PASTURE DRY MATTER AS INFLUENCED BY UREA APPLIED WITH AGROTAIN, ELEMENTAL S AND LIME

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Abstract:
Two field trials were set up on permanent dairy pasture sites in Lincoln and Ashburton Canterbury, New Zealand during September 2009-July 2010. The pastures were mainly comprised of perennial ryegrass (*Lolium Perenne* L.) and white clover (*Trifolium repens* L.) Our objective was to investigate the differences in pasture dry matter, N response (NR) and response efficiency (NRE) between standard urea with elemental S, Agrotain treated urea + S and Agrotain treated urea + S + lime (PhasedN) over a 12 month period. The 5 treatments of PhasedN, urea + S, urea + Agrotain + S, control + S, and an absolute control (no S or N) were replicated 5 times. The fertilizer treatments were broadcasted at a rate equivalent to 25 kg N/ha three times throughout the year. In both trials, urea applied with Agrotain improved NUE by exhibiting higher PDM, NR and NRE compared with those of standard urea. Such increases in PDM were 5.6% and 6.6% over urea treatment for Ashburton and Lincoln trials respectively. The improvements in PDM were even higher (i.e. 7 to 8%) in PhasedN treatment compared with those of standard urea treatment. These results suggest that combining urea with Agrotain, elemental S and lime into a single granular chip offers a better management option to improve economic returns and to apply S where P levels already high or it is deemed uneconomic.

Keywords: Urea, Agrotain, elemental S, Lime, Pasture dry matter and N response.

Introduction

Nitrogen (N) is an essential component of any farm system, promoting plant growth and enabling the formation of protein in crops and animals. In legume based pasture system in New Zealand, apart from the two major N inputs (animal excreta and biological N fixation by legumes), a significant amount of N (0.33 million tones on annual basis) comes from application of chemical fertilisers, predominantly urea, which is commonly applied to the whole paddock after every single or two rotational grazing throughout the growing season (spring-autumn) to meet animal feed demand and to sustain productivity (Ledgard 2001; Saggar 2004; Quin et al., 2005; Blennerhassett et al., 2006). Urea applied in granular form has been linked to poor N use efficiency (NRE) (kg of dry matter produced per kg of applied N) compared with other ammonium-based fertilizers like diammonium phosphate (DAP) or sulphate of ammonia (SOA) (Watson et al., 1990; Zaman et al., 2008; Zaman and Blennerhassett, 2009). We know from past experimental trials that a positive pasture N response is variable but is typically of the order of only ca 10 kg dry matter per kg N applied. A response of that magnitude means that the pastures are utilizing less than 50% of the N applied. Such poor NUE of applied urea is because of the knowledge gap in understanding fast urea hydrolysis as influenced by soil types, soil moisture, temperature, rate and timing of urea application, and its uptake and metabolism by plants (Watson et al., 1994; Castle and Rowarth 2003; Chen et al. 2008; Zaman et al., 2008). Among the several options available to improve NUE of urea, coating granular urea with urease inhibitor (UI) (N-(n-butyl) thiophosphoric triamide, nBTPT) (Agrotain), may have the most potential (Blennerhassett et al., 2006, 2007; Chen et al., 2008; Martin et al., 2008; Watson et al., 2008; Zaman et al., 2008, Zaman and Blennerhassett, 2009). Apart from N, sulphur (S) also plays a key role in plant and animal nutrition, while lime is commonly applied as soil amendment to maintain soil pH and improve productivity in grazed pastures. However information about the interaction of urea applied with Agrotain, elemental S and lime on pasture productivity is lacking. Recently Summit-Quinphos developed a new product by combining granular urea, sulphur and lime into a single chip called **PhasedN**. The objective of our study was to investigate the effect of applying urea with Agrotain, elemental S and lime on pasture N response.

Materials and Methods

Two field trials were set up on permanent dairy pasture sites in Lincoln and Ashburton Canterbury, New Zealand during September 2009-July 2010. The pastures were mainly comprised of approximately 80% to 85% perennial ryegrass (*Lolium Perenne* L.) and 15% to 20% white clover (*Trifolium repens* L.) managed for dairy grazing (3.5 cows/ha). To avoid the effects of recent excreta deposition from grazing animals on the added treatments, the experimental area was fenced off 12 months before the start of the experiment. Twenty-five field plots, each plot of 1.5m^2 area with 1m border, were established in 5 rows separated by 1m buffer zone. Pastures from each plot were cut to a height of 6 cm above ground level using a lawn mower to ensure uniformity prior to N application at 25 kg N/ha. The 5 treatments of urea + Agrotain + S + lime (PhasedN), urea + S, urea + Agrotain + S, control + S, and an absolute control (no S or N) were replicated 5 times. Urea was applied at 25 kg N/ha. Since PhasedN contained 28% S, therefore 4.2 g of elemental S per plot was added to those plots with no PhasedN. To ensure annual maintenance requirement of P, all plots received P at the rate of 40 kg P/ha using triple super phosphate (TSP).

To compare the difference in NR between standard urea plus S and PhasedN, pastures were harvested from each plot at different times to determine pasture dry matter. This occurred three times after each fertiliser application before the treatments were reapplied and the procedure repeated. Farmers commonly apply urea after every single or two rotational grazing, but Agrotain and lime in PhasedN should theoretically give some slow release characteristics therefore we reapplied the fertiliser treatments after 3 cuts rather after 1 or 2 cuts to ensure we measure the full N response. At each cut, pastures were harvested from each plot, and then transferred to a plastic bag for bulk weight. For moisture fraction and pasture N analysis, 4 randomly hand picked pasture samples from each plot were transferred to pre-weighed paper bag, weighed and dried at 60^{o}C for 1 week. After drying, dry pasture weight was recorded to calculate moisture fraction. The dried pasture sample in each bag was then ground to less than 0.2 mm and analyzed for total N. Nitrogen response efficiency was calculated by subtracting pasture dry matter of the control from that of the fertilizer treatment and then dividing by the amount of N applied.

Statistical analysis

ANOVA was carried out on pasture yield and NR for cumulative data over the entire 12-month period. Least significant difference (LSD) values at $P<0.05$ were calculated when the treatment effect was significant

Results and discussions

In both trials, urea applied with Agrotain improved NUE by exhibiting higher PDM, NR and NRE compared with those of standard urea (Table 1). Such increases in PDM were 5.6% and 6.6% over urea treatment for Ashburton and Lincoln trials respectively. The improvements in PDM were even higher (7 to 8%) in PhasedN treatment compared with those of standard urea + S treatment probably due to the presence of Agrotain and lime in Phased N, which have the potential to give slow release characteristics to urea.

Table 1: Cumulative PDM, NR and NRE as influenced by application of urea with Agrotain, elemental S and lime in Ashburton and Lincoln trials

Treatments	**PDM** (kg/ha)	**NR** (kg/ha)	**NRE** (kg DM/kg of N)	**% increase in PDM over urea +S**
Ashburton trial				
Control (no N or S)	11,230			
Control + S	12,096			
Urea + S	12,957	860	11	
Urea +Agrotain + S	13,687	1591	21	5.6
***PhasedN**	14,000	1904	25	8
LSD at 5%	700	807		
Lincoln trial				
Control (no N or S)	11,510			
Control + S	12,365			
Urea + S	13,288	924	12	
Urea +Agrotain + S	14,163	1798	24	6.6
PhaSedN	14,264	1899	25	7.3
LSD at 5%	766	820		

***PhasedN**: urea + Agrotain + S + lime

These results confirm our earlier findings that urea applied with Agrotain in different trials in South Island and North Island improve fertiliser N response and minimise N losses (Blennerhassett et al., 2006; Zaman et al., 2008; Zaman and Blennerhassett, 2009). The improvements in pasture DM and twice NRE of urea + Agrotain and PhasedN treatments compared with standard urea + S could be attributed to a number of factors including delayed urea hydrolysis, reduced NH_3 volatilization, efficient N uptake and its metabolism and interaction of N, S and lime. A number of studies have confirmed that urea hydrolysis starts soon after urea application and is completed within 2 to 3 days. Such fast urea hydrolysis increases soil ammonium (NH_4^+) concentration and localized soil pH; which are known to accelerate NH_3 volatilization (Sanz-Cobena et al., 2008 & 2010; Watson et al., 2008; Zaman et al., 2008 & 2009). Delaying urea hydrolysis by Agrotain is reported to slow NH_4^+

production in soil and thus minimizes its losses to the atmosphere via NH_3 volatilization. It is known that delaying urea hydrolysis by Agrotain provides plants an opportunity of at least 7 days (depending on NBTPT degradation in soil) to take N in either urea or NH_4^+ form; both of these N forms are known to convert to plant protein at a low energy cost compared with nitrate-N (NO_3^-) (Middleton and Smith 1979; Liantie et al., 1993; Schjoerring et al., 2000; Quin et al., 2006). Retention of urea by Agrotain also reduces the potential for losses to soil processes such as immobilization and allows more time for rainfall or irrigation water to wash applied urea from surface soils to rooting zone to facilitate its uptake. The two trials demonstrate that there is considerable potential for improving the production of pastoral farms by using PhasedN instead of standard urea. The size of the average fertiliser efficiencies with PhasedN at both sites, are remarkable. Our results suggest that combining urea with Agrotain, elemental S and lime into a single granular chip offers a better management option to control urea hydrolysis, minimize NH_3 losses, counteract the changes in soil pH brought by urea, improve economic returns and to apply S where P levels already high or it is deemed uneconomic.

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