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Nitrous Oxide Emission From Old And New Pastures

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INTRODUCTION

Agriculture accounts for 8% and 10% of total greenhouse gas (GHG) emissions in Canada and the United States, respectively. Urine and dung from grazing livestock are dominant sources of N_2O-N emission, globally (Mosier et al., 1998). Intensifying pasture production through fertilizer-N application, planting improved species and improving pasture management may increase biomass yield and soil carbon sequestration, but relatively small emissions of N_2O-N may offset these positive effects (Conant et al., 2005). Fertilizer-N application increased soil organic carbon in surface soils for crested wheatgrass pastures in North Dakota, but annual N_2O-N emission was three-fold greater than heavily and moderately grazed native pastures (Liebig et al., 2006).

The urine spot may be the major source of N_2O-N emission on extensive pastures where stocking rates are low. However, as stocking rates increase to accommodate increased production of intensive pastures emission characteristics of the urine spot may be representative of the entire paddock as the area of annual urine coverage increases and urine spot overlap occurs. Very little information exists on the impacts of grazing and grazing management on N_2O-N emission from cropland pastures in parkland regions compared to cereal production (e.g. Lemke et al., 1999). The objective of this study was to compare ungrazed, grazed and urine spot sites in two intensively grazed pasture types for N_2O-N flux and annual N_2O-N emission rates.

MATERIALS AND METHODS

Pastures, which existed on a silt loam Typic Haplustol soil, were rotationally grazed 30 to 32-yr-old grass (quackgrass, Kentucky bluegrass and smooth bromegrass) and 4 to 6-yr-old meadow bromegrass stands, replicated three times in a randomized complete block design. Annual N_2O-N emission rates and NO_3-N and NH_4-N supply rates were compared from 2003 to 2005 in ungrazed (exclosed), grazed (pasture area) and urine spot microsites within replicates. All microsites were within 20 m of a 5 x 5 m exclosure in each replicate/paddock (Figure 1). Pastures were broadcast with 100, 13 and 25 kg ha^{-1} of N, P and K each spring. Pastures were stocked with beef heifers using the "Put and Take" method from 1999 to 2005; average stocking rates were similar ($P \leq 0.05$).

Each year in July two urine spots were marked as cattle grazed close to the exclosure (Figure 1.). One was used to determine N_2O-N flux and the other to determine soil nutrient supply. N_2O-N flux was determined from an adjacent pasture microsite (grazed) and a permanent exclosure microsite (ungrazed). Gas samples were collected from microsites with a non-steady state chamber method (Anthony et al.,1995) using sample collection protocols described by Rochette et al. (2004). Measurement began in July of each year and continued until July of the following year. Gas sampling was initiated after snow melt and continued until the soil was frozen in the fall. Annual cumulative N_2O-N loss estimates were calculated for each sampling unit by linear interpolation between data points (Lemke et al. 1999).

Soil nutrient supply rates for NO_3-N and NH_4-N were determined using cation and anion resin probes after Qian and Schoenau (1995) within the companion urine spot and at three additional grazed microsites close to the exclosure (Figure 1). Burial periods for the urine spot was 7 d and 14 d for the pasture microsites. Data are shown as 14 d supply rates and analysed statistically within the respective microsite types.

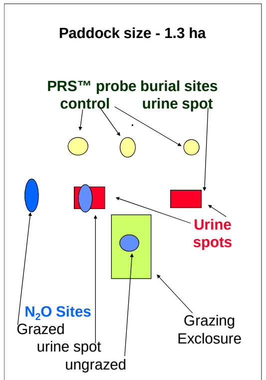


Figure 1.

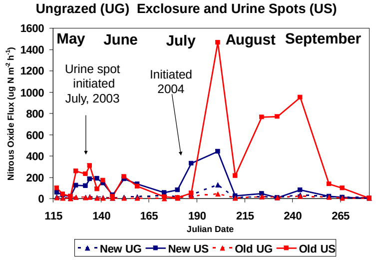
Statistical Analyses

Annual N_2O-N emission rates were analysed as a split-plot arrangement with pasture type as the main plot and microsite as the sub-plots, treating year as a repeated measure using Proc Mixed (Littell et al. 1996). Nutrient supply was compared between pasture types within grazed and urine spot microsites over years in a randomized block design in a similar manner. Where required mean comparisons are made using LSMean comparisons within analyses of variance.

RESULTS AND DISCUSSION

N_2O-N flux for grazed and urine spot microsites were highly variable, while those from the ungrazed control were low and consistent (Figure 2). However, N_2O-N flux from urine spots, particularly the old grass, were higher than the ugrazed sites, with the grazed (pasture) site intermediate. N_2O-N flux from old grass urine sites were very high after initiation from July until late fall (Figure 2).

Fig. 2. N2O-N Flux for the 2004 Season for Ungrazed (UG) Exclosure and Urine Spots (US)



ANOVA indicated that annual N_2O-N emission rates were significant for pasture type, microsite and the interaction at P. = 0.05, 0.01 and 0.09, respectively. Averaged over microsites and years old grass had a higher N_2O-N emission than the new pasture However, averaged over pasture types urine spot emissions were larger than the other microsites, which were similar (Table 1). Thus, the urine spot appears to have a larger impact on N_2O-N emission from old than new pastures. The degree to which it might impact the overall emission rate depends on pasture coverage.

Table 1. Annual N_2O-N emission rates averaged over years for old grass and new pasture types and ungrazed, grazed and urine spot microsites within pastures

Pasture Type	Ungrazed	Grazed	Urine Spot	Mean
	N_2O-N (kg ha^{-1})			
Old	0.24	2.9	8.3	3.8[a]
New	0.76	1.2	2.6	1.5[b]
Mean	0.50[a]	2.1[a]	5.5[b]	
	CO_2 equiv. (kg ha^{-1})			
Mean	148	622	1628	

[ab] Means followed by the same letters within rows or columns are similar (P. < 0.05).
CO_2 equiv. is N_2O-N emission rate for microsite mean Multiplied by 296.

Within the urine spot microsite the NO_3-N supply rate was 2.3 times higher for the new compared to old pasture, while the NH_4-N supply rate was 2.3 times higher for the old than new pasture (Table 2). We expected that the NO_3-N supply rate for both pastures would be relatively high with the urine spot the more elevated. We didn't expect that the NH_4-N supply rate to differ and remain high in the old compared to new pasture.

Table 2. NO_3-N and NH_4-N supply rate averaged over years for grazed and pasture microsites during two weeks in July following urination.

Pasture Type	Grazed		Urine Spot	
	NO_3	NH_4	NO_3	NH_4
	ug 10 cm^2 14 d^{-1}			
Old	37[b]	31	97[b]	141[a]
New	68[a]	25	222[a]	69[b]

[ab] Means followed by the same letters within rows are similar (P. < 0.05).

Conventional soil analyses showed that NH_4-N concentration in the urine microsite was elevated immediately after urination for both pastures (Table 3).

Table 3. Soil NO_3-N, NH_4-N and mineral-N at 0 – 5 cm-soil depth averaged over pasture type after urination (companion spot), July, 2004.

Microsite	NO_3-N	NH_4-N	Mineral-N
	mg kg^{-1}		
Ungrazed	12[b]	8[b]	20[b]
Grazed	27[b]	14[b]	41[b]
Urine Spot	188[a]	304[a]	492[a]

[ab] Means followed by the same letters within rows or columns are similar (P. < 0.05).

CONCLUSIONS

1. The study monitored pasture microsites and not entire areas, therefore the real impact must be estimated with assumed urine coverage ungrazed and grazed areas. Assuming that urine and ungrazed areas each accounted for 10% of the pasture area and using interaction means from Table 1 weighted annual emission rates would be 3.15 and 1.28 kg ha^{-1} N_2O-N or 932 and 379 kg ha^{-1} $CO_{2\ Eq}$. for old and new pastures respectively. The old pasture would require 151 kg ha^{-1} more carbon sequestered in roots, residues and dung than the new pasture to offset pasture N_2O-N emission. We assume that methane from cattle grazing would be similar as pasture production and nutritive value was similar.

2. We don't know why urine on the old pasture had the higher N_2O-N emission rate, but the relatively high NH_4-N supply rate (Table 2) compared to the new pasture indicates that oxidation to NO_3-N may have been inhibited leading towards chemo-de-nitrification processes. Except for a short period after urination de-nitrification was likely limited in both pastures, because soil was relatively dry.

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