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Modelling olive orchard response to water stress and definition of critical thresholds of soil water status

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The knowledge of the plant response to water stress is very important to predict the dynamic of potential transpiration reduction under limited soil water condition. The water stress response is influenced by soil, plant and climate and in particular by soil matric potential, hydraulic conductivity, osmotic head (in saline ecosystem) and evapotranspirative atmospheric demand, as well as by root spatial distribution and plant properties.
The macroscopic approach, taking into account global stress indicator (relative transpiration, xylematic water potential, etc), can allow to assess empirical functions, able to describe the plant response to water stress, on the basis of the observed plant response to soil water status. Using the macroscopic approach it is not necessary to evaluate separately difficult and time consuming soil and plant parameters, like the gradient of water potential at the interface between the roots surface and the soil.
Modelling the plant response under water stress condition is crucial to identify the exact irrigation timing. In order to assess the water stress functions, is necessary to estimate critical thresholds of soil water status, below which plant transpiration starts to strongly decrease.
The main objective of the work is to investigate the relationships between soil matric potential and measured transpiration, as well as to define the critical plant water status conditions, determined according to measured leaf and stem xilematic potentials. Furthermore, the performance of existing models, simulating the relative transpiration as a function of the soil matric potential, is assessed.
The soil water retention curve was used to determine, at the different depths, the soil matric potential according to the measured of soil water contents obtained with capacitive sensors (Diviner 2000, Sentek).
Actual transpiration was monitored by measuring the sap flows with thermal dissipation probes (TDP), while the leaf and stem water potentials were determined by using the Scholander pressure bomb.
The study area is located in the South-Western coast of Sicily (Italy); the dominant crop is represented by table olive grove and it is characterized by typical Mediterranean semi-arid climate. According to the USDA classification, the soil can be classified as silty clay loam. The investigation period included 2008 and 2009 irrigation seasons. Meteorological data were collected by means of a weather station of the SIAS (Servizio Informativo Agrometeorologico Siciliano), located nearby the study area.
Experimental data allowed to define the critical threshold values of the soil water status (soil water content and matric potential) below which the actual transpiration tends to reduce when soil water content decreases. For values of soil water content greater than the critical threshold, the actual transpiration resulted almost constant. A similar behaviour was observed when the xylematic potentials are used to quantify the crop water stress.
The investigation also showed that the best performance of the examined models, used to estimate transpiration, can be obtained when non-linear models are considered.

Keywords: Olive orchard, Water stress functions, Sap flows, Leaf water potentials.