Developing suitable methods for effective characterization of electrical properties of root segments

Solomon Ehosioke[1], Maxime Phalempin[2], Sarah Garré[3], Andreas Kemna[4], Sander Huisman[5], Mathieu Javaux[2], and Frédéric Nguyen[1]*

(1) Department of Architecture, Geology, Environment & Constructions, university of Liege, Liège, Belgium (2) Earth and Life Institute, Environmental Science, Université catholique de Louvain, Louvain-la-Neuve, Belgium
(3) Biosystems Engineering Department, Gembloux Agro-Bio Tech, University of Liege, Gembloux, Belgium (4) Department of Geophysics, Steinmann Institute, University of Bonn, Germany
(5) Agrosphere (IBG3), Forschungszentrum Jülich GmbH, Jülich,Germany. Corresponding author: solomon.ehosioke@ulg.ac.be

Motivation

Background - 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.

***Contribution* -** This work is aimed at studying the electrical properties of roots at the segment scale (1-5cm), this could help to account for the contribution of individual root segments to the bulk electrical response of the full root architecture.

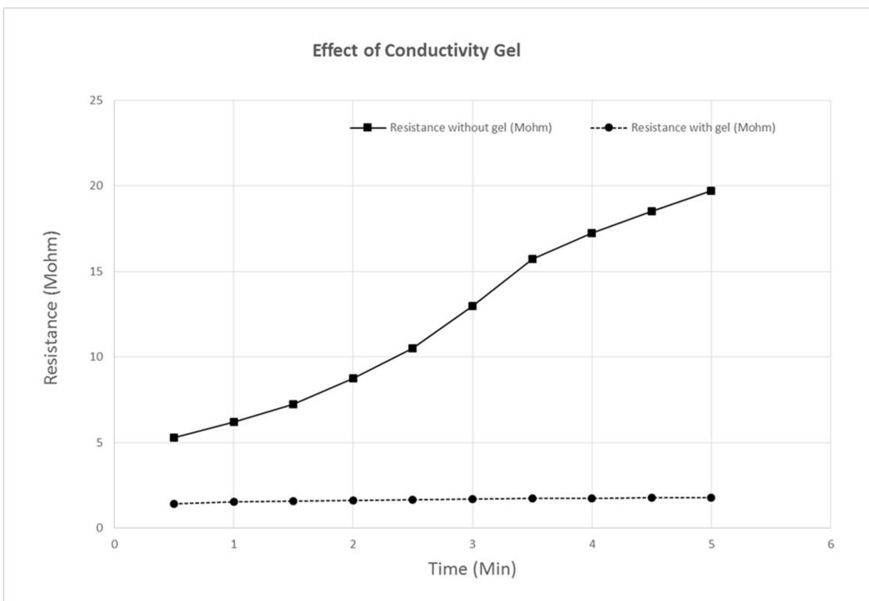
Methods

The target plants were grown in three different media (pot soil, hydroponics and mixture of sand, perlite and vermiculite) so as to compare the electrical response of the roots of plants grown in different media. 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.

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





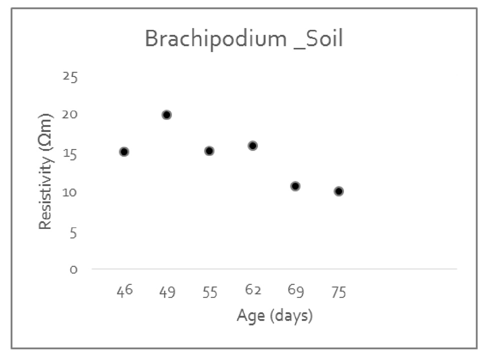


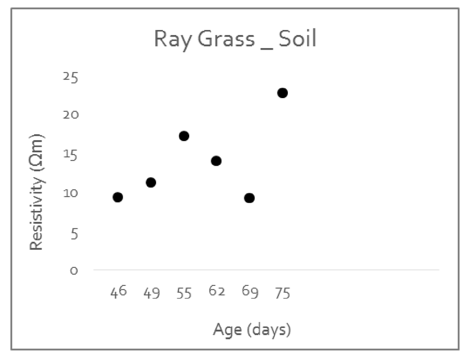
L-R: The growth media, experimental set-up and conductivity gel. The effect of contact resistance was minimized by the use of conductivity gel
(Rodisonic , from pannoc Nv/SA Belgium)

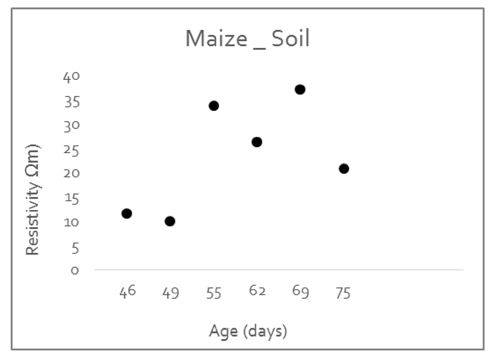
Results

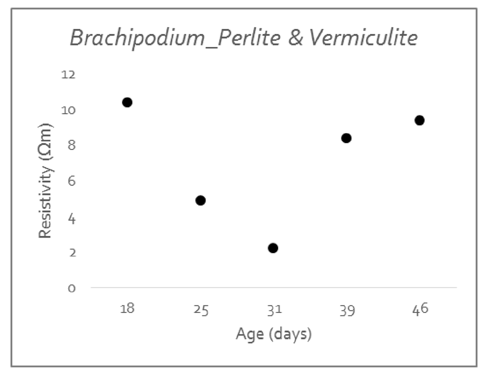
Effect of Age and Growth media

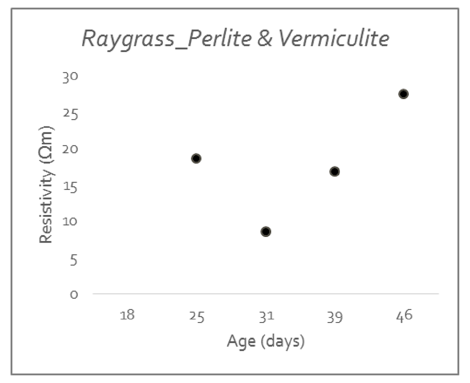
A. Soil vs Perlite & vermiculite

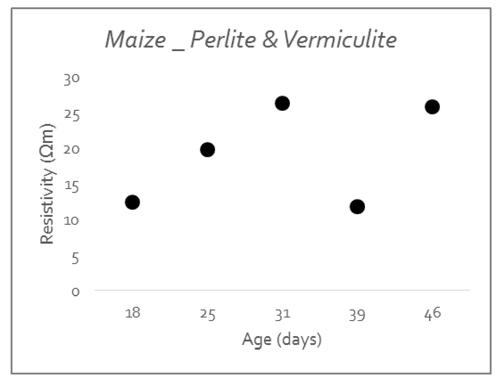




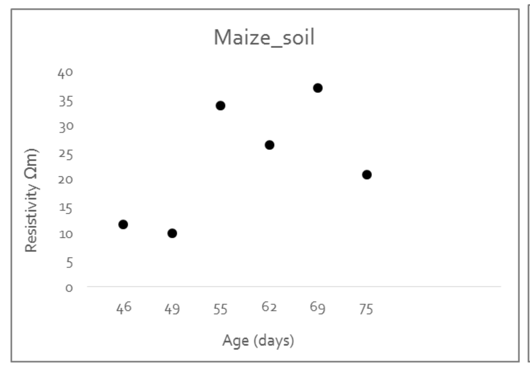


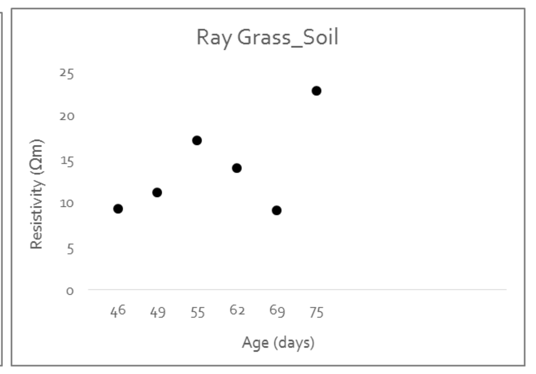


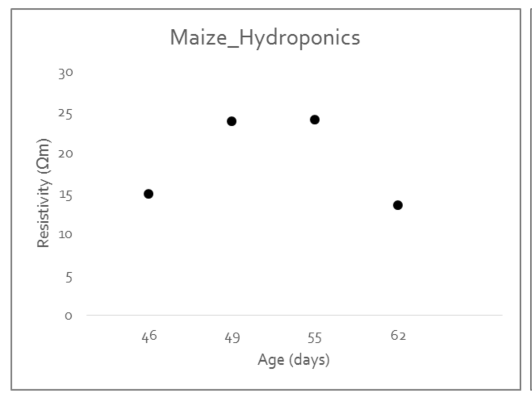


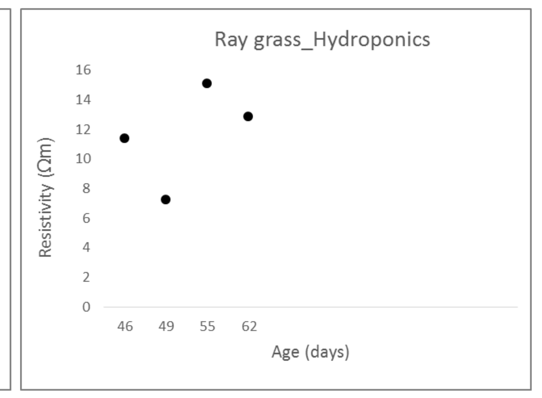


B. Soil vs Hydroponics



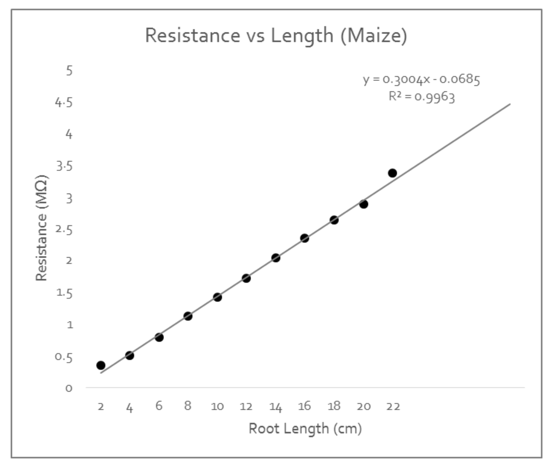


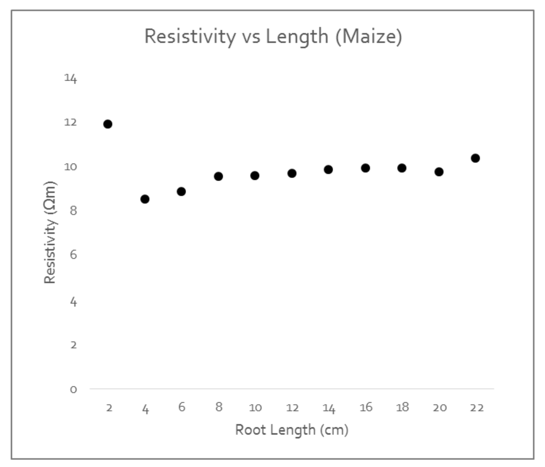




- There seems to be a linear trend in the soil media but it is not very clear because of fewer data points.
- This was different in the other growth media.
- More data points are needed for statistical analysis, only the soil seem to be showing a trend
- Measurements should be done on same plant over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

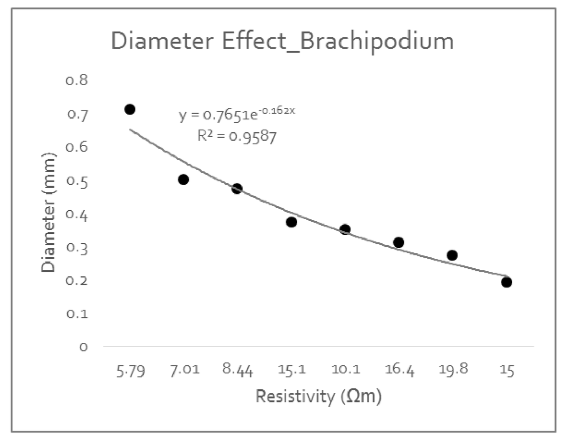
Length effect

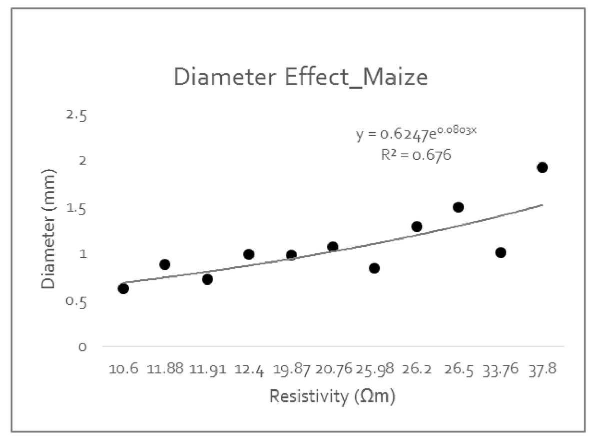


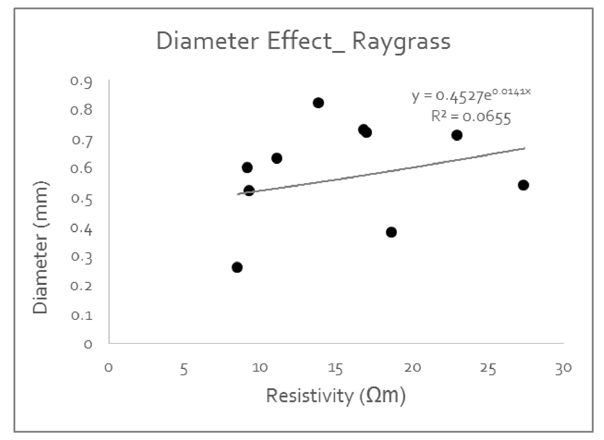


- The root length shows a linear trend with resistance .
- No trend with resistivity.

Diameter effect

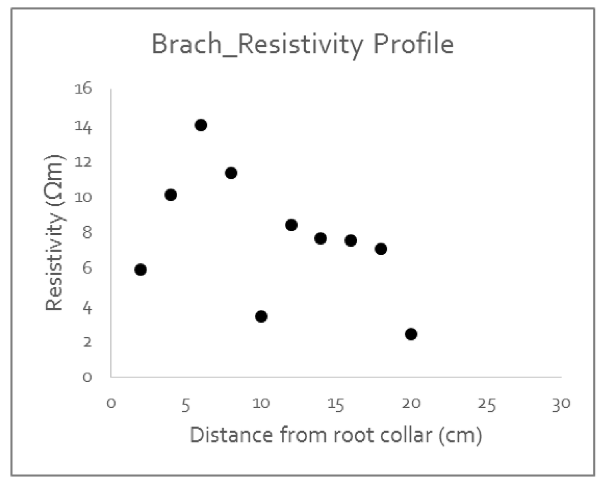


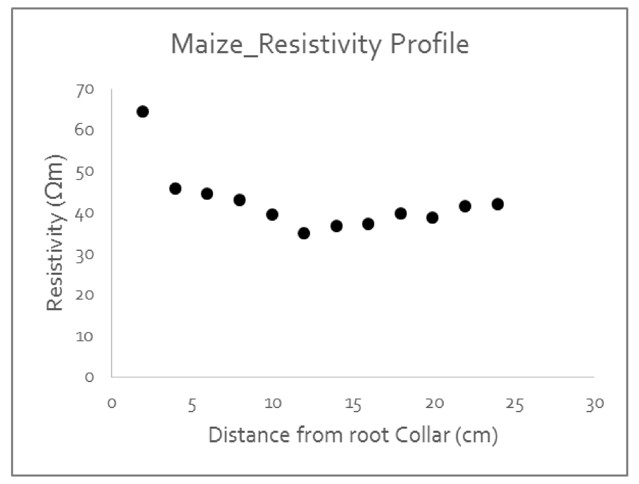


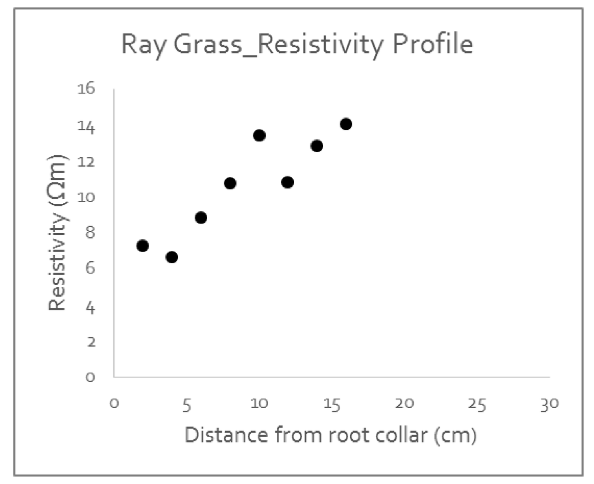


Large diameter should result in large cross-sectional area and lower resistance and thus lower resistivity, but in this case Maize and Ray grass showed a different trend which might be due to some other phenomenon. Resistivity would depend on the diameter, what could be responsible for this anomaly? Root internal structures or surface properties ? could cross section and microscope help? More studies is still needed to verify this phenomenon.

Resistivity profile along the root segment







Summary - The results were found to be different from that of previous authors [1] and [2] which could be due to the following reasons;

- The roots were much older at the time of measurement (46 days) compared to 8 days and 13 days for the Corn and willow roots
- There were also plenty of root hairs at the time of measurements.
- This study used intact roots rather than excised roots.
- Both the corn and the willow used by[1] and [2] were grown hydroponically.

Conclusion

The results show that the growth medium 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. More work is in progress to further confirm these results and to develop an SIP system for effective characterization of electrical properties of roots at the segment scale which could be up-scaled to the full root architecture .

References

1. Anderson, W. P., & Higinbotham, N. (1976). Electrical Resistance of Corn Root Segments. Plant Physiology, 137-141.
2. Cao, Y., Repo, T., Silvennoinen, R., Lehto, T., & Pelkonen, P. (2010). An appraisal of the electrical resistance method for assessing root surface area. Journal of Experimental Botany, Vol. 61, No. 9, pp. 2491–2497.

EGU General Assembly 2017, 23-28 April, Vienna, Austria

… Funded by the F.R.S-FNRS

FREEDOM TO RESEARCH