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A daily water balance model with a dynamic wetted area for estimating drainage from soil moisture observations in an irrigated orchard

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Drainage below the root zone of irrigated crops and trees is often an unknown component of the water balance. This drainage water could recharge underlying aquifers and flow to streams and is not part of water consumed by crops, as used in water productivity computations. Drainage from fields with irrigation systems that wet only part of the soil is difficult to estimate. The objective of the research was to develop a water balance model with a dynamic wetted area for analyzing soil water balance components from daily soil moisture observations. The method was applied in an olive orchard in Cyprus, with approximately 35% canopy cover. Soil moisture sensors (SMT100, Truebner and 5TM, Decagon) were installed at six trees, at 10-, 20-, 40- and 60-cm depth, approximately 90 cm from the trunk of the tree. Soil moisture was recorded hourly. The trees were irrigated weekly, with a single spaghetti tube with a discharge rate of approximately 135 L/hr. Daily reference evapotranspiration was computed with the Penman-Monteith equation from meteorological observations recorded inside the orchard (WS500, Lufft). Rainfall was measured with a tipping bucket rain gauge (15189, Lambrecht).

The model computes a daily volumetric water balance for the canopy area of the tree. During the irrigation season, soil moisture observations were assumed to represent the soil volume wetted by irrigation. Drainage below the 70-cm root zone occurred when soil moisture exceeded the field capacity, as derived from hourly observations. A canopy-area crop coefficient (Kcc-max) was estimated for all irrigation days without drainage by minimizing the sum of the daily evapotranspiration in excess of the maximum evapotranspiration (Kcc-max ETo). This one-sided error was controlled by maintaining a positive difference between Kcc-max and Kcc the day after irrigation. Wetted areas were subsequently computed for all irrigation days without drainage. For irrigation days with soil moisture above field capacity, the wetted area was adjusted manually, such that drainage was smaller on the second day than on the irrigation day, using a Kcc-max for both days. During the May to November 2019 irrigation season, drainage was 8 mm over the field area, for a field capacity of 36%, a Kcc-max of 1.3, and an error of 16 mm. Assuming a field capacity of 38%, drainage was 3 mm over the field area, with a Kcc-max of 1.4, and an error of 17 mm. Overall, the model provided a quick and robust way of estimating the irrigation water balance components.

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