2D Geoelectrical Tomography for Detecting Root Biomass in Coffee trees

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Introduction

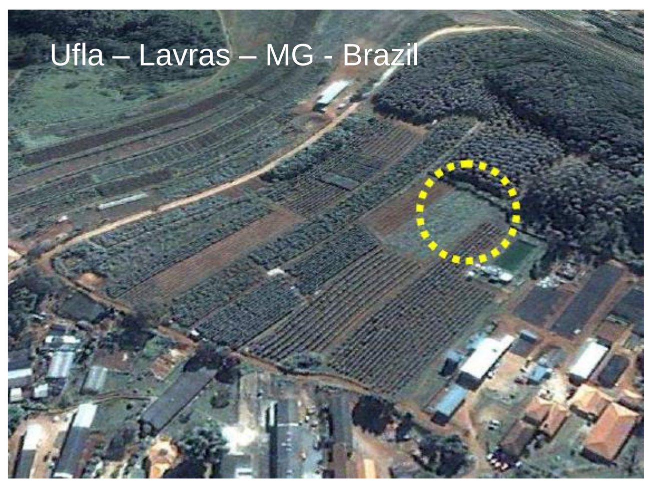
Roots play an important role in plants and are responsible for several important structural and biochemical functions. However, its research under natural conditions is very labor intensive and time consuming. Several methods related to root studies were described in the literature and these include destructive and non-destructive sampling (Box,1996). Among them one can cite: excavation, monolith, auger, profile wall, container, and others (Bohm,1979; Box, 1996). Most of them are destructive, which prevents future measurements at same location, and require separation of the roots from the soil, commonly by washing.

*Other more sophisticated methodologies, classified as non destructive sampling, involve root studies using glass wall, rhizotrons, minirhizotrons (Johnson et al., 2001). In this case, image analysis helps to evaluate roots behavior and allows the researcher to return to the same location for new data collection. In addition , other methodologies are being tested and used to study plant root systems in order to avoid destructive root sampling such as ground-penetrating radar, x-ray imaging, isotopes, magnetic resonance, electrical and seismic methods (*Gregory et al., 2003; Butnor et al., 2006; Loperte et al., 2006; Amato et al., 2008, 2009).

The use of electrical resistivity tomography is among these techniques and its use has been documented by several authors. ERT is a technique for imaging soil subsurface electrical structure using conduction currents. From a series of electrodes, electrical current is injected into the soil and the resulting potential distribution is measured (Kearey et al., 2002; Samouelian et al., 2005). Considering roots can affect soil resisitivity properties (Loperte et al., 2006; Amato et al., 2008, 2009), the aim of this study was to use ERT, also know as geoelectrical tomography, for detecting root biomass in coffee trees.

Material and Methods

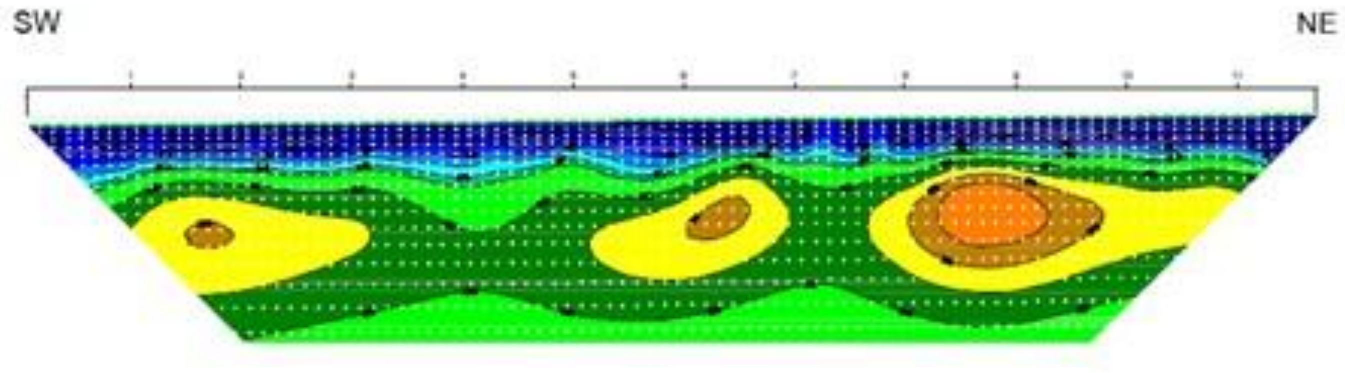
Experimental area



Data acquisition

Electrical resistivity measurements were performed in a soil transect under coffee plants. Pole-dipole configuration was used and measurements were taken 0.25 m apart by using an ABM AL 48-b resistivimeter (EEG Geofisica, Italy).

Above: (a) resistivimeter, (b) micro electrodes, (c) electrode line, (d) connections detail and (e) electrodes line position .



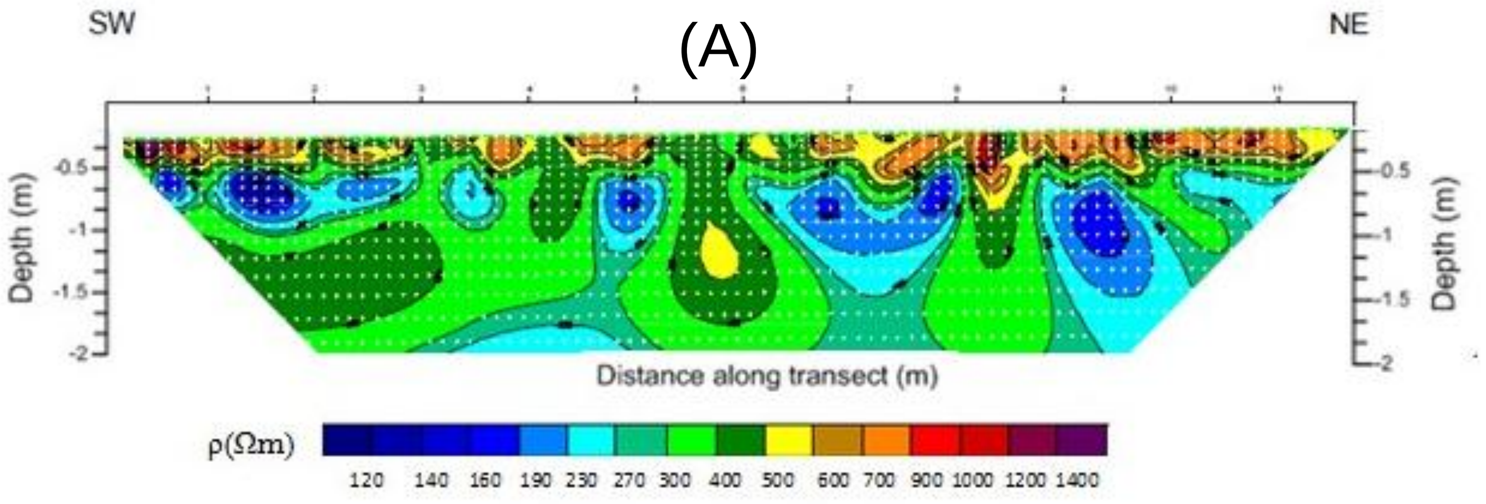
Soil tomogram in bare soil.

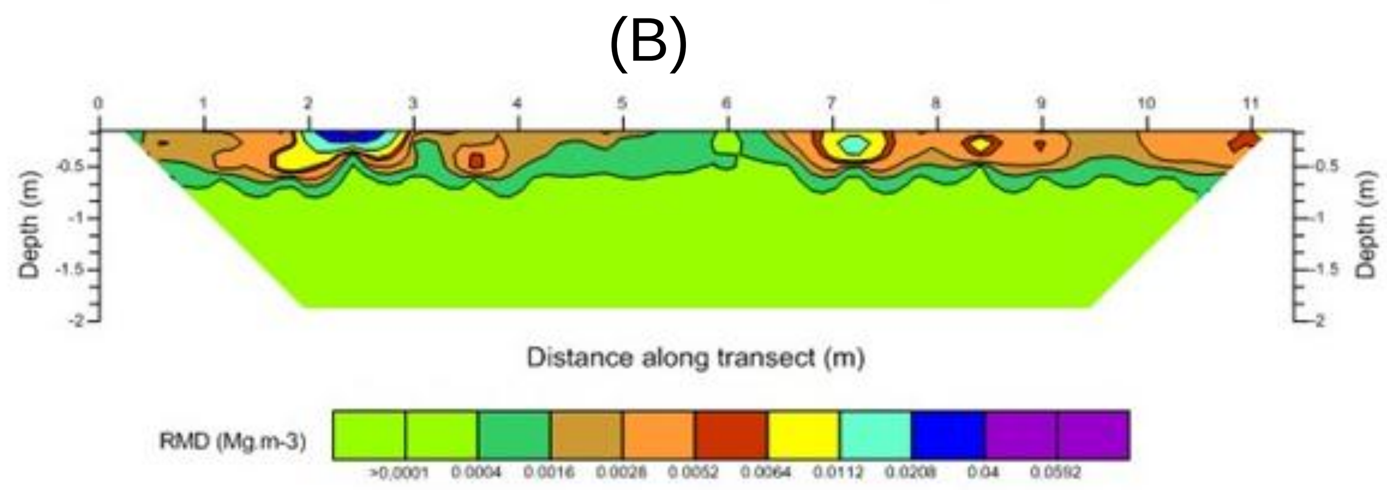
Root sampling and processing

Roots were sampled along the soil transect at 0.5 m intervals and at 3 soil depths (0.10, 0.20, 0.30 m). After separation, soil dry mass and root dry mass were determined and used to calculate root mass density (RMD) values.

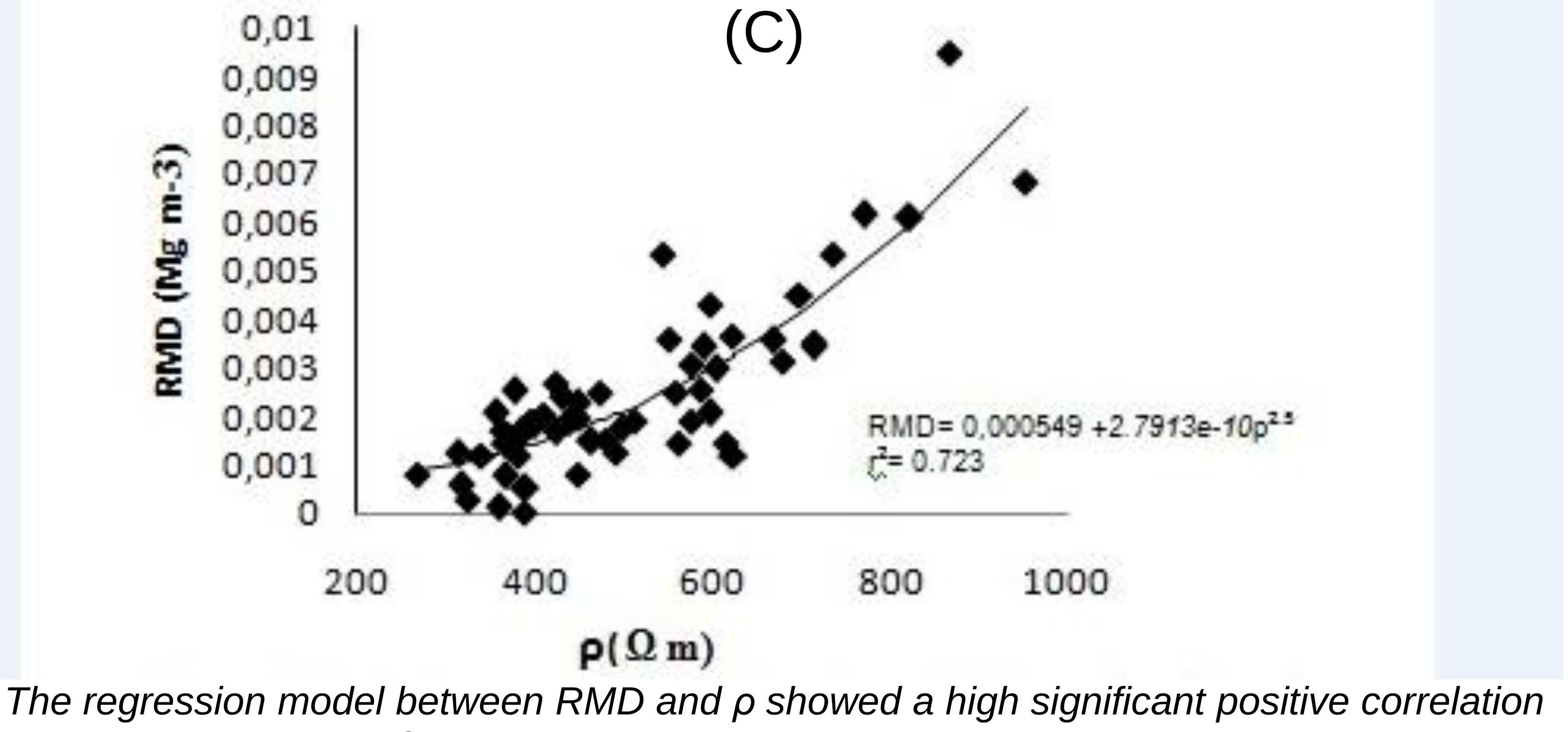
Results

Soil electrical resistivity (ρ) values ranged from 120 to1400 Ωm along the soil transect to a depth of 2 m (A). At the first 0.30 m soil layer, these values ranged from 267 to 952 Ωm. Yet, root dry mass per unit soil volume (RMD) values (B) at the same depth, ranged from 0,000019 to 0,009469 Mg m^{-3} showing high horizontal (x-axis) spatial variability.





The spatial distribution of ρ closed matched the spatial pattern of RMD with highest values found at 0.10 - 0.30 m soil layer and low values at deeper layers. In both situations, RMD and ρ high variability are closely related to the upper soil layer (A and B). Values of ρ below 0.40 m are more related to soil intrinsic characteristics than to the presence of roots.



The regression model between RMD and ρ showed a high significant positive correlation (p<0.01, n=59) with a r^2= 0.723 (C).

Conclusions

In our research we generated a high-resolution 2-D geoelectrical tomography along a soil transect under a coffee tree (Coffea arabica L.) stand, and compared it with destructive soil sampling. Data results showed that soil resistivity is quantitatively related to root biomass and the technique provides a basis for nondestructive spatial detection of root biomass in situ.

These preliminary results showed that the electrical resistivity tomography can contributes to root systems studies in coffee plants; however, considering the diversity of soils and conditions were plants are cultivated in Brazil, more experiments are necessary to confirm the found results.

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