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A fast procedure to discriminate water content and salinity contributions to EMI-based electrical conductivity

Angelo Basile (1), Dario Autovino (1), Antonio Coppola (2), Roberto De Mascellis (1), Giovanna Dragonetti (3), Mohammad Farzamian (4), Fernando Montero Santos (4), and Solange Scognamiglio (1)

(1) Institute for Mediterranean Agricultural and Forestry Systems, National Research Council of Italy, (CNR-ISAFOM), Ercolano (NA), Italy., (2) School of Agricultural, Forestry and Environmental Sciences (SAFE) University of Basilicata, Potenza, Italy., (3) Mediterranean Agronomic Insitute (IAMB), CIHEAM, Valenzano (Bari), Italy., (4) DEGGE-IDL, University of Lisbon, Lisbon, Portugal.

The assessment of the soil solution salinity is a crucial task in irrigated production systems in the Mediterranean-like climate, where the ecological conditions predispose to salt accumulation within the soils. In this framework, the electromagnetic induction methodology is a fast and non-destructive tool which is very useful for hydrological and agronomic purposes. Nonetheless, the measured apparent conductivity strongly depends on both water content and soil salinity. Hence, in saline soils is not easy to estimate, at the same time, both variables. Our effort was aimed at distinguishing these two contributions affecting the measured electrical conductivity. In an experimental field with corn cultivation located in southern Italy, we sampled undisturbed soil specimens to measure in the laboratory, by means of TDR probes, the variation of the bulk electrical conductivity with varying volumetric water content using non saline water. Then, in the same field, two plots were irrigated with non-saline water and saline water, respectively. The irrigation lasted roughly 6 weeks with one irrigation per week on average. After the last irrigation, we performed several electromagnetic measurements in both plots at 6 depths (depth range 0.25-1.8 m) and with a 1 m spacing till the soil was dry. Then, the same day of the corn harvesting we opened a trench in the saline plot. Soil water content and bulk electrical conductivity were measured by TDR probes along the transect at four depths. Moreover, we sampled the soil at several depths and positions in order to measure in the laboratory the soil solution electrical conductivity. From the electromagnetic data, by means of an inversion procedure performed by TerraEM software, we calculated the bulk electrical conductivity of the non-saline plot. Then, we retrieved the volumetric water contents by means of the relationship bulk electrical conductivity vs. volumetric water content previously measured in the laboratory. Since the field was homogeneous, the obtained water contents of the non-saline plot were compared to the water contents of the saline plot. These last were directly measured in the field at several depths by means of TDR probes in the same day of the electromagnetic measurements. The agreement between the trends of the measured and estimated water content values was very good, but the absolute values were different unless a shift constant that we empirically estimated. Then, since both the volumetric water content and the bulk electrical conductivity were known, we inverted the Rhoades formula to calculate the electrical conductivity of the soil solution. This approach allows to obtain a good estimation of the electrical conductivity of the soil solution and soil water content by coupling very easy and non-destructive electromagnetic field measurements with a simple laboratory calibration performed by TDR.