

**Review of New Zealand field trial results and subsequent media advertised claims  
for Sustain-Urea comparisons (May 2009)**

**Dr C. J. Watson**

Data reviewed:

**Summit Quinphos**

- Sustain Trial - Maungaturoto
- Nitrogen and Molybdenum Trial - Lincoln
- Sustain Trial - Ashburton Border Dyke
- Sustain Trial – Ashburton Spray Irrigation
- Sustain Trial – Mid Canterbury
- Sustain Trial – Morrinsville Ash
- Agrotain Rate Trial – Karaka
- Agrotain Rate Trial – Ohinewai
- Zaman M., Nguyen M.L., Blennerhassett J.D., Quin B.F. 2007. Reducing NH<sub>3</sub>, N<sub>2</sub>O and NO<sub>3</sub><sup>-</sup>-N losses from a pasture soil with urease or nitrification inhibitors and elemental S-amended nitrogenous fertilizers. Biol Fertil Soils
- Blennerhassett J.D., Quin B.F., Zaman M and Ramakrishnan C. 2006. The potential for increasing nitrogen responses using Agrotain treated urea. Proceedings of the New Zealand Grassland Association 68:
- Canterbury PhD study – Powerpoint slides provided.
- Jagrati's PhD study.

**Ravensdown**

- Crop & Food Research Confidential report No. 2016. Ravensdown pasture fertilizer trial. R. J. Martin, M. U. Riddle & R. C. Butler. October 2007.
- Comparison of Agrotain-treated and standard urea on an irrigated dairy pasture. R. J. Martin, T. J. van der Weerden, M. U. Riddle & R. C. Butler.

**Ballance Agri-Nutrients**

- A comparison of Sustain and urea fertilisers. Revised report prepared for Ballance Agri-Nutrients. December 2007. Chris Smith, Stewart Ledgard, John Waller.
- A comparison of the effectiveness of two coated urea products in reducing volatilization losses from urea. Report for Ballance Agri-Nutrients. February 2008. Mike Sprosen, Stewart Ledgard.
- The effectiveness of two coated urea products in improving the efficiency of urea applied to a Manawatu silt loam soil. Report for Ballance Agri-Nutrients. June 2008. Phil Theobald, Stewart Ledgard and Mike Sprosen.

## **Terms of reference for a review of New Zealand field trial results and subsequent media advertised claims for Sustain-Urea comparisons**

Review trial results for Sustain (Agrotain treated Urea) vs. Urea to establish if claims being made on the difference in performance of these products are justified and expressed in a manner consistent with trial results.

The review is to include the following:

- Trial experimental design
  - o Was it appropriate to meet the aims and objectives of the trial
  - o Was it scientifically sound
  - o Was it consistent with international best practice
  
- Management of trials
  - o Were appropriate management practices applied to meet stated aims and objectives
  - o Were the collection, handling and sample evaluations adequate, appropriate and consistent with New Zealand and International practices
  - o Was the trial design and duration appropriate to provide valid comparisons in a manner consistent with New Zealand and International practices
  
- Data collection, management and interpretation
  - o Was data collected, processed and interpreted in a consistent manner and in line with accepted New Zealand and International procedures
  - o Has data been interpreted adequately and in a manner consistent with scientifically based New Zealand and International procedures

In addition provide specific comment on:

- Trial duration: Do any differences in trial length (duration) invalidate comparisons of results
- Methods of calculating difference between products and trials: Are the methods used to express difference in line with accepted New Zealand and International procedures
- Have seasonal conditions (especially temperature and moisture fluctuations) been taken into account in trial design and the interpretation of data
- Mode of action of any observed differences: Have trials exhibited results inconsistent with a volatilisation mode of action
- Have media advertisements been presented in a manner that clearly and unambiguously reflects scientific results

### **Trial experimental design**

The experimental design and statistical analysis of the trials reviewed would generally appear to be appropriate to meet the aims and objectives of the trial. Three replicates is the minimum replication required. The greater the size of the plots and the greater the number of replicates, the greater the chance of showing significant differences between treatments. The plot sizes used by Summit Quinphos are small (generally 2 x 2m). In the N x Mo trial at Lincoln the plot size was only 1m x 1m and in the Zaman et al., (2007) paper the cut area of the plots was only 75cm x 75cm. Generally, fertilizer response trials would be undertaken using larger plot sizes, particularly when the area has been previously grazed. The report for Ravensdown used larger plots (5 x 1m) with 6 replicates (12 reps of control plots). In the report for Ballance 4-6 replicates were used, but plot sizes were not given.

### **Management of trials**

Information on the management of trials is not always clear in places. In several of the Summit Quinphos trials they do mention that a basal dressing of P & S was applied (Ashburton Border Dyke, Ashburton spray irrigation, Mid Canterbury & Biol Fertil Soils paper). It is important to know whether the sites where Sustain Yellow was applied are likely to be sulphur responsive. Sulphur analysis of herbage would have helped to determine whether the response to Sustain Yellow was due to sulphur. The only P, K & S herbage analysis is reported by Zaman et al., (2007), but this was done before the treatments were applied. We analysed a sample of Sustain Yellow (urea + Agrotain + S) in our labs a few years ago and found the product to be very acidic (pH 4.5) and it did not contain nBTPT. I put this down to the fact that nBTPT decomposes very rapidly under acidic conditions. It is surprising that Yellow Sustain did not inhibit nitrification, when it is such an acidic product. Did Summit Quinphos check the nBTPT concentrations in their products before using them? In fact, they provide little information on the products used in many of their trials (e.g. rates of S, nBTPT or DCD). In their Agrotain rate trials they quote rates as urea + Agrotain at 0.5L/ha, 1.0 L/ha, 2.0 L/ha and 3.0 L/ha. I'm not sure what this means. It is usual to express concentrations on a urea weight basis (i.e. l/t urea).

To increase the chance of showing small significant differences between treatments, it would be preferable to use an area that had not been grazed or received slurry, since the previous growing season. However, I know that this is not always possible.

In two of the Summit Quinphos trials (N x Mo trial and Biol Fertil Soils paper) the pasture is described as perennial ryegrass plus white clover. In the report prepared for Ravensdown, the dairy farm in Canterbury where the trials were undertaken also contained ryegrass/white clover pasture. It is not clear in the report for Ballance whether there was clover present in the swards. The potential contribution of clover to the yield of the control plots (no N fertilizer applied) or low N treatments, adds a confounding effect. The yield of the control plots will be higher if clover is present than if it is not. This would make the pasture N response (kg DM/kg N applied) lower than would be the case

if there was no clover in the controls. The clover content of the control plots would be expected to become more prevalent over time, when the plots are re-used. In N response trials, if clover is not removed (i.e. sprayed out) then the clover content (in control and treated plots) should be stated at each stage of the experiment.

In a number of the Summit Quinphos trials, 50% of the total plot clippings were returned to the plot area in an attempt to mimic recycled N from grazing animals. However, grass clippings being returned to the pasture will behave very differently to urine and dung being recycled by grazing animals. In fact, the benefits of recycled N in excreta of grazing animals is controversial and some workers have shown no benefit or only a small effect, due to the negative impact of treading on the grass sward. Returning 50% of the grass clippings to the plot area will exaggerate differences between treatments and the response efficiency (kg DM/kg N applied) will be higher than would be the case if there was no recycling of the clippings. Re-applying fertilizer to the same plots throughout the year may also have a carry-over effect. The first cut is the only one where this multiplicative effect is absent. Calculating N response efficiencies (kg DM/kg N applied) at cuts 2, 3 etc is therefore meaningless. Yield data at cuts 2, 3 etc is fine but not expressed per kg N applied. The cumulative DM yield over say 5 fertilizer applications is sound, as this is what a farmer would do and the response efficiency would be calculated by dividing total DM yield (taking control into account) by total N applied. However, if there is considerable clover content in the control plots, the pasture N response (kg DM/kg N applied) will be lower than if there was no clover present.

The methods used to measure N<sub>2</sub>O emissions and NH<sub>3</sub> volatilisation are well established techniques and are fine for comparative purposes between different N fertilizers. The difficulty comes in scaling up to kg N/ha and comparing directly with DM yield measurements. NH<sub>3</sub> volatilisation measurements in closed chambers will depend greatly on the air flow rate. If the chambers are closed continuously, for say 2 weeks, the soil will dry out as it will not be exposed to natural rainfall and there will be temperature differences and differences in grass growth compared to an uncovered area of the pasture, receiving the same treatment. It is highly unlikely that under these conditions NH<sub>3</sub> volatilisation could be related directly with DM yield. To get a better estimate of NH<sub>3</sub> emissions, the enclosures should have been randomly located to a new location each day within a treated plot. In the NH<sub>3</sub> volatilisation studies in the Ballance report the enclosures do not appear to have been moved over the 14 day experimental period. As grass growth in the enclosures and in the soil sampling area could have been different, it is difficult to relate the 2 sets of data. The NH<sub>3</sub> data and soil moisture/mineral N data can really only be used to compare N fertilizer treatments.

### **Data collection, management and interpretation**

There is a fundamental difference between the fertilizer companies in the way some of the results are expressed. Nitrogen response efficiency is calculated by subtracting the pasture DM yield of control from the fertilizer treatments and dividing by the amount of N applied. This is a well recognized way of expressing results. However, Summit Quinphos are exaggerating the effect of the Sustain products by expressing the results as

the increase over urea at the same rate as a %. For example, cumulative DM yield after 5 applications in the Maungaturoto trials - it is stated '*Cumulative data after 5 applications indicated that Sustain Green and Yellow applied at the normal rate of application of 30 kg N/ha achieved not only the greatest yield increase over urea (83.7 and 88.2% respectively), but also the greatest response efficiencies 24.6 and 25.2 kg DM/kgN applied*'. This statement is misleading. In this example the DM yield due to urea at 30 kg N/ha increased from 14,233 (control) to 16,241 kg DM/ha which is a 14.1% increase. With Sustain Green at 30 kgN/ha the DM yield was 17,921 kg DM/ha which is a 25.9% increase in yield over the control. Therefore the % increase in yield by Sustain Green over urea was  $25.9 - 14.1\% = 11.8\%$  increase, which is significant at 5% level. It is misleading to express results as percentages of percentages and say that the yield increase over urea at the same rate is 83.7%.

In the Maungaturoto trials at application 4 (autumn), using Summit Quinphos's way of expressing results, Sustain Green is claimed to give an increase in DM yield over urea at the same rate (30 kg N/ha) of 325.4%, yet this value is not significant! In this example with an LSD of 688 there would need to be over a 400% increase in DM yield for the effect to be significant. So quoting an increase of 325.4% is highly misleading, when taken out of context. This is a rather extreme example, but it does serve to make the point. There are a number of cases where very high % increases in N response over urea at the same N application rate are quoted, yet DM and N uptake are actually not significant. No statistics appear to have been done on the N response and N response efficiency data. The statistics for these parameters would be different to those for the actual yields and due to their greater variability would make it harder to show significance.

The terminology used in some of Summit Quinphos's reports is ambiguous. For example, in the Maungaturoto trial, in places it is written '*When the two N application rates were compared, 30 kg N/ha produced more yield than the higher rate 60 kg N/ha*'. This is clearly not the case. Cumulative DM yield of Sustain Green and Yellow at 30 kg N/ha averaged 17,966.5 kg DM/ha whereas at 60 kg N/ha the yield was 20,407.5 kg DM/ha. What they meant was that the efficiency of Sustain to improve urea was lower at 60 kg N/ha compared to 30 kg N/ha. This is not surprising as the response to N will depend on the shape of the dose response curve. The response at the lower rate (30 kg N/ha) is more likely to be on the linear part of the growth curve.

In another example, the Nitrogen x Mo trial, Lincoln – Cumulative DM yield after 5 applications states '*These results showed that in Temuka free-draining soil at Lincoln, pasture yield can be increased by about 60 to 80% by using Sustain products instead of straight urea*'. In this case the cumulative yield with urea was 16,363 kg/ha. A 60% increase in yield would be 29,453.4 kg/ha and an 80% increase in yield would be 29,453.4 kg/ha. The Sustain products significantly increased the yield over urea, but not by this amount. They are expressing the results as % change in N response over urea alone, taking the control into account (i.e. percentages of percentages), so this is misleading. In the discussion, they imply that there are differences between treatments,

but in fact they are not significant e.g. for cumulative DM yield after 5 applications there is no significant difference between Sustain Green and Yellow products.

In the Nitrogen x Mo trial, Lincoln – the LSD<sub>5%</sub> values of DM yield at each application do not match the summary table.

The assertion by Summit Quinphos that improvements in N uptake and fertilizer efficiency with urease and nitrification inhibitors are greater than can be explained solely by reductions in NH<sub>3</sub> emissions, N<sub>2</sub>O emissions and NO<sub>3</sub> leaching, needs to be treated with caution, as there is no hard evidence to support this hypothesis. As explained earlier, it is hard to see how NH<sub>3</sub> volatilisation measurements in closed chambers for 2 weeks can be directly related to DM yield (due to differences in soil moisture, temperature, grass growth etc). There is evidence in the literature that less energy is expended by plants in assimilating NH<sub>4</sub><sup>+</sup>N compared to NO<sub>3</sub><sup>-</sup>N, particularly at high light intensities, but further plant physiological studies are required to substantiate their hypothesis.

The Canterbury PhD greenhouse study using fine particle applications of Sustain compared with granular urea is interesting, but it is difficult to explain such large effects (3 times higher N response), particularly as urease inhibitors are known to cause leaf tip scorch. How did they prevent foliar applications getting into the soil? I cannot comment further as only preliminary results were presented. The report for Ballance evaluated FPA forms at 3 field sites but results were variable. FPA resulted in increased responsiveness when compared with granular N fertilizers in some cases, but decreased effectiveness in others. Further field studies are obviously required to substantiate the greenhouse studies by Summit Quinphos.

#### **Additional comments:**

##### **Trial duration**

Re-applying fertilizer to the same plots throughout the year may have a carry-over effect. This would affect the response efficiency (kg DM/kg N applied) at later cuts. Returning plot clippings will confound the effects. The clover content of control plots may become more prevalent over time when the plots are re-used.

##### **Method of calculating differences between products and trials**

The way that some of the results are expressed is misleading, as explained above.

##### **Seasonality**

The trials have been undertaken at different times of the year to take into account temperature and moisture fluctuations. The urease inhibitor will only be effective if there is NH<sub>3</sub> loss from urea. This will depend on a range of factors including, soil properties, temperature, soil moisture content, rainfall after application and air exchange rates at the soil surface. So, to properly evaluate the products, trials need to be undertaken on a number of different soil types and over a number of different years, to cover a range of edaphic and climatic factors. Summit Quinphos and Ballance have evaluated the products at many different sites.

To study the effect of seasonality, the trial should be located in a new area to overcome carry-over effects. This has been done in the Ravensdown study where they moved to a new location within the same paddock for each of the 4 trials. However, their study was only done at one site (dairy farm in Canterbury).

### **Mode of action**

The assertion by Summit Quinphos that improvements in N uptake and fertilizer efficiency with urease and nitrification inhibitors are greater than can be explained solely by reductions in NH<sub>3</sub> emissions, N<sub>2</sub>O emissions and NO<sub>3</sub> leaching, needs to be treated with caution, as there is no hard evidence to support this hypothesis.

### **Media advertisements**

The results of trials by all fertilizer companies show that Agrotain treated urea reduces NH<sub>3</sub> loss from urea and increases DM yield and N uptake. However, it will only be effective if conditions are conducive to NH<sub>3</sub> loss from urea. Results support previous findings in the UK that there is no additional benefit in increasing the rate of Agrotain above 1 l/t (250 ppm nBTPT w/w).

Based on the information provided to me by Summit Quinphos, in my opinion they are exaggerating the effect of their products by:

- 1) quoting high % increases of Sustain over urea at the same rate when differences in DM yield and N uptake are actually not significant.
- 2) presenting N response efficiency data that have not been shown to be statistically different.
- 3) Using misleading terminology, in some cases.

Dr C. J. Watson