THE EFFECTS OF UREA AND AMMONIUM SULPHATE NITRATE (ASN) ON THE PRODUCTION AND QUALITY OF IRRIGATED DAIRY PASTURES IN CANTERBURY, NEW ZEALAND

Jim Moir[1], Keith Cameron[1], H J Di[1], Ants Roberts[2] and Wybe Kuperus[3]

[1]Centre for Soil and Environmental Quality, PO Box 84, Lincoln University
[2]Ravensdown Fertiliser Co-operative Ltd, Pukekohe
[3]Dexcel Ltd, Lincoln

Abstract

This paper examines the effects of two different forms of nitrogen (N) fertiliser, urea and ammonium sulphate nitrate (ASN) on the production and quality of spray irrigated dairy pastures in Canterbury. Pasture production and a wide range of pasture quality parameters were measured in a mowing trial of randomised design on the Lincoln University dairy farm. Treatments consisted of three fertiliser forms (urea, urea plus sulphur (S) and ASN) applied at two annual rates of N (150 and 250 kg N ha^{-1}). Measurements included pasture dry matter (DM) yield, botanical composition, pasture N and S uptakes, 'standard' pasture quality measurements, such as carbohydrate and protein levels, and a detailed assessment of levels of individual proteins in the pasture.

Under the conditions of this trial representing typical centre-pivot irrigation and high soil fertility, the total annual dry matter yield ranged from 15.9 (Control) to 19.4 (ASN 250) t DM ha^{-1} and was strongly influenced by rate of N fertiliser application but not fertiliser type. ASN showed a small significant yield advantage ($P < 0.05$) over urea at the 150 N rate but not at the 250 N rate. Clover levels did not vary significantly with type or rate of fertiliser applied. Pasture quality, as measured by 'key' quality indicators was generally unaffected by fertiliser treatments throughout the season, although some differences in specific amino acid levels were detected. The implications of the impacts of N fertiliser use on pasture quality are discussed.

Introduction

There is very little available research information in New Zealand that demonstrates the effect of fertiliser type on pasture quality. Most research demonstrates the effects of fertiliser on pasture yield alone (Craighead *et al.*, 1997). However, in conjunction with dry matter yield and animal intake, pasture quality is a critical factor influencing milk production and the health of the grazing dairy cow (Rogers and Stewart, 1982; Currie and Trigg, 1990).

High yielding irrigated dairy pastures in Canterbury often receive regular inputs of strategic fertiliser nitrogen (N) while sulphur (S) inputs are typically only applied once a year with phosphorus (P) fertiliser. South Island alluvial soils are inherently S deficient and have low S retention capabilities, and as a result soil sulphate S levels can drop dramatically even within one season. Given these soil-plant conditions it has been suggested that a combination S / N fertiliser may provide pasture yield advantages over strategic N alone. However, there are no published research results available to support this or whether there is any influence of strategic N and S fertiliser use on the quality of irrigated dairy pastures through the season.

The objective of this study was to determine and compare the effects of Ammonium Sulphate Nitrate (ASN) and urea on dry matter production and pasture quality of typically high producing irrigated dairy pastures in Canterbury, New Zealand.

Materials and Methods

This research was conducted on the new Lincoln University dairy farm, on free-draining Templeton (sandy) soils. The site was a recent conversion (2001) from long-term sheep pastures to dairying and had high soil fertility status (Olsen P 30 μg P g^{-1}, Sulphate S 24 μg S g^{-1}, pH 5.8).

The trial was conducted as a mowing trial under centre pivot irrigation from August 5th 2002 to August 5th 2003 with grazing animals excluded. Field plots (2 x 5 m) were laid down in a randomised block design. Fertiliser treatments consisted of three fertiliser forms; ASN, Urea or Urea plus S (as gypsum), applied at two rates of N: 150 or 250 kg N ha^{-1} yr^{-1} over six applications. A control was included, and all treatments were replicated four times. Basal nutrients and lime were applied in accordance with current fertiliser policy on the Lincoln University dairy farm. All fertiliser applied to the main paddock area was excluded from the trial area by covering plots with plastic sheets at the time of application.

Irrigation water (no effluent) was applied by the centre-pivot irrigator (overhead spray) in accordance with normal centre-pivot irrigation practice in Canterbury. Centre-pivot irrigators are used on these dairy farms to supply small amounts of water on a regular rotation around the farm. During the 2002/03 season on the Lincoln University dairy farm irrigation water was applied from late-September 2002 until May of 2003 at an equivalent rate of between 7 to 10 mm per application (every 24-48 hours), depending on the farm requirements.

Pasture was harvested approximately every 20-30 days, depending on the current farm grazing rotation interval. A wide sickle-bar mower was used to harvest plots which minimised any mechanical damage or bruising to herbage samples. Dry matter yield, botanical composition and dry matter response to fertilisers were measured at each harvest. Standard pasture quality analyses were also performed at each harvest using near-infrared spectroscopy (NIR) and included quality parameters such as crude protein, fibre, carbohydrate and metabolisable energy contents of samples. The N and S contents of samples were also measured at each harvest. Detailed amino acid composition analyses were performed on both ryegrass and clover sward components at five times through the season when pasture quality was considered to be of high priority. Amino acid analyses were performed in: (1) September (early lactation), (2) late-October (peak milk production), (3) late-December, (4) early-February, and (5) mid-March.

Results and Discussion

Pasture Yield

Total annual dry matter yield ranged from 15.9 (Control) to 19.4 (ASN 250) t DM ha^{-1} (Figure 1). Pasture growth was higher on fertilised treatments ($P < 0.01$) when compared with the control, with the maximum (ASN 250) yield representing a 22 % yield increase. The '250 N' treatment significantly out-yielded the lower '150 N' rate within the 'Urea' ($P < 0.001$), 'Urea+S' ($P < 0.01$) and 'ASN' ($P < 0.05$) fertiliser types. Annual yields on the ASN 150 N treated plots (18.06 t DM ha^{-1}) were significantly higher ($P < 0.05$) than for Urea (16.95 t DM ha^{-1}) at the 150 N rate (Figure 1). However, there was no significant difference in annual dry matter yield across fertiliser types at the 250 N rate.

The higher annual yield of ASN 150 reflects a cumulative effect whereby the ASN 150 out-yielded the Urea 150 treatment by a small non-significant ($P > 0.05$) margin over a number of harvests. The ASN 150 treatment also exhibited the largest difference in pasture growth over other 150 N fertiliser treatments (ns, $P < 0.05$) at the first harvest of the trial in September of 2002, perhaps showing some advantage over other fertiliser types at lower soil temperatures. However, the ASN 250 treatment showed no pasture growth advantage over other 250 N fertiliser treatments during this spring period.

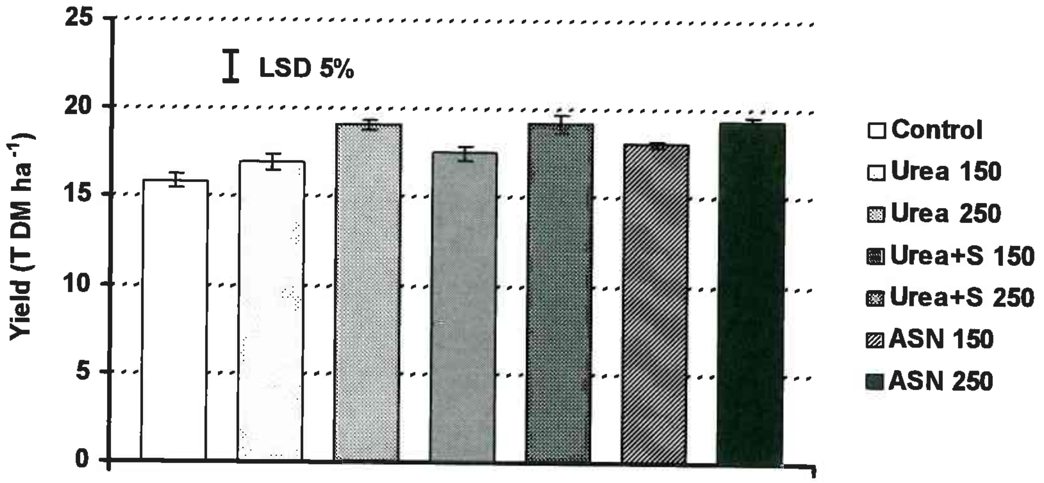

Figure 1. Total dry matter yield

Nitrogen Response

Pasture N responses, expressed as kg DM grown per kg of N applied as fertiliser are presented in Figure 2. N responses ranged from near 0 to 30:1, and reflected the variable and seasonal nature of pasture growth responses to N fertiliser. In general, N responses were highest in early spring (August / September), with good responses in Autumn (April) and lower responses at other times.

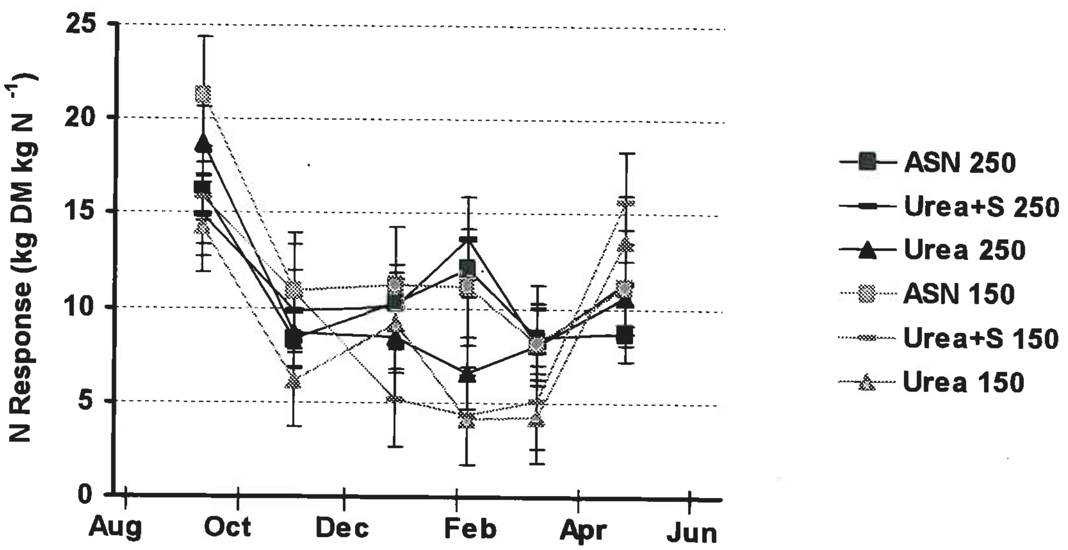

Figure 2. Pasture N response in the first harvest following fertiliser applications

Pasture N response following fertiliser application in August was greater for the ASN 150 treatment compared to the Urea 150 treatment, however the difference is not statistically different ($P > 0.05$).

Overall, the ASN 150 treatment appears to have a slightly higher 'mean' N response throughout the season than other treatments in this trial. However, the variability of the data resulted in a non-significant difference, and hence the overall level of pasture N response was not significantly correlated to fertiliser type, nor to rate of N fertilisation.

Botanical Composition
Botanical separations of pasture samples were conducted at all harvests, and the seasonal clover contents across treatments are represented in Figure 3. Clover contents started at 15% of total dry matter in September of 2002, peaked at mean values of 45% in December, then fell slowly to low levels (< 10%) across all treatments by the winter of 2003 and reflected the seasonal nature of clover growth.

As expected, clover growth was suppressed to some extent by N fertilisation. Clover production on control plots was 5 to 10 % higher than on N fertilised treatments over most of the season. However, given the moderate to high levels of N fertiliser rates applied in this trial, sward clover levels were significantly higher than expected throughout the season. In this respect, all pastures were of very high quality. The data also indicate that there was no significant difference between the effects of ASN and urea on the clover content of the sward at either 150 or 250 N rates. Likewise, when overall N 'rates' were pooled across all fertiliser types, the differences between the two fertiliser rates on clover content could not be separated.

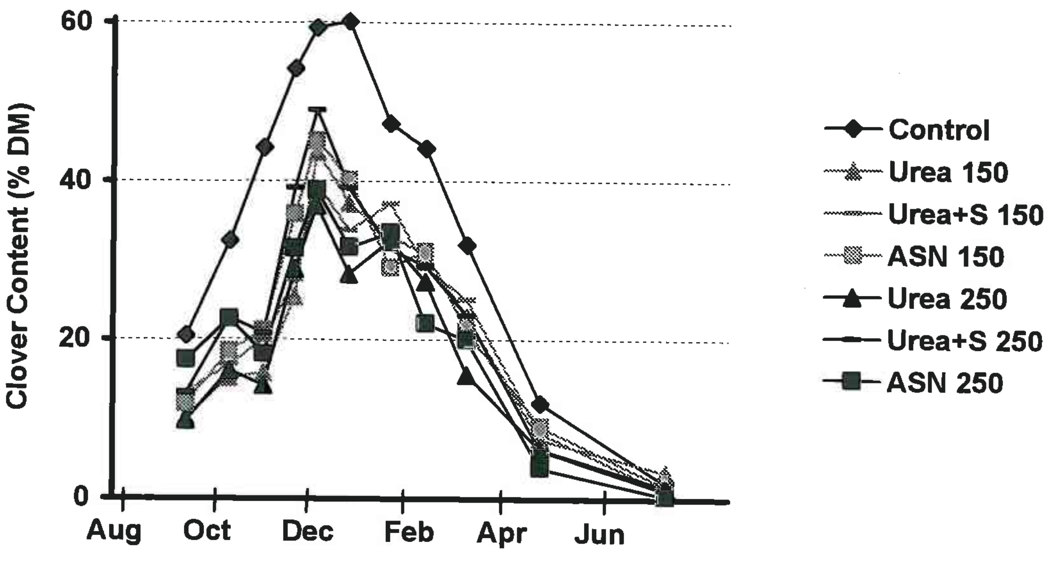

Figure 3. Clover content of pasture

Pasture N and S Uptake
Pasture N levels ranged from 2.7 % w/w in October to 3.8 % w/w in late December (data not shown). In general pasture N concentration was highest in the 250 N treatments, but this trend was not always clear. No one fertiliser type appeared to show any advantage in the elevation of herbage N levels. Approximately half of the amount of N applied as fertiliser was apparently recovered by the pasture plants (e.g. N-uptake at the 250 kg N ha^{-1} rate was 669 kg N ha^{-1} minus N-uptake in the 'control' (545 kg N ha^{-1}) = 124 kg N ha^{-1}).

Sulphur levels in herbage were strongly influenced by fertiliser treatment. Values ranged from 0.42 to 0.54 % w/w for ASN and Urea+S treatments, and lower levels of 0.36 to 0.43 % w/w on Urea treated and control plots (data not shown). All observed herbage S concentrations were well above the recognised S deficiency level of 0.30 % w/w and reflect the high sulphate-S levels in the soil (24 µg S g^{-1}). These results suggest that luxury plant S uptake occurred, which would explain why no pasture growth response to S fertilisation was apparent in this trial. Annual S uptake by pastures ranged from 62 kg S ha^{-1} on the control to 97 kg S ha^{-1} for the ASN 250 treatment. On S fertilised treatments, total plant S uptake was equivalent to approximately 26 % of that applied as fertiliser at the 250 N rate.

Pasture Quality (NIR Analyses)
Standard pasture quality analyses were conducted on all mixed pasture samples at all harvests to investigate the effects of the fertiliser treatments on feed quality. Quality indicators included crude protein, carbohydrate, fibre and metabolisable energy levels. Overall, fertiliser rate and type had negligible effect upon levels of the pasture quality indicators (e.g. metabolisable energy content, Figure 4).

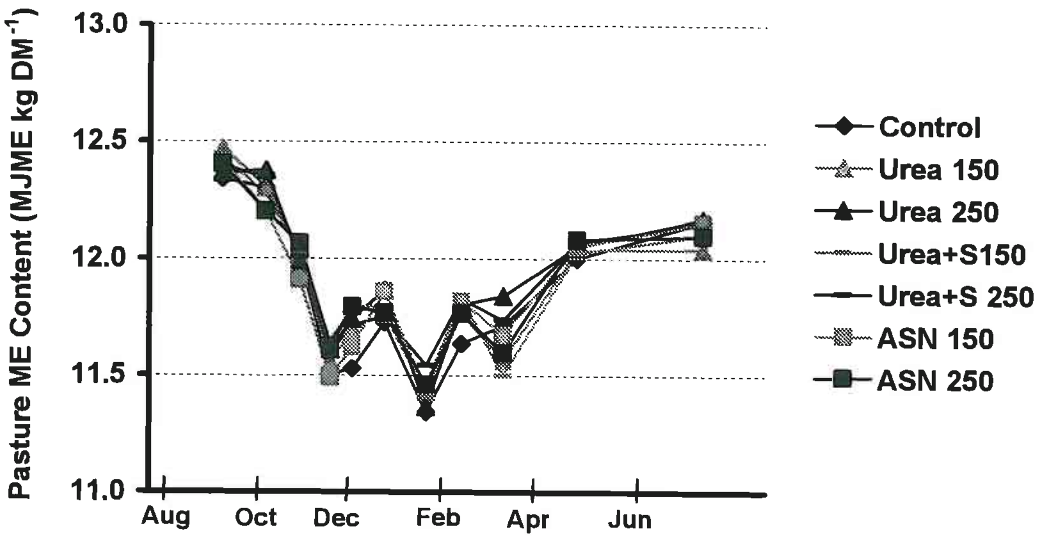

Figure 4. Pasture ME content through the 2003 / 2004 season

Most pasture quality indicators, such as the critical 'metabolisable energy' measurement gave nearly identical values across all treatments at each sampling (Figure 4). Much of the variation in the levels of all measured quality indicators could be attributed to seasonal variation rather than treatment effect of fertiliser or N rate.

In summary, the two N fertilisation rates applied in this study had little if any effect on pasture quality indicators throughout the season. This is an important new finding because it demonstrates that at the 'typical' on-farm N rates used here, farmers could use urea or ASN to grow up to 20 % more dry matter with virtually no drop in pasture quality, given adequate soil fertility. Maintaining pasture quality will also depend on maintaining high levels of clover in the sward.

Pasture Quality (Amino Acids)
In addition to 'standard' pasture quality analyses, herbage samples also underwent HPLC analysis to determine the levels of a wide range of individual amino acids. These samples were selected from five harvests representing key periods for pasture quality through the season. Samples were taken in September, October, November, January and March.

Amino acids such as methionine and lysine are critical proteins influencing milk production in dairy cattle (Schwab *et al.*, 1992). The influence of N (and S) fertilisers on amino acid levels in pasture is therefore of real interest.

Amino acids were determined separately on the grass and clover plant material and the results are presented here as a mixed pasture sward to represent that eaten by the grazing cows. The seasonal variation in methionine content of mixed sward samples are given in Figure 5 below as an example. Results indicate that the levels of some amino acids can rise and fall quite dramatically through the season. Amino acid levels across replicates were variable, and therefore the effects of fertiliser type and rate on protein levels are difficult to separate. Therefore the data indicate that variation of amino acid levels in the pasture samples due to fertiliser treatment is small, but in some instances, may be potentially significant. More detailed statistical analysis of these data sets would be required before any definite conclusions could be drawn about the influence of these fertiliser treatments on amino acid levels in pasture.

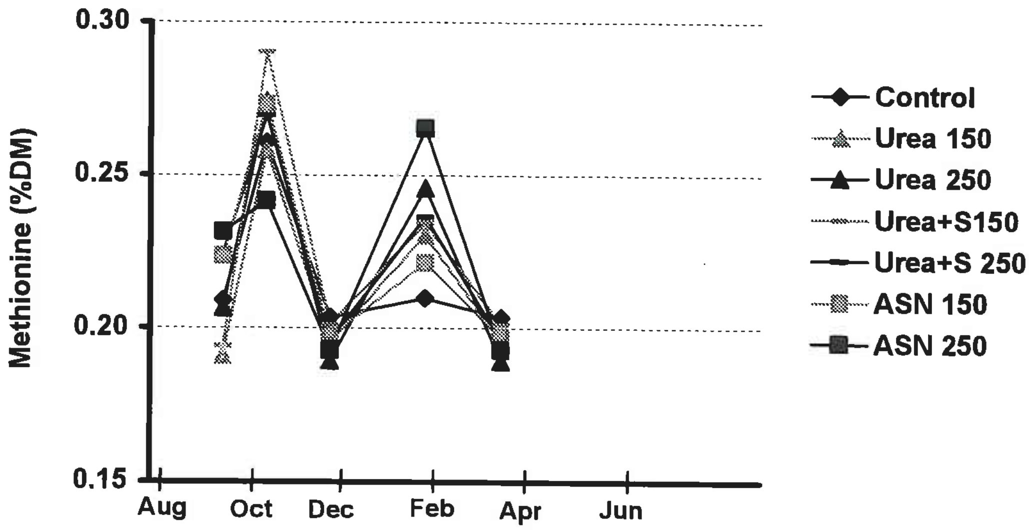

Figure 5. Pasture methionine content over the 2002 / 2003 season

Conclusions

The influence of ASN and urea at two rates of N application on the production and quality of irrigated dairy pastures in Canterbury, New Zealand was investigated. Under the conditions of this trial representing typical frequent centre-pivot irrigation and high soil fertility, pasture production ranged from 15.9 (Control) to 19.4 (ASN 250) t DM ha^{-1} yr^{-1} and was strongly influenced by the rate of N fertiliser application. ASN showed a small significant yield advantage ($P < 0.05$) over urea applied at the 150 N rate but not at the 250 N rate.

The clover content of the sward did not vary significantly with the type, or rate of fertilisers. Seasonal variation in sward clover levels was high, and moderately high clover contents were maintained on fertiliser treated pastures (from 10 - 45%). Clover levels in the pastures were 5 – 10% lower on fertilised plots compared to the control.

The fertiliser types and two N fertilisation rates applied in this study had little if any effect on key pasture quality indicators throughout the season. This is an important new finding because it demonstrates that at the N rates used here farmers could use urea or ASN fertiliser to grow up to 15 - 20 % more dry matter with virtually no drop in pasture quality.

Further pasture quality analyses revealed that amino acid concentrations in the herbage varied widely over the season. The data indicate that the variation of amino acid levels in the pasture samples due to fertiliser treatment is however small.

Acknowledgements

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