Geophysical Research Abstracts
Vol. 19, EGU2017-6581, 2017
EGU General Assembly 2017

Influence of the individual or combined application of biochar and slurry on soil macro-aggregate formation under varying moisture conditions

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The formation of aggregates is of large importance for the structure and the storage of organic matter (OM) in soil. Although positive effects of organic soil additives on the formation of macro-aggregates (> 250 μm) have been reported, the influence of biochar especially applied in combination with other organic amendments remains unclear. Furthermore, studies on the effect of varying soil moisture conditions in form of drying-rewetting cycles on soil aggregate dynamics in the presence of biochar are almost missing. The objectives of this study were to analyze the effects of biochar and slurry applied to the soil individually or in combination on the formation of macro-aggregates under constant and under varying moisture conditions.

We sampled four silty loam soils, carefully crushed the soil macro-aggregates, and incubated the soil at 15 °C for 60 days with the following additions: (i) none (control), (ii) biochar (12 % of dry soil mass), (iii) slurry (150 kg N ha-1), (iv) biochar (6 %) + slurry (75 kg N ha-1), (v) biochar (12 %) + slurry (75 kg N ha-1), (vi) biochar (6 %) + slurry (150 kg N ha-1) and (vii) biochar (12 %) + slurry (150 kg N ha-1). The samples were further subdivided into two groups that were incubated under conditions of constant soil moisture and of three drying-rewetting cycles. The CO_2 fluxes were continuously measured during the incubation period and the samples were analyzed for microbial biomass C, macro-aggregate yields and macro-aggregate-associated C after finishing the experiment.

We found the application of biochar to result in lower macro-aggregate yields with or without slurry compared to the control or the individual slurry application. In contrast, similar or higher C contents in the macro-aggregate fraction of the biochar treatments as compared to the control or slurry treatments were found indicating an occlusion of biochar in macro-aggregates. Due to the sorption characteristics of biochar, we assume the aggregate formation to be partially abiotic with direct interactions between biochar, (adsorbed) slurry, and the mineral phase of the soil. Therefore, in the presence of slurry, a prolonged period of microbial processing does not seem to be necessary to render the biochar suitable to form aggregates.

Drying and rewetting of the samples resulted in significantly lower aggregate yields especially for the biochar/slurry mixtures. The drying of slurry as thought to be the most important macro-aggregate binding agent in these treatments might irreversibly disrupt large amounts of the macro-aggregates formed. Additionally, the general lower microbial biomass C and CO_2 emissions for the samples experiencing drying-rewetting cycles compared to the constantly moist soils point toward less microbial activity under varying moisture conditions. This might have led to less microbial derived aggregate binding agents contributing to the lower aggregate yields found for the samples from the drying-rewetting treatments.

Beside the amount and type of binding agents derived from organic soil additives, the formation and stability of soil macro-aggregate seem also to be controlled by climatically controlled soil moisture conditions.