KEYNOTE LECTURE: Monitoring crop root systems using electrical impedance tomography

Maximilian Weigand[1], Egon Zimmermann[2], Johan Alexander Huisman[3], Andreas Kemna[1]

(1) *Department of Geophysics, Steinmann Institute, University of Bonn, Germany*
(2) *Electronic systems (ZEA-2), Central Institute for Engineering, Electronics, and Analytics, Forschungszentrum Jülich, Germany*
(3) *Agrosphere (IBG-3), Institute of Bio- and Geosciences, Forschungszentrum Jülich, Germany*

keywords: crop root systems, SIP, EIT

In recent years, interest in using geophysical methods for the non-invasive investigation of plant roots has reemerged and led to a wave of studies based on geophysical methods developed for hydrogeophysical applications. We here propose to use low-frequency (mHz to kHz) electrical polarization measurements to infer structural and functional information on crop root systems. Based on the polarization of electrical double layers (EDLs) at various biological membranes, we hypothesize that the magnitude of polarization relates to the overall surface area of EDLs in root systems. Furthermore, based on fundamental assumptions on EDL polarization, we assume that characteristic relaxation times can be linked to characteristic length scales of the polarized structures. Combined with the knowledge that nutrient dynamics and other physiological reactions influence the structure of EDLs in bio matter this provides us with a unique link to characterize and monitor not only the structure, but also the physiological function of root systems in-situ.

To highlight this potential of multi-frequency electrical impedance tomography (EIT) for root research we then present recent time-lapse imaging results from controlled laboratory experiments. In this context we discuss current shortcomings and challenges of measuring root systems on the laboratory scale. Following this, we present the setup and preliminary analysis of a full-season field monitoring experiment using multi-frequency EIT, installed in a maize test field. We discuss approaches to analyze and interpret such results, as well as the technical framework necessary to manage and analyze the huge amounts of data.

We conclude that electrical polarization measurements offer unique possibilities for the non-invasive characterization and monitoring of crop root systems, both in the laboratory and the field scale. Improvements in data acquisition techniques and analysis procedures required to succeed in the biogeophysical field are beneficial to the whole electrical monitoring community, besides offering an additional, urgently needed non-invasive investigation method for the root research community.