agKnowledge
TNM™ "Total Nutrient Management"
September 2004
THE Fertiliser Review
ISSUE 13

GOOD NEWS FOR SOIL LIFE

Chemical fertilisers destroy the life in soils - they make soils acid, they kill earthworms, they stifle soil microbe activity and are otherwise ruinous to farming and agriculture. True?

Such statements are normally followed by - but our fertiliser (ie RPR, reverted super, dicalic super, vermicast, compost, liquid fertiliser or slurry fertiliser) is not like those 'nasty' chemical fertiliser - our products enhance soil life. Really? How about some facts?

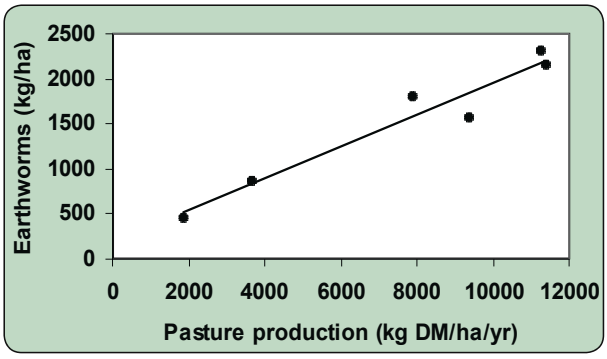
One of the classic experiments in soil fertility in New Zealand was published in 1954. It detailing results from an experiment on a fertile soil at Palmerston North. It ran for 4 years (1946 to 1950). There were three key treatments: grass grown alone, grass grown with clover, and, grass and clover plus fertiliser. No nutrients were returned to half the plots (ie all the pasture produced was removed) and on the other half nutrients were recycled by returning either the pasture clippings or returning dung and urine. The key results are given below:

Treatment	Pasture production (kg DM/ha/yr)	
	No recycling of nutrient	Recycling of nutrients
Grass alone	1900	3700
Grass + clover	7900	11300
Grass + clover + fertiliser	9408	11400

In hindsight these results are not surprising: adding clover to the pasture mix greatly increased pasture production because it 'fixes' nitrogen from the air and transfers it to the N deficient grass via decaying roots and leaves. This effect is of course much greater when there is full recycling of the clover N via clipping or animal excreta. Adding fertiliser enhanced production further and this effect was, as expected, greatest when there was no recycling (remember the site was on a fertile alluvial soil).

This was one of the first experiments in New Zealand that established the simple principle: clover, fertiliser and the grazing animal are all components of a productive pastoral soil.

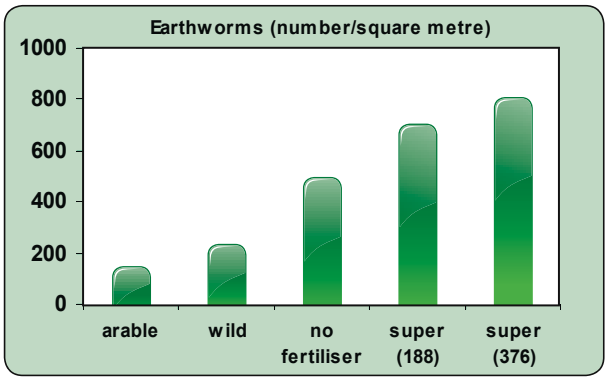
These scientists also looked into the soil. The figure below shows the relationship between total pasture production and the number of earthworms in each treatment.



The more pasture grown the greater the number and weight of earthworm. Why? Because the more pasture the more dead and decaying plant material is returned to the soil. This is food for earthworms, and like most organisms, the more food the greater the population. And notice how large the numbers are: At a pasture production of 10 tonnes DM/ha there were about 2 tonnes of earthworm per hectare.

These results have been repeated in many other experiments. The data below come from a long-term fertiliser trial in Canterbury. In this case, earthworm numbers were measured under a pasture which had either, no fertiliser, or super at either 188 or 376 kg/ha/yr for 37 years. Earthworm numbers were also measured in an adjacent arable soil (cultivated continuously for 11 years) and in a wilderness area which had never been used for agriculture).

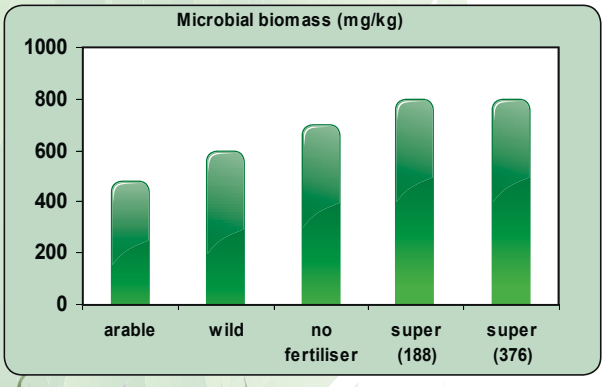
The same principle emerges. Continuous cultivation is very exploitive - most of the plant material grown is removed from the soil and very little food equals very few earthworms. Plant growth may be small on the used 'wild' soil but there was some recycling of plant material and hence the earthworm numbers were slightly higher. Replacing the 'wild plant' with pasture under grazing increases the food supply and hence the numbers of earthworms. And adding fertiliser (even, as



in this case, with that nasty 'acid' fertiliser, superphosphate for 37 years) increase earthworm numbers even because it increased total pasture production and hence the recycling of plant material.

Earthworms are only one of many organisms that live in soils. Healthy soils are in fact teeming with other life, particularly micro-organisms, such as bacteria and fungi. Indeed, it is estimated that a teaspoon of good quality soil contains about 100 billion bacteria! It is now possible to measure the weight of microbes - the microbial biomass in soils and the results below are from the same long-term field trial in Canterbury, mentioned above. And guess what - the more plant litter going back into the soil the more micro-organisms. They respond in the same way as the bigger soil critters do to an increase in food supply.

Taking a broader perspective, scientists at Ruakura undertook a major survey of the biological health of New Zealand pastoral topsoils in New Zealand in 1984. They measured the microbial biomass in 21 topsoils from throughout New Zealand. These were very fertile, high producing soils under pasture, which had been regularly fertilised for more than 20 years. The average microbial biomass (ie liveweight of bugs) was about 10 tonnes/ha with a range of 5-15. As the authors concluded: "The total weight of micro-organisms in fertilise topsoil under pasture is equivalent to about 25 cows/ha or 250 sheep/ha.



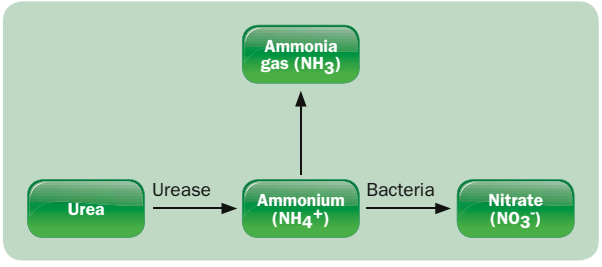
Obviously the "stocking rate" below the ground is far higher than above the ground." More descriptive perhaps, we could say that our soils are like Dolly Parton - well endowed!

There are literally hundreds of trials, nationally and internationally, which similarly demonstrate this simple principle: in pastoral soils the numbers of macro and micro organisms increases in proportion to their feed supply, which in turn is proportional to the amount of plant litter, and other excreta returning to the soil, which is proportional to the stocking rate, which in turn depends on the total pasture production. Any thing you do on the farm to increase pasture production - and that includes using those 'nasty' fertilisers like super, urea, DAP etc - is good for soil life.

My Advice?
When the salesman calls, tell him you know the truth!

UREA: VOLATILISATION LOSSES ON N

When fertiliser urea is applied to the soil, it hydrolyses - a fancy technical term meaning that it is converted from urea (not normally taken up by plants) to ammonium, by an enzyme called urease (see below). This normally happens within hours and days. Equally quickly, special soil bugs (bacteria called Nitrosomonas and Nitrobacter) convert the ammonium into nitrate (see also the article in this issue of The Fertiliser Review on Nitrification Inhibitors). Under normal conditions (ie in an aerated soil with a pH between 5.5 to 6.5), at any given time, there is very little ammonium present relative to the amount of nitrate.



Under some conditions ammonium from the urea is converted into the gas ammonia and which volatilises - goes into the air. This is not desirable because it decreases the effectiveness on the urea (ie lower production per kg N applied). [Note ammonia is not a greenhouse gas].

What conditions are required for this volatilisation to occur? First, the soil pH must be high - some authorities say > 6.3. Also, volatilisation increases with temperature and decreases with soil moisture content. Rainfall greatly reduces the risk. For example, on a moist soil in Canterbury with a pH 6.1, losses of

ammonia from urea (applied at 100 kg N/ha) after 3 days were 30%, 10% and 2% respectively, when the urea application was followed immediately by rainfall of zero, 4 mm and 16 mm. When the soil was dry the losses were typically about 30%. These experiments were conducted in the summer.

How do we apply these results to the more practical situation, were urea is applied at low rates (20-50 kg N/ha per application) during the autumn and spring? In the 1960s and 1970s hundreds of N fertiliser trials were conducted on pastures looking at their effects on autumn, winter and spring production. Many of these trials compared urea with other types of N fertiliser which do not volatilise ammonia (eg ammonium sulphate, calcium nitrate). The general conclusion was that urea was effective as these other types of fertiliser N (ie gave comparable DM responses per kg N applied). This suggests that under our typical New Zealand situations, ammonia volatilisation is of minor importance.

Similar comparisons have been done on pastures in the UK. Their results suggest that volatilisation losses from urea are about 5% in their autumn and 20% in their summer. To apply these results to New Zealand we must bear in mind that they generally use higher rates of fertiliser (100 to 400 kg/ha) and their soil pH levels tend to be higher (> 6.5). Both factors will increase volatilisation losses.

I think it is fair to conclude that ammonia volatilisation from urea under typical New Zealand situations (ie 20-50 kg N/ha per application in the autumn, winter and spring) are small (at worst 5-10% of the N applied). However losses are likely to be higher with summer applications (0-30%) and will be greatest when the soil is dry, the pH high (> 6.0) and there is no significant rainfall (< 16 mm within days) after application.

To minimise the volatilisation of ammonia from urea manufacturers have developed various techniques to reduce the rate at which urea hydrolyses: this includes coating the urea (eg with sulphur or resins) changing the chemical formulation to reduce its solubility, or adding urease inhibitors (eg Agrotain). These are all good ideas but unfortunately they add cost. Are they worth it? I see it this way. The maximum benefit that can be achieved from one of these sophisticated products is related to the size of the volatilisation loss. If you are a typical urea user (as described above) then a price margin of 10% above urea would seem appropriate. However in some situations, (summer applications, cropping, market gardening - any situation where high rates are used in warm conditions) a greater margin may be appropriate.

My Advice? Be wary of the salesman who tells you that you will get large benefits from using their specially treated urea which does not volatilise.

A CASE OF CONFUSING ADVICE?

Now and again I come across situations which cause me despair. This is one such case. Unsolicited, a dairy farmer called me. This farmer had recently had soil tests (3) and pasture analyses (2) taken from the farm. These results, together with the farm details, were then sent to seven fertiliser companies, inviting them to make recommendations. The local veterinarian was also consulted. Of the seven companies four visited the farm. All documented their recommendations which are summarised in Table 1.

The main points are:

1. One company recommended only liquid fertiliser and another recommended liquid fertiliser in conjunction with a solid fertiliser called 'Rok Solid'. This has a very low NPKS rating.
2. One company recommended their 'environmentally friendly, quick-acting, soil-friendly, reverted superphosphate, plus salt, and another took the opportunity to suggest a vermicast-based product (vermicast is an old English word meaning worm poo), plus salt.
3. One company recommended a low rate of super together salt.
4. One company made no recommendation, but requested further information, suggesting that Gafsa RPR was a cheaper option because no S was required.
5. Only one company said no fertiliser required, recommending instead a monitoring program.
6. The vet recommended no fertiliser but that the animals be supplemented with Se and salt. Concern was expressed at the high soil and plant K levels and further monitoring was recommended.
7. Four companies recommended the trace elements, Se and Co.

Confused and befuddled the farmer called me and asked for my opinon. After visiting the farm I summarised the soil and plant test information (Table 2).

Quite clearly the farm is very fertile and the levels of all the major nutrients, and the soil pH, are well above the range required for maximum production. Indeed, this soil has sufficient nutrient reserves to operate without further fertiliser additions for many years without losing any production. My guess is that no fertiliser would be need for 3-4 years but I would put in place a soil and plant testing monitoring program

to follow the soil nutrient levels as they are 'mined back' to the optimal range.

The key pasture test results, those that can impact on animal health, are given on Table 3.

Table 1: Recommendations from seven fertiliser companies and the local veterinarin are summarised below:

Company	Farm visit	Recommendation	Comments
A	no	"Organic 100" liquid fertiliser (25 l/ha), "Rok Solid" (300 kg/ha)	3 year program. "Rok Solid" is a solid fertiliser with NPKS rating[1] of 0.1, 0.8, 1.4, 0.1
B	no	DCP 10 (200 kg/ha), Agsalt (50 kg/ha), Se, Co	DCP10 is reverted super with NPKS rating[1] of 0, 10, 0, 6
C	yes	Superphosphate (100 kg/ha), Agsalt (100 kg/ha), Se, Co	
D	no	Liquid fertiliser; chelates of Ca (2), Mg (2), Na (3), B (2), Co (0.3), Se (0.1), I (0.2).	Figures in brackets are litres/ha
E	yes	Revital Ultimate (600 kg/ha), Agsalt (50 kg/ha), Se, Co, B	Revital Ultimate is a vermicast-based product with an NPKS rating[1] of 1.1, 1.5, 0.3, 0.5. A further application of similar product is recommended in the autumn
F	yes	No P, K, S, Mg or lime	Monitoring program recommended
G	yes	No specific recommendation	Required more information but suggested to use Gafsa RPR if applying any P. Concern re high pasture K
Veterinarian		Se (to fertiliser and drench), Na (drench)	Concern re high K levels in pasture

Notes: 1) the NPKS rating is the N, P, K and S content expressed as a %

Table 2: The essential soil tests results arel summarised below:

	pH	Olsen P	K	Sulphate S	Organic S	Mg	Na
Average	6.2	72	18	25	14	52	5
Optimal	5.8 - 6.0	35 - 40[1]	7 - 10	10 - 12	10 - 12	8 - 10[2]	3 - 4

Notes: 1) assuming a goal of near optimum production.
2) 8-10 for maximum pasture production but soil Mg needs to be 25-30 to minimise the incidence of hypomagneseamia.

Table 3: The key pasture test results, those that can impact on animal health, are given below:

	Concentration (%)			Concentration (ppm)					
	Mg	K	Na	Co	Se	Cu	Mo	B	I
Average	0.27	4.2	0.08	0.07	0.04	12	0.60	7	0.41
Optimal	> 0.20	2.5-3.0	> 0.10	0.04	0.03	8-10	< 1.0	15-16	0.15-0.50

Note that these results are for mixed pasture samples collected in autumn. This needs to be considered when interpreting these results. The key points I think are:

1. The Co and Se levels are marginal. This may not be a problem if the animals are being supplemented directly. But, it is cheaper to get these trace elements into the animal via the fertiliser than by direct supplementation. Therefore, I would recommend both these trace elements..
2. The Na levels are low. But, pasture Na levels are notoriously variable. I would not panic, but routinely test pasture Na levels. If they are consistently below 0.10% then directly supplementation is required. This is cheaper than trying to increase pasture Na levels with salt.
3. The B levels look low but once again they can be variable. Since B is not required by animals, I would not worry about B if the pastures looked healthy (ie plenty of clover).
4. The potassium levels are on the high side. But once again do not panic. Pasture K levels can be higher in the summer and autumn. Once again I would want to collect more information before I made a prognosis.

The other point I would bear in mind when interpreting this information is: How are the cows looking and milking? In this case this herd was in excellent condition, well feed and in good heath. There had been, and were no, health problems in this herd.

Returning now to the advice offered. In my opinion this farmer would have been wasting money if the advice from companies A,B, C, D and E had been accepted. The vet got close, but then again remember he sells supplements. One company (F) got it right in my view.

My Advice? One in seven are not good odds for getting the fertiliser program right. In fact your neighbour is more likely to be a better source of advice! So tread carefully. To help you do this, complete the decision tree (on Page 5):

Questions for the Salesman?

MAGIC BULLETS?

NITRIFICATION and UREASE INHIBITORS: Eco-N, Ncare, Taurine and SustaiN

Environment Waikato and Bay of Plenty recently commissioned a report from agKnowledge Ltd on nitrification and urease inhibitors: what are they? what do they do, how do they work, and how effective are they? Recommendations for further work were also requested.

The peer reviewed report was tabled at a meeting of the Environment Committee of Environment Waikato on 11 August 2004. Copies are available from Environment Waikato PO Box 4010, Grey Street, Hamilton 3247 ($20 per copy).

Given that the report is publicly available there is no need to repeat it again in The Fertiliser Review. Some of the more interesting points are as follow:

1. The idea of using such chemicals to reduce nitrate leaching and/or gaseous losses of N, goes back more that 50 years in the scientific literature. Although 'new' to us in New Zealand, some of these chemicals have been used, particularly in the USA, for 40 years.

2. Hundreds of field trials measuring the effects of these chemicals on crop production, nitrate leaching and gaseous losses have been reported in the international literature, mostly from North America and Europe. The results are variable.

3. As far as New Zealand is concerned DCD is the most popular nitrification inhibitor and is the active ingredient in the New Zealand products, EcoN (Ravensdown Fertiliser Co-operative Ltd), NCare (Ballance AgriNutrients Ltd) and Taurine (Summit-Quiphos Ltd - yet to be relaeased) product (EcoN).

4. Agrotain is the only commercially released urease inhibitor and is an active ingredient in SustaiN (Summit-Quiphos Ltd).

5. New Zealand research began in 1995 and to date 14 experiments have been conducted. These are mostly small scale plot trials or lysimeter studies, focussed in one region (Canterbury). It is difficult to extrapolate these results to the typical on-farm field situation.

6. Collectively the strongest conclusion, based on the international and national research currently available, is that the 'concept is proven' - these products look like useful tools to manage the twin problems of nitrate leaching and gaseous losses. Further full scale field research is however required covering all the combinations of soil and climate in New Zealand before science will be in a position to provide farmers with robust information on the costs and benefits of these chemicals.

My advice: I was asked during question time: Doug you provide fertiliser advice to farmers all over New Zealand. Would you recommend these products at this stage? My answer: No, wait until further large scale research has been completed and the results are in. In the meantime continue to apply all those best management practices you know about (eg not overdoing fertiliser N inputs, applying the correct amount of N fertiliser at the right time etc).

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