PRELIMINARY STUDY ON EVALUATING A MINIATURIZED MULTISPECTRAL CAMERA FOR NON-DESTRUCTIVE CHLOROPHYLL ESTIMATION IN COFFEE ARABICA LEAVES

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Accurate estimation of leaf chlorophyll content is essential for monitoring crop health, nutritional status, and physiological responses to environmental stress [1&2]. While hyperspectral imaging has demonstrated excellent performance for chlorophyll estimation, its high cost and large data volume restrict widespread adoption in practical agricultural applications [3]. This study evaluated the performance of a novel miniaturized multispectral camera (S1-EVK2) for estimating chlorophyll a, chlorophyll b, total chlorophyll, and SPAD values in Coffea arabica leaves, and benchmarked its performance against laboratory-based hyperspectral imaging systems (Hyspex VNIR, Hyspex SWIR, and Specim IQ). Reference chlorophyll concentrations were obtained through acetone extraction, while SPAD measurements were acquired using a handheld chlorophyll meter. Partial Least Squares Regression (PLSR) models were developed using spectral reflectance data following seven different preprocessing methods and evaluated using leave-one-week-out cross-validation together with an independent test set.

Among the evaluated systems, the Hyspex VNIR camera achieved the highest predictive performance for chlorophyll a (R^2 = 0.89, RMSEP = 1.87 mg L^{-1}, RPD = 3.10), total chlorophyll (R^2 = 0.83, RMSEP = 3.50 mg L^{-1}, RPD = 2.56) and SPAD estimation (R^2 = 0.92, RMSEP = 2.34, RPD = 3.72). For chlorophyll b, the Hyspex SWIR camera provided the best performance (R^2 = 0.57, RMSEP = 2.12 mg L^{-1}, RPD = 1.58), although prediction accuracy for this pigment remained modest across all systems ($R^2 \leq 0.57$, RPD < 1.6). The S1-EVK2 multispectral camera delivered reasonable performance for chlorophyll a (R^2 = 0.79), total chlorophyll (R^2 = 0.72) and SPAD readings (R^2 = 0.83) despite employing substantially fewer spectral bands and a lower spectral resolution. Furthermore, the optimal regression models were applied to multispectral images to generate pixel-wise chlorophyll distribution maps of coffee leaves. These findings demonstrate the potential of the S1-EVK2 multispectral camera as a compact, low-cost alternative to laboratory-based hyperspectral imaging systems for non-destructive chlorophyll assessment and spatial chlorophyll mapping in coffee plants.

References

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