Direct and Indirect Short-term Effects of Biochar on Physical Characteristics of an Arable Sandy Loam

Biochar addition to agricultural soil is reported in several studies to reduce climate gas emissions, boost carbon storage, and improve soil fertility and crop productivity. These effects may be partly related to soil physical changes resulting from biochar amendment, but knowledge of how biochar application mechanistically affects soil physical characteristics is limited. This study investigated the effect of biochar application on soil structural and functional properties, including specific surface area, water retention, and gas transport parameters. Intact soil cores were taken from a field experiment on an arable sandy loam that included four reference plots without biochar and four plots with 20 tons ha(-1) biochar incorporated into the upper 20 cm 7 months before sampling. Water retention was measured at matric potentials ranging from wet (pF 1.0) to extremely dry conditions (pF similar to 6.8), whereas gas transport parameters (air permeability, k(a), and gas diffusivity, D-p/D-o, where D-p is the gas diffusion coefficient in soil and D-o is the gas diffusion coefficient in free air) were measured between pF 2.0 and 3.0. Water retention under dry conditions and measured specific surface area were not significantly greater in the biochar-amended soil than the reference soil probably because of the relatively low biochar application rate. Yet, the biochar-amended soil showed a significant decrease in soil bulk density and an accompanying increase in total porosity. Water retention and air-filled porosity (epsilon) were both markedly greater in the biochar-amended soil than in the reference soil between pF 1.0 and 3.0. Soil macroporosity (equivalent to >0.1 mm pore diameter) and the ratio of macroporosity to total porosity were also significantly greater in the biochar-amended soil. As a result, the level of the pore organization (PO, k(a)/epsilon) was greater in the biochar-amended soil. Across the tested matric potentials, biochar amendment caused average increases of 28 to 34% in epsilon, 53 to 161% in D-p/D-o, and 69 to 223% in k(a), with the most significant increases occurring around natural field capacity (pF 2.0). Overall, the results suggest that biochar application even at a relatively low rate can alter soil functional characteristics, especially under normal field moisture conditions.