agKnowledge
"The Independent Fertiliser Experts"
Spring 2021

Fertiliser Review

ISSUE 45

OVERSEER

The major conclusion from a recent independent review of Overseer is that it is not fit for purpose, meaning it should not be used in a regulatory setting. This theme can be traced back to a report from the Parliamentary Commissioner of the Environment (2018) but others including myself have been raising the red flag for some time. (e.g., Fertiliser Review No 31, 2013). In other words, the message is not new; what is new however is the force with which it has been delivered. Even the Government has been sent scrambling to come up with alternatives.

There is no point in regurgitating what has already been said but I would like to add a personal perspective. In 1992 I became the National Science Leader (Soils and Fertiliser) in the newly formed AgResearch. There was an urgent need to develop dynamic nutrient models for P, K and S in particular, as distinct from the static equilibrium models then in use to offer fertiliser advice. The reason? Because we wanted to offer fertiliser advice based on economic outcomes not just the amount of fertiliser required to maintain soil fertility.

The first step in the process was to summarise all the field trial work on P, K, S and lime – a very large task in itself. This data was then used to develop the set of dynamic nutrient models which first appeared in a software package called OUTLOOK. It was a simple step from the dynamic models to construct NUTRIENT BUDGETS. A nutrient budget for N was also included. Thus, OUTLOOK was both an econometric nutrient model and a nutrient budgeting tool. Of relevance to this discussion, the early estimates on the predicted N losses were shown as +/- 30%. There was no pretence at accuracy given the purpose and application then envisaged for the models – a robust farm management tool to be used by knowledgeable experts.

I left AgResearch at the end of 1997 and had no further input into OUTLOOK, but I came to learn that the two functions of what was OUTLOOK were divided into the Econometric Models for Lime P, K and S and separately, OVERSEER, a new nutrient budgeting package.

Now operating as a private science consultant, it became necessary from time to time to use the Overseer nutrient budget. I became increasingly concerned about constant changes being made to the model without any apparent peer review and raised this concern with the then AgResearch Science Leader in 2005. I was reassured that a Technical Group was going to be established to peer review the ongoing development of Overseer. This did not eventuate.

One of the glaring weaknesses of Overseer at this time was its inability to model cropping situations and much effort was made to rectify this. I became involved with a Technical Group to review this new cropping sub-model, only to learn that it was not adequately peer-reviewed and, more importantly, the whole Overseer enterprise was under-resourced. High-level discussions followed and the consequence was that the whole management of the operation was to be shifted out of Ruakura Research Centre and into a new company based in Wellington, Overseer Ltd.

Dr Caroline Read was appointed CEO, and among other changes, she appointed a Technical Advisory Group. We met twice, as I recall, and achieved nothing. The only thing I learnt was that many of the sub-models, which make up Overseer, had not been adequately peer-reviewed.

Furthermore, I became increasingly concerned about how Overseer was being incorporated into Regional Council's Plans for managing water quality, and specifically for estimating nitrate N losses. In particular, I was concerned by the lack of understanding about the potential errors in the Overseer output.

I decided to put my concerns in writing. The consequence was a lengthy article in Fertiliser Review No 31, 2013. This article warned of the dangers of using Overseer in a regulatory setting because the errors in the estimated rates of nitrate leaching could be as much as 100%. It was inevitable, in my view, that sooner or later, farmers would be arguing with their Regional Councils, and most likely in the law courts, about the 'true' rate (the quantitative amount) of nitrogen leaching from their farms. The stakes were high because of the way things were shaping, a farm could be deemed non-compliant based on the predicted Overseer N leaching rate. That possibility it appears is now dead – thank goodness.

Personally, I was happy for Overseer to be used for the function it was designed for – to undertake "what-if" analysis on a given farm to understand how the effects of different farm management practices impact on nitrate leaching. In this setting, a qualitative answer only was required to understand the trends over time. However, the Reviewers do not see it that way. They say that the modelling approach used in Overseer is irreparably flawed and that other approaches to this vexed issue must be examined.

For me, the whole debacle reflects poorly on the conduct of agricultural science in these commercially and environmentally sensitive times.

SCIENCE METHOD

One of the disciplines required when following the scientific method requires the need to be conversant with the relevant scientific literature. When framing a hypothesis, and before designing and conducting an experiment, it is always useful to consider what has gone before. Maybe the hypothesis has already been tested. Maybe the proposed experiments and the relevant answers are already in the published literature and there is simply no need to repeat the research. If this important step - think of it as due diligence – is omitted there is a danger of wasting R & D dollars for no gain.

I was thinking of such matters when reading a recent (2019) paper entitled *"BRIEF COMMUNICATION: Conventional or Albrecht-Kinsey fertiliser approach in a commercial scale dairy farm systems comparison"* by Bryant and co-workers from Lincoln University.

The paper reports the results from an 'experiment' (The paratheses are necessary because the experimental treatments were not replicated as is required for a *bone fide* scientific trial) which compared the performance of two dairy farms, one fertilised using the conventional fertiliser approach (I will refer to this as the Quantity Approach) and the other fertilised using the Albrecht-Kinsey, Ratio Approach (see Fertiliser Review 26)

The authors concluded, "Although conclusions about the impact of soil fertiliser regime on animal health are premature, at the farm scale any differences in pasture and animal productivity associated with fertiliser policy are not apparent in the current measures."

This appears to be a rather guarded way of saying that the claims made for the Albrecht-Kinsey Ratio theory approach are rubbish. And to make matters worse, the fertiliser costs for the Ratio Approach were much greater than for the Quantity Approach.

If these authors, and those who contributed to funding this experiment, had done their due diligence, they would have learnt that these conclusions are entirely predictable based on previously published science!!! (For a summary see Fertiliser Review 26 and 44).

The same can be said for a trial conducted at Massey University (2001-2009) comparing the production from a dairy farm operated conventionally versus a farm managed according to organic principles. This was a replicated trial and the results were entirely predictable based on previous research (see Fertiliser Review 19, 25 and 28).

Both these trials demonstrate the importance of that first step in the scientific process – what does the existing literature say? They also show that omitting this due diligence step can result in a waste of the R & D dollars.

This brings me once again to that 'hoary chestnut', Regenerative Agriculture. I wonder how the claims made by RA adherents would have stacked up against some old-fashioned due diligence?

RA practitioners stress the need for rotational grazing and optimizing the return of litter to the soil. A literature search would have shown that the benefits of rotational grazing are well-grounded in science going back to the pioneering work by McMeekan in the 1950s. At about the same time, Peter Sears showed that optimising the return of plant material (dung, urine, plant litter) increases pasture production by about 40%. The modern NZ farmer uses these findings every day.

What about complex seed mixes? A literature search would have turned up the early work by Bruce Levey who warned farmers back in 1936 about the "futility of wasting seed in complicated seed-mixtures…". More recently, John Dawson, a Waikato based farm consultant found the same thing when exploring whether complex seed mixes resulted in more resilient summer pastures.

It is, we must remind ourselves, no accident, nor a conspiracy by the seed industry, that clover/ryegrass pastures are so ubiquitous in New Zealand's largely temperate climate.

The same applies to grazing management. RA practitioners talk about lax grazing being optimal. But any literature search would have unearthed a mountain of research showing that maximum production of clover-based pastures is achieved when light interception and hence photosynthesis is optimized and that this occurs when grazing management is operated within the limits of 1500 to 3500 kg DM /ha.

Taking our literature search further: what does the accumulated science say about withholding fertiliser inputs? What about adding 'tonics' like seaweeds and humates to activate the soil biology and hence release locked up nutrients? Unfortunately, the scientific literature does not support these possibilities.

Finally, a thorough literature review would have discovered that there is very little information on the economics of RA – hardly surprising given its 'newness'. The only analysis that I have found comes from NSW Australia and it indicates that the rate of return from a group of RA farms was about 1% relative to 4% for conventional farms.

Thus, a thorough literature review would indicate that apart from rotational grazing and optimising the return of litter, which are currently both widely practised, RA has little to offer NZ pastoral farmers!

So how is it that the recent Landcare Research review entitled "Regenerative Agriculture in Aotearoa New Zealand, 2021" got it so wrong? I can only suggest that this is what you get when you ask people with no background in agricultural science and, perhaps little understanding of agriculture per se, to undertake such a vital task.

And the die is now cast – this deeply flawed review will be used by the politicians and their slaves to justify considerable R & D expenditure on RA. If this happens it will be yet another example of a predictable waste of money based, not on the foundation of sound science, but driven by an ideology.

PRICE WATCH (BALLANCE AGRINUTRIENTS, 6/9/21)

There have recently been some major increases in the cost of some fertilisers. In particular the cost of DAP and Triple super have increased significantly relative to the more standard generic products we use in New Zealand. This is reflected in the figures below.

Common nitrogen fertilisers:

Product	Price ($/tonne ex-works)	Cost ($/kg N) ex works
N Rich Urea	843	1.83
SustaiN	899	1.96
PhasedN	760	2.17
Sulphate of ammonia[1]	529	1.72
N rich Ammo30[1]	670	1.84
DAP[2]	1150	3.10

Notes: 1) Assuming that the sulphur (S) in sulphate of ammonia is valued at $0.88/kg S and 2) the phosphorous (P) in the DAP is valued at $2.79/kg P.

Common phosphorous fertilisers:

Product	Price ($/tonne ex-works)	Cost ($/kg P) ex works
Superphosphate	344	2.79
Surephos	359	3.06
DAP	1150	4.10
Triple super	1117	5.88

Notes: 1) Assuming sulphur (S) costs $0.88/kg and 2) N costs $1.83/kg and 3) magnesium (Mg) cost $1.83.

It is clear that DAP and Triple super are now very expensive products, when considered either as a source of N (DAP) or as a source of P (DAP and Triple Super).

Super is still the cheapest form of P. Sulphate of ammonia, followed by N Rich Ammo and urea are the cheapest forms of N. The margins on SustaiN and Phased N are hard to justify, given their claimed mode of action, and when applying these products at normal rates of N (20-30 kg N/ha) (see Fertiliser Review 37).

In the recent past, the use of Triple super and DAP have been justified based on their lower transport and spreading costs. This no longer appears to be the case.

Consider a hill country situation where the transport and spreading costs are $100 tonne. Assume the farm is at maintenance and requires annual inputs of 27 kg P and 32 kg S per ha.

Option 1: Superphosphate at 300 kg /ha, cost $103/ha ex-works plus $30/ha for transport and spreading. Total cost on-ground $133/ha

Option 2: A Special mix of Triple super (140 kg/ha) and Sulphur Gain (50 kg/ha) would apply the same amounts of P and S. Cost ex-works $195 and $19 for transport and spreading. Total cost $210/ha.

It is tempting to think of applying DAP as a source of N, with the intention to get some nitrogen (N) 30 kg/N/ha on the farm ahead of lambing. This, I suggest, is an expensive option.

Consider:

Option 1: Apply 65 urea kg/ha (30 kg N/ha), costs $55/ha ex works, with transport at spreading at $200/tonne adds a further $13.0/ha. Total cost $68/ha.

Option 2: To apply the same amount of N as DAP requires 166 kg DAP/ha, cost ex-works $190/ha, with transport and spreading $33.2/ha. Total cost $223/ha.

The additional cost is rationalised on the basis that the annual P requirement is being applied at the same time. But this assumes that no other nutrients, such as potassium and sulphur, are required to maintain the fertility of the soil. Thus, the soil P fertility may be maintained but at the soil K and S levels, so important for clover growth, will decline. A case of false economy.

My Advice

Now more than ever, it is appropriate to stick to the generic products (super, urea, potash). If possible, stay away from branded products and compound fertilisers.

SPOT THE PROBLEM

A farmer sent to me details of a fertiliser brew he had been recommended. He sought my advice.

The components of the fertiliser mix are set out below:

Component	kg /tonne & (%)
Sechura RPR	412 (41%)
Dolomite	300 (30%)
Potassium sulphate	110 (11%)
Special blend	100 (10%)
Sulphur bentonite	40 (4%)
Organibor (Boron)	25 (2.5%)
Copper sulphate	5 (0.5%)
Zinc Sulphate	4 (0.4)
Selenium (2%)	4 (0.4%)

Some commentary is illuminating:

1. The mix was recommended to be applied at 475 kg/ha and costs $571/tonne (ie $271/ha). This would supply 21 kg P, 22 kg K and 30 kg S per hectare.

2. By way of comparison, 300 kg/ha SuperTen 7K would provide 23 kg P, 23 kg K and 27 kg S per hectare and cost $132/ha!

3. Sechura RPR makes up 40 % of the mix. Of all the available RPRs it is one of the best and dissolves at about 30% per year. BUT: these products only work in an acidic environment and should not be applied with a liming material like dolomite! How much total P applied is plant available is anyone's guess.

4. Magnesium (Mg) is not required on sedimentary soils, as in this case. Adding it into this mix is probably a waste of money.

5. Potassium sulphate is a very expensive way of buying potassium (K). The K is potassium chloride costs about $1.82 /kg. Allowing for the sulphur (S), the K in potassium sulphate costs over $2.0/kg.

6. The trace elements Boron (B), Copper (Cu) and Zinc (Zn) are not generally required on NZ pastoral soils, especially on sedimentary soils as in this case.

7. The mix contains 10% of a Special blend. Just what this is, is not explained

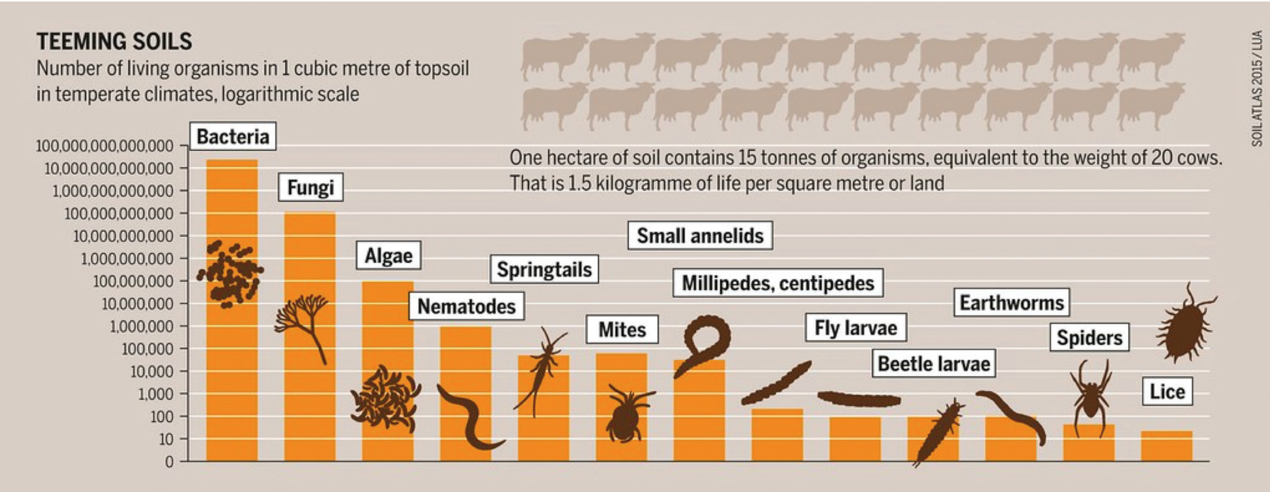
My Advice

Steer clear of this type of proprietary brew.

SOIL BIOLOGY AND BIODIVERSITY

If you listen to those who espouse Regenerative Agriculture or are ardent Organic farmers you could be led to believe that we (scientists) know nothing about soil biology and worse, are ignoring this new frontier. It is appropriate, therefore, to reconsider what we know about what is going on under our feet – in the soil. I am indebted to Professor Leo Condron of Lincoln University for drawing this to my attention in his paper "The marvel of soil biodiversity" (2017).

The graphic below shows the number of living organisms in a cubic meter of topsoil in a temperate soil. Noting the logarithmic scale, the numbers are astronomical. For example, there are about 100,000 billion bacteria and 10,000 billion fungi. To put that into some useful perspective 1 gm of soil contains 1 billion bacteria and 10 meters of fungal hyphae. One hectare of soil contains about 15 tonnes of organisms, about the same weight as the livestock above the ground!



Source: https://www.flickr.com/photos/44112235@N04/43585176080

Author: Heinrich-Böll-Stiftung

And this underground ecosystem is biodiverse with over 100,000 species of bacteria and fungi, 25,000 species of nematodes, 40,000 mites and 7,000 earthworms.

The soil biomass is classified by size:

Microflora is made up of the smallest organisms; bacteria (< 2 microns) and fungi. Together they make up about 90% of the soil biomass

Microfauna (10 microns - 0.1 mm) make up the remaining 10% and includes protozoa and nematodes.

Mesofauna (0.1 - 2 mm) are flightless insects such as mites and springtails.

Macrofauna (2 - 20 mm) includes earthworms, termites, and slugs and snails

The latter, and especially the earthworms, do much of the ‘heavy lifting’ in the soil and break down the larger plant fragments and mixing them into the soil. In temperate soils, it is estimated that earthworms turnover about 70 tonnes per hectare of topsoil annually. However, the bulk of the breakdown of organic matter in soils is done by the bacteria and fungi which are in turn consumed by the microfauna.

This vast ecosystem is fed (with energy and nutrients) by the breakdown of organic matter derived from plants and animals, including animal excreta and the remains of other organisms.

Given this information it is easy to understand why soil biomass increases with the amount of litter returned to the soil (see examples Table 2 and Figure 5, Fertiliser Review 42)

PHOSPHATE RESERVES

I am often asked; will we run out of fertiliser? Of particular concern is the nutrient phosphorous (P).

According to the United States Geological Service (USGS), worldwide production of phosphate rock was 223,000 thousand metric tonnes in 2020 (i.e. 0.22 B tonnes) The World Reserves are estimated to be 71,000,000 million tonnes (i.e. 71 B tonnes). Reserves are defined as the currently mined resources plus known resources available for mining given current costs and technologies.

Assuming that a) there will be no increase in demand, b) that no new economically viable reserves will be found, and c) current technologies to extract P from the reserves will not change, the existing known resources will last for about 300 yrs – about 15 generations.

The distribution of known economically extractable reserves are shown in Figure 1. It is clear that the dominant source is Morocco including Western Sahara.

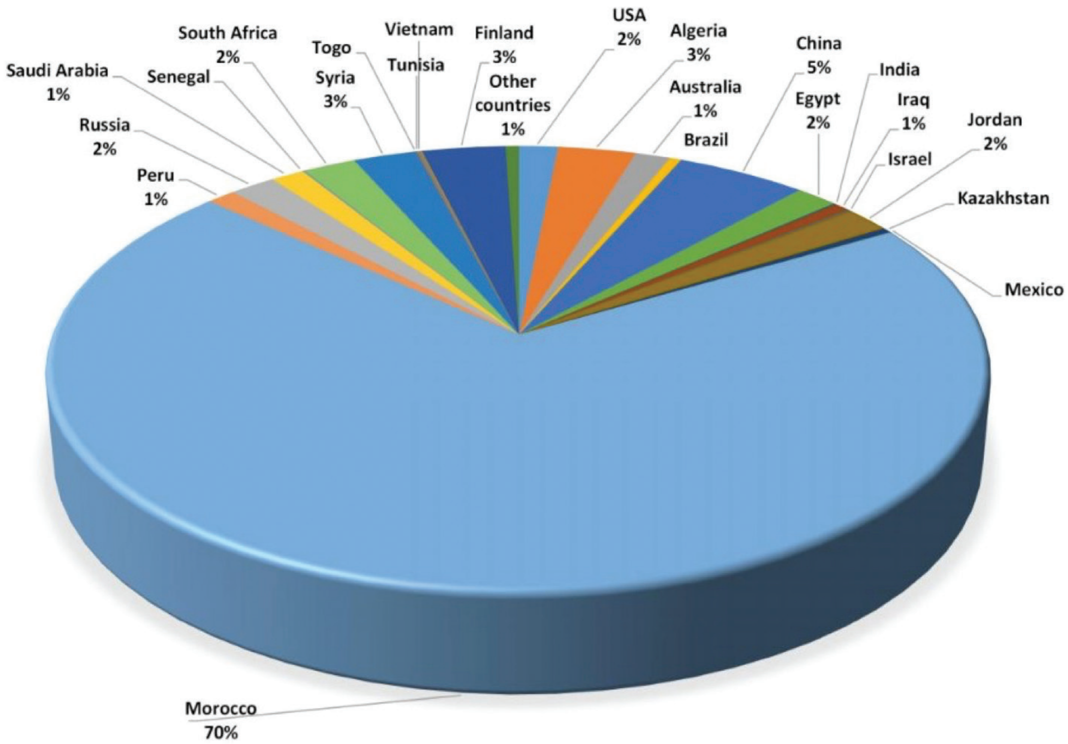


Figure 1 Distribution of economically extractable reserves of phosphate rock.

The production of PR mined in 2020 is set out in Table 1. The largest producers are China, followed by Morocco (including Western Sahara), United States, and Russia.

Country	Tons (millions)
United States	24
Algeria	1.3
Australia	2.7
Brazil	5.5
China	90
Egypt	5
Finland	1
India	1.5
Israel	2.8
Jordan	9.2
Kazakhstan	1.5
Mexico	0.6
Morocco[1]	37
Peru	4
Russia	13
Saudi Arabia	6.5
Senegal	3.5
South Africa	2.1
Syria	0.4
Togo	0.8
Tunisia	4
Uzbekistan	0.9
Vietnam	4.7
Other	1.1
Total	**223**

Table 1. Mine production of phosphate rock in 2020

New Zealand imports 150,000 tonnes of P per year (i.e. about 1.25 M tonnes of phosphate rock assuming an average rock P content of 12%). This represents about 0.5% of current worldwide production. This comes from various sources including Morocco, Togo, South Africa, China and Vietnam.

And now to the question: will we ever run out of phosphate rock? As noted above the estimated known reserves will last about 300 years but this assumes that a) no new economically viable reserves will be found, and that b) current technologies to extract P from the P reserves will not change. Neither of these two assumptions are likely to be true, but we have no way of quantifying them because it is not possible to predict the future. However, because the whole world depends on fertiliser P you can be sure that a lot of eyes are watching this space.