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Using FAO-56 model to estimate soil and crop water status: Application to a citrus orchard under regulated deficit irrigation

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Agro-hydrological models allow schematizing exchange processes in the soil-plant-atmosphere continuum (SPAC) on a wide range of spatial and temporal scales. Each section of the SPAC system is characterized by complex behaviours arising, for instance, the adaptive plant strategies in response to soil water deficit conditions. Regulated deficit irrigation (RDI) has been considered as one of the potential strategies for sustainable crop production in regions characterized by water scarcity. Moreover, reducing water supply at certain growth stages can improve water use efficiency (WUE) and quality of productions, without affecting significantly crop yield. Environmental policy requires to improve WUE in crops with high water requirements, so that it is necessary to identify easy-to-use tools aimed at irrigation water saving strategies, without the need of tedious and time consuming experiments. Accurate evaluation of crop water status and actual transpiration plays a key role in irrigation scheduling under RDI, in order to avoid that water stress becomes too severe and detrimental to yield and fruit quality.
Objective of the research was to assess the suitability of FAO56 agro-hydrological model (Allen et al., 1998) on citrus orchards under different water deficit conditions, to estimate soil and crop water status. The ability of the model to predict actual crop water stress was evaluated based on the temporal dynamic of simulated relative transpirations and on the similarities with the corresponding dynamic of measured midday stem water potentials, MSWP. During dry periods, simulated relative crop transpiration was correlated to MSWP with the aim to assess the model ability to predict crop water stress and to identify “plant-based” irrigation scheduling parameters.
Experiments were carried out during three years from 2009 and 2011 in Senyera (39º 3’ 35.4” N, 0º 30’ 28.2” W), Spain, in a commercial orchard planted with Navelina/Cleopatra citrus trees. Three RDI treatments were considered: in the first (control, T0-100%), irrigation doses (Id) were determined according to evapotranspiration and precipitation data obtained from a meteorological station installed nearby the plot, whereas in the other two, water application was reduced to 40%Id (T1-40%) and 60%Id (T2-60%) only during the initial fruit enlargement phase (July-August), being the plots irrigated at 100%Id for the remaining periods of the year. In each plot, soil water status was monitored along a soil profile with an Enviroscan probe (Sentek Sensor Technologies), whereas MSWPs with a Sholander chamber (Solfranc SF-Pres-35), on leaves wrapped in bags at least 2 hours before the measurements. At the end of each season, crop yield was determined on each treatment, by weighting the total production of at least 8 trees.
It was observed that FAO-56 model simulates with a reasonable accuracy, acceptable for practical applications, the average soil water content in the root zone, with estimation errors lower than about 2.0%. On the other hand, relative transpiration simulated by the model follows the general seasonal trend of midday stem water potential, allowing therefore to identify the actual crop water status as recognized in the field.