A Novel Model-Based Constrained-Optimization Approach To Maximize Water Productivity Under Deficit Irrigation

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Farms around the world currently account for 70% of all water consumed annually. However, increasing municipal and industrial demands for water means there is less water allocated for agriculture, necessitating the use of deficit irrigation. This project proposed a novel model based constrained optimization approach to maximize crop yield under deficit irrigation. AquaCrop-OSPy was first used to run simulations of different irrigation strategies, such as fixed interval and Evapotranspiration (ET) based irrigation, using 36 years of historical weather data from Champion, Nebraska. ET based irrigation was used in this project because it has the best non-optimized yield and is easy to implement. Experiments were then designed to simulate the effect of water stress on the four crop growth stages using different deficit irrigation amounts and historical weather data. Based on the experimental data, four sigmoid models were created using log-transformed linear regressions to predict the effects of irrigation deficit on the final crop yield for each of the four growth stages. An optimization problem was formulated to find the best irrigation distribution for each of the four crop growth stages given a total seasonal irrigation constraint, so that the predicted yield can be maximized. This optimized irrigation strategy was tested in simulation using maize and clay loam soil under 36 years of historical weather data with both rain and no rain conditions. The optimized approach under both weather conditions had between an 8 to 35% increase in yield under various deficit irrigation amounts compared to the non-optimized ET-based approach.

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