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Field Crop Irrigation - Multi-Objective Optimization and Sensitivity to Weather Forecast Accuracy

Theodor Bughici (1), Eran Tas (2), Erick Fredj (3), and Naftali Lazarovitch (1)

(1) Jacob Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Sede-Boqer campus, Israel (bteodor@gmail.com, lazarovi@bgu.ac.il), (2) The R.H. Smith Faculty of Agriculture, Food and Environment, The Hebrew University of Jerusalem, Israel (eran.tas@mail.huji.ac.il), (3) Lev Academic Center, Computer, Jerusalem, Israel

Accurate irrigation and fertigation of field crops are crucial for maximizing crop yield while avoiding overuse of water and fertilizer. Irrigation management takes into account many plant and environment variables such as soil physical properties, root depth and salinity stress tolerance. In addition, the key environmental factor controlling crop development is the weather—i.e., precipitation and evapotranspiration (ET_0). Numerical weather forecasts that can predict precipitation and ET_0 have advanced rapidly in recent years but are still far from perfect. Moreover, the definition of what is an accurate forecast for crop irrigation is still absent as the definition of adequate accuracy may vary between crops, irrigation regimes, seasons and climates. We used a case study of sprinkler irrigated spring potato in coastal Israel as a test case to define a minimal accuracy level of ET_0 predictions for irrigation. First, in order to optimize the irrigation management, we used a genetic algorithm (NSGAii) running a numerical model that simulates water flow, solute transport and root water and solute uptake (HYDRUS 1D). The optimized crop model was based on historical mean ET_0values with the objectives of minimizing excess solute and water leaching and maximizing yield. Next, we used the optimal irrigation management for simulating the spring irrigation season of 2016 and perform a global sensitivity analysis. By modelling crop irrigation based on varying forecasted ET_0 bias ranges as well as crop and soil parameters we were able to rank the parameters by contribution to crop-model output variance. The optimal irrigation regime was found to be one of deficit supply of water with irrigation intervals of 48, making it very sensitive to ET_0 forecast accuracy. This procedure of optimization and sensitivity analysis can be extended to a wide range of case studies and help define what is an adequate weather forecast accuracy suitable to base crop irrigation upon.