Universidad del País Vasco Euskal Herriko Unibertsitatea

Reduction of N_2O emissions from grasslands under Atlantic conditions with the use of inhibitors (Basque Country, northern Spain)

Menéndez S.[1], Merino P.[2], Pinto M.[2], González-Murua C.[1] and Estavillo J.M.[1]
[1]*Department of Plant Biology and Ecology. University of the Basque Country, Apdo. 644. E-48080 Bilbao, Spain.*
[2]*NEIKER, Bº Berreaga, 1. E-48160 Derio. Bizkaia. Spain.*
Corresponding author: sergio.menendez@ehu.es

Introduction

The inefficient use of nitrogen fertilizers can lead to large N losses which, apart from economic loss, can lead to undesirable ecological problems such as nitrate leaching or hazardous gas emissions such as nitrous oxide (N_2O). Previous studies in the Basque Country of Spain (Estavillo *et al.*, 1994 and 1996) determined that the greatest losses were in spring and autumn following fertilisation events. In order to reduce gaseous emissions to the atmosphere, nitrification inhibitors, such as dicyandiamide (DCD) or 3,4-dimethylpyrazole phosphate (DMPP), and the inhibitor of the urease activity N-(n-butyl) thiophosphoric triamide (NBPT) have been developed.

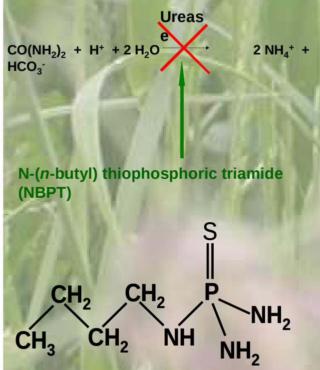
Materials and Methods

All the experiments were carried out in a cut grassland in the Basque Country (northern Spain) in which a randomized complete block design with four replicates was established. Each experimental plot covered an area of 12 m² (4 × 3 m). The meteorological conditions of the location during the different assays are described in Table 1.

Three different fertilizers were applied (Table 2). Two nitrification inhibitors, DCD and DMPP, and one urease activity inhibitor were added to the different fertilizers. DCD and DMPP were applied at a rate of 25 kg ha^{-1} and 1 kg ha^{-1} respectively. NBPT was applied at a rate of 0.076 mL per liter of slurry. In the case of the urea NBPT was applied at a rate of 0.2%.

Static chambers were used to measure daily N_2O emission after fertilizer application (Menéndez *et al.*, 2006). Cumulative gas emissions during the sampling period were estimated using the average flux in two successive determinations, multiplying it by the length of the period between the measurements, and adding that amount to the previous cumulative total. Percentages of reduction by inhibitors were subjected to statistical analysis (ANOVA, $p \leq 0.05$).

Urease Inhibitors



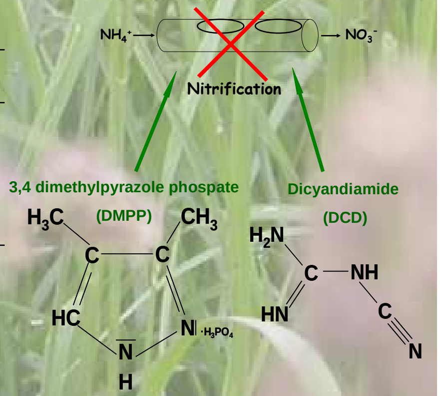
N-(*n*-butyl) thiophosphoric triamide (NBPT)

Table 1. Climatic characteristic during the different trials (WFPS: soil water content expressed as percentage of water filled pore space).

Experiment	Date	Mean Air Temperature	Mean Soil Temperature	Total Rainfall	Mean WFPS
1	Autumn 1998	14.7	14.2	337.8	79.7
2	Autumn 2001	8.0	6.5	170.6	75.9
3	Autumn 2002	15.8	14.3	112.6	75.7
4	Spring 2003	19.6	17.8	114.4	60.9
5	Spring 2005	15.2	13.6	214.8	71.1

Field capacity

Nitrification Inhibitors



3,4 dimethylpyrazole phospate (DMPP)

Dicyandiamide (DCD)

Results and discussion

Cumulative losses can reach up to 16% of the applied N, depending on the type of fertiliser and weather conditions. The highest losses took place in experiment 4 (Table 2) when the conditions both for nitrification and denitrification were in their optimum.

Furthermore, when WFPS was over 70%, denitrification was the main observed process, being probably losses in form of N_2 instead of N_2O that would explain the lower percentage of losses in other experiments compared to experiment 4.

Table 2. Nitrogen application rates, length of experiment, cumulative N_2O emissions and efficiency of different nitrification inhibitors and urease activity inhibitors in the five experiments.

Experiment	Treatment†	Rate ha^{-1}	Date	Length (days)	% of applied N without inhibitor	% of applied N with inhibitor	% Reduction with inhibitor
1	M (DCD)	80 kg N	Autumn 1998	20	1.55	0.90	41.9
	S (DCD)	85 kg NH_4^+-N	Autumn 1998	20	1.45	0.58	60.2
2	M (DMPP)	125 kg N	Autumn 2001	60	6.02	2.54	57.8
	S (DMPP)	125 kg NH_4^+-N	Autumn 2001	60	2.35	0.91	61.2
3	S (DMPP)	135 kg NH_4^+-N	Autumn 2002	22	8.52	2.67	68.7
4	M (DMPP)	97 kg N ha^{-1}	Spring 2003	59	4.58	4.17	8.9
	S (DMPP)	97 kg NH_4^+-N	Spring 2003	59	15.97	11.32	29.1
5	U (NBPT)	70 kg N	Spring 2005	29	3.46	3.17	8.4
	S (DMPP)	70 kg NH_4^+-N	Spring 2005	29	3.26	3.00	8.0
	S (NBPT)	70 kg NH_4^+-N	Spring 2005	29	3.26	2.83	13.2

† M, ammonium nitrate sulphate; DCD, dicyandiamide; S, slurry; DMPP, 3,4-dimethylpyrazole phosphate; U, Urea; NBPT, N-(*n*-butyl) thiophosphoric triamide.

Autumn

Inhibitor's efficiency was different in each experiment (Table 2). In autumn, DCD reduces losses up to a 42% and a 60% in mineral and slurry fertilizers respectively, while DMPP reduces up to 58% and 69% respectively. In the experiments carried out during spring (experiments 4 and 5), the efficiency of DMPP was lower, being of 9% and 30% when it was applied to both mineral and slurry fertilizers.

With respect to NBPT, low inhibition efficiency was observed (less than 13%). If we compare it with DMPP, NBPT was more efficient than DMPP when it was applied to slurry. DMPP efficiency between autumn and spring varies, thus suggesting that environmental conditions constrain inhibition effectiveness. (Table 1). The conditions found in experiment 5, high rainfalls and warm temperature, could lead to a faster degradation or leaching of both inhibitors.

Conclusions

Maximum losses depend on the treatments as well as the weather conditions and soil water content. These conditions can affect to soil mineralization rate, nitrification rate or denitrification rate. The efficiency of inhibitors is also affected by temperature. DMPP can reach efficiencies up to 42% and 69% when it is applied to mineral and slurry, respectively. Meanwhile NBPT should be tested under different conditions in order to observe its maximum efficiency

References

Estavillo J.M., Rodriguez M., Domingo M., Muñoz-Rueda A. and González-Murua C. (1994) Denitrification losses from a natural grassland in the Basque Country under organic and inorganic fertilization. Plant and Soil 162, 19-29.
Estavillo J.M., Rodriguez M., González-Murua C. (1996) Nitrogen losses by denitrification and leaching in grassland. Fertilizer Research 43, 197-201.
Menéndez S., Merino P., Pinto M., González-Mura C. and Estavillo J.M. (2006) 3,4-Dimethylpyrazol phosphate effect on nitrous oxide, nitric oxide, ammonia, and carbon dioxide emissions from grasslands. Journal of Environmental Quality 35, 973-981. Menéndez, S., P. Merino, M. Pinto, C. González-Mura, and J.M. Estavillo. 2009. Effect of N-(*n*-butyl) thiophosphoric triamide and 3,4 dimethylpyrazole phosphate on gaseous emissions from grasslands under different soil water contents. J. Environ. Qual. 38:1-9.

Grassland in a Changing World
Germany, Kiel
August 29th - September 2nd 2010
23rd General Meeting of the European Grassland Federation

Acknoledgements
This project has been funded by the Ministry of Science and Innovation (AGL2009-13339-CO2-01) and (SUM2006-00017-CO3-02) and by the Basque Government (ETORTEK, K-EGOKITZEN).