Effects of lime application management on nitrous oxide emission and nitrogen use efficiency: An example from an Irish intensive grassland system

Ognjen Žurovec[1], David Wall[1], Fiona Brennan[1], Meritxell Grau Butinyac[1, 2], Dominika Krol[1] and Karl Richards[1]

[1] Department of Environment, Soils and Land-Use, Teagasc, Johnstown Castle, Wexford, Ireland.
[2] School of Natural Sciences, National University of Ireland Galway, Galway, Ireland

E-mail: ognjen.zurovec@teagasc.ie

Abstract

Here we present the annual nitrous oxide (N_2O) emissions from a medium-term grassland trial established in Wexford, Ireland. The objective was to investigate the link between N_2O emissions and a range of soil pH levels achieved under different liming programs over an 8-year period. N_2O emissions were measured over 12 months by a static chamber method. Grass yields and plant nitrogen uptake were recorded to provide yield-scaled N_2O emissions. The results indicate that improvement of soil pH with liming is a low-cost management change, which has the potential to increase soil productivity and reduce N_2O emissions in intensive grassland ecosystems.

Keywords: nitrous oxide, liming, pH, grassland, Ireland

1. Background

Increased application of nitrogen (N) fertilisers and animal excreta in the dominant intensively-grazed grasslands is one of the main drivers of soil acidification in Ireland. Furthermore, Agriculture in Ireland contributes to almost 90% of the total nitrous oxide (N_2O) emissions. Most N_2O emmited is mainly derived from denitrification in grasslands. N_2O is therefore a primary target for greenhouse gas mitigation in Irish agricultural systems.

It has been demonstrated that the $N_2O/(N_2+N_2O)$ product ratio of denitrification is pervasively controlled by pH, both in pure cultures of denitrifying bacteria and in soils (Bakken et al., 2012). Many previous studies showed that the $N_2O/(N_2+N_2O)$ ratio is increased when the pH of soils is reduced. However, the potential of liming as an N_2O mitigation strategy is not fully understood, as both nitrification and denitrification can be enhanced by increases in soil pH. The evidence for the pH effect on N_2O emissions comes almost exclusively from laboratory experiments and field trials carried out on freshly limed soils. Therefore, rigorous testing of different liming strategies under realistic field conditions are needed in order to assess the potential of liming as a strategy for reduction of N_2O emissions from soils.

2. Methods

A liming and phosphorus trial has been established on perrenial ryegrass (*Lolium perenne*) grassland in Johnstown Castle, County Wexford, Ireland in 2011. By applying different lime rate to treatments on the site over a period of eight years, we achieved a wide range of soil pH values across treatments, ranging from 5.0 (unlimed control) to pH 7.0 (limed three times since 2011). N_2O emissions from four pH (lime) treatments and two phosphorus sub-treatments were measured by a static chamber method over a period of 12 months. All treatments received 300 kg of fertiliser N split in 8 applications after each harvest in order to mimic a typical grazing fertilizer application regime over the growing season. Soil and herbage samples were taken regularly from

the plots in order to measure soil and grass yield parameters across the growing season.

3. Results

There was a significant ($P<0.05$) effect of liming, and the consequent increase of soil pH, on cumulative N_2O emissions (Figure 1). The highest cumulative N_2O loss was recorded for unlimed control plots (C, pH=5.0), while a treatment with the highest pH (L3, pH=7.0) had the lowest N_2O emissions. Yield-scaled N_2O emissions followed the same trend. The results demonstrate that improvement of soil pH with liming is a low-cost management change, which has the potential to increase soil productivity and reduce N_2O emissions in intensive grassland ecosystems.

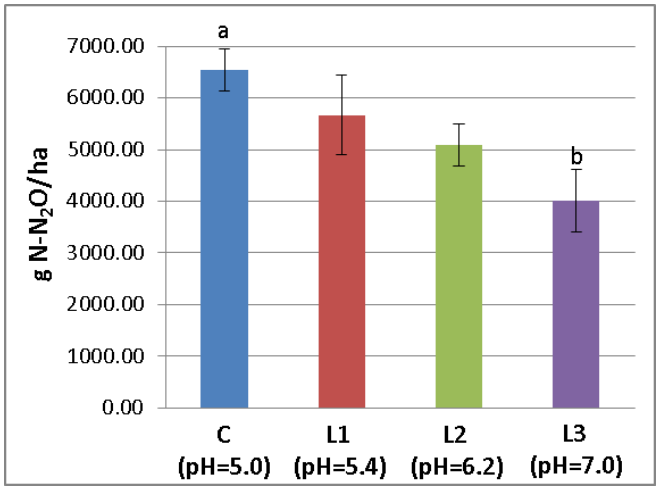

Fig. 1: Mean cumulative N_2O emissions for four pH (lime) treatments

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References

Bakken, L. R., Bergaust, L., Liu, B., & Frostegård, A. (2012). Regulation of denitrification at the cellular level: a clue to the understanding of N_2O emissions from soils. *Philosophical transactions of the Royal Society of London. Series B, Biological sciences*, *367*(1593), 1226–1234.