agKnowledge
"The Independent Fertiliser Experts"

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THE BIG CHALLENGE

The Minister for Primary Industries, the Hon Nathan Guy, has throw down the gauntlet to New Zealand's pastoral sector: **increase productivity by 50% by the year 2025.** Achievable or simply aspirational? I'm going to stick my neck out and say – **definitely achievable.** Why such confidence?

Confining myself to my area of expertise - soil fertility and pasture nutrition - I know there is currently a large untapped opportunity staring us in the face – it is called optimizing clover-based pasture production by optimizing the soil fertility. No new science is required. All we need to do is apply the proven technology developed since the 1950s, and refined in the 1990s, on how to grow high producing white clover pastures. No excuses, no ifs and buts. Just do it. My bullishness in founded on the following threads of information.

Client cases

About 70% of the farms I have visited, and assisted, in the last 10 years have what I call unbalanced soil fertility – one or a combination of the 16 nutrients required for plant growth (See Fertiliser Review No 16) are missing. Deficiencies of potash (K), sulphur (S) and Molybdenum (Mo) are the biggies. Consequently the clover has, or is, disappearing. Remember clover has a higher requirement for all nutrients relative to grasses AND can only grow as fast as the most limiting nutrient. If the soil fertility is not balanced clover growth will suffer.

Nutrient deficiencies limiting clover growth are a double whammy economically for the farmer, because not only do clovers provide free N (about 200kg N/ha/yr in a good pasture), but it is also a better stock food (more animal production per kg clover DM). Furthermore, it cost only about 4-5 cents/kg DM (marginal costing based on current costs). It is the cheapest ruminant feed on the planet.

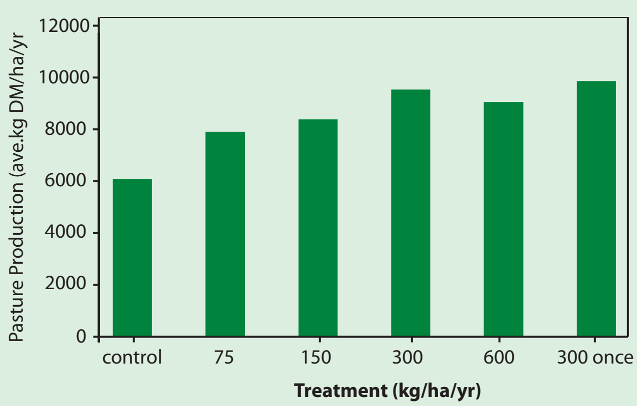
The dairy industry is largely oblivious to this problem because they are simply compensating (covering up) poor pasture performance with fertiliser N and supplementary feeds. This is consistent with the fact that recent survey data shows that for the average farmer feeding costs have increased from $0.80 to $1.4 per kg MS produced. The sheep and beef sector cannot normally exercise this supplementary feed option, hence many of them are left in despair – they know that their pastures are not pulling their weight, they know that the clover is disappearing but they cannot find solutions from the normal sources – i.e. the fertiliser industry. Sadly, many are being drawn into the arms of the quack merchants, in their desperate search for solutions.

In short, we have lost sight of the importance of our white clover pastures and we have lost the necessary technical skills. The problem is, in my view, widespread and it demands urgent attention.

Recent Field Trials

The second piece of evidence comes from 2 recent field trials in which I have been involved. Both were established to demonstrate to farmers the benefits of optimal soil fertility and to show them what nutrient deficiencies look like. That is to say, the sites were not specifically chosen because they were nutrient deficient. We were looking at the effects of optimizing the soil fertility (balanced soil fertility) on two commercial farms.

One trial was on a large dairy farm. The owners were told by their fertiliser co-operative that, although the soil K levels were low (Quick Test 4) it was not possible to increase soil K and that, in any case, correcting the low K levels was not economic. With funding from Ballance AgriNutrients Ltd a field trial was established looking at the effects of increasing K inputs on pasture production. The results are shown in the graph below: the average (over 3 years) increase in pasture production resulting from correcting the soil K deficiency was about 30-40%. This was mainly expressed in an increase in clover growth (see photo).

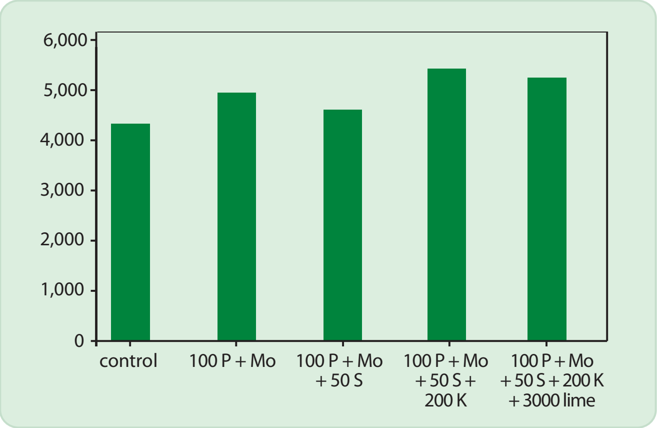


The effects of increasing potassium application on a pumice soil with a soil K level (control) of 4

Effect of potassium application on pasture production (plot on left is QTK = 4, plot on right QTK = 8)

The second trial was on an intensive beef property on a sedimentary soil. This farmer was becoming increasingly concerned that his pastures were deteriorating – decrease in clover content, more weeds and an over all lack of vigour. He called in the experts who advised him variously that the problem was due to soil compaction, or soil hydrophobicity, or poor pasture species, or lack of calcium. The list was extensive.

We (the farmer, his group of mentors and Mr Bob Tompson his Consultant from Northland) decided (with financial help from Ballance AgriNutrients Ltd) to put down a trial. The soil nutrient levels were: pH 5.7; Olsen P 28, QTK 5, organic S 11. The trial contained the following treatments: control, optimal P, optimal P+Mo, Optimal P+Mo+S, Optimal P+Mo+S+K and Optimal P+Mo+S+K plus lime. The purpose of the trial was to demonstrate to this farmer what optimal soil fertility looked like in terms of pasture production composition and vigour. After 12 months the pasture response to optimal soil fertility (100P+Mo+S+K) was about 25% (see below).



Visual Impact

Soil fertility and pasture nutrition is a well-developed science in New Zealand. Since the 1950s literally thousands of field trials such as those described above have been conducted, dotted all over New Zealand. And many farmers would visit these trials and see for themselves what pasture nutrient responses looked like, and importantly, what a pasture should look like when the soil fertility is optimized. However, no such trial work has been done in the last 20 or so years and thus we now have a generation of farmers who, without this visual prompting, have lost sight of what good soil fertility and pasture nutrition looks like. This then, is the value of the trials described above – they have enormous visual impact and I would like to see a series of such demonstration trials dotted around the country to fill this void. Such activity these days is called 'technology transfer. '

Excuses, Excuses, Excuses.

As discussed elsewhere (see Fertiliser Review 23) clover has a higher requirement for all nutrients relative to grasses. For this reason clover is the first pasture component to disappear if the soil fertility is not optimal. In my experience poor soil fertility is the major reason for the poor clover growth in New Zealand pasture. But what do I hear? Excuses, excuses, excuses!!! I have grown tired of hearing all the reasons why we now cannot grow good quality, persistent clover-based pastures.

We are told it is droughts (funny how quickly healthy clovers recover), insect pests (yes they come and go and cause local damage for a time). Then there is a bunch of soil physical and biological factors offered as excuses: no soil bugs, soil compaction, soil pugging, soil hydrophobicity. And don't forget all the theories the seed merchants come up with; wrong cultivar, no endophyte, wrong sowing time. I despair, the list appears endless: it seems that some people will believe that the seed went on upside down, or that the rain is not as wet as it used to be! And the people who benefit from all of this nonsense are the seed merchants and those who sell fertiliser N and pesticides.

I do not accept this nonsense. As I said to a group of Consultants recently "given the right soil fertility white clover is a weed!" Yes, there are exceptions (< 800 mm of rainfall is one I will accept) but by and large most farmers could do well to remember this simple rule. It is my opinion that the major cause for lack of pasture persistence is poor soil fertility and hence poor clover growth and hence lack of N for the grasses.

Prognosis

NZ Pastoral Industry Inc. needs to relearn the importance of the clover-based pasture and how to grow it. If we did just this one thing right we would get ourselves close to the Minister's goal.

How to make that happen? We cannot rely on the Fertiliser Co-operatives. I have been telling them what I have been finding on farm for many, many years – I am dismissed as some old broken-down, passed-use-by-date, scientist. In any case the fertiliser industry is busy at the other end of their business called environmental compliance, which for you farmers means nutrient budgets and Farm Nutrient Plans.

Come to think of it many in the private consulting business are also busy in this space.
The point is this. Production research and extension was shut down in 1990 when the CRIs were formed. The "Environment" is now the only game in town. And then along comes Minister Guy cajoling the old horse – more, more, more. Great idea but we are not tooled up for that – are we?

OVERSEER

Overseer (the latest version is Overseer 6) is now being written into many Regional Councils policies and plans as THE tool for estimating nitrate leaching losses on farms. We need to remind ourselves about its strengths and weaknesses.

What is Overseer?

Overseer is a world-class tool and it represents our best scientific knowledge at present. It was developed by agResearch and in now jointly owned by them together with the Fertiliser Cooperatives and the Ministry of Primary Industries. Importantly it was developed as an EXPERT SYSTEM to be used by EXPERTS to do 'what if scenarios'. Taking the case of nitrate leaching: OVERSEER can be used to look at the effects of various farm management practices (e.g. stocking rate, fertiliser N inputs, effluent management, feeding pads and herd homes) on the likely long-term rate of nitrate leached (kg N/ha/yr) from a given farm. From this type of analysis a farmer can select the best options to manage the farm N loading and determine the likely costs of the various options. This is the strength of Overseer – this is why it was developed and how it is best used.

Errors in Overseer

Most people are familiar with the concept of errors in the context of political polling: 45% of people on average preferred Joe Blogs as Prime Minister and the margin of error was 6%. The margin of error reflects the uncertainty around the average. Uncertainly arises because 1) the method of measurement may be inaccurate or the operator did not use the measuring equipment correctly and 2) all biological parameters are variable reflecting the underlying biological variability. For example the MS production per cow or the live-weight of a class of stock.

Overseer is a mathematical model, which attempts to describe complex biological processes, which vary over time and space. (Think here of soil moisture which varies over season and depends on where the measurement was made in a given paddock).

We will focus now on the topical problem: Overseer estimates the rate of N leaching from a given farm (or block within a farm) but these estimates come with a degree of uncertainty – an error. These are not errors in the sense that someone has made a mistake, although that might contribute in some cases – they are errors in the scientific sense – they reflect our uncertainty about complex and variable biological processes.

Staying with the example of estimating nitrate leaching, we can differentiate 2 types of errors: Type A and Type B (see figure 1).

Type A Errors

Type A errors fall into several categories:

- Errors arising from using incorrect or inaccurate input data. Examples affecting N leaching include: pasture clover content, pasture development, soil type, subsoil physical characteristics. Type A errors also arise because the necessary information is not known at the level of detail required (i.e. at the farm and paddock scale). Examples include, soil type, soil slope and subsoil texture.
- Errors arising because the mathematical models in Overseer are simplifications of complex biological systems and because these models have not been tested in all possible situations.

Type B Errors

In the vernacular, Type A errors are reflected in the expression 'bullshit in bullshit out'. In contrast, Type B errors have a different source. They arise because the amount of N leached per unit area is variable over time (monthly and yearly and depending, in particular, on the timing and intensity of rainfall events) and in space (being higher under urine patches and in pockets within a paddock that have a more friable soil texture or are lower in the landscape). Figure 2 (Thank you Dr Roberts of Ravensdown) shows the variation in nitrate concentration over time in several bores.

Not surprisingly when the **predicted** rates of nitrate leaching from Overseer are compared with the **measured** rates there is uncertainty - an error – associated with the amount of nitrate leached as measured in the field. This error is indicated in the horizontal lines in Figure 3. Very importantly, Overseer estimates the long-term average N leached based on the average rainfall for the average soil type and texture class and therefore does not express this type of variability.

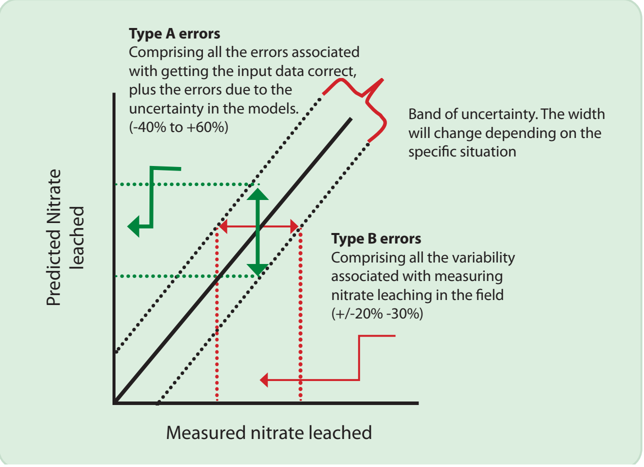


Figure 1: Types of errors associated with Overseer6

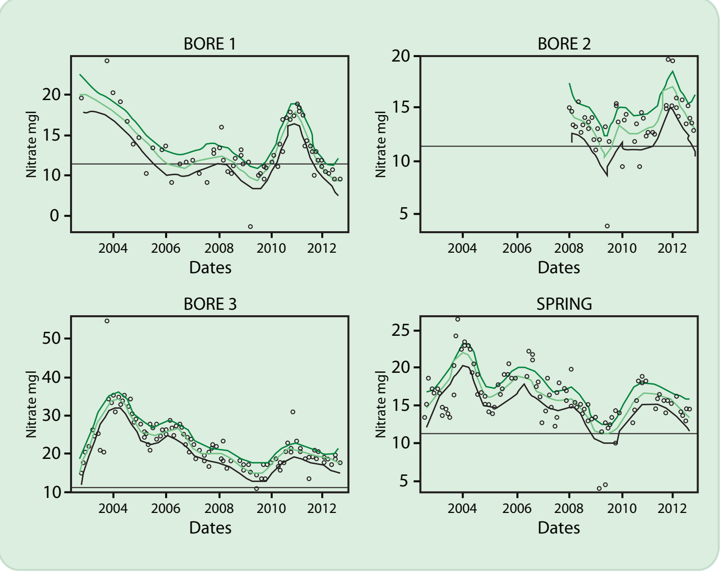
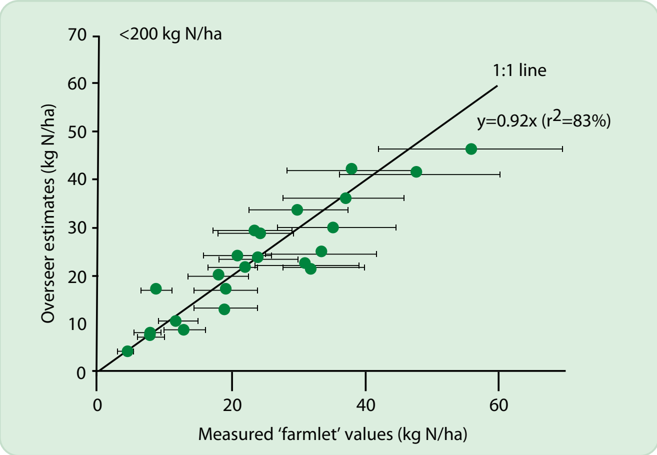


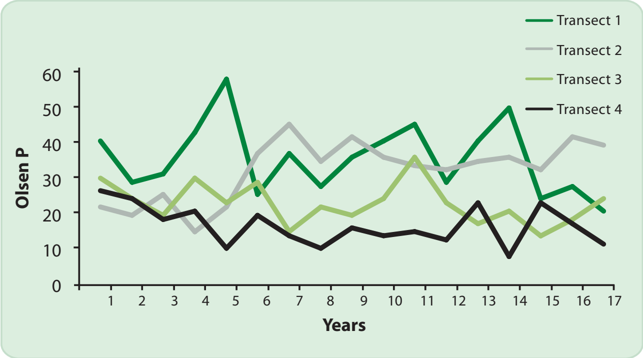
Figure 2: Variation in measured groundwater nitrate nitrogen concentrations

Figure 3 (below): Comparison of the predicted N leached from Overseer and the observed (measured) leaching loss (the horizontal lines indicate the errors (variability) in the N leached in the field.



It is important to realize that these type B errors in the estimates of N leaching do not arise from errors in measuring nitrate concentrations in water samples taken from the field to the lab. Even if the most precise laboratory method for measuring N concentrations was used, the variability (the error) in measured N concentrations in the field will be the same (+/- 20-25%).

There is nothing unusual about the variability in estimates of N leaching. All biological attributes are variable. The graph below shows the Olsen P levels on 4 transects sampled annually for 17 years, by the same person at the same time of the year. Generally the same amount of fertiliser P was applied annually.



The levels are variable and this arises because soils are not uniform and animal excreta is not applied uniformly (Type B errors). In this case the same person collected the soil samples and hence it can be assumed that Type A errors were minimized. The typical variability in Olsen P levels is about 20%.

Total Errors

Thus the total variability in the Overseer estimates of nitrate leaching can be formulated thus:

Variability (error) = Type A errors + Type B errors.

In a perfect world, in which we had a perfect N model, tested and calibrated in every given combination of climate, soil type and farm system, and had perfect knowledge about the correct input variables (i.e. Type A errors were zero), the error in Overseer estimated N leaching will be about 20-25%. In other words if the estimated N loss is 30 kg N/ha/yr, the 'true' value could lie in the range 22 to 38 kg N/ha/yr. But we do not live a perfect world and hence the question begs: how large are the Type A errors? What are the possible errors if you get the input data wrong?

Size: Type A Errors

Take perhaps an extreme, but by no means unusual, example. For some soil types Overseer 6 requires considerable information regarding the physical properties of the soil. For example, consider a dairy farm on a Waimakariri silt loam. Overseer requires the following information: is the topsoil stony? (yes/no), what is the soil texture (light, medium heavy), is there a non-standard soil layer? (yes/no), is the non-standard layer sandy, stony, or stony matrix? At what is the depth of the non-standard layer (7 depth increments down to 1.3 m)? This combination of input variables can result in predicted N leaching losses from 79 to 135 kg N/ha/yr (a range of 56 kg N/ha/yr or 70%).

Another, this time, real example: agKnowledge is undertaking the ground-work for a resource consent for a client in the South Island. Our task is to estimate the nitrate loading across a number of farms. There are 4 soil types to consider. The predicted N leaching losses range from 29 to 136 kg N/ha/yr, depending on the choice of soil type. Importantly these differences in soil type occur over small distances (100m) and would not be apparent to those except for trained pedologists. (In this case the area was mapped by a trained pedologist at the appropriate scale).

The problem is this – we do not have soil maps with the required information at the scale required to provide accurate input data at the farm and block scale. Thus, we have to make a 'best guess' and the cost of doing so in terms of the possible error in the estimate N leaching is large - in the examples above +/- 56 to +/- 107 kg N/ha/yr.

Default Values

Overseer incorporates 'Default Values' - if a user is uncertain about which inputs values to choose, they are instructed to use the default values. In other words Overseer does the 'best guessing'. Ron Pellow of Ravensdown recently published data showing the effects of adopting the 'default' values. He and his co-authors applied Overseer to a well-defined research farm. They reported that, relative to using the default options in Overseer, applying some farm specific input data reduced the predicted N leaching from about 37 to about 21 kg N/ha/yr (about -40%). Relative to using default options, other farm specific data increased the predicted N leaching from about 38 to about 63 kg N/ha/yr (about +60%). Changing some input variables had little effect. The conclusion is obvious – using default values while giving the impression of safety does no necessarily reduce Type A errors.

User Protocols

Another approach being used to overcome the impacts of Type A errors is to develop a "User Protocol" - one is currently being developed by DairyNZ in conjunction with the owners of Overseer (agResearch, MPI and the Fertiliser Co-ops). This should ensure that Overseer is used in a consistent manner and should reduce the extreme misuse of Overseer, and counter the worst effects of 'rubbish in equals rubbish out', but it will not eliminate all Type A errors. For example, let us say 10 consultants apply Overseer to a given dairy farm. The protocol should ensure that the estimated N leaching from all 10 consultants should be similar, right? But what if all 10 consultants used the default values – they could all be consistently wrong, applying Pellow's conclusions above.

Finally it was noted above that the Overseer N leaching model has not been tested and hence calibrated in all the possible combinations of climate, soil type and farm system. It never will be, for the cost of doing so is prohibitive. This will always give rise to uncertainty in the use of Overseer. A report for the Ministry for Primary Industries (February 2013) warns that Overseer nutrient losses derived in such situations (i.e. untested situations) "need to be considered extremely cautiously".

To conclude: In terms of the Type A errors in Overseer, the words of that famous Eagles tune apply: "you can check out any time you like but you can never leave." The errors in Overseer cannot be avoided – it is the best we have got, but it is not perfect.

Uses for Overseer

The uncertainties in the predicted losses of nitrate from Overseer have been highlighted above, not to undermine Overseer's importance and utility - it is world class and it does represent the best science we have available. It is a very good tool for what it was designed to do and that is to determine how changes in farm management affect N leaching. In this setting we are using Overseer **qualitatively** – we are not concerned about the absolute number but the **qualitative** direct of change. A problem arises when Overseer is used **quantitatively** because of the associated errors. It is for these reasons that I am against using Overseer for regulatory purposes.

Let us suppose that a Regional Council (RC) introduces a rule, say, that if the N leaching as determined by Overseer exceeds a certain limit (lets assume 30 kg N/ha/yr) then a farming operation is deemed a ‘discretionary activity’, meaning that farming can continue but only at the discretion of the RC. Assume that the RC determines that a given farm is leaking about 35 kg N/ha/yr. Unhappy with this the farmer employs a Farm Consultant who runs Overseer and comes up with a figure of 25 kg N/ha. The farmer then goes back to the RC for a review but fails to make progress. Because the farm’s ongoing viability depends on this issue, the farmer takes Court action. Who is right? How does a Judge decide?

The Judge is told that both Consultants are accredited Overseer users (they have both passed the Massey University Nutrient Management program) and that both have used the Overseer protocol. He learns that both estimates fall within the error range for estimating nitrate leaching (+/- 20-25 %, Type B errors). He hears that one Consultant used the Overseer default values and the other used what he believed be more accurate farm derived input variables. Argument ensues: One side argues that the predominant soil type is X, the other says Y. They agree that both soil types are present but they cannot agree on the proportional area of each. One argues that there is a non-typical subsurface layer, which has a clay texture, at least on part of the farm. The other disagrees, conceding that there are small areas of such soils but they are trivial in terms of their impact. On and on! The Judge in desperation calls in an Expert who informs the Court that the Overseer model has not been tested in this specific situation and expresses a need for caution! What does or can a Judge do in this dilemma? I can foresee endless litigation if Overseer is used in a regulatory role. Can this situation be avoided? My answer is YES.

An Alternative Way?

It is understandable that the RCs need a process to manage and reduce N leaching into water-ways. Within that process they need a quantitative benchmark to measure their progress. At the moment they are fixated on using Overseer in this role by introducing rules such as: If the predicted N loss from a given farm as estimated by Overseer is X, then we will decide whether that farming activity is acceptable or otherwise. But I believe that there is a better way forward, which a) equips the RCs with the necessary tools to manage nitrate leaching and b) puts Overseer into the role for which it was designed.

Dealing with the first matter. Most RCs have extensive and robust water quality measuring systems in place. The trends in this information should inform the RCs whether water quality is improving or otherwise. This should be their focal point – **their benchmark**.

The next question is: how to link what is happening in terms of water quality back to the farm? Picking up on the philosophy of the Land & Water Forum this link should be, as much a possible, based on collaboration – as in ‘we are in this together, lets work together to solve the problem’. Other qualities of this RC/farmer link should include trust and involve a minimal amount of dictatorial intrusion – the farmer should be left free to choose those farm management options that best suit his farming system. I propose that this link should take the form of a Nutrient Management Plan (NMP). This is how I envisage it working.

Let us assume that the RC has put to the farmers, in language that they understand, the water quality information for a given catchment (see Fertiliser Review 30). Suppose that this data shows that N in the important contaminant limiting water quality and that it is increasing, and hence farmers are asked to help the community to reduce farm N loadings.

Armed with this information a farmer employs a Consultant to look at management options that he could use on his farm and with his farming system to reduce N leaching. Using Overseer they look at the effect of reducing stocking rate, using less N fertiliser, putting in a feed-pad or indeed a herd home - there are now many mitigation options to choose from. In undertaking this exercise they are focused, not on the actual amount of N leached, but the direction of the change in N leaching, as indicated by Overseer - they are using Overseer in a **qualitative** not a **quantitative** sense.

From this exercise they then select the best options and then undertake a cost- benefit analysis. Overseer is but one to the tools they bring to the decision making table. From this list they prepare a NMP for the farm. This sets out the management options which farmer will implement to reduce N leaching. This Plan, the NMP, once agreed to by the RC becomes the contract – the agreement between the farmer and the RC.
How does the RC monitor and measure progress – what levers has it got? It should be a simple matter for the RC to audit the NMPs if required. Farm management practices are tangible and can be assessed accordingly. Not all farms need to be audited just a selected representative few. More importantly the RC has the ongoing information from its water-quality monitoring program to check progress. If improvements are being made - well and good. If not then the RC, with the farmers, needs to implement additional measures on the farm. It is an iterative process to a collective societal goal.

The beauty of this approach is that it is collaborative, it allows farmers freedom to choose their own farm management practices and importantly it removes Overseer, with all its uncertainties, from the regulatory equation, and allows Overseer to be used in the role it was intended for.

AGRISSENTIALS: ROK SOLID

I have written previously about this product – “When is a Fertiliser not a Fertiliser” (Fertiliser Review No 15). It is back on the radar because a farmer recently purchased some of this product and sent to me a sample for analysis. From the lab results the amount of total nutrients and plant available nutrients in a tonne of the product can be calculated and, assuming current fertiliser prices, the value of these nutrients can be estimated. The results are show in the table below:

Nutrient	Total Nutrients		Plant Available Nutrients	
	kg/tonne	$ value/tonne	kg/tonne	$ value/tonne
Nitrogen (N)	3	4.8	0.29	0.47
Phosphorous (P)	5.4	18.1	0.8	2.69
Potassium (K)	1.8	2.88	0.9	1.44
Sulphur (S)	0.3	0.12	0.1	0.04
Total		**25.9**		**4.64**

A tonne of Rok Solid contains about $30 worth of **Total** nutrients. Not all these nutrients are plant available and our best estimate of the value of plant available nutrients is about $5. Now for the really sad news: the invoice accompanying the purchase indicates that the farmer paid $400.00 per tonne! $400 for $5 worth of nutrients?????

The company describe their product Rok Solid as, "A rock mineral based dry fertiliser blend, formulated to restore both essential minerals to tired soils and the microbial activity necessary to process them." Given that N, P, K and S are the essential minerals required on most New Zealand soils, the first part of the claim seems remarkable. And to claim that adding a dry rock dust to soils will enhance the soil microbiological activity seems ludicrous.

How can farmers be protected from this nonsense? There is now no "Fertiliser Act" and hence no legal definition of the word 'fertiliser'. Legally you can sell anything and call it a 'fertiliser'. The Fertiliser Quality Council is, to make matter worse, toothless: it is voluntary, so why join? And it only requires 'truth of labeling" not proof of agronomic effectiveness. At present the only recourse for farmers who feel they have been ripped off is the Fair Trading Act administered by the Commerce Commission. So that is my advice Mr Farmer – don't get angry, go talk to them.

HEALTHY SOILS LTD

The Straight Furrow (June 4, 2013) published, under the banner heading "Biological fertiliser trials convincing" the following statement: "Scientific field trials of biological fertilisers on Shortlands Station in Central Otago have proved **categorically that they work** (my emphasis) …." . I would have thought that any farmer reading this might be tempted to purchase some of these products.

I emailed Healthy Soils Ltd, Research and Development Officer, Mr Bill Thompson, asking if I could view and assess the trials results. He responded with this:

"Healthy Soils Ltd. shares your concern that fertiliser providers need to provide evidence regarding the effectiveness of their products." So far so good. But then this statement:
"We will continue the trial for a further year and anticipate that the results will be made publicly available" (in a peer reviewed scientific journal).

This prompts a few questions: If the trials have proved "**categorically that they work**" then why the need for a further year research? Perhaps they meant, "the trial results to date are interesting but we need a further confirmation?" If this is the case then the 'categorical' claim should be modified? More importantly from my perspective, it seems that Healthy Soils are happy to promote the conclusion of the trials – "**categorically….they work**" – and not doubt derive sales as a result - but are not prepared to open their research to peer review. The promotional cart, as they say, is before the science horse!

So watch this space. Good on them if they come clean and allow scrutiny of their research but in the mean time I would recommend that farmers keep their cheque-books in their back-pocket.

agKnowledge and The Science of Farming


Dr. Doug Edmeades

THE Fertiliser Review

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