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Quantifying the impact of varied NPK fertilizer levels on oil palm plants during the nursery stage: A Vis-NIR spectral reflectance analysis

Abstract

The utilization of Vis-NIR spectroscopy, coupled with advanced statistical analysis methods, offers enhanced precision in monitoring the nutrient status of plants compared to traditional practices. This research aims to explore the efficacy of spectroscopy as a method for detecting and monitoring plant nutrient levels. The reflectance spectra of AA Hybrida 1S oil palm plants were measured in the 325–1075 nm wavelength range. Different quantities and application intervals of nitrogen, phosphorus, and potassium (NPK) fertilizers were systematically examined to assess their impact on the physical condition and reflectance of the plants. The relationship between different fertilization methods and nutrient levels is analysed using spectral index and principal component analysis (PCA), employing and testing several spectral pre-processing techniques, such as moving average smoothing, Savitzky-Golay derivatives, and standard normal variate (SNV) transformation. Spectral index calculation showed with statistical significance that 0.8 g of NPK supplied every two weeks improved the nutrient conditions in plants after five months. Moreover, PCA analysis showed that SNV pre-processing enabled the best classification between stressed and non-stressed nutrient status. Among the spectral bands analysed, the red-edge band (660–770 nm) demonstrated significantly better performance than the green band (540–560 nm) in identifying nutrient-stressed conditions. This is attributed to the strong light absorption by chlorophyll in the red region and the pronounced reflection caused by leaf cell structures in the NIR region.

Keywords

NPK; Nutrient status; PCA; Spectral reflectance; VIS-NIR spectroscopy