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Soil penetration resistance affected by root exudates

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The mechanical properties of soil and mucilage have a significant effect on root penetration resistance which can become a limiting factor for root growth in dry and compacted soils. Our hypothesis is that the way how root exudates alter penetration resistance in soil is controlled by the interplay of two mechanisms: on the one hand mucilage stabilizes the soil resulting in an increased penetration resistance, on the other hand mucilage holds water, which tends to reduce soil penetration resistance. To quantitatively test our hypothesis we consider fine-grained soil, a needle which has 30° apex angle and another needle with 60°. The needles are used for the penetration of the soil, which is used to simulate the plant root growth in the real condition. Chia seed mucilage was used in the study to mimic the effect of root mucilage. The growth of root was simulated by penetrating the needles at constant speed into the soil using a rheometer. Measurements were repeated for various water contents, compactions and at various mucilage concentrations (0%, 0.1%, 0.3%, 0.5%).

Our experiments show that the concentration of the mucilage affects penetration forces significantly in the soils. Penetration forces are significantly less in the soils for low concentration mucilage (0.1%) and high in the higher concentration mucilage (0.5%). This may be because higher concentration of mucilage stabilizes the loose soil by binding the soil particles together. While the low concentration mucilage softens the soil mass due to the presence of more water and in this way reduces the penetration forces. Results also show the penetration resistance is also significantly affected by root geometry. The 60° needle experienced higher penetration resistance than the 30° needle when the soil is dry and the density of the soil is low. The 30° needle experienced higher penetration resistance than the 60° when the soil wet and the density is high.