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Why biochar application did not improve the soil water retention of a sandy soil: An investigation into the underlying mechanisms.

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Biochar application to soil is currently being widely touted as a means to improve soil quality and to enhance the provision of numerous ecosystem services, including water storage, in soils. However, evidence for hydrological effects in the primary literature remain inconclusive with contradictory effects reported. The mechanisms behind such contradictory results are not yet elucidated. As such we aimed to investigate the effects of biochar on soil water retention and infiltration, as well as the underlying mechanisms. To do so we set up two field experiments with biochar produced from herbaceous feedstock through slow pyrolysis at two temperatures (400°C and 600°C). In the first experiment both biochars were applied at a rate of 10 t ha-1 to separate plots in a sandy soil in a North European grassland. In a separate experiment, the biochar produced at 400°C was applied to a different set of plots in the same grassland at rates equivalent to 1, 5, 20 and 50 t ha-1. Soils from these experiments were analysed for soil water retention and infiltration rate as well as aggregate stability and other soil physical parameters. The pore structure of the biochar was fully characterised using X-ray computed micro-tomography (XRT) and hydrophobicity determined using contact angle measurements. There were no significant effects of biochar application on soil water retention, field saturated conductivity or aggregate stability in either experiment. XRT analysis of the biochars confirmed that the biochars were highly porous, with 48% and 57% porosity for the 400°C and 600°C biochars, respectively. More than 99% of internal pores of the biochar particles were connected to the surface, suggesting a potential role for biochars in improving soil water retention. However, the biochars were highly hydrophobic as demonstrated by the high contact angles when water was applied. We suggest that this hydrophobicity greatly diminished water infiltration into the biochar particles, prohibiting an effect on soil water retention. Our results indicate that, in addition to characterizing pore space, biochars should be analysed for hydrophobicity when assessing their capacity for improving soil physical properties.