Impact of pyrochar and hydrochar on soybean (Glycine max L.) root nodulation and biological nitrogen fixation

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The aim of this study was to identify effects of carbonized organic material (biochar) on soybean growth, root nodulation and biological nitrogen fixation, and to elucidate possible underlying mechanisms. Soybean (Glycine max L.) was grown in four arable soils amended with carbonized organic material produced from wood or maize as feedstocks, by pyrolysis (pyrochar) or hydrothermal carbonization (hydrochar). Nodulation by Bradyrhizobium, biological nitrogen fixation (BNF) assessed by N-15 techniques, plant growth, nutrient uptake and changes in chemical soil properties after soil amendment were determined. Data were analyzed by means of a three way ANOVA on the factors soil, carbonization technique and feedstock. It turned out that soybean root nodulation and BNF was influenced by the carbonization technique used to prepare the soil amendment. Hydrochar, in average and across all soils, increased nodule dry matter and BNF by factors of 3.4 and 2.3, respectively, considerably more than pyrochar, which led to 1.8 and 1.2 fold increases, respectively. Nodule dry matter and BNF correlated positively with available soil sulfur and negatively with available soil nitrogen. Hydrochars provided more available sulfur than pyrochars, and hydrochars caused a decrease in nitrogen availability in the soil solution, thereby exerting a positive influence on nodulation and BNF. Pyrochar amendment increased soil pH but had no effect on nodulation and BNF. Plant growth was affected by the soil and by the feedstock used for the biochar, and increased slightly more in treatments with pyrochar and hydrochar made from maize, which was richer in nitrogen and potassium. The results show that carbonized organic materials, and specifically hydrochar, have the capacity to increase BNF in soils. We suggest that this enhancement in BNF in response to soil amendments with carbonized organic materials is due to an increase in available sulfur and a reduction of available soil nitrogen.
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