agKnowledge
"The Independent Fertiliser Experts"

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SMARTFERT

Background

It has been the "Holy Grail" of the international fertiliser industry for over 50 years – the development of a truly, cost-effective, controlled release nitrogen (N) fertiliser, suitable for the broadacre. Some have been developed but at present their cost limits their use to horticulture and turf-culture.

The theory is that if the rate of release of N from a fertiliser granule matched the plants demand for N, this should increase N use efficiency (NUE, e.g. more production per unit N applied) and/or reduce N losses to the environment (e.g. leaching).

Theoretically there are several types of controlled release N fertilisers:

1. N fertilisers, which are chemically modified to reduce the solubility of the N compound in the fertiliser (e.g. urea-aldehyde polymers). There are no examples of these products in New Zealand.

2. Soluble N fertilisers, which are coated with a material to slow or control the movement of the N from the granule to the soil solution (e.g. PhaSedN which is sulphur coated SustaiN).

3. Soluble N fertilisers, to which bio-active chemicals (e.g. urease and nitrification inhibitors) are added which slow down the transformations of the fertiliser N once it is in the soil.

In New Zealand there has been considerable interest in, and research on, the Type 3 products (e.g. SustaiN® – urea treated with a urease inhibitor, LessN – urea treated with an unknown bio-active material and EcoN – a solution containing the nitrification inhibitor DCD). Independent research on these products indicates that they are not as effective as claimed[1] or, in the case of the new product from Ballance AgriNutrients Ltd (PhaSedN), there is simply no field research.

[Note 1. For further reading go to Edmeades D.C. and McBride R.M. 2011. Evaluating the agronomic effectiveness of fertiliser products. Proceedings of the NZ Grassland Association 73: 119-124 and Fertiliser Review 15, 22, 24, 30].

A New Product

Six years ago I was retained[2] by an Auckland company (now called Eko360 Ltd) to provide them with scientific advice on how to evaluate and test a slow release N product they were planning to import from Malaysia.

[Note 2. I hasten to add that I have no pecuniary interest in the product or the company and my name cannot be used in any promotional material].

The first step was to establish whether this new product (now called SmartFert) was indeed a slow-release N fertiliser. We started in the laboratory[3] measuring the rate of release of N from different formulations (number of coatings on the product). The results (Figure 1) showed that, relative to urea, it is a slow-release fertiliser and that the number of coatings controlled the rate of release of N. At this laboratory level we could say that it is indeed a controlled release N fertiliser.

[Note 3. With any new product it is tempting to race straight into field-testing. However field trial results are not precise and the results are difficult to explain unless the basic chemistry of the product is known. See example on the product RePlenish later in this edition]

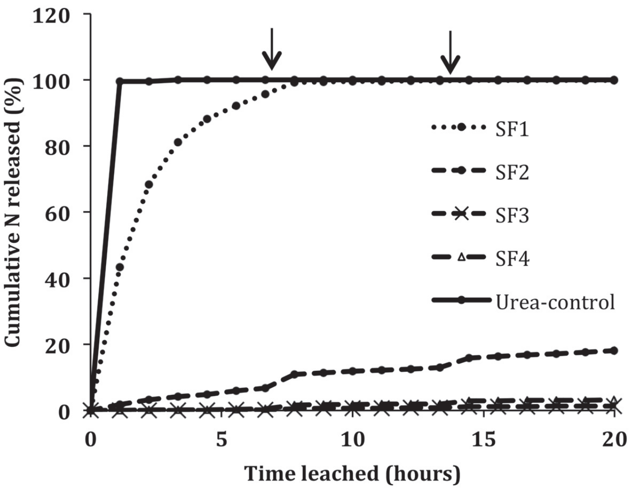

Figure 1. Cumulative nitrogen (N) released (% of total) over time from urea and 4 experimental controlled release products (SmartFert, SF) with differing manufacturing specifications. The arrows on the graph represent the over-night pauses in the leaching experiment.

The next step was to establish whether a similar pattern of results would occur when the products were in contact with the soil. A glasshouse experiment was conducted using the N uptake by ryegrass plants over time, as the measure of the release rate of N, ensuring that there were no losses of N to the atmosphere or via leaching. The pattern of the N release as measured by N uptake was similar (Figure 2) confirming that, in the presence of soil, the product behaved as predicted from the laboratory tests.

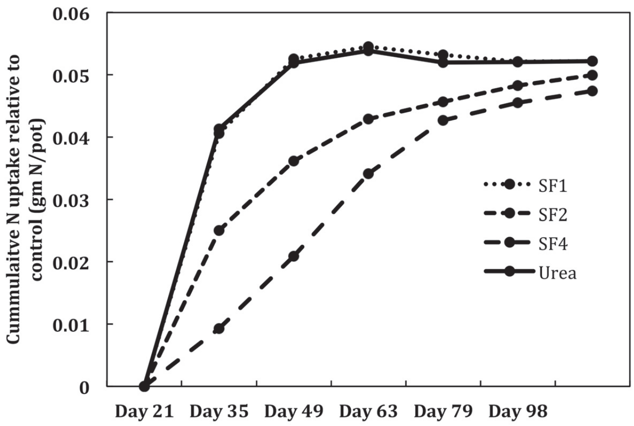

Figure 2. Cumulative nitrogen (N) uptake by ryegrass after single applications of urea and SmartFert (SF 1, 2 & 4) over time in the glasshouse study in the spring.

To the Field

Would we get similar results in the field where other factors, such as soil temperature and moisture, cannot be controlled? Three field trials, all on pasture, were conducted in the spring of 2014. Single applications of different rates of N applied as urea were compared with the same rates of N as SmartFert 4 (SF 4).

The results were encouraging. Typically pasture responses to urea occurred within the first 2-3 months after the initial application and then declined over time out to six months. The effects of the SmartFert took time to develop and were at a maximum 3-5 months following application (see Figure 3 for example).

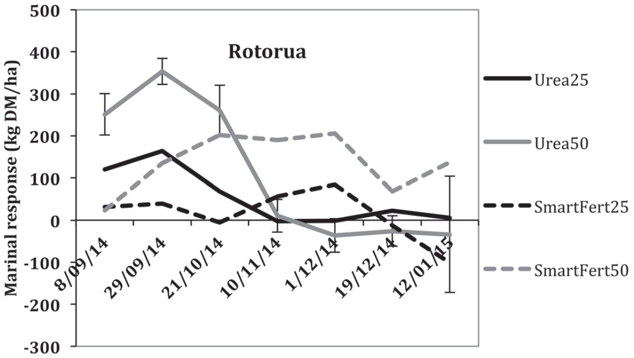

Figure 3 Marginal pasture responses (kg DM/ha) relative to control over time after applications at 2 rates of urea and SmartFert (25 and 50 kg N/ha applied once) on a pumice soil near Rotorua. The error bars are +/- standard error of the difference (SED) for each harvest.

One of the three trials included a comparison of SmartFert applied once at 90 kg N/ha, with urea applied once at 90 kg N/ha, and urea applied in 3 applications of 30 kg N/ha (Figure 4). Intriguingly the cumulative yields for these three treatments were similar raising the question – could a single large application of the controlled release product SmartFert do the same job as small frequent additions of the same total amount of N applied as urea?

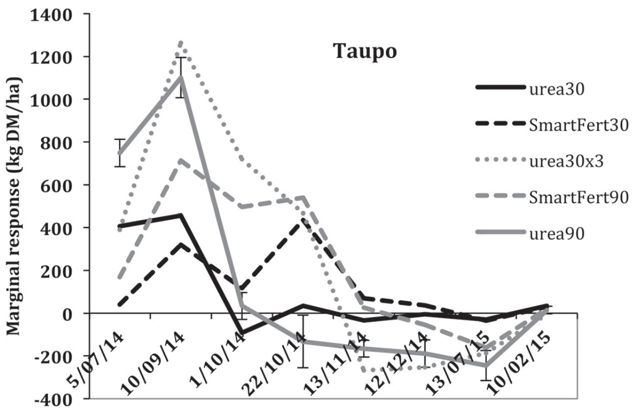

Figure 4 Marginal pasture response (kg DM/ha) relative to urea over time after applications of 2 rates or urea or SmartFert (30 and 90 kg N/ha applied once) and a split application of urea (30 kg N/ha x 3) on a pumice soil at Taupo. The vertical bars are +/- SED for each harvest.

Given these results - from the laboratory to the glasshouse and into the field - it was concluded that proof of concept had been attained – the product could be classed as a controlled release fertiliser but further research was required.

More Trials

At this point Ballance AgriNutrients Ltd became interested in SmartFert and conducted their own trials comparing it with their proprietary product SustaiN (urea treated with urease inhibitor). Two trials were conducted in the spring of 2015. The results from these trials with SustaiN in place of urea (Figure 5 for example) showed the same trends as found with urea (see Figure 3).

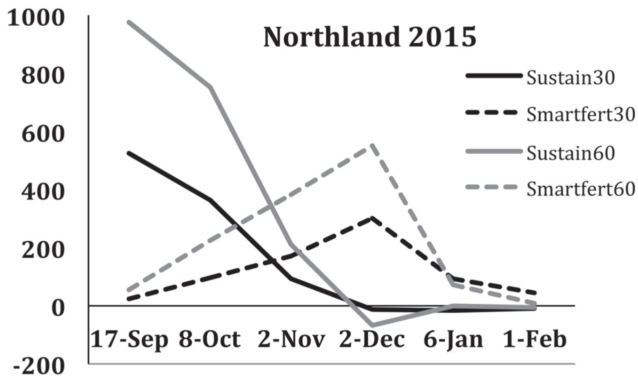

Figure 5 Marginal pasture responses (kg DM/ha) relative to control over time after single applications of two rates of Sustain and SmartFert (30 and 60 kg N/ha) in 2015.

Three further trials were conducted in 2016 and compared a single application of SmartFert applied at 100 kg/ha with 3 applications of SustaiN applied at 33 kg/N/ha (Table 1). These results confirmed the earlier results shown in Figure 4. Single large applications of Smartfert were as effective as multiple applications of the same amount of N, in this case, SustaiN.

Site	Control	SustaiN (100 x 3)	SmartFert (100 x 1)	SED
Northland	5141	6246	6456	263
Rotorua	3707	4799	4623	164
Canterbury	5824	6363	7610	442

Table 1. Cumulative pasture production (kg DM/ha) at three sites comparing SustaiN applied in three applications of 33 kg N/ha with a single application of SmartFert applied at 100 kg N/ha.

Effects on Pasture N Concentrations

The mixed-pasture N concentrations, expressed as the difference from the Control was measured in some trials. The results (see Figure 6 for example) suggest that large increases in pasture N concentrations can occur immediately following application of urea and that this effect was much less for SmartFert. This occurred on some but not all of the trials.

Given that a) most of the N leached from pastures arises from the urine patch and that b) there is a linear relationship between N intake and urine N, these results suggest the possibility that SmartFert at least in some situations may decrease N leaching.

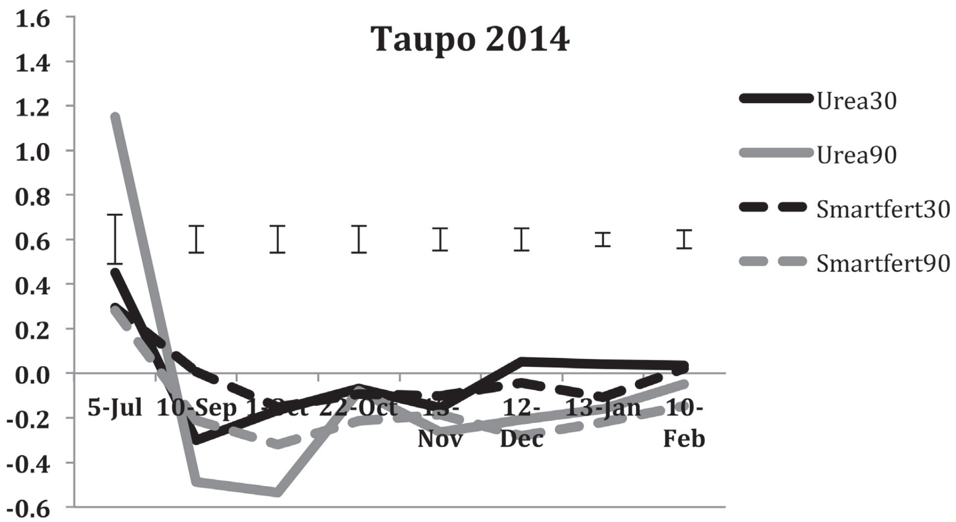

Figure 6 Marginal pasture nitrogen concentrations (N%) relative to control over time after single applications of two rates of urea or Smartfert (25 and 50 kg N/ha). (The vertical bars are the s.e.ds.)

Future Research

In theory if the rate of release of N from a fertiliser N granule better matches the plants demand for N, this should increase NUE and/or reduce N losses to the environment. Increases in NUE, relative to urea and SustaiN, were measured in some of the trials and on a few occasions they were large enough to be statistically significant but they were not consistent across all trial sites. This raises the question: in situations were SmartFert increases NUE relative to urea, does this mean that N losses (leaching and/or volatilization), are lower. This requires further investigation.

Similarly, the possibility that SmartFert reduces the N concentration in pasture relative to urea, and hence could reduce the N concentration in urine and consequently reduce leaching losses of N from the urine patch, also requires quantification.

What about cropping? Can one large application of SmartFert eliminate the need for multiple applications of N as the crop develops? Will it be possible using this technology to develop N products with different release characteristics that better match the unique demands of different crops?

Advice to Farmers?

The results to date confirm that SmartFert is indeed a controlled release source of N relative to soluble urea and SustaiN. Its effects on pasture production are slower but last longer and a single application of SmartFert is as effective, in terms of total pasture production, as multiple, smaller applications of SustaiN or Urea.

SmartFert is now on the market and is available from Ballance AgriNutrients Ltd and via the proprietors Eko360 Ltd.

[This article is based on results published in a) Edmeades, D. C. 2015. Evaluation of a controlled release nitrogen fertilisers. Journal of the NZ Grassland Association 77:147-152 and b) Edmeades D. C. and McBride, R.M. (2017). Further field evaluation of the controlled release nitrogen fertiliser SmartFert™. Journal of the NZ Grasslands Association 79: 73-78]

FERTILISER ADVICE

Time for a little disruptive technology?

Fertilisers are typically the largest item of discretionary expenditure on most Sheep & Beef farms and many Dairy farms. Despite this most farmers are lackadaisical when it comes to setting the fertiliser policy. A range of justifications exist:

1. Do what Dad did, after all he was successful, wasn't he?
2. Adjust last years fertiliser budget up or down depending on a gut feel about the market forecasts. After-all we had a good year last season.
3. Copy the neighbour – he is a good farmer, isn't he?
4. Do what the accountant says – he wouldn't put me crook?
5. Do what the fertiliser salesman recommends – seems like a genuine bloke, doesn't he?

A more professional approach is long overdue. Consider this: if a farmer has a legal problem he/she will go to a lawyer. For accounting advice he/she will go to an accountant. The doctor is visited for health reasons. The children are educated by trained teachers. But for some reason when it comes to the big-ticket item of discretionary farm expenditure any attempt at objective professional approach goes out the window.

Soil fertility and pasture nutrition is a mature science. We know there are only 16 essential nutrients. We know how to measure them in soils and pastures and what the optimal levels are. There should be no reason why soil fertility is limiting pasture production in New Zealand. But it is and it is common. About 70% of our clients presented initially with one or a combination of potassium (K), sulphur (S) or molybdenum (Mo) deficiencies. Correcting these limitations often increases pasture production by 10-20% and sometimes more.

Thus there is a large opportunity to be captured by employing a more professional approach and applying existing technology in soil fertility and pasture nutrition. No further research is required - just apply the currently available technology.

Old Recipes May Not Work

It is important to realize that old recipes may no longer work. There are good reasons for this. We have been farming in many regions for about 100 years and most of the product produced over that time, whether meat, wool or milk, has been exported taking with it large amounts of nutrients. Some has of course been replaced with fertiliser applications but this may not always have been the case. Consider our sedimentary soils. Initially these soils had good reserves of potash (K) and all that was required to grow good quality clover-based pastures was P, S and Mo and the right soil pH. This traditional recipe that worked so well for granddad may no longer apply because the soil K reserves have now been depleted. Some K is now required in the fertiliser mix to ensure good clover growth.

Also over the last 100 years farming has intensified and there have been significant changes in land use – I'm thinking in particular of the expansion of the dairy industry. This has placed further demands on soil nutrient reserves and is another good reason to review the fertiliser policy.

The same applies to some trace elements. There was a time when trace element requirements could be predicted based on the soil group. Sedimentary soils needed molybdenum (Mo), and some coarse pumice soils and peats required copper (Cu). This pattern no longer applies and we are finding cases of Mo deficiency on volcanic soil and Cu deficiency in Southland. This, is it assumed, is because the original reserves of these trace elements have been depleted.

How to Disrupt

What to do given that fertiliser is a big-ticket item and given that old recipes may no longer work? In my view a full audit of the fertiliser policy is required. And at this point I must declare my vested interest. This is precisely the service agKnowledge Ltd offers farmers. The steps are simple enough:

Step 1: Assess the pastures. Are they 'pulling their weight?' Are they showing signs of hidden nutrient deficiencies?

Step 2: Set up a robust soil, clover and pasture monitoring program on the farm

Step 3: Determine the optimal nutrient levels for your farm, taking into account the farm goals.

Step 4: Determine the nutrient inputs required to optimise soil fertility and hence pasture production.

Step 5: Determine which fertiliser products are required to apply the required nutrients at the least cost.

Step 6: Monitor progress in 12 months by collecting more soil samples walking the same transects in the same monitor paddocks. Repeat Steps 1 to 5.

Fertiliser Advice based on Economic Outcomes

Despite fertiliser being a big-ticket item the right questions are rarely asked: what are the optimal settings - soil nutrient levels - for the soil fertility on my farm? How do I reach the optimal settings at the lowest cost? Am I getting a return on my fertiliser dollar? Can I get a bigger return for my fertiliser dollar?

These are economic questions and we need the tools to answer them. In the early 1990s an econometric fertiliser model was developed by AgResearch for this purpose. It is now out-of-date and the fertiliser industry is currently upgrading it. However I have been informed that it will only be available to fertiliser company personnel.

With funding from AgMardt, agKnowlege Ltd has developed its own econometric model. The beta version is undergoing testing and we are hoping it will be up and running in the New Year. This tool will enable us to develop fertiliser policies based on their likely economic outcomes.

[For further reading see Edmeades, D.C., McBride, R. M. and Gray, M. 2016. An assessment of current fertiliser practices in NZ Hill Country. Hill Country: Grasslands Research and Practice Series 16: 173-178].

REPLENISH FROM TERRACARE FERTILISERS LTD

Terracare Fertiliser Ltd operate out of Te Awamutu. They specialize in making and selling dicalcic superphosphate. Their premier product is called “RePlenish”. It contains about 9% total phosphorus, of which 77% is soluble in citric acid and 44% is soluble in water. For comparison, superphosphate contains about the same amount of total P of which 88% is citric soluble and 80% is water soluble. These results reflect the fact that the P in RePlenish is less soluble (it is present as dicalcium phosphate) compared to the P in super (monocalcium phosphate).

Many and various claims are made for dicalcic phosphates (refer to Fertiliser Review 1, 3 & 12). Relative to soluble P fertilisers like superphosphate, they are claimed to be more effective agronomically (more production per unit P applied), better for soil and animal health, and in addition, reduce P runoff.

Mr Paddy Shannon, an independent soil scientist, recently presented the results of a field trial he conducted, on behalf of the company, comparing superphosphate with RePlenish, at various rates of total P applied: 0, 20, 40, 80 and 120 kg P/ha. The trial, on a P deficient volcanic soil, was well designed and conducted and ran for 3 years.

The key result from the trial was that RePlenish increased pasture production, relative to superphosphate, by 7% at the lowest rate of P applied (20 kg P/ha) to 13% at the highest rate (120 kg P/ha). If this was the only trial in the world you would be entitled to conclude that dicalcic P is agronomically better than soluble monocalcium P, when applied at the same rate of P. But therein lies the rub. It is not the only trial and these results must be seen in the context of all the evidence.

In 2000 I reviewed and published[4] all the trial work in New Zealand in which a dicalcic P fertiliser was compared with soluble P fertilisers, at the same rate of P applied. There were in this set of 10 replicated, multi-year, trials; 51 occasions (including years and rates) when the two forms of P were compared.

[Note 4. Edmeades, D. C. 2000. The agronomic effectiveness of lime-reverted and dicalcic superphosphate: A Review . NZ Journal of Agricultural Research, 43: 1-6].

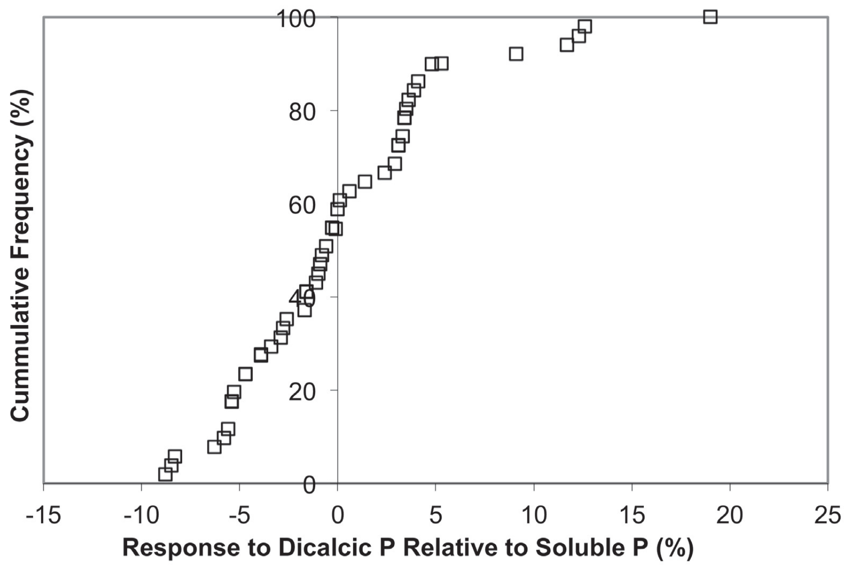

Figure 7 Cumulative frequency distribution of relative pasture response (%) from Dicalcic P relative to soluble P.

Figure 7 shows the full 51 comparisons presented as a cumulative distribution function. The observed differences ranged from –10% to +20%, of which 19 (38%) were positive and 22 (62%) negative. A total of 17 were statistically significant, either positive (9) or negative (8). The average difference was 0.2%.

Putting the technical words aside, what this set of data means is that there is little, if any, difference between dicalcic and soluble monocalcic P in terms of their agronomic performance after taking into account the background noise. In fact the distribution of the 'responses' (Figure 7) looks much the same as the distribution of crop 'responses' to an agronomically insignificant amount of water (Figure 8). In other words, what you see in Figure 7 - the range in the observed differences - is an expression of the background 'noise' in the field trial data, noting that the coefficient of variation in pasture trials is typically about +/- 10%.

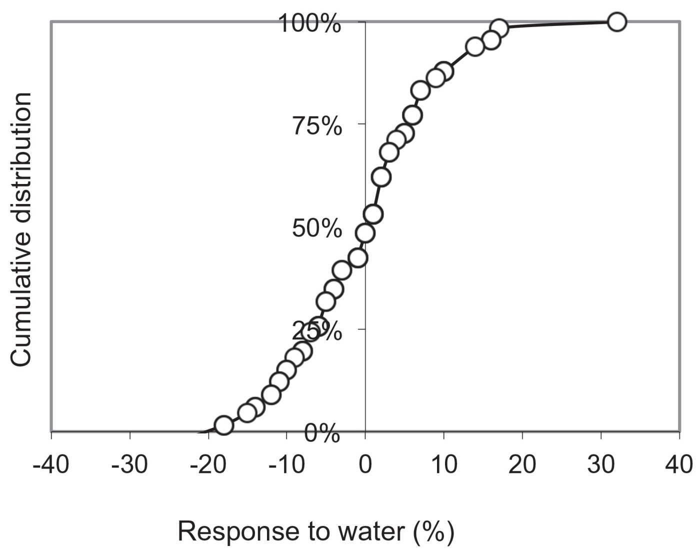

Figure 8 The background noise in field trial results. The cumulative frequency distribution of the relative crop response (%) to a small agronomically insignificant amount of water relative to a control (no treatment).

Where do these recent results fit within the context of the national set of field trials? The observed cumulative responses over three years were in the range 7-20% depending on the amount of P applied. They are consistent with the full family of data (Figure 7) and hence do not change the overall conclusion that dicalcic P products are no better or worse than soluble monocalcic P fertilisers.

It matters not that the RePlenish results were statistically significant. The statistical significance of a given result does not always infer causation. Type II errors, as they are called, occur in any set of biological comparisons. At a probability level of 95% certainty, they occur on average 5% of the time. That is why in the total set of data (Figure7) statistically *significant negative 'responses'* to dicalcic P occurred in 8 trials. If these 8 results are accepted as real then it must be concluded that dicalcic P can depress pasture production. Perhaps it can - maybe it can be toxic to plants under some circumstances? But a proprietor is unlikely to accept this possibility in which case the negative results are accepted as background noise. If it is concluded that the negative 'responses' are due to the background then one is logically obliged to accept the positive 'responses' as noise also.

[Note 5 For further background reading on this topic see Fertiliser Review 34 and for a formal account see Edmeades D. C. 2002. The effects of liquid fertilisers derived from natural products on crop, pasture and animal production. Australian Journal of Agricultural Research 43: 965-976].

It is likely that the good people at Terracare Fertilisers Ltd will use the results from their recent trial to promote their product RePlenish. They are likely to say that RePlenish increases pasture production relative to soluble fertiliser by 7 to 20% depending on the rate of application and simply ignore the full set of data. If they do this they can be accused of "cherry picking" the data.

UREA AND SUSTAIN CAN DECREASE PASTURE PRODUCTION?

I have heard it said that fertiliser N is something like a drug – once you get onto it you have to keep going. There may well be some substance to this possibility.

One of the unexpected results coming from the SmartFert trials (see earlier article in this edition) was to find that single applications of either urea or SustaiN, after the initial flush of new growth, actually decreased pasture growth in the longer term (see Figures 3, 4, 5). The same effect was not so apparent with the controlled release N product SmartFert although this may be because the trials did not go for long enough.

Why does this occur and why have we not seen this before? I figured that much of the previous research on urea was done either in short-term trials lasting a few months or with sequential applications over the whole season. Either way any depressions in pasture growth may have been missed.

I went searching in the literature and sure enough it was all there! A 1985 paper[6] reported the results from fertiliser N trials conducted in 1980 and 1981 in the Waikato. To quote from the abstract; "N usually increased pasture production in harvests 1 and 2 but reduced it in harvest 4 and 5…." Some of their results are reproduced in Figure 9 and show that the occurrence and size of the depression were dependent on the time of the year and the rate of N applied.

[Note 6. Feyter, C., O'Connor, M.B., Addison B. 1985. Effects of rates and time of nitrogen applications on the production and composition of dairy pastures in the Waikato district, New Zealand. NZ Journal of Experimental Agriculture 13: 247- 252].

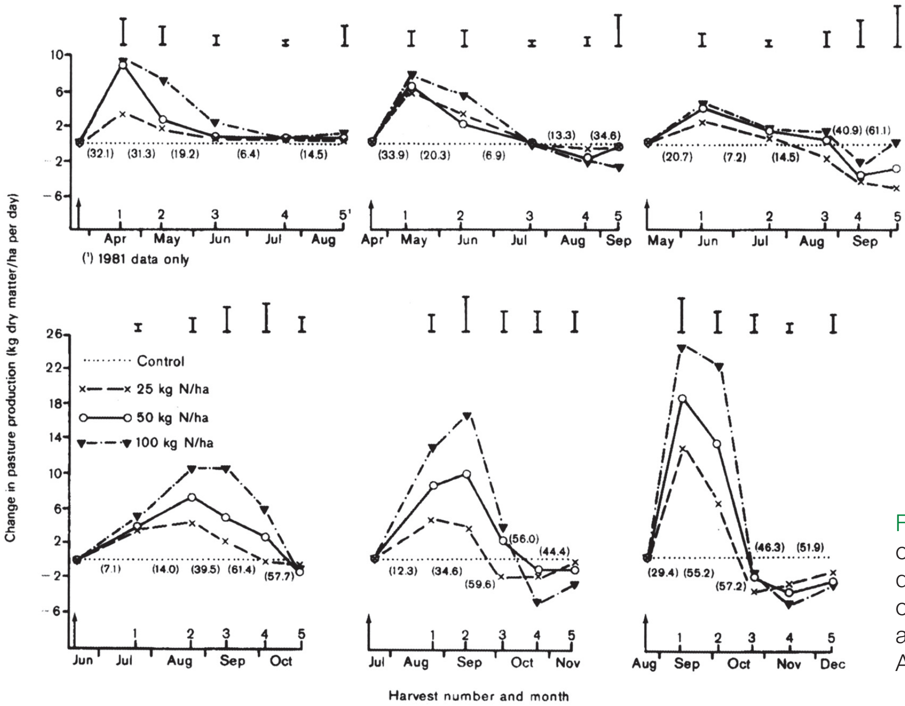

Figure 9 Effects of nitrogen (N) fertiliser on daily pasture production, expressed as difference from control (daily production of controls in brackets) for each time of N application. Vertical bars represent $LSD_{0.05}$. Arrows show date of N application.

This depressive effect of urea-based fertilisers on pasture production either did not occur, or was much reduced, with the controlled-release N fertiliser SmartFert. Once again further research is required to 'unravel' this knot'.

Feyter et al (1985) showed that these depressions in total pasture production were due to a decline in clover production (Figure 10). Is it possible that controlled-release N fertilisers, like SmartFert, are 'gentler' on clover relative to soluble N fertilisers?

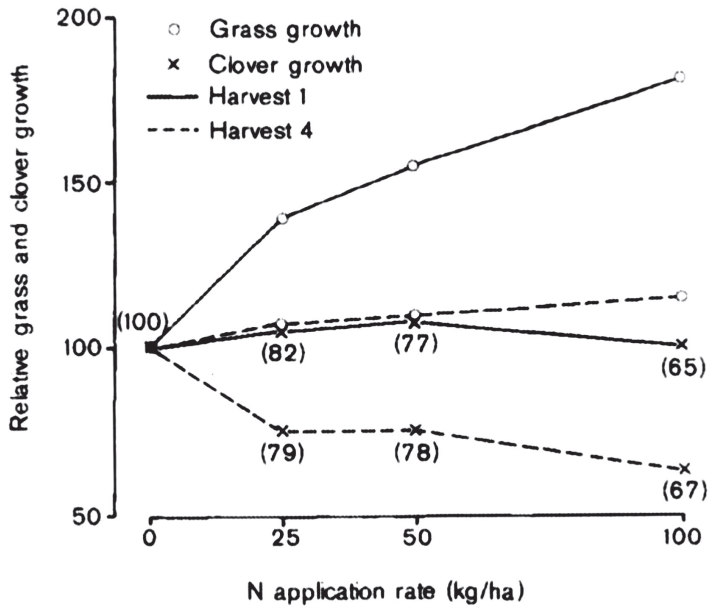

Figure 10 Mean effects of nitrogen (N) on grass and clover growth and on clover content of pasture (in brackets) in harvests 1 and 4, relative to control (100).