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Fertilizer type effect on nitrous oxide (N₂O) emissions in a Swedish long-term field experiment

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Fertilization in agriculture contributes substantially to an increase in nitrous oxide (N₂O) emission to the atmosphere, optimizing fertilization is one of the mitigation strategies to reduce greenhouse gas (GHG) emissions while maintaining high crop production. In the Ultuna long-term frame trial, treatments including organic amendments and different types of mineral nitrogen fertilizers have been applied since 1956 to quantify their effects on crop production, soil carbon and nitrogen cycling. However, the understanding of their effect on GHG emissions from soils is still quite limited. For this reason, we chose four treatments, including no fertilizer (control), calcium nitrate, ammonium sulfate and calcium cyanamide to study the mineral fertilizer type effect on N₂O emissions and the plant-soil-microbe interactions over one crop growth period.

N₂O fluxes in the growing season were continuously measured from the 1 June to 15 Oct in 2019, using a Picarro N₂O analyzer and 12 automated eosAC chambers. The frame trial has a randomized complete block design and we chose treatments in three blocks as replicates. In each plot, we placed two sensors to measure soil moisture and temperature. A mixed model was used to test the effect of fertilizer type and measurement date, with consideration of auto-correlations in the repeated measurements. Soil moisture and temperature were added to the regression model to quantify the controlling factors of the N₂O fluxes. Measurement date was treated as a continuous variable.

The effects of both treatment and measurement date were statistically significant. Despite its higher pH values, the calcium nitrate treatment emitted significantly more N₂O than the control: 90.8±23.4 compared with 32.2±8.3 nmol m⁻² s⁻¹, respectively. The treatment with calcium cyanamide had pH-values and total N similar to those in the calcium nitrate treatment, but N₂O emissions were 72% lower (25.0±6.5 nmol m⁻² s⁻¹) than the emission in the calcium nitrate treatment. Due to low soil pH, N₂O fluxes were constantly low in the ammonium sulfate treatment, with an average emission of 24.3±6.3 nmol m⁻² s⁻¹. The temporal dynamics differed a lot between treatments, as suggested by significant interaction between treatment and measurement date. Further, regression with soil moisture and temperature showed that both variables contributed to explaining the temporal variation of N₂O fluxes mainly in the control and calcium nitrate

treatments. In contrast, N₂O fluxes in the calcium cyanamide treatment were low throughout the growing season, suggesting that it effectively suppressed not only nitrification in the early growing season, but also the denitrification process in the late growing season.

Considering the highest maize biomass and lowest N₂O emissions the calcium cyanamide treatment, using calcium cyanamide as nitrogen fertilizer has a great potential to reduce N₂O emissions from agricultural soils without compromising crop production.