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Effect of Biochar on Greenhouse Gas Emissions and Nitrogen Cycling in Laboratory and Field Experiments

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The extensive use of nitrogen (N) fertilizers in agriculture is a major source of anthropogenic N_2O emissions contributing 8% to global greenhouse gas emissions. Soil biochar amendment has been suggested as a means to reduce both CO_2 and non-CO_2 greenhouse gas emissions. The reduction of N_2O emissions by biochar has been demonstrated repeatedly in field and laboratory experiments. However, the mechanisms of the reduction remain unclear. Further it is not known how biochar field-weathering affects GHG emissions and how agro-chemicals, such as the nitrification inhibitor 3,4–dimethylpyrazole phosphate (DMPP), that is often simultaneously applied together with commercial N-fertilizers, impact nitrogen transformation and N_2O emissions from biochar amended soils.

In order investigate the duration of the biochar effect on soil N_2O emissions and its susceptibility to DMPP application we performed a microcosm and field study with a high-temperature (400 ˚C) beech wood derived biochar (60 t ha^{-1} and 5 % (w/w) biochar in the field and microcosms, respectively). While the field site contained the biochar already for three years, soil and biochar were freshly mixed for the laboratory microcosm experiments. In both studies we quantified GHG emissions and soil nitrogen speciation (nitrate, nitrite, ammonium). While the field study was carried out over the whole vegetation period of the sunflower *Helianthus annuus* L., soil microcosm experiments were performed for up to 9 days at 28˚C. In both experiments a N-fertilizer containing DMPP was applied either before planting of the sunflowers or at the beginning of soil microcosms incubation. Laboratory microcosm experiments were performed at 60% water filled pore space reflecting average field conditions.

Our results show that biochar effectively reduced soil N_2O emissions by up to 60 % in the field and in the soil microcosm experiments. No significant differences in N_2O emission mitigation potential between field-aged and fresh biochar were observed for the specific biochar used in this study. N_2O emission reduction occurred even in the presence of DMPP in the field and in the laboratory microcosms. Our results suggest that simultaneous measurements of soil samples from the same field site in the laboratory yield similar biochar effects to those quantified in the field and that the mechanisms of N_2O mitigation seem to be independent of plant growth and application of the commercial nitrification inhibitor DMPP.