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SOIL TESTING: GETTING IT WRONG!!

[Editor's note: *Protocols are available indicating the Do's and Don'ts of soil testing to minimise the effects of variability in soil fertility. All acknowledge the problem but are either simplistic or confusing when offering solutions. None explain the practical consequences of getting it wrong. This article is an attempt to put more thought and science into what we are attempting to do and why*].

We are finding a large number of cases where farmers have been given bad fertiliser advice. We think that the reason for this is because the proper soil sampling protocols have not been followed – the soil test results look good, (i.e., at optimal or above), but the pastures are poor - low clover content and companion grasses lacking vigour - suggesting that the soil test levels have been over estimated.

To give some idea of the size of the problem we recently summarised the soil test data collected from client's farms, at the time of the initial farm visit. About 60% - 80% of these farms were deficient in either P, K or S, and this was reflected in the poor quality of the pastures (see examples in Fertiliser Review 44).

Why is this happening?

Variability in Soil Fertility

Fertiliser are a major item of expenditure on most farms and soil test results are relied upon to make decisions as to what type and how much fertiliser to apply. But how good are we at this vital task? How accurate are soil tests?

The problem is that soil fertility, especially in the pastoral setting, is inherently variable. This is largely because animals do not return nutrients evenly to the soil (Figure 1 for example). The soil under dung and urine patches is nutrient rich and this is particularly the case under urine patches. Consider: urine is rich in K and the rate of K application in a urine patch is similar to that for N i.e., up to about 600 kg K/ha/urination. It is not difficult to understand why soil K levels are inflated under urine patches.

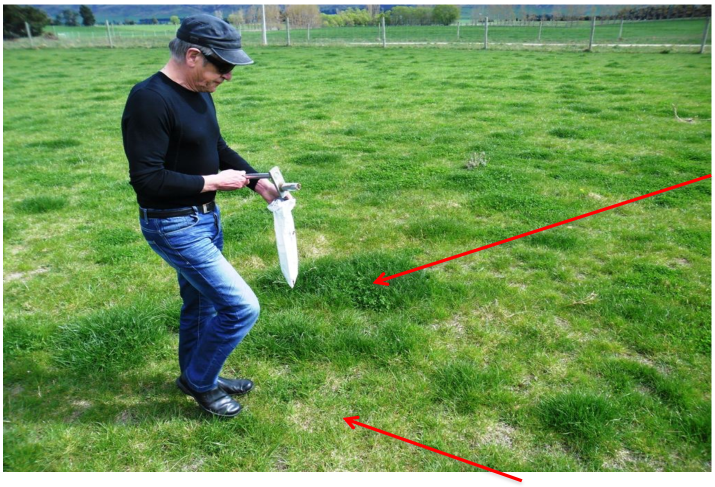


Figure 1 A mosaic of dung and urine patches as reflected in the pasture composition and vigour in a clover-based pasture.

The data in Figure 2 demonstrates what this variability ‘looks’ like in practice. In this example the soil Olsen P levels were measured annually for 18 years across one transect. The same operator collected the soil samples at the same time of the year and the annual fertiliser inputs were constant. Importantly the standard soil testing protocol was followed avoiding dung and urine patches. This then is the ‘background noise’ against which we are working.

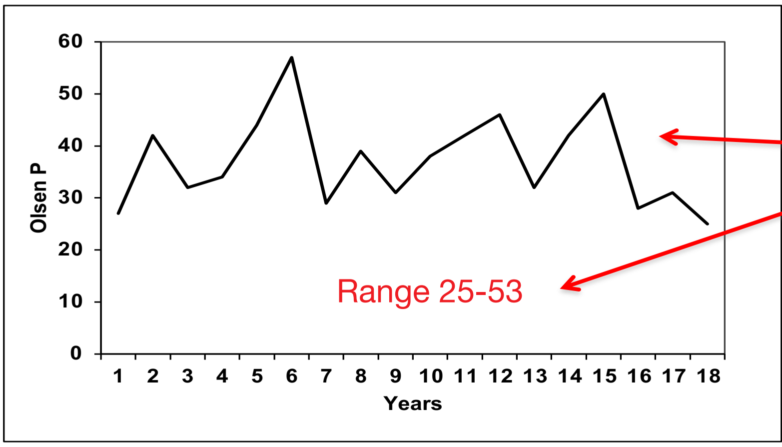


Figure 2 Soil Olsen P levels measured annually for 18 years on the same transect.

The total variability can be summarised as the coefficient of variation (CV) as shown in Table 1. Using the Olsen P data as an example, if the CV is 15% then a reading of 25 Olsen P units means that the confidence interval will be about +/- 10 Olsen P units (i.e., a range of 15 to 35 Olsen P units). If you repeatedly sampled the same paddock, then 90 times out of 100 the Olsen P will lie in the range of 15-35. Alternatively, an Olsen P reading outside this range would indicate that it is statistically different from 25.

Table 1. Variability in soil tests as indicated by the Coefficient of Variation (CV)

Soil test	Coefficient of Variation (CV) (%)
pH	2-5
Ca	10-15
K	20-30
Mg	10-15
Olsen P	15-20
Sulphate S	20-40
Organic S	15-20 (estimate)

The point is: there is a lot of variability in soil test results. This does not mean that soil testing is of little value. It does mean that a good understanding of the problem is required.

Understanding the Problem.

It is against this ‘noisy’ background we need to ask; what are we attempting to measure when collecting a ‘representative’ soil sample (15 to 20 cores at 75 mm depth) for the purpose of offering fertiliser advice?

What we should be attempting to do is to collect 15 to 20 cores which reflect the background noise – we are wanting to determine the average soil fertility of those areas devoid of the hot spots (see Figure 1 for example). It is these areas which need to be improved with fertiliser inputs. To be explicit, we are not wanting to define the average fertility of the paddock including the hot spots. If we did that the results would be inflated soil tests levels and hence no fertiliser, or very little, would be recommended. This is, you will recall, the problem we identified earlier.

[If the purpose of soil testing was to estimate P runoff, then the average of randomly collected soil samples including the hotspots would be required].

It is because of all this ‘noise’, and the potential contamination from hot spots I advise consultants, “never believe soil test results until you have assessed the pastures.” Soil test results need to be ‘ground proofed’ – measured against some other independent information - before they are accepted as ‘real’. The handiest method for this purpose is visual pasture assessments. Much can be learnt about the underlying soil fertility by ‘reading’ clover-based pastures.

Clover has a higher requirement for all nutrients relative to the companion grasses. For this reason, the clover content of a pasture, (where it is growing and its colour and vigour), is a good proxy for the underlying soil fertility (compare the clover content and pasture vigour in the examples in Figure 3). If the soil tests are not consistent with the Pasture Visual Assements (PVA) then it is more likely than not that the soil test results are incorrect.

Figure 3 Examples of good and bad pasture.

We have developed a system to rate pastures, on a 1-10 scale, based their overall vigour, colour, clover content and companion grasses (Fertiliser Review 46). If you wish to learn more you can purchase a copy of the booklet “Pasture Visual Assessment” (PVA) from the agKnowledge website. https://agknowledge.myshopify.com/

Choice of Transect?

On Flat to Rolling country the shape of the soil testing transect, whether zigzag, circle and diagonal, does not matter. The goal is to collect random samples (20 cores per sample) avoiding all hot spots (for example see Figure 1).

In Rolling, Easy and Steep country, the transfer of nutrients by animals is more marked (Figure 4).

Figure 4 Animals move nutrients from the slopes to camping areas.

Animals move nutrients from the slopes where they graze, down to the flatter areas, where they camp, rest and defecate, particularly around gateways, troughs, hedges, trees. The accumulative effects over time can have a large effect on soil nutrient levels (Figure 5).

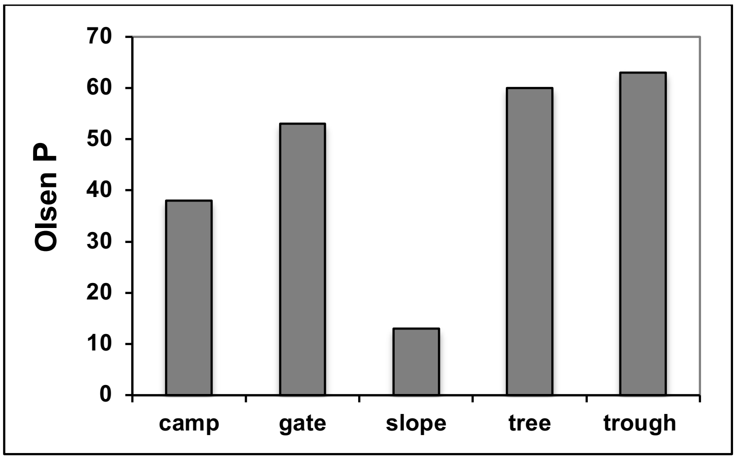


Figure 5 The effect of position in the landscape on Olsen P levels in Hill Country paddocks (average of 7 paddocks).

For this reason, the position of the transect within the landscape becomes very important as indicated schematically in Figure 6.

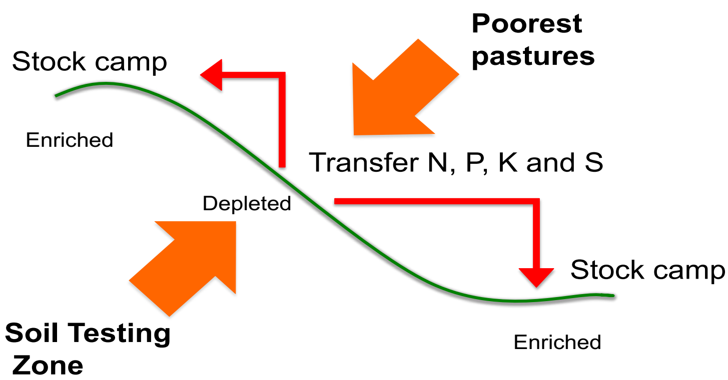


Figure 6 In Easy and Steep Hill country nutrients are moved from the slopes to the camping areas.

For these reasons the soil testing transect should be along the contour (blue line in Figure 7) and not across it (red line in Figure 7).

Figure 7 In Rolling, Easy and Steep country the soil sampling transect should be along the contour.

The differences in soil fertility can be very large and can influence the subsequent fertiliser advice. This is especially the case for soil K (Table 2) because the amounts of K in the nutrient cycle are about 10 times the amounts of P and S. In the examples below both sites were K deficient (below 'opt 7-10') based on the samples collected along the contour. This would not have been 'picked up' if the soil samples had been collected across the contour.

Table 2. Soil test levels from samples collected along and 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

Some Other Thoughts

Some soil testing protocols emphasis the use of GPS when soil testing to identify which paddocks are to be sampled and the position of the transects within each paddock. This is not necessary – a good farm map is quite adequate for this purpose. In any case GPS coordinates give a false impression of precision and accuracy of soil testing and as discussed above this is never achievable. Also, it is not necessary to collect soil samples at predetermined distances along the transect. Random samples (15-20) along the transect, avoiding dung and urine patches, is all that is required.

On flat to rolling paddocks animals move nutrients from the back of paddocks towards the gateways. On well-established dairy farms this can mean that the areas furthest from the gateway become depleted in nutrients. In other words, the gateway-hotspot can extend well into the paddock. In these cases, the soil sampling transect should be limited to the back section of the paddock.

My advice

If you have been told that your soil tests indicate adequate fertility but the pastures are poor and not improving, it is time to rethink. Maybe you need some independent advice?

FOLIAR NITROGEN (N)

The Rural News (March 11) ran an article “Foliar feeding ‘lifts N efficiency.” It reported results from 4 pasture trials in Wales which compared conventional (granular) applications of urea fertiliser with foliar applications. This article could be traced back to a report published by the European Innovation Partnership (EIP) Wales in 2022, in which it is claimed that foliar-feeding increased Nutrient Use Efficiency (NUE) (kg DM/kg N applied) by about 200%-300% kg DM, relative to conventional application of granular fertiliser N. These are very large increases! To put this into the New Zealand context, NUE for urea are typically in the range 10-20 kg DM/kg N applied, relative to control.

The Rural News article shows a picture of a ‘Tow and Fert’ spreader. It is reasonable to assume that these trials were conducted using the ‘Tow and Fert’ technology developed and widely promoted in New Zealand. I have expressed my concerns about the claims made about this approach (Fertiliser Review 35, 37, 38, 40, 44). Given these concerns and given the high reported NUEs, I decided to investigate further.

It turns out that the 3 treatments (control, conventional, foliar) in these experiments were not replicated - to my way of thinking this is a fatal flaw in any biological experiment. It means that there is no way of knowing whether the effects of the treatments are real and not just a reflection of the background variability (noise) in the trial. No statistical analyses were presented.

Of equal concern is the design of the trials and in particular the choice of N treatments. The trials ran for 3 years. The inputs of foliar N were (in kg N/ha/year): 63 (year 1), 70 (year 2) and 101 (year 3). The comparable inputs for the conventional N treatments were (kg N/ha/year): 245, 248, and 266.

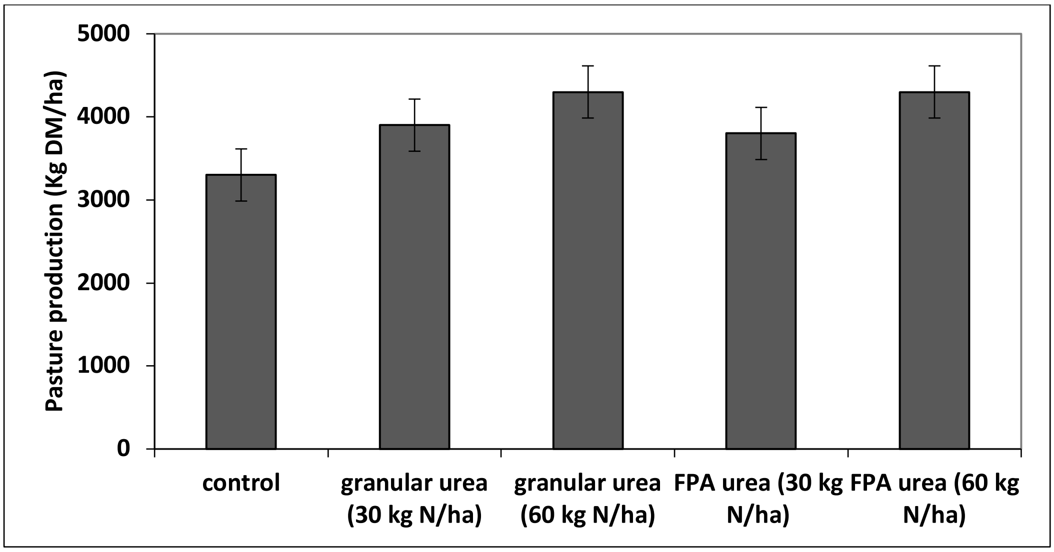
To be a fair comparison, the rates of N should have been the same for both the foliar and conventional treatments. This comparison was not made! I am left wondering; is the NUE of foliar application of urea better than for conventional granular urea applications, when compared at the same rate of N application?

A theoretical complication arises from the design of the trial and in particular the shape of the relationship between pasture production and fertiliser N applied in this trial. The inputs of granular urea were on average 253 kg N/ha/year and 78 kg N/ha/year for foliar N treatment. Consider what conclusions could be made if the pasture production was optimal at say 100 kg N/ha/yr and that the difference in yield between the two treatments was not significant? We cannot answer this question because the shape of the pasture production versus N applied rate is not known.

Interestingly, these 4 Welsh trials mimic a trial conducted in Somerset, UK, in 2020. The results of this trial are also cited by the ‘Tow and Fert’ as evidence of the benefits of foliar application of urea. Unfortunately, the treatments used in this trial were also not replicated and hence the results cannot be relied upon.

My advice?

Follow the science. And to reinforce the point, the graph below, (which comes from Fertiliser Review 37) shows data from a trial on pasture in the Hawkes Bay in which granular and Fine Particle Application (FPA) urea (read foliar urea) were compared at the same rate of application. There is no effect of the method of application of N on pasture production when the comparison is made at the same rate of application.



More About Some Snake Oils

A paper was presented at the 2024 New Zealand Grasslands Conference entitled "Can additives or controlled release coatings improve the nitrogen use efficiency of urea fertiliser?" The question is timely. The current cap on nitrogen (N) fertiliser use is 190 kg N/ha/year and for this reason the 'push is on' to find ways of making this N go as far as possible. Expressed formally, the goal is to increase Nitrogen Use Efficiency (NUE); to optimise the production per unit of N applied.

A mowing trial was conducted on an irrigated pasture in Canterbury. The trial ran for 1 year. There were 7 treatments.

1. Control (no urea N)
2. 190 kg N/ha in 9 applications of 21 kg N as urea.
3. 190 kg N/ha in 5 applications of 38 kg N as urea.
4. 190 kg N/ha as a controlled release N (CRN)
5. Treatment 3 + additive ProGibb (2 gm/ha)
6. Treatment 3 + additive Agrisea (5 l/ha)
7. Treatment 3 + additive N-Boost 3 l/ha

The objective was to measure the effect on pasture production of a) different rates and timings of urea b) a control release N fertiliser and c) adding 3 additives to urea.

Importantly, the site was N deficient. The pasture DM response to urea, averaged over both treatments, relative to the control, was 2445 kg DM/ha; that is 12.8 kg DM per kg N applied. Changing the rate and timing of urea had no effect, suggesting that the 'small and often' theory does not apply, at least in this case.

The controlled release urea (CRN) product used in this trial was Rustica, a product made in China. Over the duration of the trial the DM production for the CRN treatment was the same as the urea treatments but there was some suggestion that this treatment altered the timing of herbage accumulation – the pasture response was lower initially, as may be expected for a CRN product. Given my experience with the NZ made SmartFert product I would need to know more about the chemistry of this product, and in particular the N release characteristics before making further comment.

ProGibb contains another plant growth hormone, gibberellic acid, and the lack of a pasture response to ProGibb in this trial is not consistent with other trial data (see Fertiliser Review 22). It is noted that this product has some specific conditions for its use; it must be applied within 4 days post - grazing (or mowing) and harvested (grazed) within 50 days post-application. I am uncertain if these conditions applied in this experiment.

Agrisea and N-Boost (formally known as LessN) when applied with urea N, had no effect on pasture production. These products are claimed to contain the plant growth hormone, cytokinin, or to have cytokinin-like activity. I have previously expressed reservations about these products (see Fertiliser Review 29 and 24 respectively) and for this reason the current results with these products do not surprise me.

Look now at the bigger picture. In 2002 (Fertiliser Review No 8) I wrote:

"If advertisements and articles in the farming press are a guide, then I think I see a new type of soil 'health' product in the market place. These are liquid products variously called soil bio-stimulants, soil activators or soil inoculants.

These products are claimed to either contain more vigorous soil microbes and/or organic substrates to feed the existing microbes. The net result, it is claimed, is enhanced soil biological activity, faster turnover of nutrients and hence improved plant growth and health".

I think these statements are perhaps even more relevant today, 20-odd years later. I can think 2 reasons. There are no regulations around the use of these types of products, and more importantly, the N cap creates a ready market for any products which claim to enhance the effectiveness of urea N.

The only safeguard for the consumer is what is offered by the amended Fair Trading Act (see Fertiliser Review 34):

"it is now illegal to make a representation about a good or service without any reasonable basis. What this means is that businesses that make claims or imply something about their goods or services must have reasonable grounds for making those claims."

"Reasonable grounds can come from: information provided by reputable suppliers or manufacturers, information the business making the claims hold, or any other reasonable source (for example, scientific or medical journals)."

"Importantly, a business must have reasonable grounds at the time (my emphasis) they are making the claim." It appears that gathering data to support a claim after it is made will not be sufficient.

My advice

If you think that the claims made for a product or service are dubious contact the company and ask for their supporting evidence. Failing that, seek independent advice. Remember let the buyer beware!!!!

REGENERATIVE AGRICULTURE

I have promised to do my best to keep you up to date on this vexed issue. Refer to Fertiliser Review: 42, 44, 46, 47, 48 and 51. Two papers were presented at the 2024 Grasslands Conference on this topic. One, a field trial on a dryland site in Canterbury, had only been in progress for 1.5 years and the other, a field trial in the Hawkes Bay, was commenced in 2022. Apart from noting that these trials are underway, there is little of practical importance to report. Indeed, I wonder out loud, why they were even presented at the conference!