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How mucilage may affect nutrient diffusion in the drying rhizosphere

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Despite detailed investigations on the distinct biochemical properties of the rhizosphere and their effects on the availability of nutrients for plants, their biophysical aspects, particularly the effect of mucilage on the transport of water and nutrients are poorly understood. The aim of this study was to investigate the effect of mucilage on the diffusion coefficient of nutrients and consequently their transport in the soil and into the plant roots.
Repeated phosphor imaging was used to monitor the temporospatial distribution of 137Cs (as an analog of K) within a modeled rhizosphere soil with and without mucilage (a sandy soil amended with mucilage extract from chia seed) under different soil water contents. The monitored profiles of activities were used to estimate the diffusion coefficient of soils with and without mucilage by solving a diffusion equation. Assuming an identical the effect of mucilage on diffusion coefficient of Cs and K, a diffusion-convection equation was numerically solved to predict the transport of K within the soil and its uptake by a single plant root during a soil drying cycle. To this end, the hydraulic and diffusive properties of the soil were parameterized based on the measured data and the K uptake and its concentration in soil were taken from literature data.
The results of this study suggest that mucilage in the rhizosphere keeps the rhizosphere wetter and maintains the connectivity of the liquid phase during a soil drying cycle, and thereby could prevent a marked drop in the diffusion coefficient. The results of modeling of nutrient uptake by a single root showed that the presence of mucilage in the rhizosphere could favor nutrient uptake by the plant root. In the case of nutrients with low concentration in the soil solution, it prevents a marked concentration drop in the vicinity of the root as the soil dries and diffusion becomes restricted. This will delay the risk of nutrient deficiency to the plant root. In the case of nutrients with a high concentration in the soil solution, the presence of mucilage in the rhizosphere may delay the risk of salinity stress as the soil dries and the concentration of nutrients increases at the vicinity of the root surface.
In conclusion, the results of this contribution show that mucilage may favor the transport of nutrient within the soil and their uptake by plant roots under drying soil condition.