

Soil-Water Dynamics in Flood Irrigated Orange Orchard in Central India: Integrated Approach of Sap Flow Measurements and Hydrus 1D Model

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Abstract: Climate change, along with the high water demand, has increased the groundwater withdrawal and is severely affecting the food-energy-water (FEW) nexus worldwide, especially in the arid and semi-arid regions. In developing countries, like India, lack of awareness and resources for adaptation of advanced technological applications for irrigation has led to inefficient agriculture practices and excessive groundwater withdrawal. In India, more than 89% of extracted groundwater used in the agriculture sector, and at the same time, only 5% of the net irrigated area is drip irrigated. In this study, we aimed to calculate the water use efficiency (WUE) of a flood irrigated orange orchard in central India. The global sensitivity of soil hydraulic parameters also assessed. Thermal Dissipation Probe (TDP-30) sap flow sensor together with HYDRUS 1D model, used to calculate the actual water demand for orange trees and leakage of water below the root zone. The model was satisfactorily able to reproduce the daily sap flow and root water uptake with a Nash–Sutcliffe efficiency (NSE) index of 0.68. The results show that the WUE of flood irrigation is only 25% and 75% of net irrigated water drained below the root zone. The results of global sensitivity analysis (GSA) for the soil hydraulic parameters suggest that the pore-size distribution index and saturated hydraulic conductivity has a significant influence on the leakage below the root zone. Whereas, the air-entry-pressure parameter and saturated hydraulic conductivity have a significant influence on transpiration rates. The study also shows the significance of initial soil moisture condition in optimizing the irrigation schedule. In conclusion, the comprehensive study suggests that flood irrigation is a gravely inefficient irrigation system for the irrigation of orchards, and a sensor-based approach may be more effective in deciding the irrigation patterns.

Keywords: global sensitivity analysis; HYDRUS; orange orchards; sap flow; water use efficiency