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Soybean Nutrient Uptake and Plant Symbionts are Influenced by Biochar

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Biochar incorporation into soil changes its physical and chemical properties, and thus the habitat of the autochthonous soil microbial community. After the decomposition of the remaining condensates on the surface of biochar, it shows often an inert character with pores and surfaces which may be colonised effectively by microorganisms. Biochar absorbs inorganic and organic compounds and was found to influence N transformation in soil directly. However, it is not clear if the adsorbed compounds serve as nutrients, if the porous biochar increases nutrient immobilization or provides protected niches for plant symbionts such as arbuscular mycorrhiza fungi (AMF), which may provide the nutrients to plants, or a combination of all mechanisms. In this study, biochar effects on soybean performance, its nutrient uptake and the abundance of plant symbionts were investigated in a mesocosm experiment.
Four soils, chosen for representativeness in terms of microbial activity and pH of mineral soils under arable land use, were amended with four distinct biochars equivalent to an application rate of 20 t/ha. After an incubation period of two months soybean seedlings were planted and grown for 8 weeks. The biochars, produced by either pyrolysis at 700˚C (pyrochar) or hydrothermal carbonization (HTC, hydrochar), originate from two feedstocks, woodchips (Wood) and *Zea mays* (Maize). The woodchips were chosen as a commercially representative feedstock, whereas the *Zea mays* feedstock is artificially enriched in its ^{13}C and ^{15}N isotope content for carbon and nitrogen flux determination. Parameters measured were plant biomass, root nodule biomass, root AMF colonization, microbial biomass, microbial biomarkers PLFA and plant and soil nutrient content. Stable isotope analysis of C and N were conducted where feasible.
The results show clear patterns in respect to the different soils and biochars used. Effects were most abundant in the soils low in pH or with high microbial activity. Marginal significant differences of the biochar treatments against the control could be found in the soils with high pH or low microbial activity. Although plant biomass was almost not affected by biochar treatment, plant symbionts showed high response especially to hydrochar treatments. Root nodule biomass in hydrochar$_{Maize}$ treated soils was 2.3-7.8 times higher than in the control. In the low pH soil AMF root colonization was increased by all biochar treatments, whereas in the high pH soil no differences were detected. Stable isotope analysis on PLFA data showed that several microbial groups incorporated biochar derived C, interestingly a clear signature of hydrochar$_{Maize}$-C was found in the AMF biomarker 16:1ω5. This may underline a partly saprophytic nature of AMF and suggests growth on hydrochar particles. The ^{15}N signature in the plant tissue leaves no doubt that at least parts of biochar-N of both types are available to plants. The study shows that biochar affects various components of the plant-soil system. The influences are very complex and depend on soil and biochar characteristics. Biochar may, but must not enhance plant symbionts and plant nutrient uptake, the outcome depends on the biochar soil combination.