agKnowledge
"The Independent Fertiliser Experts"

Spring
2022

Fertiliser Review

ISSUE 47

REVOLUTION IN THE AIR?

Aerial application of fertiliser, which became widespread in the 1950s, revolutionised hill country farming in New Zealand. We are, in my view, on the cusp of another revolution with the introduction of variable rate technology, which will mean that fertiliser can be applied with greater precision to our hill country. The 'slip, slap, slop' approach of the past, can be replaced with precision placement of fertilisers - putting fertiliser where it is needed and avoiding places where it is not needed (e.g., nutrient-rich stock camping areas) and environmental hotspots (e.g., water ways). This technology has the potential to enhance nutrient-use efficiency and at the same time reduce the environmental footprint of hill country farming.

The problem

The fertility in hill country soils is spatially extremely variable. Over-lying the natural variability due to parent material and topsoil depth, there is the added problem which arises because animals do not return nutrients evenly across the landscape. Over time they transfer large amounts of nutrients from the slopes to the camping areas (Figure 1).

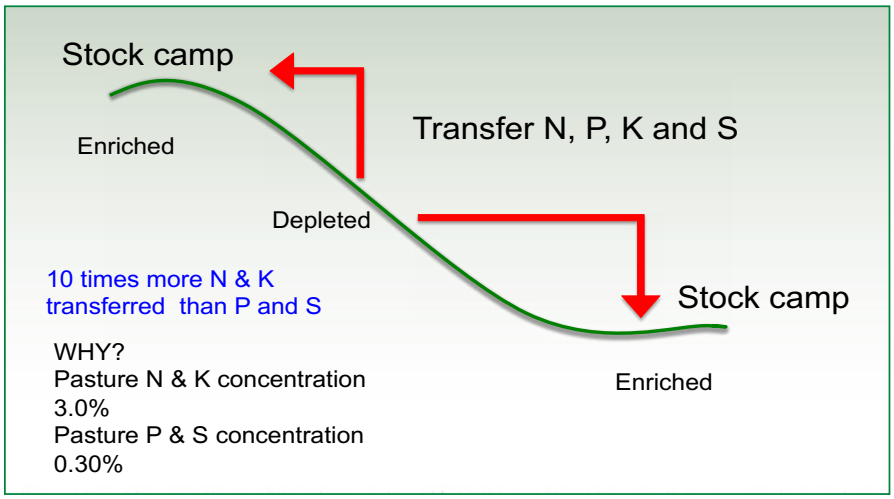

Figure 1 A schematic representation of nutrient transfer in hill country.

The effects of this are readily apparent in the landscape (Figure 2) and importantly the amounts of nutrients involved are of practical importance, as reflected in the Olsen P levels at various positions in the landscape (Figure 3).

Figure 2 The consequences of nutrient transfer in the hill country environment.

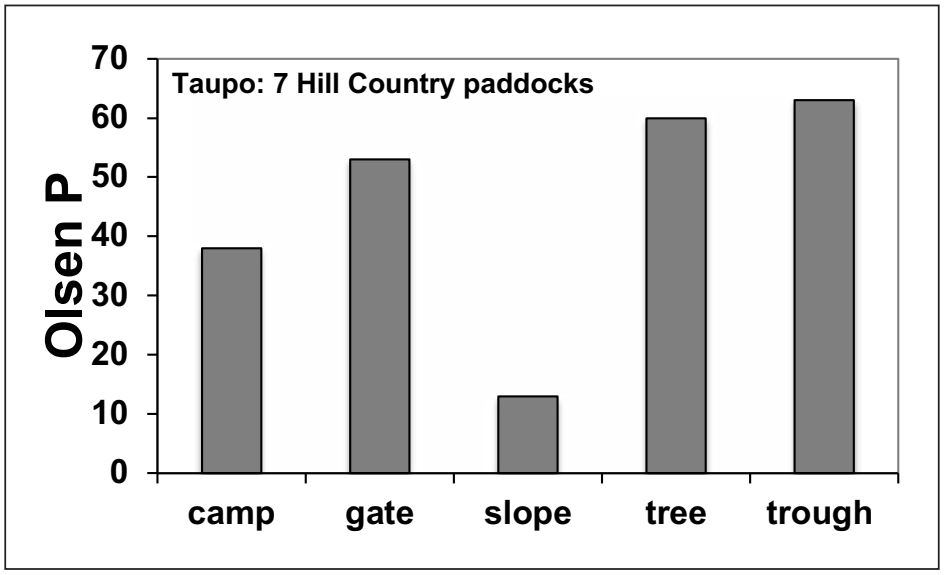

Figure 3 Olsen P levels in various components of the landscape.

Because of this movement, the mid-slope areas, given time, become depleted in the key nutrients. This is particularly so for nitrogen (N) and potassium (K) because there is about 10 times more N and K going around in the soil/pasture/animal cycle as noted in Figure 1.

This is not much of a problem for N, as clover growth is favoured on N depleted soils, other things being equal. But it becomes a problem particularly for K (see later) because of the larger amounts of K in the nutrient cycle. As the soil K (and subsequently P and S) become depleted, clover production also declines and with it the source of fixed N, so necessary to maintain good quality grasses. It should be no surprise that the worst pastures in hill country are in the mid slope areas.

Variable Rate Technology

The endpoint of this nutrient movement is the development of two zones - the nutrient depleted mid-slope areas, which typically makes up a large proportion (up to about 70%) of the total farmed area, and camping areas. Applying fertiliser to the camp sites is a waste of resources as the animals will continually 'top-up' these areas with nutrients. The smart thing to do is to apply the fertiliser to the nutrient depleted mid-slope zones. These areas will be more responsive to fertiliser and hence will result in the biggest 'bang' for the fertiliser buck. Importantly, it is not a matter of applying less fertiliser to the whole farm, but spreading the same amount of fertiliser onto a smaller area where it will have its largest effect on pasture production.

It is now possible to map farms to differentiate areas within the farms based say on slope (flat, mid-slope and steep). More usefully, given the problem we are addressing, the farm can be divided into nutrient rich areas (gullies, ridges) and exclusion zones (rivers, water-ways, wetlands). This map can be loaded into the aircraft's on-board computer system which, based on its GPS position, automatically opens or closes the fertiliser hopper.

I am informed that with the precision of the farm mapping technology, coupled with the latest variable rate technology, it will be possible to apply fertiliser in this manner putting the fertiliser where it is most needed and at the same time protecting the environmentally sensitive areas on the farm.

SOIL TESTING IN HILL COUNTRY

The movement of nutrients in hill country has important implications for soil testing. If the intention is to improve hill country productivity, then logically soil samples should be taken from the nutrient depleted mid-slope areas which have the poorest pasture (Figure 4). In practice this means the soil sampling transect should run *along* the contour and not *across* the contour as indicated in Figure 5.

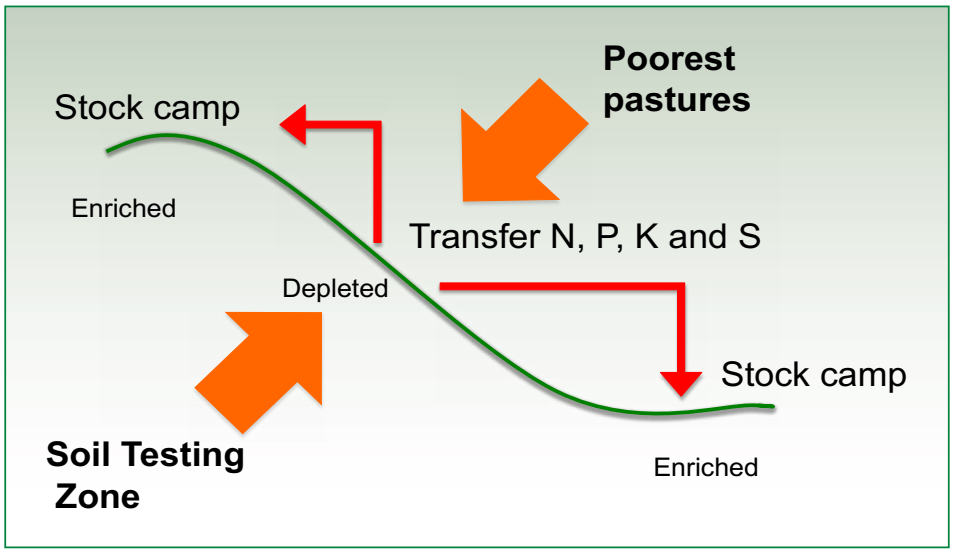

Figure 4 The soil samples should be collected from the nutrient depleted mid-slope areas.

Figure 5 The soil sampling transects should be along and not across the contour.

To emphasise the point the data in Table 1 summarises results from two sites which were sampled either along or across the contour.

		Soil P	Soil K	Soil S
Site 1	Along contour	36	5 (opt 7-10)	18
	Across contour	58	14	56
Site 2	Along contour	20	5 (opt 7-10)	8
	Across contour	43	31	11

Table 1. Soil test results from samples collected along and across the contour at two sites.

The soil nutrient levels for P, K and S are lower in the samples collected along the contour. This is most pronounced for K because, as noted earlier, the amounts of K being transferred are about 10 times greater than for P and S. In terms of offering fertiliser advice the impact of this is very important. Armed only with the results from the samples collected *across* the contour, the K deficiency, apparent in the samples collected along the *contour*, would have been missed.

This issue will come into sharp focus if rules and regulations are introduced requiring that fertiliser P inputs are verboten on soils if the Olsen P levels is above the economic optimal range.

BIOZEST™

I frequently receive articles about new products on the market. Many are not worthy of comment because there is little that can to be learnt from them. But now and then I am sent material that demands attention.

I was recently sent a paper published in a bonafide science journal entitled "Cell signalling compound improves pasture and livestock productivity and the environment." The product is marketed as Biozest™ a liquid product which is applied to pastures at 1 litre/ha.

Biozest™ is described by the authors as "A biogenic agricultural compound [which] enables pasture to synthesise more soluble sugars and delivers benefits attributable to bioactive molecules: phenylpropanoids." These compounds we are told "……help plants overcome biotic and abiotic stress to increase pasture quality and yield." They also, "…. improve the conversion efficiency of pasture protein to milk and meat." The paper goes on to present results from a sequence of experiments, mainly on pastures, but also some involving small groups of animals.

The experimental details of each experiment are sometimes not given or are not clear. As far as I could discern, the major experiment unit compared the effects of Biozest™ with a control (no Biozest™ treatment), on a split paddock or paddocks basis, or, in the case of the animal experiments, in small groups of animals. Pasture production was measured using a plate-meter.

Without going further into the experimental details, the essential results, are summarised in Table 2.

Factor Measured	Claimed Response
Pasture production	89% and 127%: 2 paddocks split
Pasture palatability	21%: pasture measured before and after grazing, 1 paddock split
Baleage	117% & 115%: 2 farms 2 split paddocks
Drought relief	121% & 260%: 1 paddock split treatment
Frost damage	85% & 107%: 1 paddock split treatment
Drought and waterlogging	489% (Feb) and 51% (August): 2 paddocks split
Stock live weight	22%: 40 animals split.
Brix test	18%: 2 farms, split paddocks
Milk production	33% and 31%: two farms (year to year comparison)
Urea discharge	26% and 25% reduction: 2 farms, details not given

Table 2. Summary of results from Biozest™.

What is spectacular about these results is their size and the multiplicity of the effects of this single product. A closer look was required.

Under the section 'methodology' we are informed that "Biozest™ is a gene mediated technology and engages ecologically through multitrophic interactions. This complexity makes conventional replicated small plot evaluations highly variable and underpowered. A systems biology approach was employed to account for complex multilevel interactions. The experimental design selected, enabled the assessment of plant and ruminant responses in their natural or typical setting. Trials were thus carried out in 'real world conditions' on commercial farms to establish the effect of Biozest™ ".

Just what this means is uncertain. Perhaps it is intended to reassure the reader that the results were as "real" as you could get and therefore believable. Unfortunately, all of this reassurance evaporates when you realise that these so called 'experiments' were not replicated and, with some exceptions, statistical analysis of the data is not possible.

The authors acknowledge that: "The full mechanism of the observed biological response has yet to be determined. However, field observations and data from several crops, support the hypothesis that the membrane bound receptors on plants recognise and react to Biozest™ applications: inducing and sustaining the innate production of phenylpropanoid cascades."

The paper contains five pages of discussion in which it is assumed that the measured effects are real and then speculates at great length on the possible biochemical pathways by which this product could enhance plant and animal production and reduce environmental damage.

In short, the paper is unbelievable. It is a good example of what I call pseudo-science, meaning false science. It uses the words of science but it fails the evidence test. Speculation wrapped up in jargon science. And it gets worse. The two authors are employees and directors of Zest Biotech, the owner of Biozest™.

REGENERATIVE AGRICULTURE – WHAT IS IT?

The Ministry of Primary Industries (MPI) have been giving this question some thought.

"We're looking to define what regenerative agriculture means from a New Zealand perspective, and develop a sound evidence base to test and confirm what works in our soils, climates, and farming systems."

This sounds helpful and promising – "……develop a sound evidence base…..".

MPI's chief science adviser, Dr John Roche, says broadly speaking, MPI sees regenerative farming as a set of practices that, in isolation or collectively, may result in improved outcomes for our productive land, freshwater and marine environments, our climate, our animals, and for the people that grow and consume our food and fibre products.

"Regenerative agriculture is not a 'one-size-fits-all' activity with prescribed inputs and outputs," says Dr Roche, "and the farmers I've spoken with do not want it defined so tightly.

Once again, this is helpful because it makes it clear that Organic Farming – an input/output system - is not a subset of Regenerative Agriculture (RA). This is important because to date the dialogue on RA has been muddied and confused by people from the organic fringe who have jumped onto the RA bandwagon claiming it as their own. In fact, with this definition, it is oxymoronic to talk about Organic Regenerative farming!

At a recent talk to NZIPIM members at Ruakura, Hamilton, Dr Roche presented the MPI vision for RA:

Regenerative agricultural practices for Aotearoa New Zealand are: *'Practices that, in isolation or collectively, can achieve improved outcomes for our productive landscapes, rivers, coastal and marine environments, biodiversity and natural ecosystems, improve animal welfare, have potential to increase profitability and add value, promote health and wellbeing for humans, whilst ensuring we can grow and consume our food and fibre products sustainably, and meet goals of taiao, whenua ora, mauri ora, and te ao tūroa'.*

I can live with RA if it is evidence-based and embraces these aspirations. Afterall most NZ farmers are already doing it!

FERTILISERS AND REGENERATIVE AGRICULTURE

Let's apply the vision outlined above, and especially the requirement for evidence, to one subset of beliefs held by those who espouse Regenerative Agriculture: viz the belief that RA will a) increase the accumulation of soil organic carbon (organic matter) and b) reduce the need for chemical fertilisers. What evidence is there to support these claims?

We have discussed the carbon cycle in relation to Regenerative Agriculture in Fertiliser Review 42. We do not need to repeat that except to remind ourselves of the essential facts.

It is true that, during their development phase, clover-based pastures accumulate large amounts of carbon (C) as soil organic matter (SOM). But this development phase only lasts about 20-50 years depending on the climate and soil group. An often cited example in New Zealand demonstrates the point. Over a period of 30 years, the C content of a initially raw pumice soil (scrubland) almost doubled under fertilised clover-based pasture, from about 4.5% to about 8.5%. Thereafter there was no further accumulation of C. As far as C goes the soil became "saturated" in organic matter.

Expressed differently, the C content of this soil increased from about 33 tonnes C/ha/75 mm depth to about 63 tonnes. This represents an increase in soil carbon of about 1 tonne of C/ha/yr. But carbon does not come alone; nitrogen (N) phosphorous (P) and sulphur (S) are also required to build SOM and they accumulate in the ratio of 100 (C):10 (N), 1.5 (P), 1.5 (S). Thus, during development about 80 kg N and 14 kg of P and S are required annually for each 1000 kg C accumulated. Assuming we are dealing with a clover-based pasture, the C and N will come from the atmosphere as photosynthesis (C) or N fixation by the clover. But what about the P and S? Given that most New Zealand soils, in their undeveloped state, are P and S deficient this means that a source of P and S, external to the farm, must be applied.

Thus, the specific Regen dreams of endlessly sequestering C in the soil to mitigate human induced global warming and to avoid the use of fertiliser are just that – dreams. They fail the evidence test.

PROBITAS

Then

In 2006 the Commerce Commission took the company Probitas and its owner Mr Ewen Campbell to court alleging that their advertising in respect to their fertiliser 'Probitas' was misleading. I was called as an expert witness. My evidence boiled down this:

Brief of Evidence 49 a. *Probitas has a high content of silica (SiO_2) and this, it is claimed, is the active ingredient. The silica in Probitas is claimed to be of a special form and when applied to soils it traps radiant energy from the sun which in turn activates the electrical and magnetic processes in the soil. This stimulates the biological and chemical processes, releasing 'locked up' soil nutrients (i.e. unavailable for plant growth) eliminating the need for traditional solid fertilisers.*

Brief of Evidence Para 69. *In my view, the claimed mode(s) of action of Probitas are false or misleading according to current scientific knowledge.*

Brief of Evidence Para 70. *At best Probitas can be described as a low-grade liming material which also contains small (about 1.0%) concentrations of K and Mg. However, when compared with current sources of liming materials and the nutrients K and Mg, it is many times more expensive. On these grounds alone it would not be recommended by most scientists and consultants.*

His Honour Judge Callander agreed with my evidence stating under the section "Are the representation and/or conduct false and or misleading?"

Judgment Para 112. *This is the final and most crucial question. It determines whether what was said by the defendants was, when looked at objectively, designed to hoodwink unsuspecting farmers. Dr Edmeades says that in each case the representations were not based on scientific principles. Put another way he says implies it was all snake oil. In the absence of any other scientific evidence, I must accept what he says as valid. The only logical conclusion is that representations were false. It follows, from any dispassionate analysis of the promotion material and the scientific principles of soil fertility advanced by Dr Edmeades, that the representation have each been proved beyond reasonable doubt to have been, misleading. While no farmer actually complained of deception, the representations and conduct were clearly deceptive and misleading. The real science shows farmers were clearly taken in and misinformed by the representation and this, ultimately, would be to their detriment.*

Judge Callander, applying the Fair Trading Act, fined the company Probitas and its owner Mr Ewen Campbell $272,000 dollars.

Now

In May 2022, a farm consultant sent to me the details of a fertiliser mix, prepared for a client, by a company called Ecofarm Aotearoa. The agent's name was Ewen Campbell. The key ingredients are listed below. The total cost of the mix given on the Order Quote Sheet was $66,745 incl. GST or $324/ha.

Product	Application rate (kg/ha)
Probitas Soil Conditioner	150
Gypsum	50
Ulexite	7
Selenium Selcote	1.5
Iodine	0.25
Ecofarm Humates	50
Silica sand	685
Inoculum	5
Total	**948**

From this it appears that the product Probitas is back in the market albeit as one component (16%) in a mix. But the major ingredient in this case is silica sand (72%). Intrigued? Applying silica sand to the soil?

I went online to the website (Ecofarm Aotearoa) – it contains several short videos presented by Mr Campbell. They contain some real gems.

Mr Campbell explains in one presentation that aluminium (Al) is the 'enemy' on volcanic soils and using superphosphate is bloody dangerous because it brings out more aluminium and that adding types of silica gets rid of aluminium toxicity. He also claims that 'marine derived forms of silica' react with sunlight to create electricity which stimulates soil biological activity and nutrient uptake. This sounds like a regurgitation of the claims he made for his product Probitas prior to the Court Case. My evidence on this point, given during the Court Case, is still relevant:

Brief of Evidence para 55: *Silica (SiO_2) is chemically and electrically inert and for this reason it is the end point of the weathering process of silicate minerals in soils. This is why it is abundant in most soils. The content of silica in the sand fraction of New Zealand topsoils is often greater than 50%. For example, podzols are excessively weathered soils and have a bleached A horizon comprising largely of silica. 'Beach sand' is essentially silica because it has been excessively weathered by ocean waves.*

However, Mr Campbell, it appears, has updated his current marketing and now includes commentary about soil organic matter, which is of course very topical. He claims, without presenting any evidence, that, on his father's farm, after 3 years (it is implied following his own advice) they have added 30 tonnes carbon/ha (10 tonnes/ha/yr). This is, of course, most unlikely - when considered against the known science which indicates that at best (i.e. during pasture and soil development) the rate of accumulation is about 1 tonne C/ha/yr. (see previous article).

Sadly, Judge Callander's words of wisdom have fallen on deaf ears. Explaining his reasoning for the large fine he stated:

Judgment Para 13: *The aim, in short, is to stop Mr Campbell in the future from engaging in unfair deceptive or misleading business practices It is also to stop other unscrupulous business people who might be thinking about doing the same sort of thing. And then of course it is to punish him on behalf of the community.*

MOLYBDENUM (MO)

Molybdenum (pronunciation mo-lib-denum) is one of the 16 essential plant nutrients. It is a trace element and is required in tiny amounts (0.1 ppm in the clover tissue is sufficient). It is normally applied if required, together with other fertilisers, at a rate of 20 grams/ha every 3-4 years to clover-based pastoral soils.

Specifically, it is required by the rhizobia, which live symbiotically on the roots of legumes, in our case clover. It is a catalyst. It enables the rhizobia to convert nitrogen gas (N_2) from the atmosphere into forms of N which the plant then converts to protein N.

In the pastoral system this protein N is ultimately added to the soil, as N in animal excreta or as N in dead plant material. A healthy clover-based pasture can add up to 200 kg N/ha/yr via this process. In absence of soil Mo, clover will not grow and hence the soil will become N deficient limiting the growth of the associated grasses.

Many New Zealand soils, and in particular the soils derived from sedimentary material, were originally Mo deficient and it was discovered in the early 1950s that small amounts of Mo had the huge effect of clover growth as shown in Figure 5, transforming them from scrubby brown N deficient grass-based pastures into lush green clover-based pastures.

Figure 5 Clover response to molybdenum.

The effect was dramatic and this is captured in the photograph shown in Figure 6. The photo was taken in 1953 when the Queen first visited New Zealand. The scientists at the Invermay Research Station carefully applied Mo to a Mo deficient site on a hillside, in the shape of a giant ER, an abbreviation of EIIR, or sometimes just ER. These are the initials known as the Royal Cypher of Queen Elizabeth II. The ER stands for Elizabeth Regina. I hope her Majesty was impressed.

Figure 6 A molybdenum response in pasture depicting Her Majesty's royal cipher.

Farmers of course initially lapped up this new technology, given its low cost and the large benefits, many adopting the approach 'if a little is good then more is better'. Unfortunately, this lead to some cases of the overuse of Mo. Too much Mo in the diet (greater than 1 ppm in the ryegrass-clover pasture will do it) can induce copper (Cu) deficiency in ruminants with disastrous effects on animal health.

Some farmers, having experienced this problem, vowed and declared never to use Mo again and they passed this knowledge onto the next generation. Thus, we now have a generation of farmers who have possibly not heard the full Mo story and how important Mo is for clover growth. The consequence is that today we are finding significant numbers of farms which have 'run out' of clover because they have become Mo deficient. It is a case of 'out of the frying pan and into the fire'.

These problems are easily diagnosed, corrected and managed. Visually, if clover is largely absent in the pasture, despite adequate levels of the other nutrients, then it is a clue that Mo could be deficient. We do not have a soil test for Mo and hence the only way to know for sure whether the clover has sufficient Mo, is to collect a sample (hand full) of clover leaves carefully avoiding dung and urine patches and get it analysed for Mo (the Mo concentration should be above 0.1 ppm). At the other extreme, if you are concerned about potential animal health problems, such as Cu deficiency is it easy to collect some 'grab-samples' of mixed-pasture sample and test the Mo concentration (it should be < 1 ppm). If the mixed-pasture Mo concentration is > 1 ppm then monitoring animal Cu levels should be undertaken and, if necessary direct Cu supplementation may be required.