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Estimation of the daily water consumption by maize under Atlantic climatic conditions (A Coruña, NW Spain) using Frequency Domain Reflectometry

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Climatic variables, such as rainfall, solar radiation, temperature and relative humidity, present a high spatio-temporal variability. Thus, they are inadequate indicators of soil water content in the root-influenced zone and/or soil water consumption by plants, which are essential parameters for assessing water availability. An interesting alternative to the estimation of these parameters is quantifying soil water dynamics using Frequency Domain Reflectometry (FDR). This technique allows to describe water dynamics in time and space, to determine the main patterns of soil moisture, the water uptake by roots, the evapotranspiration and the drainage.
Therefore, the aim of this study was to quantify the soil moisture dynamics in the root-influenced zone and to assess the daily water consumption by the crop. The studied site is located in an experimental field of the Centre for Agricultural Research (CIAM) in Mabegondo located in the province of A Coruña, Spain (43º14'N, 8º15'W; 91 masl). The study was carried out from July to October 2009 in a field devoted to maize (Zea mays, L.). The soil of this site is silt-clay textured. Long-term mean annual temperature and rainfall figures are 13.3 ºC and 1288 mm, respectively. During the study period, maize crop was subjected to conventional agricultural practices. A weekly evaluation of the phenological stage of the crop was performed. Evapotranspiration was estimated according to the Penman-Monteith equation using meteorological data from a station located in the experimental site. An EnviroSCAN FDR equipment, comprising six capacitance sensors, was installed in the studied site following the manufacturer's recommendations, thus assuring a proper contact between the probe and the soil. Soil water content in the root-influenced zone (0-60 cm depth were considered) was hourly monitored in 20 cm ranges (0-20 cm, 20-40 cm, and 40-60 cm) using FDR. Evaluations were performed on days with slight or no rainfall.
The estimated average drainage was 0.057 mm day-1, during the study period. The average of the estimated potential evapotranspiration was 4.64 mm day-1. The daily average of soil water consumption by the crop was 2.95 mm day-1 for the whole range of depths, namely from 0 to 60 cm. The greatest consumption occurred between 14 and 19 hours, up to 53.64% of the total. Average daily water consumption decreased with depth. The highest daily water consumption was observed in the shallowest soil layer, from 0 to 20 cm (1.883 mm day-1), whereas the lowest one was registered in the layer from 40 to 60 cm depth (0.399 mm day-1). Overall, daily water consumption increased significantly with soil water content (p-value < 0.001). In addition, a significant positive correlation was found between measured daily water consumption and estimated evapotranspiration (p-value < 0.001). Moreover, significant correlations were found between water consumption and global solar radiation and sunny hours. These relationships were observed in the two shallow soil layers, from 0 to 20 cm and from 20 to 40 cm; whereas, in the layer from 40 to 60 cm, significant relationships were detected between water consumption and maximum and minimum temperature and relative humidity. In general, maize roots extracted more water from the 0-20 cm soil layer. In contrast, water content in the deepest part of the soil profile was close to saturation, even on the driest days of the studied period. In conclusion, the use of FDR allows a more accurate estimation of the water consumption by maize. Therefore, monitoring soil water content would be useful in the assessment of saturation risks or water stress (drought), thus aiding in the decision making, for instance, in the irrigation management. Results from this study may help improving irrigation practices in humid zones.