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Effects of irrigation scheduling on soil moisture and water use efficiency in quinoa

Ann Sophie Bernhard[1], Inga Buschmann[2], Sebastian Heintze[3], Jörn Germer[4], Folkard Asch[5]

[1] *University of Hohenheim, Department of Management of Crop Water Stress in the Tropics and Subtropics,*
[2] *University of Hohenheim, Department of Management of Crop Water Stress in the Tropics and Subtropics, Germany*
[3] *University of Hohenheim, Department of Management of Crop Water Stress in the Tropics and Subtropics,*
[4] *University of Hohenheim, Inst. of Agric. Sci. in the Tropics (Hans-Ruthenberg-Institute), Germany*
[5] *University of Hohenheim, Inst. of Agric. Sci. in the Tropics (Hans-Ruthenberg-Institute), Germany*

Abstract

Efficient irrigation management is critical for sustainable crop production in water-scarce regions. While drip irrigation systems improve water application efficiency, irrigation performance largely depends on decision-making regarding the timing and quantity of water application. This study evaluates the effects of different irrigation scheduling strategies on soil moisture dynamics, crop yield, and water use efficiency of quinoa (*Chenopodium quinoa* Willd.) under field conditions in northeast Morocco.

A field experiment was conducted using a resolvable row-column design with six irrigation strategies, i.e. sensor-based irrigation, model-based irrigation (FAO Cropwat), farmers' practice-based irrigation, sensor-based irrigation combined with artificial intelligence using weather forecast data, and two deficit irrigation treatments. All plots were drip-irrigated, and treatments were applied from the end of flowering onwards. Soil moisture was continuously monitored using Dragino LSE01 sensors at multiple depths and positions, complemented by periodic soil moisture profile measurements using a PR^2 Profile Probe. Weather data were collected on-site to characterise climatic conditions and to estimate crop water demand.

Preliminary results show that irrigation strategies had a highly significant effect on total irrigation quantities ($p < 0.001$), with farmer-based and model-based approaches applying the largest quantities, deficit irrigation treatments the smallest, and sensor- and AI-based strategies resulting in intermediate levels. Treatment effects on average soil moisture in 20 cm depth within the rows were smaller but still significant ($p = 0.008$). The highest soil moisture levels were observed under farmer-based and model-based irrigation, whereas deficit irrigation resulted in the lowest values. However, most treatments showed overlapping soil moisture ranges, and only the difference between deficit irrigation and farmer-based irrigation was statistically significant ($p = 0.0169$).

These findings suggest that while irrigation strategies strongly influence water application, their impact on soil moisture in the main root zone is more moderate, highlighting

Contact Address: Inga Buschmann, University of Hohenheim, Department of Management of Crop Water Stress in the Tropics and Subtropics, Steckfeldstraße 62, 70599 Stuttgart, Germany, e-mail: inga.buschmann@uni-hohenheim.de

the potential of sensor- and AI-based irrigation to reduce water use without substantially reducing soil moisture levels. Additional results, including crop yield, biomass components and water use efficiency, will be presented.

Keywords: Artificial intelligence, drip irrigation, irrigation scheduling, quinoa, soil moisture, water use efficiency