A comparison of N_2O emissions after application of dairy slurry on perennial grass or bare soil prior to planting an annual crop in coastal British Columbia, Canada

S. Bittman, C.G. Kowalenko, A. Friesen and D.E. Hunt
Pacific Agri-Food Research Centre, Box 1000, Agassiz, BC, Canada, V0M 1A0

Keywords: nitrous oxide, dairy slurry, perennial grass

Introduction Because of restrictions on land application of manure in autumn and winter, dairy farmers in coastal British Columbia (BC) must apply half of their annual manure supply from mid-Feb. to mid-April. Although two thirds of their land is in perennial grass, most of this manure is applied to bare soil, usually maize land, prior to planting. This is done for convenience and to avoid damaging grass stands with equipment traffic. Farmers are encouraged to allocate more manure to grass to minimise soil NO_3 concentrations after maize harvest, because maize takes up less N than grass, and the bare fields after harvest are subject to wintertime leaching. However, the effect of this practice on emissions of N_2O is not known. Our objective was to compare the effect of spring application of manure on bare land and on grass with respect to emissions of N_2O. A second objective was to compare early, late and split applications of manure.

Materials and methods The trial (randomised complete block design with 6 replications) was conducted in 2001 and 2002 on a silty loam soil at Agassiz, BC. This coastal location has moderate summer and winter temperatures and about 1500 mm of annual precipitation that falls mainly in autumn and winter. Liquid dairy manure (dry matter of 4.0 and 6.9, total ammoniacal N (TAN) of 1.6 and 2.0 g/kg, total N of 4.0 and 6.9 g/kg, and pH of 7.8 and 7.4, in 2001 and 2002, respectively) was surface-broadcast by hand on a tall fescue sward or on bare soil prior to planting an annual crop. The manure was applied as a single dose of 100 kg TAN per ha in late Feb (TSUM 285 in 2001 and 235 in 2002) or early April (TSUM 533 in 2001 and 457 in 2002), or the dose was split evenly between the two dates (grass only). N_2O and soil NO_3-N (0-15 cm depth) were measured regularly on all plots from the first manure application until early to mid-June, prior to crop planting. At this time, emission rates were low, with relatively little difference among treatments. Emissions of N_2O were measured by drawing air from vented static chambers into a continuous N_2O analyser (Thermo Electron Corp. 46C, Franklin, MA, USA).

Results and Discussion Cumulative N_2O emissions were 6-10 times ($P<0.05$) greater from bare soil than from grass plots treated with manure (Table1). Emissions were similar or greater from bare soil without manure than from grass with manure. On bare soil, early application produced more N_2O in 2001 but less in 2002, while the effect of date of manure application on grass was comparatively small. Herbage production and N-uptake (May harvest) were generally greater from early than from late manure applications while split applications were intermediate (not shown), which is consistent with previous studies and local recommendations. The grass plots averaged very low soil NO_3 levels (Table 1) even soon after manure application (not shown). The bare soil plots, including the un-manured plots, had much higher average soil NO_3 levels than the grass plots (Table 1). Cumulative N_2O emission was linearly related to average concentration of soil NO_3 ($r^2=0.92$). Low concentrations of soil NO_3 are typical in grassland and reflect rapid uptake of ammonia and NO_3 by the grass crop and by soil microbes. The results suggest that farmers should apply manure on grass fields in early spring to minimise both emissions and residual soil NO_3 in autumn. Methods for reducing damage to swards will need to be implemented. The effect of harvested or incorporated winter cover crops on emissions needs to be examined.

Conclusions This study shows that N_2O emission is greatly reduced when spring manure is applied on perennial grassland rather than on bare soil prior to planting annual crops. The reason appears to be characteristically low soil NO_3 levels under grass. Date of manure application has little effect on grass but can either increase or decrease emissions on bare soil. For annual crops, manure should be applied just before or after planting to minimise soil NO_3 concentrations.

Table 1 Cumulative N_2O emissions and mean soil NO_3-N (Feb.-June) as affected by dairy slurry applied at 100 kg TAN ha^{-1} to bare soil and perennial grass

Treatment		N_2O Emissions kg N_2O-N ha^{-1}		Soil NO_3 kg NO_3-N ha^{-1}	
		2001	2002	2001	2002
Bare soil	No manure	0.64c[#]	0.72c	6.9c	8.1c
Bare soil	Manure Feb 27/26	2.24a	2.19b	19.2a	19.1b
Bare soil	Manure April 2/8	1.77b	2.99a	10.5b	22.2a
Grass	No manure	0.10d	0.30c	0.2d	0 d
Grass	Manure Feb 27/26	0.12d	0.45c	0.4d	0 d
Grass	Manure April 2/8	0.21cd	0.48c	0.7d	0 d
Grass	Manure Feb/April	0.16d	0.47c	0.4d	0.1d

[#] values in column not followed by the same letter are significantly different at P=0.05