Geophysical Research Abstracts
Vol. 14, EGU2012-6432-1, 2012
EGU General Assembly 2012

Biochar application to temperate soils - effects on soil fertility and crop yield

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Biochar (BC) application to soil as a potential soil amendment is currently intensively explored. Depending on feedstock and highest treatment temperature (HTT), BC application to soil may contribute to the soil nutrient status by directly adding nutrients to the soil as well as by increasing pH, cation exchange and water holding capacity. These parameters are known to play an important role in the soil nutrient status and nutrient availability. A positive effect on plant growth after BC application to tropical soils has been observed repeatedly; however, the effect of BC application to soils in temperate climate regions is much less explored.

We investigated the effect of BC to temperate soils and crop yield using a randomized pot experiment in a greenhouse with three agricultural soils (Planosol, Cambisol, Chernozem) and four BC types (from straw, mixed woodchips and vineyard pruning, all pyrolyzed at 525°C). In order to analyze the effect of pyrolysis temperature, we additionally applied vineyard pruning BC pyrolyzed at 400°C. Selected treatments were planted with mustard (Sinapis alba L.), followed by barley (Hordeum vulgare). Soil sampling was carried out after barley harvest. Investigated soil parameters included pH, electrical conductivity (EC), C/N ratio, cation exchange capacity (CEC), CAL-extractable P and K, EDTA extractable Cu, Fe, Mn, Zn as well as nitrogen supplying potential (NSP). Biomass production of the two crops was determined as well as its elemental composition.

Biochar application (3% wood-based BC) caused a considerable pH increase for the acidic Planosol. The effect of BC application on CEC was dependent on the original status of the soil, notably soil pH and texture. 3 % BC application (wood) decreased CEC by 3.5 % and 10 % for the Chernozem and Cambisol, respectively, but increased CEC by 35 % for the acidic, sandy Planosol, which may be due to the strong liming effect found for the Planosol. BC application significantly raised CAL-extractable K for all soils. CAL-extractable P only increased in the Planosol and Cambisol at 3% application rate.

Mustard yield decreased by 67% for vineyard pruning BC if nitrogen deficiency was not compensated for, straw-derived BC only caused a 2 % decrease of mustard yield. Barley yield was still significantly lower in most BC-treated pots compared to the controls, however, plant yields were less reduced for the second crop. Only straw-derived BC treatments showed a significantly higher barley yield (1955 $\pm$ 40 g m-2) compared to the control (1837 $\pm$ 70 g m-^{2}).

The results of the elemental composition of the barley grains showed that Al uptake in the Planosol significantly decreased after application of wood and straw BC, which may be due to the pH increase after BC application. In addition, Ca uptake in barley grains was significantly higher in the 3% wood BC treatment compared to the control. This may be caused by a higher Ca content of the wood BC as revealed by XRF. Mn uptake, on the other hand, was significantly reduced after BC application.