agKnowledge
"The Independent Fertiliser Experts"

Spring
2018

Fertiliser Review

ISSUE 40

SMART PRODUCTS OR GOOD MARKETING?

Ballance AgriNutrients Ltd (Ballance) have been gloating over their success. The comment was made in relation to last year's annual report: "Even though revenue at $805m was 4% down on the year before and sales volumes dropped by 1%, the cooperative improved its performance (gross trading result increased from $22m to $56m)" because, the CEO explained **"farmers spent more on smart products"** (Emphasis added).

I wondered what that might mean? A look at their product list suggests little has changed. The base generic products; super, potash, urea, elemental S, serpentine super, and all the various mixes, appear to be the same. What is more prominent in their public offering is what might be called 'smart products', SustaiN and PhaSedN. Certainly Ballance has highlighted these two products in recent advertising.

Recall (Fertiliser Review 33, 37) SustaiN is urea treated with a chemical called Agrotain. This chemical slows the conversion of urea N to ammonium N and hence through to nitrate N. The weak point in this chemical chain is the ammonium N because under the appropriate conditions (warm and humid) some of this can be volatilized into ammonia gas.

SustaiN has the same N concentration as urea (46%). PhasedN is the result of combining SustaiN, fine elemental S and lime in a compacted granule. It contains 25% N as urea and 28% S mostly as elemental S.

At present (August 2018) urea costs $520[1]/tonne and a tonne contains 460 kg N. Thus the cost of the N is $1.13/kg. SustaiN costs $575/tonne or $1.25/kg N. After taking into account the value of the S, the N in PhasedN is $1.44/kg N.

Thus the N is SustaiN costs 10% more than the N in urea and the N in PhasedN is 27% more than urea N. Are these margins justified?

Ballance claims that the addition of Agrotain to urea reduces volatilization of ammonia N by 50%. This is probably true based on the evidence but care is required to interpret this claim.

At typical rates of application of N to pastures the amount of N lost from urea via volatilization is in the range 0-5% of the total amount of N applied. At an application rate of say 30 kg N/ha (65 kg urea/ha) up to 1.5 kg N/ha may be lost. The value of this lost N is about $1.69 or about 5% of the total cost of the urea applied (65 kg urea/ha).

Another way of looking at this is to compare the effects of urea and SustaiN on pasture production. I have assembled a data-base of international trials comparing urea and SustaiN (including mixes of urea plus Agrotain) on plant production. The average difference is about 2% +/- 1% (see Fertiliser Review No 34). This is consistent with N volatilisation losses of 0-5% of the total N applied.

Whichever approach is taken it seems like the 10% margin on SustaiN is excessive compared to the likely benefits. The calculation above assumes the worst-case scenario where urea is used as recommended on pastures i.e. at rates of 20-30 kg N/ha per application during autumn, winter and spring.

[1. as this goes to print, there have been price changes in these products but the marginal differences are approximately the same.]

There is however a case to be made for SustaiN when front-loading high rates of N (> 100 kg N/ha) on crops and especially in the summer.

Dealing now with PhaSedN. The N in this product costs about 30% more than the N in urea after taking into account the S, which it contains. Can this be justified? This product is recommended for use in the autumn-winter period. The advertising states: "Using PhaSedN should result in a more rapid and efficient supply of sulphate sulphur for plants than can be achieved with other products." This claim is questionable because the form of S in PhaSedN is elemental S, which is a slow release – it takes time for this to breakdown to the plant available. To claim that it is "…..a more rapid and efficient supply of sulphate sulphur for plants' is simply nonsense.

The advertising encourages farmers to use PhaSedN because "SustaiN reduces the amount of volatilization by half on average." But this product is specifically recommended for use in the late autumn and winter – the time of the year when ammonia volatilisation is minimal!

PhaSedN does contain some S as slow release elemental S and the claim is made that this "…offers significant benefits, as it provides the plant with a long-term source of sulphur…." But so do the products Sulphur Gain Pure or sulphur fortified super, so why buy a more expensive form of S (see Fertiliser Review 33).

Theoretically there appears to be no reason to indicate that the form of the nutrients N and S in PhaSedN are agronomically superior to other forms of comparable N and S fertilisers. The price margin of about 30% is in my view excessive.

My Advice?

SustaiN and PhaSedN may be examples of what the Ballance AgriNutrient's CEO refers to as **"smart products"**. If this is so then the smart part is in the advertising and marketing and hence their positive effect on the cooperative's balance sheet.

But creating problems that do not exist to any practical extent (e.g. volatilization) or claiming benefits which can be achieved using other cheaper products is not smart science. There is also an ethical question: is it sound business to make profits at your shareholders expense and then brag about it?

REGENERATIVE AGRICULTURE

Regenerative agriculture is becoming a new buzzword. Wikipedia defines it as follows:

> **Regenerative agriculture** (RA) is an approach to food and farming systems that rejects pesticides, artificial fertilizers and aims to regeneratetopsoil, increase biodiversity,[1] improve water cycles,[2] enhance ecosystem services, increase resilience to climate fluctuation and strengthen the health and vitality of farming and ranching communities.[3][4][5][6]
>
> Regenerative agriculture is based on applied research and thinking that integrates organic farming, permaculture, agroecology, agroforestry, restoration ecology, Keyline design and holistic management.
>
> On a regenerative farm biological production and ecological structure grow more complex over time. Yields increase while external inputs decrease.[7]

As a definition this is woefully inadequate because most of the components of RA mentioned in this definition require further definition and indeed some of them are so vague as to be meaningless.

It helps to consider what is definitively not RA. It is, we are told, more than organic farming, although it embraces some of it's principles, namely a rejection of agrichemicals including fertilisers. We are told that it is not industrial monoculture farming (i.e. continuous cropping).

So what is RA? Table 1 attempts to encapsulate all the key concepts that RA promotes. I have also added some commentary to put these concepts into a New Zealand context.

Table 1. Concepts promoted by Regenerative Agriculture

Concept	Comment
Rotational, planned, *in situ grazing*	This is the basis of New Zealand's pastoral agriculture
Closed system, minimizing exploitive practices and replacing what is removed.	All biological systems contain inefficiencies but our *in situ*, grazed, clover-based, pastoral system is as good as it gets in terms of efficient nutrient cycling.
Perennial crops/pastures	This is the basis of New Zealand's pastoral agriculture
Builds soil organic matter	As a consequence of our clover-based pastoral system the organic matter content in NZ soils are among the highest on the world: building organic matter is what we do.
Encourages biodiversity and riparian planting.	NZ farmers have been on this 'case' for some while now
Healthy – soils, plants and animals including humans	These goals are a given for most farmers

From this analysis New Zealand's pastoral system looks very much like RA in practice - and for the most part it has been for a long time. So why all this fuss about RA? Where does this idea come from and why is it being promoted in New Zealand?

From my reading, the concept of RA has evolved from ecosystems very different from our own. Think of the prairies of the USA, the steepes of Russia, the outback of Australia and pampas of South America. Historically these vast tracts of 'natural' grasslands were grazed intermittently by roaming herbivores. Typically they have low soil fertility and biological activity, low production and extremely poor feed quality. Initially they were not farmed in our modern sense of the word.

Over time civilization has encroached on these grasslands. Areas are now being used as rangelands or ranches. Grazing is not managed and although animal products are being removed, inputs of things like fertiliser are negligible – in short they are being exploited and hence depleted. Alternatively, where soil and climatic conditions are appropriate, and in some cases augmented with irrigation, these natural grasslands are being converted to cropping monocultures. We know from history that continuous cropping is exploitive, particular of nutrients and organic matter.

This is the context that has given birth to RA and it is totally understandable that there are some people who want to regenerate these degrading ecosystems. It is easy to understand why there is a movement called RA. Yes; if nutrients are removed in animal products they must be replaced. Yes; controlled grazing is preferable, for lots of reasons, relative to set stocking, a lesson NZ taught the pastoral world in the 1950s. Yes; protecting and enhancing soil organic matter is wise husbandry as are crop rotations especially with the inclusion of regenerative, N-adding legumes, whether as a crop or as a forage. And yes: making the nutrient cycles as tight as possible improves nutrient-use efficiency.

But: to impose RA on NZ pastoral farmers as some new, wise, progressive agricultural system suggests either a complete ignorance of our pastoral agricultural system or is the sign of someone seeking to create a new headline and/or to sell another form of quackery.

As my colleague Dr Robert McBride said: RA sounds like a new way of peddling the same old bullshit!

FINE PARTICLE APPLICATION (FPA) FERTILISERS

FPA fertilisers are made by fine grinding common fertilisers, such as granular urea or DAP, and dissolving them or suspending them in water. They are then applied to plant and/or soil as a spray.

I have written elsewhere in the Fertiliser Review (Fertiliser Review 5, 35, 37, 38) about these types of products. Based on the evidence available to me such products are not more efficient or effective than the granulated fertilisers from which they are mostly derived. Furthermore given their cost and composition, they are a very expensive way of applying nutrients to the farm.

It has been suggested that FPA fertilisers are more effective because applying nutrients, and in particular N, as liquid or in suspension 1) provides better coverage and hence more even distribution of fertiliser nutrient and that 2) foliar uptake is more efficient/effective than uptake via the roots. There is little evidence in my opinion to support these claims

I am pleased to say that other scientists in New Zealand have reached the same conclusion. A colleague, Mr Jeff Morton, has recently published a review (Morton et al 2108, NZ Journal of Agriculture Research) of the agronomic research on these types of products. They summarized data from 22 trials in New Zealand and concluded that:

"…there was insufficient experimental evidence to recommend the use of FPA fertilisers over the standard granular form of application"

I would express the conclusion more directly: Research to date shows that FPA fertilisers are not more efficient or effective than granular fertilisers.

Promotion

This conclusion makes the claims offered by those who promote FPA look rather forlorn. Mainland Minerals claim:

"Fine particles of fertiliser ensure even plant uptake through the soil leading to improved dry matter quantity and quality. Applied by truck, aeroplane or helicopter."

Similarly, in an advertisement promoting Tow and Fert it is claimed:

Liquid foliar application of fertilisers is the only way you can reduce costs, improve profitability, look after the environment and grow better grass.

My advice?

For the farmers: If your concern is to get the best bang for buck from your fertiliser dollar then FPA fertiliser is not for you.

For the companies: I recommend that they carefully read the Morton et al (2018) paper in the context of the Fair Trading Act!

UREA AND SUSTAIN DECREASES PASTURE PRODUCTION?

In the last Fertiliser Review (No 39) I drew attention to field trial data which showed that urea and SustaiN (see earlier article in this edition) can and do depress pasture production, given time. A single application of urea or SustaiN initially increases total pasture production but after several harvests (a few months) total production decreases. The size of the depression is proportional to the rate of application. This effect is not apparent with a controlled release form of urea, Smartfert.

I was surprised by the lack of comment and feedback on this, what I thought was, an important result. Afterall New Zealand farmers use a lot urea, and one assumes, its derivative product SustaiN.

Subsequently a report summarizing data from two recent field trials on peat soils conducted by AgResearch (Dr G Lucci *pers com*) has come to my attention. These results reinforce the point (Figure 1). Initially (cut 1, following the application of urea) both sites were very responsive to N but, given time (cut 3), total pasture production declined with increasing rates of N applied.

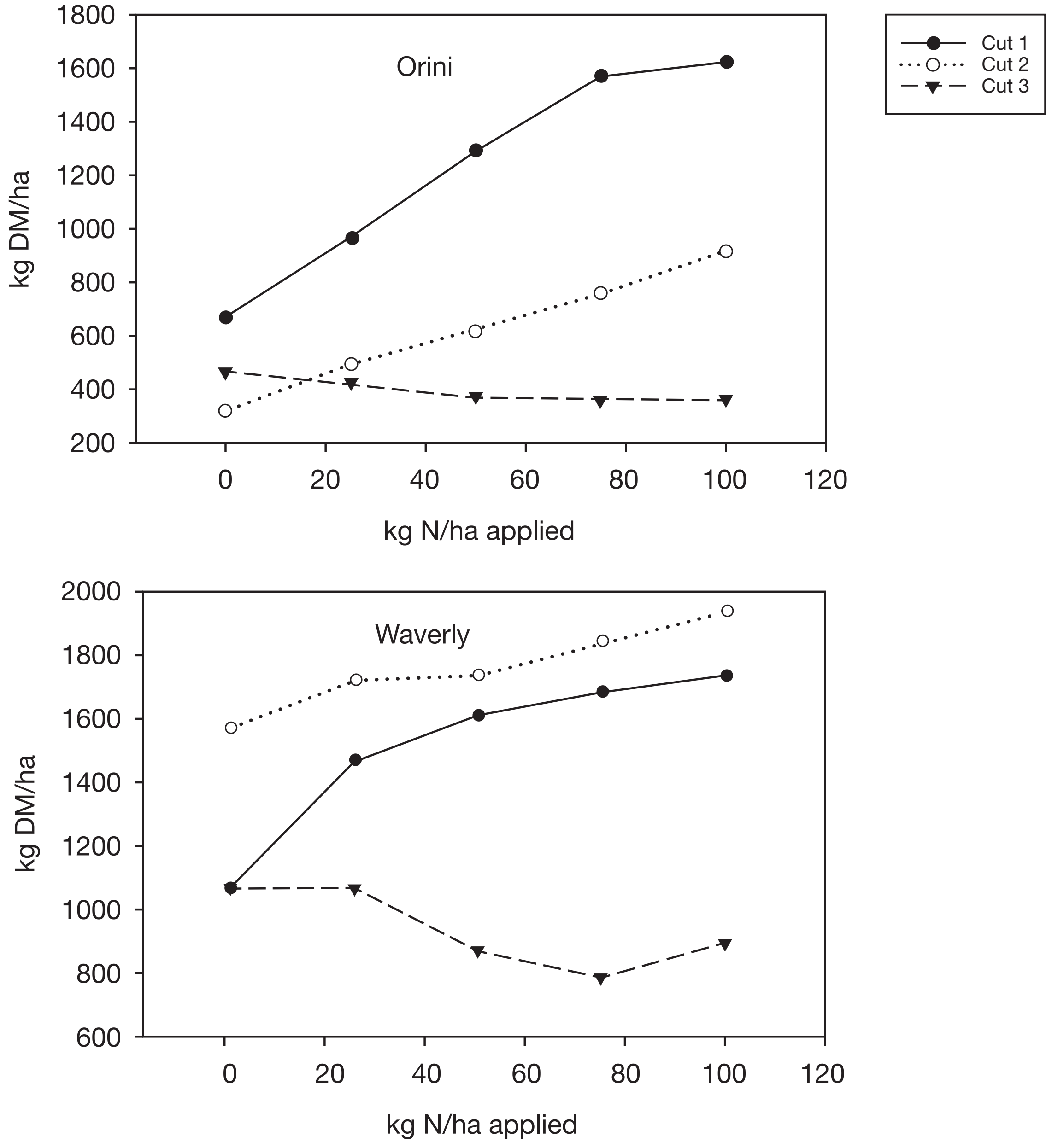


Figure 1 The effect of urea N on pasture production over time at two sites on peat soils.

It is believed that this depressive effect of soluble N products like urea and SustaiN is because they depress the growth of the clover component of the pasture at the expense of the grasses. When the initially positive effect of fertiliser N on the grass runs out the total pasture production (grass plus clover) is less than it was initially (before the N was applied) and hence the overall depression in production.

In practice farmers who apply N fertiliser regularly (e.g. after every grazing) will not 'see' this effect because it will be masked by the boost in production from subsequent fertiliser N application.

I do wonder however about the farmer who applies N as a one-off during the season. If fertiliser N is applied going into the spring or autumn flush then, once again, is it possible that this depressive effect will be covered up by the natural flush of new pasture due to the improving growth conditions?

Then again is it as some farmers report; if you start using urea you have to keep going otherwise you go backwards? I wonder?

LIME

It is a perennial question: Lime or fertiliser – which is more important? What is the priority? Are there some decision rules?

The relationships between soil pH and the predicted annual pasture response to lime at three rates of application are shown in Figure 2. This is based on the results from lots of field trials. If the initial soil pH (i.e. the soil pH prior to liming) is about 5.0 the likely pasture response to 2.5 tonne/ha of lime is about 10%. If the initial soil pH is 5.5, the response is about 5.0%, and applying lime to soils with pH levels in the range 5.8-6.0 has no additional effect on pasture production. This is of course why we say that the optimal soil pH for clover-based pastures in 5.8-6.0.

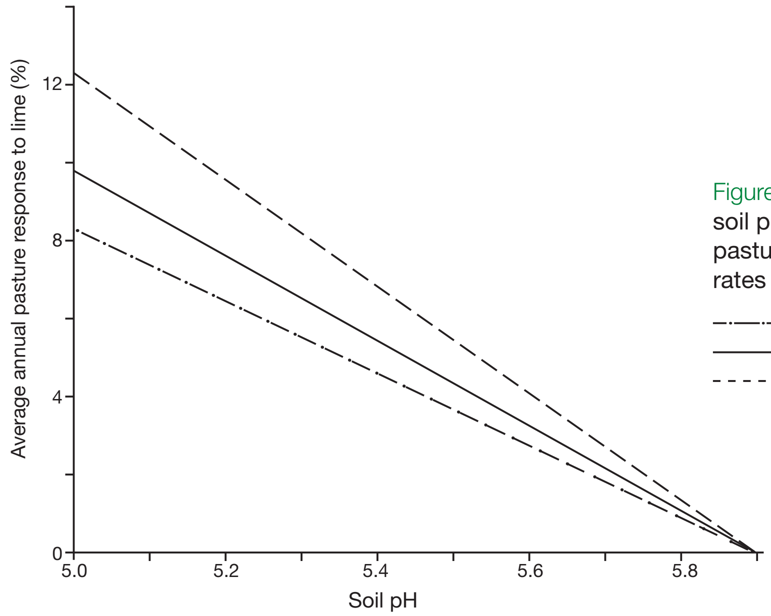


Figure 2 Relationships between soil pH and average annual pasture response (%) to lime at 3 rates of application:

- ·–·–·– 1.25 t/ha;
- ——— 2.5 t/ha;
- - - - - 5 t/ha.

Thus, the maximum benefit from liming soils in terms of the increase in pasture growth, for soils in the pH range of 5.0-5.5, is in the range of 5-10%. In comparison the pasture responses that can arise from correcting nutrient deficiencies, of say P, K, S or Mo, are of the order of 10-40%.

Thus, the first rule of thumb; correcting nutrient deficiencies (i.e. applying fertilisers) has a higher priority than liming because the return on the investment is always greater.

Once the nutrient tanks are full and the soil fertility is optimised (i.e. all the soil tests are in the optimal range) then liming can be considered.

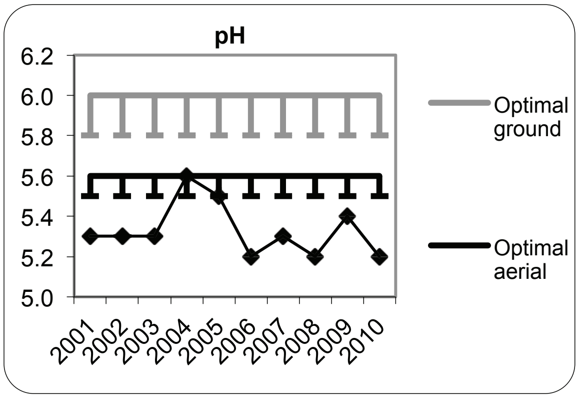
Given current cost and prices it is always economic to lime to the biological optimal soil pH range (5.8-6.0) where lime can be ground-spread. This arises because, although the benefits of liming in terms of increasing pasture production may be low, especially if the initial soil pH is > 5.5, ground-spread liming is relatively cheap – the cost-benefit ratio favors liming.

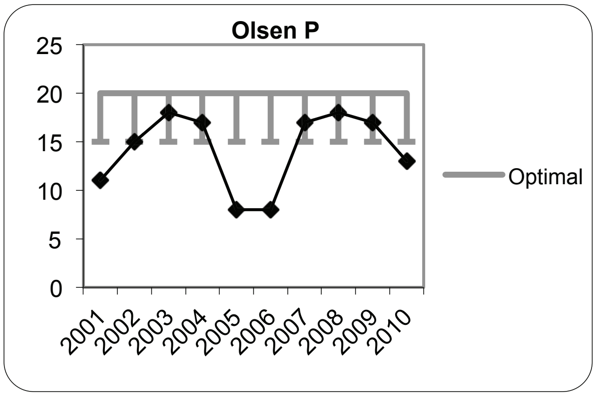
The situation is different where aerial application of lime is necessary. Given current costs, the economic optimal soil pH is about 5.5 to 5.6. In other words liming is only economic (the benefits are greater than the costs) if the initial soil pH is < 5.5.

I have only come across this situation once in practice. This occurred on a large dry-stock operation in the Hawkes Bay hill country. The soil nutrient levels (P, K and S) were all optimal but the soil pH levels were very low and declining (Figure 3).

Generally soil P stays put so when the P tank is full (i.e. within the optimal range, in this case Olsen P 15-20) P fertiliser can be withheld for one year without any loss in production – the Olsen P level might fall by 1-2 units per year. So in this case fertiliser P was withheld for one year and the fertiliser dollar redirected into a lime program – 3 tonne/ha was flown on to increase the soil pH from 5.2 up to the economic optimal of 5.5-6.0. Once the liming program was completed a maintenance P, K and S program was resumed.

Figure 3 Changes in soil pH and Olsen P over time on a Hawkes Bay dry-stock farm.





The problem arises when the soil nutrient levels are very deficient AND the soil pH is very low. At very low soil pH levels pasture growth can be limited by soil acidity – clovers in particular are very sensitive to acid conditions. In this situation correcting nutrient limitations alone is of little benefit because plant growth is restricted by soil acidity. Both lime and nutrients are required simultaneously to increase pasture growth. This situation is rare in New Zealand and traditionally only occurs on the peat soils in the Waikato and on the Pakahi soils in Westland.

SOIL ACIDIFICATION: A SUSTAINABILITY ISSUE FOR HILL COUNTRY?

There are many biochemical reactions in the soil that produce acid (H^+). These reactions are natural and are not the consequence of poor soil management. We need to live with this fact and this is why regular liming is necessary to maintain soil pH levels and hence productivity.

The rate of acidification is proportional to the production of the soil. High producing pastoral soils acidify at a rate equivalent to about 400-500 kg limestone per hectare. In other words this is the amount of lime that is required to neutralize the annual production of acid. This is the basis for the widespread practice on dairy farms of applying 2.5 tonnes/ha of lime every 4-5 years. As noted above, this is always economic.

The rate of acidification in hill-country is much lower – about 100 kg/ha of limestone is required to maintain the soil pH and if lime is not applied the soil pH will decline at about 0.01 pH units per year. This will not have any detrimental effect on production in the short term (within a generation) but becomes important over generations. For example over 50 years the decline in pH will be about 0.5 units. Thus a healthy pastoral soil today with a pH of 5.5 will become a struggling clover-based pasture with a pH of 5.0 within two generations.

One solution to the problem is as described above – withhold fertiliser inputs for one year and divert the funds into a capital lime program. But this can only be done when the nutrient tanks are full. What to do if these conditions do not apply?

The ideal would be to apply the small annual amount of lime with the normal fertiliser input, to offset the annual rate of acidification. To do this we need to develop a granulated lime product[1] that can be dry mixed with the superphosphate so that the annual fertiliser program not only applies the desired amount of nutrients but also sufficient lime to maintain the soil pH.

1). This should not be taken as an endorsement for the granulated fine lime products in the market today which are in my opinion over-priced given their calcium carbonate content.

WHEN IS AN EXPERIMENT NOT AN EXPERIMENT?

An "experiment" (the inverted commas are required because the treatments were not replicated as is required in scientific experiments) has been in progress in Canterbury for several years now (it commenced in 2014/15 and was completed in 2017/18). The experiment compared two contrasting approaches for giving fertiliser advice: the classic, conventional approach, based on ensuring that all the 16 essential nutrients are optimal (the Quantity Theory – see Fertiliser Review 26) compared to what is now referred to as the Albrecht – Kinsey approach (the Ratio Theory - see Fertiliser Review 26)

Two dairy farms, side-by-side, and under common ownership, were involved; fertiliser was applied to one farm based on the Quantity Theory and on the other the Ratio Theory was applied. In other respects the two farms were 'identical'. Many measurements were made: animal production and health, pasture growth and composition, soil chemistry, biology and some soil physical properties.

The results can be accurately and succinctly summarized. There was no practical difference in all of the properties measured except for the soil calcium and magnesium levels, which were adjusted to obtain the 'ideal' ratio of Ca and Mg levels on the 'Ratio farm'. However the fertiliser costs were higher on 'Ratio' farm relative to the 'Quantity' farm. These results from an unreplicated trial are entirely consistent with research in the USA. In a replicated trial it was found that the fertiliser costs on the Ratio treated plots were 2 times that of the Quantity treated plots but there was no difference in yield.

This is of course not surprising. It has been known for a long time that the Ratio Theory is flawed and results in expensive fertiliser advice for no additional benefit.

As I reported in Fertiliser Review 26:

The most recent review of the literature[2] on this topic concludes:

"The data do not support the claims of the BCSR [the Base Cation Saturation Ratio theory], and continued promotion of the BCSR will result in inefficient use of resources in agriculture and horticulture."

[[2]. Kopittke, P. M and Menzies, N.W. 2007: A Review of the Use of Basic Cation Saturation Ratio and the "Ideal' Soil. Soil Science Society of America. 71 (2) March-April 2007, 259-265)]

INTRODUCING

Another former AgResearch colleague, Mr Bob Longhurst, joined the agKnowledge team in 2015. For this edition of the Fertiliser Review I invited him to prepare an article about his new job. Eurofins completed the analysis: we thank them for their support. He reflected accordingly:

Driving through the central North Island it is not hard to spot yellowish pastures with low fertility grasses and moss and little clover. The clovers are struggling to get a foothold, what is going on? I decided to investigate on a drystock property in the Rangitikei District. Despite capital fertiliser inputs two years ago the pastures were still not thriving.

This LUC VI (Land Use Capability 6) hill country (15-25° slopes) contains sedimentary soils of the Brown soil series with loess over sandstone and/or mudstone. Anion storage capacity is 55-60%. Altitude ranges between 450-550m and the annual rainfall is ~1250mm. The farm's carrying capacity is around 9-10 SU/ha with a sheep: cattle ratio of 65:35.

Armed with a deep soil auger and some pasture clippers I set out to investigate. The Hill soil was sampled at two depths: 0-7.5cm; 7.5-15cm as we suspected aluminium (Al) might also be a possible issue. Pasture samples were also collected and dissected for "clover-only", as this provides the best "canary in the mine" indicator of soil fertility.

Clover analysis

Two clover-only samples were analyzed for the key nutrients affecting clover growth. The averaged results are shown below:

Clover-Only Analysis								
Sample Name	N (% DM)	P (% DM)	K (% DM)	S (% DM)	Mg (% DM)	Cu (ppm)	Mo (ppm)	B (ppm)
Clover	4.12	0.35	2.95	0.22	0.23	7	1.04	19
Low	4.0-4.4	0.30-0.34	2.0-2.4	0.25-0.27	0.15-0.17	5-7	0.10-0.14	13-14
Deficient	<4.0	<0.30	<2.0	<0.25	<0.15	<5	<0.10	<13

The key points in terms of clover growth:

1. Sulphur concentrations were deficient.
2. Nitrogen and copper concentrations were low.
3. Molybdenum concentrations were high.

Soil analysis

The soil test results for two soil depths are given below relative to the ideal ranges.

Soil analysis								
Depth (cm)	Olsen P	K	Sulphate S	Organic S	Mg	Na	pH	Al[2]
0-7.5	13	7	6	11	15	3	5.5	6.8
7.5-15	4	5	8	10	14	3	5.4	7.8
Optimal[2]	15-20	*7 - 10*	*10 - 12*	*10 - 12*	*8 - 10*	*3 - 4*	*5.5 -5.6 [1]*	*<3.0*

Notes: 1) Economic optimal range when lime has to be flown on.

2) Al = Aluminium (units ppm or mg/kg)

The key points in terms of pasture production are:

1. Sulphate-S concentrations were below optimal.

2. Olsen P levels are below optimal.

3. Soil pH is within the economic optimum range for hill country where aerial application of lime is required.

The clover-only analysis and the soil test both confirmed that sulphur was the most limiting nutrient. While the long-term supply of S, as measured by the Organic-S test, indicated that S levels were adequate, the immediately available Sulphate-S test indicated that S is deficient and limiting plant growth. Therefore, it would be appropriate to recommend a Sulphur-super type fertiliser product to remedy the farm's fertility problem.

Soil pH and aluminum

The soil pH in the topsoil of 5.5 is typical for North Island hill country. However, a closer look at the soil Al levels indicates that not all is well 'underground'. Aluminum is part of the soil mineral matrix and can be solubilized and made plant available as the soil pH decreases below 5.5. The amount of Al in the soil solution is largely determined by the amount of non-dissolved Al and by the pH of the soil. Thus, as soil pH decreases the Al concentrations in soil solution increases.

For ryegrass/white clover-based pastures, Al toxicity is rare on soils with a pH > 5.6. As the pH decreases below 5.6, Al toxicity problems are likely to increase. Generally, soil Al values <3 mg/kg are probably not toxic to pastures, values between 3-10 could be toxic (depending on organic matter content of soil), and >10 are probably toxic. Aluminum increases as pH decreases, therefore soil pH can be an indicator of likely Al toxicity problems.

There are many biochemical reactions in soils that produce acids and that is why pastoral soils acidify slowly over time (0.01 to 0.05 pH units/year). One such reaction occurs when fixed clover N is returned to the soil and is then ultimately leached – this causes acidification in the subsoil. The effect of high soil Al (as found on this farm) is also likely to be limiting pasture production by stunting root growth and causing shallow rooting of plants. Pastures (and crops) then become increasingly sensitive to the wetting and drying cycles of the soil. Higher fertility species such as ryegrass and white clover are more sensitive to Al toxicity than lower fertility species such as Browntop, Yorkshire fog and lotus.

Al toxicity only occurs in acidic soils and hence can be eliminated by increasing the soil pH to at least 5.6 by liming. One tonne of lime/ha is likely to increase soil pH by 0.1 units. However, the surface application of lime will take time to 'penetrate' down into the soil and hence affect the 'subsoil' acidity in this case.