SMALL SCALE CHARACTERIZATION OF VINE PLANT ROOT WATER UPTAKE VIA 3D ELECTRICAL RESISTIVITY TOMOGRAPHY AND MISE-À-LA-MASSE METHOD: A CASE STUDY IN A BORDEAUX VINEYARD (FRANCE)

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We applied the 3D electrical resistivity tomography (ERT) and Mise-à-la-Masse (MALM) methods to highlight vine plant Root Water Uptake (RWU) in a vineyard in the Bordeaux district, France. The site presents a well-known pedological setting and was recently characterized via geophysical surveys (Mary et al., 2017, in prep). Two plants growing in a sandy-loamy layers were selected for the experiment. During a scheduled irrigation (240 liters of water during
3 hours), we collected five ERT and MALM datasets to highlight the processes associated to root water uptake (RWU). The experiment was conducted during the summer (June, 2017) to stress out the potential of RWU with the plant previously kept in water stress condition. In the framework of plants/subsoil interactions, ERT has been downscaled to image the root zone geometry. Amato et al. (2009) tested the ability of 3-D ERT for quantifying root biomass on herbaceous plants. Cassiani et al. (2015) demonstrated the reliability of the method in an apple orchards using ERT to identify Root Water Uptake (Cassiani et al., 2014). Electrical Resistivity Tomography can give essential information about the soil and the root system extension and functioning for an estimation of fraction of transpirable soil water to characterize the soil water deficit experienced by the plant (Brillante et al., 2016). On the other hand, suggested for the first time by Schlumberger (1920), the idea of the MALM is to use a subsurface conductive mass itself as a current electrode (the second electrode being placed at a great distance and connected on the other pole). A current is passed and the difference of potential is measured between surface (or boreholes electrode) and the remote one. The distribution of the potential reflects the shape of the body and its extension. ERT are nowadays widely adopted tools for plant root area purposes, while MALM is a relatively new method applied in this context. The MALM method can be considered a novel application to plant systems, and presents the promising capability to image root distribution per se, rather than RWU effects as ERT does. The main limitation of ERT, which often limits the use of the technique for a raw and indirect characterization of root system position, is its sensitivity for a number of parameters such as water content, electrolyte composition and concentration, soil textures variations and temperature. We hereby proposed the Mise-a-la-Masse method (MALM) as a support of the micro-ERT to quantify where the roots are growing into the soil and how they contribute to water redistribution after the irrigation. To strengthen our assumption that the plant root system act as a conductive body, MALM with the injection on the stem was compared with MALM with the injection into the soil in the vicinity of the stem for different time lapse during the RWU. Moreover, for the first time in this framework, the MALM measured in the field was compared with simulation to have greater confidence on the results interpretations.

For the background time (T0), differences obtained between the stem and soil injection clearly validated the assumption that the whole root system is acting as an electrode. Indeed, results obtained with simulation better fit measured data considering distributed sources in depth and reflecting a probable root zone area. On the other hand, for the injection into the soil, the simulation was effective only considering a punctual source. Considering temporal variations, both MALM and ERT follow the same pattern changes according to the time period i.e during the irrigation, about 2 hours after the irrigation and one day after. MALM was simulated considering ERT inverted data as initial model, in order to test the MALM capabilities to retrieve correctly the characteristic at the plant scale. We then perform the data inversion to recognize the sources, ergo the roots system, by the minimization between simulated and measured data.

Our results proved that the advanced combination of ERT and MALM are able to detect spatiotemporal subsoil variations associated with RWU, suggesting the potential of this approach to improve the vineyard irrigation management.

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