Characterization of Electrical Properties of Root Segments Using Resistivity Method

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Motivation

Challenges- The root system represents the hidden half of the plant which plays a key role in food production and therefore need to be well understood. Root investigation has been a great challenge because they are buried with limited access, coupled with the subsurface heterogeneity and the transient nature of the processes in the root zone. The traditional method of root studies such as point sampling often disturbs the natural system under investigation and does not account for the transient nature and spatial variability of the root zone. Root mass density (RMD**)** correlated with Bulk electrical resistivity from ERT but failed to account for the individual root segments and their contribution to the bulk electrical resistivity.

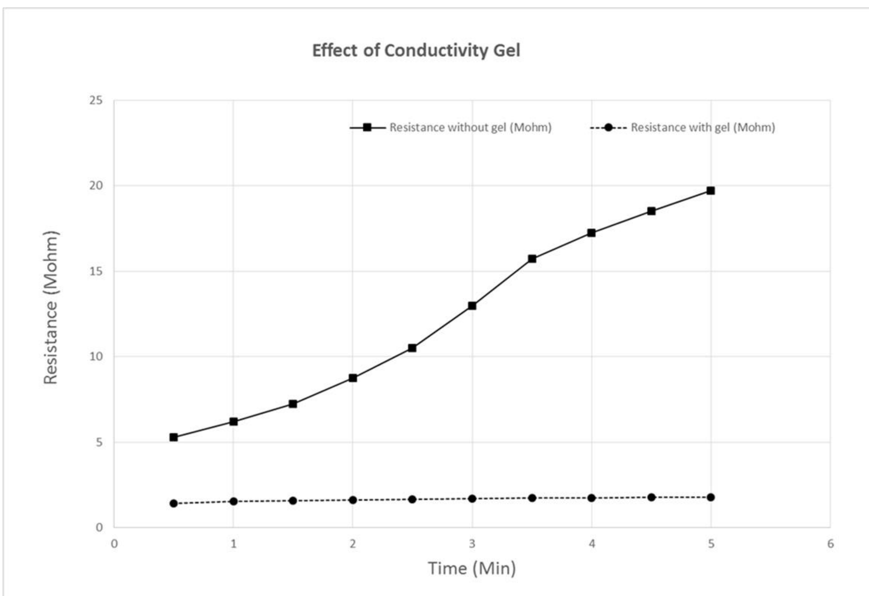
Possible solutions – This work is therefore aimed at studying the electrical properties of roots at the segment scale (1-5cm) for better characterization. Emphasis is on developing a method in the lab, which can be applied in the field to effectively characterize root biomass.

Methods

The target plants were grown in three different media (pot soil, hydroponics and mixture of sand, perlite and vermiculite)so as to compare the anatomical differences in the roots of plants grown in different media and also to compare their response to electrical signals. The seeds were first germinated in a rockwool and then transferred into different growth media. The resistance measurement was carried out on each replica using a voltmeter (Fluke 289 multimeter). The axial resistivity was calculated from the measured resistance and geometric parameters.

$$\rho_{root} = R_{root}\frac{\pi D^2}{4L_{root}}$$

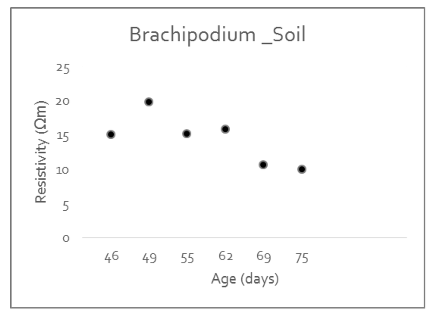


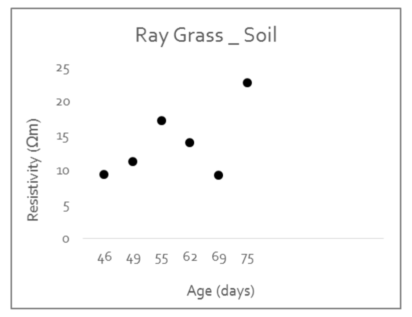



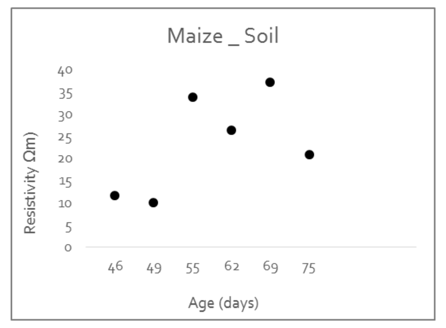
L-R: The growth media, experimental set-up and conductivity gel. The effect of contact resistance was minimized by the use of conductivity gel
(Rodisonic , from pannoc Nv/SA Belgium)

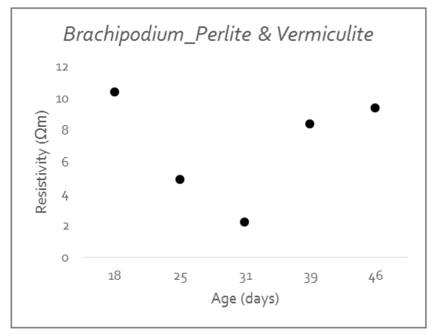
Results

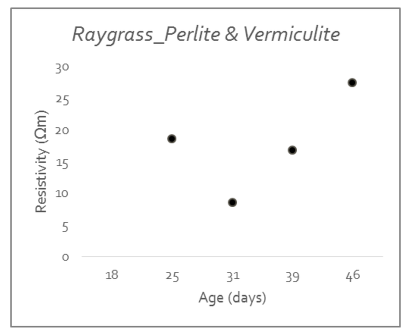
Age Effect_Growth media

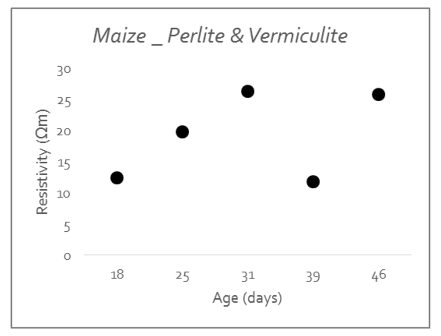


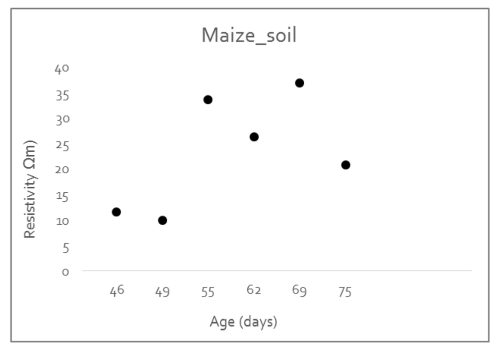


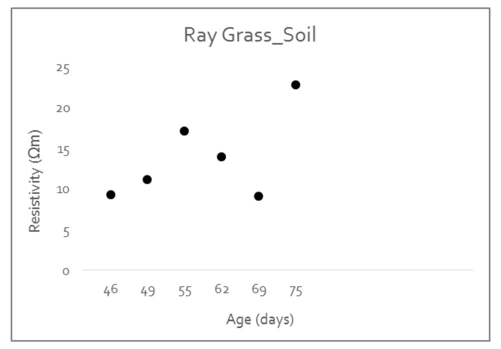


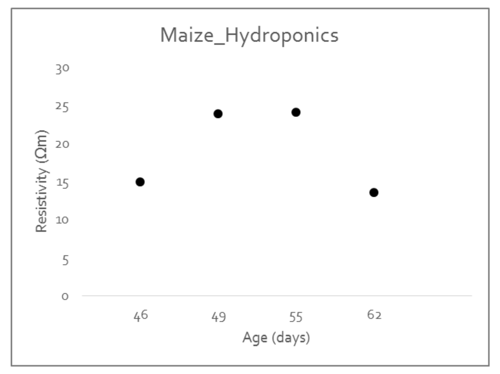


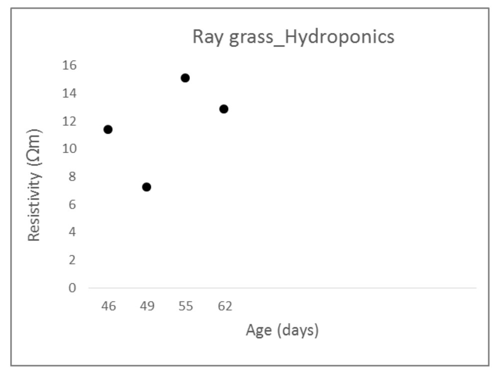






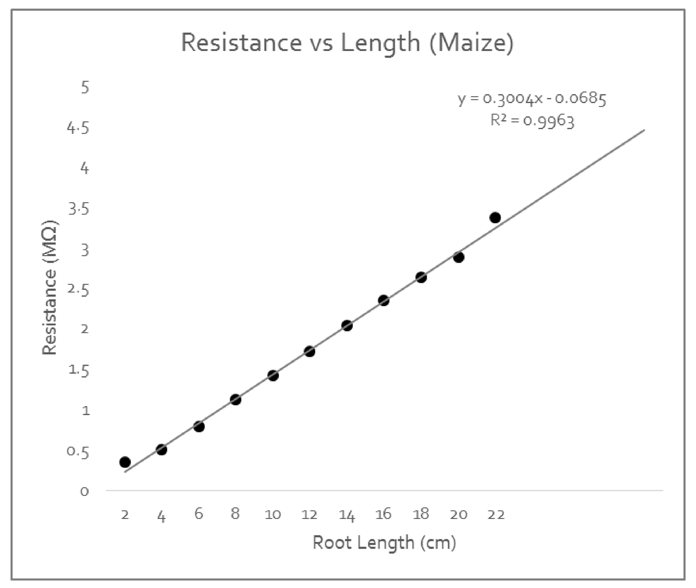


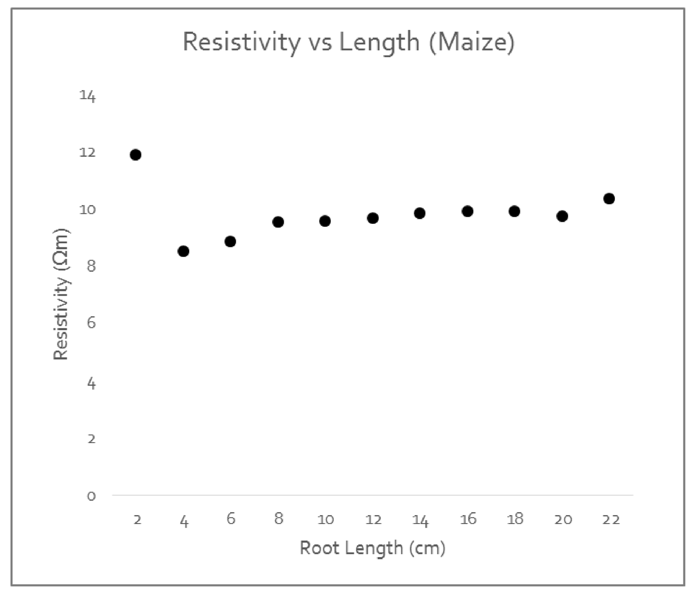




- There seems to be a linear trend in the soil media but it is not very clear because of fewer data points.
- This was found to be different in the other growth media.
- More points are needed for statistical analysis, only the soil seem to be showing a trend
- Measurements should be done on same plant over time rather than replica.

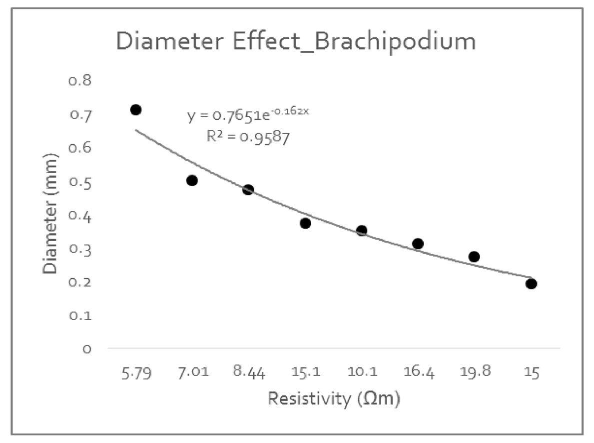
Length effect

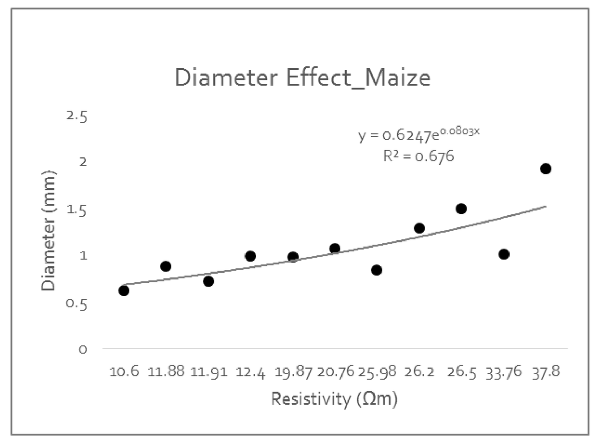


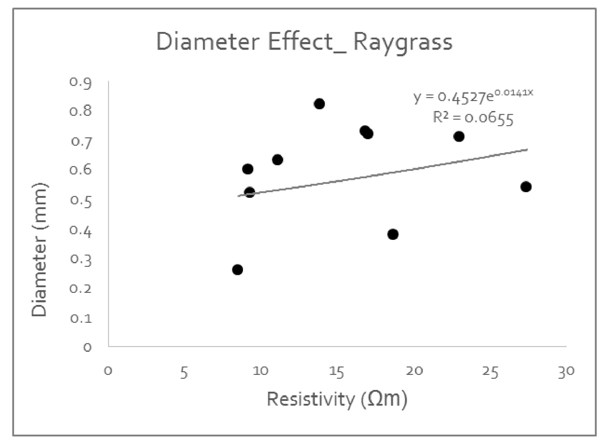


- There is linear trend relating the root length and resistance but the resistivity shows no trend with root length.

Diameter effect

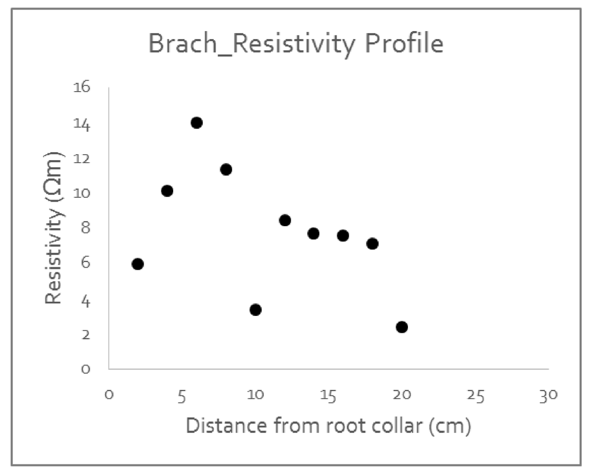


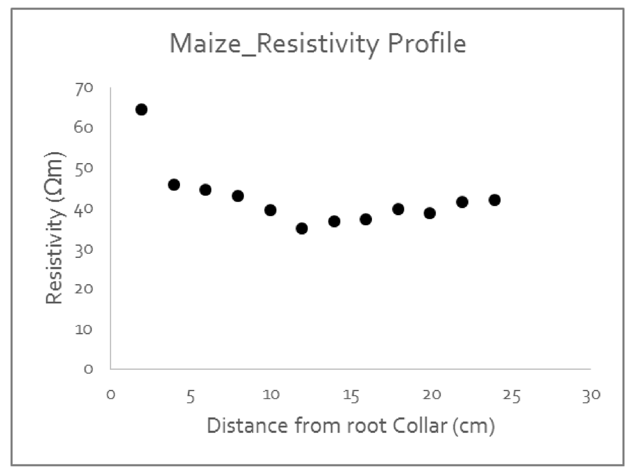


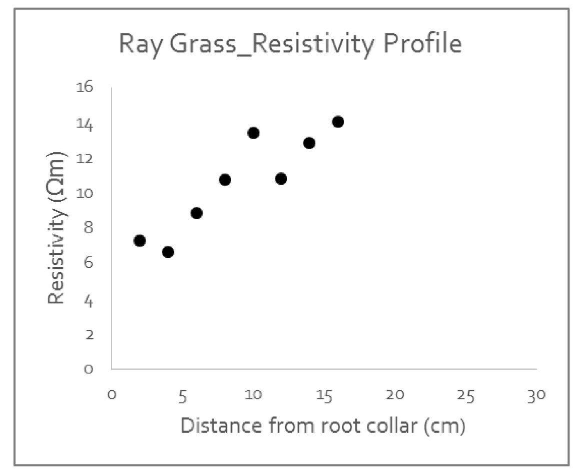


Large diameter should result in large cross-sectional area and lower resistance and thus lower resistivity. In this case Maize and Ray grass showed a different trend which might be due to some other phenomenon, thus more studies will be necessary to confirm the result. Resisitvity would depend on the diameter > change in terms of internal structure or surface properties ? could cross section and microscope help?

Resistivity profile along the root segment







The result s were found to be different from that of previous authors [1] and [2] which could be because the roots were much older at the time of measurement (46 days) compared to 13 days and 8 days for the willows and corn roots respectively recorded by various authors. There were also plenty of root hairs at the time of measurements. This study used intact roots rather than excised roots. Both the willows and the corn used by[1] and [2] were grown hydroponically.

Conclusion

The results show that the growth media has a significant effect on the electrical response of the studied roots. The result could be further improved if measurements were made on a specific root over the study period. Measurement of the root diameter using the caliper requires great care to avoid major errors. Further work is still needed to further confirm this result and to further characterize the electrical response of roots using spectral induced polarization (SIP) and electrical impedance spectroscopy (EIT).

References

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