

THE P FIXATION BOGEY



**(CONTINUED FROM
THE FERTILISER REVIEW NOS 1&2)**

So far we have discussed how fertiliser P is converted in soils into either organic or inorganic P and stored in these forms until required by the plant. We have noted that this is a good thing – otherwise P would be leached. The efficiency of this process is such that in the long-term 80-85% of the fertiliser P is utilized.

For optimum production the soil P organic and inorganic tanks must be full and different soils have different size tanks as indicated by the Anion Storage Capacity (ASC).

The question arises – can this accumulated organic and inorganic P be used and if so how? There is also the related question – is this a good idea?

Take a fertile soil that has full P tanks – say an ash soil with an Olsen P of 35-40 or a sedimentary soil with Olsen P 25-30. If the farming operation is continued and no fertiliser P applied, the reactions that initially gave rise to the accumulation of inorganic and organic P, will be reversed. The pasture will mine the soil P reserves and the amount of available P (Olsen P) will decline. So too will production. Many trials demonstrate this truth.

The rate of soil P depletion depends on the starting point. On sedimentary soil with a medium Olsen P (15-20) to start with, the decline is about 5% per annum. On ash soils with high initial Olsen P (>40) it may be 2-3 years before a decline in Olsen P and production is observable (remember these soils have big nutrient tanks). But inevitably, given time (>5 years), soil P reserves will become depleted and production decline.

The answer to the question then, is yes; accumulated soil P reserves can be utilized, simply by continuing to farm without applying fertiliser P. But is this a good idea?

There are legitimate financial reasons for doing this, for example as short-term strategy when cash is short and prices

are low. But there are dangers. Such a strategy is the soil fertility equivalent to using financial capital for day-to-day operations. Sooner or latter the capital must be replaced!

Can liming affect the amount of accumulated P, as is frequently asserted? The general answer is no – for most soils liming should not be undertaken in the expectation that P inputs can be reduced.

However, there are a few soils in New Zealand (the sedimentary soils in the drier parts of Hawkes Bay) where it has been shown that liming can ‘unlock’ accumulated organic and inorganic P. The effect is equivalent to about 20 kg P/ha over 5 years, not sufficient to significantly reduce fertiliser P inputs. Furthermore, it is not known whether this is repeatable – will it occur following the next application of lime?

There are a number of proprietary products on the market that claim specifically to ‘unlock soil P’. These include Nitrosol (Rural Research Ltd) and Combo (Mark Bell-Booth Ltd). It is claimed in the advertising that these products stimulate soil biological activity thereby releasing locked up P.

Such claims are nonsense. Properly designed and conducted scientific trials with these and similar products show they have no practical effect on soil quality and plant growth when applied at recommended rates.

But lets look at this from another perspective. Since the dawn of civilization farmers have known the value of soil organic matter. It has many beneficial effects on the productivity of soils and most farmers do everything they can to build up and preserve soil organic matter.

If products like Nitrosol and Combo did as they claimed, and broke down soil organic matter to release the organic P, this would contradict one of the basis tenets of good soil husbandry. Strange, is it not, that these same companies purport to support the move towards sustainable, organic, environmentally safe, soil management practices!



MAGNESIUM FERTILISERS FOR PASTURES

There is evidence that the magnesium (Mg) status of New Zealand's pastoral soils is declining. We should not be surprised. There are significant losses of Mg, by leaching and through the removal of animal products, from any intensive farming operation. If these losses are not replaced then soil Mg reserves will decline. It is inevitable that more and more farmers will need to add Mg to their fertiliser mix.

I recently reviewed the New Zealand literature on this subject, including data from 48 field trials. The agronomy is straight forward.

Absolute Mg deficiency occurs only on soils with a soil test levels < 5. Adding fertiliser Mg – 25 kg Mg/ha is sufficient

- to such soils increases pasture production. Increasing the soil Mg above 5 has no further effect on pasture growth but increases the Mg concentration in the herbage. Field trials show that very large inputs of fertiliser Mg are required to get the pasture Mg concentrations high enough in spring (> 0.2%) to provide protection against hypomagnesaemia.

Of the common Mg fertilisers, magnesium oxide (MgO) (called variously magnox, causmag and calmag) and serpentine super are quick acting and therefore suitable for all situations. Dolomite however is slow release, which limits its use to the maintenance situation. Also note that all the Mg in MgO and dolomite is plant available but only 70% of the total Mg in serpentine super is plant available.

The Table below shows when, why and how Mg fertiliser should be used.

The Suitability of Various Magnesium Fertiliser to Achieve Four Different Goals

Goal	Fertiliser type	Rate of Application	Comments
Eliminate soil deficiency quickly (<6 months)	MgO, serpentine super	20-30 kg plant available Mg/ha initially	Annual maintenance inputs will be required to keep soil Mg > 5
Build up soil Mg quickly (< 6-12 months) to alleviate hypomagnesaemia	MgO	100-200 kg plant available Mg/ha initially	Annual maintenance inputs will be required to maintain spring pasture Mg above 0.20%
Build up soil Mg slowly (< 5-10 yrs) to alleviate hypomagnesaemia	MgO, serpentine super, granmag, dolomite	20-30 kg plant available Mg/ha/yr in addition to maintenance of 20-30 kg/ha/yr.	Soil Mg levels should rise slowly over 5-10 years and should be maintained such that spring pasture Mg > 0.20%.
Maintain current soil Mg levels	MgO, serpentine super, granmag, dolomite	20-30 kg plant available Mg/ha/yr depending on rainfall, and soil texture	Monitor soil Mg levels and adjust input accordingly.

Given the current prices the cost per kg Mg can be calculated for each of the main products, as follows:

Goal	Typical Price ¹ (\$/tonne)	Total Mg (%)	Plant Available Mg (% of total Mg)	Cost (\$/kg Mg)
Serpentine super	163.50	6.8	70	1.02 ²
Granmag ³	437.30	30	100	1.45
MgO	450.00	55	100	0.82
Dolomite	170.00	11	100	1.38 ⁴

- Notes:**
- 1) ex works as at August 1999
 - 2) after deducting the value of the P (\$1.20/kg P) and S (\$0.40/kg S)
 - 3) granulated MgO available only from BOP – currently being reformulated
 - 4) after deducting the value of the liming component (\$18/ tonne lime-equivalent)

MgO is currently the cheapest form of Mg but it is a fine powder and difficult to mix and spread. The latter also applies to dolomite. Granmag is granulated MgO and the process of granulation adds cost. It is suitable for mixing with other fertilisers.

My advice?

- If soil Mg levels are < 5, fertiliser Mg (25 kg Mg/ha) should be applied
- Monitor soil Mg levels. If they are declining below 10 include Mg in the fertiliser mix as part of the fertiliser maintenance program
- If you are already using a super-based fertiliser mix, and just want to maintain soil Mg levels use serpentine super or a blended super – MgO mix.
- For large capital inputs use MgO (100 Mg kg/ha) applied separately from the normal fertiliser inputs. But remember that this measure alone may not completely eliminate hypomagnesaemia.



SOLID VERSUS LIQUID FERTILISER?

A persistent claim made by many liquid fertiliser proprietors is that foliar feeding is more efficient and/or effective than the application of solid fertiliser to soils. In particular it is claim that foliar feeding avoids “P fixation” and therefore lower inputs of fertiliser nutrients can achieve the same level of production.

This claim was in fact tested many years ago in a field trial at Rukuhia that compared applications of NPK applied either in a liquid form, sprayed onto the pasture, or in a solid form. The trial was on a P deficient Horotiu silt loam with a high ASC..

The results (Table 1) show there is no benefit in applying nutrients in a liquid form relative to normal solid fertiliser inputs.

Table 1. Effects of Nutrients Applications Applied as either Liquid Fertiliser or Solid Fertiliser (Karlovsky et al 1978)

Source of P	Amounts of NPK Applied (kg/ha/yr)	Relative Pasture Production (control = 100)	
		Applied as Liquid	Applied as Solid
Control	0	100	100
Mono-calcium phosphate	0, 15, 0	113	117
Di-ammonium phosphate	14,15, 0	120	114
Di-potassium phosphate	0, 15, 37	118	119
Phosphoric acid + urea	20, 15, 0	105 ¹	114
Glycerophosphoric acid	0, 8, 0	108	108
	Average	113	114

Notes: 1) some scorching occurred following application

Some proprietors will say that this comparison is not valid because the liquid fertilisers used did not contain an organic base, such as seaweed, or blood and bone, or fish waste. The contention is that it is the ‘goodies’ in the organic matter of these types of products that protect the nutrients from harmful soil processes, and therefore make the nutrients more efficient.

This too has been tested (Table 2). Nutrients applied on their own were more effective!

Table 2. Effect of Fertiliser Nutrients Applied With and Without Organic Matter.

Treatment	Relative Pasture Yield (control = 100)
Control	100
Proprietary Liquid Fertiliser (with organic matter)	104
Synthetic Liquid Fertiliser (no organic matter)	109

A variation on this theme is that traditional solid fertilisers such as DAP, are more effective than solid granular fertiliser if finely ground and applied as slurry. This claim has been tested on three nutrient deficient soils in the Hawkes Bay (Table 3).

Table 3. Effect of Form of Application of DAP Fertiliser on Pasture Yield (Korte et al 1996)

Treatment	Amounts of Nutrients Applied (kg/ha) ¹			Pasture Yield ² (Control = 100)
	N	P	S	
Control	0	0	0	100
FPA (DAP slurry) ³	3.3	3.3	5.3	103
DAP solid	3.6	3.6	0.4	103

Notes: 1) mean inputs for 3 trials on dryland yellow grey earths
 2) mean over 3 trials. The relative yields for the normal fertiliser treatments were 120-130
 3) as recommended by the proprietor

The result is the same and the overall conclusion is obvious. The form, in which the fertiliser is applied, either as a liquid, or slurry, or as a solid, has no effect on production.

All the above trials compared solid and liquid fertilisers applied to give the same inputs of nutrients. In other trials this comparison was done on an equal cost of nutrients basis.

Table 4. The effect of solid and liquid fertilisers compared on an equal nutrient input basis and an equal cost of nutrient applied on pasture production. (Karlovsky et al 1978)

Treatment	Relative Yield ¹ (Control = 100)
Control	100
Liquid fertiliser	106
Solid fertiliser (equal nutrient basis)	106
Solid fertiliser (equal cost basis)	118

Notes: 1) means of 4 trials all on nutrient deficient sites

These results demonstrate a simple fact. It is far cheaper to buy nutrients in a solid form and therefore more nutrients can be applied for the same cost. For this reason solid fertilisers are a more cost-effective means of getting nutrients the pastoral system.

My advice? If your concern is sustainable, cost- efficient production, then purchase all nutrients in a solid form. It is far cheaper.

(In the next issue of The Fertiliser Review we will look at trial results for specific liquid fertilisers and show some cost comparisons)

PRICE WATCH : PHOSPHATE FERTILISERS

Product	Typical Price (\$/tonne) ⁶	Cost (\$/kg P) ⁸
Superphosphate (0, 9, 0, 12) ¹	160 to 168 ⁷	1.24 -1.33
Triple superphosphate (0, 20, 0, 0)	442 to 464 ⁷	2.21-2.32
Superplus (0, 15, 0, 7) ²	295.30	1.78
Triple super/S-super (0.15,0,7) ³	278.40	1.67
DAP (18, 20, 0, 0)	508 to 513	1.97
MAP (11, 22, 0, 0) ³	508.00	1.99
Egyptian RPR (0,13, 0, 2) ⁴	193.10	1.48 ⁹
Gafsa RPR (0,13, 0, 2) ⁴	203.00	1.56 ⁹
Sechura RPR (0,13, 0, 2) ⁵	177 to 189.00 ⁷	1.45 ⁹

- Notes:** 1) available only through BOP Fertiliser Ltd and Ravensdown Fertiliser Co-operative Ltd and their agents
 2) available only through BOP and its agents
 3) available only through Ravensdown
 4) available only through Summit-Quinphos (NZ) Ltd
 5) available through Asura Fertilisers Ltd, BOP and Ravensdown

- 6) ex works exclusive of GST
 7) depends on region and company
 8) after deducting the value of the other nutrients (S, @ \$0.40/kg and N @ \$0.66/kg)
 9) for the 3 slow release RPRs this is the cost per unit total P. The cost per unit available P will be higher than indicated

Based on this data I would offer the following advice:

- Avoid products such as DAP, MAP and triple super, except perhaps for special one-off situations such as correcting a nutrient imbalances as may occur when soil P levels are low but soil S levels are high.
- If an RPR is required use the cheapest product – currently Sechura. This is also the most reactive of the 3 RPRs currently available
- If sulphur is required in addition to P, which is generally the case, use the cheapest form of P – currently superphosphate.

SUPER VERSUS RPR?

I have had some recent interesting correspondence with a farmer from Wairoa. His question? The costings that I have provided in The Fertiliser Review to date (see Price Watch article this issue) are based on ex-works prices - what is the effect of transport and spreading costs? It is a good question.

His costings are as follows:

Component	Superphosphate (0.9.0.11)	RPR 8 S (0.11.0.8)
Cost to farm gate	195.51	211.45
Cartage to airstrip	8.44	8.44
Airstrip hire	4.50	4.50
Flying	48.37	48.37
Total	256.82	272.76

Notes: 1) all costs in \$/tonne and include GST

Using these on-ground costs we can derive the following:

Product	On-ground cost (\$/tonne)	Nutrients supplied in one tonne of fertiliser (kg)		Value of S in 1 tonne of fertiliser (\$)¹	Value of P in 1 tonne of fertiliser (\$)²	Column 1 ² Cost of P (\$/kg P) of fertiliser	Column 1 ³ Cost of P (\$/kg P) of fertiliser
		P	S				
Superphosphate	256.82	90	110	44.0	212.82	2.36	2.36
RPR 8S	272.76	110	80	32.0	240.76	2.19	8.03

- Notes:** 1) based on 40 cents/kg S
 2) assuming all the RPR P is available

3) assuming only 30% of RPR P is available

This analysis suggests that the RPR/S mix is a cheaper option, but this comparison assumes that all the P in the RPR is immediately plant available, just like the P in super. (Column 1, above)

In fact, AgResearch scientists have found that the average annual rate of dissolution for the most reactive RPR, (Sechura) is 30% with a range from 0% to 70%.

Applying this average to the cost per unit of available P can be calculated (Column 2, above).

Thus we have 2 extremes. If you assume that all of the P in RPR becomes plant available in the year of application, like super, then the cost is about \$2.00/kg P on the ground. Alternatively if it is assumed that only 30% becomes plant available in the year of application, then the cost is about \$8.00 / kg P.

Where does the 'truth' lie?

The short answer is that it lies between these extremes, \$2.00 to \$8.00/kg P.

The technical problem here is that with slow release products like RPR you are paying today for something from which you will not get the benefits for some years to come.

The calculations to factor in this cost are complicated and the only published work on this subject comes from the late Dr Sinclair (AgResearch).

He calculated the time taken before RPR was more cost effective than super for different dissolution rates.

Fraction of RPR Dissolving in Year 1	Time (years) for RPR To Be More Cost Effective Than Super
10%	> 25
20%	> 25
30%	10
40%	6
50%	4

Assumptions: 1) discount rate 10%, S:P ratio 1:1, cost of super \$199.

These figures were calculated some years ago when the price of super was approximately the same as RPR (ie super \$199 and RPR \$195 per tonne). This is not the case today with super at \$160-168 (depending on the company) and RPR \$180 to \$200 (depending on the company) (see Price Watch –this issue). In other words, the breakeven times, based on current costs, will be even greater than indicated above.

Furthermore, we now know that not all RPRs are the same

(see The Fertiliser Review No 1). Of the currently available materials the order of reactivity is Sechura > North Carolina > Gafsa >> Egyptian. The average dissolution rate of 30%, given earlier, applies only to Sechura. The less reactive the RPR the longer the break-even point.

These figures demonstrate a simple principle - if you switch to an RPR you have to be in for the long haul – on average 10 years if you are using the best RPR - before you will commence to reap the economic benefits. Expressed differently, the cost of the P on the ground, even for the best RPR is more than super P for at least 10 years.

A further assumption in this comparison is that the elemental S in RPR 8S is agronomically equivalent to the sulphate S in super. This is not so.

To be agronomically equivalent to sulphate S, elemental S must be very fine (at least 100% < 0.5 mm and 50 % < 0.25 mm). None of the elemental S products on the market today are this fine. For example the proportion of elemental S in ag-grade elemental S, that oxidizes and becomes plant available in the year of application, is about 30-40%. For the S enriched super products (eg S-super 30 and Maxi-super 50) it is about 50-60%. Thus, a kg of elemental S is not as effective as a kg of sulphate S in the year of application. – it is therefore worth less.

But surely elemental S is more effective than sulphate S because it does not leach? This is so only when the rainfall is high (> 1500 mm) and on soils with low phosphate retention (ASC < 20) as occurs on peats, podzols and coarse textured pumice soils. In all other cases sulphate S is as effective as elemental S, with the proviso that the elemental S is sufficiently fine.

Thus, with the exceptions noted above, in most situations sulphate S is as effective as fine elemental S, and more effective than most of the currently available elemental S products.

Strictly speaking therefore we should put a higher value on the sulphate S in super than elemental S. But how much?

The only other comparable sulphate fertiliser is ammonium sulphate. If we deduct from it the value of the N (at \$0.66/kg N) then we can arrive at a figure of \$0.69/kg sulphate S – certainly more than the \$0.40 cents for elemental S.

Taking this alone into account (ie and assuming all the RPR P is available) would mean that the cost of P on the ground is about \$2/kgP for super and \$2.19/kgP for RPR 8S.

The point is this: for slow release products such as RPR and

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elemental S, the costs on the ground need to be modified by the agronomic value of the nutrients once in the soil. A perspective emerges which is not reflected in company price lists and is certainly not present in the farming press.

My advice?

- If you are thinking RPR/elemental S mixes, think again. They are currently more expensive when the agronomic value of the nutrients are considered.
- The exception to the above occurs if the current soil P reserves are high (Olsen P 30 for an ash soil or > 20 for a sedimentary soil and S is not required (soil sulphate and organic S levels > 15). This in my experience is not common.
- If you want to register as a certified organic farmer you have no option but to use RPR and elemental S products. Choose the most reactive (for RPR) or finest (for elemental S).
- If you have been using RPR for 10 years, stay with it. From now on you will be reaping the financial benefits. But watch the price differential between super and RPR. The trend over the last years has been for it to improve in favor of super. The savings may not be as great as they were when you started.



LIME REVERTED SUPER

The agronomic effectiveness of lime reverted supers and lime:super mixes was reviewed in The Fertiliser Review No 1 (October 1989). It was concluded that they are agronomically similar, and when compared on the basis of an equal weight of P applied, they are no more or less effective than ordinary super.

For this reason the various lime reverted supers and lime:super mixes on the market can be compared on a cost of P basis.

Relative to superphosphate all the lime reverted products and lime:super mixes are more expensive per unit of P and the products offered by Northfert and Hatuma are much more expensive than those available from BOP and Ravensdown.

Why should this be so? There are several reasons;

Lime:super mixes are made by mixing a liming material, normally limestone, with superphosphate. Thus, relative to super, there are the additional costs of lime and mixing. At \$18/tonne for ground limestone and a standard mixing charge of \$4-5/tonne would add about \$0.10/kg P - sufficient to explain the prices charged by BOP and Ravensdown.

However, these additional costs - of lime and mixing - do not alone explain the prices charged by Northfert and Hatuma who justify their additional margin with a number of claims including:

- The P in reverted super is more effective than the soluble P in super. This is expressed variously in claims such as: reverted P is not 'fixed' in the soil like soluble P or is not leached; plants utilize reverted P more effectively than soluble P because it is in a non-acid form. These claims are nonsense as many field trial results demonstrate (see The Fertiliser Review No 1 October 1989).
- Northfert state that they provide a service to farmers through their staff with respect to 'soil testing and reporting, and animal health monitoring' and build this cost into their fertiliser charges. This is of course the situation with most fertiliser companies.
- Both companies emphasize the beneficial effects of their products on soil, plant and animal health. This may be so but these are the same benefits that result from using super and lime separately.
- Northfert state that the lime material they use in single reverted super is 'a blend of calcium carbonate (limestone) and calcium oxide'. The latter while more soluble and therefore faster acting than limestone, is also more expensive. This may be an advantage on very acid soils (pH < 5.5) where it was essential to raise the pH within a matter of months. This is not a general occurrence in the grassland situation and in any case could be achieved using a liming material alone.

My advice:

1. Apply lime and super separately. This will achieve all the benefits of reverted super products but at lower cost.
2. If you wish to use a lime reverted super choose the cheapest - at present those available through BOP and Ravensdown.
3. Avoid the products offered by Northfert and Hatuma if you are trying to maximize production at the least cost.

Company & Product	Rating (% P, K, S)	Cost ¹ (\$/tonne)	Lime component ² (% by weight)	Cost (\$/kgP) ³
BOP Lime:super	(0,7,0,9)	129-134 ⁴	25	1.32-1.40
Ravensdown Lime:super	(0,7,0,9)	125-130 ⁴	25	1.27-1.34
Northfert Single reverted super	(0,5,0,7)	138-145	45	2.20-2.34
Hatuma Dicalcic phosphate	(0,4,0,6)	126	50	2.55
Superphosphate	(0,9,0,12)	160-168	0	1.24-1.33

Notes: 1) ex works exclusive GST 2) except for Northfert the lime component is ground limestone
3) after deducting the value of the sulphur content @ \$0.40 /kg S 4) prices depends on location