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REGENERATIVE AGRICULTURE – REVISITED

The very title "Regenerative Agriculture" (RA) carries the implication that conventional farming is "degenerative". This is given further impetus with its emphasis on soil health and quality. It would be easy to believe, listening to the RA rhetoric, that conventional agriculture has trashed the quality and health of our soils and that they are the pioneers at this new frontier. Certainly, the Minister for the Ministry of Primary Industry (MPI) thinks so.

In a letter (dated 5 June 2020) supporting RA, the Minister for MPI says, "……what is new about RA is their emphasis on soil quality and health…". This indicates that he has been poorly briefed.

Two decades ago a group of about 20 New Zealand soil scientists were convened and challenged to develop a robust definition of soil health and quality. We came up with a set of 7 soil tests that could be used collectively to define soil quality (Table 1) and optimal ranges were established for each test.

Table 1. The suit of soil quality indicators (SQI) required to define soil health and quality.

Soil Property	Soil Test
Soil Chemistry	Olsen P (mg/L)
	Soil pH
Soil physical	Bulk density (t/m^3)
	Macroporosity (%)
Soil biology	Carbon (%)
	Nitrogen (%)
	Mineralizable N (kg/ha)

The concept of soil quality depends on what the soil is to be used for - is the soil fit for purpose intended – and is therefore functionally defined. Nevertheless, this basic suit of 7 soil tests were regarded as the minimum set for the major soil uses in New Zealand.

This set of Soil Quality Indicators (SQI) has been used in national surveys conducted between 2014 and 2017 by the regional councils. In total 416 soil samples, collected from all the major land uses, have been analysed. The

results are instructive. Eighty-three (83%) of all the tests were within the relevant target ranges, and importantly *all the biological tests* were optimal. The exceptions were Olsen P (50% were either above or below the optimal range) and macroporosity (44% were below the optimal range).

The practical conclusion that flows from these results is that the biology of our soils is good but we need to be more accurate in the way we recommended fertiliser P and avoid overcropping and running high stocking rates on vulnerable soils.

If I were advising the Minister of Primary Industries, I would gently remind him that the current interest in soil quality and health of New Zealand soils is not as new as he and the RA enthusiasts think, and that the biological activity in our soils is second to none. In other words, our agricultural practices are not degenerative in terms of the soil life – the soil biology.

THE SOIL FERTILITY STATUS OF NZ SOILS

What we do

Dr. Robert McBride works for agKnowledge in the South Island. He has done so for 11 years and has visited over 500 farms, gathering the relevant information and then advising farmers on how to optimise soil fertility. He recently decided to summarise his decade of information. This is a summary of what he found (The full paper can be found in "The Journal" NZIPIM, December 2020).

We use three criteria to assess the soil fertility in clover-based pastures. This is the basis upon which we offer fertiliser advice.

1. **Visual assessment of the pasture.**

   To the trained eye it is amazing what can be learned about the underlying soil fertility in clover-based pastures: e.g. the colour and composition, especially of the clover component, the symptoms of nutrient deficiencies shown in the clover leaves, the vigour of the ryegrass component, the occurrence of low fertility grasses (such as browntop and sweet vernal), the weed loading and the prominence of excreta patches, plus a bunch of other information. agKnowledge has developed a 10-point rating system to describe the over-all pasture vigour from a soil fertility perspective.

2. **Clover-only tests.**

   Clover, because it has a higher nutrient requirement than grasses, is the canary in the soil fertility mine, its abundance, and where it is growing in the pasture, provides strong visual clues of the underlying soil fertility. Better still, carefully collected and analysed clover-only samples are a vital adjunct to the soil test and visual assessment results.

3. **Soil tests.**

   There are seven soil tests calibrated for use in New Zealand soils (see Fertiliser Review 26), and soil samples must be carefully collected avoiding nutrient-rich areas. Even when the correct protocols are followed, soil test results are variable with CVs between 20%-30%. Great care is therefore required when interpreting soil test results. As I was taught: "Never believe soil test results until you have assessed the pasture".

What was found?

The visual assessments recorded by Dr. McBride are summarised in Table 2, for both dairy and dry-stock farms. An ideal New Zealand pasture comprises 30%-40% clover with the balance being ryegrass (these days

the companion plant may also be chicory or plantain), the excreta patches are not obvious and the pasture is a uniform green colour. Such pastures would score say 9-10/10 on our visual assessment scale. By way of contrast, a very poor pasture (say 1-2/10) contains less than 5% clover, which has small leaves and is only growing in the nutrient-rich excreta patches. Overall the pastures would be yellowish-brown in colour and between the prominent excreta patches, low fertility grasses and flat weeds are dominant.

The results in Table 2 show that most of the pastures in both dairy and dry-stock farms fall far short of the ideal.

Table 2. A summary of the visual assessment on dairy and dry-stock farms.

Visual Assessment		
	Dairy (208)	**Drystock (272)**
Vigour (1-10)	5.5	4.5
Clover (%) (Ideal 30-40%)	17	15

The soil test results are summarised in Table 3. They reflect the pasture visual assessment and indicate widespread deficiencies in these 3 nutrients.

Table 3. A summary of the soil test results on dairy and dry-stock farms.

Soil Tests (% deficient)		
	Dairying (219)	**Dry-stock (308)**
Olsen P	82	42
Soil K	65	57
Soil S	67	78

As previously noted, clover is the “canary in the mine” as far as soil fertility is concerned. It is very sensitive to nutrient limitations and chemical analysis of the clover is the most direct and reliable measure of any nutrient limitations. The clover-only results are summarised in Table 4. They reinforce the conclusions that can be drawn from the visual assessments and the soil tests – nutrient deficiencies are widespread in this set of South Island pastoral soils.

Table 4. A summary of the clover-only tests on both dairy and drystock farms.

Clover-only (% deficient)		
	Dairy (128)	Drystock (313)
Phosphorus (P)	10	26
Potassium (K)	67	53
Sulphur (S)	10	35
Molybdenum (Mo)	20	25

Discussion

Pastoral farming is the single biggest industry in New Zealand. It earns about $20b annually in revenue. Its competitive advantage depends on growing clover-based pasture and historically this has been its strength.

However the results above for the South Island - our experience in the North Island is much the same - suggests that we have taken our eyes off the soil fertility ball. We have lost the art of growing healthy clover-based pastures.

We can estimate from these results that the average pastoral farm is currently operating at about 60% to 80% of its full potential. Expressed differently, there is considerable opportunity to improve the productivity of the pastoral sector. The good news is that this opportunity can be captured with existing technology which is known to work.

THE MISSING LINK?

There has been, and still is, much discussion in New Zealand around the issues of pasture persistence and resilience. The seed companies are investing a lot of money and effort into developing grasses, particularly but not exclusively ryegrasses, to overcome these problems.

Furthermore, DairyNZ tell us that the amount of pasture eaten (I assume they mean clover-grass pastures) in the dairy sector, after increasing from 1990 to 2004, has now plateaued. This is important because farm profitability on dairy farms is directly linked to pasture eaten (see Fertiliser Review No 41). I wonder! The soil fertility results discussed above suggest a further possible reason which may explain both problems.

Clover has a shallow root system and as a consequence requires higher levels of soil fertility to thrive, relative to grasses and crops. As a guide, the optimal nutrient ranges for the various major nutrients are set out in Table 5.

Table 5. Biological optimal soil nutrient ranges for NZ clover-based pastures.

Nutrient	Ranges
Olsen P	30-40 (dairy depending on production); 10-30 (dry-stock depending on productivity)
Potassium	7-10
Sulphate S	10-12
Organic S	10-12
Magnesium	8-10 (25-30 for animal health)
Calcium	>1
Sodium	Not required for plants (3-4 for animal health)

Importantly the clover plant, like all plants, can only grow as fast as allowed by the most limiting nutrients. The results in Tables 2, 3 and 4 indicate that many soils are deficient in one or a combination of either P, K, S or Mo. This will severely limit clover growth. As clover growth declines so too does the amount of free N fixed by the clover plant, and hence the amount of N going into the soil.

As the soil N status declines so too does the ryegrass growth and vigour. In other words, the clover-based pastoral system collapses. The pasture is not resilient and persistent and the amount of total pasture grown, and its quality, due to the loss in clover, declines. In order to maintain production, farmers are forced to compensate by the use of fertiliser N or bringing in more supplements.

Anecdotally, I have seen this sequence of events play out many times. A farmer will take me to a paddock that has 'runout' and tell me his sad story. Three years ago he was told by the seed merchant to resow the pasture with a new ryegrass cultivar. Initially, the new pasture looked good but it did not persist. The clover gradually disappeared and pasture became N deficient – that yellowish-brown hue with prominent excreta patches. At this point, his fertiliser rep advises him to apply more fertiliser N!

Yes, the pasture was no doubt N deficient and unproductive. But the least-cost solution is not more supplements and/or fertiliser N. Correcting the underlying nutrient deficiencies and getting the clover "humming" is the best option. Remember that a kg of clover/ryegrass pasture DM costs about 4-5 cents. Fertiliser N fed ryegrass costs about 10-12 cents/kg DM, crops about 15-20 cents, and supplements above 30 cents.

RPRS REAR THEIR UGLY HEAD – AGAIN?

Mr. Robin Boom (Agronomic Advisory Services) is running a trial on his Taumaranui hill country farm, comparing a number of phosphate (P) fertilisers, including some Reactive Phosphate Rocks (RPRs), against soluble P fertilisers (eg superphosphate). The results from the **first year** of the trial have been published in Country-Wide (February 2021).

Country-Wide reported that *"A mix of Sechura reactive rock phosphate (RPR) and elemental S has out-performed all other fertilisers for dry-matter (DM) in a short-term comparison in the King Country."*

Country-Wide goes on to suggest that these results have excited some people, especially those companies which sell a particular 'brand' of RPR – Sechura. Specifically, the cause for the excitement is that it 'appears' that Sechura RPR outperforms superphosphate. The key results from this trial, as far as this article is concerned, are: control, 7,365 kg DM/ha; superphosphate, 9,884 kg DM/ha and Sechura RPR + sulphur, 9,907 kg DM/ha.

The proprietors are reported as saying:

"….even though Sechura RPR is not far ahead of superphosphate in Boom's 'trial' the fact it is ahead is significant."

"results back up earlier trials, including the six-year national series completed in the 1980s by AgResearch that showed superior pasture production performance from RPR over superphosphate on many soil types, particularly wetter, low pH soils…" and that:

"What this trial shows is that the right RPR and sulphur will grow more than superphosphate."

I disagree with these conclusions for the following reasons.

First, the National Series, and other related research, by MAF and then AgResearch, in the 1980s and 90s showed that the best RPR (Sechura) dissolves at about 30% per year and that as a result, there is a lag effect of about 3-4 years. In other words, it takes about 3 years of annual applications before Sechura RPR 'catches up' to soluble P fertilisers like superphosphate, in terms of pasture production.

In this Boom trial, the difference in pasture production between Super and Sechura was a meagre 23 kg DM/ha. Although no statistical information about the trial is provided, it is most unlikely that this difference is statistically significant (i.e., it is not real). Indeed Boom himself is reported in Country-Wide saying that there was "considerable variability between the plots" which I take to mean that the 'background noise" in the trial was considerable. To throw more doubt on the results the technique used by Boom for measuring pasture production can be seriously questioned and 12 months is insufficient time to compare P fertilisers, especially slow-release products.

To cap it all off, when I spoke to Mr. Robin Boom about his trial, he said that the results were 'indicative only' and should not have been published at this stage. Indeed he went further and said he did not approve the publication of the results in Country-Wide!

My Advice?

Ignore the results coming from this trial until the author has made available the statistical analysis.

BIOHELP

An article in our local newspaper (Waikato Times, Tuesday, February 9, 2021) carried a headline "Micro-organisms mean less leaching". It referred to a farmer who "…..for the past 17 years has been applying a concoction of micro-organisms to his soil to reduce the use of nitrogen fertiliser, balance the soil and reduce N leaching from his property." We are told that the farm now has an "extremely low" leaching number of between 10-15 kilograms of nitrogen per hectare."

The article goes on to quote the owner of Biohelp, Mr. Scott Hobson. "……by increasing the soils capacity to synthesize energy from sunlight and fix nitrogen using specific bacteria, minerals that have been locked up in the soil can be released generating available nitrogen "even without legumes present." It appears illogical that a microbe or mix of microbes that fix N, release locked up nutrients, and at the same time reduce N leaching!

This made me suspicious. Yes, there are free-living bacteria that can fix nitrogen from the atmosphere but my soil science 101 told me that they only occur in waterlogged soils and the amount of N they fix is small in comparison to an inoculated clover plant. My other concern was that I had researched this topic (soil inoculants, bio-stimulants, and activators) some time ago (See Fertiliser Review 8) and concluded that, while there were many such products on the market, very few of them were effective. The major problem is that most soils are already teeming with all sorts of micro-organisms and that any added 'new-comers' are simply swamped out by the resident population.

Maybe I had missed something so I decided to dig deeper. The newspaper article refers to an in-house trial that compared the urine from cows eating "biologically stimulated pasture" compared to the urine from cows eating a conventionally fertilised pasture. Sure enough, on the Biohelp website, there is a paper entitled, "A comparison study between Biohelp NZ biological treatment of pastures and conventionally fertilised pastures on nitrogen leaching from cow urine."

This study was conducted on a 165 ha dairy farm in which one paddock (Paddock 20) had been treated with Biohelp products (CM3 @ 25 l/ha and Microlife @ 0.5 l/ha) twice yearly since 2013. It was described as "the worst paddock on the farm." During the study period, the conventionally fertilised pasture received per hectare 144 kg N, 112 kg S, and 61 kg P. In comparison the Biohelp treated Paddock 20 received 90 kg N kg, 17 kg S, and 25kg K.

In autumn of 2019 urine samples were collected from the herd while they were on the rotary platform, after they had been grazing Paddock 20 for 24 hours.

Samples were then collected from the same herd several days later under similar weather conditions from conventionally treated pasture.

From these measurements, (the amount of urine voided and the N concentration) and after making many, many assumptions, the likely amounts of N leached from the 'conventional' urine and the 'Biohelp' urine were compared. The difference was a 67% decrease in N leached from the Biohelp treated pastures!

Even if it is assumed that the many assumptions made in the calculations are correct this result is not credible. Firstly the treatments (conventional v Biohelp) are not replicated and there is no evidence that the experiment was balanced – i.e. the treatments were confounded. Was the Biohelp Paddock 20 the same as the other conventional paddocks in all respects, except for the Biohelp treatment? We know that the fertiliser treatments, including the N fertiliser inputs, were different. We know that Paddock 20 was once described as "the worst paddock on the farm."

Also, the results are implausible. It is reported that the pasture N concentration were similar, despite the difference in N inputs. Instead, we are asked to accept their results that the urine volume, N concentration, and the number of urine events were lower in the Biohelp treatment! It begs the question: by what mechanism, can a concoction of soil microorganisms which, while releasing locked up soil nutrients including N, have such remote effects on animal physiology?

My Advice

Be aware!

TOW AND FERT

It is a useful truism: If something is "too good to be true it probably is!" I have written cautiously before about Tow and Fert. It is a technology coming out of Dannevirke (NZ). They are essentially an engineering company (Metalform) who have put a lot of time and effort into developing equipment that can deliver all kinds of fertiliser and lime products onto pastures as a solution or as a slurry.

I have no problem with that at all. What concerns me are the claims they are making for this system of applying fertiliser. Their website proclaims a 47% reduction in N required for the same production. A very recent (Dairy Exporter January 2021) advertisement claims that a farmer, adopting foliar application using Tow and Fert reduced their 'N' inputs across their farms by up to 33% and grew more grass. These are very big and bold claims.

These anecdotal claims are at odds with New Zealand data (see Fertiliser Review 3, 38, 40, 41) which show that the form of fertiliser (solid versus suspension (FPA) versus liquid) has no effect on pasture production when products are compared at the same rate of nutrient application.

My Advice

Be aware!

ALBRECHT-KINSEY SOIL TESTING SYSTEM PUT TO THE SWORD AGAIN!

In the Fertiliser Review No 26 we discussed at length the Albrecht-Kinsey soil testing theory (the so-called Base Cation Saturation Ratio theory, BCSR), which is used as the basis for making fertiliser advice. It is used frequently by those in, what I call the "quack fringe," of the fertiliser industry. Recall: it was concluded, based on a considerable amount of research, that this approach is flawed, or as expressed in a recent 2007 international review:

"The data do not support the claims of the BCSR [the Base Cation Saturation Ratio theory], and continued promotion of the BCSR will result in inefficient use of resources in agriculture and horticulture."

One of the great qualities of sound research is that it is predictive. So when a trial was being set up in Canterbury in 2012 to test this theory I went on the record, predicting that it would be a waste of time and research resources. The results now published in the NZ Journal of Animal Science and Production in 2019 prove the point.

To recap: Two adjacent cropping farms in Canterbury, under common ownership, were converted to dairying at the same time in 2012. The fertiliser policy on one farm was based on the conventional approach and the other was fertilised according to the BCSR theory. Every effort was taken to ensure that the management on the two farms, apart from the fertiliser policy, was similar.

The different fertiliser policies were established over the first 2 years (2012/13 and 2013/2014) and subsequently many soil, pasture, farm management, and animal performance attributes were measured over 4 seasons (2014/15 to 2017/18).

There was no effect over 4 years of fertiliser policy on milk yield and pasture growth. The clover content was higher (16%) on the BCSR farm than on the conventional farm (10%). This was attributed to the slightly higher fertiliser N inputs into the conventional system 151 v 115 kg N/ha. No reason was advanced to explain why the fertiliser N inputs were different.

Proponents of the BCSR theory frequently claim that altering the ratio of the soil cations (calcium (Ca), magnesium (Mg), and potassium (K)) to specified ranges results in better animal health. However in this case the Empty Rate (%) and the proportion (%) of Downer Cows were not significantly different. The authors comment that there was "a noticeable difference between the two farms for farmers/owners over the past two to three seasons has been the improved reproductive performance and fewer health issues at calving", No data is advanced to support these observations.

Another fondly held belief of BCSR theorists is that achieving the desired balance of cation ratios will result in the desired soil pH (normally they will claim that to be 6.5-7.0). The soil pH levels were the same in both treatments in this case. They also claim that soil structure can be improved by altering the Ca/Mg ratio. Regretfully no measurements of soil structure were reported from this trial.

So what is the cost of achieving a nil result? Both farms had been under cropping and different fertiliser inputs were required to "set-up" the trial. In particular large amounts of fertiliser, Ca and Mg were required on the BCSR farm to achieve the desired soil Ca and Mg ratios. The fertiliser set-up costs in the initial first two years were $1,337/ha on the BCSR farm and $805/ha on the conventional farm.

Conclusion

As I said at the outset these results are entirely consistent with the extensive published literature on this subject. If only the people who funded the research - and several science institutions were involved – had done their homework they could have saved their efforts and dollars for a nobler cause.