis, a crop yields 2.5 t with the application of ten kilograms of P. The addition of an extra three to thirteen kilograms of P costs say $6.60, resulting in an increased yield of fifty kilograms of wheat valued at $7.50 (based on wheat valued at $150/t on-farm). This is a very healthy return of 13.6 per cent in the extra dollars invested in the extra P fertiliser. However, the next 3 kg of P to increase the total to 16 kg of P a hectare provides an unmeasurable yield increase and so it is unprofitable.

This example shows the margin involved with applying extra P fertiliser can be good, but accurately measuring small profitable yield increases on a paddock scale can be difficult with the variations commonly occurring.

Another approach to measuring the profit is to determine a break even, where grain yield just pays for the P fertiliser cost and any extra yield is a gain. This is shown in Table 4.

For example, where 20 kg of P is applied, any yield increase above 0.24 t/ha is the marginal profit, based on P fertiliser costing $2.20/kg.

This table demonstrates that when grain prices are comparatively high P fertiliser inputs should not be spared to optimise yields. Conversely, when gross returns are lower you should select a fertiliser rate carefully.

Wheat trial results often show that yield responses above those required to break even are achieved with successive P applications (see Table 5).

Table 5 is based on the results of two hundred and fifty trials conducted in the central west. Results from trials yielding less than two thirds of a tonne a hectare owing to severe drought were not included. The principle detailed above of profitable responses holds true even more today with the higher average yields achieved, improved agronomy and longer cropping histories.

WHICH IS THE CHEAPEST FERTILISER?

The cost of an applied kilogram of available P should be the overriding determinant of which fertiliser to use. However, the need to apply other nutrients such as molybdenum, zinc or even sulphur may influence the choice of P product. P fertiliser concentrations sold vary

Table 4. Breakeven yield for applying different rates of P.

P/ha costing $2.20 /kg	Breakeven yield (t/ha) Gross on-farm grain return ($/t)				
	100	140	180	220	260
5	0.11	0.08	0.06	0.05	0.04
10	0.22	0.16	0.12	0.10	0.08
15	0.33	0.24	0.18	0.15	0.13
20	0.44	0.31	0.24	0.20	0.17
25	0.55	0.39	0.31	0.25	0.21
30	0.66	0.47	0.37	0.30	0.25

Table 5. Yield responses from successive P application in lower, medium and higher rainfall zones.

	Rainfall zones								
	Lower			Medium			Higher		
Soil phosphorus rating	Low	Medium	High	Low	Medium	High	Low	Medium	High
Phosphorus applied — kg P / ha	Yield increase — t/ha								
First 5 kg P	0.13–0.54	0–0.27	0	0.20–0.54	0.13–0.54	0–0.20	0.20–0.74	0.20–0.67	0–0.20
Second 5 kg P	0–0.47	0–0.13	0	0.07–0.54	0.07–0.34	0	0–0.54	0–0.27	0
Third 5 kg P	0–0.20	0	0	0–0.34	0–0.34	0	0–0.40	0–0.20	0
Fourth 5 kg P	0–0.07	0	0	0–0.20	0–0.07	0	0–0.20	0–0.13	0

Source: Corbin E. J, (1972) Factors Affecting Nitrogen and Phosphorus Requirement of Wheat in Central Western New South Wales — *Agricultural Gazette of N.S.W.* February.

widely and the Comparison Chart on the back page will help you make your choice.

To compare product cost use the following formula:

$$\frac{\text{Cost per tonne delivered on-farm}}{\text{per cent of P in product}}$$

Example

The quoted cost of a tonne of Trifos (17.9 per cent available P) is $435 delivered on-farm so the cost is calculated as follows:

$$\frac{435}{17.9} = \$2.43 \text{ per kg of P fertiliser.}$$

As a comparison, MAP (10 per cent nitrogen, 22 per cent available P) is quoted at $525/t delivered on farm so the calculation is as follows:

$$\frac{525}{22} = \$2.39 \text{ per kg of P fertiliser.}$$

In this example MAP is the cheapest P fertiliser and the nitrogen component comes at no cost.

APPLICATION TECHNIQUES

Banding

Banding P fertiliser with or close to the seed being sown is the most effective and profitable application method. This ensures young seedlings can adsorb a large amount of the available P quickly. Particularly on acidic soils, this technique ensures the P fertiliser only comes in contact with a small volume of soil so a lower percentage is tied up than is the case if it was mixed through the soil.

Many sowing rigs are equipped to band fertiliser with and below the seed. To optimise the response with this equipment, band about 10 kg/ha P with the seed, placing the rest below or to the side.

High rates of some blend and starter fertilisers (i.e. fertilisers containing a combination of nitrogen and P and possibly other elements) banded in direct contact with seed can damage germinating seedlings under some circumstances, especially when soil moisture at sowing is marginal for germination. Usually it is the nitrogen component that causes the germination damage and not the P component. Do not band these fertilisers with the seed where more than 15 to 20 kg/ha nitrogen is applied in eighteen centimetre rows. Proportionally lower nitrogen rates per hectare apply to wider row spacings i.e. 12 to 15 kg/ha nitrogen for twenty seven centimetre row spacings.

Topdressing or broadcasting

Because applied P moves very slowly through soils, topdressing or broadcasting before or after sowing is much less effective and results in poorer grain yield responses when economic rates are considered. Where there is no other practical alternative application method, use at least double the rates suggested above.

CROP ESTABLISHMENT METHODS

Good P nutrition helps crops to establish with good seedling vigour. Limited research has not shown any significant responses in the relationship between P fertiliser rates and crop establishment method – crops respond equally to increased P when sown into cultivated seedbeds, direct-drilled or no-tilled.

With direct-drilled or no-tilled established crops the P is banded in the soil and remains undisturbed if the paddock is not cultivated to prepare for the following crop. Therefore applied P is less exposed to the soil, which will result in residual P being better preserved.

FERTILISER STRIPS

There is merit in altering fertiliser rates during sowing as a way of confirming that the chosen rate is optimal. Simply switching off the fertiliser or increasing the application rate significantly for a short distance to make a strip can provide evidence of a response. However, when fertiliser containing more than one element is sown, e.g. DAP or MAP, care is needed is assessing which element is responsible for the response.

Where comparative strips are established, every effort should be made to measure grain yield differences. Weigh bins are useful to accurately establish yield differences. Modern harvesters equipped with yield monitors also make accurate comparisons. In addition to yield, grain protein and other quality characteristics are worth comparing.

Banding P fertiliser with or close to the seed being sown so young seedlings can adsorb a relatively large amount of available P quickly, has proven to be the most profitable application method.

CROP MATURITY

Applying P advances crop maturity and brings crops into head, flowering and grain-fill earlier. In some situations there can be up to a week's difference in heading between higher P rates and no P fertiliser.

CHEMICAL FORMS OF PHOSPHORUS

Of the commonly available manufactured fertilisers, no consistent yield or grain quality differences favouring different forms of P fertiliser have been found, e.g. between MAP mono-ammonium P and DAP di-ammonium P. MAP is often preferred because of its non water absorbing characteristics. DAP is commonly used in the drier areas and on acid soils as it is less acidifying. The choice is commonly based on economics not agronomics.

Some liquid forms of P fertiliser may have an advantage on some alkaline soils.

Slow release fertilisers like rock phosphate are not suitable for annual cropping enterprises as they release available P too slowly.

HOW MUCH P TO APPLY IN VARIOUS SITUATIONS

Following high yields last season

High yielding crops extract more P than average yields. Because of this there needs to be compensation in the rotation for this relatively higher extraction when dollars are more likely to be available for investment.

Following low yield in an average and better-than-average season

Where the previous crop yield was below average or below expectations and adequate P fertiliser was applied, other contributing factors like overall nutrition (e.g. nitrogen), rotation, disease and weed management, timely operations and variety selection could be responsible for the disappointing yields and low water use efficiency. Paying attention to these factors will possibly be the only way of achieving profitable grain yields in this situation. Where the problem is rectified, adequate P fertiliser should be applied as it is most likely that nearly all of the previously applied P will not be readily available to the following crop.

When resowing

When it is necessary to resow in a season, apply additional P fertiliser to that already sown with the seed as a supplement to ensure seedlings have enough during the early growth stages. As the crop grows it will take up the earlier applied P as the roots find it. In most situations, around 5 kg/ha of P fertiliser is enough.

Only where resowing is accurately made back on top of the original rows could using no additional fertiliser be justified.

When sowing much later than the suggested sowing time

Apply P fertiliser to match the reduced yield potential in this situation. No amount of extra P fertiliser will compensate for or improve grain yield when sowing is delayed.

Following a drought

Commonly, drought-affected paddocks are cropped again in the successive year. When crop failure is solely due to drought and there is no other obvious cause of the poor yield, there will be some carryover P where enough was applied previously to meet expected requirements. This carryover P will be available to following crops, but some fresh P fertiliser should still be applied to take full advantage of the buildup in residual P.

In practical terms, the amount of P applied after a drought can be reduced by one-third compared to that which might have normally be used. However, in paddocks with very low available P the full amount should be used. One of the best ways to generate cash for drought recovery is to invest in adequate rates of P fertiliser. Because cash flow is often tight after a seasonal failure, investing in soil testing can help decide where to invest in crop fertiliser with scarce dollars.

Paddocks cropped the second year after drought should be fertilised at full rates.

Following a waterlogging loss

Waterlogging that lasted long enough to cause crop failure in the previous growing season may result in much of the available soil P being converted to an unavailable form. Therefore, it is good practice to soil test to determine available soil P levels before sowing in the following season.

During the pasture phase of the rotation

When establishing pastures under a covercrop, drilling at sowing an extra 30 to 50 per cent more P fertiliser to the crop's requirements can result in significant pasture production gains. In higher rainfall areas topdressing P onto surface rooting annual pastures often achieves useful responses.

Applied P moves very slowly through the soil profile over time, especially during the common seasonal variations when little soil activity occurs during dry spells. Topdressed P on pastures can be ineffectual because of the lack of movement into a moist soil zone, especially in drier areas or when a run of drier seasons is experienced.

After a pasture phase where surface applied P has accumulated there may be an advantage in cultivating once before the next grain crop. This would help in mixing the surface accumulated P a little deeper into the soil where it can be more readily accessed by the crop's roots.

VARIETY RESPONSES

There is no conclusive evidence to suggest currently grown winter crop varieties respond differently to varying P fertiliser application rates, provided they are planted within their suggested sowing windows.

APPLICATIONS TO CROPS OTHER THAN WHEAT

Very limited research has been undertaken to correlate responses of crops other than wheat to soil tests, but grain product quality and prices have the greatest influence on the economics of applying P fertiliser. Indications are that grain yield responses of barley, oats and triticale are similar to those for wheat. Comparatively lower grain prices may slightly reduce the profitability of applying P fertiliser at rates suggested above to feed barley or oats, for example, but the profitability is still there so optimum fertiliser rates are only slightly lower than those suggested for wheat.

Canola responds very well to P. It is more responsive to P than wheat and has a higher requirement. Always ensure enough P is sown as canola does not receive any benefit from VAM in accessing P from the soil. Apply 20 kg P/ha to achieve 2.5 t/ha yield, i.e. 8 kg P/ha on average in medium P soils for every tonne of canola you expect to harvest. P rates from 20 to 30 kg/ha are commonly used in medium to higher rainfall areas.

Grazing crops sown early for the dual purposes of grazing and grain need extra P fertiliser to those rates suggested for grain only crops. When they are grazing, stock remove P in the plant so it is not available later for grain development. Suggested rates above should be increased by 20 per cent.

Pulses have similar requirements to wheat of around 4 kg P per tonne of grain expected. In most situations, 10 to 15 kg P/ha are sown with these crops. Make sure enough P is sown with lupins as they receive no benefit from VAM.

TISSUE TESTING FOR PHOSPHORUS

Tissue tests can indicate whether there is enough P or there is a deficiency in growing crops. They are also useful for diagnostic assessment. However, as crops need the vast majority of their P during early development it is not feasible to correct detected deficiencies in the growing crop.

FOLIAR APPLICATIONS

Winter crops take up P through leaves very inefficiently. As P is in high demand during early growth it is not feasible to apply enough P to such a small leaf and stem target to achieve yield responses.

Adequate phosphorus fertiliser at sowing is critical in achieving high canola yields, as it is very responsive (P 20 kg/ha on the left compared with nil P on the right).

Fertiliser comparison chart

This table gives the equivalent rates of the various fertilisers to supply a given amount of phosphorus. For example: 10 kg/ha P is supplied in 116 kg/ha Single Super, or 45 kg/ha Starterphos, *or* 77 kg/ha Starter 15. The table can be used regardless of whether fertiliser rates are in lbs/acre or kg/ha. As well as supplying this amount of P, Starterphos supplied 4.5 kg/ha N and Starter 15 supplies 11.5 kg/ha N (see columns on right of table).

	Fertiliser Application rate (kg/ha)							Kg of nitrogen applied (in addition to phosphorus) with:				
Kg of Phosphorus Applied	**Single Super 8.6% Sol. P**	**Trifos 17.9% Sol. P**	**MAP Starterphos 10:22:0**	**DAP 18:20:0**	**Pivot 15 Starter 15 15:13:0**	**Hifert 24:16:0**	**Hifert 32:10:0**	**MAP Starterphos 10:22:0**	**DAP1 8:20:0**	**Pivot 15 Starter 15 15:13:0**	**Hifert 24:16:0**	**Hifert 32:10:0**
5	58	28	23	25	38	31	50	2.3	4.5	5.7	7.5	16.0
6	70	34	27	30	46	38	60	2.7	5.4	6.9	9.0	19.2
7	81	39	32	35	54	44	70	3.2	6.3	8.1	10.5	22.4
8	93	45	36	40	62	50	80	3.6	7.2	9.3	12.0	25.6
9	105	50	41	45	69	56	90	4.1	8.1	10.3	13.5	28.8
10	116	56	45	50	77	62	100	4.5	9.0	11.5	15.0	32.0
11	130	91	50	55	85	69	110	5.0	9.9	12.7	16.5	35.2
12	140	67	54	60	92	75	120	5.4	10.8	13.8	18.0	38.4
13	151	73	59	65	100	81	130	5.9	11.7	15.0	19.5	41.6
14	163	78	63	70	108	88	140	6.3	12.6	16.2	21.0	44.8
15	174	84	68	75	115	94	150	6.8	13.5	17.2	22.5	48.0
16	186	89	72	80	123			7.2	14.4	18.4		
17	198	95	77	85	131			7.7	15.3	19.6		
18	209	101	81	90	138			8.1	16.2	20.7		
19	221	106	86	95	146			8.6	17.1	21.9		
20	233	112	90	100	154			9.0	18.0	23.1		

The above figures are only approximate - they are rounded off to the nearest whole figures.

Approximate sulphur content: Single Super, 12%; Trifos, 1%; Starterphos, 3%; Starter 15, 10%; Starter 18, 17%; DAP, 3%; MAP, 3%.

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Disclaimer

The information contained in this publication is based on knowledge and understanding at the time of writing (December 2001).

However, because of advances in knowledge, users are reminded of the need to ensure that information upon which they rely is up to date and to check currency of the information with the appropriate officer of new South Wales Department of Agriculture or the user's independent adviser.

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