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Surface Electrical Resistivity Tomography: a non-invasive tool to assess the compaction in paddy soils

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Soil compaction has direct effects on soil physical properties (increase in soil strength, bulk density, decrease in total porosity, soil aeration, water infiltration rate, and saturated hydraulic conductivity) often reducing root penetration and plant growth, thereby causing a reduction of soil productivity. However, the presence of compacted layers in rice paddy fields increases the efficiency of the traditional flooding irrigation method. For this reason, the use of monitoring tools to detect depth, thickness and lateral continuity of compacted soil layers in paddy fields is of crucial importance for the assessment of their irrigation efficiency. Electrical Resistivity Tomography (ERT) is a non-invasive geophysical method which allows to detect soil horizons with different degrees of compaction. Particularly, arrays constituted of short electrodes spaced a few centimeters can be used to investigate with high vertical resolution the soil profile.

In a sandy loam paddy field located in the Lomellina region (PV; RISTEC project, RDP-EU, Lombardy Region), a surface ERT survey was conducted in February 2019 to verify the effectiveness of this technique in assessing soil compaction. The ERT was carried out with Wenner arrays of 48 electrodes spaced 0.1 m along a 5 m transect, to investigate the soil profile up to about 1 m depth in proximity of a soil profile trench dug for soil description and sampling. The results of the traditional soil survey (accurate description of soil horizons, including the compacted layer) were considered as reference data to evaluate the reliability of ERT results. During the ERT survey, soil samples were collected at different depths and distances along the ERT transect: texture, bulk density and porosity were successively measured in laboratory. Moreover, the volumetric soil water content was measured with a probe (ML2 ThetaProbe, Delta-T Devices). Main results show that the correlation between electrical resistivity (ER) and bulk density, soil porosity and volumetric water content is well in line with those observed in recent studies. Data points in the scatter plots are clustered based on the bulk density values; particularly, the cluster corresponding to high bulk density values (i.e. compacted soil) includes the measurement points at the depth where the ERT image shows a greater ER gradient. This depth also corresponds to the compacted layer observed during the investigation of soil profile with traditional methods. These results confirm that compacted layers can be effectively detected in ERT images by identifying depths characterized by higher ER gradients in soils with a relatively homogeneous soil texture. Consequently, an

integrated approach combining surface ERT and soil sampling with a hand auger at a few depths to check the texture homogeneity and eventually collect a few soil samples for further analysis (e.g., bulk density, volumetric water content, soil hydraulic conductivity) could be explored to assess the presence and continuity of compacted layers in paddy soils, instead of intensive and extremely invasive surveys.