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EFFICIENT FERTILISER USE ON THE DAIRY FARM

Based on Dexcel survey results (2001 to 2004 inclusive) the average dairy farmer spends $0.41 on fertiliser (including transport, spreading and N fertiliser) per unit MS produced. The top 10%, based on EFS, spend $0.35. For the average farmer producing 85,600 kg MS this difference in efficiency represents big dollars – about $5,000. Our own one-on-one work with farmers supports this conclusion. We are typically pulling about $5-10k of savings out of our client's fertiliser budgets without limiting production. Often production increases, because the fertiliser inputs are more balanced (see article this issue 'All you need to grow').

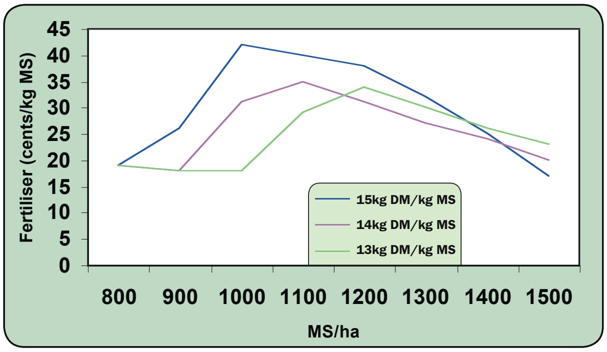
So why do some farmers spend more than $5,000 (and often more) on fertiliser that is not needed? It is a question I have been pondering for some time.

To get to the bottom of this we set-up a 'model' dairy farm. We calculated the theoretical costs of fertiliser per unit MS, for a range in MS production, increasing from 800 kg/ha up to 1500 kg/ha. The calculations were done for three feed conversion efficiencies: low, medium and high (ie 15, 14 and 13 kg DM/kg MS).One of the important assumptions in these calculations is that the maximum production from pasture is 16 t/ha. Once this is exceeded (by the feed demand required to achieve the increasing production targets) then fertiliser N was added into the management (at 10:1 conversion efficiency), but only up to 200 kg N/ha. If further feed was required to achieve the production target, supplements were introduced. All the other assumptions are given in Table 1.

Table 1: Assumptions used to calculate fertiliser-use efficiencies

1	maximum pasture production (with no fertiliser N) = 16 t DM/ha
2	14 kg DM consumed = 1 kg MS
3	all cows wintered on
4	supplements feed on feed pad and nutrients go to effluent block
5	80 % pasture utilization, but 100% utilization of fertiliser N derived pasture
6	I kg/ha fertiliser N = 10 kg DM/ha and maximum of 200 kg N/ha/yr: at $494 urea/ tonne on ground
7	soil fertility at economic optimal
8	0.7 kg 20% potassic super per 1 kg MS at $273/ha on ground
9	500 kg lime/ha/yr to maintain pH at $40/ tonne on ground
10	supplements at 20 cents/kg DM (assuming no wastage or labor cost)
11	350 kg MS/cow
12	one cow produces $11 of nutrients in effluent/yr
13	supplement is maize silage giving $29 of nutrient per tonne DM

Figure 1: The relationship between fertiliser costs per unit MS production and MS production per hectare for three levels of feed conversion efficiency



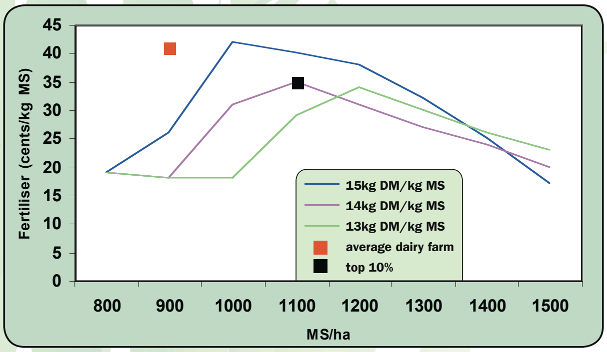
What does this tell us? Staring with the most efficient feed conversion scenario (13 kg DM/kg MS - the green line above), we see that it should be possible to get close to 1000 kg MS/ha without fertiliser N or supplements. The fertiliser-use efficiency is very high (< $0.20/kg MS). To increase production from this point it is necessary to include increasing amounts of fertiliser N to meet the feed demand, and accordingly, fertiliser costs per unit MS increases up to about $0.34. Because we have limited the amount of fertiliser N to not more than 200 kg N/ha, further increases in production above 1200 kg MS/ha can only be achieved by adding supplements. This causes the fertiliser-use efficiency to decline from about $0.34 to about $0.25 – you are getting more MS without adding to your fertiliser costs.

As the feed-use efficiency on the farm declines (in our example from 13 to 14 to 15 kg DM/kg MS), the curve is displaced to the left and the peaks get higher. A farm with a low feed-conversion efficiency (15 kg DM/kg MS), and using 200 kg N/ha, to produce 1000 kg MS/ha has a very low fertiliser conversion efficiency of about $0.43.

To summarize: adding fertiliser N decrease the fertiliser-use efficiency and this effect is greatest when the feed-use efficiency is low. Adding supplements improves the fertiliser-use efficiency.

Feeling good? Well think again. The same graph is repeated again (figure 2) but this time with the Dexcel survey data is included.

Figure 2: A comparison of the theoretical and actual fertiliser-use efficiency on dairy farms.



There a two possible conclusions from this data our assumptions and calculations are incorrect or there is a lot a fertiliser-use inefficiency. I'm inclined to the later for two reasons: Leaving aside the theoretical data above, and just applying the Dexcel survey information, suggests that industry-wide this inefficiency represents about $70-80m annually. This is the efficiency gain if the average farmer became a top 10% farmer.

Also these types of figures are consistent with the results we are finding with our clients.

And there is good news: increasing fertiliser-use efficiency goes straight to the bottom line (a happy farmer) and it is good for the environment (a double happy farmer). .

What to do?

From our own work – one-on-one - with farmers, there are three major areas of nutrient-use inefficiency on most dairy farms:

1. Using dairy shed effluent as a resource. The average dairy cow produces about $11 worth of nutrients in dairy shed effluent annually. A 500 cow herd represents about $5,500 of effluent nutrient per year! Making efficient use of these nutrients will mean $5,500 less on your fertiliser bill immediately.
2. Farm at, not above, the economic optimal nutrients levels. It costs money, and it is bad for the environment, to maintain unnecessarily high soil nutrient levels, for no financial gain.
3. Purchase the least-cost fertiliser to supply the nutrients you need and remember old recipes may not work if the soil is out of balance (see article this issue "All You Need\ To Grow").

Still confused?

Call your Consultant, Fertiliser Rep or give us a bell at agKnowledge – this is what we do best.

ALL YOU NEED TO GROW?

Advertisers are always flattered when their slogans get into general use, - yeah right? My defense is I'm using the phrase for a slightly different reason.

I see a number of advertisements for fertilisers, soil conditioners and biostimulants and the like, that make a virtue of claiming they contain many, many elements, up to 50 in one case! This fact alone should alert the unwary. However, I do get asked a more serious but related question: how many nutrients are required for pasture plants to achieve optimal production. The answer is 16. Here is why.

The 16 essential nutrients (Table 2) are normally divided into major nutrients (ie present in 'major' amounts) and the micronutrients (required in lesser amounts and hence sometimes referred to as minor elements). In this sense, major and minor do not mean more or less importance – all are required at the same time.

Table 2: The 16 essential plant nutrients and their chemical symbols

Major nutrients	Minor nutrients
Carbon	Copper (Cu)
Hydrogen (H)	Zinc (Zn)
Oxygen (O)	Boron (B)
Nitrogen (N)	Manganese (Mn)
Phosphorus (P)	Iron (Fe)
Sulphur (S)	Molybdenum (Mo)
Potassium (K)	Chlorine (Cl)
Calcium (Ca)	
Magnesium (Mg)	

These are the only elements required for plant growth and if you try to grow a plant without one of these nutrients it will not grow to its potential, if at all. So what about all the other elements in nature (120 of them at last count on the Periodic Table)? It turns out that if a plant has all of the 16 elements listed above, then adding one of these other 104 elements makes no difference – they do not further enhance plant growth and some are toxic.

Now for some qualifications: There are some agriculturally important plants (eg sugar beet, fodder beet and mangolds) which do require sodium (Na, as in common table salt). And there are others (eg sugar cane) which appear (there is still scientific doubt about this) to benefit from silicon (Si) applications (as in say serpentine, a magnesium silicate).

Also the bacteria on the roots of clover – the ones that convert atmospheric N into clover protein, need tiny amounts of Co, but Co is not included above because it is required by the bug and not the host plant. With these exceptions aside, plants and particularly pasture plants need only 16 nutrients.

So why do we **add** Co and Se in our fertilisers if they are not required for plant growth? The reason is simple. These two trace elements are required by animals and the simplest most cost-effective way of doing this is to add it to the soil and let the plant and animal do these rest.

Okay then, why do we **not add** Mn, Fe, Zn, B and Cl to our soils? The reason is that at the normal soil pH levels we deal with in New Zealand (ie 5.0 to 6.5), there is plenty of these nutrient already in the soil for most situations. Indeed the only know case of Mn deficiency in New Zealand occurred in wheat on an over limed soil (pH < 6.5). Boron is required however on brassica crops and on white clover crops growth for seed production. But no cases of B deficiency in pastures per se have been reported.

So the list is down from 16 to 11. Of these, carbon, oxygen and hydrogen are obtained by the plant from the soil (as water H2O) and from the atmosphere (as carbon dioxide CO2) and via the process of photosynthesis are made into carbohydrates (the stuff that gives the plant its structure). So providing there is sunshine (energy), water (normally in the soil) and carbon dioxide (in the atmosphere) the problems of C, O and H are solved.

We are now down to 8: N, P, K, S, Ca, Mg, Mo and Cu.

Calcium we can eliminate immediately – thanks to our young soils (ie not strongly weathered) and the fact that we use lots of super (20% Ca) and lime (35% Ca), Ca deficiency is unheard of in New Zealand. Note that a) the active ingredient in lime is the carbonate not the Ca, and, b) hypocalcaemia in animals is not due to low soil and plant Ca levels – it is a hormonal disruption within the animal which prevent it from releasing bone Ca in early lactation.

Down to 7.

Most New Zealand soils currently have good reserves of Mg – at least those sedimentary soils derived from the sea. Mg deficiency for pasture growth first appeared on the coarser pumice soils – they had little or no reserves of Mg and hence Mg had to be applied via the fertiliser. However, Mg deficiency is becoming more widespread for the simple reason that after farming for 50 -100 years we are mining down, the originally, adequate soil reserves. Within another generation it is likely that most farmers on the volcanic soils will also need to add fertiliser Mg.

A similar logic applies to Mo and Cu. When pastoral farming started in New Zealand you could tell by the soil group whether one or other of these two trace elements were required. Peat soils were deficient in Cu and most sedimentary soils needed Mo. The same pattern does not necessarily apply today. Certainly, these two soil groups require ongoing inputs of Mo and Cu, but we have exhausted the original supply of these trace elements in other soils – for example I have found 3 cases of Mo deficiency in the Waikato! The only way to be sure about whether these trace elements are required on your farm is with regular pasture testing (clover-only samples for Mo and Cu and mixed-pasture samples for Cu intake into the animal).

Down to the big 4: N, P K and S. Most New Zealand pastoral soils in their virgin state were deficient in N, P and S and most soils used for dairying needed K. Maintenance inputs will continue to be required on these soils. This is the reason why so much discussion about fertiliser revolves around these big four nutrients, and incidentally it is, for this quirk in nature, reason that scientists like me get labeled, wrongly, as NPKS addicts!

There are two sources of N in our clover-based system. Clovers should be nodulated. These nodules contain bacteria which convert atmospheric N into clover plant protein, which is subsequently returned to the soil as dung, urine and plant residues. This process adds about 1.3 billion dollars worth of N to our pastoral soils but we top this up, especially dairy farmers, by adding extra fertiliser N.

We typically think of the clover N – the $1.3b of N from the atmosphere - as free, but it does in fact come at a cost. Clovers have higher requirements for P, K and S (and indeed all the other 13 nutrients) than grasses. So while we do not need to add fertiliser N to the clover-based pastures, we must add sufficient P, S and K to maximize clover growth.

Several last points.

All 16 nutrients are required for plant growth, but the rate of growth of the plant – assuming adequate sunshine and water – will depend on the rate of supply of the most limiting nutrient. This is Leibig's (he was father of plant nutrition) famous "Law of the Minimum". No point in adding, say, more P and S to a soil which is K deficient, or Mo deficient or whatever. This is the meaning of 'balanced nutrition'.

And try not to confuse the plants 'requirement' for nutrients with the plants 'need' for nutrients. All 16 nutrients are required, but on your farm, on your soil, and given your fertiliser history, not all these nutrients are needed. How do you know what is needed? Have good monitoring program and regularly monitor soil, plants and animals.

FERTILISER: WHAT TO DO IN A DOWNTURN?

Because fertiliser is the 'big ticket' item on the list of discretionary income it is tempting to cut back inputs, or withhold inputs, as a means of financial survival, when forecasts turn grey. This can be a good strategy if the soil nutrient tanks on the farm are already full (ie the soil tests levels are all at or above the economic optimal levels). But most sheep and beef farmers are not in this position and hence the question – what to do?

Most of you will remember the late 80's and early 90's. Subsidies were gone and the commodity markets crashed. They were lean years for most farmers and many had no option but to cut expenditure and that included fertiliser.

But there are some things that can be learned by looking backward.

The Meat and Wool Board's Economic Service (now Meat and Wool NZ) survey 112 sheep and beef farmers over a three year period from 1985/86 through to 1987/88. The farms fell into three groups as far as fertiliser history was concerned: 16% withheld fertiliser inputs, 45% cut back and applied < 100 kg/ha, and the remaining 39% applied more than 100 kg/ha. The essential results of this survey are summarized below:

Fertiliser history (1985/86, 86/87, 88/89)			
Measurement (88/89)	**No fertiliser**	**< 100 kg/ha**	**> 100 kg/ha**
Area (ha)	352	463	347
Fertiliser ($/ha)	6.4	23.6	50.1
Stock units (/ha)			
1985	9.8	10.3	11.2
1989	9.4	10.2	11.4
Lambing %	93	99.3	109.9
Wool (kg/su)	4.5	5.4	5.8
Lamb wt (kg)	11.3	18.1	14.1
Gross revenue ($/ha)	253	333	441
Expenditure ($/ha)	207	256	291
Profit ($/ha)	46	81	150
Interest ($/ha)	61	48	30
Equity (% total assets)	68	80	89
Land value (% change 85 - 89)	+10.3	+9.5	+19.1

As the Meat and Wool Economic service noted, there is a clear linkage between fertiliser history, stock performance and profitability. In this sense fertiliser should not be regarded as discretionary. It should be treated by all accountants and farmers as a capital input – without it you are doomed!

But note the sting! The farmers who continued to apply fertiliser had low debt. You could argue that the only reason they continued with fertiliser is that they could afford to? But this is, in my view, false logic (I can say this now because I'm no longer a public servant and like farmers have to live by my commercial wits). As discussed in the last Fertiliser Review (No 15), and as demonstrate by the above, fertiliser is always a good investment if the nutrient tanks are not already at optimal. And what is optimal? Well that depends on your farm, where it is now and where you want to be in five year time.

POTASSIUM: MALIGNANT OR MALIGNED?

I come across cases so many cases of potassium (potash = K) deficiency in pastures these days that I'm getting bored. And it is not just on dairy farms. You can see it driving up to the house: urine patches as prominent as a beer gut at a triathlon, pasture full of flat weeds, pasture looking yellowish-brown, and pastures with little or no clover. It is one of the easiest nutrient deficiencies to pick visually.

And then come all the excuses:

Here is a list:

1. Dad used a lot of potash but he ran into terrible metabolic problems.
2. I've been told that you can't increase the soil K levels.
3. I've just been using DAP – no one told me it did not contain K
4. We have been doing fine until recently using urea and super, (ie no potash) but now the pasture look terrible.
5. I was told that the pastures were looking yellow because of a lack of N. (nitrogen) so I've just been sticking on more and more urea.
6. Potassium leaches doesn't it?

It is time we revisited potash.

Some history

Most New Zealand soils had sufficient reserves of K initially – in the soil and from the bush burn (as in pot ash). For some soils, particularly the volcanic soils in the Waikato and Taranaki, this was only a thin veneer and it was rapidly exhausted under dairying (milk contains a lot of K). Not surprisingly K deficiency in pasture was first noted in these regions and the effects of potash applications particularly on clover growth were outstanding.

From the mid 1950's onwards potash became an essential ingredient in the fertiliser on dairy farms. And farmers being farmers reasoned that if a little bit is good then a big bit is better and, they ran into metabolic problems. Excessive K inputs they found were not good. I suggest we are copping an anti-potash backlash today, and hence farmers are, deliberately or otherwise, cutting back on K inputs and are now running into K deficiency. Hence my frequent observations.

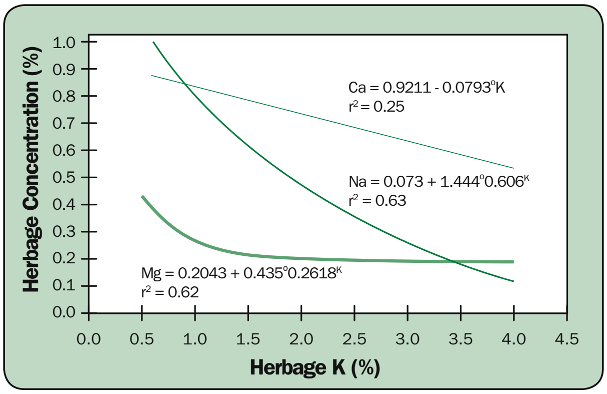
Things were different in the sheep and beef sector for two reasons. First, most of our hill-country soil are formed from sedimentary material, which happens to be rich is K reserves. Fertiliser K was not required. Also dry stock farming is less demanding in terms of K requirements. Thus, potash traditionally has never been part of the fertiliser formula in this sector. But things are changing here too, if my observations are correct. Hill country soils, and especially those with a sprinkling of ash are becoming K deficient. Potash sufficiency can no longer be assumed.

Dealing now with some of the issues

Potash and Pasture Nutrients

A cherished myth is potash decreases pasture Ca, Mg and Na concentrations and that this causes metabolic problems. My colleague Jeff Morton (formerly of AgResearch), summarized data from many field trials from throughout New Zealand (see figure 3).

Figure 3: The effect of increasing pasture K concentrations on the concentrations of Ca, Mg and Na.



These data support the general statement that potash decreases pasture Ca, Mg and Na. But what are the likely practical implications of this?

Pasture Mg concentration decrease very little once the pasture K concentration is above 2% (the line is flat). And if soil K levels are not deficient, the pasture K levels will be above 2.%. The point is that on most healthy (ie non K deficient pastures) adding further K will have little practical effect on Mg.

Increasing pasture K levels has a large negative effect on Na but this also is unlikely to have any practical implications because a) Na is not required for pasture growth and b) the Na levels of most pastures in New Zealand are above the critical level required for optimal animal health. The important exceptions are some of the central plateau pumice soils, where Na supplementation can be beneficial if the pasture Na levels are consistently below 0.10%.

As discussed elsewhere (see article “All You Need to Growth in this issue) Ca deficiency in New Zealand is unheard of and hence the negative effect of K on pasture Ca is unlikely to be of practical important.

The point that needs stressing is this: the generalization that K depresses pasture Ca, Mg and Na is true, but it does not follow that these effects will have detrimental effects in terms of animal health.

Potash and Animal Health

Morton and coworkers have taken this further. In a farmlet trial in Taranaki they examined the effect of different fertiliser K inputs over three lactations (no potash (KCl), 50, 150 and 380 kg/ha/yr – yes those rates are right!). They reported that the potash treatments had no effect on MS production, or reproductive performance, or the incidence of clinical metabolic disorders. They also found that in this specific experiment potash inputs, even at these high rates had not effect on pasture Mg or Ca concentrations but did depress pasture Na concentrations. These results are consistent with what can be inferred from figure 3. In other words the specific are consistent with the generalization – always important in biological science.

Can Soil K levels be increased?

The answer is generally yes. And it takes about 40-60 kg K/ha (80-120 kg KCl/ha) to increase the soil K level by 1 unit. If the current soil K level is say 5 and you want to lift it up to 7 (the optimal range is 7-10 on ash soils and 6-8 on sedimentary soils) then 160-240 kg KCl/ha is required on an ash soil, **over and above the maintenance input.** In the Taranaki trial above the soil K tests increased from 7 to 14 with an input of 1150 kg KCl over 3 years. This works out, assuming a maintenance input of 150 KCl/ha/yr, to about 100 kg KCl/ha per K Quick Test unit.

So for soils which are currently deficient, large inputs of K are required for a number of years to optimize production. Frequently, I hear people saying we’ve been putting on heaps of potash and the soil K levels have not moved. When questioned they revel that heaps is something like 100-200 kg KCl/ha, only sufficient to maintain the soil K levels on high producing dairy farm.

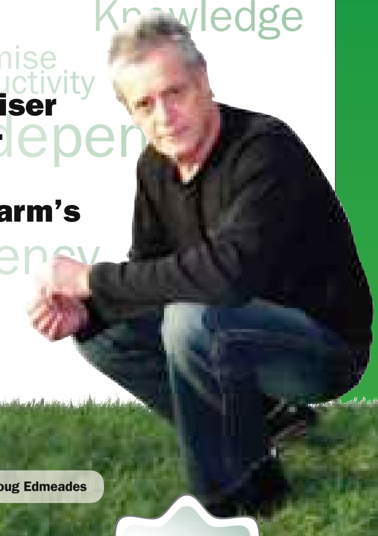
I must concede however that there do appear to be some soils (I’m thinking here of very porous pumice soils, well developed peats) which simply cannot retain K no matter how much is applied. But these are, in my view, and until further data is in, the exceptions to the rule.

K leaching?

Yes K like other soluble and hence mobile nutrients (include sulphate S, Ca, Mg, nitrate N,) leaches. In the Taranaki trial we have been discusses it was estimated that K leaching represented about 25% of that applied. However if you applied the argument: if it leaches I will not use it then you would not use any nutrients on the farm except P! Yes nature sucks, get used to it!

The message

Do not forget that K is an essential nutrient (see article this issue, ‘All you need to grow’) and it is required in large amounts. Using it rationally (ie as science suggest) will not adversely affect animal health.



Dr Doug Edmeades