Nitrification inhibitors and soil pH effect on N2O emissions in a cut grassland

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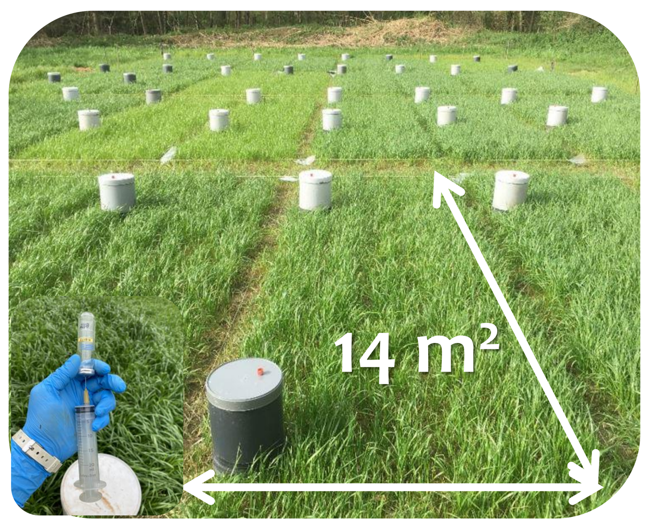
BACKGROUND & OBJECTIVES

The intensive management of agricultural soils has led to high nitrogen inputs which have resulted in a significant increase of N_2O emissions from soils. Soil acidity regulates the enzymatic activity of the processes of nitrification and denitrification responsible for these emissions. Huérfano et al. (2022) observed that the nitrification inhibitors (NIs) DMPP and DMPSA showed efficiencies reducing N_2O emissions in a ryegrass forage system of 16% and 29% respectively at soil pH 5.8. The objective of this work was to search if this mitigation effect might be optimized by means of increasing soil pH.

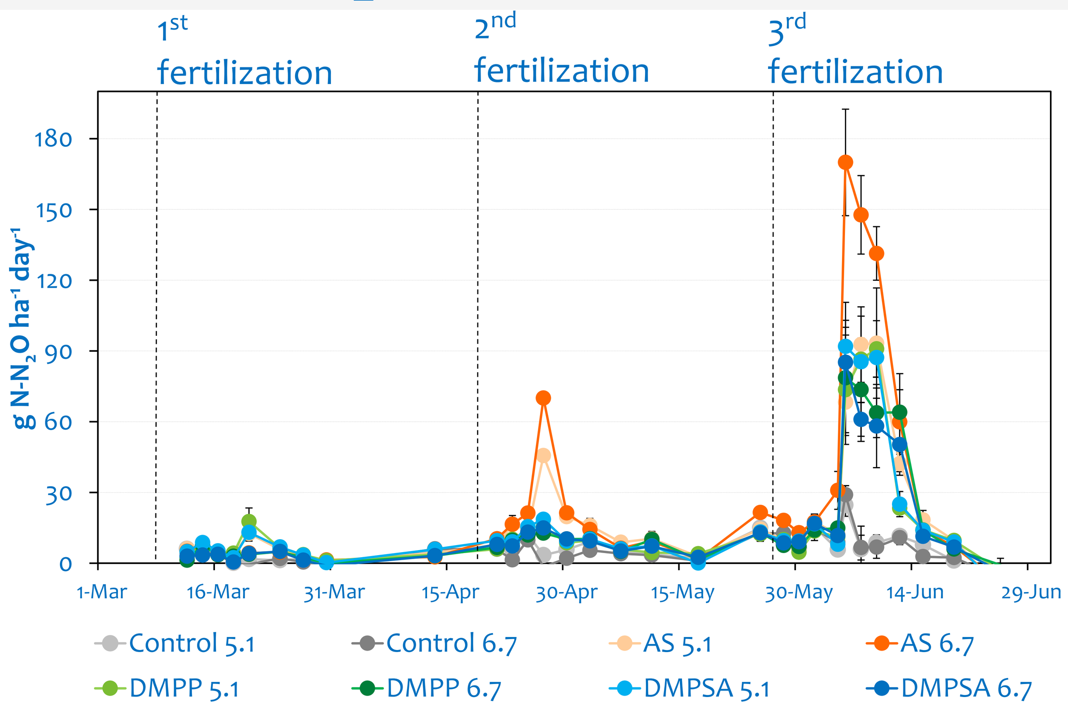
MATERIALS & METHODS

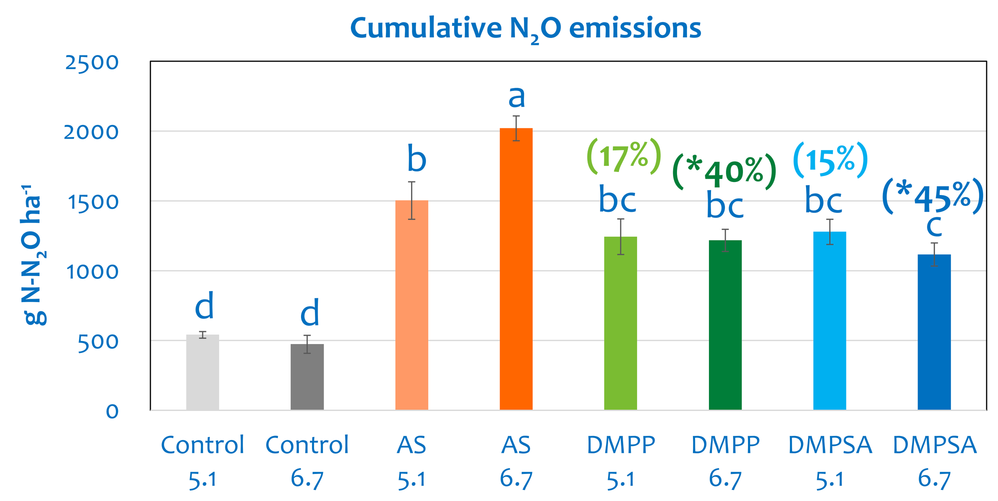
A field assay with ryegrass (*Lolium multiflorum* L.) was established in the 2019-2020 growing season, with three fertilizer applications and three consequent forage cuts. Eight treatments were assayed resulting from the combination of two different soil pHs (5.1 and 6.7) and four different N fertilizer treatments: AS (ammonium sulfate 21%) applied alone or combined with DMPP and DMPSA and an unfertilized control. N_2O emissions (closed chamber method and gas chromatography) and soil N mineral contents (colorimetry) were determined. Nitrifying and denitrifying populations were also determined as the abundance of microbial nitrogen-cycling functional marker genes by qPCR: 16S rRNA for total bacterial and archaeal populations, *amoA* for ammonium bacterial and archaeal oxidizers (AOB and AOA, respectively).



RESULTS

N_2O emissions

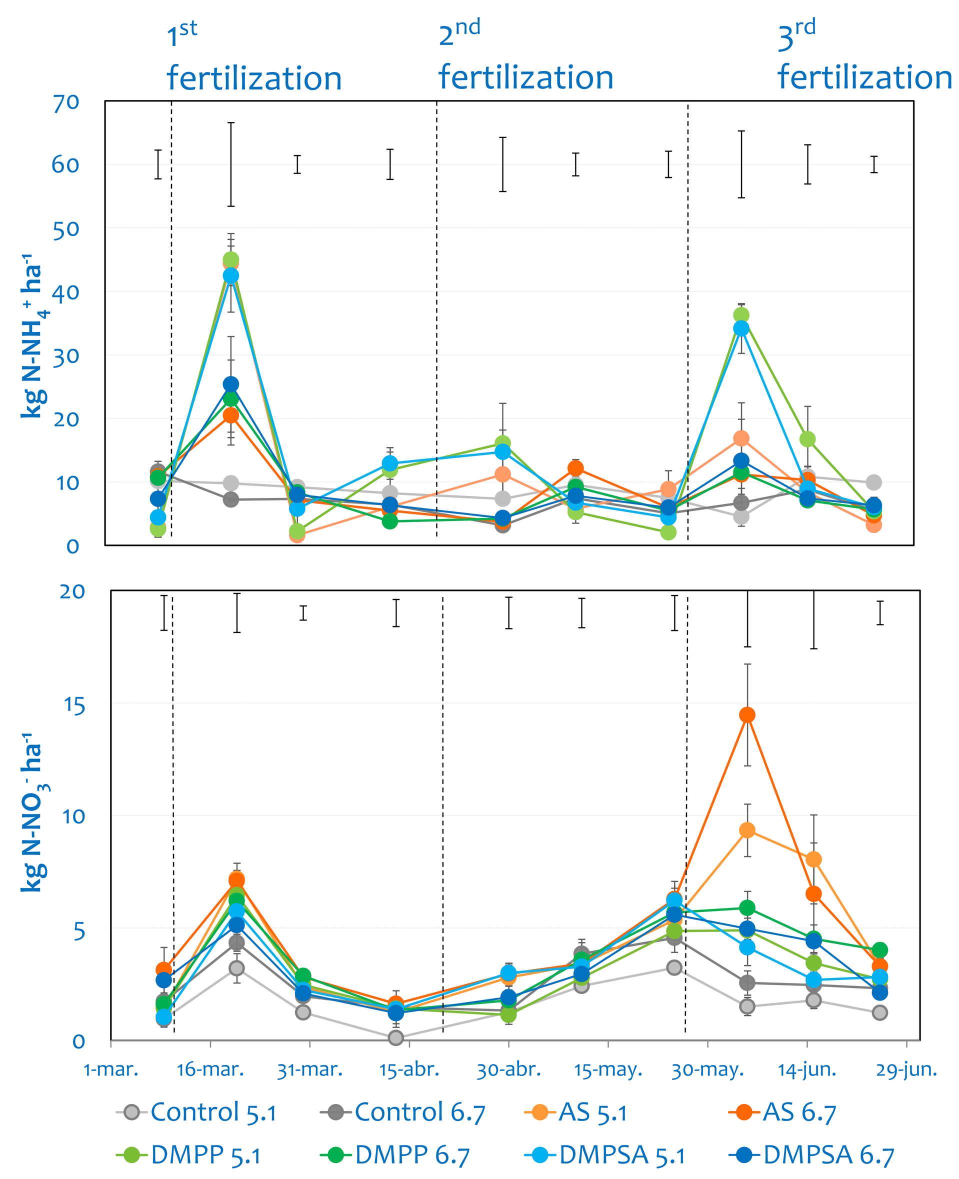




Bars with different letters are significantly different (Duncan test; P<0.05; n=4). Values in brackets indicate the reduction induced by the respective inhibitor (AS vs. DMPP or DMPSA) within its respective pH, and its significance (T-student test).*

- N_2O emissions were highly conditioned by the edaphoclimatic conditions. After the 1st fertilization the high soil water content did not favor neither nitrification nor N_2O emissions. After the 2nd and 3er fertilization, both NIs, either at soil pH 5.1 and 6.7, reduced significantly N_2O emissions.
- Regarding cumulative emissions, under pH 5.1, the efficiency of both NIs reducing N_2O emissions was around 15-17%, whereas at pH 6.7 this effect was increased up to 40-45%.

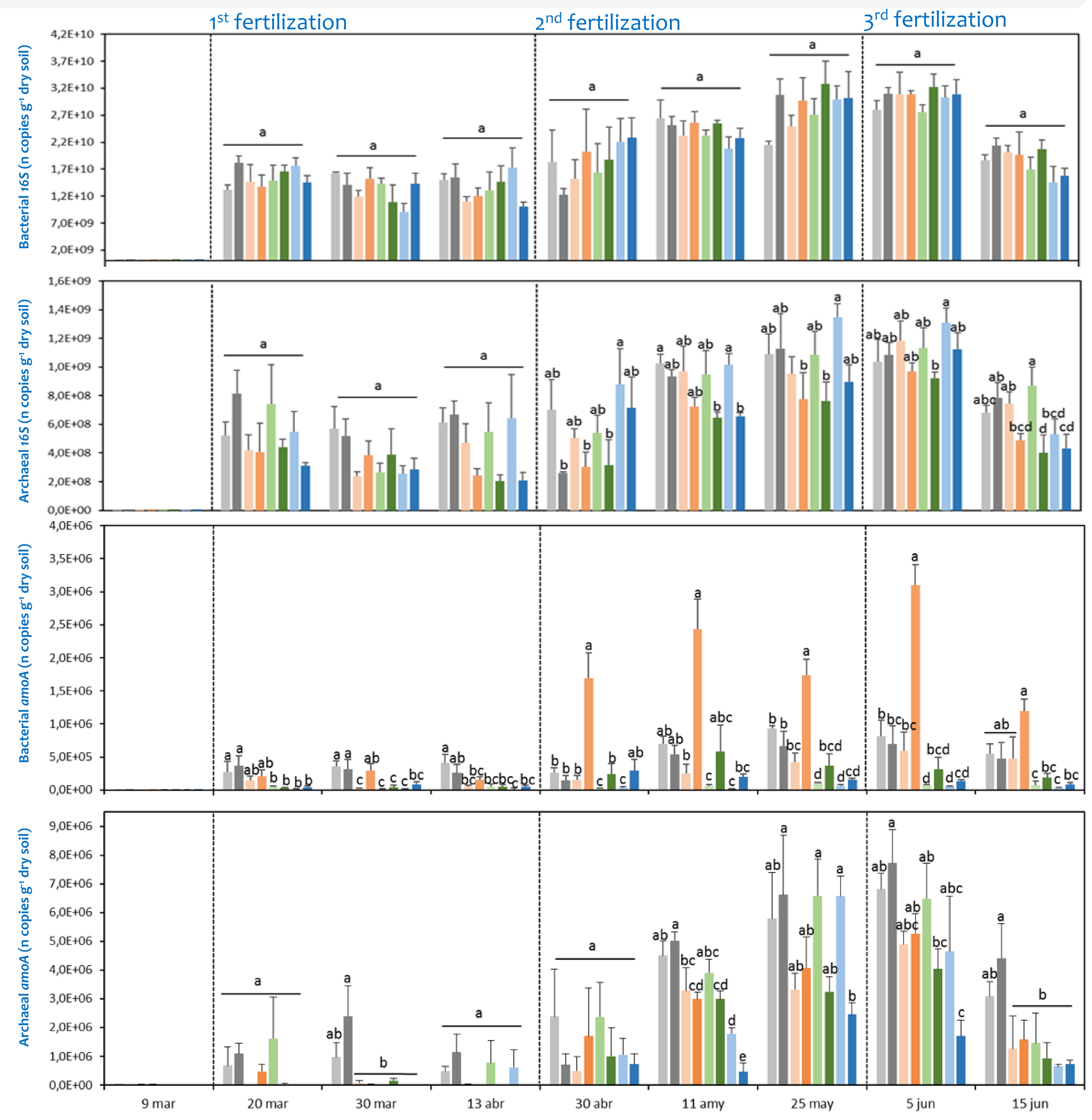
Soil mineral N content



Vertical bars on the top indicate the least significant difference (LSD) (P<0.05; n=4) for each sampling time.

- After the 1st and 2nd fertilizations no effect of either fertilizer or NIs application was observed in the soil $N\text{-}NO_3^-$ content.
- The highest content of $N\text{-}NO_3^-$ was observed at pH 6.7.
- It the 3rd fertilization period the effect of NIs reducing the soil $N\text{-}NO_3^-$ content could be observed at both pH 5.1 and 6.7 conditions

Genes abundance



Treatments sharing the same letter within each date do not differ significantly at P<0.05.

- Neither soil pH nor NIs application led to significant changes in total soil bacterial population, while total archaeal population was lower under pH 5.1 in comparison with pH 6.7.
- In general, AOB abundance in the fertilized treatments was higher at pH 6.7. Nevertheless, when soil water content was not favorable for nitrification (1st fertilization period), AOB abundance did not increase in response to the application of AS. When NIs were applied, the AOB population was even lower than in the unfertilized control.

CONCLUSION

Supporting the principle that soil acidic conditions do not favor the nitrification process, soil N_2O emissions and nitrate contents were higher under pH of 6,7. Consequently, both NIs efficiency was also higher at pH 6,7. When NIs were applied, the AOB population was even lower than in the unfertilized control. Even though AOA are usually more abundant in grassland soils, as in this experiment, AOA, unlike AOB, showed no response to the application of AS at pH 6.7. These results suggest that AOA are not contributing into a great extent to N2O emissions.

References

Huérfano, X., Estavillo, J.M., Torralbo, F., Vega-Mas, I., González-Murua, C., Fuertes-Mendizábal, T. 2022. Dimethylpyrazole-based nitrification inhibitors have a dual role in N2O emissions mitigation in forage systems under Atlantic climate conditions. Science of the Total Environment 807, 150670.

Acknowledgments

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