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"The Independent Fertiliser Experts"

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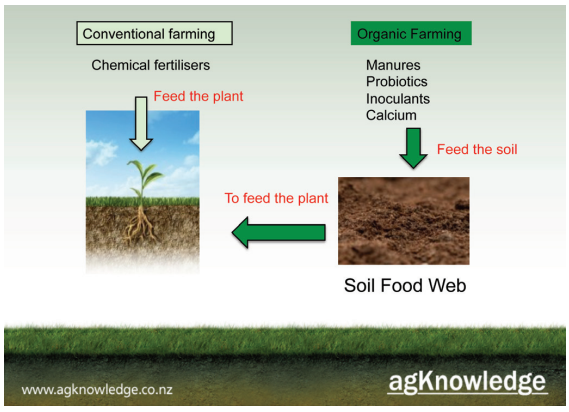
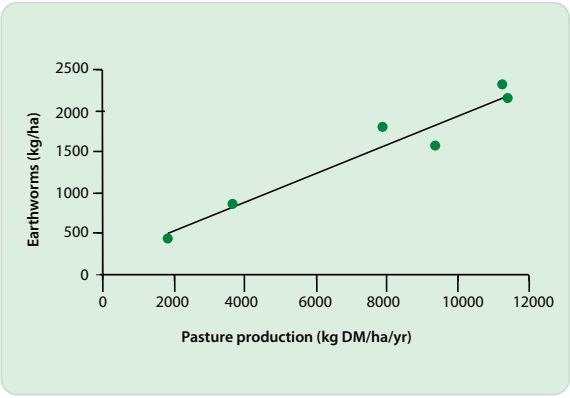
FEED THE SOIL VERSUS FEED THE PLANT?

Those who espouse Organic and/or Biological Farming claim that the way to increase soil production and enhance soil and food quality is to "feed the soil". By that they mean add manure, humates, inoculants, probiotics and calcium to stimulate the soil biology (they use the term the "soil food web"). They claim that if this is done it will unlock soil nutrients thus feeding the plant. They reject the classical view of soil fertility and plant nutrition which requires undertaking soil and plant tests to identify which if any nutrients are deficient for the crop of interest, and adding these nutrients to optimize plant growth (see diagram). This can be referred to as "feeding the plant." Who or which is right?

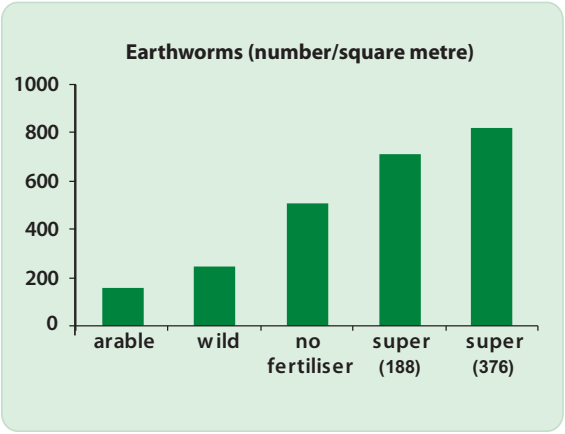


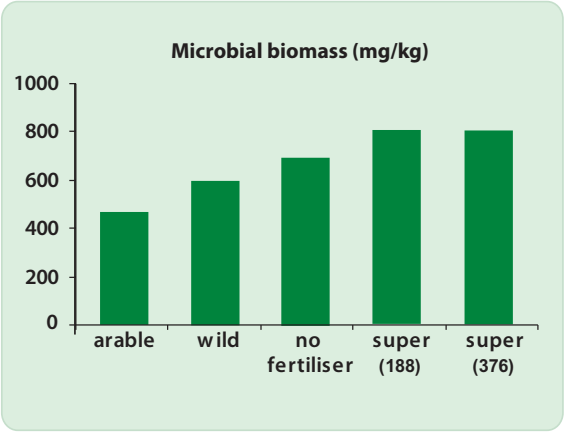
Consider this: Assume you are growing 10 tonnes/ha of pasture DM annually and utilising 80%. Where does the 20% (2 tonnes) go? The answer; into the soil. About half of this is carbohydrate (sugars). This is the food for all the critters (big and small) in the soil-food-web – soil biomass is a better term. As pasture production increases so too does the amount of biomass 'food' going back into the soil.

This fact is clearly illustrated in one of the earliest soil fertility trials in New Zealand. This trial was on a very infertile soil and by adding fertiliser (P, K and S in this case) and returning the dung and urine, pasture production increased and with it, so did earthworm numbers (see below).



The results from the long-term trial in Canterbury demonstrate the same point (see below). Correcting the soil P and S deficiencies (in this case by applying super) resulted in more pasture growth and more residues returned to the soil, thus increasing earthworm and biomass numbers. This is the way our pasture system works - feed the pasture and the rest (the soil organic matter and soil biomass) will look after itself.





Can it possibly work the other way – feed the soil (i.e. the soil biomass) and everything else, including plant growth, will be optimised? Certainly adding heaps (+10 tonnes/ha) of manure or compost to infertile soils will increase plant growth but this is the same as adding nutrients as chemical fertilisers. The manure or compost is simply a carrier of nutrients and it is known from long term trials that adding manures and fertiliser at the same rate of nutrient application results in the same yield (see Fertiliser Review No 4).

What about adding calcium (Ca) to feed the soil bugs? Our New Zealand soils have an abundance of Ca and further additions are most unlikely to have any effect (Fertiliser Review No 7). The same applies to adding soil inoculants (preparations of soil bacteria or fungi) (see Fertiliser Review No 8). Pastoral soils are already teeming with these micro-organisms and any added new ones will simply get swamped out by the existing populations. Which leaves probiotics, things like soil tonics, liquid fertiliser made from seaweed, or fish or other biological materials. These products simply do not have sufficient of anything to stimulate the soil biomass (see Fertiliser Review No 29).

The last point to emphasis is that soils do not make nutrients, they only store them. The nutrients removed from the land in products etc must be replaced and if you are not doing this you are going backwards, mining the soil.

My Advice? Be very wary of those sales folk coming up the drive who claim that their magic brew, snake oil, probiotic or soil tonic is designed to stimulate the soil microbial activity and that this in turn will unlock nutrients and increase plant and animal production and health.

MORE SOIL TESTING PROBLEMS

I have highlighted elsewhere (see Fertiliser Review 23, 27) problems arising when soil testing protocols are not followed and the gimmick of All Paddock Testing (APT). Here is another example.

A client contacted me. He was concerned that his pastures were deteriorating. Could I help? It was obvious to me during the farm visit that the pastures where poor. They lacked vigour and the clover content was poor. The pastures exhibited all the symptoms of potassium deficiency.

After going around the farm, and with the input from the farmer, we selected 5 paddocks that represented the various blocks (areas of different history, land use, slope and pasture composition and vigour) on the farm. This is the tried and true way of taking into account the variation in soil fertility across a farm.

From these results the farm could be divided into 2 blocks. The Effluent block was quite clearly different from the remainder of the farm and the results from the other 4 samples were similar, allowing for the normal variability in soil test results. It made sense therefore to average these results into one block. The results are summarised below relative to the optimal ranges.

Block[1]	Olsen P	K	Sulphate S	Organic S	Mg	Na	pH
Main (4 paddocks)	28	5	12	15	23	6	6.3
Effluent (1 paddock)	22	9	52	15	41	4	5.9
Optimal[2]	35-40	7-10	10-12	10-12	8-10 (25-30)[3]	3-4	**5.8-6.0**

Notes: 1) Note that where more than one sample is collected per block the average is given.
2) The optimal ranges required to maximize long-term profitability.
3) The range in brackets is the requirement for animal health.

The Olsen P levels were below the optimal range on both blocks. This would be limiting clover growth and hence total pasture production. More importantly the Main block – most of the farm – was potassium (K) deficient. This was consistent with the visual symptoms of nutrient stress in the pastures. Remember the only way to 'ground-proof' a soil test is to visually assess the pastures – they should be consistent.

I then learned that this farmer had all the paddocks on the farm (45) soil tested by the local Ballance AgriNutrients (BAN) rep. This information enables several comparisons to be made. The results from the 4 non-effluent paddocks sampled by either agKnowledge or BAN are shown below. The results obtained by BAN especially for P, K and Sulphate S were inflated relative to the agKnowledge results. In particular the average soil K level from the agKnowledge samples was 5 indicating soil K deficiency consistent with the visual symptoms in the pasture. Based on the BAN results K was not deficient.

Paddock	Sample	Olsen P	K	Sulphate S	Organic S	Mg	pH
7	agK	31	3	7	15	27	6.4
	BAN	**37**	**5**	**24**	**14**	**29**	**6.6**
20/21	agK	24	4	21	15	22	6.4
	BAN	**35**	**14**	**51**	**15**	**33**	**6.4**
26/27	agK	33	8	10	13	20	6.1
	BAN	**44**	**19**	**35**	**15**	**30**	**6.2**
33	agK	25	5	12	15	23	6.3
	BAN	**24**	**8**	**37**	**10**	**30**	**6.3**
Average	***agK***	***28***	***5***	***12***	***15***	***23***	***6.3***
	BAN	***35***	***12***	***37***	***14***	***31***	***6.4***

In other words if the farmer was to rely solely on the BAN results he would be given the impression that the soil fertility on his farm was fine when fact it was not.

The same upward bias in the soil test results, especially K, is apparent when the average results from all 43 paddocks are compared to the average of the 4 samples collected from representative areas on the farm by agKnowledge.

	Olsen P	K	Sulphate S	Organic S	Mg	Na	pH
BAN (43 samples)	34	9	35	11	28	5	6.4
agK (4 samples)	28	**5**	**12**	**15**	**23**	**6**	**6.3**

This upward bias in soil test results occurs when the proper soil testing protocols are not followed. All excreta patches and other nutrient-rich areas must be avoided when soil testing. If soil tests do not match the pasture assessments (assuming they are done by an experienced practitioner) then the tests should be thrown out. Once again the farmer was probably lulled into a false sense of security thinking that, because all the paddocks had been tested, he could be confident about the soil nutrient levels and hence his fertiliser program. Nothing could be further from the truth. It cost the farmer $3,000 to have all his paddocks tested - $3 grand only to be misled!

BIOLOGICAL FARMING – WHAT IS IT?

It is a good question – is it different from organic farming? The NZ Dairy Exporter (January 2014) contains an article by Phyllis Tichinin, who is a self proclaimed Biological Consultant. The article is entitled "Re-Energising the Farming System." Apart from wondering what the title actually means, I read it with great interest thinking it may contain the answer to the question. Here is what we are told and my analysis.

First we are told that biological farming is about *"improving profit, yield and soil quality with fewer chemical inputs."* This sounds like conventional farming, does it not? Most farmers are driven by reducing inputs costs, improving profits and at the same time looking after their soils.

Later we get, biological farming is consistent with *"restoring the integrity of the soil microbiology."*

What does that mean - our soil microbes have lost their integrity? If the statement is intended to convey the view that the microbial activity in our soils is poor then it is inconsistent with known science. Our NZ soils and in particular our pastoral soils are teeming with biological activity.

More specifically we get this definition: *"Biological farming is a systematic approach to getting all the mineral building blocks, not just nitrogen, phosphorus and potassium, available to the plant for optimum growth."* Who is going around saying the plants only need N, P and K. If this is so why then does the fertiliser industry sell other nutrients such as sulphur, magnesium, and molybdenum? Indeed plants require 16 nutrients and you can get them all from your conventional fertiliser company.

Ms Tichinin goes on to assert that by getting the mineral building blocks in place *"allows microbes to thrive"* and *"they contribute natural growth stimulants, nitrogen, phosphorous, antibiotics and communication enzymes to the crop."* This argument repeats one of the old assertions of the organic movement: *"feed the soil"* (i.e. the soil biology, the soil food web) they say and in turn that will feed the plant. This is not how the soil-plant system works (see earlier article).

She states that *"The real difference is biological farmings emphasis on reaching certain calcium to magnesium ratios to create more open, aerated soil encouraging good drainage, root growth and microbe comfort."* This is nonsense. What is microbe comfort and in any case there is no such thing as an ideal ratio of calcium to magnesium and changing this ratio does not affect soil structure! (see Fertiliser Review No 26).

She claims that *"Conventional agricultural scientists generally think that the calcium in lime is mostly useful for raising the soil pH."* Once again this demonstrates a woeful ignorance of basic chemistry. Calcium does not change the pH, it cannot. The active ingredient in lime is not calcium, but the carbonate – it is the carbonate that changes the soil pH.

She claims, *"Biological consultants don't assign as much importance to soil pH and instead focus on calcium/lime as a way to stimulate soil microbe communities."* I agree that lime stimulates microbial activity, but as my own research shows, this occurs because lime increases the soil pH and soil bugs are most active at a pH of 5.8-6.0. When it comes to soil acidity and liming, soil pH is everything and calcium is irrelevant because our soils have heaps of calcium – calcium deficiency has never been reported in NZ.

She goes on: *"Biological farming combines an understanding of soil chemistry, physics and microbiology with sound farm management practices to address and solve soil structure and plant nutrition at their root cause."*

It is clear to me from the examples above that the opinions she propagates as a Biological Consultant are not based on an understanding of soil chemistry, physics and microbiology.

Finally she claims *"Biological farming is certainly science, but it is holistic, cutting edge science."* I strongly disagree - the biological farming she describes in this article is pseudo–science. Yes it uses scientific terms and phrases but none of these are supported by evidence. It is hollowistic nonsense. Why the Exporter reports this drivel is beyond me.

An Important Aside: My colleague Dr McBride, who has worked in the organic industry in the USA, suggests that there is no difference in practice between Organic farming and Biological farming except that Organic farming has a quasi-legal definition, which requires endless paper work. Biological farming is simply Organic farming without the hassle!

PHOSPHATE ROCK RESERVES – SUSTAINABLE?

New Zealand's agriculture depends on the application of fertiliser the most expensive of which is phosphorus (P) which costs about $3.20/kg P. New Zealand imports about 1m tonnes of phosphate rock most of which is used to make superphosphate and in addition NZ imports made-up DAP and MAP mainly for use on crops. Given the importance of phosphate rock to NZ farming I am often asked: "will we ever run out?"

A recent paper in "Better Crop" sheds some light on the issue. Starting in 1847 (this is essentially the starting point for the fertiliser industry) about 500 tonnes of phosphate rock (PR) was used commercially worldwide. This progressed to about a 100 m tonnes in 1974. Today the world uses about 210 m tonnes annually.

The authors make the distinction between PR Reserves and PR Resources. The Reserves are an estimate of how much PR there is which can be economically produced (mined) with today's technology. The PR Resources are the total amount of PR of any grade, and including current PR Reserves, that may be produced (mined) in the future.

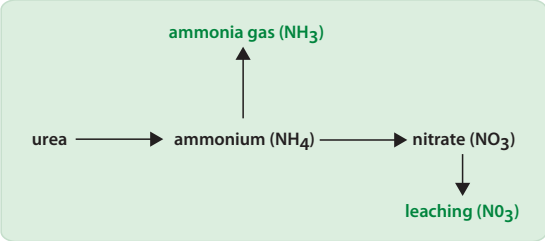
The PR Reserves are estimated to be 60,000 m tonnes and at the current rate of consumption there are 300 years of reserves – about 15 human generations. However the known Resources are such that there are about 1,400 years of supply – about 70 generations. If the climate alarmists are right we may well be pyrolysed by then, or alternatively, if the sceptics are right, we may have frozen to death in another ice age.

SUSTAIN

SustaiN (often referred to as SustaiN Green) was originally introduced onto the New Zealand market by Summit-Quinphos which subsequently became Altum which is now subsumed into Ballance AgriNutrients Ltd.

This product has been discussed more often than any other over the years in the Fertiliser Review (see Fertiliser Review 15, 22, 24, 28, 30). It is back in the lime-light because it has been heavily promoted by Ballance AgriNutrients Ltd this autumn. Accordingly, farmers are more aware of it and are asking questions.

SustaiN is urea, coated with a chemical called agrotain, which is a urease inhibitor – it slows down the conversion of the urea, to ammonium (NH^+_4) and hence to nitrate N (NO^-_3)



In theory this should, at least in some circumstances, reduce the volatilization of ammonium (NH^+_4) in the soil solution to ammonia gas (NH_3) and hence increase the efficiency of urea N – more pasture or crop production per unit N applied. The technical term is Nutrient Use Efficiency (NUE).

There are 2 ways of measuring the effectiveness of SustaiN relative to urea. Losses of ammonia gas can be measured *directly following the application of urea or SustaiN to the soil. This is normally done in small enclosures placed on the soil from which the volatilized ammonia gas is captured and measured. Alternatively it can be measured indirectly* by comparing the effects of urea or SustaiN on pasture or crop production. If there is no difference in the relative production is can be inferred that either treating urea with agrotain is ineffective or that ammonia volatilization is not occurring to any practical extent.

Indirect Agronomic Approach

At the 2012 Grasslands Conference in Gore we (Dr Robert McBride and myself) published a summary of all the field trials we could find at that time comparing SustaiN with urea. There were 16 trial-years of data and the average difference between urea and SustaiN was 4%, with a range from -25% to + 53%, and a confidence interval of +/-4%. Note that the confidence interval from -4% to +4% includes zero and that most of these trials were conducted during the spring, autumn and winter period using low rates of urea N (< 100 kg N/ha).

[Note: when comparing 2 treatments, say A and B, in a number of field trials, there will always be a range in the measured differences between the treatments. This is due to the natural variability in pasture and crop production (i.e. not every trial gives exactly the same difference i.e. 'response'). If product A is always better than B then there will still be a range of responses but they will always be positive. The problem arises when the difference between A and B is not large, relative to the background noise which is typically +/- 5-10%. This is the situation above where some of the measured differences between SustaiN and urea where negative and some were positive and the range straddles zero. If nothing else this tells us that the agronomic differences between the products is small and probably within the range of experimental error].

Two conclusions can be drawn from this agronomic data viz:

- There is no agronomic difference between SustaiN and Urea when applied at the same rate of N. This is consistent with the confidence interval of +/- 4% containing zero.
- More charitably, these results are consistent with an average response to SustaiN over Urea of about 4%, which suggests that the volatilization of ammonia N from urea is small (about 4%) when urea is applied in spring, autumn and winter at rates < 100 kg N/ha.

Direct Measurement

Turning now to the direct measurement of the volatilisation of ammonia from urea in the field.

The first such experiments in NZ were conducted in Canterbury by Scott et al in the 1980s, in the summer please note. (I will refer to this as the Scott research). Losses due to volatilisation of ammonia from urea increased with increasing rate of N applied from about 12% (30 kg N/ha/application) to above 30% (200 kg N/ha). They also reported a strong seasonal effect - at 30 kg N/ha/application, losses where 7-11% in August-September and about 13-15% in summer and autumn.

In subsequent trials also conducted in the summer they measured losses of N due to volatilisation (after 8 days), from a soil at field moisture capacity, of about 2% (16 mm water applied within 3 hrs after urea applied) up to 33% (no water applied). In all these experiments the equivalent of 100 kg N/ha was applied.

Other researchers at Lincoln University also reported a strong seasonal effect on the losses of ammonia N from urea, applied, please note, at 500 kg N/ha: 18% (summer) 29% (autumn) and 8.5% (winter). They also reported that factors most affecting the volatilization losses of N were soil pH (following urea application) and temperature.

Just recently Ballance AgriNutrients Ltd published the results of an experiment conducted under contract by Landcare. (I will refer to this as Zaman's research). Once again these trials were conducted in the summer. They reported losses of N of about 18% (30 kg N/ha) and 22% (60 kg N/ha) and that these losses could be reduced to 6-11% if 10 mm of water was applied 8 hr after application of the urea. Their results also showed that the N volatilization losses from SustaiN where reduced by 50% relative to the same rate of urea.

Without going into the details these New Zealand results are similar to those reported overseas and combining all this information it is reasonable to conclude:

1. Volatilization losses of ammonia from urea are determined by soil pH, soil temperature, rate of urea N application and time after application.
2. In practice this means losses of N from urea can exceed 30% at rates of N application of > 100 kg N/ha (217 kg urea/ha/application) when applied in warm moist conditions (i.e. as may occur in summer and autumn).
3. For rates of application of urea N of < 60 kg N/ha (< 130 kg urea/ha) applied in warm moist conditions (i.e. as may occur in summer and autumn) the losses are in the range 10-20%.
4. There is no research measuring the direct losses of N from urea at rates < 60 kg N/ha in the seasons spring, autumn and winter.

Thus, there is a large gap in current knowledge especially given that most of the urea used in NZ is applied on pastures during spring, autumn and winter typically at rates of 20-30 kg N/ha (i.e. < 60 kg N/ha). In the absence of any direct measurements the best we can do is accept the inference from the indirect field trial measurements, which suggest that the volatilization losses of N under these conditions is low (about 4% maximum).

Claims Made by BAN

There are two promotional brochures in the market at present. A smaller one is entitled "SustaiN", subtitled "Powered by AGROTAIN". It is claimed that SustaiN

Green is proven to reduce ammonia volatilisation by 50%. This is only true if it qualified to say that this applies only to summer application when urea losses are predictably higher than for other seasons. This qualification is not offered.

Later in the brochure there is this interesting table:

Application Rate	Conditions	Expected Volatilization loss
Less than 50 kg N/ha	Best practice (good soil moisture, 5 cm or more of pasture cover, light rainfall following application).	0-5%
Less than 50 kg N/ha	Typical conditions (not optimal, not adverse)	10-15%
Less than 50 kg N/ha	Adverse conditions (dry, no rain following application, poor pasture cover.	20-40%

This table appears contrived. First there is no research in which volatilisation losses of N from urea has been measured at rates of < 60 kg N/ha in spring, autumn and winter. If this table has relevance at all it applies only to summer applications of urea in which case it is unlikely that there is a farmer out there who would apply 108 kg urea/ha (50 kg N/ha) in a single application in the summer when the pasture is not growing!!!! It has to be asked what is the point of the brochure if not to create an illusion of knowledge where there is none.

The second brochure is even more bewildering. It is a larger A4 offering entitled *"SustaiN Green"* subtitled "AGRESEARCH TRIAL SUMMARY, Assessment of agrotain-treated urea in pasture nitrogen response trials". It provides graphics of the results reported by Black and Zaman (referred to above) and then goes on to discuss these results in relation to 5 recent field trial comparing SustaiN and urea, undertaken by agResearch on behalf of Balance AgriNutrients Ltd.

The wording in the Brochure, which describes these results is not convincing:

"Aggregated by season and overall, although not statistically significant there is a consistent trend for SustaiN Green to outperform urea…" And "The "Overall average" effect aggregated across all applications and all sites indicated an 8% increase in N response efficiency (kg DM/kg N) for SustaiN Green over urea. Again, although not statistically significant due to the high variability in individual applications, this is consistent with what would be expected based on reduced ammonia volatilization."

Curiously the brochure states that these trials were designed to test if there was any agronomic benefit of SustaiN Green over urea *other than that attributable to a reduction in ammonia volatilization* (my emphasis). Now it is being suggested that SustaiN does other things besides reducing volatilisation? Just what that may be is not clarified.

The brochure then goes on, quite illogically, to draw the following conclusion: SustaiN reduces volatilisation of 50% (based on Zaman summer experiment) and that urea volatilisation is about 10-15% (everyone knows this, it is claimed), therefore the 8% difference between SustaiN and urea found in these 5 field trials is due to effects other that the volatilisation. Quite frankly this is unbelievable junk science.

My Advice: In my opinion BAN has not proved its claim that SustaiN enhances the efficiency of urea N use when urea is used as recommended in most pastoral situations.

STICK WITH SCIENCE (contributed by Dr Robert McBride)

[**Editors Note:** *Robert, who graduated PhD in soil science in America has now been working for agKnowledge Ltd in the South Island for 3 years. This is his take on the current situation in NZ*]

I was recently told by someone that "there is so much about soils that we just don't know" (they had just attended a session on soils at biological farming conference).

On the one hand the statement is true; the structures of certain organic molecules for example are not fully understood. However, speaking from a practical agricultural standpoint the statement is utter nonsense; soil science as a discipline has been studied since the 1880's and the earliest and most intensively studied area has been soil fertility. In fact, soil fertility has been studied at such great lengths that currently there is very little research taking place. In New Zealand there were research institutions dedicated to studying soil fertility and many thousands of experiments were carried out in every province and optimum soil nutrient levels for pasture were determined long ago. These studies have been summarized and response curves published.

If you have good soil test information, the nutrient inputs needed to achieve a given level of pasture production are predictable.

The problem farmers face most definitely in not a lack of information, it is a lack of access to and the ability utilize the information that is now shelved collecting dust. Again, soil has been extensively studied for well over 100 years and practically speaking there are no deep dark mysteries waiting to be unlocked. For example, dicyandiamide (DCD) was 'discovered' by Lincoln researchers and heralded as a breakthrough and subsequently patented and sold in New Zealand starting in 2004. In fact this 'new' discovery was not at all new. The effect of DCD on soil nitrogen was first studied back in 1913. It was comprehensively studied in the 1950's, and used commercially as a nitrate inhibitor since the 1980's. Not exactly cutting edge; there are heaps of DCD studies collecting dust on shelves all over the world, just as there are with every other aspect of soil fertility.

Why then, with all this information, are farmers frustrated by underperforming pastures while continuing to pour on heaps of fertiliser? The short answer is that the wrong fertiliser is being used. Plants respond to the most limiting nutrient, and unless that nutrient is in the mix there will be no improvement. If your pasture is low in K and your fert rep tells you that "K is expensive and doesn't pay" (and I hear this a lot) that is exactly wrong; if K is the most limiting nutrient, K is the only thing that pays. You can put on as much super as you want, but it will have no effect until the K deficientcy is remedied.

The long answer is that very little fertility research is taking place because political pressures (and thus funding) are almost entirely focused on environmental issues. As a result there is little if any practical hands-on-training in pasture nutrition and soil fertility at universities or anywhere else. The people with the technical backgrounds and field experience have moved up into management positions or retired. Fert reps, once employed for their technical skills, simply do not have the experience or training, and their focus is on things like nutrient budgets and sales quotas.

The consequences can be seen down any rural road travelling at 100 kilometers per hour; weak, hungry pastures sprinkled with bright green dung and urine patches. In desperation farmers turn to urea as an effective but short term and expensive solution, or they try magic minerals and liquid potions which are generally ineffective and always expensive. When farmers get really desperate they rip it all up and plant

agKnowledge and The Science of Farming

some new species which look good for a year or two and then it reverts right back to the same rubbish it was before –which is the only thing that will grow when there is a nutrient deficiency.

In summary everything that needs to be known about fertility in regard to growing economical high producing pastures is already known and well understood. The fact that most pastures are not performing is simply a lack of application of that knowledge. Science has had the answers to pasture fertility for a long time, so don't become an N addict, don't waste your money on voodoo, and don't wear the tractor out regrassing; go with good science, it works.

Dr. Doug Edmeades

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