Turning date palm waste into biochar for improved soil hydro-physical characteristics and tomato (*Solanum lycopersicum* L.) growth under varying irrigation in calcareous sandy soils

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Improving soil health, water conservation, and crop productivity is of critical importance for sustainable agricultural development, especially in arid and semi-arid regions. Biochar has attracted a huge attention of the researchers as a potential soil amendment to improve soil hydro-physical characteristics for sustainable water management in arid and semi-arid areas to boost crop productivity. However, limited studies are available to investigate effects of biochar application of soil water storage and plant water composition. Therefore, the effectiveness of date palm waste-derived biochar in improving soil hydro-physical properties and tomato growth was explored in lab-scale and greenhouse trials. Date palm tree was turned into biochar through pyrolyzing at 300°C (BC3), 500°C (BC5), and 700°C (BC7) and separated into various size fractions i.e., D0.5 (<0.5 mm), D1 (0.5–1 mm), and D2 (1–2 mm). Calcareous sandy soil was filled in columns, where top 10 cm of soil layer was mixed with the produced biochars at application rates were 1%, 2.5%, and 5% along with a control (without biochar). Thereafter, the columns were irrigated with 25 cm^3 water per week for 6 weeks to complete 6 wetting–drying cycles. Results demonstrated that the saturated hydraulic conductivity was decreased, whereas, cumulative evaporation increased with biochar application. Application of BC3 and BC5 resulted in 10.2% and 13.3% higher cumulative evaporation, respectively, while BC7 reduced the cumulative evaporation. On the other hand, $D_{0.5}$, D_1 and D_2 resulted in 5.0%, 7.7% and, 7.8% increase in cumulative evaporation, respectively as compared to control. Thereafter, the effectiveness of the produced biochar on soil water conservation, water infiltration, salt-distribution, and tomato growth was explored in pot trials (4% application rate of biochar) under regulated deficit irrigation (RDI: 40%, 60%, and 80% of ETc) and partial root drying (PRD) system by using fresh and saline water. Biochar application resulted in 5.48%–8.11% increment in soil moisture than control (where soil moisture level decreased by 24.95%–27.38%). Soil salinity was in the range of 0.5–1.4 dSm^{-1} under biochar applications as compared to control (0.7–2.1 dSm^{-1}). Cumulative infiltration after one minute was 1.89–2.79 cm and 1.74–2.79 cm under biochar treatments and control, respectively, while, infiltration rate was 0.98–2.63 cm min^{-1} and 1.48–1.68 $cm.min^{-1}$ for fresh and saline water, respectively. Overall, biochar application significantly improved the hydro-physical characteristics of sandy soil, subsequently enhancing water conservation and boosting tomato plant growth.