USING HUMIC COMPOUNDS TO IMPROVE EFFICIENCY OF FERTILISER NITROGEN

Phillip Schofield[1], Nicky Watt[2] and Max Schofield[3]

[1]*Abron Farm Consultant, 3/129 Maraekakaho Rd Hastings*
Phillip.schofield@abron.co.nz
[2]*Operations Manager, Cloverdale Holding Ltd, Ferrimans Rd, Ashburton*
[3]*Masters Candidate, School of Biological Science, Victoria University, Wellington*

Abstract
Over recent years the need to improve the efficiency with which fertiliser inputs are used has become increasingly important. In particular nitrogen (N) fertiliser applications, commonly used to increase pasture production in dairy pastures, have come under scrutiny for many reasons.

The increasing cost of energy is driving the price of N fertilisers upwards. The effect of nitrogen leaching into groundwater, rivers and streams in New Zealand's main dairying districts is also becoming apparent. Currently all local authorities have implemented or are in the process of implementing regulations aimed to reduce contamination of groundwater by nitrate (NO_3) leaching from farmland.

We have been evaluating the use of humic compounds applied with nitrogen fertiliser at Cloverdale Holdings a 730 Ha, 2900 cow dairy unit near Ashburton since December 2009. The trial work has consisted of half paddock (6 ha) plots where treatments have been applied in conjunction with regular fertiliser applications on the farm. Pasture dry matter production was assessed by cutting 4 x 0.5 square metre sample areas at each harvest date for each treatment.

Three trials are discussed.

Granular urea was applied on its own at a rate of 30kgN/Ha or with 3 kg/ha of soluble humic acid granules. We recorded between 3% and 12% greater dry matter production where soluble humic acid was included with granular urea applications.

We compared applications of granular urea with liquid fertiliser consisting of dissolved urea, bio-stimulants and humic compounds. The comparison of dry matter production per unit of nitrogen fertiliser applied showed that dissolved urea with humic compounds and bio-stimulants produced approximately three times more dry matter per unit of applied nitrogen than solid urea applications.

When dissolved urea was applied either on its own, or with the addition of humic compounds and bio-stimulants, we found 12.5% greater dry matter was achieved by adding humic compounds and bio-stimulants to dissolved urea applications.

These results are discussed in relation to farm profitability, pasture quality, animal health and the N leaching requirements that are proposed by Environment Canterbury.

Introduction

Over the last thirty years there has been a rapid increase in the use of urea and other nitrogenous fertilisers on New Zealand pasture as a means to increase dry matter production. Dairy pastures in particular often receive several applications of urea over the course of a year with total applications of up to 400 kg of N per ha per annum being increasingly common in more intensive dairying areas of the country. This practice is coming under increasing scrutiny for many reasons.

As the price of energy increases so does the cost of nitrogenous fertilisers. Increasing N costs mean the economics of using high amounts of nitrogen fertiliser become marginal and is dependant on the price the farmer receives for the milk they produce from the extra pasture grown.

Nitrogen fertiliser applied as urea or ammonia is converted to nitrate in the soil before being taken up by the pasture plant root system (Lynch, 1982). Nitrate is very mobile in the soil and travels readily down the soil profile and in doing so may contaminate ground water. New Zealand streams, rivers, lakes and groundwater systems are under close scrutiny as their quality appears to have deteriorated with increased intensification of land use. This is causing problems for farmers, particularly in areas that have seen increased areas of dairy farming, as local authorities begin to regulate the amount of N fertiliser that can be applied and the timing of those applications in order to reduce the N leaching from dairy pastures.

Over the last twenty years interest in reducing the impact farm fertiliser practices have on the environment has escalated. This has driven an increasing amount of interest in the use of humic compounds and other biological stimulants as possible tools to help improve the efficiency with which fertiliser nutrients are used by crops and pastures (Du Jardin, 2012). There have been many studies that show the use of humic compounds such as humic acid, fulvic acid and mixtures of these can increase the efficiency of nutrient applications (Billingham, 2012). There has been little field trial work in New Zealand investigating the use of humic compounds despite their increasingly widespread use. The trials described here were conducted with the aim of measuring the response to dairy pastures in terms of dry matter production on commercial farms where fertiliser N was applied either with or without humic compounds.

Materials and Methods.

Three trials were carried out over four years. In each of the trials treatments were applied to 6 ha areas on commercial dairy farms. The standard paddock size on the farms is 12 ha so paddocks were divided in half longtitudinally and treatments were applied on each side of the paddocks. The trial areas were under either centre pivot or rotorainer irrigation and were irrigated as required according to rainfall and soil moisture levels that were monitored using aquaflex monitoring sites. Pastures on the farms were predominantly mixed swards of perennial ryegrass and clover. Pasture production was measured by taking pasture cuts on four 0.5 square meter replicate plots for each treatment at each harvest date. After the fresh weight of herbage was weighed for each plot, all herbage from each treatment was bulked up and a subsample was sent to Hill Laboratories for nutrient analysis, feed analysis and dry matter assessment. Pasture dry matter present at each harvest was calculated for each replicate plot. The data collected for each harvest was analysed using the software package R. Students t test analysis was used to provide mean dry matter production per hectare and standard error of the means of each treatment at each harvest date. Humic acid treatments were applied as soluble humic acid granules mixed with the solid fertiliser before it was spread on the paddock or as humic acid solution that was mixed with dissolved urea in the case of liquid applications. The liquid fertiliser applications were applied in water at a 150 litre per ha application rate using standard boom spraying equipment. Liquid fertiliser applications were made to pastures with covers of 1800 to 2000 kg of dry matter per hectare. The humic acid product used was a potassium hydroxide extract of humic compounds derived from leonardite.

Trial 1.
We compared regular applications of urea at 65 kg/ha (30 units of N per ha) either with or without 3 kg of soluble humic acid granules per ha. Six fertiliser applications were made over the twelve month period during which the trial was conducted. Pasture cuts were conducted six times during the trial period.

Trial 2
We compared regular applications of urea at 55 kg/ha (25 units of N per ha) with liquid applications of dissolved urea at 20 kg/ha (9 units of N per ha). The dissolved urea treatment had 6 litres per ha of humic compounds per hectare added to the spray mix.
Treatments were applied six times per year and the trial was run for two years and during this time data was collected from nine harvests.

Trial 3
Dissolved urea applications were made at a rate of 20 kg/ha (9 units N per ha) either with or without the addition of 6 litres per ha of humic compounds. The fertiliser treatment was applied 5 times during the course of the year long trial and five harvests were made from four replicate plots of each treatment.

Results
In the first trial it is clear that more dry matter production was grown at each harvest where humic acid granules were included with the fertiliser. Fig. 1 shows the mean dry matter production per hectare for each treatment at each harvest date.

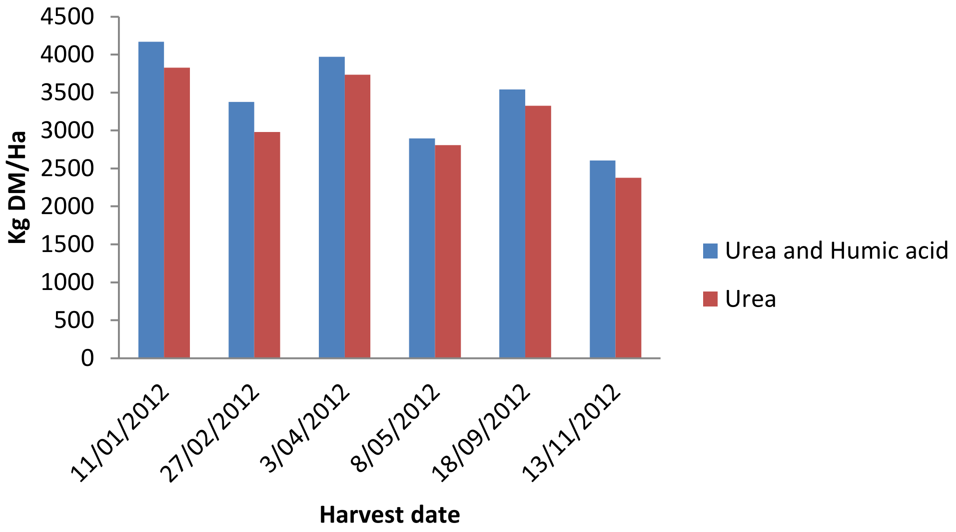

Figure 1. Pasture production from plots treated with either urea or urea with humic acid granules.

During the course of the trial 9% more pasture dry matter was produced where humic acid was included in the urea fertiliser applications. Standard error in the trial was high and the treatment differences were not statisticly significant. (p-value = 0.145) however the total amount of extra dry matter produced through the addition of humic acid to the urea during the twelve month trial was 1,680 kg/ha.

In the second trial we found that the dissolved urea with humic compounds resulted in greater dry matter production than where solid urea was applied in eight of the nine harvests. Fig. 2 shows the total dry matter production per ha harvested from each treatment on the nine harvest dates.

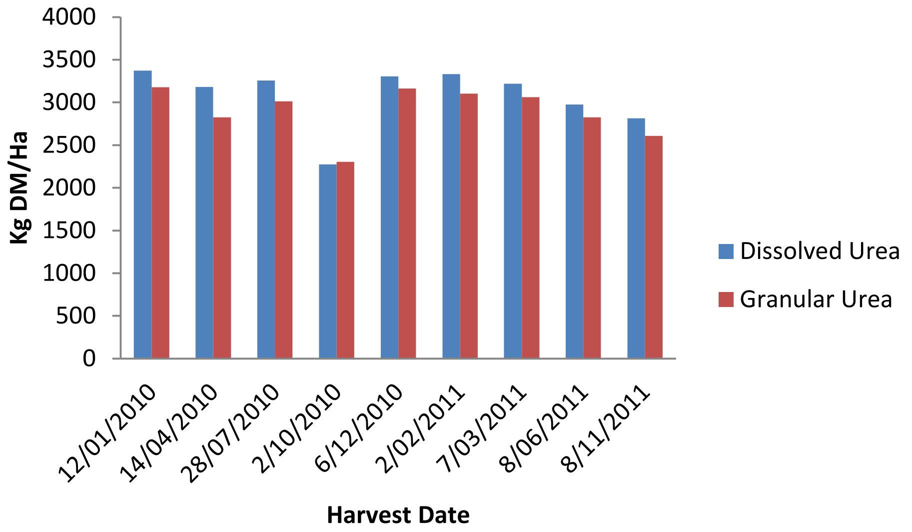

Figure 2. Pasture production at nine harvest dates from plots treated with dissolved urea and humic compounds or granular urea

Analysis of the dry matter production per unit of applied nitrogen (Fig. 3) shows that there was more than three times as much dry matter produced per kg of nitrogen applied where dissolved urea with humic compounds added was used compared to applying granular urea on its own.

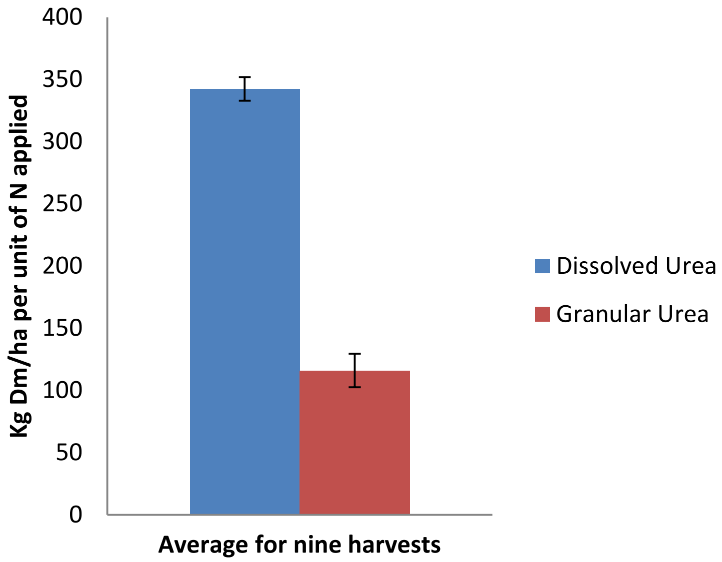

Figure 3. Average pasture production per unit of N fertiliser applied at nine harvest dates from plots treated with dissolved urea and humic compounds or granular urea

Standard error bars included in Fig. 3 indicate the difference in dry matter production between the two treatments based on dry matter production per unit of N fertiliser applied were highly significant.

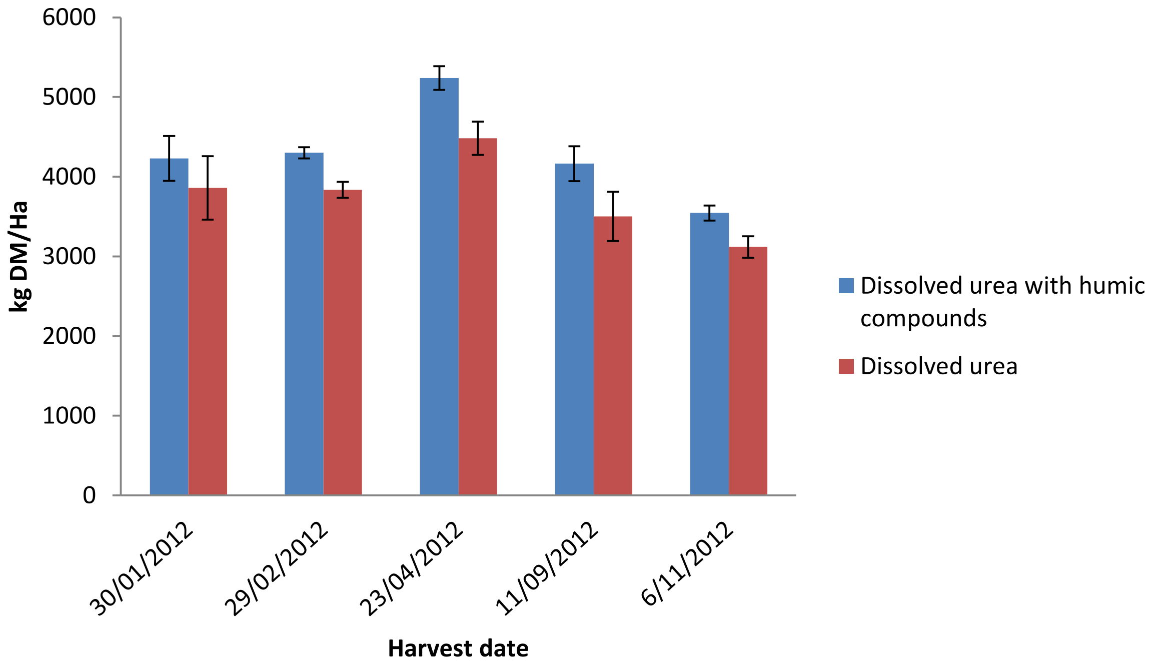

Figure 4. Pasture production from five harvests on plots treated with dissolved urea or dissolved urea with humic compounds added.

Where dissolved urea was applied with humic compounds included in the spray solution we found dry matter production was increased between 9% and 18% during the course of the trial (Fig. 4). Bars on the graph denote standard error and indicate that the differences were statisticaly significant on four of the five harvest dates. During the trial period 14% more pasture dry matter was produced through adding humic compounds to dissolved urea treatments. This represents an extra 2681 kg DM/ha being produced through the addition of humic compounds to liquid nitrogen fertiliser applications.

Discussion

The series of trials described here indicate that the addition of soluble humic compounds to solid urea applications may result in 9% greater pasture dry matter production. Also, the use of humic compounds with dissolved urea applications will result in 14% greater pasture dry matter production than the use of dissolved urea on its own. This work has also clearly demonstrated that the use of nitrogen fertiliser as a liquid or foliar application with humic compounds included in the spray solution will result in a large increase in the amount of pasture produced per kg of nitrogen fertiliser added when compared to the use of solid urea fertiliser.

Humic acid granules were included with granular urea applications at what appears to be very low rates (3kg/ha), however at these rates it appears the very soluble humic compounds do have an effect on the urea fertiliser and enhance its activity and possibly improves the uptake of the added nitrogen in some way. Humic compounds are known to chelate minerals and it is possible that their addition to highly soluble fertilisers such as urea increases the nitrogen available for pasture uptake by reducing losses through leaching during irrigation or rainfall. Humic compounds are also known to stimulate soil biological activity and this may improve the conversion of urea to plant available nitrogen forms in the rhizosphere of the pasture plants. Visual Soil Assessments (Shepherd 2009) indicate that the trial areas where humic compounds were used tended to have deeper root systems and more dense root systems. This is another possible reason for the greater dry matter production from urea plus humic compounds compared to urea on its own.

Where humic compounds were added to dissolved urea and foliar fertiliser applications were made it is likely that the chelation of urea enhanced plant uptake and improved the ability of the pasture plants to utilise the nitrogen fertiliser.

These results have significant implications for farmers using nitrogen fertiliser and trying to minimise leaching of nitrates. Liquid or foliar applications of nitrogen fertiliser with the inclusion of humic compounds has been shown to be a more efficient method of applying nitrogen to pastures than the use of granular urea applications. Based on these trials it can be seen that pasture dry matter production can be maintained using only one third of the nitrogen fertiliser inputs using foliar application to pasture covers of 1800 to 2000 kg/ha DM.

With the current, increasing need to reduce N leaching from farms the use of humic compounds with solid nitrogen fertilisers will allow pasture production to be maintained when fertiliser applications are reduced by 10% or more. When a foliar nitrogen fertiliser programme that includes humic compounds is employed, pasture production can be maintained using one third of the solid fertiliser quantity.

Using the Overseer model, the farms where this work was carried out are currently leaching 18kg N per ha while maintaining total pasture production of over 21 tonne of dry matter per ha. Over a period of four years the nitrogen fertiliser requirements have reduced from 250 kg of N per ha to between 80 and 100 kg while pasture production during the same period has increased from 15.25 tonne harvested to 17 tonne harvested per hectare. It appears that the use of humic compounds with fertiliser nitrogen shows great promise as a means by which farmers can reduce N fertiliser inputs while maintaining or increasing pasture production. This allows farmers to maintain high levels of pasture production while meeting the requirements to lower the N leaching from their farms.

An added benefit of reducing nitrogen fertiliser inputs using humic compounds while maintaining overall pasture production is that there is a reduction in the nitrate level in the forage that animals are eating. This seems to benefit animal health with reduced levels of lameness, better conception rates and reduced somatic cell counts commonly reported on farms adopting this approach. Initial work by Magesan and Gifford (2011) indicates that N leaching from farms where soil biological activity is encouraged through the use of humic compounds and other biostimulants is significantly lower than farms using the standard soluble NPK based fertiliser strategy.

Conclusions

Nitrogen fertiliser efficiency can be improved by the inclusion of humic compounds with either solid or dissolved urea. Highest efficiency is achieved where dissolved nitrogen and humic compounds are applied to actively growing pasture. These improvements in efficiency of nitrogen fertiliser applications provide a means by which farmers can meet nitrogen leaching requirements being imposed by regional authorities throughout New Zealand.

More work is needed to confirm the best types of humic compounds or biological stimulants to use in a New Zealand pastoral situation. Better efficiencies are likely to be achieved as we gain a greater understanding of how humic compounds modify soil biological activity and the plant's uptake of fertiliser nitrogen.

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