Quantification of Crop Water Requirement Using Soil Moisture Based Nonlinear Autoregressive Exogenous (NARX) Machine Learning Model

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Traditional evapotranspiration (ET) based irrigation technique involves uncertainties from different sources including ET data and crop coefficients resulting in over- or under-irrigation. While over-irrigation causes waste of water, under-irrigation causes water-stress. Considering how to capture soil moisture (SM) dynamics in the rootzone to quantify the crop water requirement with higher accuracy, this research aimed to develop a machine learning model from weather data and observed soil moisture in the plant rootzone using modern computational technique and sensor technology. The nonlinear autoregressive exogenous (NARX) algorithm, which can use some external variables and the previous system response to predict the future system response is used in this research. Methodology included 5 different steps: data collection and processing, model development, parameter selection, use of trained network for prediction, and model output analysis. Previous (lagged) total soil moisture (TSM) in the rootzone with average daily air temperature and relative humidity were used as the input variables into the NARX model to predict TSM, hence, to calculate the crop water requirement using a water balance model. A data set from an olive orchard was used in this research. Results show that the NARX model can successfully capture the TSM dynamics and can quantify the crop water requirement with high efficiency and accuracy (R2 value of 0.98) with an average water savings of 21.1% for the test set. An analysis shows that the application of this model can save significant amount of revenue to irrigate an agricultural field if the model is installed in a pump controller in the future.

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