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Nitrogen application to dairy pasture – the effect of rate and timing of spring nitrogen applications on the concentration of pasture nutrients

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ABSTRACT

Nitrogen (N) fertiliser was applied to ryegrass/white clover dairy pasture in late winter/early spring. Four rates of N (0, 20, 40, 80 kg N as urea) were applied to pregrazed and premown pasture with a residual herbage mass of 1000 kgDM/ha^{-1} (stubble height of 1.5 cm). Samples were collected from separate 2m^2 plots 2, 4, 6 and 8 weeks after N application to detect nutrient changes over time from N application and analysed for major nutrients (crude protein (CP), acid detergent fibre (ADF), neutral detergent fibre (NDF), soluble carbohydrate (SOLCHO) and dry matter (DM) %) as well as net herbage accumulation. Nitrogen was applied to separate areas on 15 August, 31 August, and 15 September to mimic the range of timing of N application used on commercial dairy farms.

Nitrogen increased herbage CP, reduced ADF and NDF and reduced SOLCHO for 4-8 weeks after application. The effect of N on fibre and protein content of pasture was reversed 6-8 weeks after N application associated with increased pasture maturity, ground temperature and daylength. Increased crude protein and reduced fibre levels were more marked and longer lasting in early spring when conditions were cooler and daylength shorter, than in late spring. Consequences of the findings for dairy cow nutrition and pasture management are discussed briefly.

Keywords: Nitrogen fertiliser rate, pasture nutrients, protein, fibre, soluble carbohydrate, pasture management.

INTRODUCTION

Nitrogen (N) fertiliser is usually applied tactically to increase pasture production during or following periods of slow growth. Improved DM production and milk yields have usually resulted from such applications (Holmes, 1982).

Nitrogen fertiliser can increase pasture crude protein% (CP), and depress soluble carbohydrate (SOLCHO), fibre and dry matter (DM)%, and increase digestibility and rumen degradability (Beheaghe and Carlier, 1973; Ross *et al.*, 1978; Beever, 1993; Van Vuuren *et al.*, 1992). Overseas evidence, with mainly non-pasture diets, indicates that cows fed diets containing high crude protein levels (>18%) have reduced milk production and sometimes lower conception rates than cows on diets with lower protein levels (Danfaer *et al.*, 1980; Ferguson *et al.*, 1988). One New Zealand study (Mackle,1995) found reduced milk protein production and reduced DM intakes by cows grazing N fertilised pasture. There is also other circumstantial evidence that these effects also occur in New Zealand cows on pasture diets (Moller, 1991).

In light of recent increased use of N by New Zealand dairy farmers and the possible negative effect of this practice on pasture quality for lactating dairy cows an experiment was conducted to examine the effects of N in winter/spring on the nutrient composition of ryegrass/clover pasture. A range of application rates and times and harvest intervals typically employed by dairy farmers at this time of the year were investigated.

MATERIALS AND METHODS

A replicated randomised split plot design was used with three different N application dates, four N rates (0, 20, 40, 80 kg N/ha) and four replicates. The experiment was conducted at the Massey University Dairy Research Unit in Winter/Spring 1993. Areas of 4x2m^2 were pregrazed 5 weeks before N application and mown to a uniform level of 1.5cm (1000 kg DM) on the day of N application. Pregrazing mimicked a normal winter grazing and mowing created the pasture residual (without soil damage, or faecal or urine contamination) often found on dairy farms at this time of the year. Nitrogen, as urea dissolved in water, was applied on 15 August (1st applicaton date), 31 August (2nd application date) and 15 September (3rd application date). In order to detect pasture nutrient changes after N application the 4x2m^2 blocks were each harvested in 2m^2 portions by mowing to 1.5 cm at 2, 4, 6 and 8 weeks respectively after each N application. The total wet weight of herbage harvested per subplot was recorded , and a subsample of this was oven dried to determine DM content. A second subsample was freeze dried, then ground for NIRS (Near Infra Red Reflectance Spectrophotometry) analysis for CP, ADF and NDF at Pennsylvania State University as described by Shenk and Westerhaus (1994). Wet chemistry methods used to calibrate for CP were TKN (Kjeldahl), ADF and NDF by the Van Soest method. SOLCHO was analysed at Agresearch, Palmerston North as described by Southgate (1976). Ground temperature was measured daily. Data were subjected to ANOVA using the Genstat programme (Genstat 5,1993).

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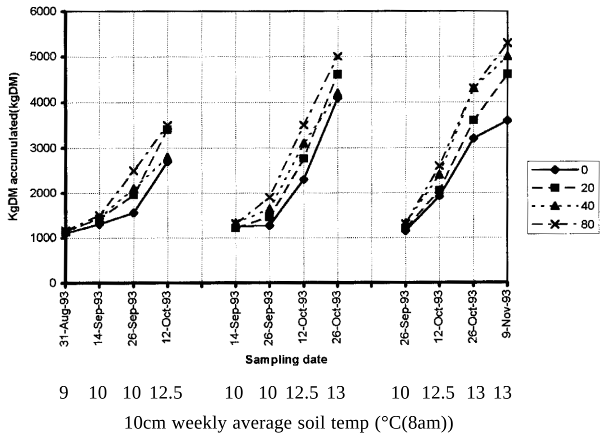
RESULTS

Net herbage accumulated from the time of N application is shown in Figure 1. Nitrogen application increased nett herbage accumulation, with the lower N (20 kg/ha) rate producing more DM per kg N applied than higher rates of N (40 and 80 kg/ha). High rates of N (40 and 80 kg/ha) resulted in the accumulation 2000 kg DM/ha two weeks earlier than low rates (0 and 20 kg/ha).

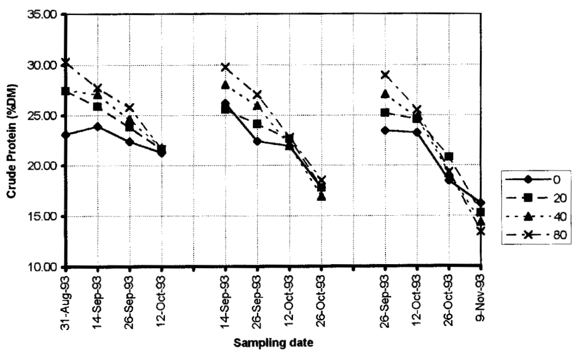
Mean concentrations of pasture nutrients for each sampling date (harvest date) for the three N application dates are presented in figures 2-5 with associated error terms (SED) attached.

FIGURE 1: Pasture accumulation over time for four N rates and three application dates.



Crude protein levels were significantly elevated at the first (P< 0.001), second (P< 0.001), and third (P< 0.01) sampling dates (2, 4 and 6 weeks after N application) compared to 0 kg N over all three N application dates, but especially at the first application date (15 August; Figure 2).

FIGURE 2: Pasture crude protein concentrations for four N rates and three application dates.



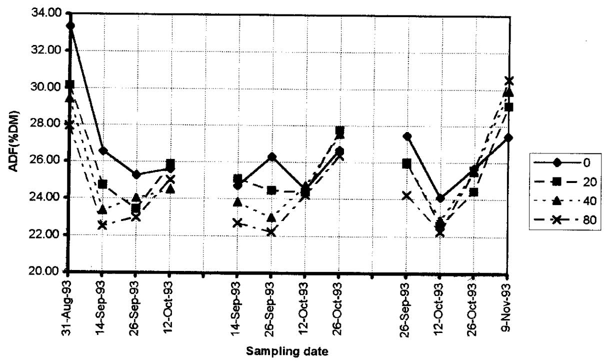
SED for CP	Replicates	1st sample	2nd sample	3rd sample	4th sample
Application date	16	0.82	1.18	0.59***	0.68***
N rate	12	0.64***	0.49***	0.46**	0.43

*significant at P< 0.05, **significant at P< 0.01, ***significant at P<0.001, +significant at P< 0.1

Acid detergent fibre levels were significantly reduced by N at the first (P< 0.001), second (P< 0.001) and third (P< 0.05) sampling dates (2 , 4 and 6 weeks after N application) compared to 0 kg N over all three N application dates, and especially at the first application date (15 August; Figure 3). Neutral detergent fibre levels were significantly reduced by N application at the first (P< 0.001) and second (P< 0.05) sampling (2 and 4 weeks after N application) over all three N application dates. This effect was reversed (P< 0.05) for NDF at the fourth sampling date.

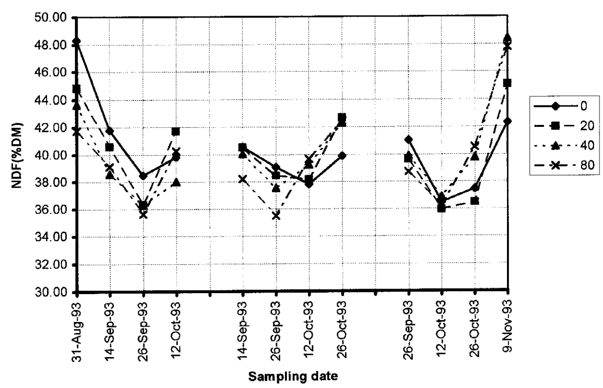
Soluble carbohydrate levels were significantly depressed by N use at the first and third sampling date (P< 0.05, P< 0.05) only. Differences in SOLCHO concentrations between N rates were more marked at the latest N application date (15 September).

FIGURE 3: Pasture acid detergent fibre concentrations for four N rates and three application dates.



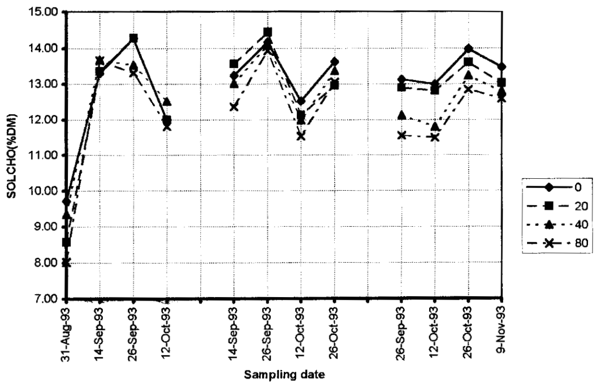
SED for ADF	Replicates	1st sample	2nd sample	3rd sample	4th sample
Application rate	16	1.19***	1.28	0.27**	0.41***
N rate	12	0.66*	0.60***	0.40*	0.45

FIGURE 4: Pasture neutral detergent fibre concentrations for four N rates and three application dates.



SED for NDF	Replicates	1st sample	2nd sample	3rd sample	4th sample
Application date	16	0.96**	1.10*	0.60*	0.86***
N rate	12	0.84***	0.65*	0.63+	1.02*

FIGURE 5: Pasture soluble carbohydrate concentrations for four N rates and three application dates.



SED for SOLCHO	Replicates	1st sample	2nd sample	3rd sample	4th sample
Application date	16	0.52***	0.23***	0.62+	0.35*
N rate	12	0.41*	0.28	0.36*	0.29

DISCUSSION

The use of N advanced the attainment of a herbage mass of 2000 kg DM/ha by about 2 weeks (Figure 1). This is consistent with other studies of N application responses (Roberts *et al.*, 1992).

Increased pasture mass of pasture was associated with reduced CP levels (R=0.87), and increased ADF and NDF levels (Figure 3). Time after N application will also have influenced this correlation. Higher ground temperature, increased daylength and the reproductive stage of ryegrass growth are all likely to have confounded the observed effects of N on pasture in this experiment.

Nitrogen fertiliser generally increased CP, and reduced ADF, NDF and SOLCHO in pasture for 4-8 weeks after application. The immediate effect of N fertiliser on the pasture nutrients measured increased with N rate and lasted longer after the first application date (15 August), when growing conditions were colder and day length shorter) than for the later N applications (30August and 15 September) .

The effects of increasing N fertiliser rate on the fibre components (ADF and NDF) were clearly different between N application dates, fibre contents being higher for high rates of N use by 8 weeks following applications on 31 August and 15 September, but not 15 August. This changeover appeared to be associated with higher pasture yields (>3000 kg DM) and pastures going to seed.

The effects of N on pasture CP, fibre and SOLCHO were marked for the earlier application dates. Pasture management in August and September on New Zealand dairy farms often involves reduced rotation lengths and the grazing of immature and highly digestible herbage, even though this practice was not recommended by Deane (1993). These results indicate that dairy cows grazing N fertilised pasture in August-September are likely to consume pasture containing less fibre, more CP and less SOLCHO than if they grazed on non-N fertilised pasture. This is likely to have consequences for rumen fermentation and require the use of energy to remove excess blood urea, with consequent effects being weight loss and reduced milk yields (Danfaer,1980;NRC,1989;Van Vuuren,1992; Moller *et al.*,1993). This study suggests that relatively long (25-42 days) rotation lengths in August-September, and the application of N fertiliser immediately after grazing may both be required to minimise potential negative effects of elevated CP concentrations in N-treated pasture on cow performance.

Farmers short of available pasture in late winter to feed cows in early lactation often graze short, high protein pasture and apply N fertiliser to remedy the feed shortage. Although N use is likely to produce extra DM, there may be some penalty to production if pasture is the sole diet at this time (NRC,1989; Danfaer,1980). Mackle *et al.* (1995) recorded reduced milk protein and DM intakes by cows consuming N fertilised pasture, but changes in pasture nutrient concentrations in their experiment were not as marked as those identified in this paper.

Pasture management and N use in spring is likely to involve a compromise between pasture nutrient balance (excess CP,and reduced SOLCHO and fibre), the need for pasture DM to fully feed freshly calved cows and pasture control. Later in spring when ryegrass reaches its reproductive stage, the N effect on pasture CP could be beneficial in terms of milk production, because in non-N fertilised pasture CP is normally declining, fibre increasing and digestibility falling at the time spring-calved cows are coming to the peak of their lactation (Moller *et al.*, 1995). Higher intake and productivity may then be possible from N fertilised pasture as DM intake is driven by digestibility (Hodgson,1990; Wilson *et al.*,1995) provided pastures are managed to avoid excessive seedhead accumulation.

CONCLUSIONS

The objective of this trial was to detail nutrient changes within pasture caused by N use in the context of timing of N application in winter/spring on dairy farms. Early application, when conditions are cool, is likely to enhance and prolong the N effect in elevating CP,and reducing ADF and NDF in pasture. Longer rotation lengths (>40 days) and lower rates of N (20-40 kg/ha vs 80 kg/ha) are likely to reduce these effects. Application of N could keep pasture more digestible later in spring when lower CP and higher ADF levels occur as ryegrass enters it's reproductive stage.

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