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Remote Sensing-Based Prediction of Asymptomatic Rice Blast Disease Using Hyperspectral Spectroradiometry and Spectral Sensitivity Analysis

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Abstract : Rice is one of the most important staple food crops in the world. Among the various diseases that affect rice crops, rice blast is particularly significant, causing crop yield and economic losses. While the plant has defense mechanisms in place, such as chemical indicators (proteins, salicylic acid, jasmonic acid, ethylene, and azelaic acid) and resistance genes in certain varieties that can protect against diseases, susceptible varieties remain vulnerable to these fungal diseases. Early prediction of rice blast (RB) disease is crucial, but conventional techniques for early prediction are time-consuming and labor-intensive. Hyperspectral remote sensing techniques hold the potential to predict RB disease at its asymptomatic stage. In this study, we aimed to demonstrate the prediction of RB disease at the asymptomatic stage using non-imaging hyperspectral ASD spectroradiometer under controlled laboratory conditions. We applied statistical spectral discrimination theory to identify unknown spectra of M. Oryzae, the fungus responsible for rice blast disease. The infrared (IR) region was found to be significantly affected by RB disease. These changes may result in alterations in the absorption, reflection, or emission of infrared radiation by the affected plant tissues. Our research revealed that the protein spectrum in the IR region is impacted by RB disease. In our study, we identified strong correlations in the region (Amide group - I) around X 1064 nm and Y 1300 nm with the Lambda / Lambda derived spectra methods for protein detection. During the stages when the disease is developing, typically from day 3 to day 5, the plant's defense mechanisms are not as effective. This is especially true for the PB-1 variety of rice, which is highly susceptible to rice blast disease. Consequently, the proteins in the plant are adversely affected during this critical time. The spectral contour plot reveals the highly correlated spectral regions 1064 nm and Y 1300 nm associated with RB disease infection. Based on these spectral sensitivities, we developed new spectral disease indices for predicting different stages of disease emergence. The goal of this research is to lay the foundation for future UAV and satellite-based studies aimed at long-term monitoring of RB disease.

Keywords : rice blast, asymptomatic stage, spectral sensitivity, IR
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