Effects of moisture and temperature on NO_x and N_2O gas emissions from bovine urine applied to soil cores

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Introduction

Nitrous oxide (N_2O) and ($NO_x = NO + NO_2$) are produced in pasture soils by both biotic and abiotic processes.

These processes are influenced by environmental, physical and chemical factors, in particular soil moisture, temperature and substrate supply.

Objective

The main objective was to obtain a better understanding of the processes and mechanisms involved in the release of NO_x and N_2O following cow urine deposition to soils at different WFPS and temperature levels.

Experimental Procedure

A laboratory experiment was conducted in which cow urine at 500 kg N ha^{-1}, was applied to 180 re-packed soil cores, with four moisture and three temperature treatments. The four moisture treatments were 11, 36, 61 and 87% of the water-filled pore space (WFPS) and temperature treatments were 5°C, 15°C and 22°C. The cores were replicated thrice in a randomized complete block design. Five destructive samplings of the cores for soil inorganic-N (NH_4^+, NO_3^-, NO_2^-) were conducted, at weekly intervals. Gas sampling for NO_x and N_2O was conducted periodically for 5 weeks.

Results

- Soil NH_4^+-N concentration decreased faster over time as soil temperature increased. However, no significant relationship was observed between WFPS and NH_4^+-N concentrations (Fig.1a).
- There was a significant interaction between WFPS and temperature on soil NO_2^- -N and NO_3^- -N concentrations ($P < 0.01$; Fig. 1b & 1c).
- The NO-N fluxes were significantly affected by both temperature and WFPS treatments ($P < 0.01$; Fig. 2a). Maximum cumulative NO-N flux (0.07%) as a percentage of urine-N applied was observed at 22°C and 36% WFPS treatments.
- When the net NO-N flux, expressed as a percentage of the net NH_4^+-N depletion rate, was plotted against the mean soil H^+ concentration, a strong linear relationship was demonstrated ($r^2 = 0.91$; Fig. 3).
- The N_2O-N fluxes were significantly affected by both temperature and WFPS treatments ($P < 0.01$; Fig. 2b).
- The maximum cumulative N_2O-N fluxes as a percentage of urine-N applied were significantly affected by WFPS ($P < 0.01$) but not by temperature and reached a maximum of 5.5% at 87% WFPS and 22°C.

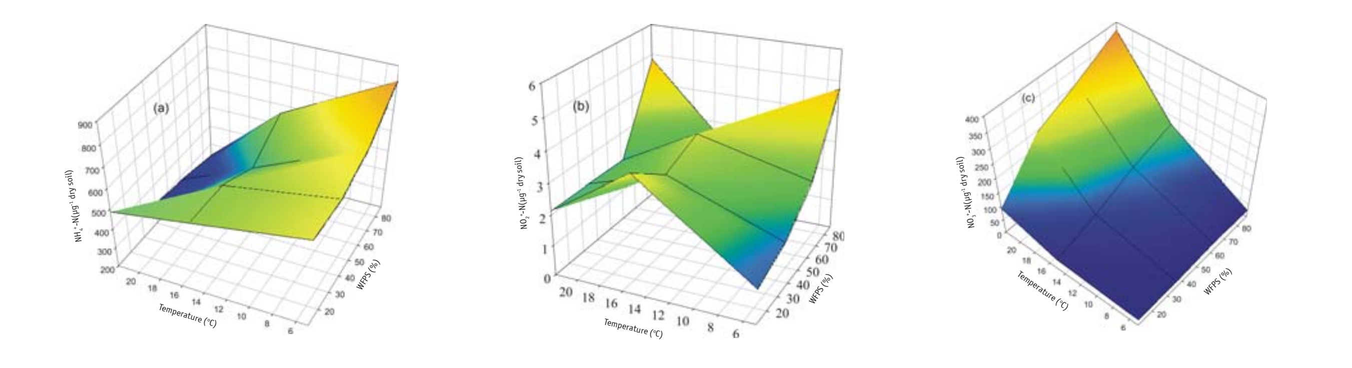

Figure. 1 The interaction of soil WFPS and temperature on (a) soil NH_4^+-N, (b) soil NO_2^- -N, and © soil NO_3^- -N concentrations over time.

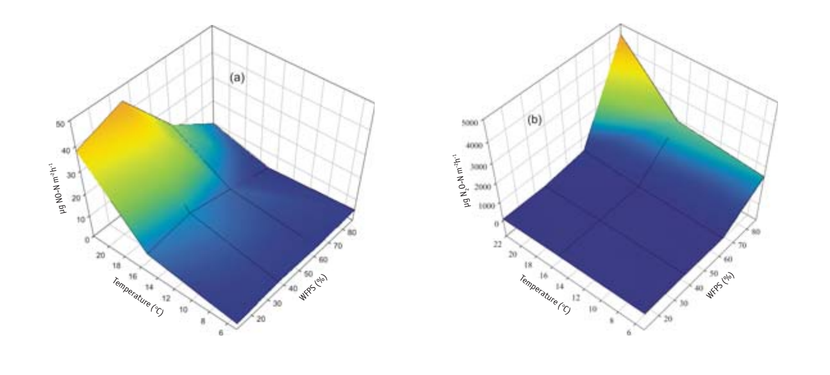

Figure. 2 The interaction of soil WFPS and temperature on (a) NO-N and (b) N_2O-N fluxes after urine application.

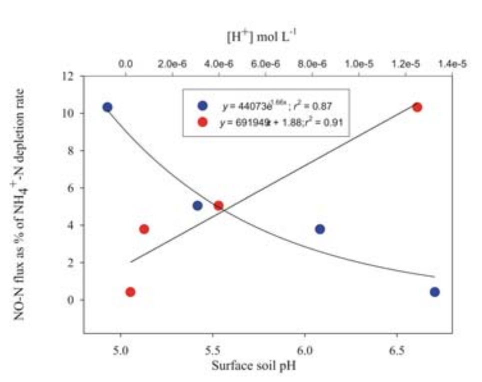

Figure. 3 NO-N flux rate as a percentage of NH_4^+-N depletion rate versus surface soil pH and soil [H^+] at 22°C averaged across all WFPS treatments. Symbols, ●, ● indicate surface soil pH and soil [H^+] respectively.

Conclusion

- Nitrification rate increased with increasing soil temperature and with increasing WFPS up to 36%.
- It was clearly identified that the soil H^+ concentration was a key determinant of the NO-N flux at 22°C and that the net NO-N flux was not solely due to biotic factors.
- The soil temperature and WFPS effects on N_2O-N and NO-N fluxes from urine treated soil were consistent with previous rationales and summaries (Firestone & Davidson, 1989; Ludwig et al., 2001) with higher NO-N fluxes at warmer soil temperatures and in drier soils, while N_2O-N fluxes were enhanced under wetter and warmer soils.
- This work suggests that nitrification rate and its effect on soil pH also influence the NO-N flux.