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Influence of contrasting plant exudate and mucilage compounds on soil water retention, hysteresis and transport

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Plants release a range of different compounds to soil including ‘hydrogels’ in seed mucilage and surface active compounds in root exudates. Two studies exploring the impacts of these compounds on soil hydraulic properties will be reported. In the first study, rhizodeposits collected by hydroponics from maize or barley, or by washing mucilage from chia seeds, were amended to soils at 0.46 and 4.6 mg g-1 concentration. Wetting and drying limbs of the soil water retention characteristics were measured by equilibrating soils over polyethylene glycol in dialysis tubing. Chia seed mucilage and maize rhizodeposits increased water retention and hysteresis considerably, behaving as hydrogels that may decrease water stress to plants. There was a contrasting impact from barley rhizodeposits, which decreased water retention and hysteresis. The differences could be explained from the physical properties of the rhizodeposits and mucilage. All had smaller surface tensions than water, but barley was by far the most surface active. Chia had the greatest surface tension and its viscosity was over two orders of magnitude greater than barley and maize.

In the other study, tensiometer and TDR probes were used to measure soil water characteristics of soils amended with either chia seed mucilage at 1.84 mg C g-1 dry soil, root exudate compounds at 14.4 mg C g-1 dry soil, or no amendment. Samples were packed in cores either homogeneously or in two different treatment layers, and placed on a suction table at -50 kPa that simulated a hydraulic gradient induced by a plant root. If layered samples were used, the amended layer was at the base and a no amendment layer above it. This was to simulate, in an up-scaled physical model, the effect of localised deposition of rhizodeposits on soil water dynamics further into surrounding bulk soil. Chia mucilage slowed water desorption, explained by its greater viscosity. In a layered sample, this resulted in 13% greater water content in surrounding bulk soil after 160 hours desorption. Root exudate compounds resulted in a slightly greater loss of water at a given water potential compared to soils with no amendment. Hydraulic conductivity was calculated from the TDR and tensiometer data. Near saturation, soils amended with root exudate compounds had greater hydraulic conductivity compared to no amendment, whereas chia seed mucilage amended soils had a lower hydraulic conductivity. As the soils drained, the calculated hydraulic conductivity converged between treatments, with insignificant differences and a large amount of error.

These two studies consistently show contrasting impacts between root exudates from different plant species, and between root exudates and seed mucilages. Whereas seed mucilage and some rhizodeposits may attenuate plant water stress by modulating water storage in seed amended layer, rhizodeposits from other species may act as surfactants that ease water capture by plants. These data and XRay CT imaging have been used to parameterise pore scale models to simulate rhizosphere water dynamics.