Manipulating dietary N in perennial ryegrass pastures to reduce N losses in dairy cows in spring

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ABSTRACT

Time of day and pasture regrowth interval were assessed as potential management strategies for reducing nitrogen (N) losses. Six groups of six lactating Friesian x Jersey cows were offered new pasture allowance either following morning milking onto pasture which had undergone a short (2 week) regrowth interval (AMS), or following afternoon milking onto pasture after a long (4 week) regrowth interval (PML). The experiment took place over nine days which included a four day adjustment period. Animals were offered the same pasture allowance and both diets contained the same metabolisable energy content. Dry matter intake was not affected by management treatment but milk production was significantly lower ($P < 0.f05$) in the PML group (18.6 kg vs. 20.9 kg MS/cow/day for PML and AMS respectively). Nitrogen content of the forage was influenced by treatment resulting in a lower N intake in the PML, compared with the AMS group (513 vs. 563 g/cow/day respectively). Subsequently reductions in milk urea N and urinary N were recorded in the PML group. The results of this study indicate the potential for taking advantage of short- and long-term changes in plant composition to manipulate N intake and utilisation, but that animal requirements for protein need to be met first.

Keywords: diet change; nitrogen intake; milk yield; perennial ryegrass**.**

INTRODUCTION

Perennial ryegrass and white clover is the most common pasture mix sown for dairying in New Zealand, but under current management regimes has a nitrogen (N) use efficiency of only 30% (Ledgard *et al.*, 1997). Typically the environment and fertiliser management result in very high pasture concentrations of N (3-4% N) in spring and autumn as farmers attempt to sustain high pasture growth rates. Generally crude protein above 18-20% (2.88% N) is surplus to animal requirements, and as the majority of plant N is soluble it is rapidly broken down during rumen fermentation and absorbed through the gut wall. Following conversion to urea in the liver excess N then enters the blood urea pool and what is not recycled is excreted. Over 80% of urea N is excreted in the urine (Kebreab *et al.*, 2001) and once in the soil, it is either recycled by the plant or lost to the system through leaching or green house gas emissions.

With increasing emphasis on reducing the environmental impact of dairying by reducing urinary nitrogen losses management strategies that improve N utilisation while maintaining productivity are required. Grazing management and timing of feed allocation have been implicated as having a major impact on N composition and subsequent N losses (Hoekstra *et al.*, 2007). Pasture N content declines throughout progressive leaf production or refoliation period (Sinclair *et al.*, 2006) and during daylight hours in response to a dilution effect of accumulating sugars (Orr *et al.*, 1997). Nitrogen excretion is strongly correlated with N intake (Tas, 2006), therefore, any management strategy that reduces N intake is likely to minimise N losses. The objective of this study was to investigate the effect of altering temporal and diurnal management of pastures to create contrasting pasture N content which would subsequently reduce N intake and excretion by lactating dairy cows.

METHODS

The experiment was carried out at Lincoln, New Zealand, in December 2009. Two grazing management strategies commenced six weeks prior to the experiment which imposed either a short (14 d) or long (28 d) regrowth interval. Both treatments received 50 kg N/ha as urea four weeks before measurements commenced. Thirty-six mixed-age, Friesian x Jersey cows, (105 ± 3.1 days in milk), were assigned to one of two pasture treatments in three replicates of six cows per herd. Animals on the long rotation treatment received fresh pasture immediately following each afternoon milking (1600h: PML) while animals on the short rotation received fresh pasture following morning milking (0800h: AMS). The target pasture allowance of 19 kg DM/cow/day was achieved using pre- and post-grazing mass to calculate the grazing area. Pasture mass was recorded using a calibrated rising plate meter (Jenquip F150 Electronic Pasture Meter) prior to and following grazing and apparent DM intake was determined from the difference in pre and post mass, number of cows and grazing area.

Following a four day adjustment period, measurements of milk yield (Delaval Alpro Herd Management system), milk protein, fat and lactose (Foss Fourier Transform infrared analyser) MUN, diet composition and urine N were recorded twice daily for four days. Immediately after morning and afternoon milking animals were retained in the yards and urine samples collected from mid-stream flow. MUN was determined on skimmed milk after cooling and centrifuging to remove fat and analysed (Talke and Schubert, 1965) by automated Modular P analyser (Roche/Hitachi). Snip samples of pasture were collected to grazing height at 0730h and 1500h and were split in two for prediction of N and metabolisable energy (ME) content by near-infrared spectrophotometer (Foss NIRSystems) on freeze dried and ground samples or for species composition on separated oven dried samples. Nitrogen intake was estimated by multiplying diet N content (g N/100 g DM) by daily DM intake (kg DM/cow/day). Data was normally distributed and group means for the five day measurement period were compared across blocks (paddocks) using the two-sample student's t-Test procedure in Excel 2003.

RESULTS

Management practice significantly affected pasture mass (P <0.05) and, as a result of rapid spring growth rates and high reproductive content, the PML pasture mass on offer was in excess of 4000 kg DM/ha which was 1.4-fold greater than the AMS treatment (P <0.01, Table 1). However, in spite of large differences in pre-grazing mass the relative proportions of reproductive material and clover were the same between treatments. Similarly, ME content was also unaffected by grazing management and exceeded 12 MJ ME/kg DM. In contrast N content was reduced (P <0.05) by 8% in the PML treatment.

Total DM intake was similar between treatments at approximately 19kg DM/day (Table 2). There was no difference in total N intake (P =0.12) however the AMS treatment produced 16% more (P <0.01) milk protein than the PML treatment (Table 2). Similarly, milk yield and milk solids were a respective 12% and 8% higher in the AMS treatment (P <0.05). Overall, milk N secretion was 110 g/day and 128 g N/day in PML and AMS respectively.

Excretion of urea N via milk and urine between AMS and PML treatments is shown by variation in MUN and UN in Table 2. Afternoon MUN was increased by nearly 40% following a 7 h grazing interval on the AMS treatment compared to 23 h on PML (P <0.001). In contrast, UN concentration in the AMS group was almost double that recorded in the PML group (P <0.01) in the morning when differences in grazing interval were less marked (17 vs. 23h respectively).

DISCUSSION

The two treatments in this study were imposed to create management strategies which produced diverging N content by using either short regrowth and morning allocation (high N content) or long regrowth and afternoon allocation (low N content). The expected benefit of reduced N content is lower N intake and improved N utilisation by reducing waste. In the current study PML successfully reduced pasture N content (P <0.05) which, in spite of lack of significance in total N intake, resulted in significant reductions in milk production, milk protein, MUN and UN (P <0.05) compared to AMS.

TABLE 1: Pre and post grazing pasture mass, botanical composition and nitrogen (N) and metabolisable energy (ME) content of perennial ryegrass pastures offered to cows in the afternoon (1600h) following a long regrowth interval (PML) or in the morning (0800h) following a short regrowth interval (AMS).

Component	Unit	PML	AMS	SEM[1]	P value
Pre mass	kg DM/ha	4612	3242	329.0	0.01
Post mass	kg DM/ha	1584	1753	47.4	0.06
Ryegrass: leaf	% diet	50.7	48.2	1.93	0.58
Ryegrass: stem	% diet	26.3	22.9	2.12	0.49
White clover	% diet	21.1	25.7	1.93	0.28
ME content	MJ/kg DM	12.1	12.0	0.05	0.38
N content	% DM	2.74	2.99	0.066	0.04

[1]SEM = Standard error of the mean

TABLE 2: Daily dry matter (DMI) and nitrogen (NI) intake, milk production, milk urea nitrogen (UN) and urine nitrogen (UN) of dairy cows offered perennial ryegrass pasture in the afternoon (1600h) following a long regrowth interval (PML) or in the morning (0800h) following a short regrowth interval (AMS).

Component	Unit	PML	AMS	SEM[1]	P value
	Kg				
DMI	M/cow/d	18.7	18.8	0.17	0.82
NI	g N/cow/d	513	563	17.2	0.12
Milk yield	kg/cow/d	18.6	20.9	0.575	0.02
Milk solids	kg/cow/d	1.73	1.86	0.036	0.04
Milk protein	kg/cow/d	0.69	0.80	0.026	0.03
Milk fat	kg/cow/d	1.03	1.06	0.013	0.35
Milk UN am	mg/dL	11.8	13.9	0.625	0.11
Milk UN pm	mg/dL	12.7	17.7	1.13	<0.001
Urine N am	g N/kg	3.37	6.00	0.627	0.005
Urine N pm	g N/kg	4.05	4.80	0.324	0.35

[1]SEM = Standard error of the mean

Other nutritional factors do not appear as influential, as both treatments showed similar ME intake so the variation in milk yield and milk solids ($P < 0.05$) suggests a possible shortfall in N supply in the PML treatment. Tas (2006) also showed a stronger relationship between milk urea N excretion and dietary N content than with N intake. Further indication of low N supply in this study was reflected by a trend in low UN content. Compared to results of Woodward *et al.* (2009) who reported spring UN content of 6.5 g/kg, our values (excluding morning AMS) are markedly lower. At less than 3%, the N content of the diet was relatively low for spring pasture, which is often in excess of 3.5% (Cosgrove *et al.*, 2007), and can be attributed to the high proportion of ryegrass stem as a result of a cooler spring and delayed heading date. Whether the low N excretion in the PML suggests a limiting supply of amino acids for milk protein synthesis requires additional investigation. Given that the energy (ME) content of treatments were equal, it is probable that milk production for the PML treatment would have matched the AMS treatment had their protein requirements been met.

Utilisation of N for milk protein production was similar for both AMS and PML at 23 and 21% of N intake respectively. These values are within a similar range of efficiency reported in previous grazing trials of 22 - 27% (Tas *et al.*, 2005; Pacheco *et al.*, 2009; Vibart *et al.*, 2009). As a means of improving the efficiency of N utilisation allocation of fresh pasture in the afternoon was suggested (Hoekstra *et al.*, 2007; Gregorini *et al.*, 2010) as there is a diurnal reduction in N content due to accumulation of sugars and that the outcome would be reduced urea N excretion in milk and urine. In the current study the elevated MUN in the afternoon following morning allocation (AMS) appear consistent with this theory. The urine N results also suggest higher N losses from the AMS treatment. However, inferences are more difficult to draw from spot sampled UN due to fluctuations which can occur in daily N concentrations.

From an environmental perspective PML may not be a N leaching mitigation strategy. Higher biomass in PML as a result of longer regrowth interval resulted in twice the stocking density per grazing bout of the AMS group, (159 vs. 78 cows/ha). The advantage of reduced N intake and N excretion per animal is offset by larger volumes of urine deposition on a smaller area during a 24 grazing period. For example assuming stock urinate 30 L/day (Kume *et al.*, 2008) this would lead to a daily N deposition of 17.7 and 12.6 kg N/ha/day on PML and AMS is respectively. Although the reverse is true if defoliation frequency, over a longer time frame, is taken into account as AMS cows would graze the same area twice as often as PML. The purpose of this study was to investigate management strategies which would improve N utilisation and minimise urinary N excretion while maintaining production. At an ‘animal level’ this objective was partially achieved by reducing urinary N, however the implications of N supply and milk production and N losses at a farm system level require further consideration.

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