

Fertiliser Review

ISSUE
33



SULPHUR FERTILISERS

Several new sulphur (S) fertilisers have come onto the market recently and others are no longer available. It is time to review the S situation.

The main S fertilisers used in New Zealand are listed in Table 1. This includes some new products: SulphurGain Pure and Phased N (both from Ballance) and Sulphur 90 Granules (Ravensdown). Durasul (Ballance) is no longer available and the other products or their equivalents are common to both companies.

On a per kg **Total S** basis, Ballance’s Durasul product was the cheapest source of S. It has been withdrawn from the market. The cheapest forms of S currently are the S enriched superphosphates such as SulphurGain and Sulphur super 30 and Maxi sulphur super, followed by superphosphate and the pure elemental products SulphurGain Pure and Sulphur90 granules. Note that these costings take into account the value other nutrients (either P or N) where present.

Table 1: The main sulphur fertilisers used in New Zealand.

Product, company, availability	Total S (%)	Other nutrients (%)	Cost (\$/tonne)	Cost
Durasul (Ballance, not now available)	95	nil	410	0.43
SulphurGain Pure (Ballance, new)	90	nil	670	0.74
Sulphur90 Granules (Ravensdown, new)	90	nil	645	0.72
Maxi sulphur super (Ravensdown)	47	5%P	421	0.62 ¹
SulphurGain30 (Ballance)	30	7% P	370	0.61 ¹
Phased N (Ballance, new)	29	25% N	608	0.98 ²
Ammonium sulphate granular (both companies)	23	21% N	570	1.31 ²
NRich Ammo 30N (Ballance), Ammo 31 (Ravensdown)	14	30% N	590	1.37 ²
Superphosphate (both companies)	11	9% P	315	0.75 ¹

Notes: 1) Assuming that a kg P costs \$2.63 (based on superphosphate and assuming that the cheapest form of currently available S costs \$0.74/kg).

2) Assuming that a kg N costs \$1.31 (based on urea)

There are 2 forms of S in fertilisers: immediately plant available sulphate S and slowly available elemental S. For superphosphate, ammonium sulphate and Ammo all the S is present as sulphate. Conversely the S in SulphurGain Pure, Sulphur 90 Granules and Phased N is present only as elemental S. The enriched superphosphates (Maxi sulphur super and SulphurGain 30) contain both forms (Table 2).

Elemental S is not plant available and must be oxidized by bugs (thiobacillis) in the soil to become plant available sulphate S. The rate of oxidation depends primarily on the particle size of the elemental S and in part on the soil temperature - the finer and warmer the conditions the faster the rate of oxidation.

Table 2 gives the approximate particle sizes of the elemental S in the various products. Durasul was relatively coarse and the Ravensdown product Maxi Sulphur Super contains the finest elemental S.

Table 2: Characteristics of the main sulphur fertilisers in New Zealand.

Product	Immediately available S (% of total S)	Elemental S (% of total S)	Particle size of the elemental S (% passing in microns) ¹			
			> 500	< 500 > 250	< 250 > 150	< 150
Durasul	0	100	55	35	7.5	2.5
SulphurGain Pure	0	100	24	21	21	34
Sulphur90 Granules	0	100	NA ²	NA ²	NA ²	NA ²
Maxi sulphur super	15	85	3	36	32	29
SulphurGain30	30	70	24	15	19	41
Phased N	0	100	16	23	18	43
Ammonium sulphate	100	0	NR ³	NR	NR	NR
Ammo 30	100	0	NR	NR	NR	NR
Superphosphate	100	0	NR	NR	NR	NR

Notes: 1) for comparison talcum powder is typically < 75 microns

2) Not available at time of writing

3) NR = not relevant

Much research was done in the 1990s measuring the effect of particle size on the rate of oxidation. Using this information, the amount of available S coming from the elemental S component in each fertiliser, in the year following application, can be determined. Adding this, where necessary, to the amount of immediately soluble available sulphate S in each product, and the total S plant available in the year following application, can be derived (Table 3) together with the cost of the total available S.

Table 3: The cost of the plant available S in the various sulphur fertilisers.

Product	Application rate	Total S applied (kg S/ha)	Available S applied (kg S/ha) ¹	Cost (\$/kg available S)
Durasul	53	50	21	1.03
SulphurGain Pure	56	50	33	1.13
Sulphur90 Granules	56	50	NA ²	NA ²
Maxi sulphur super	106	50	8 (from soluble) + 30 (from elemental) = 38	1.17
SulphurGain30	169	50	15 (from soluble) + 24 (from elemental) = 39	1.60
Phased N	175	50	36	2.95
Ammonium sulphate	217	50	50	1.31
Ammo 30	357	50	50	1.37
Superphosphate	476	50	50	0.75

Notes: 1) Plant available within a year of application in warm zones of NZ where elemental S < 250 microns fully oxidizes in the year of application. For colder zones the elemental S needs to be < 150 microns to fully oxidize in the year of application.

2) Not available at the time of writing.

On this basis the cheapest source of plant available S by a good margin is superphosphate, followed by SulphurGain Pure and Maxi Sulphur Super.

Note that these costs apply when the products are used in the warm zones of NZ (everywhere except Otago and Southland and including the High Country). In these cooler climates the available S coming from the elemental S will be less and hence the unit cost higher. Also the calculations above consider only the S becoming available from the elemental S in the year following application. The coarser elemental S particles will contribute to the pool of available S over time. This has not been factored into the calculations.

Which Product to Use?

Where both P and S are required then superphosphate (ratio S to P = 1.16) is the obvious starting point. If a higher ratio of S:P is required, for example in situations of high S leaching (i.e. soils with either low ASC (P Retention < 20) or under high rainfall (> 2000 mm)), pure elemental S products (SulphurGain Pure or Sulphur 90 Granules) could be mixed with superphosphate or the S fortified superphosphates (Maxi S Super or SulphurGain30S) could be used

There are situations where it is sensible to augment fertiliser N applications with some immediately available S. For example it is suspected that temporary S deficiency can occur in pastures in the late winter early spring because a) the available soil sulphate has been leached out and b) it is too cool yet for the soil bugs to breakdown the pool

of organic S into plant available sulphate S. Thus products like ammo 30 and ammonium sulphate could be used in the first round of N applications in the spring. Phased N appears to be an expensive option for this purpose.

Sometimes only S fertiliser is required, for example on soils with above optimal levels of P and K. This situation can occur on long-standing effluent blocks or in the High Country in the South Island. The pure elemental S products are appropriate in these circumstances.



OLD RECIPES MAY NOT WORK

There are large areas of the both the North and South Islands covered with sedimentary soils. Traditionally these soils only needed fertiliser P and S, some molybdenum (Mo), and from time to time, lime. No K was required in the fertiliser because they originally contained sufficient reserves of soil K to make good any K losses. Furthermore, these soils were largely used for dry stock farming which, relative to dairying, is not as demanding for K.

Times have changed. We have now been farming some of these soils for 100 years or more and have over that time exported a lot of K without replacing it with fertiliser K inputs. These losses have increased over time as farm economics has demanded higher stocking rates and per hectare production. Furthermore, large areas of these soils are now under irrigated dairying, which greatly increases the demand for K. What follows are some examples from agKnowledge clients which demonstrate the point.

Figure 1 shows the soil K levels on two blocks on a mid Canterbury farm, converted to irrigated dairying in 2005. The soil K levels have declined over time and are now below the optimal range of 7-10. At the time of the farm visit these pastures were terrible – low clover content, high weed loading, lots of bare ground. In the absence of heaps of fertiliser N to keep the grasses growing, the pastures turned yellow with highly visible excreta (K rich) patches - all classic symptoms of K deficiency.

The farmer was aware that the vigour of the pastures was declining and wondered why fertiliser K was not recommended. His fertiliser company advised him that these soils have plenty of reserve K and hence do not need fertiliser K. This may have been the case years ago under dry-stock farming but clearly whatever

reserves of K that were present have been insufficient to maintain the pool of plant available K (soil K in the range 7–10) under intensive dairying.

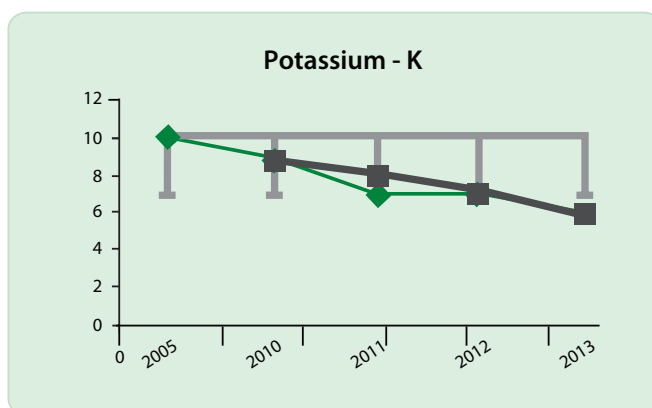


Figure 1: Changes in soil K over time on 2 blocks on a dairy farm in Canterbury (the grey-scale bar is the optimal range).

This problem is not exclusive to dairying. The next 2 examples (Figure 2) are from dry stock farms, one in Canterbury and the other in Southland. They demonstrate the same point – soil K levels declining because the K losses (from product removed from the farm plus leaching) have not been replaced. Importantly, on both of these farms the pastures were poor exhibiting all the classic symptoms of K deficiency.

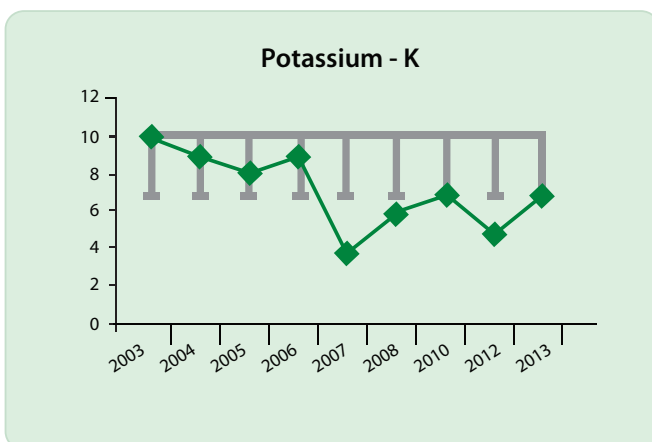
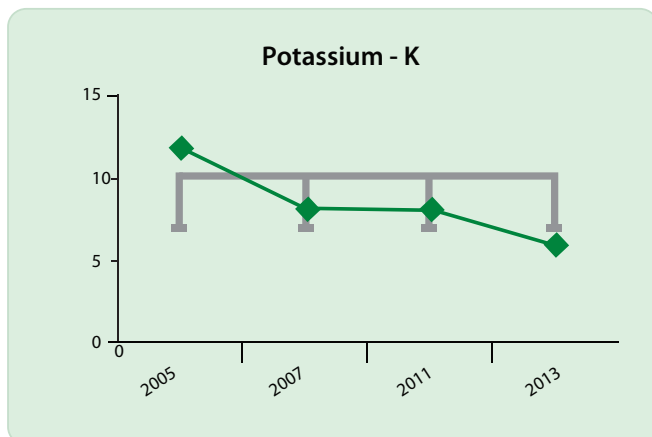


Figure 2: Changes in soil K levels over time on sheep & beef farms in Canterbury (top) and Southland (bottom).

Interestingly the rates of decline of the soil K level equate to the removal of about 30 kg K/ha/yr which is roughly equivalent to the maintenance input required to maintain optimal soil K levels for farms of this intensity.

What to Do?

If your pastures are not pulling their weight; lack vigour, poor clover growth, not persisting, full of weeds, then chances are that one of the 16 essential nutrients (see Fertiliser Review No 16) is missing and chances are it is potassium, currently a forgotten

nutrient in New Zealand. Repeating what you did, or were told to do, last year by the fertiliser rep will not solve the problem.

This problem is serious in its occurrence and its cost in terms of lost pasture production. The industry is in denial (see below) so unashamedly I am going to add a plug for my business – give us a call 0800 33 73 46 or email enquiries@agknowledge.co.nz)

Industry in Denial

Potassium deficiency is the most frequent problem we find in pastures. The problem is in our experience rife. Sadly the fertiliser co-ops appear to be in denial over this issue. I have raised the problem with both the Green and the Blue Machines on numerous occasions over the last 6 or so years. I even sent to one, a chapter and verse report on cases of misdiagnosed K deficiency, documenting the soil tests, clover-tests and visual assessment information. They deny it all. According to them there is no issue and imply that I have perhaps lost my marbles, lost the plot, or am otherwise going mad with K on the brain.

As far as I am concerned I have ‘walked the extra mile’ with them on this issue and have thereby discharged my responsibility to them. It is now necessary to inform farmers – potassium deficiency may be a factor limiting pasture production that is currently not being diagnosed and corrected. It could be costing you big dollars in lost production.

Sensitive to my criticism, one co-op has defended itself with these words: “We agree with him (DCE) that fertiliser recommendations should be exact science, which is why (we) make sure that our sales team is suitably qualified and properly trained.” My point exactly “sales team.”



BEWARE: THE RESIN TEST AND REACTIVE PHOSPHATE ROCKS

A farmer contacted me - he was concerned that his pastures were no longer ‘pulling their weight’ – could I help? Certainly, when I visited, I had to agree that the pastures lacked vigour and the clover content was low. The question was why? I took away all his soil test records hoping they might reveal the cause.

The most interesting aspect coming from the accumulated soil test information from the farm was a steady decline in the Olsen P levels on the farm (Figure 3). When I raised this with the farmer he acknowledged that he also had spotted this trend and had raised it with his fertiliser rep (Altum now part of Ballance). He was told that because he had been using RPR as the sole source of fertiliser P for many years, the Olsen P test was not relevant because it did not measure the residues of undissolved RPR that accumulate over time and contribute to the pool of plant available P. He was also told that the Resin P test was better measure of plant available P where RPR is used because it did measure the RPR residues. The farmer did not pursue the matter further accepting in good faith what he was told.

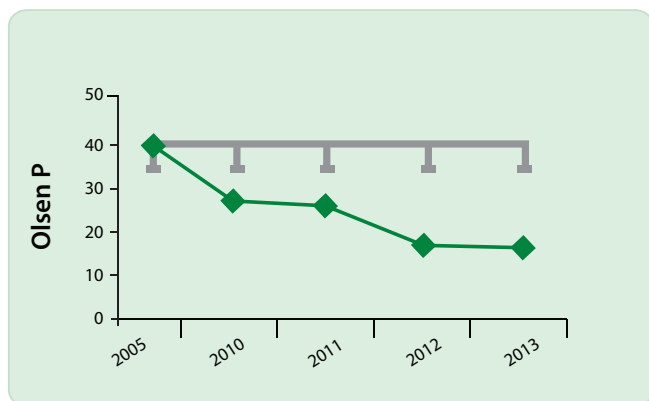


Figure 3: Changes in Olsen P over time on an irrigated dairy farm in Canterbury using RPR as the sole source of P.

Curious, a quick look at the Resin P data showed that, like the Olsen P levels, the Resin P levels also declined

over time. In fact, there was a direct relationship between the two (Figure 4) meaning that when the Olsen P level changes, either up or down, so too does the Resin P level – in other words they are measuring the same pool of available soil P, albeit extracting different amounts, completely contradicting what the farmer had been told.

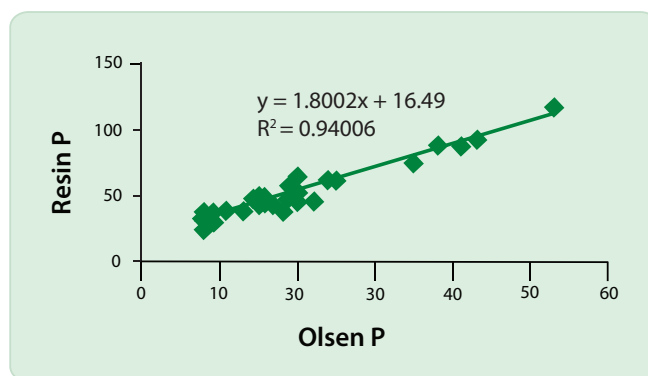


Figure 4: The relationship between Olsen P and Resin P.

This is of no surprise to me. The Resin Test was introduced by R J Hill Laboratories in the mid 1990s, on very dubious technical grounds (see Fertiliser Review No 8). AgResearch who funded the research were not consulted regarding its introduction!!! If our advice had been sought by R J Hill Laboratory we would have said that the test should not be introduced for several reasons:

- 1) It was only properly calibrated on 4 sites.
- 2) It was only calibrated in the situation where a) the RPR was Sechura (the most effective of the RPRs) and b) where it had been applied for 4-6 years.
- 3) The Resin Test, even if it does measure residues of Sechura RPR, which is dubious as we will discuss shortly, does not and cannot estimate the particle size of the residues remaining in the soil, which is the most important factor determining the plant availability of the P in RPRs.

In 1992, nine of what were called the National Series of RPR trials were modified. Originally each trial included 5 rates of soluble P (control, 0.5, 0.75, 1.0 and 2 x maintenance) and Sechura RPR P (control, 0.5, 0.75, 1.0 and 2 x maintenance) applied annually for 6 years. Each plot was split and high rate of soluble P (2 M) was applied to each half plot. Pasture production was measured for a further 12 months and at the end of this period the soil Olsen P and Resin P levels were measured.

If we plotted the Olsen P and Resin P data we would expect to see a graph resembling Figure 5. For the treatments that had only received soluble P there would be no RPR residues and hence the Olsen and Resin Test would both be measuring the same pool of soil P, albeit at different proportions, with both Olsen P and Resin P increasing with increasing amounts of soluble P applied (see line (a) in the Figure below).

Where RPR had been applied for 6 years at the various rates, we would expect a) the Resin P levels to be higher for a given Olsen P level, because of the RPR residues, and that the difference would increase with increasing Olsen P (total amount of P applied) (line b). Because the same amount of P has been applied we would not expect that the Olsen P levels on the RPR residue plots to increase as much as the Olsen P levels under the soluble P treatment.

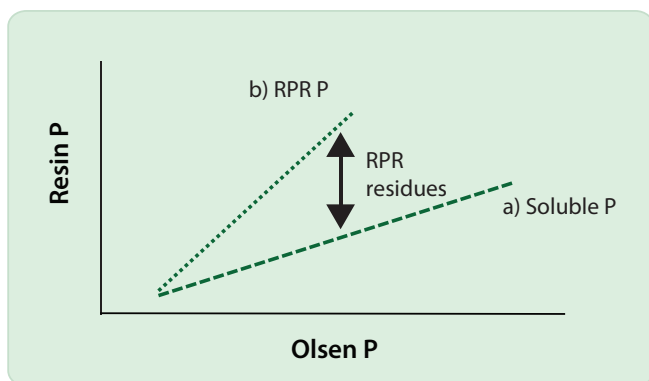


Figure 5: Schematic diagram of the likely changes in Olsen P and Resin P in plots treated for 6 years with different rates of soluble P fertiliser (no RPR residues) and Sechura RPR.

The data below (Figure 6) show the actual relationship between Olsen P and Resin P for the 9 trials. The open circles refer to treatments, which had received only soluble P fertiliser annually for 6 years, and the closed circles refer to treatments to which Sechura RPR had been applied for 6 years.

At first glance it looks a little bit like Figure 5 but all the points in the sector; Olsen P < 15 and Resin P > 50, are for the lowest rate of P applied i.e. those plots receiving the least amount of RPR and hence likely to have the lowest levels of RPR residues.

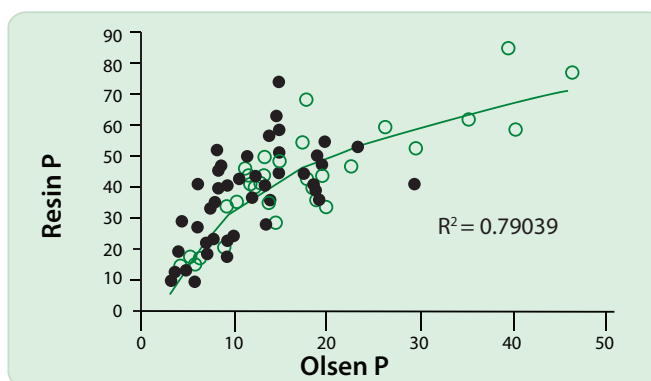


Figure 6: Actual relationship between Olsen P and Resin P for plots treated for 6 years with rates of soluble P fertiliser and Sechura RPR.

Remember that this data only refers to plots that had received the best RPR in terms of reactivity (Sechura) and applied annually for 6 years. If we are going to see evidence that the Resin Test measures RPR residues and the Olsen P does not, then this is where we should see it. The evidence is not convincing. This data suggests that the Resin Test does not in fact measure residues of RPR from Sechura.

My Advice: Ignore the Resin Test or, if your Consultant insists on using it, then remember; if the optimal Olsen P for near maximum production is in the range 30-40 then the equivalent Resin Test should be 60-70.



ALUMINUM SOIL TEST

Aluminium (Al) is the second most abundant element in soils after silicon (Si). It is one of the components in the mineral matrix found in all soils. Minerals in this sense are not to be confused with the essential plant nutrients. At 'normal' soil pH levels (pH > 5.5) the Al in the soil minerals is not soluble and Al is not found in the soil solution. It has no effect on plant growth.

As the soil pH declines, small amounts of Al from the soil minerals can be solubilized and move into the soil solution. And the amount in solution increases logarithmically as the pH declines (Figure 7). Our pasture cultivars, and especially the clovers, are extremely sensitive to even tiny amounts of Al in soil solution and this toxicity is expressed initially through the inhibition of root growth.

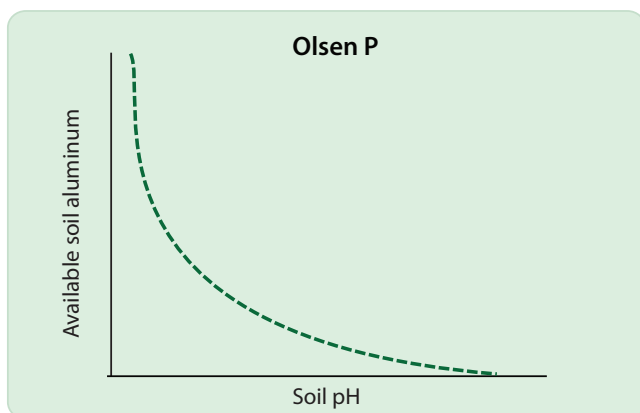


Figure 7: The typical relationship between soil pH and available soil aluminium.

A long time ago (1983) I wrote a paper entitled "Aluminium toxicity in New Zealand: preliminary results on the development of diagnostic criteria." It described a glasshouse experiment on 2 soils looking at the effect of soil pH on the growth of clover. It was concluded that Al (measured in a calcium chloride extract) of > 3-5 ppm may be toxic to white clover. This was, as the title made clear, a very preliminary result.

I was subsequently to learn much more about Al toxicity in studies I undertook in Australia (on an ANZAC Fellowship) and then subsequently back home at Ruakura. The really important things were that a) it is not the concentration per se of the Al in soil solution that is important but the Al activity (equals chemical energy not concentration) in solution and b) that our common forage legumes were very sensitive to tiny amounts of Al (micro-mole amounts in chemistry jargon).

The next logical step in this research was to develop a soil test that measures the activity of Al in the soil solution that the plant would 'see' in the soil in the field. For reasons I need not expand on, this is a technically difficult problem and has as yet not been solved.

What to do in the mean time? First, appreciate that the critical level set in the preliminary work is just that – do not place too much weight on it. Secondly, and most importantly, the amount of 'active Al' in the soil solution depends largely on the soil pH and we know that if the pH is > 5.5 there will be very little active Al in the soil solution.

My Advice: When making decisions about the use of lime, use the soil pH, not the current preliminary Al test, as your guide. And remember where lime has to be applied by air the economic optimal pH is about 5.5-5.6 - it is not economic to lime above this pH range. For ground spread lime and under most farming types/systems it is economic to lime to pH 5.8-6.0 providing there are no nutrient limitations.



ALL Paddock TESTING (APT)

A farmer who knew I was not a keen supporter of APT (see Fertiliser Review No 26 & 29), and, as it turned out, was something of a wag, sent to me a set of soil test results from his dairy farm – could I interpret them for him?

No sweat. I plotted up, in histogram form, the Olsen P (Figure 8) and Quick Test K data (Figure 9) adding the optimal ranges (see dotted lines; 35-40 Olsen P and 7-10 Quick Test K) suitable for a high producing dairy farm.

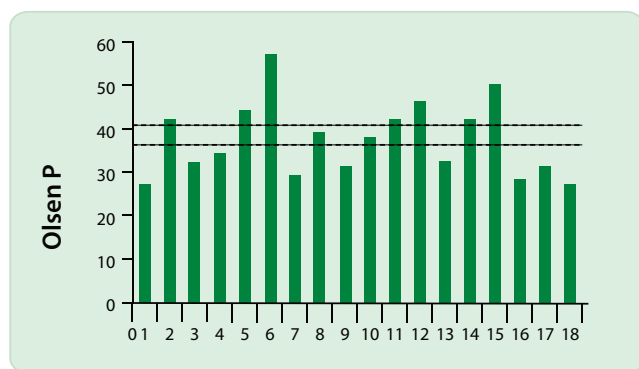


Figure 8: Histogram of Soil Olsen P levels.

In terms of advising on P fertiliser inputs it was obvious; Paddocks 6, 11, 12 & 15, need no P fertiliser - they are above the optimal range. Numbers 1, 3, 4, 7, 9, 13, 16, 17, 18 need capital fertiliser to bring them into the optimal range and the remainder only required a maintenance application to maintain the current soil test levels.

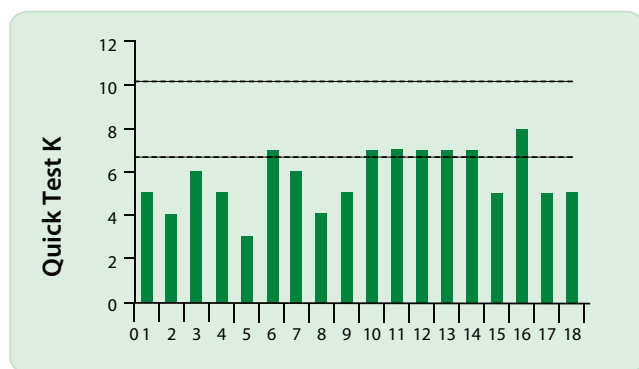


Figure 9: Histogram of Soil Quick Test K levels

The same deal on the K requirements: maintenance only on 6, 10, 11, 12, 13, 14, 16 and capital inputs

on the rest. I put together a list of the appropriate fertiliser mixes for each paddock – cool as – and sent them to him.

Then came the sting! He phoned, chucking his head off. Doug – these results are from 1 transect from one paddock sampled on 18 different occasion over time! The joke was on me.

Seriously now – the results above are real. They are from the same transect across one paddock sampled on 18 separate occasions. They show the net effect of temporal and spatial variability in soil tests. The more normal way we see such data is shown below (Figure 10) – the actual data wobbles up and down around a mean of about 35-40.

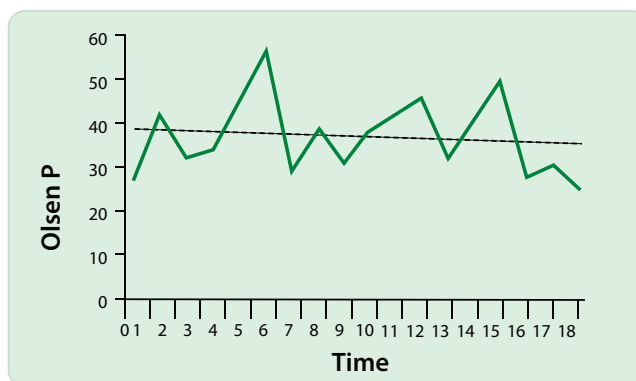


Figure 10: Changes in Olsen P over time on 1 transect in one paddock.

Importantly these results are not unusual. They are consistent with a coefficient of variation (CV) of about 20% for Olsen P and 30% for soil Quick test K, science that has been known for some time. They demonstrate the fallacy, indeed stupidity, of APT. As I have said before, do not go chasing variability.

agKnowledge and The Science of Farming

My view: Those involved in taking soil tests and interpreting the results must come to grips with the implications of spatial and temporal variability in soil test results. Such variability does not invalidate the value of soil testing and the need to have a good soil testing program on any farm. BUT – caution is required when interpreting the results – do not interpret them literally and look for long term trends.



Dr. Doug Edmeades

THE Fertiliser Review

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