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Precision Agriculture in Early Pest Detection

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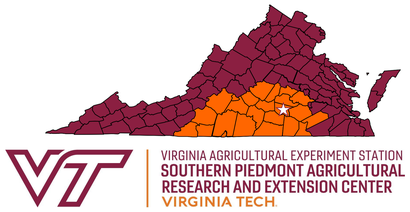

Abstract

Managing insect pests is one of the challenges in tobacco production that continue to negatively impact tobacco yield and quality, threatening the sustainability of production in Virginia. Implementing effective, environmentally-friendly and cost-effective pest management rely on early detection and identification of the stress factor are two of the most important components of integrated pest management (IPM). Technological advances in imaging can offer new tools for effective monitoring and timely implementation of pet management practices. This project was developed to determine whether spectral reflectance can be used to detect biotic stresses and if the identified spectral signatures are species-specific. Our greenhouse results indicated that spectral reflectance can be used to detect pest presence as early as one week after infestation, and the spectral signatures associated with the infestations were species-specific for tobacco budworm and stink bugs. The extracted bandwidths from the collected drone images were sensitive enough to detect treated and untreated plots in the field and those representing 392-503 nm wavelengths were negatively correlated with aphid numbers.

Approach

Cultivars: CC35 CU263, NC196, K326, K326-LA, and PVH2310 were used in greenhouse and field assays.

Greenhouse

- Measurements: Spectroradiometer, ADS FieldSpec 4 Hi-Res; three repeated measures 1, 2, and 3 weeks after infestation.
- 15 indices (1) were calculated based on the recorded reflectance (350-2500 nm); indices: CAI, CARI, MCARI, DWSI5, ARI1, CasiNDVI, NDLI, NDWI, NDNI, Clrededge, LCI, Modified NDVI, reNDVI, HI, and MCARI_A (see handouts for description)
- Insect pests used in bioassays: Tobacco budworm Heliothis virescens (Lep., Noctuidae), stink bug Nezara viridula (Hem., Pentatomidae), and tobacco aphid Myzus persicae (Hem., Aphididae) were caged on tobacco plants (Fig 1; results pooled across cultivars)

The southern green stink bug

Tobacco aphid

Tobacco budworm

Field trials

Measurements:

- Drone equipped with a Pika L hyperspectral sensor (data collection in June); collected range: 392-1035 nm
- Satellite imaging by Apollo Mapping (Boulder, CO); MS bands, 8-band MS at 1.2-m; 30-cm Pan

Insect pests: Natural infestations with multiple pests with tobacco aphids being the primary

Cultivar: CC35, NC196, K326, K326-LA, and PVH2310 are presented here.

Experimental plots: 30 plots analyzed: 'Control' with Admire Pro in transplant water and 'Untreated' with no pesticide treatment

Results

Greenhouse

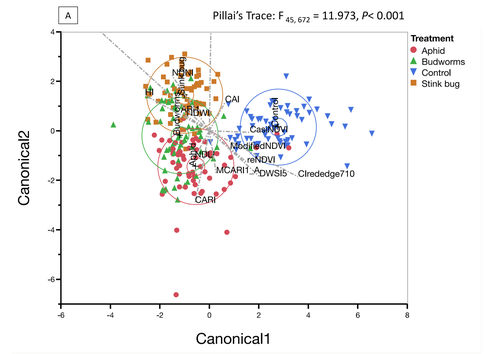

Figure 1: Infestations were detected one week after infestations (A). On weeks 2 (B) and 3 (C) aphid infestation was not separable from the non-infested controls based on the calculated indices.

Field trials:

- ***Satellite or drone hyperspectral image?***

The resolution of the images collected by satellite (Fig. 2A) was not sufficient to classify experimental plots.

The hyperspectral data collected from the drone (Fig. 2B) classified insect presence in the field plots (Fig.3)(Pillai's Trace: $F_{48, 300}$ = 357.83, P< .001).

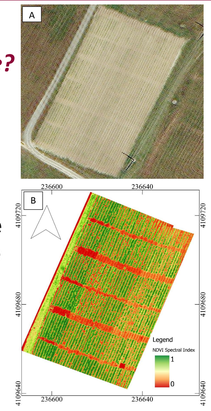

Figure 2: Satellite collected RGB image (A), and a drone collected NDVI (B)

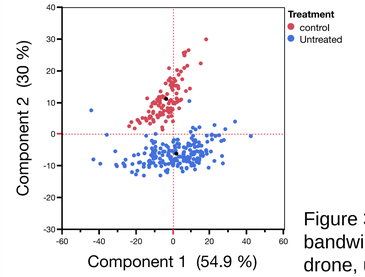

Figure 3: Using the 300 bandwidths collected by the drone, untreated and control plots clustered separately.

- ***Is the observed treatment clustering influenced by the number of aphids?***

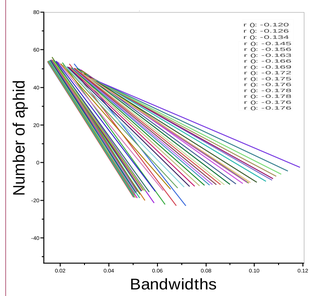

Figure 4: 55 out of the 300 bandwidths ranging between 392 and 503 nm showed correlations with the number of aphids in untreated plots.

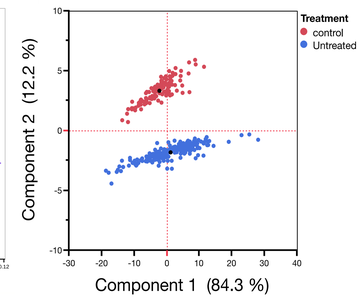

Figure 5: The 55 bandwidths correlated with the number of aphids, (Fig. 3) successfully classified control and untreated plots.

Conclusions & Future directions

- Spectral measurements detected pest presence in the greenhouse as early as one week after infestations in the greenhouse. However, over time aphid infestations were non-distinguishable from the non-infested controls.
- Although satellite images alone could not be used to detect biotic stress, drone imaging effectively separated untreated and control plots.
- In untreated plots, aphid numbers were correlated with the bandwidths corresponding to 392-503 nm wavelengths; when tested, those selected bands also separated untreated and control plots (see Figs. 3 and 4). Thus, the clustering based on all bandwidths may not be entirely due to other environmental factors
- This experiment will be repeated next year to reconfirm findings and to evaluate the effectiveness of drone imaging on tobacco budworms and flea beetles.

Acknowledgment

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References

Index database: a database for remote sensing indices. Institute of Crop Science and Resource Conservation (INRES), University of Bon, Germany: https://www.indexdatabase.de/