NITROGEN CYCLING IN PASTURES GRAZED BY LACTATING DAIRY COWS

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ABSTRACT
Increasing use of intensive rotational grazing for livestock production in the USA raises questions about the potential for nitrate-N (NO_3-N) leaching losses. In grazing experiments with lactating dairy cows at two sites in the Upper Midwest, we monitored milk production, soil NO_3-N concentration, and NO_3-N leaching. Dietary supplementation increased milk yield, but there was no measurable impact on NO_3-N leaching losses. Leaching volumes and NO_3-N losses were small on these silt loam soils, even directly under urine patches. The results suggest that NO_3-N leaching is not likely to be a problem on fine-textured soils in the Upper Midwest under pastures dominated by deeply-rooted perennial species, as long as N inputs are moderate and animal management does not degrade the pasture.

KEYWORDS
Nitrogen uptake, soil nitrogen, nitrate leaching, feed supplements, milk production

INTRODUCTION

The practice of intensive rotational grazing of livestock is becoming popular in the USA because of lower costs, more attractive labor tasks, higher profitability, and apparent conformation to good ecological principles. Data from humid, marine climates suggest that significant ground water contamination by NO_3-N has occurred under intensive grazing (Russelle, 1996). Grazing animals harvest herbage from a broad area and return most of the ingested N to small, concentrated excreta patches; a single urination by a dairy cow applies the equivalent of 500-1000 kg N/ha on an area of 0.2 to 0.5 m^2 (Steele, 1987). About 15 to 30% of dietary N typically is ìexcretedî in the form of milk. Milk production increases with proper feed supplementation (Pell, 1992), and N excretion in urine may decrease simultaneously (Valk and Hobbelink, 1992). Our objective was to collect the first data on apparent N use efficiency and consequent NO_3-N leaching losses under this intensive rotational grazing in the Upper Midwest Region of the USA.

MATERIALS AND METHODS

Permanent paddocks were fenced in established pastures on the US Dairy Forage Research Center Farm, Prairie du Sac, WI, and the West Central Experiment Station, Morris, MN. Pastures were comprised primarily of *Bromus inermis* Leyss and *Elytrigia repens* (L.) Nevski at the MN site, and *Poa pratensis* L., *E. repens, B. inermis*, and *Trifolium repens* L. (about 12% of pasture DM) at the WI site. Pasture received 65 kg fertilizer N/ha annually at WI and no fertilizer N at the MN site. In 2 years in WI and 1 year in MN, lactating dairy cows were grazed for 12 to 24 h in each paddock at intervals determined by forage regrowth.

Cows were divided into groups fed different levels of supplement. At the WI site, one-third of the cows consumed pasture (and minerals) only and other groups received supplement equal to about 0.33 or 0.67 of their daily DM intake. In 1994, this supplement averaged 5.6 and 10.5 kg/d, respectively, and contained about 155 g/kg crude protein (CP), and in 1995 it was a constant 6.0 and 11.6 kg/d containing about 195 g CP/kg. Before and after the grazing season, cows were fed diets with grain:forage ratios of 0:100, 25:75, and 50:50 for the 0, 0.33, and 0.67 supplement treatments, respectively, and daily milk production was measured for about 275 d. At the MN site, cows received either 4.5 or 9.0 kg supplement/d containing 128 g CP/kg in 1995 and daily milk production was measured for 67 d from May 19 through July 24. Milk CP concentrations were determined once per week at both sites.

The soil at the MN site was a Doland silt loam and at the WI site was a McHenry silt loam. Before grazing began, large diameter (30 cm) polyvinyl chloride drainage lysimeters were installed to depths averaging 70 cm (WI) or 115 cm (MN). Each grazed paddock contained 12 lysimeters, and adjacent mechanically harvested areas contained four lysimeters each for control and urine (3 L per lysimeter applied twice each grazing season) treatments. Leachate volume and concentrations of NH4-N and NO3-N were determined for each lysimeter. Soil cores were taken to 1.5 m in autumn to monitor soil NO3-N concentrations.

RESULTS AND DISCUSSION

Milk production increased linearly with replacement of pasture by supplemental feed at the WI site in both years, with total milk yield increasing from 17.3 kg/d on pasture alone to 26.3 kg/d with 0.67 supplement. Total milk yield was 22.0 kg/d at the MN site, with no effect of supplementation. Nitrogen excretion in milk increased with supplement addition in all three site years ($P<0.1$). Supplement and pasture contained similar CP concentrations at the WI site. Pasture herbage samples have not been analyzed from the MN site, but we expect that the supplement contained less CP than grazed pasture. If cows substitute supplement for pasture, then N excretion in dung and especially urine likely decreased with increased feed supplementation, implying that dietary N use efficiency increased with supplementation.

No significant leaching occurred during summer at either site. During the period from fall to spring, total water leaching losses at the WI site averaged 2.6 cm in 1994-5 and 1.4 cm in 1995-6, reflecting differences in over-winter precipitation. Essentially no drainage occurred at the MN site, due to the drier than normal spring in 1995 and the deeper volume in the lysimeters. In the absence of animals and except in years of very high rainfall, leaching losses in the Upper Midwest typically are small under perennial species grown on fine-textured soils (Randall et al., 1994).

There were no detectable differences in NO_3-N leaching losses among supplement treatments at the WI site, but losses were higher directly when urine was applied to mown grass. As expected, there was tremendous variability among lysimeters (Fig. 1). Total losses in grazed paddocks ranged up to 27 kg NO_3-N/ha from July 1994 to June 1995 and 18 kg NO_3-N/ha during the next 12 months, but 87 and 77% of these lysimeters lost less than 1 kg NO_3-N/ha after the two respective grazing seasons. Annual leaching losses directly under urine spots (applied twice during each grazing season) averaged 22 kg NO_3-N/ha.

Nitrate losses measured under pastures on these silt loam soils were insignificant over three site-years. High water and N use by the deeply rooted pasture species and low fertilizer N rates likely helped conserve N. Use of appropriate dietary supplementation with lactating dairy cows increased milk yield in 2 of 3 site years, but did not affect already low NO_3-N leaching losses in these fine-textured Upper Midwest soils. Questions remain about the potential impact of leaching losses on shallow or coarse-textured soils and in highly N-fertilized pastures, and in areas with adverse animal impact (e.g., near water tanks).

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Figure 1
Frequency diagrams of nitrate-N losses in drainage lysimeters located in pastures under intensive rotational grazing management with lactating diary cows at Prairie due Sac, WI. All three diet supplements (0, 0.33 and 0.67 DM are included, because there were no differences in nitrate loss among treatments.