Title: Use of Multispectral UAV Imagery to Monitor Late-Season Defoliation in Peanut Production Systems

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Introduction

Foliar diseases intensify during the final stages of peanut development, causing canopy deterioration and defoliation especially leaf spot infection induced by *Cercosporidium personatum* (Cantonwine et al., 2008). As leaf loss increases, the risk of pod loss during digging may also increase if harvest is delayed. Furthermore, defoliation reduces the amount of green canopy biomass and leaf area available to intercept solar radiation, leading to changes in canopy reflectance and a decline in vegetation index values derived from multispectral imagery. Therefore, UAV-based multispectral imagery offers a rapid and non-destructive approach for monitoring crop condition and assessing the impact of different fungicide programs on disease-induced defoliation. Thus this study evaluated the relationship between UAV-derived vegetation indices and late-season canopy condition in peanuts under different fungicide programs.

Materials and Methods

The experiment was conducted in 2021 at the University of Georgia Lang-Rigdon Experimental Farm (Tifton, GA, USA). Three runner-type peanut cultivars (Georgia-06G, Georgia-18RU, and TifNV-High O/L) were grown under four fungicide programs: a non-treated control (NTC), chlorothalonil applied five times (RED), chlorothalonil applied seven times (CL), and chlorothalonil applied three times combined with two applications of pydiflumetofen (CLM). Multispectral imagery was acquired using a 3DR Solo UAV equipped with a MicaSense RedEdge sensor (blue, green, red, red-edge, and near-infrared bands). Flights were conducted around midday at 45 m altitude with 80% image overlap, producing imagery with 2.29 cm pixel resolution. Images were processed in Pix4Dmapper using ground control points and radiometric calibration, and reflectance maps were imported into ArcMap for canopy extraction and vegetation index calculation. Vegetation indices were related to chlorophyll content and defoliation through correlation and regression analyses.

Results and Discussion

The fungicide programs generated contrasting levels of canopy deterioration and defoliation, ranging from substantial leaf loss in the non-treated control (NTC) to enhanced canopy preservation in protected plots. This gradient offered a suitable range of crop conditions to assess the sensitivity of multispectral vegetation indices to late-season canopy decline. As disease-induced deterioration advanced, leaf area and green biomass reductions modified canopy reflectance, leading to a decline in vegetation index values. Such spectral changes align with the expected impact of defoliation, which limits photosynthetically active tissue and increases the soil background influence detected by the sensor.

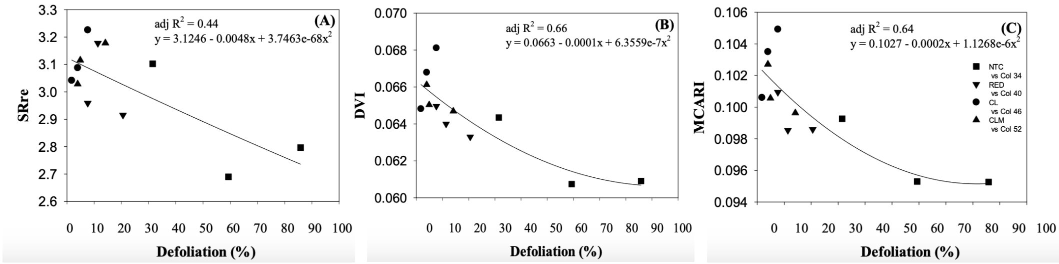

Figure. Relationships between SRre (A), DVI (B), and MCARI (C) and defoliation (%) at 128 DAP across four fungicide treatments (NTC, RED, CL, and CLM).

SRre, DVI, and MCARI showed the strongest relationships with defoliation (R^2 = 0.70–0.88), suggesting their capacity to characterize structural and physiological shifts linked to disease pressure. The robust performance of SRre likely stems from the red-edge region's sensitivity to chlorophyll content and canopy density, whereas MCARI emphasizes chlorophyll signals while reducing background noise. Similarly, DVI effectively captured reflectance changes caused by reduced green vegetation cover. The consistent decrease in these indices as defoliation intensified indicates their reliability as indicators of peanut canopy condition during the final stages of development.

Variations in disease management strategies contributed to the observed spectral differences among fungicide programs. The NTC plots, experiencing higher disease severity, consistently exhibited lower index values due to biomass loss and increased soil exposure. Conversely, fungicide-treated plots maintained greener, denser canopies, yielding higher index values. Intensive protection programs, including seven chlorothalonil applications (CL) or the combination of chlorothalonil and pydiflumetofen (CLM), preserved canopy integrity for extended periods. These results demonstrate that multispectral UAV imagery can discriminate differences in canopy preservation resulting from different fungicide treatments.

These findings demonstrate the potential of multispectral UAV imagery as a rapid, non-destructive approach for monitoring late-season peanut health and quantifying disease-induced canopy decline. Since severe leaf loss increases the risk of pod loss during digging and harvest, the ability to remotely detect canopy deterioration may support more informed management decisions. Furthermore, this technology provides an efficient tool for evaluating the efficacy of fungicide programs under field conditions.

Conclusions

SRre, DVI, and MCARI effectively characterized late-season peanut canopy condition and were strongly associated with chlorophyll content and defoliation. These results demonstrate the potential of multispectral UAV imagery as a non-destructive tool for monitoring canopy deterioration and supporting digging time decisions in peanut production systems.

References

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