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Rhizobacteria Mediated Changes in Soil Physical and Hydrological Properties

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Large communities of microbes are associated with plant roots in the rhizosphere, which is a critical interface supporting the exchange of water and nutrients between plants and their associated soil environment. The diverse communities of rhizobacteria mediate plant-soil feedback through a multitude of interactions including those that contribute to plant abiotic stresses. For example, enhancement of plant drought stress tolerance by plant growth promoting rhizobacteria (PGPR) has been increasingly documented in the literature, however, investigations to date have been largely focused on PGPR-root/plant interactions and related plant responses to PGPR activities that induce drought tolerance. Comparatively, much less is known about PGPR's role in mediating physiochemical and hydrological changes in the rhizospheric soil that may also impact plant drought stress tolerance. Using UD1022, aka Bacillus subtilis FB17, as a model bacterium, we demonstrated via soil water characteristic measurements that UD1022-treated soil samples retained more water, had lower hydraulic conductivity than its controls. In addition, we investigated the effects of UD1022 on soil water evaporation via combined neutron radiography, neutron tomography, and X-ray tomography imaging techniques. Neutron radiography images confirmed greater water retention in UD1022-treated soil samples than their controls due to reduced water evaporation. Combined neutron and X-ray tomography 3D images revealed that water distribution in UD1022-treated soil samples was heterogeneous, i.e., there were more disconnected water pockets compared with the controls where water was distributed more uniformly. Our study provides pore-scale mechanistic explanation for increased water retention and reduced evaporation rate from UD1022-treated soil samples, which is mainly attributed to the production of extracellular polymeric substances (EPS) by UD1022 due to EPS' hygroscopic and chemical properties (viscosity and surface tension). However, our latest experiments showed similar effects by a UD1022 mutant with eps-producing genes removed, suggesting that the beneficial impacts of rhizobacteria may not be limited to their ability to EPS production alone. These findings have practical implications in, for example, "rhizosphere engineering" to improve/restore soil structure, support sustainable agricultural production, and mitigate climate change.