Spectral reflectance and physiological studies of cocoa leaves in response to macronutrient deficiency

ABSTRACT

In cocoa (Theobroma cacao), macronutrients of nitrogen (N), phosphorus (P) and potassium (K) are the essential elements that may drastically affect growth, appearance and most importantly, yield. However, detection of macronutrients can be slow while nutrient analysis can be time consuming. Adaptation of hyperspectral analysis techniques along with physiological study for the determination of specific nutrient stress in cocoa could allow early detection and precision in fertilization. The objective of the study was to investigate the prediction possibility of N and K deficiency in cocoa seedlings using a spectroradiometer. Spectral reflectance of fully expanded cocoa leaves from 350 to 1000 nm; growth (height, girth, leaf area) and physiological studies (photosynthesis, transpiration rate, chlorophyll content) were measured at monthly intervals for 3 months after treatment. A total of 72 seedlings (3 treatments x 4 replication x 6 sampling = 72 seedlings) with treatments (T1: 15-N: 15-P: 15-K; T2: 0-N: 15-P: 15-K; T3: 15-N: 15-P: 0-K) were arranged in a factorial randomized complete block design replicated four times in a greenhouse. Multispectral reflectance showed that leaves with no N (T2) had the highest reflectance peak at about 550 nm as absorption of incident light by chlorophyll decreased. This was further supported by T2 cocoa seedlings with significantly lowest readings in growth, net photosynthesis, transpiration rate and chlorophyll content ($P \leq 0.05$). Next, cocoa seedlings with no N and K involved response to nutrient stress by showing a shift in the red edge with greater reflectance at 675-750 nm. This is because healthy cocoa seedlings with complete ratio of NPK absorbed light as energy for photosynthesis and reflect near infrared light by bouncing off from the mesophyll layer. Overall, reflectance measurements could be a powerful non-destructive technique to decide on fertilizer application and timely correction of nutrient deficiencies before irreversible stress or damage occurs.