ABSTRACT

Proximal Soil Sensing and Spatio-Temporal Analysis for Site Specific Management in Cocoa Plantations

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Exports of cocoa (*Theobroma cacao L.*) from Trinidad and Tobago have been steadily declining. Soil spatial variability has been implicated as one of the major causes of inconsistency in Trinidad and Tobago's cocoa yields. Field-scale characterization of soil spatio-temporal variability for the implementation of site-specific management (SSM) has the potential to optimize efficiency, profitability, sustainability, and reduce environmental risks in Trinidad and Tobago's large cocoa plantations.

Traditional methods such as grid sampling combined with geostatistical analysis are labour intensive, time consuming, invasive and costly. Electromagnetic induction (EMI) devices, allow rapid field-scale characterization of soil apparent electrical conductivity (ECa). The EMI device has however, had limited usage under tropical conditions. In this study, the potential of the EMI geophysical technique for determining spatial and temporal variations of soil properties and identifying soil-based management zones for site-specific management in cocoa fields was evaluated.

Spatial measurements of ECa at shallow, ECa_s (0-0.75 m) and deep, ECa_d (0.75-1.5 m) were conducted using EMI at the International Cocoa Genebank, Trinidad (ICGT). Results of correlation analysis show that ECa_d and ECa_s gave the strongest linear correlation with clay-silt content ($r = 0.67$ and $r = 0.78$, respectively) and soil solution electrical conductivity, ECe ($r = 0.76$ and $r = 0.60$, respectively). Spearman's rank correlation coefficients (r_s) ranged between 0.89 and 0.97 for ECa_d and 0.81 and 0.95 for ECa_s signifying a strong linear dependence between measurement days. Thus, in the humid tropics, cocoa fields with thick organic litter layer and relatively dense understory cover, experience minimal fluctuations in transient properties of soil water and temperature at the topsoil resulting in similarly stable ECa_s and ECa_d. Multiple linear regressions indicated that clay-silt content and ECe dominated the signal surface response at both ECa_d and ECa_s depths accounting for 67% and 63% in ECa variability, respectively. Since ECa_s covers the depth where cocoa feeder roots concentrate and is similarly temporally stable as ECa_d, ECa_s of the wettest month surveyed (August 2009) was used as a secondary data in cokriging to improve the spatial and temporal estimation of clay-silt content and ECe. The cokriged data was

subjected to fuzzy cluster classification to delineate management zones. Two management zones were identified using the fuzzy performance index and normalized classification entropy. This zone delineation potentially facilitates cost-effective, environmentally friendly and energy efficient management of the field. Future work might want to relate the proposed management zones with yield maps, to demonstrate the agronomic benefits of this classification.

Keywords**:** Management zones; Fuzzy clustering; Spatial variability; Humid tropic; Precision agriculture.