Effect of biochar amendment on rice yield, soil respiration and greenhouse gas emissions from heavy metal polluted and non-polluted paddy from Tai Lake plain, China

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Recently, an urgent need for use of biochar from crop straw material as an option to mitigate climate change and improve food productivity has been raised world wide. In this study, a field trial was carried out in 2009 to compare the mutual effect of biochar application on rice yield and GHGs emission from heavy metal polluted and non polluted rice paddy from the Tai Lake plain, Jiangsu province, China. Two plots of rice fields were chosen for study. One was polluted due to with downwind emission from a metal smelter factory and the other was non-polluted in 1km distance in upwind direction. The biochar amendment was made by pyrolysis of wheat straw produced in SanLi biomass engineering company, China. it was applied at rate of 0, 10 and 40t/ha with and without nitrogen addition respectively. Yield, soil properties was determined after rice harvest and greenhouse gases emissions were monitored using closed chamber devices at 1wk interval during growing season of rice (Oryza sativa L., cv. Wuyunjing 7).

Soil pH (H_2O), soil microbial biomass carbon and total N increased and soil bulk density decreased under biochar application in both polluted and non-polluted plots without N addition, especially at higher application rate. Rice yield reached 9.5t/ha and 10.2t/ha respectively under biochar application alone, which was respectively no significantly smaller and significantly higher than that under N addition alone of the non-polluted paddy and no significant difference of polluted paddy.

The figure of GHGs emission from the rice paddy under biochar application was very complex. In non-polluted plot, no significant changes in of N_2O emission but increase in CH_4 emission was observed without N addition. Both CH_4 and CO_2 emission was significantly increased with N addition in the non-polluted plot. However, there was indeed a much significantly decrease in N_2O emission factor, showing an offsetting potential of using biochar for reducing N emission from N fertilization in agriculture. It is also very interesting that a small increase in CH_4 emission but a big decrease in total soil CO_2 emission during the whole rice growing season was observed both with and without N addition in polluted plot. There was a significant ($p<0.01$) correlation of soil respired CO_2 emission with available Cd and Pb content in the polluted plot, demonstrating that biochar amendment increased soil microbal biomass and decreased soil respiration through decreasing available Cd and Pb in polluted soil.

Biochar amendments change nutrient dynamics and microbial community structure and activity in Flemish loamy soils

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Increasing levels of greenhouse gases in the atmosphere have lead to the search for new technologies to mitigate climate change. The use of biochar, which includes all kinds of carbonized biomass types, is believed to sequester carbon (C) into soils. However the addition of biochar to soils may also change physico-chemical soil properties, microbial activity, nutrient dynamics and consequently soil productivity. Due to the excessive historic addition of manure and mineral fertilizers, Flemish soils are prone to nutrient losses, and especially nitrogen (N) leaching, with detrimental effects on the environment. We hypothesize that addition of biochar may prevent N leaching from these soils.

An incubation experiment was conducted over 98 days into two silty loamy soils, with different management histories, to which four different types of biochar were added. Biochar, prepared from either poultry litter or pine chips and combusted/pyrolized at both 400 °C and 500 °C, was added at a rate of 20 $Mg.ha^{-1}$. Every two weeks pH, mineral N (NO_3^-, NH_4^+) and plant available phosphorus (PPP) was determined. Initially and after 14, 56 and 98 incubation days cation exchange capacity (CEC) and additional soil microbial parameters, such as phospholipid fatty acid analysis (PLFA) for the microbial community structure, microbial biomass (by the fumigation-extraction method) and enzyme activities were measured.

Due to the biochar amendments nutrient cycles in these loamy soils were affected. Depending on the charring temperature and the biomass feedstock, N dynamics differed significantly among the treatments. Higher charring temperatures slowed the rate of N mineralization down. In pine wood biochar amended soils even an immobilization of N was observed. PPP increased in poultry litter amended soils, however charring temperature increase the amount of PPP. Also microbial community structure, biomass and activity were affected by the different biochar amendments. These changes were linked to the changed nutrient dynamics.

We conclude that the addition of biochar to Flemish loamy soils has a tremendous effect on soil nutrient dynamics. Especially N leaching and the accompanied environmental harm may be prevented by adding specific biochar types to these soils.