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Biochar suppression of N2O emissions from an agricultural soil: effects and potential mechanisms

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Biochar is biomass that has been heated in a low-oxygen environment to between 350 and 800°C that is subsequently used as a soil amendment. As well as benefits to soil fertility, biochar has potential as a tool to mitigate climate change on a large scale due to its recalcitrance, high carbon content and observed effect of reducing soil greenhouse gas emissions. Previous studies have shown that biochar-amended soil may emit less nitrous oxide (N2O) than soil alone. Our aim was to investigate the effect of fresh, hardwood biochar on N2O emissions from a clay agricultural soil from Lincolnshire, United Kingdom with a combination of field and laboratory studies. We then investigated the mechanism to try to explain the observed suppression of N2O emissions with biochar.

In biochar-amended field plots, quarterly greenhouse gas measurements over two years have recorded one occurrence of significant suppression of N2O emissions (80%), with other measurements showing generally low emissions of N2O across all treatments. In laboratory experiments, biochar suppressed N2O emissions following simulated rainfall events in a low-N agricultural soil (72 % suppression), in the same field-moist soil incubated with biochar in the field for 10 months (40 % suppression) and in a relatively high-N soil from a neighbouring field (83 % suppression).

We hypothesised that biochar amendment may suppress soil N2O emissions by increasing the water holding capacity (WHC) of the soil, thus rendering the biochar-amended soil less anaerobic compared to control soil at the same gravimetric water content. Water was added to raise soil to the same WHC (87 %) with and without biochar at a range of addition rates. Biochar significantly suppressed N2O emissions with 5 % biochar addition by 67 % and 10 % biochar addition by 98 %. We concluded that the increased WHC of biochar-amended soil could not explain the suppression of N2O emissions.

Subsequently, we formulated two hypotheses: (1) that biochar may be immobilising inorganic-N in the soil by physical or biological means; and (2) that biochar amendment may affect the activity/abundance of functional groups of soil nitrifier and denitrifiers. In this presentation, we discuss our research using 15N-labelled ammonium and nitrate to soil in order to investigate the effects of biochar on soil N transformations. We also present results demonstrating the effects of biochar amendment on the activity/abundance of microbial function groups involved in nitrification and denitrification using quantitative PCR analysis of nirK and AmO enzymes within biochar-amended soil.