Mitigation of N_2O emissions by soil pH management (MAGGE-pH): growing evidence

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Direct emissions of nitrous oxide (N_2O) from farmed soils account for a large share of the climate forcing through food production. The FACCE ERA-GAS project "Mitigating Agricultural Greenhouse Gas Emissions by improved pH management of soils, MAGGE-pH" explores possibilities to reduce N_2O emissions by liming soils beyond the minimum needed for crop growth. Research ranges from N_2O emission measurements in liming trials to manipulative laboratory studies and molecular assessments of functional microbial communities in long-term and more recently limed soils. The overarching goal is to understand how changing soil pH, a well-known and easy to control soil property, affects biotic and abiotic nitrogen transformations and their N_2O yields. There is ample evidence that liming acidic soils improves bacterial N_2O reduction to N_2 in denitrification and coupled nitrification-denitrification, primarily due to enhanced maturation of the N_2O reductase at high pH. On the other hand, liming appears to increases the N_2O yield of nitrification by enhancing bacterial over archaeal ammonia oxidation. The net effect of liming on N_2O emissions hence depends on which process prevails, which varies in time and space. MAGGE-pH therefore also works on implementing improved pH algorithms into current N_2O emission models to upscale the N_2O mitigation potential of liming based on regional soil pH maps. Here we present first results of field and laboratory studies, confirming the pervasive effect of pH on N_2O source and sink processes, confirming that liming soils beyond the level needed for sustaining plant growth will reduce the overall N_2O emissions, albeit with marginal effects in systems where nitrification is the dominant source of N_2O.

The *Achilles' heel* of N_2O mitigation by liming could be the emission of carbonate-CO_2, which could more than negate the effect of reduced N_2O emission on climate forcing. However, the conventional view adopted by IPCC that 100% of the carbonate CO_2 evades is wrong, and we argue that the effect of the extra lime needed to take pH above the minimum required for good crop growth is more likely to be a CO_2 sink. Recent soil monitoring projects in Germany, Ireland and UK demonstrate an ongoing gradual acidification of cultivated surface soils in Central Europe. If not halted and reversed, this acidification will plausibly increase N_2O emissions and decrease yields, eventually resulting in an increased GHG footprint per unit of yield. MAGGE-pH addresses this problem by exploring limitations to proper pH management for selected regions by means of socio-economic modelling.

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