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Spectral response to early detection of stressed oil palm seedlings using near-infrared reflectance spectra at region 900-1000 nm

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ABSTRACT

A method was developed based on spectral analysis and classification models for early detection of water stress level in the leaves of oil palm seedlings. The healthy (well-watered: D0) and water-stressed (subjected to water stress for five days: D1-D5) leaves of oil palm seedlings were investigated to identify and classify the stress levels. The stress levels were grouped as light, moderate, and severe. The region 900–1000 nm was selected because it is highly correlated with water content, particularly in terms of first and second derivatives. The measured reflectance spectra at 900–1000 nm were pre-processed using smoothing, standard normal variate (SNV), and first and second Savitzky-Golay (SG) derivatives. Principal component analysis (PCA) was performed on several transformed datasets to reduce the reflectance spectral dimension and derive the principal components (PCs). Support vector machine (SVM) and linear discriminant analysis (LDA) classification models were employed to the scores of PCs to achieve six classification levels of water stress. Classification accuracy was assessed using the overall accuracy and confusion matrix of testing datasets. The SVM and PCA-LDA classification models predicted the water stress levels with high average overall classification accuracy of 92 % and 94 % using the smoothed + SNV + first derivative and smoothed + SNV spectral dataset, respectively. The findings confirmed the potential of 900–1000 nm region to distinguish the different levels of water stress in oil palm seedlings.

1. Introduction

Oil palm (*Elaeis guineensis*) is a palm species that has been widely cultivated in Southeast Asia, specifically in Malaysia and Indonesia. Malaysia is the second-largest producer and a net exporter of oil palms [1], which has considerably increased the economic development of the country [2]. Oil palm serves the dual roles of being a source of edible oil and a renewable energy resource [3]. However, the production of oil palms can be hindered by infections such as Basal stem rot (BSR) disease. This disease also known as Ganoderma boninense (G. boninsense), is the major threat to the cultivation of oil palms [4]. BSR is a fatal fungal infection that significantly affects the cultivation of oil palms in Malaysia, specifically destroying the basal stem and roots of oil palms. The fungal pathogen destroys these parts of the oil palm by infecting the xylem tissue of the trunk through the generation of enzymes that decompose the lignin constituent, which is subsequently destroyed by the fungus [5]. This infection subsequently causes an interruption in the flow of water and nutrients in the plant [6], resulting in the yellowing and necrosis of leaves, a small canopy, and unopened spears [7]. These physical symptoms of the infection are signs that distinguish healthy oil palms from infected or damaged ones.

Effective crop management involves preventing the onset of diseases and stress while the plants are still in an asymptomatic phase. Young palms are now beginning to get infected, leading symptoms to appear earlier than they did in the past when the disease or water stress in oil palm plants was only observed at a late stage [8,9]. Several studies have been conducted in Malaysia to investigate BSR in seedlings and trees of oil palm using a variety of techniques that include visible and near-infrared (Vis-NIR) hyperspectral images [10], dielectric spectroscopy [11], hyperspectral imaging [2], thermal images [12], remote sensing

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