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Crop water stress monitoring tools for drip-irrigated rice cultivation with reclaimed wastewater

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Abstract

Lowland rice cultivation is characterised by high water demands for irrigation to ensure crop development. Rice in Andalusia is currently grown under flooded conditions. Due to rising temperatures and decreasing precipitation water scarcity is a pressing concern, and solutions for effective water management in rice cultivation systems are imperative. This study investigates the applicability of infrared thermometry and spectral indices for monitoring crop water stress in rice cultivation utilising reclaimed wastewater under varying soil water levels. A field experiment was conducted over two cropping seasons (2022–2023) at the Technological Center for New Water Technologies (Seville). The effluent of the experimental wastewater treatment plant was used for irrigation. The rice was grown in 100 m^2 plots with three replications per treatment. Climatic data was obtained from a nearby station and crop water requirements were calculated following the FAO-56 methodology. One water metre per treatment was installed to monitor the volume of irrigation water applied. Infrared thermometers and spectral reflectance sensors were installed to continuously measure canopy temperature and vegetation indices (NDVI) in both treatments. Stomatal conductance was monitored via a Leaf Porometer throughout the growing season. Crop temperature and climatic data were used to derive reference non-water-stress baselines to calculate the Crop Water Stress Index (CWSI) in rice grown under aerobic conditions. The reference baselines obtained were stable between 12–17h (local time) and between growth cycles. The CWSI index calculated with the reference baselines derived in this study was sensitive to the variations in crop water status caused by the irrigation treatments. The dynamics of CWSI resembled those observed in stomatal conductance, demonstrating the validity of the method for continuous monitoring of crop water status in the experiment. During early crop development, the CWSI index is inaccurate due to reduced visible soil in the thermal sensor's field of view. The complementary information of the NDVI corrects the interpretation of the CWSI index in early phenological stages. The study highlights the feasibility of infrared thermometry and spectral indices for real-time assessment of crop water stress, offering a valuable tool for precision agriculture and informed decision-making in water management strategies for rice cultivation.

Keywords: Deficit irrigation, infrared thermometry, *Oryza sativa*, spectral indices, thermal sensing, water-use efficiency

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