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Greenhouse gas emissions (CO₂ & N₂O) of an acid soil after adding liming products, observed at 2 experimental scales (*in situ* and undisturbed cylinders)

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With its known interest in agricultural production, the use of liming products on acid soils can also be considered as a lever for mitigating soil N₂O emissions. Several studies have shown that liming acid soils reduces their N₂O emissions¹⁻³. This decrease is explained by an increased reduction of N₂O to N₂ during the process of denitrification in these soils whose pH has been raised⁴. An optimum pH of 6.8 has been observed, below which the N₂O reduction path is progressively inhibited⁴. Nevertheless, the interest of liming to reduce GHG emissions from soils is also conditioned by the carbon evolution from the carbonates brought into the soil, in this case their release in the form of CO₂. The Tier 1 methodology proposed by the IPCC considers that all the carbon brought by carbonate liming products is emitted into the atmosphere in the form of CO₂. However, this 1:1 ratio is discussed in some studies⁵⁻⁶. Often analysed separately, too few studies have simultaneously analysed the effect of carbonate liming product inputs on CO₂ and N₂O emissions. Thus, the objective of our project is to consolidate knowledge on the effect of carbonate liming product inputs on the cumulative emissions of two GHGs, CO₂ and N₂O.

This study was conducted on the soil of a cultivated plot located in the Morvan region (France). The soil of this plot has a sandy-clay-silt profile with an initial acid pH (5.6). The study includes measurements on undisturbed soil cylinders (height 20 cm, diameter 10 cm) with controlled moisture conditions, as well as *in situ* measurements. The soil cylinders were sampled in March 2021 and incubated at 20°C for 107 days and were divided into 2 batches. All cylinders in the 1st batch (called MC treatment) received (a) 1.45 g of a marine calcium carbonate – CaCO₃ with a neutralising value (VN) equal to 40 (marketed as Calcimer®) on the exposed soil surface to achieve a pH of 6.8 and (b) 0.08 g nitrate nitrogen (0.032 mg N g⁻¹ soil) and those in the 2nd batch received a single addition of 0.08 g nitrate nitrogen (control). These cylinders were regularly closed for 3 hours to determine the intensity of their N₂O and CO₂ emissions.

In situ, emissions were monitored during the rye cultivation period until harvest (October 2021 – July 2022), using the static chamber method (55cm x 55cm). The chambers were placed on the plot before sowing the crop and randomised by treatments: control (no liming product input) and two limed treatments (SC = synthetic calcium carbonate - VN = 54 and MC) incorporated into the soil surface in order to also reach a pH of 6.8. N₂O fluxes are expressed in g N ha⁻¹ d⁻¹ and converted to CO₂ equivalents considering the global warming potential of the gases (N₂O and CO₂ for our study).

On undisturbed soil cylinders, we observed both lower N₂O and CO₂ emissions from the limed soil treatment (MC) compared to the control soil treatment, with a reduction of more than 10% in cumulative GHG emissions (Figure 1). *In situ*, the N₂O emissions were particularly low for each treatment (< 25 g N₂O-N ha⁻¹ d⁻¹) which could be explained both by the unusual environmental conditions of this year (dry conditions) and the low bulk density of the soil, being well aerated all along the experimental period. Globally, no effect of the limed treatment was observed on the soil N₂O emission *in situ*. Conversely and consistent with results obtained on the undisturbed soil cylinders, the CO₂ emissions *in situ* were highly and significantly lower in the two limed treatments (MC and SC) compared to the control treatment (Figure 1) with a reduction of more than 37% in cumulative GHG emissions. Calcium carbonate being a source of carbon, this unexpected latter result now requires to be understood in a mechanistic point of view. Currently, we can suggest a possible stabilisation of soil organic carbon (SOC) after liming application.

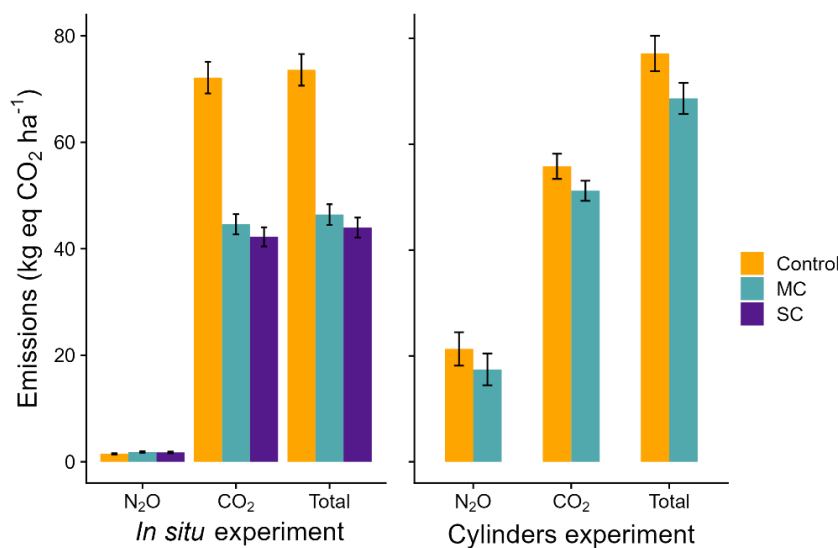


Figure 1: The average emissions measured throughout the experimental period *in situ* (left) and on cylinders (right). For both gases, N₂O and CO₂, the emissions are expressed in kilogram of CO₂ equivalent per hectare. Total refers to the addition of N₂O and CO₂ emissions. Error bars = s.e.m. n=9 (*in situ*) and n=8 (cylinders). MC stands for Marine CaCO₃ and SC for Synthetic CaCO₃.

Overall, our results show that the liming strategy for acid agricultural soils to mitigate GHG emissions, adopted in the methodology of the low-carbon label for field crops in France⁷, could be refined with respect to the CO₂ emissions component. Beforehand, future studies need to ensure that those results are sufficiently generic and the acquisition of in-depth knowledge of the evolution of the C brought to the soil by carbonate liming products would be necessary.

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