INFLUENCE OF TILLAGE AND LIMING ON N2O EMISSION FROM A RAINFED CROP

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Nitrous oxide (N_2O) is the main greenhouse gas (GHG) produced by agricultural soils due to microbial processes. The application of N fertilizers is associated with an increase of N_2O losses. However, it is possible to mitigate these emissions by the introduction of adequate management practices (Snyder et al., 2009).

Soil conservation practices (i.e.no tillage, NT) have recently become widespread because they promote several positive effects (increases in soil organic carbonand soil fertility, reduction of soil erosion, etc). In terms of GHG emissions, there is no consensus in the literature on the effects of tillage on N_2O. Several studies found that NT can produce greater (Baggs et al., 2003), lower (Malhi et al., 2006) or similar (Grandey et al., 2006) N_2O emissions compared to traditional tillage (TT). This large uncertainty is associated with the duration of tillage practices and climatic variability.

Liming is widely use to solve problems of soil acidity (Al toxicity, yield penalties, etc). Several studies show a decrease in N_2O emissions with liming (Barton et al., 2013) whereas no significant effects or increases were observed in others (Galbally et al., 2010). The aim of this work was to evaluate the effects of tillage (NT vs TT) and liming (application or not of Ca-amendment) on N_2O emissions from an acid soil during a rainfed crop.

Material and Methods

An eight months study was conducted in the Cañamero's Raña (SW Spain) measuring N_2O emissions. A total of 16 plots were established in the field following a split-plot design with four replicates. The main factor was tillage (NT vs TT) and the second factor was liming (i.e. application or not of a Ca-amendment), consisting of a mixture of sugar foam (rich in $CaCO_3$) and red gypsum. Therefore, the four treatments studied were: NT + amended, NT + not amended, TT + amended and TT + not amended. At the beginning of October (i) the Ca-amendment was appliedand incorporated into the 0-7 cm soil layer at a rate of 469 kg sugar foam ha^{-1} and 703 kg red gypsum ha^{-1}; (ii) 36 kg N ha^{-1}, 92 kg P_2O_5 ha^{-1} and 92 kg K_2O ha^{-1} were applied using $(NH_4)_2HPO_4$ and KCl; (iii) the NT plots were not ploughed and the TT plots were disturbed down to 20 cm using a cultivator (2 passes); and (iv) all plots were sown with hybrid rye at a rate of 140 kg ha^{-1}. At the end of January, a second top-dressing N fertilization was carried out applying 70 kg N ha^{-1}as $NH_4NO_3$to all plots. Nitrous oxide emissions were sampled periodically by using the closed static chamber technique and analyzed by gas chromatography using a HP-6890 gas chromatograph equipped with a Plot-Q capillary column and a ^{63}Ni micro electron-capture detector (Abalos et al., 2013).

Results and Discussion

Total cumulative N_2O emissions at the end of the experiment (May) are shown in Figure 1. Nitrous oxide cumulative fluxes increased due to N fertilizer application (control vs N-fertilized plots). This effect is well-documented. Regarding N-fertilized plots, N_2O losses from TT were significantly higher than NT *(p=0.003);* the influence of liming was significant only at *p=0.074* and, tillage x liming interaction was also significant at *p=0.034.*With respect to traditional tillage, the application of sugar foam+red gypsum as Ca-amendment decreased significantly *(p=0.010)* cumulative N_2O emissions. Liming had no significant effect on cumulative N_2O fluxes from NT plots. Denitrification rather than nitrification can be considered the main biotic process responsible for N_2O emission because soil WFPS exceeded 60%. The mechanisms by which liming influence N_2O fluxes are not fully understood and accordingly contrasting results have been found (Barton et al., 2013). Under the environmental conditions of our experiment, liming probably decreased N_2O emissions by promoting greater N_2O reductase activity, thus leading to a complete reduction to N_2. The higher crop productivity of NT compared to TT (data not shown) probably reduced N_2O emissions due to increased N uptake by vegetation and a consequent lower availability of soil mineral N.

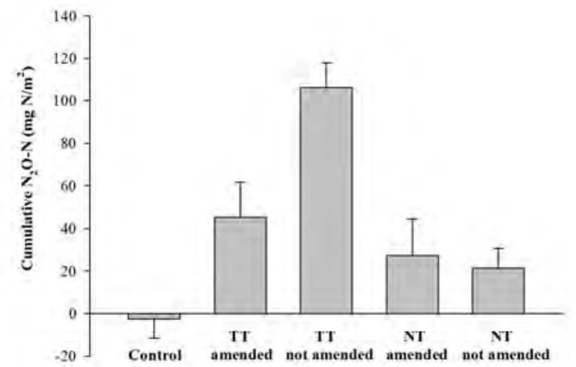

Figure 1. Total cumulative N_2O-N emissions.Error bars indicate standard errors.

Conclusion

Our results show that (1) NT may decrease N_2O losses compared to TT; and (2) liming may reduce these emissions when TT is used. Thus, this study underlines the key role ofno tillage and liming as effective N_2O mitigation strategies for rainfed crops of semiarid areas.

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