Effect of DMP-based nitrification inhibitors and soil pH on nitrifying and denitrifying soil bacterial populations

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INTRODUCTION

The main source of N_2O from agricultural soils are direct and indirect emissions as a consequence of increased fertilization, and the application of ammonium-based fertilizers combined with nitrification inhibitors (NI), such as dimethylpyrazol-based NIs (dimethylpyrazole phosphate DMPP and dimethylpyrazole succinate DMPSA), has been proposed as a strategy to mitigate these N losses. Moreover, continued N addition in agricultural soils leads to soil acidification, affecting crops yield, soil nitrification and denitrification processes, and the N_2O fluxes derived from both processes. Liming is the most common agricultural strategy to reduce soil acidity and, given the significant effect that soil pH has on microbial processes responsible for production and consumption of N_2O in soils, the efficiency of NIs would be influenced by liming.

MATERIALS & METHODS

Laboratory soil incubation experiment: 12 treatments incubated in darkness at 21ºC during 45 days at a water filled pore space of 75%.

FACTOR 1

Soil pH conditions:

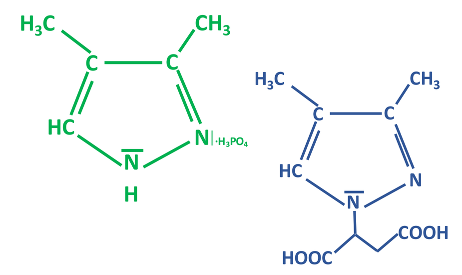
- pH 4.5
- pH 5.7
- pH 7.0

FACTOR 2

N fertilization (100 kg N ha^{-1}):

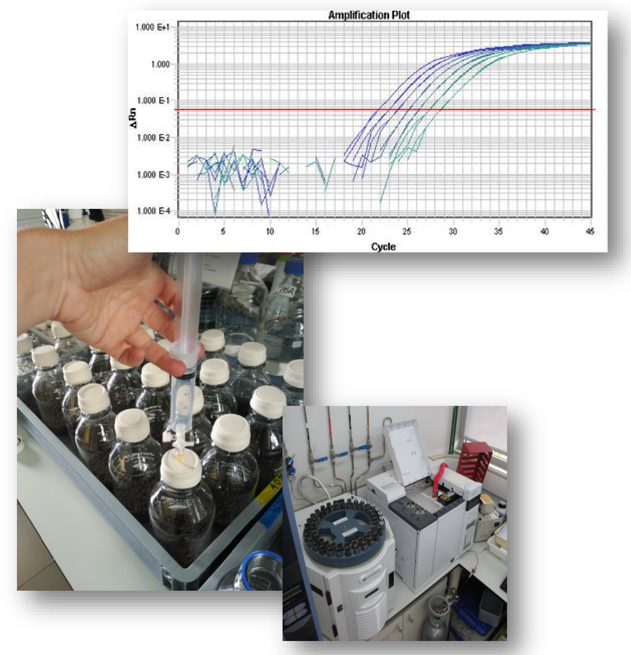
ammonium sulfate 21% (AS)

- Control
- SA
- SA+DMPP
- SA+DMPSA



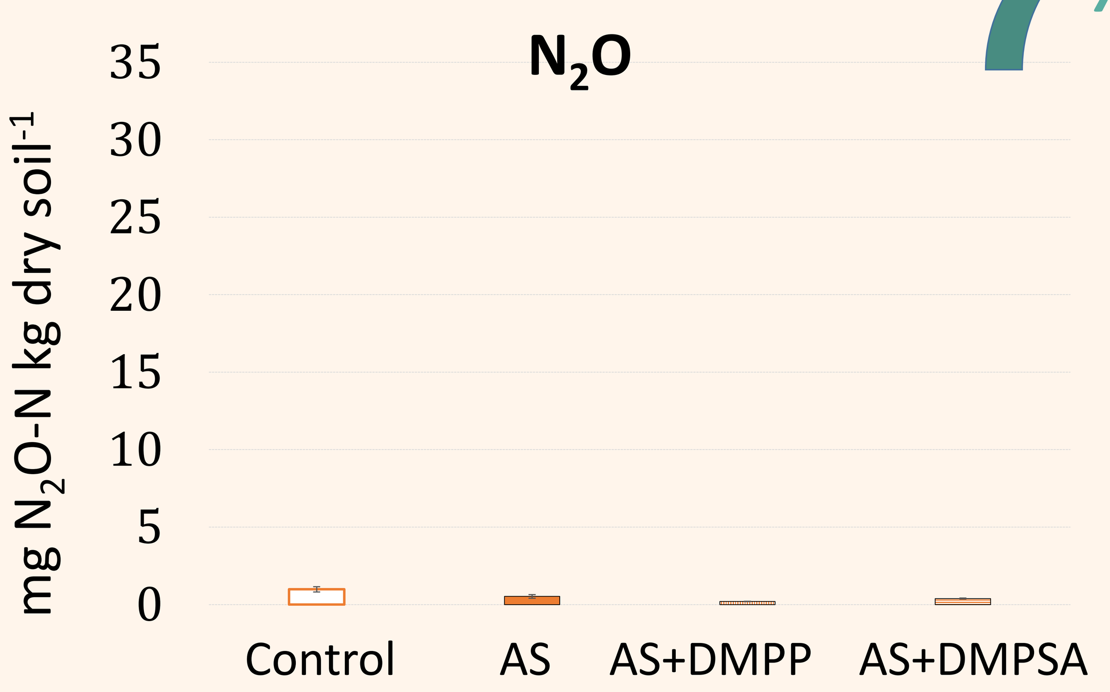
MEASUREMENTS

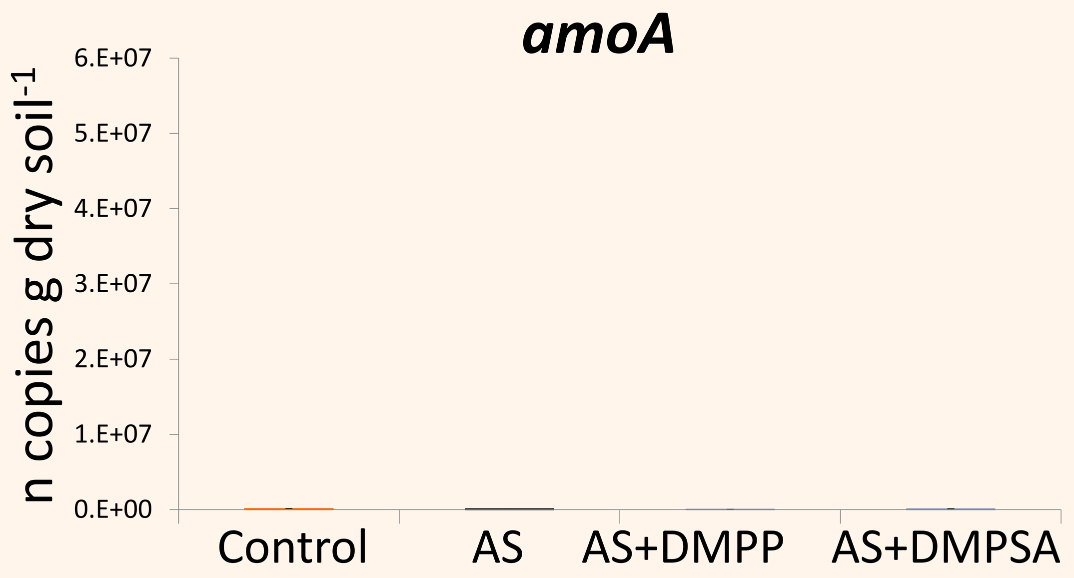
- N_2O emissions
- Nitrifier bacteria abundance (*amoA* gene) and denitrifier bacteria capable to reduce up to N_2 abundance (*nosZ* gene) 21 days after fertilization, the day of maximum N_2O rate.

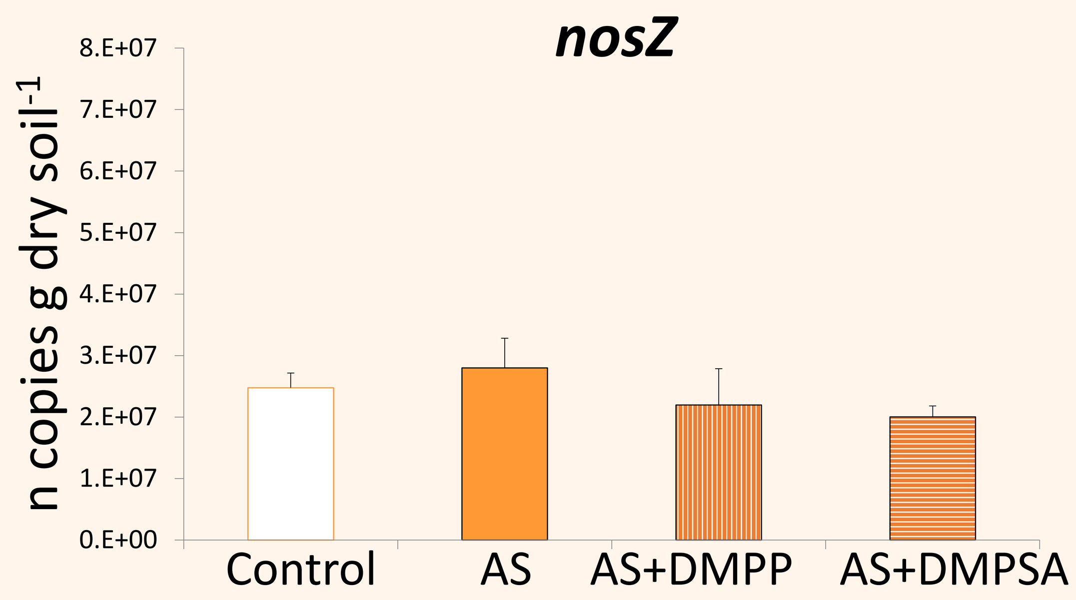


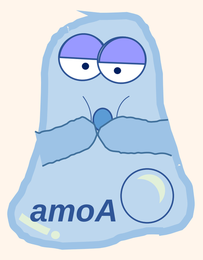
RESULTS

pH 4.5





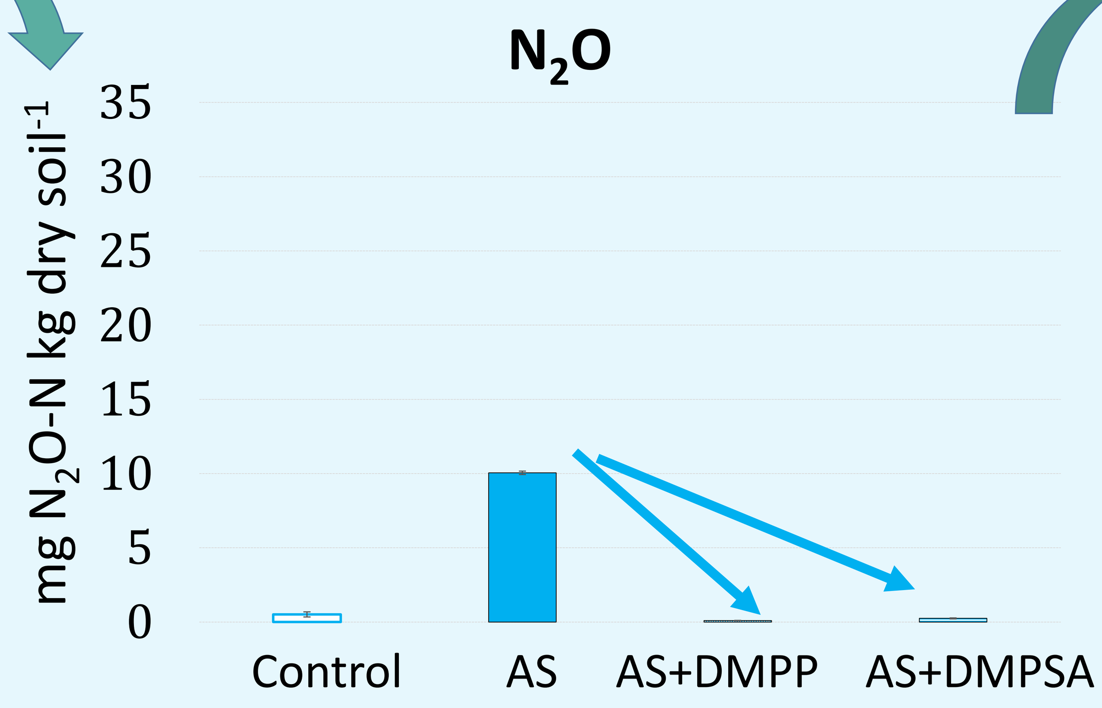


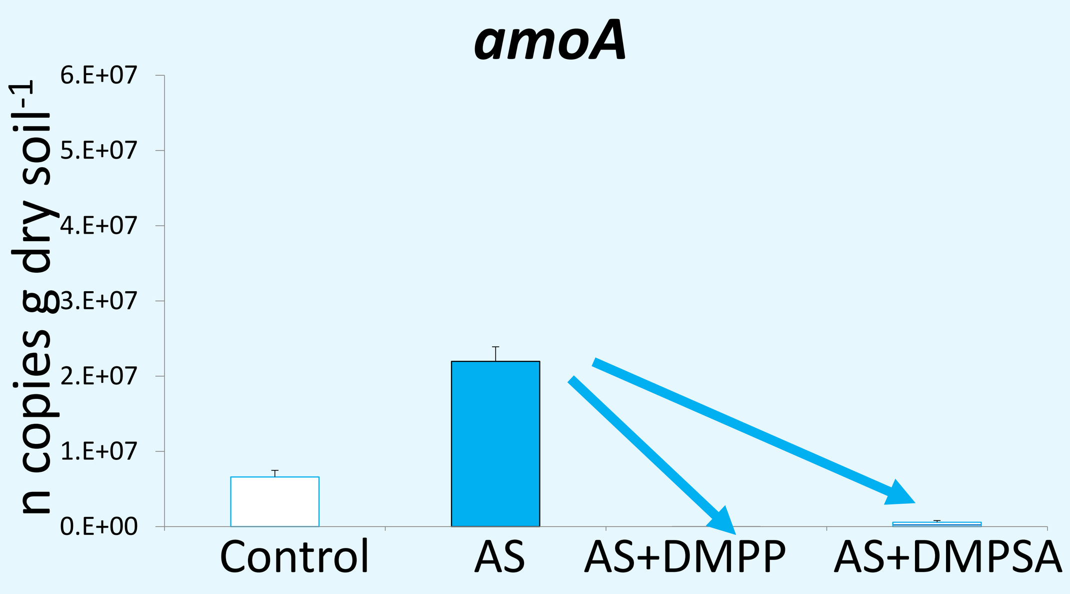


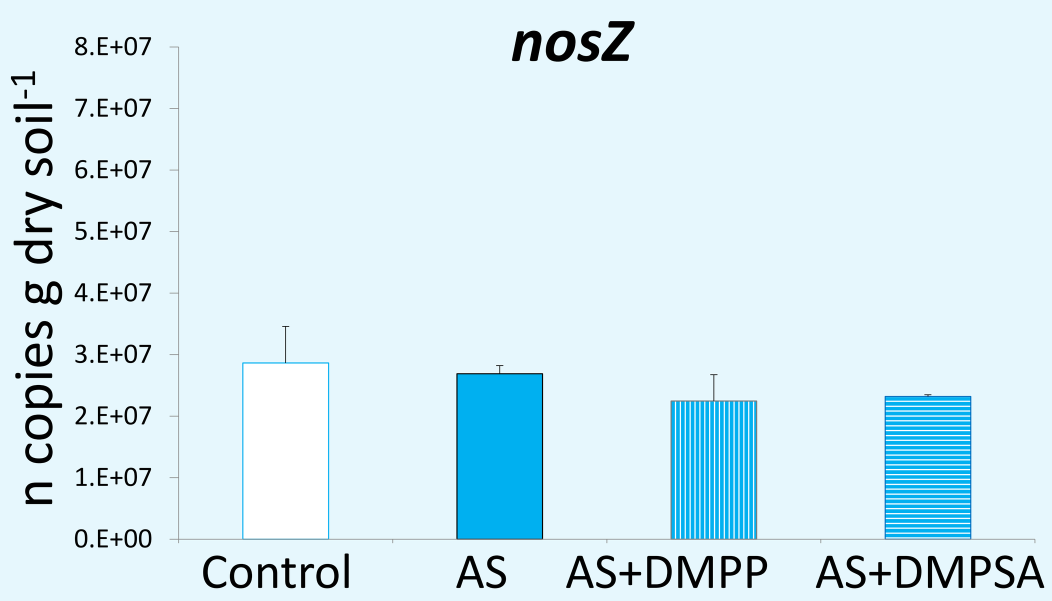
At pH 4.5 nitrifier populations are inhibited leading to null N_2O emissions coming from AS. There is no frame for NIs to reduce emissions. However, NIs exerted a significant inhibition of AOB populations, being N_2O emissions even lower than those of the unfertilized control

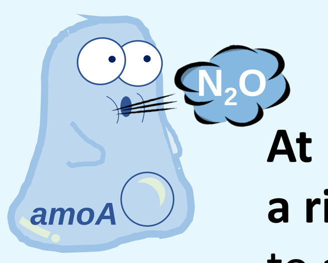
X 15

pH 5.7





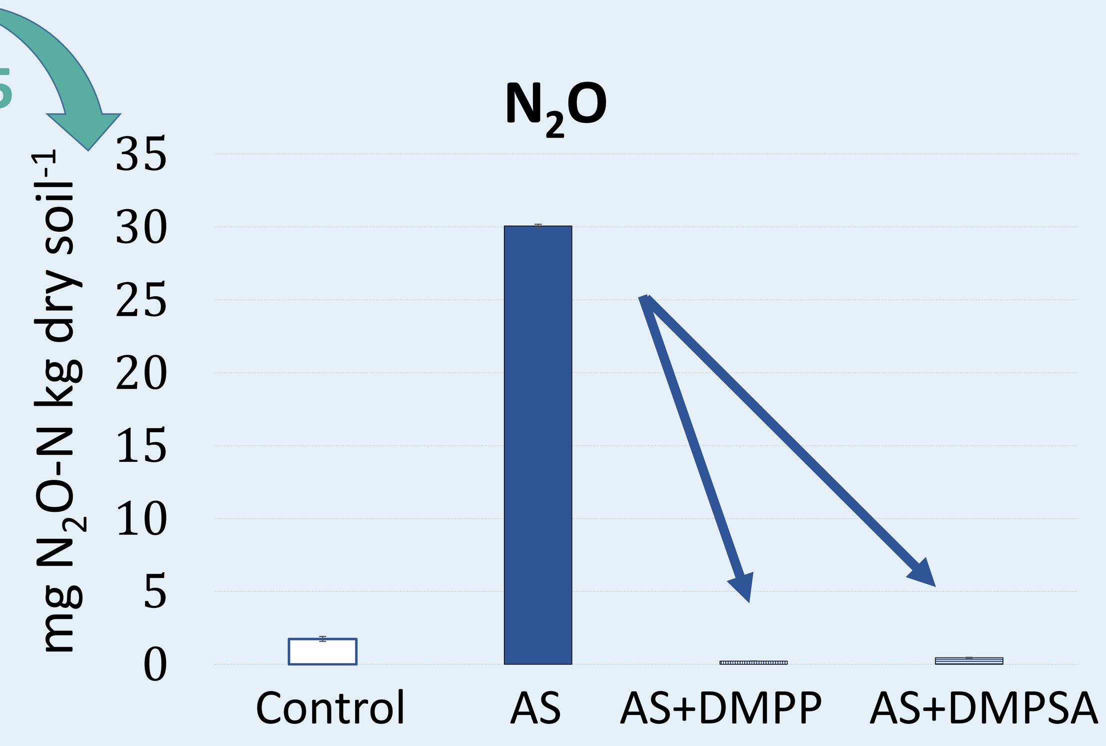


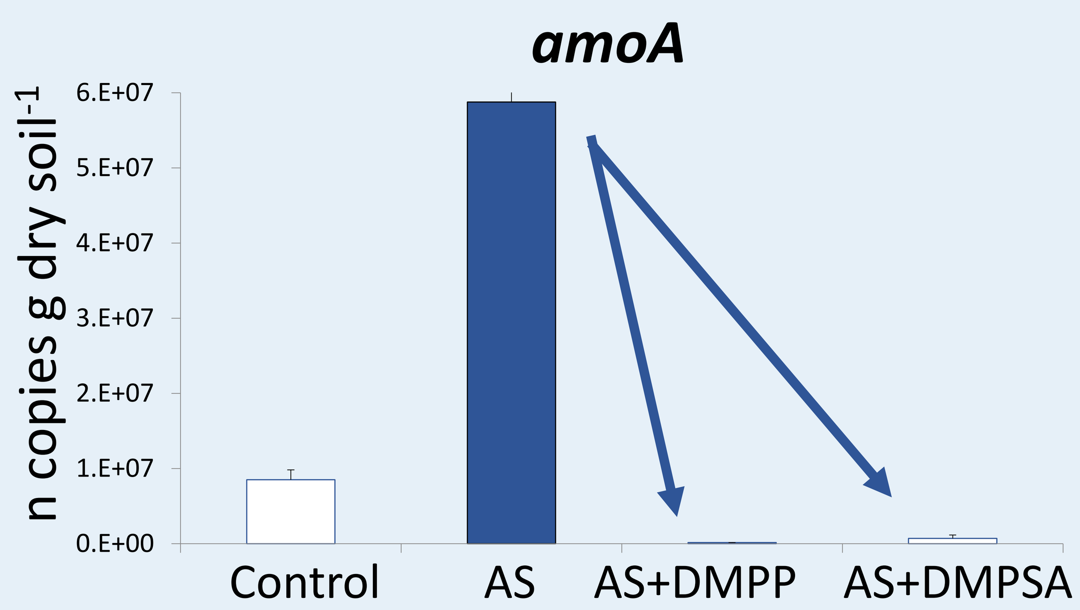


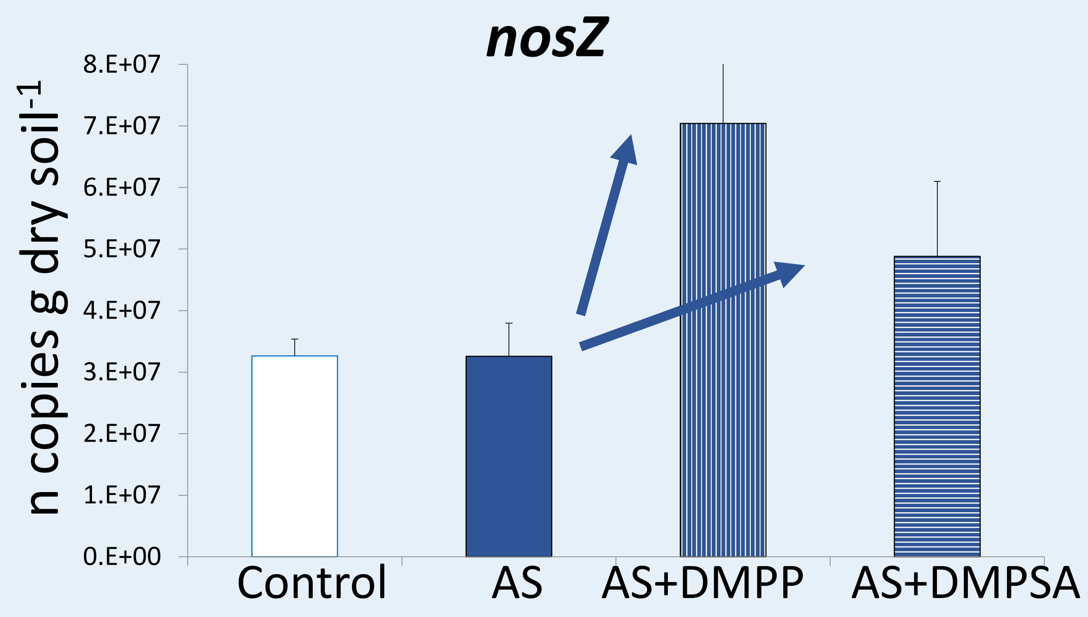
At pH 5.7 the application of **AS induced a rise in the nitrifier population** leading to an increase of N_2O emission by 15-20 times with respect to pH 4.5. NIs were able to diminish this emission up to values below the unfertilized control, significantly decreasing AOB populations.

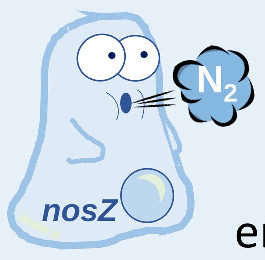
X 3.5

pH 7









At pH 7 the **induction of AOB** due to AS application was even higher, with N_2O emissions 45 times higher than in soils at pH 4.5. **NIs lowered** this emission up to values below the unfertilized control **by playing a dual role**; 1) decreasing targeted AOB populations and 2) increasing non-targeted denitrifier populations bearing *nosZ* gene, so favoring the complete reduction of N_2O up to N_2.

CONCLUSION

- The response of nitrifying and denitrifying soil bacterial populations to fertilizer amendment is dependent of the soil pH, being fertilizer N_2O derived emissions higher at high pH values .
- DMP-based NIs show a dual role reducing N_2O emissions coming from fertilizer, not only reducing nitrifiers population but also shifting denitrifiers population, that is also dependent on the soil pH value.

Acknowledgements

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