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PASTURE SULPHUR REQUIREMENTS

It started over a decade ago while I was National Science Leader (Soils and Fertiliser) at Ruakura. I insisted that before another sulphur (S) fertiliser trial was approved we must first summarise all the past research. This was done, not just for S, but for phosphorous (P) also. The results from literally thousands of field trials from throughout New Zealand were summarised and put onto a data-base.

I mention this because, now, some 10 years latter, my colleagues, Dr Ants Roberts (now of Ravensdown) and Dr Bruce Thorrold (now at Dexcel), and I, have just had accepted for publication a scientific paper reviewing all this information on S. It is a long review and so I will summarise the key findings in 2 issues of the Fertiliser Review. In this issue we will deal with the questions: how much S and when, should application be split and what about the form of S?

How much S is required?

Looking only at those trials that measured pasture production at several fertiliser S rates, we can determine the amount of S required to reach maximum pasture production. It turns out that 2 groups of soils could be identified (Table 1). The pumice soils, podzols (highly weathered soils) and peats, together with some coarse textured recent soils in the South Island required about 40-50 kg S/ha/yr to achieve maximum production. This is the amount of S required to overcome the most server S deficiencies. For all other soils 20-25 kg S/ha/yr is sufficient to achieve maximum production.

Table 1. The amounts of fertiliser S required for maximum produciton

Soil category	Soil groups	Typical properties	Fertiliser S required for maximum production
High loss	Pumice, Peats, Podzols, Sth Island recent soils	Low ASC (<60), high rainfall (> 1500 mm), coarse texture, low organic S	40-50 kg S/ha/yr
Low loss	All others eg Sedimentary, volcanic,	ASC > 60, lower rainfall (< 1500mm). high soil organic S	20-25 kg S/ha/yr

What I have called High Loss soils are those under high rainfall (> 1500mm) with little ability to hold S (ie low Anion Storage Capacity). They typically have low organic S levels and are often coarse textured. All of these conditions mean that S is more susceptible to leaching on high loss soils relative to low loss soils. Higher S inputs are therefore required.

Is the time of application of fertiliser S important?

Many trials have compared the effect of timing of fertiliser S applications (ie the same amount of S applied either in spring or autumn) on pasture responses and production on S deficient soils (Table 2).

Table 2. Effect of timing of fertiliser S applications

Form of S	Trials	Number	Annual response (%)	
			Autumn applied	Spring applied
Sulphate	All trials	17	21	21
	Pumice soils	7	23	24
	Other NI	4	8	8
	Sth Island	6	28	27
Mixtures[1]	All trials	32	46	50
Elemental	All trials	8	12	12

Notes: 1) 55% sulphate S: 45% elemental S
2) all on free-draining soils

These results seem to say that on soils that are S deficient, it does not really matter if the fertiliser S is applied in spring or autumn - the size of the responses are about the same.

Single versus split applications?

Is it better to split fertiliser S applications?

Once again there have been trials conducted in which all the fertiliser S was applied in a single application compared with the same amount of S applied in split applications, spring and autumn. The key information is summarised on the following page (Table 3).

Table 3. The effect of single or split applications of fertiliser S

Trials	Number	Annual response (%)	
		Single application	Split application
All trials	21	42	45
Pumice soils	9	25	27
Peat soils	2	165	193
South Island	9	34	35

For peat soils, and to a much lesser extent, Pumice soils, there is an advantage in splitting applications. It can be assumed that this occurs because peat soils have a low anion storage capacity and that sulphate is therefore more readily leached. But aside from these soil groups, splitting the applications of fertiliser S has no overall benefit.

Is Elemental S better than Sulphate S?

It depends. Let me explain. Plants cannot make use of elemental S unless it is oxidised to plant available sulphate S. This is a biological process performed by specialised bugs in the soil called thiobaccillus, And it takes time. The major factors affecting the rate of conversion of elemental S to plant available S are the particle size (this determines the surface area exposed to the bugs) and the temperature and moisture.

To fully oxidise and become plant available in the year of application elemental S needs to be finer than 250 micron in the warm, moist upper North Island and less than 75 microns in the cool south. And herein lies a problem - not many elemental S products meet this specification. I recommend that you ask your supplier to give you a particle size analysis of his product(s).

On the positive side, because elemental S is a slow release product it does have advantages, relative to sulphate S, in some situations. These include:

1. Where fertiliser is applied infrequently: In the High Country in the South Island fertiliser is typically applied once every second or third year. Trial results show that elemental S is better than sulphate S in these circumstances.

2. On High Loss soils (see Table 1): on these soils sulphate S can be more readily leached, adding some of the annual S requirement in an elemental form may be an advantage.

For all other soils and situations sulphate S is as effective as elemental S providing the latter is sufficiently fine to completely oxidise in the year of application.

Final thoughts

When I was learning my trade back in the days when superphosphate was virtually the only fertiliser available, the rule of thumb for S was: if you are applying sufficient super to meet the pasture P requirement then you will be automatically supplying sufficient S - super we all know contains both these nutrients. The data says that it still holds true for most New Zealand pastoral soils. The exceptions are the High Loss soils and the High Country soils. On high loss soils an elemental S fortified product is required and in the High Country a slow release product is an advantage.

But do not sweat the small stuff. S is very cheap ($0.40/kg) relative to P ($1.50/kg). So I'm inclined to the view expressed by our old mentor Dr Allan Sinclair. S deficiencies should be sought (get the soil auger out), found (sample those transects) and destroyed (put that S fertiliser on). No point in limiting the effect of the expensive nutrients like P by going shy on the cheapest!

LIME-FLO: LIQUID LIME

A number of companies are offering liquid lime products, or more correctly, slurried ground limestone products. Prominent among them is the Mainland Mineral's product 'LIME-FLO'. It is reasonable to ask: what is LIME-FLO, what does it do and how much does it cost?

Claims

From Mainland Mineral's literature and advertising LIME-FLO is very finely ground calcium carbonate (5-20 microns) in a slurry, to which can be added, depending on the specific farm, sulphur, salt and trace elements and soil bio-stimulants. It can be applied at rates of 70-200 kg/ha.

The company advertising claims that LIME-FLO is "an exceptional product and one of the best ways to increase livestock productivity on Hill Country". Specifically, it is claimed that LIME-FLO will:

- Increase soil Ca levels
- Improve soil structure
- Boost soil biological activity
- Increase pasture palatability.

Why Use LIME-FLO?

The company literature emphasises the importance of Ca in the soil-plant-animal system and states, "Without adequate calcium levels, soil is a poorer medium for producing sufficient pasture of quality and quantity. Lime is essential for optimum production in Hill Country but conventional liming is often neither practical nor affordable." And, "Using the technology of fine ground, high analysis limestone applied in suspension, excellent results are achieved rapidly and affordably". LIME-FLO it is claimed "is the best and most cost effective way of giving hill country a production boost that lasts."

In correspondence from Mainland Minerals, it is claimed that 25 kg LIME-FLO was equivalent to 2500 kg of agricultural ground limestone. This arose, it is claimed, because LIME-FLO is 100 times finer and therefore dissolves 100 times faster.

How valid are these claims?

The Importance of Calcium?

Mainland Minerals are correct in stating that Ca is a very important nutrient. If deficiency it would limit pasture production and quality

and impact on animal health. However, Ca deficiency in New Zealand soils, plant and animals is unheard of (Hypocalcaemia in our dairy herd is not related to low soil and plant Ca levels. Rather it is a hormonal imbalance problem). Indeed, if we have a problem with Ca it is a problem of too much. This arises because New Zealand soils are young (not very leached) and we have a long history of using both superphosphate (20% Ca) and limestone (40% Ca).

Why then do we use lime in New Zealand? The active ingredient in lime, on our Ca sufficient soils, is not the Ca but the carbonate. The carbonate neutralises the soil acidity and causes the soil pH to increase. It is from this reaction in the soil that all the benefits of liming arise, including increasing pasture production and quality, improved soil biological activity and in some cases better soil structure. The greater the change in soil pH (up to a limit of 5.8-6.0 for pastures) the greater the benefits.

As a rule of thumb 1000 kg/ha limestone increases the soil pH by 0.1 pH units. Thus, it is predicable that an application of LIME-FLO at 70 - 200 kg/ha will increase the soil pH by about 0.01 to 0.02 pH units. To claim therefore that a small amount of LIME-FLO (eg 25 kg/ha) has the same effect as 2500 kg limestone/ha therefore defies the laws of chemistry.

Does finer equal better?

It is generally true that for sparingly soluble materials, such as lime, the finer they are the faster they react with the soil. LIME-FLO, if the advertising is to be believed, is very fine (5-20 microns) relative to ground limestone (typically 95% < 1000 micron and 50% < 500 microns). Thus, it is predicable that LIME-FLO will dissolve faster (react more quickly) than ground limestone, possibly as claimed by 100 times.

However, we must not confuse the speed of reaction with the size of the reaction. Relative to applying 2500 kg limestone/ha, 25 kg/ha LIME-FLO will apply 100 times less Ca and carbonate. Sure, it will dissolve more quickly but it will have 100 times less effect on the soil Ca and pH levels, as discussed above. So finer is better only when the same amounts of lime are applied, which is clearly not the case with LIME-FLO.

Evenness of Spreading?

The company literature extols the benefits of the evenness of spreading and I think it is probably true that applying nutrients in a slurry-form results in a more even spread. However, in the case of LIME-FLO, it is only a more even spread of about 100 times less product! In any case, in the hill country environment this may be irrelevant. Nutrients and acidity are continually transferred in these situations from the mid-slope areas to the stock camps on the ridges and valleys. It could be argued that even spreading is a disadvantage agronomically in these circumstances. In any case, as has been discussed elsewhere (The Fertiliser Review No 3) the type of fertiliser (solubility) and form (liquid, slurry or solid) has very little effect on the agronomic performance of fertilisers. This conclusion can logically be applied to lime also.

The Additives?

The company literature says that trace elements and soil bio-stimulants can be added with LIME-FLO. But we recommend caution. Certainly some trace elements are required in some situation such as Mo, Co, Se and Cu. But indiscriminate use of trace elements is not recommended (see The Fertiliser Review No 7). It is unlikely however that the inclusion of these could account for the cost of LIME-FLO (see latter). Also as discussed elsewhere (The Fertiliser Review No 8) the value of soil bio-stimulants is also debatable.

Costs?

The table below sets out the costs of applying LIME-FLO, at 2 rates, compared with applying the same amount of ground limestone. Note that this comparison is made on the basis of the cost of the ingredients plus the application costs (ie exclusive of freight) because this appears to be the basis on which Mainland Minerals quote their products.

LIME-FLO, it appears, is more expensive relative to applying the same amount of lime as ground limestone by a factor of between 6-15. Looked at differently, if the standard cost of spreading is deducted from the prices given by Mainland Minerals then the cost of the lime and the other components in LIME-FLO is between $650 to $750 per tonne compared with ground limestone at $15-$20/tonne. Can this additional expense be justified?

This article was sent to Mainland Minerals for their comment prior to publication. They suggested the qualifications as given in Note 1 above and that the cost of "finely ground marble limestone" used above is not accurate and [it] "is not procurable at the price you stated". This appears to suggest that we have underestimated the cost of LIME-FLO. However, Mainland Minerals failed to respond to our request for more accurate figures and hence we have used the costings given to us originally by the company. Mainland Minerals also suggested that the article ignored the "negative costs associated with bulk liming", presumably arising from uneven application of bulk lime. In fact, this issue is covered in the article under the paragraph, "Evenness of Spreading" (see above).

Rate of application	Type of application	Indicative on-ground cost ($/ha) (excl transport and GST)	
		Lime-Flo[1]	Ground limestone
70 kg/ha	Ground spread	55	9[2]
	Aerial	67	6[3]
200 kg/ha	Ground spread	101	11[2]
	Aerial	172	11[3]

Notes:
1) As quoted by Mainland Minerals for a 40 ha job and assuming that the aerial application is by helicopter, noting that they offer a discount based on the size of the job and that fixed-wing application may be cheaper.
2) Assuming limestone at $18/tonne and ground spreading at $7.50/ha as quoted by Te Awamutu Bulk Spread Ltd
3) Assuming limestone at $18/tonne and spreading at $65/tonne (at an application rate of 70 kg ha) and $37.5/tonne at 200 kg/ha, as quoted by Taumaranui Co-op Ltd

Conclusions

In my opinion many of the claims made for LIME-FLO are not justified simply on the basis that insufficient Ca, and in particular carbonate, is applied per hectare, when the product is used as recommended. In any case, the same result could predictably be achieved, albeit more slowly, by applying the same small rates (70 - 200 kg/ha) of ground limestone, at a fraction of the cost.

Finally, it just may be possible that LIME-FLO could have effects on pasture palatability and animal health by sticking onto the leaves of plants and subsequently being ingested by animals. This is similar to the addition of lime to animal feedstuffs. But this has not yet been tested, and in any case, does it justify the margin charged for LIME-FLO?

My Advice? Not the product for the farmer wishing to optimise the return on his fertiliser dollar.

SECHURA RPR

A farmer from the Wairarapa called me recently. He had received a visit from the Sechura RPR salesman who made several claims about the product that he wanted to 'run past me'.

How does it compare on a cost basis?

The farmer was quoted a price of $235/tonne. Since Sechura contains about 13% P then this works out at $1.80 per kg P. Compared with superphosphate ($1.50/kg P) it is a more expensive form of P given today's prices. Note this comparison is based on the total P content. When you factor in fact that RPR P is slow release then this margin is larger.

Sechura RPR has a liming effect?

It is true that Sechura RPR has a liming effect. This arises because . technically correct but of little practical consequence. Sechura RPR does contain calcium carbonate (ie limestone) but the amount is small about 5-10%. Lets say you applied Sechura at 200 kg/ha/yr (ie 26 kg P/ha/yr) then the input of lime would be 10-20 kg/ha lime equivalent.

As a rule of thumb 1000 kg/ha lime will increase the soil pH by 0.1 pH unit so we can predict that the increase in pH from 200 kg/ha Sechura would be about 50 times less - about 0.002 pH units. And indeed that is similar to what has been measured in a number of field trials. Applications of 2 times maintenance for 6 years increased the soil pH by 0.05 pH units.

The point is this. The liming effect of this RPR is of little practical importance. You certainly should not postpone your normal liming program because you are using RPR.

Sechura RPR contains the trace element Molybdenum

This is also true, and what is more, there are sufficient amounts of Mo in this RPR to have practical effects in the field. Is this a good thing? Well that depends. If you are on a Mo deficient soil then yes it is a benefit, albeit and expensive one. But if you are having Cu deficiency problems on the farm then the extra Mo could be a curse. Far better in my view to get the necessary plant tests done and apply Mo as required.

Sechura RPR is good for Animal Health?

To the extent that Sechura RPR, like all fertilisers, increases pasture production, it is good for animal health - a well-feed animal is a healthy animal. The question is perhaps: is Sechura RPR unique in its beneficial effects on animal health? I am not aware of any evidence to support this claim. I do know that this claim is almost universal for proprietary fertilisers from liquid fertilisers to Fine Particle Fertilisers, to Dicalcic, to ground basalt rock. Hence I smell a rat: how come so many products, which claimed to work in different ways, all do the same thing!

My advice? Sechura is the best of the RPRs but even so, it cannot compete on known agronomic evidence, and today's prices, with super. And remember, in case you think I'm biased, I do not sell fertiliser products and do not set the fertiliser prices?

SOIL TESTING: WHICH LABORATORY?

I am frequently asked, which is the best laboratory for soil and plant testing? It is one of those FAQ's, for those of you who read websites. So to save you all time here is my opinion.

There are three major laboratories in New Zealand in terms of soil Testing. I am deliberately not including the minor players such as Quantum Laboratories (Waipawa) and some American labs who operate in New Zealand through local agents. These labs in my opinion should be avoided at all costs (see The Fertiliser Review No X for the reasons).

The three biggies are:

RJ Hills Laboratories (Hamilton), (privately owned)

eLab Ltd (Hamilton) (formerly the Ruakura Soil and Plant Testing Laboratory and now owned by Gribbles Ltd)

ARL Ltd (Hastings) owned by Ravensdown Fertiliser Cooperative Ltd.

All three laboratories provide the basic soil test, as we will discuss latter, for much the same price. They do offer discount-for-volume deals to Consultants but you, the farmer, will only get this discount if your Consultant passes it on to you. Also note that if you are a Ravensdown shareholder you can get a much better deal through ARL.

Because the labs are price neutral they compete on service, which can be defined as turn-around-time (how long before I get my results?), ease of use (courier packs, simple forms), personal service (backup, queries etc), and loyalty (discount for volume).

They also compete by offering other tests, in addition to the basic tests. It is this aspect that differentiates the laboratories. It also, unfortunately, is the cause of much confusion, especially for farmers trying to make sense of their results.

To unravel this we must go back to some basic principles.

There are two types of soil tests (Table 1.). What I have called Type One, measure soil properties which are not directly related to soil productivity but nevertheless impact on soil fertiliser advice. This group includes the tests that measure the ability of a soil to hold nutrient such as Ca, Mg, K and Na (the cation storage capacity, CSC) and nutrient such P and S (the anion storage capacity, ACS). Soil organic matter, soil organic S and bulk density are other examples. These soil properties are either not affected by fertiliser inputs or do not change much over time and therefore are normally done on a one-off basis.

Table 1. Types of soil tests

Type One	Type Two
Anion storage capacity (ASC)	pH
Cation storage capacity (CSC)	Olsen P, Resin P
Bulk density	MAF Quick test (QT) K, Ca, Mg, Na
Organic matter	Sulphate S
Reserve K	Organic S
Available Al	

The Type 2 tests are the really important ones because they measure the amounts of nutrients in the soil and should relate to soil productivity. To be useful these tests must be calibrated. By this I mean that field trials are undertaken to determine the relationship between the test and some other property, generally plant production (Fig 1), but it might also be the nutrient concentration in the plant or some factor related to animal health. Once the relationship has been defined the test has diagnostic value - a given test value can interpreted in relation to plant or animal production. Without this calibration the soil test has limited value.

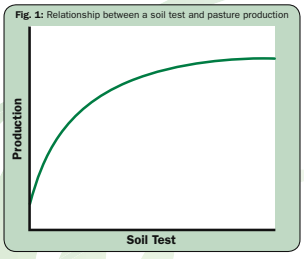

Fig. 1: Relationship between a soil test and pasture production

Obviously the calibration needs to be carried out for all the situations (ie soil groups, climate, crop type etc) for which the test is to be used. This has been done for some, but not all, tests and so we can draw up a list of soil tests used in New Zealand which have been calibrated and the extent of the calibration (Table 2).

The better the relationship the more accurate the test. For example, literally hundreds of trials have been conducted in New Zealand to determine the relationship between pasture production and various soil P tests. It just happens that the Olsen P test gives the best relationships with pasture production in our New Zealand circumstances. The resin P test, by contrast has only been calibrated on 6 sites and for only one RPR. It calibration and hence interpretation is therefore limited.

Table 2. Soil tests and their calibration

Soil Test	Calibration	Soil Test	Calibration
pH	Yes	QT Ca	Limited
Olsen P	Yes	QT Na	Limited
QT K	Yes	Reserve K	Limited
QT Mg	Yes	Available Al	Limited
Sulphate S	Yes	Resin P	Limited
Organic S	Yes	Available Co	Limited

If these were the only soil tests reported in New Zealand things would be less confusing, but alas, some labs report a bunch of other soil test results. Including:

1. The MAF QT results are sometimes reported as me% (called millequivalents per 100 gm soil), a now outdated soil chemistry term which only causes confusion for farmers.
2. The MAF QT results are sometimes reported as % base saturation. Science has shown that such results can be misleading when used a basis for fertiliser advice.
3. Extractable trace elements including Co, Cu, Zn, Mn, Fe etc of which only the Co test is calibrated to any extent.
4. Soil volume weight, which has very little interpretative value in the field.

Is it any wonder that farmers are confused when they get their results back from the lab?

I have challenged the offending laboratories on these issues and the response is along these lines: We are an analytical laboratory and we do not interpret the results. We are just providing our clients with the tests they want. In my view this is irresponsible. I accept that labs need to service their clients needs but does this extend to selling them results that are confusing at best and misleading at worst. I think it is time for a shake up in this industry.

My advice? In the table below I have listed the various soil tests in terms of what I have defined as their usefulness.

So stick to the basics when it comes to soil testing. Use the lab that will give you the best deal on the essential tests and if needed the one-off tests. Ignore everything else.

Table 3: Soil tests and their relative usefulness

Usefulness	Test
Essential (measure frequently ie every 1-2 years).	Soil pH, Olsen P, QT (Ca, Mg, K and Na), sulphate S, organic S,
Useful (one off measurements)	ASC, CSC, reserve K (sedimentary soils only), available Al (if soil pH < 5.5), soil Co
Of no or limited value	Volume weight, Ca, Mg, K and Na saturation ratios, resin P, trace elements (except Co)

TNM™

"Total Nutrient Management"

Update

In The Fertiliser Review No 10 we briefly introduced our new Total Nutrient Management (TMN) service. This issue of The Fertiliser Review contains a flier to tell you more about this service - what it is and how it can be of benefit to you.

To date we have processed 40 farms through the system, 20 dairy farms and 20 sheep and beef farms. The feedback has been excellent and the enclosed flier contains comments from some of these farmers.

Our findings to date are as follows:

For the dairy farms the average saving in fertiliser expenditure is about $20,000. This is without compromising any production goals. These savings come from 3 areas:

a) farming at and not above the economic optimal soil nutrient levels (ie the nutrient levels which optimise profitability in the long term)

b) fully utilising the nutrient value of the dairy shed effluent

c) choosing the least-cost fertiliser to match nutrient requirements.

The benefits are slightly different for the sheep and beef farms. First, there is no dairy shed effluent. Second, it appears that most sheep and beef farmers are currently operating at soil nutrient levels below the economic optimal. In other words there is opportunity for many sheep and beef farms to increase profitability by cranking up nutrient inputs now that the economic outlook is brighter. The benefits from choosing the most cost-effective products is however the same.

Introducing Mr Grey Smith

To meet the increasing demand for the TNM service, agKnowledge has retained the services of Mr Grey Smith (MAgSc) to service our TNM clients in the Southern North Island. Grey will be well known to many of you in this region. He was the MAF District Scientist (Soils and Fertiliser) in Palmerston North for 20 years and in this capacity conducting many fertiliser field trials all over the region. He then spent 11 years as a Technical Rep for Ravensdown Fertiliser Co-operative Ltd servicing the same region. Grey has a well-deserved reputation for thoroughness and integrity. He can be contacted on 06 3268075.

Environment Bay of Plenty (eBOP)

Most of you will know that the lakes in and around Rotorua are under threat. The primary problem is nutrient enrichment - nutrients getting into the lake from various sources including: geothermal activity, native and exotic forests, grasslands and urban activities (particularly from septic tanks and the Rotorua sewage scheme).

Not surprisingly farms and farmers are under scrutiny. For this reason eBOP asked agKnowledge Ltd to put 6 farms (3 dairy and 3 sheep and beef) adjacent to the lakes through the TNM process. The purpose of the exercise was to learn what management practices the farmers could implement to reduce nutrient loadings into the lakes.

Leaving aside the specific details the study identified several generic practices that if implemented, could help reduce nutrient loadings. These are generic and could be applied to any farm in any location. They are worth reflecting upon:

1. Developing a robust soil testing and monitoring program for the farm to follow changes in soil nutrient levels over time relative to fertiliser inputs.
2. Operating their farms at the economic optimal nutrient levels. These are farm specific and should be determined for each farm.
3. Treating dairy shed effluent as an important nutrient source and applying it to an appropriate area of land to optimise nutrient efficiency and minimise nutrient losses. The effluent area should be treated separately with respect to soil testing and monitoring, and fertiliser nutrients applied only if required.
4. Calculating a nutrient budget for the farm to calculate the rates of nitrate leaching and P runoff and examining management options to minimise these nutrient losses.
5. Undertaking cost-benefit analyses to determine which management practice(s) are most cost effective in terms of reducing nutrient loadings of N and P to waterways.

Optimise farm profitability

Make your fertiliser dollar go further

Decrease your farm's environmental footprint

Dr Doug Edmeades