DM YIELD AND N2O EMISSIONS AS AFFECTED BY 3,4-DIMETHILPHIRAZOLPHOSPHATE, A NITRIFICATION INHIBITOR APPLIED DURING WINTER IN NORTHWESTERN SPAIN

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Nitrogen (N) additions to cropland soils are the largest source of anthropogenic nitrous oxide (N2O). N2O is an important contributor to global greenhouse gas radiative forcing. Slurries and inorganic N fertilizer application may cause important emissions of N2O. It has been proved that the use of nitrification inhibitors (NI) may increase N use efficiency by crops and also decrease N2O losses. The objectives of the study were to determine in a field trial (after autumn and spring fertilizations) the effect of N fertiliser source on the crop yield and to evaluate the influence of the dimetil pirazole as NI, when is applied together with cattle slurry and ammonium calcium nitrate, on crop yield and N2O losses.

Materials and Methods

The experiment was carried out between October 2012 and May 2013 at the CIAM Research Centre (NW Spain), on a silt loam soil classified as Humic Cambisol. The average annual temperature in the study area is 13.3 ºC and the average annual rainfall 1128 mm (10-year average). Fertilizers were applied twice (on November 15th and on April 18th). Italian ryegrass was sown at 40 kg ha-1 on November 16th. The trial was carried out as a completely randomized block design with three replicates and seven treatments. Two treatments consisted on cattle slurry injected into the soil with or without DMPP as NI, and four treatments resulted of combinations of a first fertilization of injected cattle slurry: with or without DMPP, and a second application of mineral N fertilizer as calcium ammonium nitrate (CAN) or CAN stabilised with DMPSA (Dimethylpyrazole succinic acid, EuroChem Agro). There was also a nil N treatment as control. The plots were cut twice (on March 14th and on May 21st) and sub-samples were collected for determination of dry matter (DM) and Kjeldahl N content. Within each plot two closed chambers were placed (diameter: 25 cm; height: 36 cm; depth into the soil: 3 cm) to monitor N2O fluxes from November 15th to May 20th. Samples were collected 40 minutes after chamber enclosure and analyzed by a gas chromatography (Agilent 7890A) equipped with an electron capture detector for N2O detection. In addition, soil samples, for the measurements of moisture as Water Filled Pore Space (WFPS) and mineral N, and meteorological station data were taken to see the influence of weather and soil properties on N2O fluxes.

Results and Discussion

Fertilizer source had a significant effect ($P< 0.001$) on the total DM yield and N uptake by the crop. The addition of DMPP to cattle slurry (Table 1) increased significantly DM yield and N uptake in the first cut (on March 14th). Due to a rainy spring, the second fertilization was applied too late, on April 18th, and in the second cut (on May 21st), there were no significant differences on DM yield or N uptake in relation to the NI use, for either cattle slurry or mineral fertilizations.

Cumulative N2O from November to May (growing season) ranged from 0.808 to 1.518 kg N2O-N ha-1 (Table 2). Spatial and temporal variability in N2O emissions were high. In period I, from November15th to March 8th, the incorporation of DMPP with cattle slurry decreased the percentage of N2O lost in relation to the N applied (Table 2, EF). The application of CS and CAN were not followed by distinct peak of emission following the second application on April, and fluxes of N2O emission were low throughout the whole period II, from April 18th to May 20th (Tabla 2). High %WFPS contents, mean value of 78% WFPS for period II, suggesting that denitrification was the major process responsible for emissions, and N2 was probably the final reaction product. Such conditions might have decreased the efficiency of DMPP and DMPSA in reducing N2O emissions as is described in other experiments under laboratory conditions (Menéndez et al., 2012).

	Kg DM ha^{-1}			Kg N ha^{-1}		
Treatment	1st Cut	2nd Cut	Total	1st Cut	2nd Cut	Total
T1	0,74d	0,71c	1,45d	11,65c	7,95b	19,60d
T2	1,34bc	1,69b	3,02c	19,45bc	19,92b	39,37c
T3	1,80ab	1,57b	3,36c	27,10ab	17,40b	44,50c
T4	1,21cd	3,46a	4,68b	18,17bc	54,00a	72,16b
T5	1,37bc	3,61a	4,99ab	20,20bc	66,73a	86,93a
T6	2,07a	3,47a	5,54a	31,89a	62,96a	94,85a
T7	1,52bc	3,52a	5,04ab	22,79b	66,58a	89,38a

Values followed by different letters are significantly different ($p<0.05$, Duncan test)

Table 1. Effect of N source on dry matter (DM) yield and N uptake from italian ryegras during growing season. T1: Control; T2: Cattle slurry (CS)+CS; T3: CS-DMPP+CS-DMPP; T4: CS+Calcium ammonium nitrate (CAN); T5: CS+CAN stabilized with NI; T6: CS-DMPP+CAN; T7: CS-DMPP+CAN stabilized with NI.

	Period I				Period II				Growing season	
Treatment	Fertilizer	N Applied Kg N ha^{-1}	Total N_2O cumulative fluxes kg N_2O-N ha^{-1}	EF (%)	Fertilizer	N Applied Kg N ha^{-1}	Total N_2O Cumulative fluxes kg N_2O-N ha^{-1}	EF (%)	Total N_2O Cumulative fluxes kg N_2O-N ha^{-1}	EF (%)
T1	C	0	0.524 (0.197)			0	0.067 (0.017)		0.591 (0.197)	
T2	CS	59	1.306 (0.639)	1.32	CS	93	0.170 (0.060)	0.11	1.476 (0.603)	0.58
T3	CS+DMPP	62	0.719 (0.424)	0.32	CS+DMPP	82	0.109 (0.023)	0.05	0.822 (0.420)	0.16
T4	CS	61	1.332 (0.400)	1.32	CAN	70	0.109 (0.037)	0.06	1.441 (0.382)	0.65
T5	CS	62	1.377 (0.869)	1.38	CAN-NI	70	0.141 (0.037)	0.11	1.518 (0.874)	0.70
T6	CS+DMPP	81	0.697 (0.416)	0.21	CAN	70	0.143 (0.087)	0.11	0.840 (0.341)	0.16
T7	CS+DMPP	58	0.619 (0.209)	0.16	CAN-NI	70	0.189 (0.018)	0.17	0.808 (0.194)	0.17

Data are the average of three replicates

Table 2. Average cumulative N2O-N emission (standard deviation in parentheses) during the periods studied. Period I: from November 15th to March 8th and period II: from April 18th to May 20th. C: Control; CS: Cattle slurry; CS+DMPP: Cattle slurry with DMPP; CAN: Calcium ammonium nitrate; CAN-NI: CAN stabilized with the NI.

Conclusion

Our results suggest that in our climate conditions the use of cattle slurry had the same impact on N2O emissions in comparison with mineral fertilization with calcium ammonium nitrate. During the growing season of italian ryegras the lowest emissions factors of the N fertilized treatments studied were found after cattle slurry+DMPP applications in autumn. The use of the inhibitor increased N efficiency by the crop.

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MITIGATION OF NITROUS OXIDE FOLLOWING GRASSLANDS CULTIVATION

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Grasslands managed by agriculture are regarded as beneficial for the greenhouse gas balance owing to their perennial nature and carbon (C) sequestration capacity (Hutchinson et al., 2007). However, grasslands renovation by tillage disturb the balance by increasing nitrous oxide (N2O) emissions (Mori and Hojito, 2007). Ploughing is practiced to improve quality and productivity of aged grasslands, and this stimulates the C and nitrogen (N) mineralization of freshly incorporated residues and microbial activities, giving an oxygen-limited environment conducive to N2O emission (Velthof et al., 2010). Composition of residues, and the extent of oxygen limitation, is likely to influence the level of N2O emissions, hence the proportion of clover in the grassland, and tillage depth, could be controlling factors. The objective of this study was to investigate shallow tillage as a potential N2O abatement option for grasslands with different botanical composition. We hypothesized that: i) rotovation (shallow incorporation) two weeks prior to ploughing, by partly un-coupling C and N turnover, would reduce N2O emissions; and that ii) legumes stimulate N2O emissions to a greater extent than grass due to faster decomposition and net N mineralization.

Materials and Methods

A 56-day field study was conducted on a sandy-loam soil in Denmark (56^{0}29'N, 9^{0}34'E) in spring-summer 2013. The experimental design was a split-plot, where whole-plots included: i) rotovation to 6 cm (RT, two weeks only); ii) rotovation with ploughing to 20 cm depth after 2 weeks (RTP); iii) direct ploughing to 20 cm depth (PL);and iv) undisturbed grassland as reference (CTL). The split-plots included: i) ryegrass (Lolium perenne L.); ii) clover (Trifolium repens L.); and iii) a mixture of ryegrass and clover (grass-clover). Chamber support frames were installed immediately after the rotovation to measure N2O. Static chambers, equipped with an internal fan, were used for taking five gas samples during an hour. Soil mineral N, moisture, plant dry matter and C:N were analysed. The fluxes were calculated using HMR (Pedersen et al., 2010), and data were analysed in R with a mixed model. 3.Results and Discussion During the first three weeks of monitoring, emissions from all treatments were similar, possibly owing to a lower temperature. The emissions of N2O then sharply increased from day 21 onward to 49, a period with accumulated rainfall of 56 mm. Higher cumulative N2O was observed from ryegrass in the PL treatment (2.2 ± 0.2 kg N2O -N ha-1), followed by RTP (1.6 ± 0.4 kg N2O -N ha-1 including emissions from RT). The PL treatment emitted 34, 30 and 38% more N2O compared to RTP in ryegrass, clover, and grass-clover, respectively. Ploughing of grasslands increased N2O emissons ($p< 0.01$) compared to CTL. Relative to PL, RTP reduced N2O emissions. There was a significant interaction between vegetation type, ploughing method and sampling day ($p< 0.01$) with respect to N2O emissions. Relatively lower emission of N2O in the RTP treatment compared to PL might be a result of crop residues being mineralized under aerobic conditions, which is supported by the dynamics of mineral N (data not shown). This will leave less available organic C when ploughed in RTP, whereas in the PL treatment both moisture and carbon availability can stimulate the demand for O2, and N2O emissions (Johansen et al., 2013). In this study, emission factors for ryegrass and clover were 2.0 and 2.2% in the