
VOLUME 62 2002

BRIEF COMMUNICATION: Simulated impacts of increased nitrogen retention in dairy cows on nitrate leaching from grazed pasture

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Keywords: nitrogen leaching; N partitioning; simulation; EcoMod.

INTRODUCTION

The intensification of grazing land has increased the amount of nitrogen (N) entering waterways, reducing their quality and clarity. Between 60 and 90% of the N ingested by grazing cattle is excreted in urine and dung (Haynes & Williams, 1993), providing the major source of nitrate leached from grazed pasture. Reducing the N content of urine can therefore have a major impact on nitrate leaching, which can be achieved by reducing dietary N or improving N partitioning in the animal. Some techniques that improve N partitioning have been evaluated. These include dietary manipulation and the use of metabolism modifiers (Di & Cameron, 2000).

Maximising the protein output in milk would also reduce the proportion of dietary N that is excreted (Tomlinson, 1992; Van Horn *et al*. 1994). An increase in protein output in milk can be achieved by increasing milk protein concentration and/or total milk production. Dairy cow breed and strain variability in milk protein concentration (Gibson, 1989) offers an opportunity for genetic selection and suggests that breeding animals with higher N concentrations in milk, and thus better N partitioning, could help reduce nitrate leaching.

This paper describes modelling of the impacts averaged over 50 years, of dairy herds with milk true protein concentrations of 3.0% of milk volume (LowMilkN), 3.5% of milk volume (MediumMilkN) and 4.0% of milk volume (HighMilkN) under the same feeding conditions, on N leaching and pasture production, in a pasture-based dairy farm in the Taupo region.

MATERIALS AND METHODS

The modelling described used EcoMod (version 4.8.0), a biophysical pastoral simulation model (Johnson *et al*., 2008), with nutrient dynamics in the urine patches simulated independently from the rest of the paddock (Snow *et al*., 2009).

The soil simulated was Oruanui Sand, with most soil properties derived from the National Soils Database (Wilde, 2003). Fifty years of climate data including daily rainfall, temperature, humidity and solar radiation, were derived from the Virtual Climate Station database (Cichota *et al*., 2008) for a site on the west side of Lake Taupo. The paddock was grazed 14 times per year, with 20 to 80 day grazing intervals. The farm had no supplementary feeding, no synthetic N inputs, and a stocking rate of 2.5 cows per hectare, with cows wintered on the farm and calving in August.

In EcoMod, the amount of N excreted in urine and faeces for a mature dairy cow is defined as the amount of N ingested minus that which is partitioned to milk or changes in body mass. Partitioning of N between dung and urine was calculated in EcoMod according to the model outputs of Kebreab (2004) and CSIRO (2007) equations.

RESULTS AND DISCUSSION

Changing the milk protein concentration had little effect on annual pasture production which averaged 11.1 t DM/ha (Table 1). The proportion of white clover in the pasture, N fixation, pasture intake and N intake (Table 1) were also similar across treatments. The percentage of N intake partitioned to excreta decreased from 87% for LowMilkN cows to 83% for HighMilkN cows (coefficient of variation (CV) 0.6%) (Table 1), with the greatest differences in early lactation. The mean annual N excretion in urine and dung was 344 kg N/ha/year for the LowMilkN simulation; 21 kg N/ha/year higher than for the HighMilkN simulation (Table 1).

The annual N leaching was highly variable within treatments (CV of 48% over the 50 years), but was comparable to that measured by Ledgard *et al*. (1999). The mean nitrogen losses were 50, 56 and 63 kg N/ha/year for HighMilkN, MediumMilkN and LowMilkN simulations, respectively (Table 1). This was equivalent to an 11% decrease in N leaching when the milk protein concentration was increased from 3.0 to 3.5%, and a 21% decrease when it was altered from 3.0 to 4.0%. The mean annual rainfall was 1,178 mm, with an average of 30% of this draining through the profile every year.

TABLE 1: Simulated effects of milk protein concentration on pasture growth, cow intake, nitrogen (N) excretion, and N leaching in the Lake Taupo region. Data are annual averages over 50 years, followed by the coefficient of variation in brackets.

Measurement	Milk protein concentration group		
	LowMilkN (3.0%)	MediumMilkN (3.5%)	HighMilkN (4.0%)
Pasture growth (t DM/ha/yr)	11.2 (35%)	11.1 (34%)	11.0 (33%)
N fixation (kg N/ha/yr)	168 (22%)	167 (22%)	167 (22%)
Pasture intake (t DM/ha/yr)	9.6 (8.2%)	9.5 (8.4%)	9.5 (8.5%)
N intake (kg N/ha/yr)	395 (8.6%)	393 (8.7%)	390 (8.9%)
N excreted (kg N/ha/yr)	344 (8.4%)	333 (8.5%)	323 (8.6%)
Proportion of N intake excreted (%)	87.1 (0.5%)	84.9 (0.6%)	82.8 (0.7%)
N leached (kg/ha/yr)	63.1 (48%)	56.2 (48%)	49.8 (49%)
Proportion of excreted N leached (%)	18.3 (48%)	16.8 (49%)	15.4 (49%)

In high drainage years of greater than 500 mm/year, annual N losses averaged; 78, 88 and 100 kg N/ha/year in HighMilkN, MediumMilkN and LowMilkN simulations, respectively.

This study demonstrates that genetic selection of cows that partition a higher proportion of ingested N into milk has some potential for reducing nitrate leaching with little effect on pasture production or composition. The reductions in N leaching are smaller than that expected from some other mitigation strategies, such as the use of stand-off pads (Ledgard *et al*., 2000) and nitrification inhibitors (Di & Cameron, 2002), which may reduce leaching by 30 to 80%. However, genetic selection of cows with improved N retention characteristics has the benefits of no changes in labour, management, costs or pasture production and the likelihood of increased milk income from increased milk protein concentrations.

ACKNOWLEDGEMENTS

This work was funded by the Foundation for Research, Science and Technology, contract number C10X0809.

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