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"The Independent Fertiliser Experts"

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MANAGING WATER QUALITY

Pastoral farming affects water quality via the losses of nutrients and sediments (Table 1). That is not to say that we should stop farming. The solution is to farm smarter to reduce the farm's environmental foot-print without damaging its economic viability. To achieve this, we need information based on sound-science.

There are in fact four contaminants that affect water quality: nitrogen (N), phosphorus (P), sediments and pathogens (nasty bugs like e-coli) and it is important, in terms of developing mitigation options, to understand the pathways by which these contaminants are transferred from the land into waterbodies (stream, rivers, lakes).

Table 1. Average losses of nitrogen (N), phosphorus (P) and sediment from 15 catchment studies in New Zealand.

Average 15 catchment studies

Land use	P loss (kg P/ha)	N loss (kg N/hayr)	Sediment (kg/ha/yr)
Non agricultural	0.2	2	174
Sheep	0.6	3	598
Sheep & beef	1.3	11	1156
Deer	1.5	8	2034
Dairy	1.9	27	299

dodd et al 2016

Nitrogen predominantly moves via leaching down through the soil profile and beyond the rooting depth of the pasture. It then gets carried, predominantly as nitrate-N, in the groundwater, into nearby streams and rivers. In contrast, the other three contaminants, plus a small amount of N, move via surface runoff – they get carried along when there is movement of water across the soil surface during high rainfall events (Figure 1). Because of these different mechanisms, the options to manage these contaminants are different (Table 2).

Figure 1 Nitrogen is lost as nitrate N via leaching. The other contaminants get into waterbodies via overland movement of water (runoff).

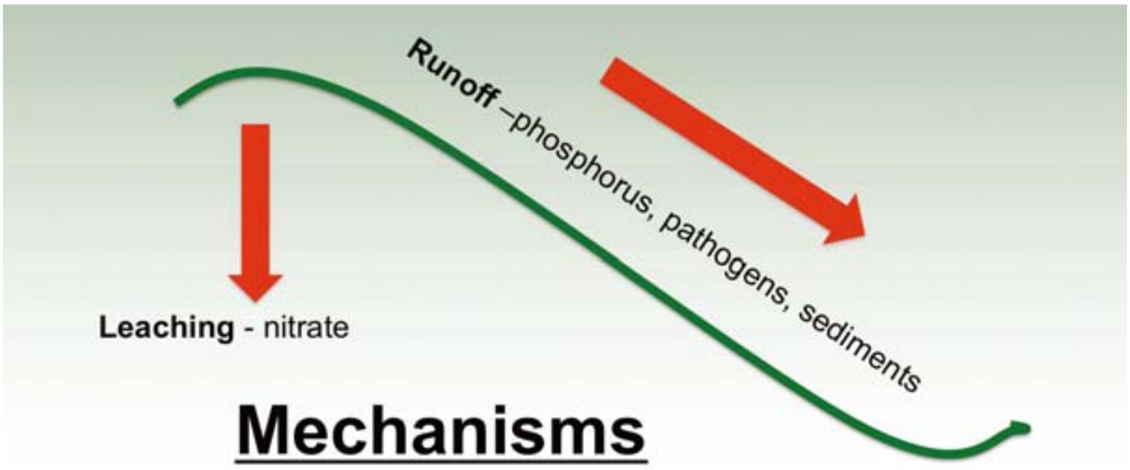

Table 2. Some of the management options to mitigate nitrogen leaching and runoff losses.

Leaching (nitrogen)	Runoff (phosphorus, e-coli, sediments)
Reduce the number of urination events per unit area especially during late autumn/winter (e.g. reduce stocking rates, put stock on standoff areas, feed-pads, or in herd homes).	Farm at and not above the economic optimal Olsen P Sediment traps not fenced (e.g. dams and bunds)
Reduce fertiliser N inputs	Riparian buffers (fenced sediment traps)
Use low N feeds to reduce the N concentration in the urine	Wetlands (fenced sediment traps which also convert nitrate N to N gas)
Avoid excess drainage (e.g. effluent, irrigation)	Avoid soil erosion

It is relatively easy to understand how sediments and pathogens affect water, at least a far as human health is concerned. The effects of N and P on water quality are a little more subtle. Both P and N can affect the growth of nuisance aquatic plant life (macrophytes and algae) which under the right conditions can lead to causing eutrophication.

The question arises: which contaminant – N or P – is worse?

Scientist have worked out that if the ratio of N:P in the water is < 7:1, further growth in nuisance aquatic plant life is limited by N; if the ratio is > 15:1, then P is limiting and between these extremes they are co-limiting. Ten years ago, Dr Rich McDowell from AgResearch and co-workers summarised data from 1100 freshwater sites monitored for at least 10 years from all over New Zealand, applying this N:P ratio criterion. They presented this information as maps (Figure 2).

Their summary was: "P limitation was the most frequent scenario in NZ streams (overall 76% of sites P limited, 12% N limited and 12 % co-limited)"

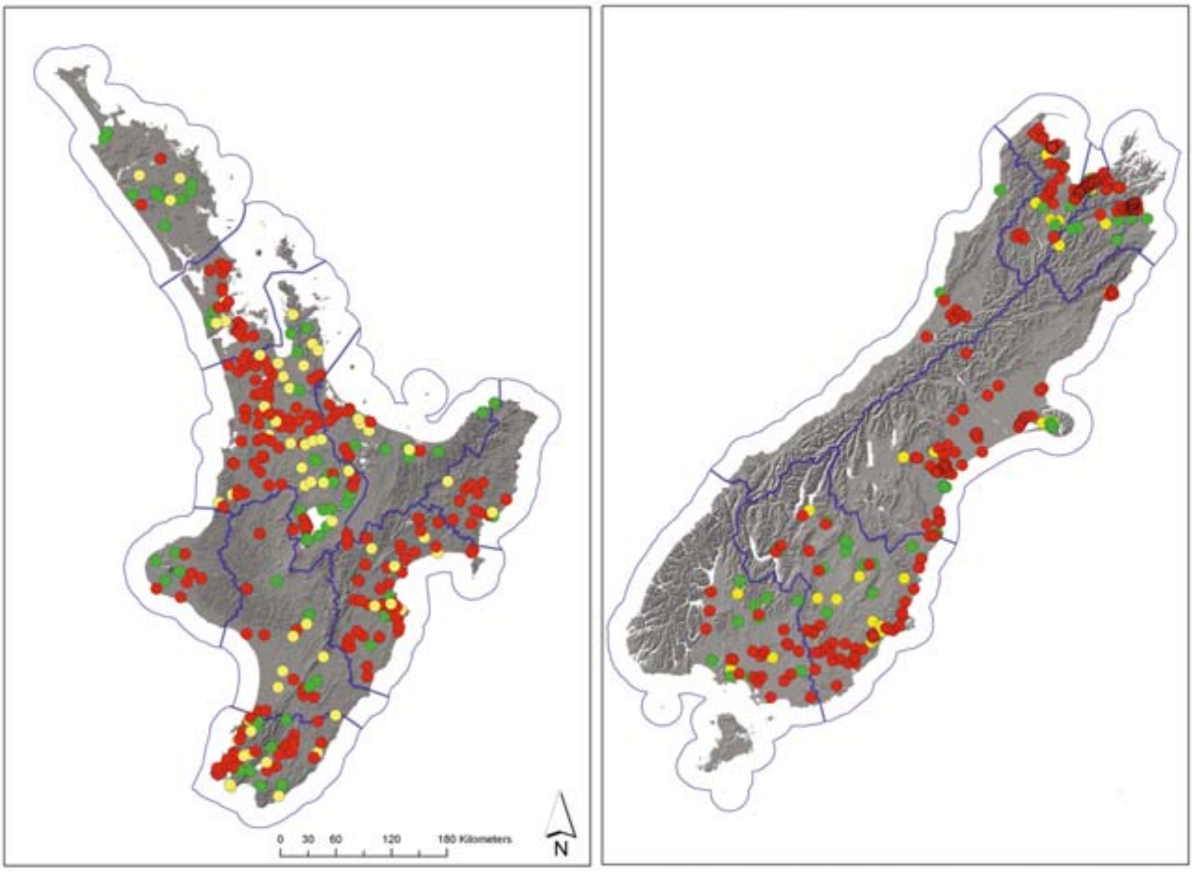

Figure 2 Sites in the North and South Islands of New Zealand with N-, co- or P-limited periphyton growth indicated by green, yellow and red dots, respectively (from McDowell et. al. 2009).

Remember, these data are 10 years old, so a little care is required when applying this information to today's situation. But the prediction from the authors of this study is worth noting:

> "We predicted that with time, as farm systems have and continue to intensify, N losses increase at a greater rate than P losses. Since the pathway for N to reach fresh waters may be more tortuous and take longer than P to reach a stream or river, *focusing mitigation on P losses may have a quicker effect on potential algal growth* [my emphasis]. In addition, with time, it is expected that P-limitation in New Zealand's rivers and streams will be more widespread as N-losses are unabated. Hence, although strategies to decrease N losses should be practiced, mitigating P losses is also central to preventing eutrophication.

This prediction makes for a good question. Assuming that this data is still relevant, why is it that over the last 10-15 years there has been so much emphasis on N leaching? One facile answer I have heard to this question is that "we have Overseer and it predicts N leaching!"

My own experience certainly supports this conclusion. I was asked by a group of farmers in the lower Waikato to summarise the water quality data in their sub-catchment (the Lake Waikare - Whangamarino subcatchment), which is one of the 72 subcatchments in the larger Waikato River system.

The Waikato Regional Council has been monitoring the water quality at five sites within this subcatchment for 20 years. With this data, together with other information about this subcatchment, I concluded that sediments, e-coli and P were the major contaminants limiting water quality in this subcatchment - N was not the problem!

Furthermore, it was possible from the data, to show that only about half of the amounts of these contaminants arose from farming activities. The balance was coming from within the lake/wetland system. The implication is that the number one priority – the low hanging fruit - to improve the water quality in this subcatchment is to limit the wild-life, including the koi carp population, which are "fowling their nest" and stirring up the sediments at the base of this shallow water system. I have every reason to predict that many of the subcatchments in the Lower Waikato are in this condition.

Given this experience, and especially from the data in Figure 2, it is my view that this type of 'forensic analysis' at the subcatchment level, is essential **BEFORE** farmers race off and possibly waste money on mitigation options which may be ineffective in terms of improving water quality.

SUREPHOS

Ballance Agri-Nutrients Ltd have introduced a new product, “SurePhos”, into the market. It contains less total P than superphosphate and a lower proportion of the total P is in a water-soluble form (Table 3). In short it is a less-soluble form of superphosphate. It is reasonable to think of SurePhos as a type of reverted superphosphate – remember “sowing” super?

Table 3. Total phosphorous (P) content and proportion of water-soluble P in selected P fertilisers.

Fertiliser	Total P	Water Soluble P (% of total)
Superphosphate	9.0	82
Serpentine super	6.8	44
SurePhos	7.8	23
Reactive Phosphate Rock	12.7	7

Ballance claims that using SurePhos instead of superphosphate, reduces P runoff by **up to 75%** [my emphasis]. This wording is a little sloppy because it suggests that the reduction in P loss could be anywhere between 0% to 75%. So, let’s put this claim into some context.

The average annual amounts of Total P lost in surface runoff are typically in the range 0.5 to 2.0 kg P/ha/yr (see Table 1 and Figure 4). The sources of this Total P are categorised as either systematic P or incidental P.

Systematic P comes from several sources a) natural sources (soil minerals), b) past fertiliser P applications, including past additions of less soluble P forms like RPR and c) from the P in dung, effluent and feed-supplements applied to the soil. The important point is that systematic P is the P, from all these sources, which has had time (months) to react in the soil and become part of the soil matrix – it is sometimes referred to as particulate P.

In contrast, incidental P is water soluble P and the major source of this is the water soluble component from recently (within months) applied P fertiliser. The distinction is important because incidental P (soluble P in the fertiliser) given time (months), reacts with the soil and becomes systematic P.

Figure 3 shows the P concentration in surface runoff over time, following the application of superphosphate, serpentine super, or reactive phosphate rock (RPR), at 30 kg P/ha, on a soil in Southland, following a ‘normal’ rainfall event.

The P concentration in the runoff water, initially (within days), followed the order: superphosphate >> serpentine super > RPR. In other words, the amount of incidental P loss was related to the proportion of P in a water-soluble form (Table 3). By day 50 there was very little difference between the fertilisers, allowing for the normal variability.

We can interpret these data as follows: The initial losses are incidental P and given time (50 days in this case) the P concentration declines as the water-soluble P in the fertiliser reacts with the soil and becomes part of the soil matrix – i.e. it becomes systematic P. And note that RPR - the fertiliser with the lowest water-soluble P, given time, also contributes to the flow of systematic P in the runoff. This of course must be the case because, to become agronomically effective, some of the insoluble P in the RPR must dissolve to become plant available soluble P and as such becomes part of the soil matrix.

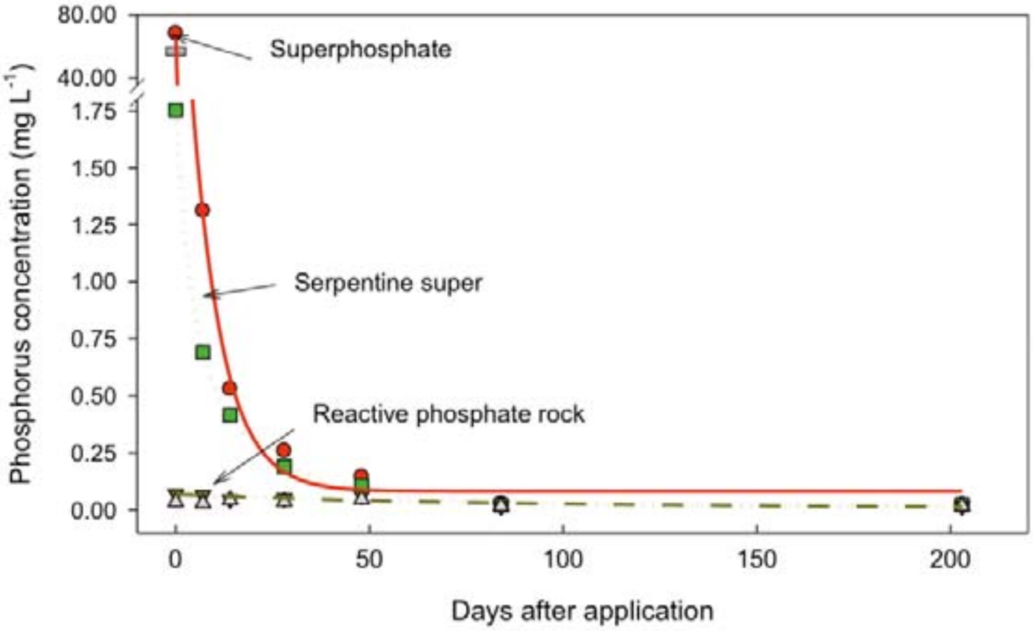

Figure 3 Phosphorous (P) content in the runoff from plots receiving superphosphate, serpentine super and reactive RPR after a normal rainfall event (McDowell and Calto 2005).

Ballance claims that SurePhos reduces P runoff by up to 75 %. What they mean is that this product reduces incidental P loss by up to 75%, relative to super. And note the “window of opportunity” to capture this benefit is narrow (50 days in this example). So, for most of the year (assuming a single annual application of fertiliser) the Total P loses come from systematic sources and are largely unaffected by fertiliser type.

As noted earlier, average Total P losses are in the range 0.5 to 2.0 kg P/ha/year. How much of this P is incidental P and how much systematic P?

Once again, I rely on Dr Rich McDowell of AgResearch (he is the guru on this topic). He says it all depends on risk, and the risk factors include: water-solubility of the fertiliser, likelihood of a rainfall event that produces runoff within about 20 days of application, hydrophobic soils (soils that do not readily absorb rainfall), soil with low phosphate retention (ASC < 15) and the application of high rates of fertiliser P. If all these factors coincide then the incidental P losses could be 80% to 90% of the Total P runoff (see Table 1, i.e. 0.4 to 1.8 kg P/ha/yr). Under ideal conditions, when all the best management practices (BMP) apply, the incidental P losses could be < 10% of the Total P runoff (i.e. 0.05 to 0.2 kg P/ha/yr).

Note that the figures used here are annual average losses. A recent 3-year study on a hydrophobic pumice soil indicated typical losses of P < 1 kg P/ha in 2 years. However in one year significant rainfall occurred with 21 days following fertiliser application and the P loss from the superphosphate treated plots was about 8 kg P/ha most of which was incidental P. At the same time the P losses from the plots receiving low-water soluble fertilisers were in the range 1.6 to 2.2 kg P/ha.

In terms of Total P losses (i.e. incidental and systematic) there are two other facts which must be considered: Figure 4 shows the likely effects of slope (topography) and soil P status on Total P loss as predicted by Overseer. Logically, the greater the slope and the higher the soil P status, (Olsen P), the more Total P runoff (incidental + systematic) will occur.

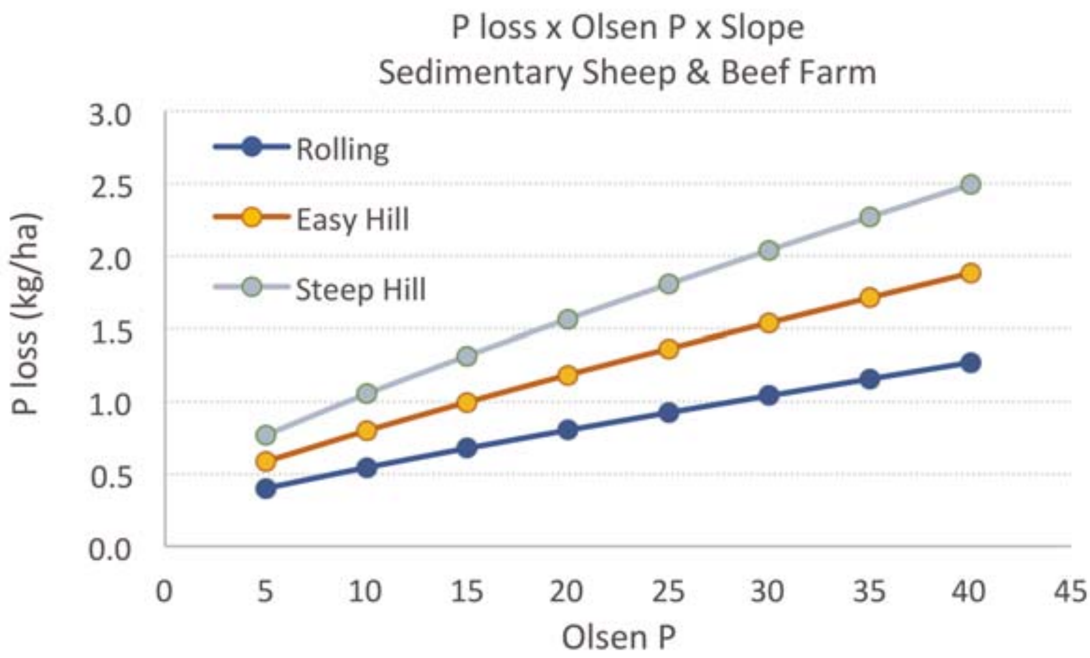

Figure 4. The effect of soil P status and slope on Total P loss (kg P/ha/yr) (incidental and systematic).

What does this all mean in practice? The worst-case scenario arises when applying water-soluble fertiliser, like super, triple super and DAP, on easy to steep land, on sedimentary soils (lower P retention) and soils with high hydrophobicity, and sufficient rainfall occurs within 20 odd days of application to cause surface runoff.

It is in these situations that using a product like SurePhos should be considered, noting that other companies, apart from Ballance Agri-Nutrients, sell low water-soluble fertiliser such a Replenish90 (Terra Care) and Dicalcic P (Hautuma) and Dical 8 (Fertco).

Costs & Benefits

Consider a typical Hill Country operation. Assume that a maintenance fertiliser is required to maintain the soil P and S nutrient levels and that this is achieved with the application of superphosphate at 300 kg/ha/yr (i.e. supplying 27 units of P and 32 units of S). Super costs about $315/tonne ex works, so allowing $100/tonne for transport and spreading, the on-ground cost is $125/ha.

SurePhos contains less P and S than super, so to achieve nutrient parity, 350 kg SurePhos/ha would be required. At an ex-works cost $330/tonne, the on-ground cost would be $151/ha.

Thus, the cost of changing from a water-soluble P fertiliser to less soluble form of P fertiliser is $26/ha. What are the benefits?

We know from past research that the P in ‘reverted’ products like SurePhos is agronomically equivalent to the P in soluble P fertilisers (Fertiliser Review 3). No benefit there. Similarly, there are no long-term environmental benefits. Switching to a less soluble P fertiliser does not reduce the Total P loss – it only affects the proportion of Runoff derived from incidental P.

Total losses of P in runoff are between 0.5 to 2.0 kg P/ha, as already noted. Currently the cheapest P on the market costs about $2.68/kg P. Thus the 'value' of the P lost in runoff is $1.34 to $5.36/ha/yr. Thus, the financial return from spending an additional $22/ha is not great.

So, is there any value proposition in products like SurePhos? I believe there is and it is all wrapped up in the politics and marketing of the 'Clean Green' image, both nationally and internationally.

Ballance Agri-Nutrients Ltd can repeat to the politicians what they say in their marketing -. SurePhos reduces P runoff by up to 75% and hence advance their green credentials accordingly. Explanations and qualifications may not be required. So too, the exporters of New Zealand's agricultural products will claim, '……all our farmers apply BMP including the use of environmentally safe, low-solubility P fertiliser' that enhance water quality. The logic is that this type of marketing will leverage maximum product prices and hence optimize the returns to farmer. The 'value' in other words lies in the advertising not the underlying science[1].

[[1] This same logic applies to Ballance's product SustaiN – urea treated with the chemical agrotain. Its marketing is based around the claim that the addition of agrotain reduces volatilization of N from urea by up to 50%. There is evidence to support this BUT what is not said is that 50% refers to a little number. In absolute terms the amount of volatilisation of N from urea, when applied at low rates (20-30 kg N/ha) during the growing season (spring and autumn) represents about 0-5% of the N applied (Fertiliser Review 32). The impressive large effects when expressed on a percentage basis, evaporate when the claim is considered in absolute terms].

NEW PRODUCT: TRIPLEPLUS

When it comes to fertiliser, superphosphate has been our traditional 'work-horse.' It contains both phosphorus (P) and sulphur (S) which historically was all that was required, initially at least, on most New Zealand soils, and especially on the pre-dominant sedimentary soils.

Super's pre-eminent position has been challenged over the years. In the mid 1980 Reactive Phosphate Rocks (RPR) became fashionable – they were cheaper than super on a total P basis, and the P was, at that time in our understanding, regarded as being agronomically equivalent to the P in soluble fertilisers. We now know after considerable research that this is not the case – the best RPRs dissolve at about 30% per year.

Table 4. Total phosphorous (P) and sulphur (S) content, cost (ex-works) and cost per kilogram available P for a selection of phosphorous fertilisers.

Product	Total P content (%)	Total S content (%)	Cost ($/tonne)	Cost ($/kg plant available P)[3]
Superphosphate	9.0	10.5	315[1]	2.79[4]
Surephos	7.8	9.5	330[1]	3.49[4]
TriplepluS	17.8	11	610[2]	3.02[4]
Reactive phosphate rock	13.1	0	265[1]	6.54[5]
Triple super	19	0	690[1]	3.36
DAP	20.5	0	785[1]	2.84[6]

Notes:
1) cost ex works Ballance Agri-Nutrients Ltd.
2) cost ex store Waharoa. Marsden Agri Ltd.
3) cost per kg plant available P assuming that the total P is plant available in all products except Reactive Phosphate Rock where it is assumed that only 30% is plant available in the year of application.
4) assuming that the sulphur component is worth $0.61/kg S. Ballance Agri-Nutrients Ltd.
5) assuming that the sulphur component is worth $0.66/kg. Marsden Agri Ltd.
6) assuming that the nitrogen component (17.6%) is worth $1.23/kg N.

From time to time, depending on international markets, products like Triple super and DAP become cost effective sources of P relative to super. That is not the case today (Table 4). The attraction of both of these products is that they are high analysis (Table 4) which means the transport and spreading component of the full on-ground costs are lower. This considerable advantage however is offset by the fact that they do not contain the S, a vital input into most soils in New Zealand. Sulphur must be added to Triple super, DAP and indeed RPRs. This reduces their marketing appeal – extra cost plus the fact that many of the elemental S products are too coarse for New Zealand conditions (see Fertiliser Review No. 33).

For these reasons, I am interested in a new product being produced in Australia. The manufacturers have been able to incorporate S into Triple super. The S is not coated onto the product – that's been tried and failed in the past – but is incorporated evenly in each granule during manufacture. The detailed specifications of this product, marketed as 'TriplepluS,' are set out in Table 5.

Table 5. Phosphorous (P) and sulphur (S) content of TriplepluS.

Phosphorous		Sulphur		
Total (%)	Water soluble (% of total)	Total S (%)	Sulphate S (% of total)	Elemental (% of total)[1]
17.8	80	11	18	82

Notes: 1) 90% of the elemental S is < 125 micron

Most of the S in TriplepluS is in a fine elemental S form (90% < 125 micron). This is very fine relative the most of the elemental products available in New Zealand and it is predictable, based on known science (Fertiliser Review 33), that all of the elemental S in this product will be oxidised and become plant available in the year of application. By way of comparison only 34% of the elemental S in SulphurGainPure, Ballance's elemental S product, is < 150 microns and only about 70% of the total elemental S is plant available in the year of application.

Cost Comparison

The data in Table 6 compares the on-ground cost of a number of fertiliser and fertiliser mixes when applied by plane.

Table 6. A comparison of the on-ground cost of a number of fertiliser and fertiliser mixes containing phosphorus (P) and sulphur (S).

Product	Rate	Nutrients applied (kg/ha)			Cost ($/tonne)	Cost ($/ha on ground)[1]
		P	K	S		
Superphosphate	300	27	0	32	315[2]	125
Special Mix 1 (80% Triple super + 20% SulphurGainPure elemental S[4])	178	27	0	32	668[2]	137
TriplepluS[5]	150	27	0	17	610[3]	107
Special Mix 1 (90% TriplepluS[5] + 10% brimstone S90 elemental S[5])	166	27	0	32	616[3]	120

Notes:
1) assuming that transport and spreading costs are $100/tonne (aerial application) for all the products. In fact this will favour the high analysis products.
2) ex works Ballance AgriNutrients Ltd
3) ex store Waharoa, Marsden Agri Ltd
4) only 66% to the total S is plant available in the year of application (see Fertiliser Review 33)
5) assuming that all the elemental S in TriplepluS and brimstone S90 very fine and is plant available in the year of application (see Table 5).

Straight TriplepluS is the cheapest option but it only applies half the amount of S as the other options. This may not be a problem on soils with adequate S status i.e. soils with an Organic S test level >10-12. Adding some elemental S (as brimstone) to the TriplepluS to provide the same S input as the other products adds further cost but it is still a cheaper option relative to using either Super or a Triple Super mix.

What makes this comparison more complex is that Super and Triple super, purchased from the Co-Ops, attract a rebate (possibly $40-$50/tonne) and that this is further confounded by the fact that, in turn, this rebate is treated as taxable income.

My Advice

This product ticks all the boxes agronomically. Its commercial success will depend on the ability of farmers to negotiate a deal and their tax position.