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Effect of root activity on soil hydraulic properties

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We studied how root activity modifies the structure and water retention characteristic of soil adjacent to the root for maize, wheat and barley. These plants were grown in pots for a 6-week growth period, then the soil adjacent to the root (rhizosphere soil) and bulk soil aggregates were harvested. These soil aggregates were then saturated and equilibrated at matric potentials between -600 kPa and saturation, and the water retention characteristics were measured. From sub-samples of these aggregates, thin sections were made and the porosity and pore-size distributions were studied with image analysis. Both image analysis and estimates of aggregated density showed that the rhizosphere soil and bulk soil had similar porosities. Growing different plants had a small but significant effect on the porosity of the soil aggregates. Image analysis showed that for all the plant species the structure of the rhizosphere soil was different to that of the bulk soil. The rhizosphere soil contained a greater number of larger pore sizes. For maize and barley, water retention characteristics indicated that the rhizosphere soil tended to be dryer at a given matric potential than bulk soil. This effect was particularly marked at greater matric potentials. The difference between the water retention characteristics of the bulk and rhizosphere soil for wheat was small. We compare the water retention characteristics with the data on pore-size distribution from image analysis. We suggest that differences in wetting angle and pore connectivity, in addition to changes in pore geometry may explain the differences in water retention characteristic that we observed. Attempts to model the soil structure using the pore-scale network model Pore-Cor suggested that changes to hydraulic properties were controlled by modifications to the pore throats with little change to pore bodies within the aggregates. This deduction however proved inconsistent with thin section image analysis. Further, the images obtained indicated a pore structure with larger pores embedded in a matrix of smaller pores. This is incompatible with the simple cubic array

model adopted in PoreCor. Consequently we conclude that the PoreCor analysis in this instance does not provide an accurate reflection of structural changes occurring in the soil aggregates studied.

The physical characteristics of the soil at the root-soil interface are crucial because they determine both physical aspects of root function such as water and nutrient uptake as well as the microbial activity that is most relevant to root growth. However, root penetration modifies the soil in the rhizosphere, which affects the transport and retention of water. To study the transport of water from the bulk soil to the root we developed a soil microcosm in which to grow roots that allowed easy access to the soil for our infiltration measurements. The infiltration of water through small circular areas into the rhizosphere, where roots had penetrated, and into bulk soil, was measured at negative pressures of -1, -2 and -3 hPa. The infiltration data was used to obtain sorptivity values and an estimate of the hydraulic conductivity of saturated soil. At a given negative pressure the infiltration of water was less through soil which had been deformed by root growth than through bulk soil. To explain these differences we consider how changes in soil density and the effect of root mucilage might influence infiltration into soil. Our data suggested that changes in the density of soil at the root-soil interface are responsible for the changes to its hydraulic properties.

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