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Agronomic and remote sensing-based assessment of paddy rice responses to salinity stress in Andalusia, Spain

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Abstract

The primary irrigation source of lowland rice in Isla Mayor (Andalusia, Spain) is the Guadalquivir River. Decreasing precipitation and increasing temperatures favour the seawater intrusion into the river, ultimately resulting in high salinity concentrations in the irrigation water and rice fields. This influx of salt, particularly sodium, disrupts the potassium-sodium (K:Na) balance in rice plants, hindering growth and reducing yields. Consequently, water scarcity and salinity significantly impact the cultivated area, resulting in harvest losses at both individual plant and plot levels.

To investigate the effects of salinity on rice varieties, a field experiment was conducted during the 2022 growing season across three farms with varying salinity concentrations (low, medium, and high). Leaf samples were collected from each farm, with two replications per treatment, and analysed for potassium-sodium ratios using flame photometry. Concurrently, local farmers provided yield data, while satellite images from Google Earth Engine were utilised to calculate vegetation indices for trial plots. These indices were then compared with potassium-sodium ratios and final plot yields obtained from the field experiment.

During the vegetative growth stage, strong correlations were observed between vegetation indices and rice yield, particularly during the rapid vegetative growth phase. Notably, NDRE exhibited the highest correlation with salinity levels, while the EVI and SAVI indices demonstrated the best fit with rice yield. Additionally, dynamics of NDVI mirrored those of potassium-sodium ratios during rapid vegetative growth, highlighting its usefulness in identifying critical phases for yield prediction under salinity stress.

This study emphasises the potential of open-source remote sensing tools for making informed decisions regarding water allocation in rice cultivation under elevated salinity conditions. By understanding the relationship between vegetation indices, salinity levels, and crop yield, farmers can better manage water resources and mitigate the negative impacts of salinity on rice production.

Keywords: Google Earth Engine, *Oryza sativa*, plant growth, sodium toxicity, vegetation indices, yield