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Imaging and characterization of crop root systems using electrical impedance tomography at the rhizotron scale

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A better understanding of root-soil interactions and associated processes is essential to achieve progress in crop breeding and management, prompting the need for high-resolution and non-destructive characterization methods. To date such methods are lacking, in particular for characterizing root growth and function in the field. A promising technique in this respect is electrical impedance tomography (EIT), which utilizes low-frequency electrical conduction and polarization properties of the subsurface in an imaging framework. We investigated the capability of EIT to image crop root systems in a series of laboratory rhizotron experiments. Multi-frequency (450 mHz – 45 kHz) EIT data were collected with the tomographic acquisition system EIT40 over a span of 3 days with a high temporal resolution, and the corresponding EIT images were computed using the complex resistivity inversion code CRTomo. The electrical imaging results, including derived parameters describing the spectral response, exhibit a good agreement with the plant structure observed via photographs. Also, the polarization effects show a steady decline which corresponds to physiological processes within the root system due to a deficit of nutrients in the rhizotron (also evident in the photographs). The results demonstrate the non-invasive capability of EIT to image root systems at the rhizotron scale and suggest that EIT can be developed as a tool for imaging, characterizing and monitoring of crop roots at the field scale. The presented work is part of the subproject ImpTom funded by the DFG within the research unit FOR 1320 "Crop Sequence and Nutrient Acquisition from the Subsoil".