agKnowledge

TNM™ "Total Nutrient Management"

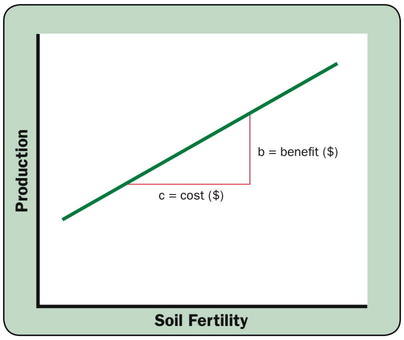
March 2003

THE Fertiliser Review

ISSUE 10

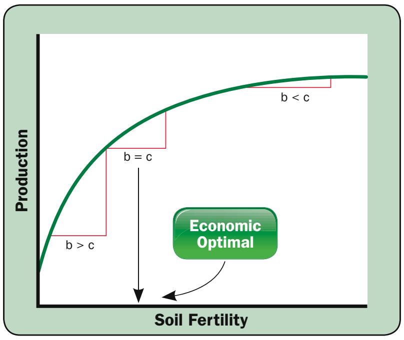
THE ECONOMICS OF FERTILISER USE

The economics of fertiliser use depends largely on two factors: The cost of purchasing and applying fertiliser and the benefit from applying fertiliser. If it is assumed that production increases in an linear fashion with increasing soil fertility we can define the costs (c) of applying fertiliser and benefits (b) from applying fertiliser as follows:



If the dollar benefit from the greater production is greater than the dollar cost of applying fertiliser to increase the soil fertility then it is profitable to apply fertiliser.

But the relationship between production and soil fertility in our legume-based pastoral system is not linear - it is a 'diminishing returns' relationship as shown below.



At low soil fertility the benefit (b) from increasing productivity are large relative to the cost (c) of increasing the fertility. It is therefore profitable to apply fertiliser. At high initial soil fertility the benefit (b) from the same increase in soil fertility (c) is small - you do not get a return from your fertiliser dollar. It is not profitable to apply more fertiliser.

There is a point along this diminishing return relationship where the cost of fertiliser equals the benefit from fertiliser. This is the economic optimal, meaning that it not economic - not profitable - to apply more fertiliser to go to a higher plane of soil fertility. So what factors affect the economic optimal?

First soil group at the broadest level (ie sedimentary, peat, pumice, volcanic, podzols) has an impact because it affects the shape of the diminishing return relationship. But more importantly the economic optimal is farm specific. Why? Because the cost structure of each farm is different. For example, the benefit derived from a given increase in pasture production will depend on how well a given farmer utilises the extra pasture. Stocking rate, subdivision, the farmers skill all impact on this. Similarly the cost of applying fertiliser can differ from farm to farm. All of this boils down to the overall profitability (the cost of inputs versus the cost of outputs) of the farm and a useful measure of this is the gross margin (the net income minus the variable costs) per hectare.

As the farming operation becomes more profitable ie as the GM/ha increases the economic optimal soil fertility level also increases. It is, given current cost and prices, about 10-15 for a hard South island Hill country farm (GM $200-300/ha), 15-20 for a central North Island Sheep & Beef operation (GM $400-500/ha), 25-30 for an intensive beef or sheep operation and up to 40-45 for a high producing dairy farm (see The Fertiliser Review No 9).

The most expensive fertiliser nutrient is phosphorus (P) at $1.50/kg P followed by potassium (K) at $0.8/kg k and then sulphur (S) at $0.40/kg. Furthermore P is the main driver of production from legume-based pasture given our universally P deficient soils. So in practice it is generally desirable to increase the soil K, S, Mg and trace elements levels so they are non-limiting (ie at the biological maximum) and then adjust the soil P level (Olsen P) to the economic optimal. This assumes of course you want to maximise the profits from your labours.

Need Help?

The economic optimal Olsen P level is farm specific. Do you want to find out what it is for your farm? See the article in this issue on what TOTAL NUTRIENT MANAGEMENT (TNM™) has to offer.

P LOCK UP? P FIXATION?

In the first Fertiliser Review (The Fertiliser Review No 1 October 1998) I wrote: "No other concept in soil science has been so misrepresented and misused as soil P fixation. It has been and still is used to sell all sorts of useless fertilisers and soil amendments to unsuspecting farmers." We go back to this issue because:

1. The Main Report (February 10, 2003) ran an article proclaiming, "P uptake less than 50%."
2. Advertising for the product Nitrosol (1999) states: "Phosphorus from years of application can still be found in the soil, locked up waiting for release. Nitrosol ……… can help to release those nutrients …."
3. From Mainland Minerals (undated advertising) we get, "most of the P applied in superphosphate on many pastoral soils is still sitting there in the soil."
4. From Foremost Fertilisers (undated advertising) we have, " ….. the amount of applied soluble phosphate that reaches the plant is not over twenty-five percent - in some soils it is not over ten percent, and may be even less."
5. From Fluid Fertiliser (undated advertising) we get, " 24% of added P is taken up by pasture."
6. From Mark Bell-Booth Ltd (undated advertising): "Release locked up P." A slogan to use Combo, a liquid fertiliser containing Maxicrop.

The adverting message is clear: P gets locked up in the soil and is unavailable for plant growth, and by implication, some products release it making it plant available.

What does science have to say?

It is true that P accumulates in the soil. A well-developed soil after many years of fertiliser inputs contains about 300-500 kg of potentially available P/ha. About 50% is in an organic form (eg from plant residues) and 50% is in the form of iron and aluminium phosphates (eg from soil minerals). This accumulated P is not immediately plant available but neither is it, as implied in the above, 'locked up and lost forever.' The processes that form these temporarily unavailable forms of P are in fact reversible. As the plant 'draws' on the small pool of plant available soil P, organic P is mineralised and becomes plant available and the iron and aluminium P compounds dissolve and become plant available.

How do we know that this is true? First, it well understood that organic residues breakdown in the soil and release their P for plant uptake. More recently it has been shown that these insoluble Fe/Al -P compounds are sources of plant available P. But more importantly, it has been shown that the overall utilisation of applied P is about 80-90%. This means that about 80-90% of the fertiliser P that is applied is somewhere in the soil-plant-animal system. Expressed differently, only about 10-20% of the applied P is lost in the long-term from the soil-plant-animal system. So if the fertiliser P input is 30 kg P/ha then 3-6 kg/ha is lost.

These losses of P are, in order of importance: P removed in products from the farm, P lost by transfer to non- productive areas on the farm (stock camps, raceways), P in runoff from soils (see The Fertiliser Review No 9) and lastly that small proportion of P that is truly fixed and lost forever in stable inorganic minerals and organic matter.

So what is the basis for these incorrect claims about low P utilisation?

We can think of the soil as a P nutrient tank. The tank is empty or at least near empty in a virgin soil. To be fully productive the tank must be full, and as discussed, a full soil P tank typically contains about 300 to 500 kg of potentially available P per hectare. Only a small proportion of this P will become plant available in any one year Indeed a productive pasture will only use, that is, take up, about 30-40 kg P/ha in any given year. Thus, it appears that the utilisation of P is small: about 6-8 % of the total pool of potentially available soil P! You see it all depends on how P utilisation is defined.

So do not be fooled. Rest assured that you are not wasting your money on P fertiliser because of 'low' utilisation. We should think of 'P fixation' as a good thing. It is nature's way of storing this very expensive and vital nutrient in an insoluble form until it is required. If it did not occur P would be leached from our soils. Think of the environmental implications of this!

So why do the advertisers play with the mathematical mirrors? In my opinion it comes down to fear and money. It is a good selling proposition. I tell you that your hard won fertiliser dollar gets locked up in the soil. You worry and think that there must be a better way. Then I sell you a "wonder product" that unlocks your P money bank. It may be a liquid fertiliser, a soil bio-stimulant, reverted super or an RPR. The proposition is the same. Unfortunately for the peddlers of such psuedo-scientific mumbo jumbo there is no science to support their claims.

SULPHUR

A farmer from Northland writes: “After about 50 years of topdressing with super and lately sulphur super we don’t see any lift in the soil test levels. Does the soil reach a certain level and then it won’t hold any more?” The short answer is YES. The longer answer is more informative.

Many soils in New Zealand were S deficient in there original state (see map) and all productive soils in New Zealand need ongoing inputs of S for maximum production For most situations 30 kg S/ha/yr is sufficient to eliminate the most extreme deficiency and maintain soil S levels. However, the plant available form of S - sulphate S is soluble and mobile and under certain conditions, excessive S can be leached and these soils need more S (40-50 kg S/ha/yr) to maintain soil S levels. These high leaching soils occur when there is a combination of high rainfall > 1500 mm, coarse texture, and low anion storage capacity and include the coarse pumice soil in the Central North Island, Northland podzols, the Peats in the Waikato and the pakahi soils on the West Coast.

Superphosphate contains both P and S and the old rule of thumb was that if super is used to supply the P requirement then sufficient S will also be applied to meet the pasture S requirements. This is one reason for the great success of super in New Zealand. For the high leaching soils which required more S, sulphur super (super fortified with elemental S was the logical choice and for those few unique South Island soils, which are S but not P deficient, a highly S enriched super was developed. These general rules still apply today but are greatly confused by the market which now offers a wide range of products, such as mixtures of elemental S with RPR, or triple super or DAP. Given today’s prices these a generally more expensive options.

Now lets look at what happens when fertiliser S - and the same applies to all nutrients which are deficient- is applied to an infertile soil under a grazed legume-based pasture. First clover growth is stimulated because clovers have a greater need for nutrients than grasses. The animal consumes the pasture and returns excreta, which of course includes all the vital nutrients to the soil. In addition dead plant material is also returned to the soil. With time and further inputs of nutrients, and the vital role of the grazing animal, organic matter begins to accumulate in the soil. The important nutrients in organic matter are N, P and S and these organic forms are made plant available as microbes break down the organic matter. Thus, the more organic matter the more fertile the soil becomes.

But this process of accumulation does not go on forever and research shows that under our climatic conditions it takes about 20-50 years to reach a maximum. Generally the drier the climate the slower the process. The amount of organic matter that can accumulate also depends on the climate but soil group also affects this. Our volcanic soils accumulate high levels of organic matter under pasture. Pumice soils are next followed by the wetter sedimentary soils (rainfall > 1000mm) followed by the drier sedimentary soils.

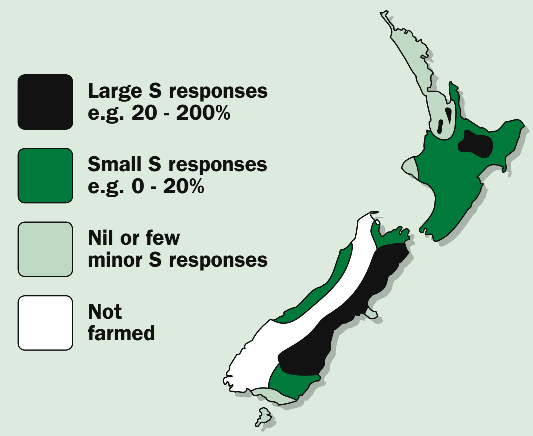
In a developed soil which has been fertilised and well managed for many years most of the S in the soil (95%) is in the organic form and only a small proportion is present as plant available sulphate S. In fact it can be shown that the pastures annual S requirement is generally much greater than the amount of sulphate S in the soil. So where does the extra S come from? Work at Ruakura in the last decade has shown that the small pool of sulphate S is in equilibrium with the much bigger pool of organic S and that as the pasture takes up sulphate S from the soil more is made available from the organic pool which in turn is kept topped up by the return of organic residues as described above.

What do we conclude from all this?

1. S accumulates in pastoral soils over a period of 20-50 years and the time required and the amount that accumulates depends on the climate and the soil group.
2. Most (95%) of the S in soils is in an organic form and only a small proportion is present as plant available sulphate S.
3. The large pool of organic S is in equilibrium with the small pool of sulphate S and as plants take up available sulphate S, organic S is broken down and made plant available.
4. The pool of organic S is kept constant by the return of dead plant material and animal excreta.

In the next issue we will advance to the next step: the soil tests for sulphate and organic S and how they are interpreted.

Sulphur responsive zones
based on recent field trials



MANAGING NITRATE LEACHING

In The Fertiliser Review No 9 (2002) we looked at how to manage P runoff. In this issue we turn attention on the other environmental biggie - nitrate leaching. What causes it and how can it be managed?

The problem

Nitrate, like its elemental sister, sulphate, is a mobile nutrient. If the N going into the soil via fertiliser N and/or symbiotic clover N fixation is not taken up by the plant or converted into non-mobile organic matter N in the soil, it is vulnerable to leaching as nitrate. High nitrate concentrations in ground water can give rise to human health problems and thus the recommended maximum nitrate concentration in drinking water has been set at 11 ppm (parts per million).

N budgets

To understand what happens it is helpful to look at some nutrient budgets for N (You are now familiar with the concept now because you all read The Fertiliser Review No 9 2002?). The table below gives real 'live' nutrient budgets from a dairy farm and a sheep and beef operation.

Table 2: Nutrient budgets for an dairy farm and sheep and beef farm (kg N/ha/yr).

		Dairy	Sheep & beef
Inputs	Fertiliser N	85	13
	Clover N from the atmosphere	178	69
	Irrigation	0	0
	Supplements into farm	6	7
Outputs	Product	63	13
	Transfer	0	0
	Supplements out of farm	0	0
	Atmosphere as gases	52	25
	Leaching	96	18
	Incorporation into organic matter	58	32
Balance		**0**	**0**

For the dairy farm the total inputs of N are 269 kg N/ha/yr (85+178+6 = 269) of which only 63 kg N/ha/yr is 'captured' as product going off the farm. The balance (206 kg /ha/yr) has to go somewhere, and in this example; 52 kg is lost as gases, 58 kg is incorporated in the soil organic matter, and the rest, (96 kg), is leached into the ground water. The N going into the farm that is not captured in product (ie 206 kg) is called the 'farm N surplus' and it is this that is the main driver of nitrate leaching. The higher the farm N surplus the higher the rate of leaching and hence the higher the likely groundwater nitrate concentration.

For the sheep & beef farm the farm N surplus is 76 kg N/ha/yr (ie 13+69+7 = 89-13 = 76) and therefore the amount of nitrate leached is much smaller.

So how can we manage the farm to reduce the farm N surplus and hence minimise nitrate leaching? The table below gives some clues. Using the dairy farm example we can calculate the Farm N Surplus and the predicted groundwater nitrate concentration for different management scenarios:

Scenario	Farm N Surplus (kg N/ha/yr)	Predicted nitrate concentration (ppm)
Low clover & no fertiliser N	47	3
Medium clover & no fertiliser N	74	3
High clover & no fertiliser N	154	7
High clover & 42.4 kg fertiliser N/ha/yr (50% applied in May, June July)	188	8
High clover & 85 kg fertiliser N/ha/yr (50% applied in May, June July)	206	9
As above and remove 50% of cows during May, June, July (feed pad or off farm)	194	5
As above and remove 100% of cows during May, Jun July) (feed pad or off farm)	193	4

Note that the farm N surplus increases with increasing N going into the system. And it does not matter whether this as fertiliser N or clover N. Those greenies who advocate restricting fertiliser N inputs as a means of controlling nitrate leaching N are sadly misguided! But do not take this to mean that I am advocating fertiliser N. Remember a kg of clover N is far cheaper than a kg of fertiliser N. What this does imply is that the choice between fertiliser N or clover N is not an economic not an environmental issue.

So why does increasing the N inputs increase the farm N surplus - surely with higher N input more animals are carried per hectare and hence more N is captured in product?

This is true to some extent but it ignores one of the great weaknesses in our animal legume pastoral system - the urine patch. Animals do not return the ingested N evenly. It comes back to the soil in big lumps, as urine. The N input in a urine patch is about 1000 kg N/ha. The pasture simply cannot take up all this N and that which is not taken up is vulnerable to leaching. The more animals per unit area the more urine patches per unit area and the more urine patches the greater the potential for leaching. The critical time of course is when the soil is already saturated with water, normally from May through August and this is why removing animal from the pasture at this time greatly reduces nitrate leaching as shown above.

So winter management is one of the largest levers to control nitrate leaching is and in particular moving animal from the farm to the runoff or onto a feed-pad. In a sense the first option takes the problem elsewhere but is logical if the over average nitrate loading is less or perhaps the catchment to which the runoff contributes is less sensitive. The second option only works if the nutrients from the feed pad are collected and returned evenly to the farm.

N Efficiency

Another way of looking at these N budgets is to consider how efficiency N is used. In the dairy example above 63 kg N/ha is captured as product out of a total input of 269 kg n/ha. The efficiency is therefore 23%. For the sheep & beef farm the N efficiency is 15%.

My colleague Dr Ledgard of Ruakura has done some wonderful research on this topic and has compared the N efficiency in dairy farms in New Zealand

	Average Dairy	Ruakura No 2 dairy		Feedlot dairy
		0 fertiliser N	200 kg/ha/yr fertiliser N	
N efficiency (%)	32	44	28	49

For the average New Zealand dairy farm about one third of the total N inputs are captured as product and removed from the farm. The N use efficiency was higher on the Ruakura No 2 dairy in the absence of fertiliser N. This could be attributed to the modest N input, solely as clover N fixation, coupled with a high pasture utilisation. However this gain in efficiency due to high pasture utilisation was lost on the farmlet receiving fertiliser N. The highest N efficiency occurred on a very high producing feedlot operation. This was due to two factors. By manipulating the ratio of protein to carbohydrate the utilisation of ingested N was optimised. Additionally because it was a cut and carry operation there were no urine patches and all the effluent from the feed lot was distributed evenly back onto the soils.

The important point to take from this is that high environmental compliance does not mean low input agriculture. It is possible to combine very productive farming operations with high nutrient use efficiency and hence minimal environmental impacts. Compliance simply means being smarter about the way we use nutrients.

LET THE BUYER BEWARE

You should be aware that the fertiliser industry is deregulated. There is no Fertiliser Act. Anyone can go into the market with a product and call it a fertiliser. There is no legal definition of what constitutes a fertiliser and there is no control over their use. The Federated Farmers FertMark scheme is voluntary and only requires ‘truth of labelling’. It does not concern itself with the agronomic effectiveness of products.

To make the farmers lot worse, anyone can put up his shingle and call himself an expert in soil fertility. Many can and do!

Is it surprising that farmers are confused about fertilisers?

To demonstrate. A Southland farmer recently engaged the services of Quantum Laboratories who did soil tests and made a fertiliser recommendation. The fertiliser mixture specified, among other things, Dunite (an ineffective source of Mg) and the trace elements iron (Fe), manganese (Mn) zinc (Zn) and boron (B) - no of which are required on pastures.

But worse. When the useful components of the fertiliser mix were costed out we found:

Component	Amount (kg/tonne of mix)	Cost ($/tonne)	Value ($/tonne of mix)
Single Super	107	187	20.0
Lime	430	20	8.6
Potash	159	419	66.6
Copper Sulphate	2.14	228	4.8
Cobalt Sulphate	0.22	1553	3.4
		Total	**103.4**

In other words the total value of the useful components in one tonne of the mix was about $100. The quoted price? $293/tonne! Even if the components in the mix, which are regarded as ineffective or not required agronomically, are included in the cost it is unlikely to account for the margin of $160/tonne ($293-$103).

In my opinion this report, the soil tests and their interpretation, falls well below the scientific standard that farmers can and should expect from professionals in this area. This arises, it appears, because of an adherence to unproven practices and philosophies, rather than a common sense application of known scientific results and practices.

ANNOUNCING A NEW SERVICE

TNM™

"Total Nutrient Management"

There are times when I feel sorry for farmers. These days to effectively cut through all the marketing mumbo jumbo about fertiliser you effectively need a degree in soil soil science and agronomy, a sound grounding in veterinary science and a sprinkling of economics. Add to this a hint of environmental compassion and legal nous to keep you free from of liability! All of this of course must be done before breakfast. God knows you are too tired after a 12-hour day in the fields.

Well help is at hand. Total Nutrient Management (TNM) is here. TNM has been developed by agKnowledge Ltd over the past few years and sets an altogether new standard in fertiliser advice.

TNM is designed for time poor farmers who want to cut through all the commercial nonsense and optimise farm efficiency and profitability, but at the same comply with all environmental requirements. So forget the RMA. Forget the Fertiliser Code of Practice. Forget nutrient budgeting. Call in the experts at agKnowledge Ltd and let them do the worrying.

Let them develop a fertiliser plan for your farm that is:

- Based on your triple bottom farm goals (production, economics, environmental)
- Science-based and objective
- Independent of product sales
- Optimises nutrient use efficiency
- Optimises farm profitability
- Complies with the RMA and Fertiliser Code of Practice

We have processed 20 farms since commencing this service in December 2002 and we know from this work TNM is a win-win. Efficient nutrient use is good for the environment and good for your bottom line.

More information?

Freephone : **0800 FERT INFO** (0800 33 73 46)
Fax: **07 834 0315**
Email: **info@agknowledge.co.nz**

PRICE WATCH

Nutrient	Product	Average cost ($/kg nutrient)[1]
Phosphorus	Superphosphate	1.44
	DAP	1.75
	RPR	1.40 - 1.73 (Ravensdown)
	Triple super	2.15
Nitrogen	Urea	0.77
	DAP	1.12
	Ammonium sulphate	1.28
Potassium	Potash (KCl)	0.82
	Potassium sulphate	1.49
Magnesium	Calmag (MgO)	0.72
	Serpentine super	0.82

Notes:
1) Prices are the averaged ex-works prices from Ravensdown and Balance (February 1 2003 for Ballance and February 2 2003. Where prices differ by more than 0.10 cents/kg the range is given and the cheapest source indicated.
2) Prices are exclusive of GST and assume the cost of S is $0.40/kg. Prices for Ravensdown are for Direct Debit and the Balance prices do not include the Merchants margin of 1-3%.
3) Where a product contains more than two nutrients the value of the companion nutrient is taken into account.

Points to Note:

1. There has been a modest decrease in the cost of the major P fertiliser since the last Price Watch (August 2002)
2. Apart from RPR there is little difference in the ex-works prices between the two companies
3. Urea, superphosphate, potash and MgO are still the cheapest forms of N, P, K and Mg respectively. The Ravensdown RPR is about the same cost as super per unit of total P but this does not account for the slow release nature of RPR

Optimise farm profitability

Make your fertiliser dollar go further

Decrease your farm's environmental footprint