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Effect of Organic Matter from Energy Recovery Processes on Soil Water Retention Characteristics: A Field-Scale Assessment of Digestate and Biochar Applications

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Abstract

Modern agriculture increasingly emphasizes the recycling of organic residues generated after energy recovery. Materials such as digestate from anaerobic fermentation and biochar produced via pyrolysis represent promising soil amendments capable of improving soil quality and enhancing its water retention capacity. Several studies have confirmed their positive effects on soil organic matter content, soil structure and aggregate stability (Šimanský et al., 2016), as well as soil retention characteristics (Igaz et al., 2018). Improving soil water retention properties is therefore considered an important strategy for increasing the resilience of agriculture to drought and climatic variability. The aim of this study was to comprehensively evaluate the effects of organic matter after energy recovery on soil retention characteristics through two field experiments focused on digestate and biochar. The results demonstrated a markedly different impact of the tested materials on soil water regime. Digestate from anaerobic fermentation significantly increased soil water content at all matric suction levels and raised field water capacity to 1200 m^3 ha^{-1} compared with the control (1110 m^3 ha^{-1}), whereas slurry application reduced soil water retention to 900 m^3 ha^{-1}. In contrast, biochar influenced soil water content in a more differentiated manner depending on matric suction and application rate, with significant increases observed mainly at lower and intermediate matric potentials and at higher doses combined with nitrogen fertilization; field water capacity increased from 924 m^3 ha^{-1} in the control to 1040 m^3 ha^{-1} under the 20 t ha^{-1} biochar treatment. The obtained results confirm that organic materials after energy recovery can significantly influence soil retention characteristics, with their effects strongly depending on material type and soil conditions. Digestate appears more effective in overall enhancement of soil water holding capacity, while biochar acts more selectively, particularly by improving water availability in the upper soil layers. These findings highlight the importance of targeted application of these amendments as a tool for improving soil hydrophysical properties and enhancing the resilience of agroecosystems to drought.

Keywords: digestate, biochar, soil water retention characteristics, field water capacity, hydrophysical soil properties, sustainable agriculture