Geophysical Research Abstracts,
Vol. 11, EGU2009-6342, 2009
EGU General Assembly 2009

Subsurface imaging of tillage systems effects on soil physical properties using electrical resistivity tomography

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Tillage systems affect soil physical, chemical and biological properties, which in turn may alter the soil environment and consequently impact on root growth and distribution, and crop yield. The degree of soil disturbance of the soil has a direct impact on the soil water content, soil temperature, aeration and on the soil structure. In this study we seek to demonstrate through the use of electrical resistivity (rho) imaging the effects of different tillage systems on the spatial variation of soil resistance to penetration and soil porosity.

Two-dimensional DC resistivity tomography was performed on a long term conventional tillage, (CT), minimum tillage (MT), no tillage (NT) and on no tilled plot just tilled NTT plots on 11.75 m transects with an Iris Syscal Pro ten-channel receiver (IRIS INSTRUMENTS, Orléans-France) resistivity meter and 48 electrodes in dipole-Dipole configuration, with inter-electrode spacing of —0.10 meters. The acquired data-set was processed with tomolab (Geostudi Astier – Livorno Italy) through a two-dimensional finite-element inversion algorithm to solve the forward modelling problem (Morelli and La Brecque 1996). Soil penetration resistance and bulk density were spatially measured along each transect at 10 horizontal positions and at 0.05 m depth increments up to 0.4 m depth. Gravimetric soil moisture and dry bulk density values by the cylinder method (Blake and Hartge 1986) with 98.125 cm3 internal volume brass cylinders were measured on triplicates for each plot at 0.05 m depth increments up to 0.5 m depth. Volumetric soil water was obtained by multiplying gravimetric value by bulk density A total of 1505 resistivity values were obtained for each transect.

Total variation in soil resistivity was highly significantly explained by tillage treatment and soil depth and by their interaction. High values were found above 20 cm layers of the tilled treatments, and the largest differences between treatments were found between 5 and 15 cm of depth. The response of soil resistivity to soil tillage was able to significantly discern between tilled and untilled soil, and between a freshly tilled soil layer (NTT at 10 cm of depth) and soil tilled in the past (CT and MT at the same depth).

Values in the deeper layer were not significantly different between treatments.The analysis of variance for soil resistance to penetration also yielded highly significant results for the main effects of soil tillage treatment and soil depth and for their interaction. Nevertheless variability of measurements was rather high and highly significant differences were only found between the untilled and all other treatments at 5 cm. The NTT treatment was significantly different from TT but not from MTT and CT.

Soil bulk density, penetration resistance and water content were also correlated with soil resistivity. Univariate analysis showed that rho is related to soil penetration resistance but data from the NTT treatment cause a deviation from linearity. This is due to the fact that soil resistivity had a strong response to newly tilled soil and was able to significantly discern it from less recent tillage, whereas penetration resistance did not show differences among tilled soils in the upper layers as commented above.