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Electrical signature of roots systems

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The properties and processes of plant roots and their rhizosphere control such critical factors as water and nutrient transport, soil carbon and nutrient dynamics, and soil microorganisms. Accurate measurement of their properties and processes is therefore of great importance and is highly challenging. Geoelectrical methods, such as the spectral induced polarization (SIP) method, hold great promise as non-invasive tool for monitoring the subsurface. Utilization of SIP for studies of roots and the rhizosphere requires a deep understanding of the mechanisms governing their SIP response. Gaining and applying such understanding is the objective of this study.

We measured the SIP signature (1 mHz to 10 KHz) of wheat roots systems in nutrient solution (hydroponic) and in soil. In the first case, we used 30-day-old wheat grown in a commercial growing medium, we washed out the growing medium and placed the root in an experimental column filled with the nutrient solution. After allowing 24 hr for equilibration, we measured the SIP signal. Immediately after this measurement we removed the plant from the medium, cut off part of its root system, and returned the remaining root to the column for another measurement. We repeated this procedure 3 times until no roots remained. In the second case, we filled two columns (3 cm diameter, 30 cm long) with a sandy loam soil. We planted a 5-day-old wheat seedling in one column, and irrigated both columns with nutrient solution. The columns were then transferred to an environmental chamber. At 9, 11 and 14 days after planting we saturated both columns with the nutrient solution, and measured SIP.

In the nutrient solution, quadrature conductivity was significantly increased in the presence of roots. The polarization correlated positively with the amounts of root in the solution. In addition, relaxation frequency increased from $\sim$2.7 Hz for a 9.8-g root sample to $\sim$10 Hz for the whole root system (27.5 g). The observed increase in polarization due to the presence of roots is in agreement with other works. It is reasonable to suggest that the observed changes in relaxation frequency are correlated with changes in the root diameter, but this possibility needs to be further examined.

In soil, the results suggest that the in-phase conductivity was not affected by the presence of roots. In all measurements, the magnitude of the low-frequency polarization (up to 10 Hz), was lower when root was present. This was a non-intuitive finding, as the root itself contributes to the polarization. One possible explanation is that organic carbon secreted by the roots changes the physicochemical properties of the mineral surface, with a resulting decrease in soil polarization. Overall, these preliminary results demonstrate the sensitivity of the SIP method to the presence and activity of roots, and the impact of roots on soil electrical signature.