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A European vision for hydrological observations and experimentation

Observing soil moisture dynamics on starch potato fields for improving irrigation management based on hydrological simulations

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In the view of global freshwater availability and an increasing water demand in agriculture to secure world nutrition, efficient water use is a key factor for sustainable irrigation management. Irrigation decision support systems often show a lack of awareness on intra-site and variety-specific optimum ranges of plant available water content, which enhances the ineffective use of irrigation water. In potato production, all phenological stages are sensitive to insufficient water supply, with optimum soil water contents ranging between 40% and 90% plant available water content. Hence, observations and simulations of soil moisture dynamics are crucial information for irrigation management. In a study to be presented we aim (i) to assess the optimum irrigation level for starch potatoes in terms of plant available water dynamics, and (ii) to compare the suitability of three different model environments for simulating soil moisture dynamics.

Four test plots (each 172 m x 72 m) were installed during the growing seasons 2021 and 2022 on two loamy sands (27 ha and 35 ha) in Mecklenburg-Western Pomerania, Germany, within one gun sprinkler irrigation lane. In each test plot, one irrigation level was applied: the longtime used irrigation level of the local farmer (100%), two deficit irrigation levels (80%, 90%), and one abundant irrigation level (120%). The 100% irrigation level was 119.2 mm in 2021 and 132.8 mm in 2022. The soil hydraulic properties determined in laboratory are typical for a loamy sand with soil moisture of 0.196 m^3 m^{-3} at field capacity and 0.038 m^3 m^{-3} at permanent wilting point. Hourly and daily simulations of root-zone (0-60 cm) soil moisture dynamics were performed using the evapotranspiration-based "Agrarmeteorologisches Modell zur Berechnung der aktuellen Verdunstung" (AMBAV) model and the soil hydraulic properties-based HYDRUS-1D and HYDRUS-2D model environments. In-situ soil moisture measurements, observed in three-time replicates per test plot in 10 cm increments up to a depth of 60 cm, were used for validation.

Field measurements confirmed that all irrigation levels impacted plant available water contents.

They ranged between 25% and 65% at the 80% irrigation level, between 42% and 94% at the 90% irrigation level, between 50% and field capacity at the 100% irrigation level and between 64% and 109% at the 120% irrigation level. All three model environments provide reliable simulation results at all irrigation levels, with an average coefficient of determination (R^2) of 70.13% (AMBAV), 76.62% (HYDRUS-1D) and 81.13% (HYDRUS-2D). Simulated soil moisture dynamics varied stronger in topsoil than in subsoil layers, mainly due to the soil hydraulic properties of a potato dam and the effects of evapotranspiration.

The in-situ measured soil moisture dynamics confirm the capability of a 90% irrigation level for starch potatoes. AMBAV´s lower input parameter requirements ensure a greater dispersion of simulated soil moisture dynamics, when compared to more precise estimations by both HYDRUS environments. The inclusion of soil hydraulic properties in irrigation scheduling provides practice-relevant information, e.g., the actual irrigation demand of a specific crop, and enables the use of hydrological models for irrigation scheduling instead of in-situ measurements.