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# NITROGEN FERTILISER REVISTED

I frequently see and hear what I regard as sloppy thinking and practices with regard to the use of nitrogen (N) fertilisers in our legume-based pastures. For example, I was recently on a dairy farm doing average production (850 kg MS/ha) but using more than 200 units of N! I pointed out to the farmer that it is possible given current animal and plant genetics, to achieve the same production without the need for fertiliser N. He appeared astounded!

It is time, I believe, to re-evaluate what we are trying to do with fertiliser N.

There is no doubt that our soils and pastures are N starved and there are two ways of getting N into the system. The traditional means is via the clover plant which has nodules on their roots which contain bacteria which convert atmospheric N into plant protein. This process is referred to as N fixation. In newly sown pastures, where the soil N status is low, clovers can fix up to 300-400 kg N/ha/yr. Typically, in developed pastures the inputs are in the order of 100 to 200 kg N/ha/yr.

This fixed N is 5 times cheaper than bag N. Therefore the key to efficient pasture production is to maximize clover growth and hence the amount of N fixed. But here is the rub - clover has a higher requirement for all nutrients (other than N of course) than grasses. For our soils this boils down to P, K, S, Mg (on some soils), the trace element molybdenum (Mo) and of course the correct soil pH (see the article 'All you need to Grow' in Fertiliser Review No 16).

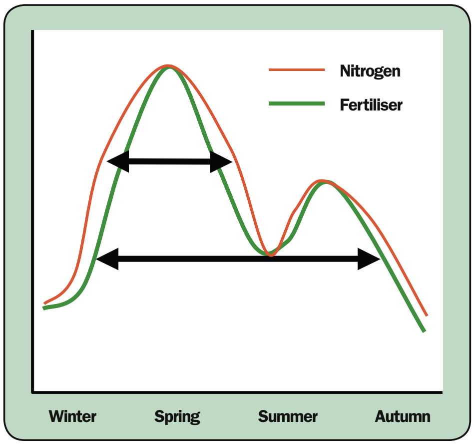
Too many times I have heard farmers and consultants blame the drought, insects or poor pasture management for lack of clover in their pastures. In all the cases I have investigated, the problem has been either one, or sometimes two of these vital nutrients being omitted or forgotten from the fertiliser mix – K, S and Mo are the main culprits. It is of little wonder why the clover has disappeared! In these circumstances clover growth is poor and hence N inputs via the clover are low. Consequently, over time the pastures become N deficient – they look yellow-brownish and in the extreme have prominent dung and urine patches. I call them Indian pastures – 'very-a-patchy.'

The farmer in alarm reaches for the fertiliser N. The effects are immediate and profound. The pastures turn green and look more vigorous. He thinks his problem is solved except that he is now addicted to fertiliser N, which is five times more expensive that clover N. His cost goes up but his production does not (see Efficient Dairy Farm, Fertiliser Review No 16).

Farmers and consultants need to be reminded that clover is our competitive advantage. Use it or lose it!

So what is the proper role of fertiliser N in clover based systems? This is how I see it.

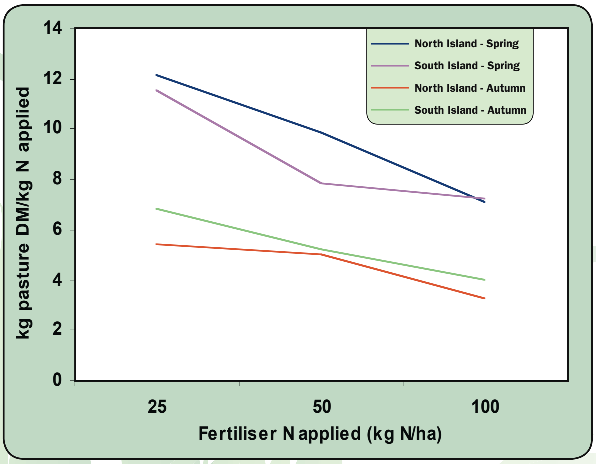
**Figure 1:** What we are trying to do with fertiliser N?




Any fool can apply fertiliser N during the spring or autumn while pastures are growing well and receive a significant response. But is it needed then? What we are trying to do with fertiliser N is to widen the shoulders of the pasture growth curve (see figure 1). Timing is everything. Science tells us to apply fertiliser N, 4-6 weeks before likely feed-shortfalls which typically occur in early Spring and late Autumn. However, this timing decision is largely one from gut feeling as we cannot be sure about the weather in advance. Feed budgeting, knowledge of pasture growth rates and soil temperatures help reduce guess work, but does not eliminate it.

What is the appropriate rate to apply fertiliser N? Once again science can help. The figure below is based on hundreds of field trials conducted in the late 1960's and early 1970s. It shows that the efficiency of fertiliser N (i.e. the kg pasture DM/kg N applied) decreases with increasing fertiliser N applied. Expressed differently, you get you best 'bang for your buck' by applying N at about 20-30 kg N/ha per application. Responses to fertiliser in clover-based pastures are not linear – more does not mean better! A qualification is need. These results were achieved on well developed 'downland' pastures which it can be assumed would have a good soil N status. Greater responses to N may be achieved on hill-country soils.

**Figure 2:** The relationship between rate of application of fertiliser N and fertiliser N efficiency (kg DM/kg N applied) for the North and South Island in Spring and Autumn (derived from 246 trials in the North Island and 165 in the South Island)




In addition, fertiliser N responses tend to be lower in the autumn relative to early spring. They also tend to be less predictable and more variable in autumn. Chances are you are likely to get a better return on your fertiliser N investment in early spring than in autumn.

One final point. The average N efficiency (kg DM/ kg N applied) for all the trials in the North Island (n = 246) was 12 (range 4-26). For the South Island the average (n = 165) was 6 (range 3-20). It is for this reason I am skeptical about some of the figures being bandied about in the advertising – 30-40-50 kg DM/per kg N! I wonder. The biology and climate have not changed that much - have they?

## THE COST OF FERTILISER P

Phosphorus (P) is the most expensive nutrient and hence the efficient use of P has a large impact on fertiliser costs. We last reviewed the cost of P fertilisers back in March 2002. It was concluded that super was the cheapest form of P for most situations. Several things have changed since then: first transport costs have increased along with the cost of fertiliser N. Both factors have changed the picture slightly.

Figure 3 below shows how the cost of P on the ground changes with fertiliser type and distance from the works, for ground spread fertiliser.

**The assumptions are:**

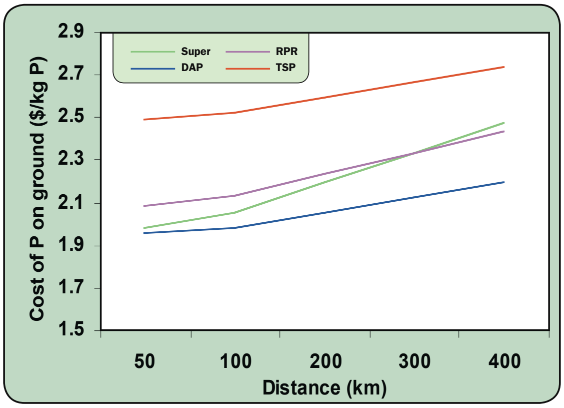
1) transport at $4.20/km per 30 tonnes

2) spreading at $30/tonne

3) Value ex works of P in DAP = $1.76 assuming the N component at $1.06/kg N as in urea.

4) Value ex works of P in super = $1.60 assuming the S component at $0.33/ kg S as in Durasul.

**Figure 3.** The effect of fertiliser type and distance from the works on the cost of P on the ground (ground-spread)

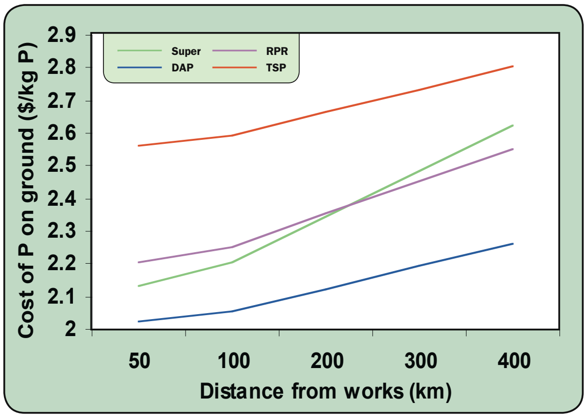



This data shows that as a source of P, triple super is priced off the market. The same is true for RPR especially considering only about 30% of the total P in RPR is available in the year of application.

For those farms close to the works (< 50 km) super and DAP are comparable as sources of P but over longer distances DAP is cheaper on the ground than super. **Note: this assumes fertiliser N is required.** In situations where no N is required or when it is necessary and desirable to apply the N at different times from the P, super is always the best option. This is certainly the case where both P and S, but no N, is required.

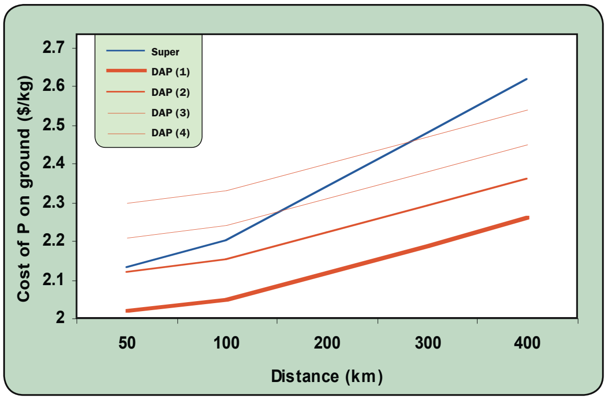
For aerial spread fertiliser, the trends are the same but the differences between the P fertilisers are greater. For sheep and beef farmers who require some N and P but no K and S, DAP appears to be a good option at present.

**Figure 4.** The effect of fertiliser type and distance from the works on the cost of P on the ground (aerial application)




These conclusions change my 2002 conclusion that super is typically the cheapest form of P. The major reason for this is the change in the price of fertiliser N - as the fertiliser N (i.e. urea) price increases the value of the P component in the DAP becomes less. To illustrate this point the figure below shows how the relative cost of P on the ground at various distances from the works, changes with the cost of N.

**Figure 5.** The effect of fertiliser N cost on the relative cost of P in DAP and super. (The cost of N ($/kg N) is 1.06, 0.96, 0.86 and 0.76 for DAP (1) to (4) respectively)




When the price of urea is high (i.e. at present $489/tonne or $1.06/kg N) DAP is a cheaper form of P than super (assuming that N is required) at all distances. When urea is cheaper (i.e. $342/tonne or $0.76/kg N) super is cost-competitive up to distances < 300 kms.

Thus, given current prices where N and P only are required DAP is a cost effective option relative to say applying the same amounts of nutrients as urea and super. There is a down side however. The DAP option means that you lose flexibility in terms of the area to which the N is applied (the whole farm gets N) and the timing of N applications (unless you have an all weather airstrip). It may be more cost effective in the longer term to apply super (at any time during the year and when most suitable time) and then use N (as urea) on a tactically important area of the farm and at a time best suited to match the feed demand.

**Advice?**

- If you do not use fertiliser N then super is always cheapest form of P.
- If you need P, K and S, but no N, super and mixes of super are the cheapest options.
- If you want to use fertiliser N but do not wish to apply it when the fertiliser P is applied, then super and urea are the most flexible option.
- If you want some N to go on with the P, S and/K then DAP mixes are currently a good option.

## MAINLAND MINERALS:
### A CASE OF LET THE BUYER BEWARE?

Our wonderful market-led economy is predicated on the legal principle: caveat emptor – "let the buyer beware". But a buyer can only be aware if he is first aware. Here is a case in point.

A Southland sheep farmer agreed to allow Mainland Minerals to run a 'trial' on his farm. Two adjacent, but similar, areas of the farm were chosen. Mainland Minerals, after taking soil and plant tests, applied their tailor-made fertiliser mix to one half of the trial area and the other remained untreated. The Mainland fertiliser mix was applied in October 2005 and both plots were grazed with the farmer's ewes and lambs. The plan was to measure and compare animal live-weights on a monthly basis through weaning and drafting.

The farmer became concerned when he noticed, shortly after weaning, that some of the lambs, and in particular the ram lambs, on the Mainland Mineral treatment were showing signs of poor weight gain, scouring and wool loss. These symptoms were not, according to the farmer, those of the ill thrift induced by Co deficiency, a typical problem in the area. These problems continued throughout the season.

The farmer alerted Mainland Minerals who took pasture and animal tissue tests in the following February and March to ascertain the cause of the problem. Subsequently, the farmer received written reports from Mr Dave McKie (Mainland Minerals) and Mr Tim Jenkins (a one-time employee of Mainland Minerals) who both reviewed the available information. They concluded that there was no obvious explanation for the observed ill thrift and essentially attempted to exonerate the company.

**The farmer contacted me and asked me to address 3 questions:**

1. Was the fertiliser mixture recommended by MM appropriate?
2. Is it possible, given the available data, to identify the cause (s) for the ill thrift.
3. Was the trial properly conducted?

## The Mainland Mineral Fertiliser Mix?

Soil tests were taken just before the trial commenced. The results indicated that both sides of the trial were:

| Sample | pH | Olsen P | K | Sulphate S | Organic S | Mg | Na |
|---|---|---|---|---|---|---|---|
| Average | 6.0 | 28 | 8 | 9 | 13 | 20 | 10 |
| Optimal | 5.8 - 6.0 | 30 - 35 | 7 - 10 | 10 - 12 | 10 - 12 | 8 - 10 | 3 - 4 |

**My interpretation of these results was as follows:**

1) No need for lime, Mg or Na
2) Apply sufficient P, K and S to maintain the current soil nutrients levels.

The table below shows the nutrient inputs required (kg nutrient/ha) by my calculations to achieve this, relative to the inputs recommended by Mainland Minerals.

| | N | P | K | S | Mg | Na |
|---|---|---|---|---|---|---|
| agKnowledge | 25[1] | 30 | 25 | 30 | 0 | 0 |
| Mainland Minerals | 5.4 | 6 | 2[2] | 6 | 1[3] | 4 |

**Notes:** 1) only if required to fill anticipated feed shortfalls. 2) as potassium sulphate an expensive source of K and S 3) as dunite an ineffective source of Mg

From this comparison it is clear that Mainland Minerals grossly underestimated the N, P, K and S inputs and recommended other nutrients, albeit in small amounts, which are in fact not required (e.g. Mg and Na). Their fertiliser mix also included lime as lime flour applied at 90 kg lime/ha. It was claimed that the application of highly available calcium as lime flour enhances the soil biological activity. I know of no science to support this assertion and it is predictable that this amount of lime will have no practical benefits.

It is noted also that Mainland Minerals used the Base Saturation Ratio Theory as the basis for their nutrient recommendations. This approach too has been debunked by science and is known to result in recommending some nutrients when they are in fact not required and not recommending others when they are required, as appears to be the case in this instance (see Fertiliser Review No 4 and the article on Superior Minerals in this issue).

Mainland Minerals also used soil tests, at least in part, to determine the trace element requirements for the soil. Soil tests for trace elements are unreliable and not well calibrated to the actual trace element requirements. In other words, they can result in inappropriate trace element advice. A more reliable approach for determining trace element requirements is to use pasture analysis and animal tissue tests.

My interpretation of the pasture analyses (sampled August 2005) was that only Se and Cu are required. My recommendation is set out below in comparison with the recommendation from Mainland Minerals:

| | B | Cu | Zn | Co | Se | I |
|---|---|---|---|---|---|---|
| agKnowledge | 0 | 1.2 kg/ha | 0 | 0 | 5-10gm/ha | 0 |
| Mainland Minerals | 1 | 1 | 1 | 30 gm/ha | 100 gm/ha | 20 gm/ha |

The pasture Co levels, at the time when the trial was set up, were 0.08 and 0.22 ppm (average 0.15 ppm) and hence no Co would be required at the time in my opinion, because it would be ineffective (it becomes immobilized in the soil) at the time it is most required (i.e. about weaning time). The local practice, as was adopted by the farmer in this case was to apply Co as a spray to the pasture as the lambs mature. Despite this, Mainland Minerals recommended Co. More significantly, they recommended an input of Se 10-20 times above the typical recommended rate of 5-10 gm/ha!

I would not have recommend B or Zn because there have been no reported cases of deficiency of these 2 trace elements in pastoral agriculture in New Zealand. Likewise, and in the absence of other information, I would not recommend I in the fertiliser.

For the above reasons it is ironic that Mainland Minerals claimed that their fertiliser mixture, “has been specifically designed to meet both the major and trace elements nutrient requirements for your operation.” In my view their fertiliser recommendation was not based on any sound principles of soil fertility and pasture or animal nutrition.

## The cause of ill-thrift?

### Pasture tests

Pasture samples were analysed in February and March 2006. Apart from Co, there is very little difference in the nutrient levels between the two treatments, allowing for normal variability. This is despite that fact the Mainland Mineral treatment included inputs of N, P, K, S, Mg, Na, B, Cu, Zn and Se. The question must be asked therefore: what was the purpose of the Mainland Mineral fertiliser? The pasture Co levels were however higher by a factor of 4-6 in the Mainland Mineral treated pasture.

### Animal Tissue Tests

Blood samples and liver samples from selected animals were tested in March 2006. The results are summarized below:

| Date | Tissue | Treatment | Cu | Se | $GSHP_x$ | $B_{12}$ |
|---|---|---|---|---|---|---|
| 3 March 06 | Blood | Control | 14 | 182 | 11 | > 1500 |
| | | MM | 21 | 655 | 17 | > 1500 |
| | | reference | 11-25 | 140 - 3000 | 4-10 | 500 - 1500 |
| 21 March 06 | Liver | Control | 985 | 1123 | - | 596 |
| | | MM | 1177 | 2663 | - | 296 |
| | | reference | 96-2999 | 450 - 9999 | - | 350 - 1500 |

The blood and liver Cu levels were slightly higher in the Mainland Mineral treated animals consistent with the Cu inputs, but were nevertheless within the respective reference ranges for both treatments. There is also very little difference in the pasture Cu levels at both sampling dates. It is therefore unlikely that Cu is implicated in the ill thrift.

The Co data are difficult to interpret. The blood B12 levels in both treatments were elevated above the reference range but the liver Co levels were low to marginal. Blood B12 concentrations (but not necessarily liver B12) reflect the dietary Co intake and therefore these results could be seen as consistent with the elevated pasture Co levels. Thus, the possibility of Co toxicity cannot be entirely eliminated, the symptoms of which are anaemia and poor weight gain.

The blood and liver Se levels were elevated in the Mainland Mineral treated animals, consistent with the input of Se in the Mainland Mineral fertiliser mix. In fact as noted earlier, the Se input in the Mainland mix was 20 times the rate normally recommended. According to Neville Grace, New Zealand’s pre-eminent animal nutrition expert, “Selenium is a toxic substance and care in its administration to animals is paramount.” One of the symptoms of Se toxicity is watery diarrhea and this is consistent with the farmer’s observations. Thus the possibility of Se toxicity occurring sometime after the application of Mainland Minerals fertiliser is a possible reason for the ill-thrift.

The difficulty with all information is the lapse of the time between the application of the Mainland Mineral mix (August) and when the animal tests were taken (March). Normally when trace elements are applied there is a rapid uptake into the pasture in the first 4-6 weeks followed by a rapid decline in the following 4-6 weeks. Thus, the animal tissues tests taken in March 2006 are likely to be only a faint echo of what may have occurred immediately following the August application of trace elements. Thus, although we cannot be certain as to the cause of the ill-thrift, there was something, according to the farmer, in the Mainland mineral mix which caused some type of stress in the animals.

## Was the trial properly conducted?

It is my opinion that this trial was poorly conceived, designed and conducted. In effect it became a test of the hypotheses: what is the effect of applying 12 nutrients (as a Mainland Minerals fertiliser mix) on lamb liveweights measured once at weaning. Not only were there no treatment replicates but the trial was confounded with 12 uncontrolled variables (nutrients). This dilemma is exposed if the question is asked: if there had been a beneficial effect from the Mainland Minerals fertiliser relative to the control, to what could it be attributed -one of the 12 nutrients or the fact that the soil to which the Mainland Minerals treatment was applied was in some way superior?

Apart from the above fatal flaws, the recommended nutrient inputs in the MM fertiliser do not appear to have been made on any sound rational basis. Some nutrients were recommended which were not required, and for others, the recommended inputs were insufficient to be of benefit. It is, in my opinion, a case of the indiscriminate use of nutrients and in particular, trace elements in the hope that something beneficial will result. Professionals are warned against this practice.

In my opinion the ‘trial’ was nothing more than a piece of reckless marketing undertaken by Mainland Minerals which exposed the farmer to unnecessary and avoidable problems, expense and stress.

## NEW VERSUS OLD PASTURE?

This is a vexed question - to renovate or not to renovate? It frequently invokes the issue of soil fertility. I see many cases of farmers going to the expense of cultivation only to end up with pastures which are no better than what they started with, simply because they did not get the soil fertility correct. All that expense and no gain! I am fascinated therefore by the results of a large scale farmlet trial conducted on the Scott Farm, Dexcel, Hamilton by Jim Crush and co workers (the full results are just published in the New Zealand Journal of Agricultural Science Volume 49: 119-135).

### The trial

The trial occupied 48 ha and ran for 4 full seasons. There were 4 treatments each replicated 3 times. The treatments were a factorial combination of old ryegrass and clover cultivars and new ryegrass and clover cultivars as follows:

**Treatment 1: 1980's ryegrasses + 1960 clovers**

**Treatment 2: 1998 ryegrasses + 1960 clovers**

**Treatment 3: 1980s ryegrasses + 1998 clovers**

**Treatment 4: 1998 ryegrasses + 1998 clovers.**

Some important features of the trial must be noted: High endophyte (> 70%) ryegrasses were sown in all combinations but the older ryegrass typically had lower endophyte levels than the newer cultivars. Also, all combinations of cultivars were newly sown. Both factors need to be born in mind when considering the results. In effect the trial compared old and new ryegrass and clover germplasm, unconfounded by cultivation and extreme endophyte differences. The soil fertility was optimized with annual inputs of all necessary nutrients and fertiliser N was applied (100 kg /ha/yr) in split applications to all treatments. The stocking rate was 3 Friesian cows per ha.

### Key Results

A trial of this scope produces a large amount of data. Only the key results can be covered in this brief summary:

1) There was no effect of cultivar age on annual pasture production which averaged 17.2 +/- 0.9 tonnes DM/ha/yr for the years 2, 3 and 4 (i.e. leaving out the establishment year).

2) The 1980's ryegrasses had faster growth rates in the spring than the 1998 ryegrasses which meant that more silage was made on these treatments.

3) The 1998 clovers and ryegrasses were more competitive than the older cultivars and tended to form a higher proportion of the swards at the end of the trial –they appeared to be more persistent.

4) The initial slight difference in ryegrass endophyte levels had little effect on the comparative pasture performance.

5) There was no treatment effect on pasture chemical composition or feed quality. .

6) There were no treatment effects on MS production per ha which ranged from 811 kg MS/ha (a poor year) to 1250 kg MS/ha.

7) There was no effect of ryegrass type on MS production per cow or per ha.

8) Clover type had an effect on MS production (1998 better than 1960) but only in one year (2001/02) because of a higher clover content in these pastures at this time.

9) There was no treatment effect on EFS.

### Some conclusions

The authors noted that the newer ryegrasses and clovers appeared to be more persistent but that over the trial period of 4 years this did not translate into better pasture or animal production. It is perhaps a pity that the trial did not go beyond 4 years to fully test this possibility. The authors concluded: "…that annual pasture production from these well managed ryegrass-white clover pastures is very close to the practical limit achievable in this region. Any major increases in herbage yield will require novel germplasm." I take this to mean that our plant breeders need to start thinking 'outside the square' in terms of future improvements to our ryegrass and clover cultivars.

At the farm level it seems that the practical conclusion is that providing the current ryegrass cultivars have some infection with endophyte (>70%) then renewing pastures with the more modern cultivars is unlikely to translate into production and financial gains. This may change in the future (5 years?) as the new generation of endophyte ryegrasses are developed and tested.

### Advice?

Put the expensive machinery away, get the soil fertility right under your current pastures and get on and do what Kiwi farmers have always been good at – clover-based pastoral farming. But of course I'm biased when it comes to pasture species – I'm a soil scientist!