PO 452

Defining the conditions of liming products application to promote the N_2O reduction in an acidic agricultural soil

key words : greenhouse gas N_2O, soil, pH, mitigation, lime

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Introduction

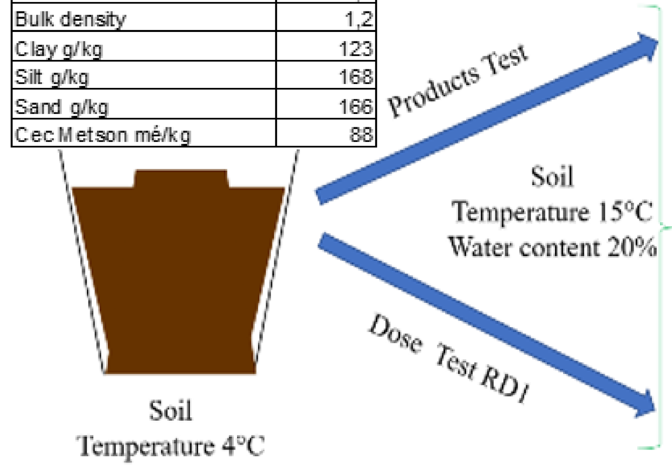
- Agriculture is an important source of N_2O, a potent greenhouse gas with a global warming potential (GWP) of ~ 300 for a 100-year timescale [(1)].
- Emissions N_2O are projected to increase in the coming years [(2)].
- N_2O reduction into N_2, catalyzed by the N_2O reductase, is the only known terrestrial pathway that remove N_2O. It appears to be mainly driven by soils pH [(3)].
- **The aim of this study is to test different liming products - including some research and development products (RD) - for their ability to promote N_2O reduction.**

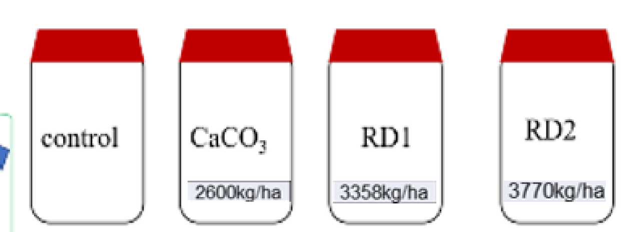
Materials and Methods

Soil characteristics & experimental design

NV = Neutralizing Value

Soil property	Value
pH	4,9
Totale organic carbon g/kg	14,9
dissolved carbon %	0,5
Bulk density	1,2
Clay g/kg	123
Silt g/kg	168
Sand g/kg	166
Cec Metson mé/kg	88





Product test : Incubation of soil samples in containers after addition of different products containing the same neutralizing value (NV): 3,5 t NV per ha.

Dose test : Incubation of soil samples in containers after addition of the RD1 product at increasing neutralizing value, from 0 to 4 t NV per ha.

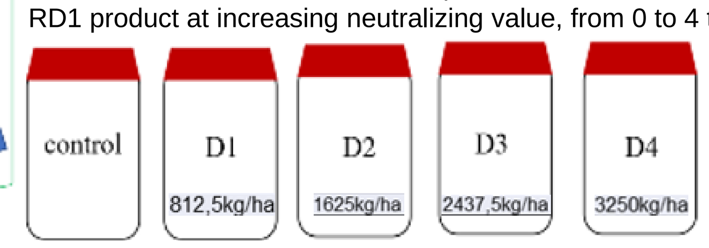


Figure M1: Design of soil incubation with liming products

Analyses

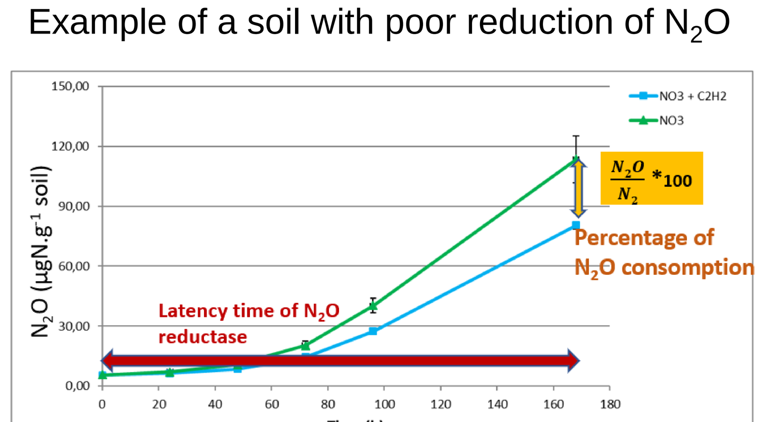
Monthly performed on soil sampled from the container including:

- Soil pH (ISO 10390: 2005)
- Soil capacity to reduce N_2O (ISO/ TS20131-2: 2018) to characterize the functioning of the N_2O reductase.

Briefly, soil slurries incubate in anaerobiosis conditions in flasks after a nitrate solution added both in the absence and presence of acetylene (C_2H_2). N_2O concentration in flasks is regularly measured.

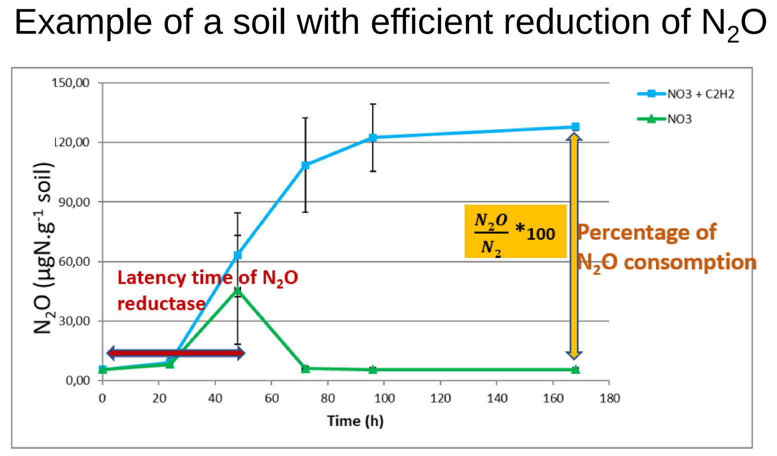
Interpretation of the soil capacity to reduce N_2O curves

Example of a soil with poor reduction of N_2O



- The latency of the N_2O reductase is high.
- The percentage of N_2O consumption at the end of the anaerobiosis incubation is low.

Example of a soil with efficient reduction of N_2O



- The latency of the N_2O reductase is low.
- The percentage of N_2O consumption at the end of the anaerobiosis incubation is high.

Figure M2 : Method of interpretation of the curves obtained when measuring the soil capacity to reduce N_2O

Bibliography

(1) Ravishankara, A.R., Daniel, J.S., Portmann, R.W., 2009. Nitrous Oxide (N2O): The Dominant Ozone-Depleting Substance Emitted in the 21st Century. Science 326, 123–125. https://doi.org/10.1126/science.1176985
(2) Aneja, V.P., Schlesinger, W.H., Li, Q., Nahas, A., Battye, W.H., 2019. Characterization of atmospheric nitrous oxide emissions from global agricultural soils. SN Appl. Sci. 1, 1662. https://doi.org/10.1007/s42452-019-1688-5
(3) Hénault, C., Bourennane, H., Ayzac, A. et al. Management of soil pH promotes nitrous oxide reduction and thus mitigates soil emissions of this greenhouse gas. Sci Rep 9, 20182 (2019). https://doi.org/10.1038/s41598-019-56694-3

Results

Liming products effect

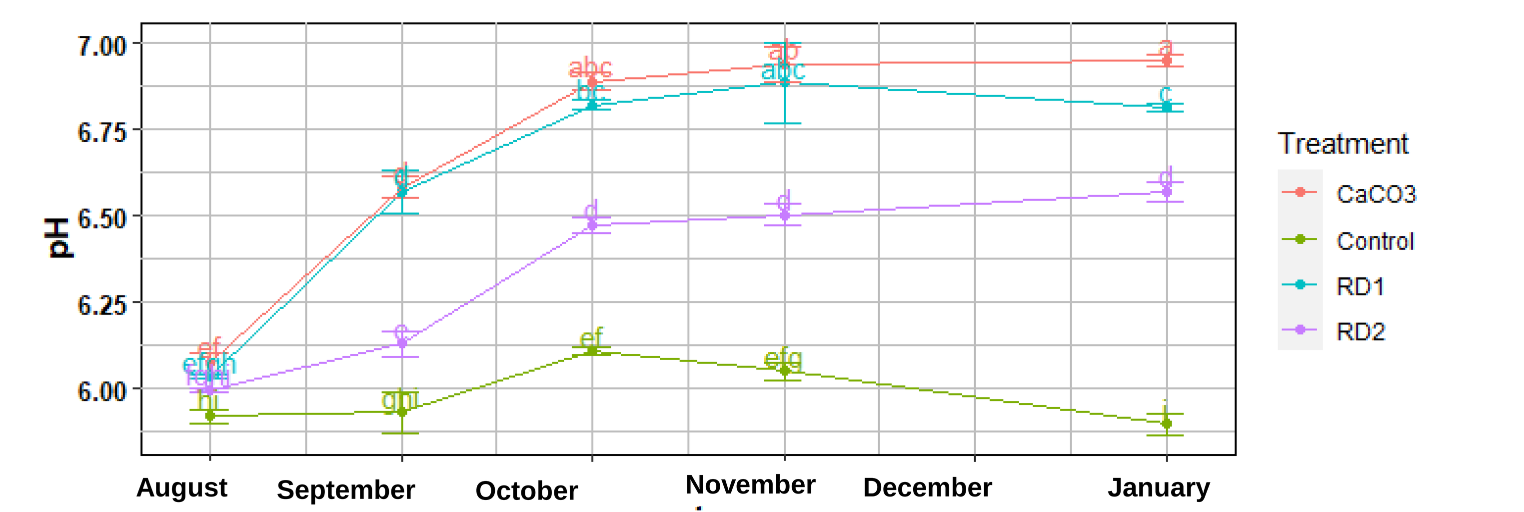


Figure R1 : Changes in soil pH after the application of the different liming products during incubation in the plastic containers. Vertical bars indicate error bars for the average of three replicates. The different letters indicate significant differences between the different treatments over time ($p < 0.05$).

The pH increase rate varies with the liming products applied despite the same NV. Fastest increase was observed for both laboratory $CaCO_3$ and the RD1 products.

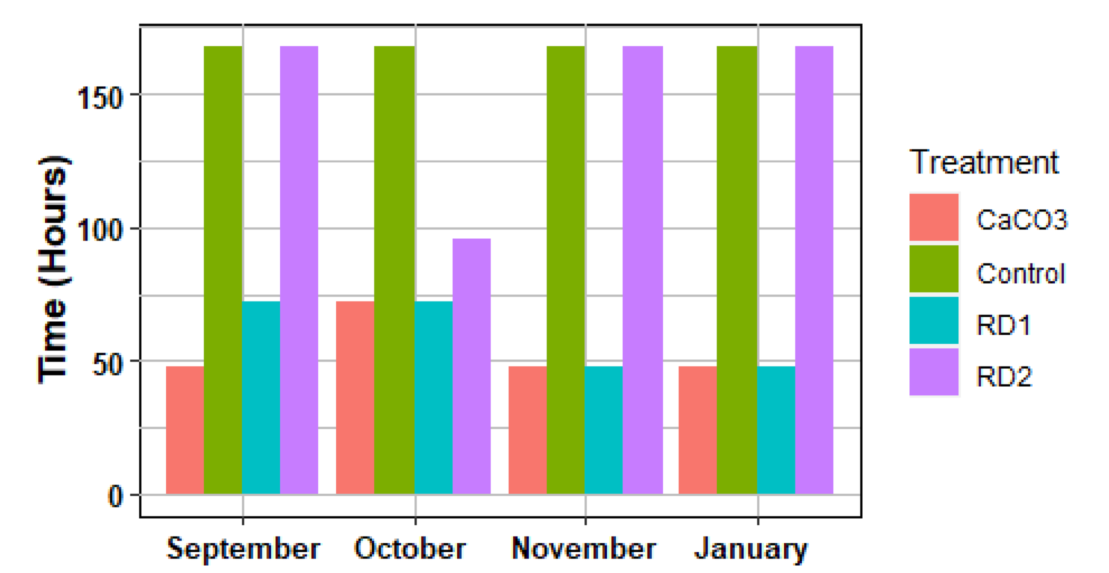


Figure R2 : Estimations of the latency of N_2O reductase in the presence of liming treatments.

The latency of the N_2O reductase depends on the liming product applied: shorter for the $CaCO_3$ and RD1 products.

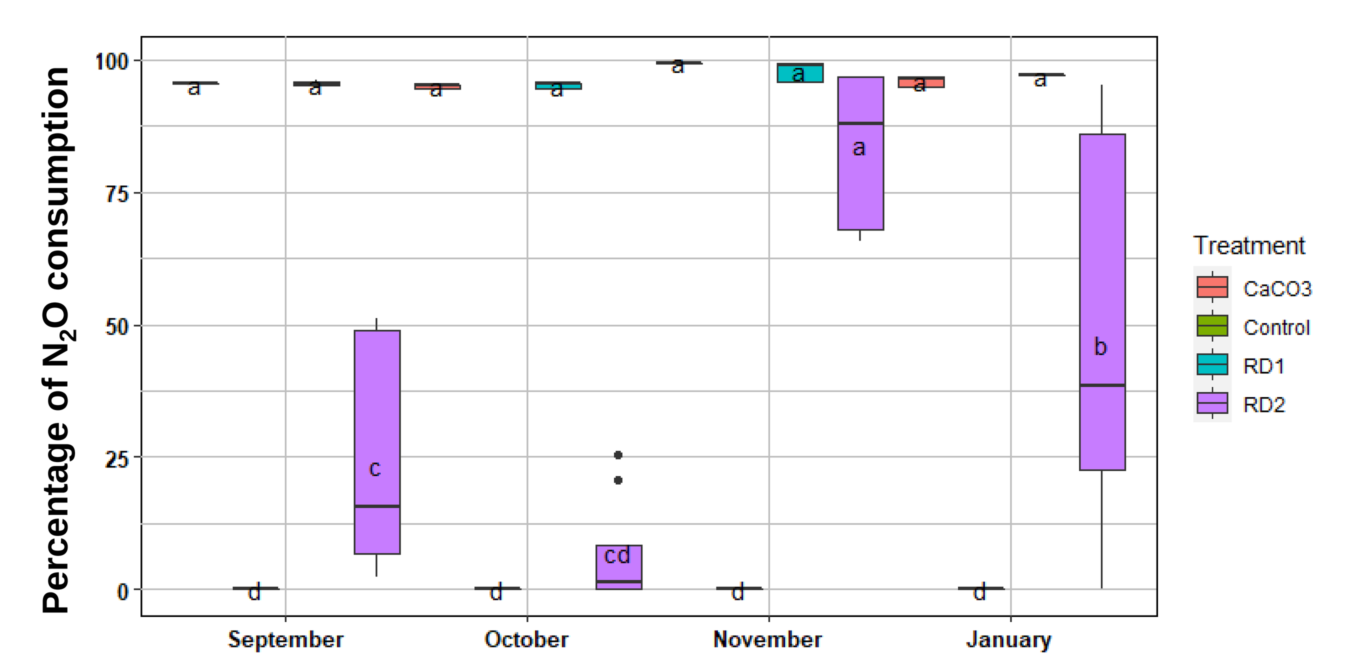


Figure R3 : Percentage of N_2O consumption during anaerobic incubation of soil samples having received the different liming products. The different letters indicate significant differences between the different treatments over time ($p < 0.05$).

The rate of N_2O consumption in anaerobiosis condition depends of the liming product applied. N_2O was totally reduced after 168h of incubation for the products $CaCO_3$ and RD1 while it was partially reduced for the RD2 product and not reduced for the control.

Dose effect of the RD1 product

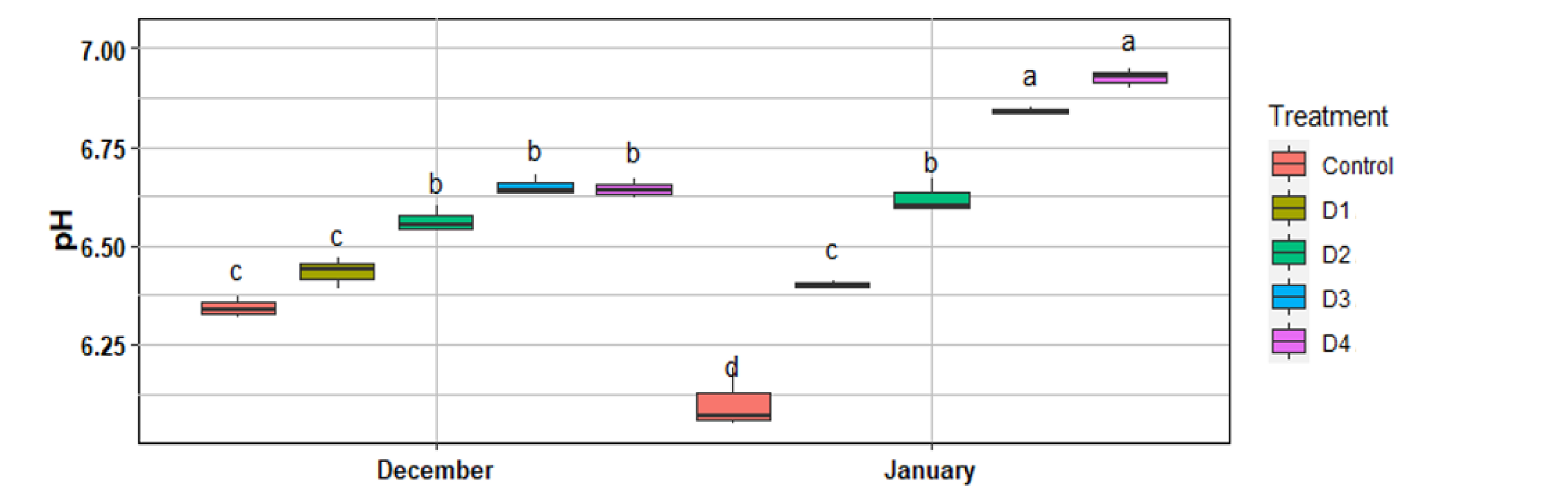


Figure R4 : Changes in soil pH after the application of different dose of the liming product RD1 during incubation in the container. Vertical bars indicate error bars for the average of three replicates. The different letters indicate significant differences between the different treatments over time ($p < 0.05$).

The pH increase rate is positively correlated with the applied dose of the RD1 product

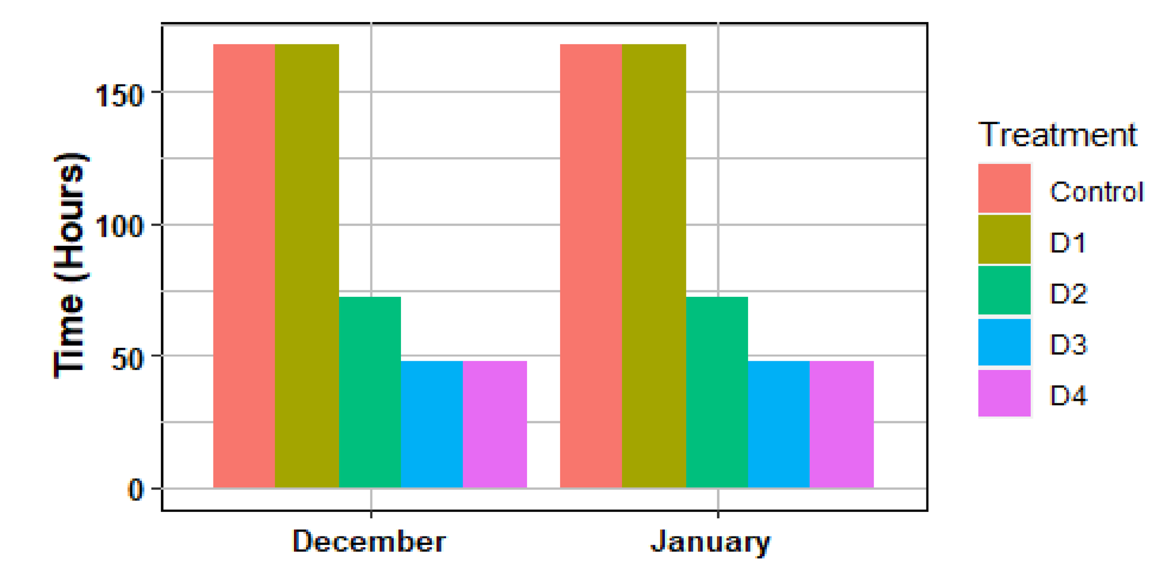


Figure R5 : Estimation of the latency time of the N_2O reductase in the presence of different doses of RD1

The latency of the N_2O reductase is affected by the dose of the liming product applied: start to decrease from the D2 dose (2 NV per ha) for the RD1 product.

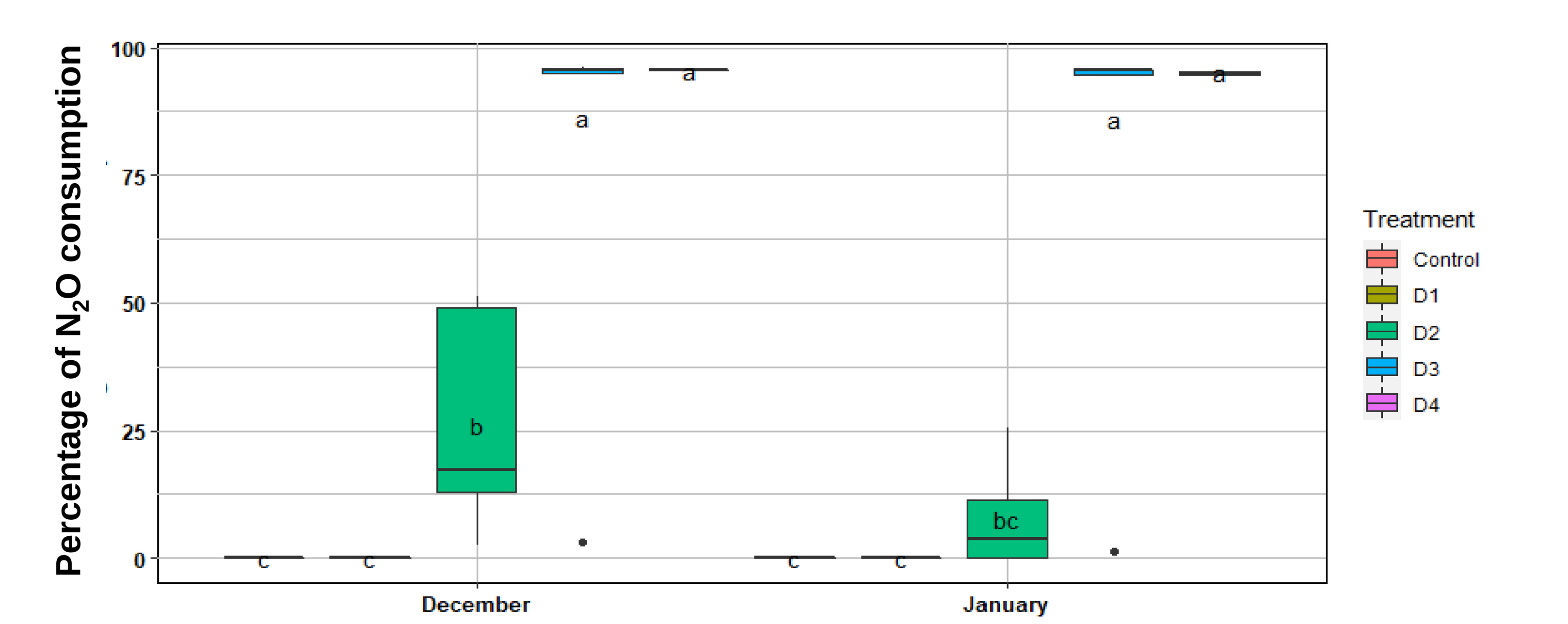


Figure R6 : Percentage of N_2O consumption during anaerobic incubation of soil samples having received the RD1 product at 4 different doses. The different letters indicate significant differences between the different treatments over time ($p < 0.05$).

The rate of N_2O consumption in anaerobiosis condition depends of the dose of the liming product applied. N_2O was totally reduced after 168h of incubation for the highest doses (D3 and D4 for 3 and 4 t NV per ha respectively) while it was partially reduced for D2 and not reduced for the lowest ones.

Conclusions

- This study demonstrates rapid changes both in soil pH and in its capacity to reduce N_2O to N_2 after addition of liming products.
- At equivalent application of neutralizing value, the intensity of these changes depends of the nature of the applied liming product.
- In our experimental conditions, the application of the liming product RD3 with a dose of 3 t NV per ha on a soil (initial pH lower than 5), was enough to increase soil pH and therefore to promote the catalysis of N_2O into N_2 by the nitrous oxide reductase.
- ✓ This study suggests **that the management of the soil pH with the right dose of the adapted product is a promising option to promote N_2O reduction into N_2 from acidic soils and therefore to decrease soil N_2O emissions.**

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