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Enhanced weathering in acid and alkaline agricultural soils: greenhouse gas emissions and soil bacterial communities implications

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Changes in agricultural management practices to enhance soil carbon (C) sequestration while maintaining crop productivity are a key opportunity to reduce the impact of humans on the environment, reducing greenhouse gas (GHG) fluxes to the atmosphere and nutrient leaching to aquatic ecosystems without compromising food and soil security. Amongst them, enhanced weathering (EW) of silicate minerals is a promising negative emission technology that can be associated with multiple co-benefits for crop production by spreading silicate minerals on arable soils (i.e. increase in crop yields, restoration of soil base cations and micro- and macronutrient stocks). A growing number of EW studies are focused on soil C sequestration and the effects on crop production. Yet, little is known about the impact of such management practices on GHG sink/source behaviour of agricultural soils and the soil bacterial communities involved.

In this context, winter wheat (*Triticum aestivum*) was grown in 20 mesocosms undergoing 4 different treatments: acid soil (pH ~5) with or without basalt addition (50 tones ha^{-1}) and alkaline soil (pH ~7) with or without basalt addition. Soil GHG emissions (CO_2, CH_4 and N_2O) were measured at six different time points spread over the growing season (from March to June). Measurements included anaerobic conditions (i.e. immediately after irrigation events) and aerobic condition (i.e. in-between events). Simultaneously, soil was sampled for the study of the soil bacterial community.

We found that basalt application led to an increase in crop yield in acid soils, while it decreased the yield in alkaline soils. GHG emissions were not reduced by the basalt amendment. Soil CO_2 fluxes peaked in-between irrigation events and were mainly influenced by the soil pH, being 2-fold higher in alkaline soils than in acid ones. Irrigation events increased both CH_4 and N_2O fluxes. Soils acted as CH_4 sink in-between irrigation events, but became sources shortly after those (up to 5-fold higher). While it was hypothesised that higher pH would result in an improved denitrification completion, the increase in pH induced by basalt application did not reduce soil N_2O fluxes. Higher N_2O fluxes were observed during irrigation events and in basalt-enriched mesocosms, as a result of combined enhanced nitrification and denitrification processes. Despite the modest effects of EW on soil GHG emissions, soil bacterial communities were very different for acid and alkaline soils, and varied significantly with basalt amendment and throughout time.

Overall, this study showed that EW resulted in an improved wheat yield and altered soil bacterial community in acid soils. However, the general effect of EW on soil GHG emissions was modest and complex.