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Prediction of Rice SPAD Values Using UAV-Based Spectral Indices and Machine Learning under Alternative Irrigation and Fertilization Strategies

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Abstract. Excessive fertilization in rice cultivation is one major environmental problem leading to soil and water pollution. Additionally, conventional fertilization requires multiple field entries during critical phenological stages, increasing production costs and labor requirements. Therefore, the development of rapid, reliable methods assessing crop nutritional status to adjust fertilizer rates ensuring environmental sustainability is critical.

Three irrigation methods dry-seeding with continuous flooding, alternate wetting and drying, and surface drip irrigation - combined with seven nitrogen treatments: a control, three conventional N rates (120, 180, and 240 kg N ha^{-1}), and three slow-release N rates (120, 180, and 240 kg N ha^{-1}) were experimented.

Leaf chlorophyll content was assessed using a SPAD meter between the flowering and maturity stages and used as an indicator of plant nitrogen status in all treatments.

Additionally, Multiple Linear Regression, Polynomial Linear Regression, Support Vector Regression, Extreme Gradient Boosting and Random Forest were applied to estimate nitrogen fertilization status in the different treatments from multispectral imagery acquired by UAV. Among the tested models, SVR provided the most accurate predictions, with strong agreement between measured and estimated SPAD values, demonstrating that integrating UAV based remote sensing with machine learning offers a reliable framework for assessing plant nitrogen status in rice cultivation.

Keywords: Rice, SPAD, UAV-based remote sensing, spectral vegetation indices, machine learning