AP 26 The effect of cattle urine on soil mineral nitrogen (NH_4^+ and NO_3^-) and Nitrous oxide (N_2O) emissions

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Efecto de la orina bovina sobre el nitrógeno mineral del suelo (NH_4^+ and NO_3^-) y las emisiones de óxido nitroso (N_2O)

Introduction

Nitrous oxide (N_2O) is one of the most important greenhouse gases (GHG). In Uruguay, agricultural activities contribute ≥ 90% of total N_2O emissions out of which 80% is from ammoniacal nitrogen (N-NH_4^+) contained in the urea of urine deposited by grazing ruminants on soils from beef and dairy production systems.

Dairy cows can deposit 12–42 L of urine per day with a 6–15 g N L^{-1} nitrogen (N) concentration (Somers et al., 2019). During urine deposition in moist soils, urea is converted to NH_4^+, then oxidized to nitrate (NO_3^-), which can be lost by leaching. Also, losses occur as NH_3^- volatilization and as N_2 or N_2O emissions. The hydrolysis of urea to NH_4^+ leads to an increase in soil pH by ~ 3 units per day and then could result in a decrease of pH within ~2 weeks.

This study aimed to quantify the effect of dairy cattle urine N on soil NH_4^+, NO_3^-, pH, as well as on nitrous oxide emissions in a mixed pasture soil.

Materials and Methods

The study was conducted at the dairy unit of INIA - La Estanzuela, Colonia, Uruguay (34°21'04.2"S 57°41'32.4"W). The experiment was arranged as a complete block randomized statistical design (CRBD) with 4 repetitions. Treatments were cattle urine with four N level: Control (N0), 1,43 (N1), 4,28 (N2), and 5,71 (N3) g N dL $urine^{-1}$ (N was adjusted by deionized water). Urine was applied on a total of 16 static flux chambers, inserted 10 cm depth, and on 1 m^2 plots located next to each chamber. Gas sampling from each chamber was done at 0, 20, 40 minutes and analysed by gas chromatography. During the experimental period soil was sampled at 0-7.5 cm depth on the sampling plots for the analysis of pH, NO_3^- and NH_4^+, following standard chemical protocols. Soil temperature and humidity (%H) were continuously measured by the ZL6 DATA LOGGER sensor at 0-10cm. ANOVA was done using the GLMM procedure of CRBD and further mean comparisons were done by t-Tests (LSD). All statistical analyses were carried out using the R-4.1.3 version software.

Results and Discussion

Urine application increased the soil pH with increasing N concentration. For all treatments, high pH peak was observed at day 3, followed by a steady and significant decrease over time. Increase in pH leads to increasing nitrification. NH_4^+ concentrations varied significantly after urine application and shows high to low from N3 to N0, respectively (Fig 1a). This is in accordance with previous studies (Somers *et al.*, 2019). NO_3^- concentrations also varied significantly over time and between treatments, and in all treatments showed a slight increment until day three, when NH_4^+ was high (Fig 1b). During the first two weeks after urine application, accumulated N_2O emissions were higher in urine treatments compared to control (Fig 2).

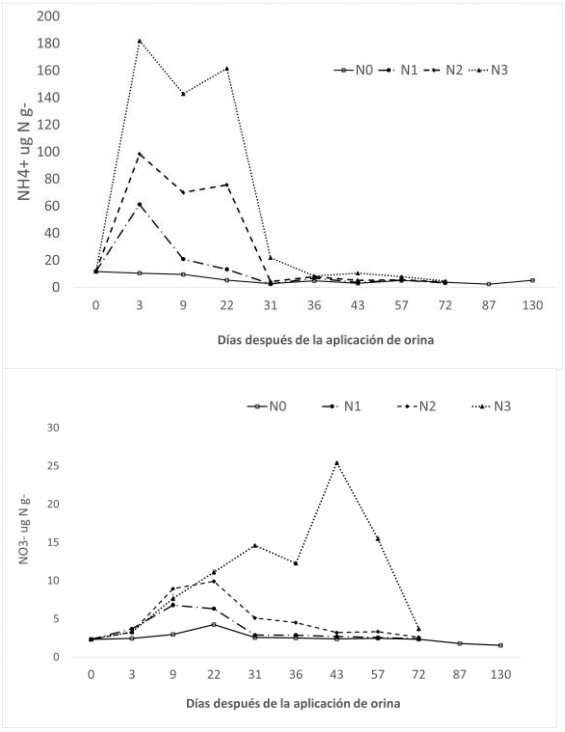

Figure 1. Changes in soil NH_4^+ (a) and NO_3^- (b) after urine application.

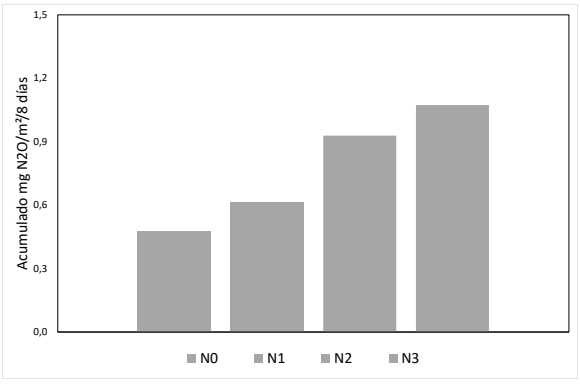

Figure 2. Accumulated soil N_2O emissions for urine treatments: N0=control, N1=1,43, N2= 4,28, N3= 5,71 g N dL $urine^{-1}$

Conclusions

The application of cattle urine on mixed pasture soil with different N concentration showed a significant change in the soil NH_4^+, NO_3^-, and pH levels. In addition, N_2O emission also increased as the urine-N concentration applied was higher. Feeding management strategies that aims to reduce the amount of N excreted in dairy cattle urine could contribute to reduce the availability of mineral N in soil, reducing possible losses as N_2O emissions.

Acknowledgements

This research was supported by the CLIFF-GRADS program of GRA and by INIA - La Estanzuela (Uruguay).

References

Somers C, Girkin NT, Rippey B, Lanigan GJ y Richards KG (2019). J. Agric. Sci. 157, 515–522