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Electrical resistivity tomography imaging: a way for assessing water uptake heterogeneity at the field scale

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A better management of irrigation water requires a better understanding of the water uptake process from the single root to the rooted field scales. Imaging of the heterogeneity of the uptake process or evaluation of the active zones of uptake with time could give a better understanding of the functioning of the root systems in situ, in relation with resources availability.
To this aim, we conducted an experimental field study with a maize crop and three different levels of irrigation (well irrigated, moderately irrigated and poorly irrigated). The soil water was monitored with classical devices for water measurements (neutron probe, tensiometers), giving pointwise measurements with depth . In order to get 2D variations of soil water content along horizontal transects in the field, we used an Electrical Resistivity Tomography technique (ERT), which enables the imaging of the electrical resistivity of the soil. Soil electrical resistivity is directly influenced by soil water content, and when measurements are repeated with time along the same transect the difference in time between resistivity values are the reflect of the variation in water content and help to localize zones of active uptake.
Electrical measurements were done with 32 electrodes at the soil surface, 30 cm apart, for a total transect length of 9 m with a Wenner alpha configuration.
The results of the three months monitoring show that variations of water content with time, as measured with neutron probe, denote an increasing depth of water extraction zone from the well irrigated treatment to the poorly irrigated treatment. This global pattern of extraction with depth is also observed with ERT imaging, but the time variation of electrical resistivity images reveals high spatial variations in the uptake pattern: variation between the row and inter row, but more surprisingly high variations at depth

too, where patches of high variation are found and places where water is not fully exploited by the plant despite the water stress. This heterogeneity of uptake increases from the well to poorly irrigated treatments.

ERT seems a promising tool for studying in situ plant water uptake in contrasted conditions.