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Kommission I: Bodenphysik und Bodenhydrologie

Wurzel-Boden-Wechselwirkung und physikalische Prozesse in der Rhizosphäre

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Titel

Wettability of natural root mucilage studied by atomic force microscopy and contact angle: Links between nanoscale and macroscale surface properties

Abstract

Organic coatings are considered as main cause of soil water repellency (SWR). This phenomenon plays a crucial role in the rhizosphere, at the interface of plant water uptake and soil hydraulics. Still, there is little knowledge about the nanoscale properties of natural soil compounds such as root-mucilage and its mechanistic effect on wettability. In this study, dried films of pure and diluted natural root-mucilage from Sorghum (Sorghum sp., moench) on glass substrates were studied in order to explore experimental and evaluation methods that allow to link between macroscopic wettability and nano-/microscopic surface properties in this model soil system. SWR was assessed by optical contact angle (CA) measurements. The nanostructure of topography and adhesion forces of the mucilage surfaces was characterized by atomic force microscopy (AFM) measurements in ambient air, using PeakForce Quantitative Nanomechanical Mapping (PFQNM). Undiluted mucilage formed hydrophobic films on the substrate with CA > 90° and rather homogeneous nanostructure whereas the contact angles of diluted samples were < 90°. AFM height and adhesion images displayed incomplete mucilage surface coverage for diluted samples. Hole-like structures in the film frequently exhibited increased adhesion forces. The spatial analysis of the AFM data via variograms enabled a numerical description of such ‘adhesion holes’. The use of geostatistical approaches in AFM studies of the complex surface structure of soil compounds was considered meaningful in view of the need of comprehensive analysis of large AFM image data sets that exceed the capability of comparative visual inspection. Furthermore, force curves measured with the AFM showed increased break-free distances and pull-off forces inside the observed ‘adhesion holes’, indicating enhanced capillary forces due to adsorbed water films at hydrophilic domains for ambient RH (40 ± 2 %). This offers the possibility of mapping the nanostructure of water layers on soil surfaces and assessing the consequences for wettability. The collected information on macroscopic wetting properties, nanoscale roughness and adhesion structure of the investigated surfaces in this study are discussed in view of the applicability of the mechanistic wetting models given by Wenzel and Cassie-Baxter.