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How root exudates alter soil penetration resistance to root growth

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Mechanical properties of the rhizosphere soil are continuously altered by the movement of earth worms, plant roots, water and microorganisms. When soil is very dry and compacted, soil penetration resistance can become a limiting factor for root growth rate. There are many studies on the effect of soil properties on soil penetration resistance, yet only little is known about how mucilage affects soil mechanical properties. Our hypothesize is that root exudates reduce soil stability in the immediate vicinity of the root and as a lubricant reduce the friction during root growth.

To quantitatively test our hypothesize we measured the penetration resistance offered by the soil under varying conditions like soil type, water content of the soil, bulk density of the soil and for various exudates, from chia, maize and wheat seeds. Growth of plant roots are simulated by penetration of metal needles with a 30º and 60º cone using rheometer equipment. (1) Penetration resistance offered by the soil depends on the type of soil itself. So, in our study we try to analyse three types of soil obtained from three different sites. All three soil types are fine grained soils. (2) Since the soils used in our study are fine grained soils, wetness and dryness of the soil has large impact on penetration resistance offered by them. A mini compaction apparatus is used to vary water content and bulk density of the soil. Penetration resistance is measured at every case of water content and bulk density. (3) Experiments are conducted in two different ways: firstly, the penetration resistance is measured with soils by injecting mucilage into the path of root penetration before the experiments. Secondly, the penetration resistance is measured simultaneous exuding mucilage into the path of root penetration during penetration experiments. This is achieved by using hallow hypodermic needle with controllable exudation rates.

In future studies we plan to combine our experiments with simulations of the coupled mechanical and hydraulic dynamics in the immediate vicinity of the roots. A better understanding of the mechanics during root growth and how it is affected by root exudates might eventually help to select plant varieties for specific mechanical soil conditions.