Evaluation of relationships between crop height and image spectral reflectance in peanut crops through the length of rotation using UAV-derived lidar and optical imagery in South Central Georgia, U.S

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Background

Peanuts are a globally valuable oilseed and legume crop for their economic and nutritional value. While considering its economic significance, it's crucial to monitor growth for management purposes which could lead to increased productivity. Monitoring large agricultural areas using remote sensing technology can provide cost-effective information throughout the crop length and aid management decision-making.

In this research, we attempt to evaluate plant development, such as abundance/density of green vegetation and plant height as crop attributes highly related to productivity.

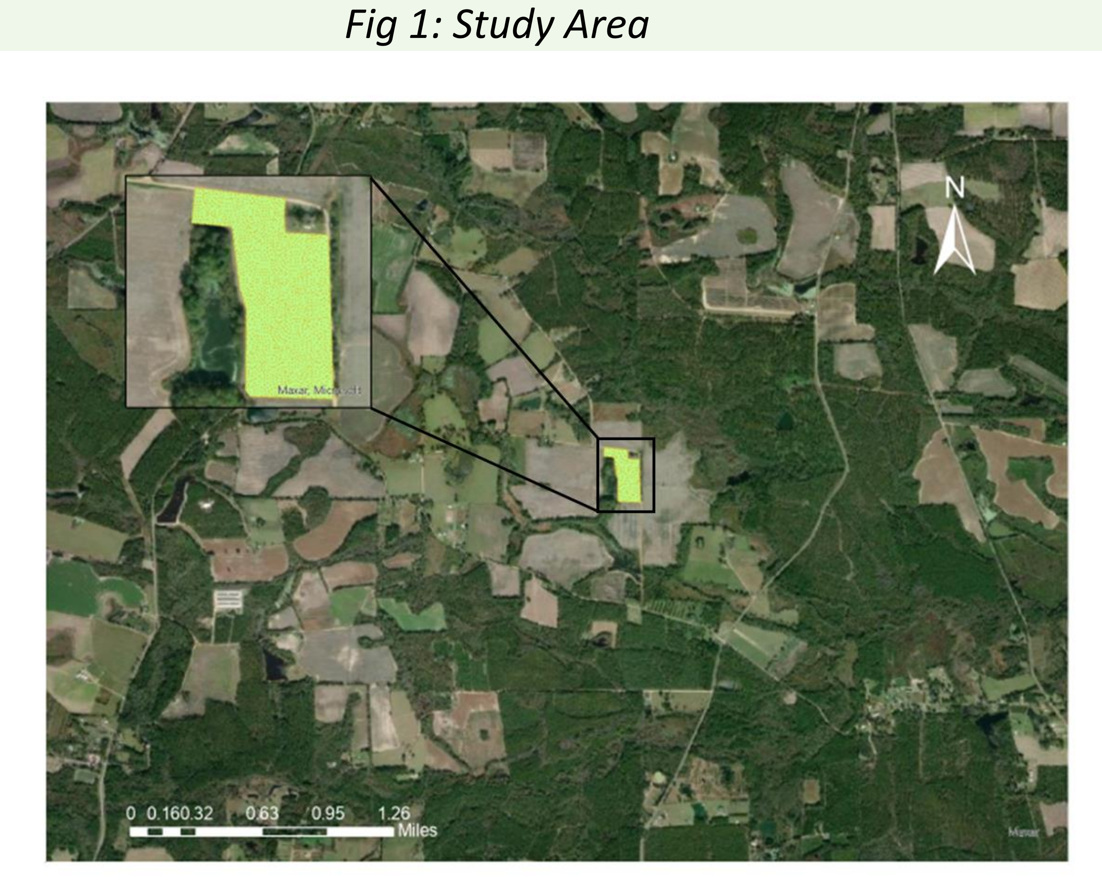
Objective

This study aims to evaluate the relationship between plant height and vegetation spectral reflectance values at different growth or crop development stages in peanut plantations.

Methods - Study Area

The research was conducted on a peanut plantation field at the Taft farm (5.34 ha) in Atkinson County in South Central GA, USA (Fig. 1).

Fig 1: Study Area



Mean Annual Temp : 65.6 F ;

Mean Annual Prec. : 47.3 inch.

Soils: Sandy Loam: silt clay 7.6%,Sand 92.4% , clay 6.68 %, silt 0.92 %

Peanut crop length: 150 Days.

Methods – Data Collection

- The field data were collected using a DJI M600 Pro UAV equipped with a Nano hyperspectral and LiDAR sensor four times during the crop cycle (Fig. 2). The field was planted in late May 2022, and we flew over the area on June 15, July 28, August 29, and September 26; at development stages DS1, DS2, DS3, and DS4, respectively.
- The spectral sensor has a range of 400-1100nm, and the lidar sensor acquires data at 1050nm. Flights were conducted at 50m altitude and at a speed of 4m/s, providing an average of 1025 points/m^2 lidar density and a 3x3 cm pixel resolution for the optical data.

Fig 2: UAV and Sensors

Fig 3: Circular Sample Polygons

- Spectral data were preprocessed by converting the raw values into radiance and reflectance, which were then stitched together to generate an Orthomosaic for the study area. Vegetation indices were then calculated and generated raster layers using R software. Vegetation indices utilized the Red and Near-Infrared (NIR) regions of the spectrum (Table 1).
- Similarly, raw lidar point clouds were processed with R to generate the high-resolution (0.2x0.2 m) Digital Elevation Model (DEM) and Canopy Height Model (CHM) raster layers for the field.

Fig 4: Processing Workflow

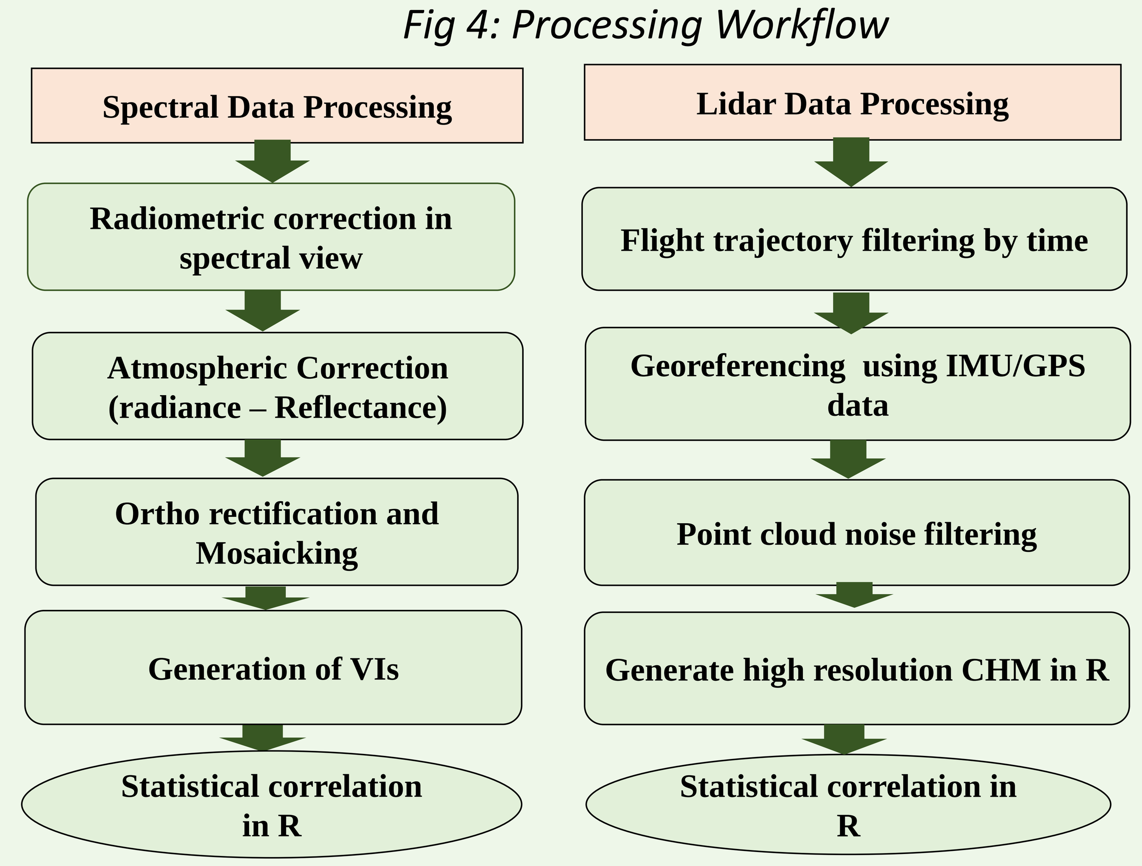


Table 1: Vegetation Indices

Vegetative Indices - VI	
Normalized Difference Vegetation Index (NDVI)	NIR - Red / NIR + Red
Normalized Difference RedEdge Index (NDRE)	NIR-RedEdge / NIR + RedEdge
Soil Adjusted Vegetation Index (SAVI)	1.5(NIR – Red)/(NIR–Red+ 0.5)
Inverse Ratio Vegetation Index (IRVI)	R650/R770

- We generated a 1000 circular sample polygons (Fig.3) randomly across the field with diameters of 15 (DS1), 50 (DS2 and DS3) and 60 cm (DS4), for each of the development stages (Fig.5).
- We masked DS1 using the Spectral Combination Index (SCI) allows to remove the only-soil pixels and keep the only-vegetation pixels for analyses.
- We extracted average pixel vales within the sample polygon boundaries from all VIs and CHM layers.
- Then we performed Pearson correlation analysis between CHM and VIs values.

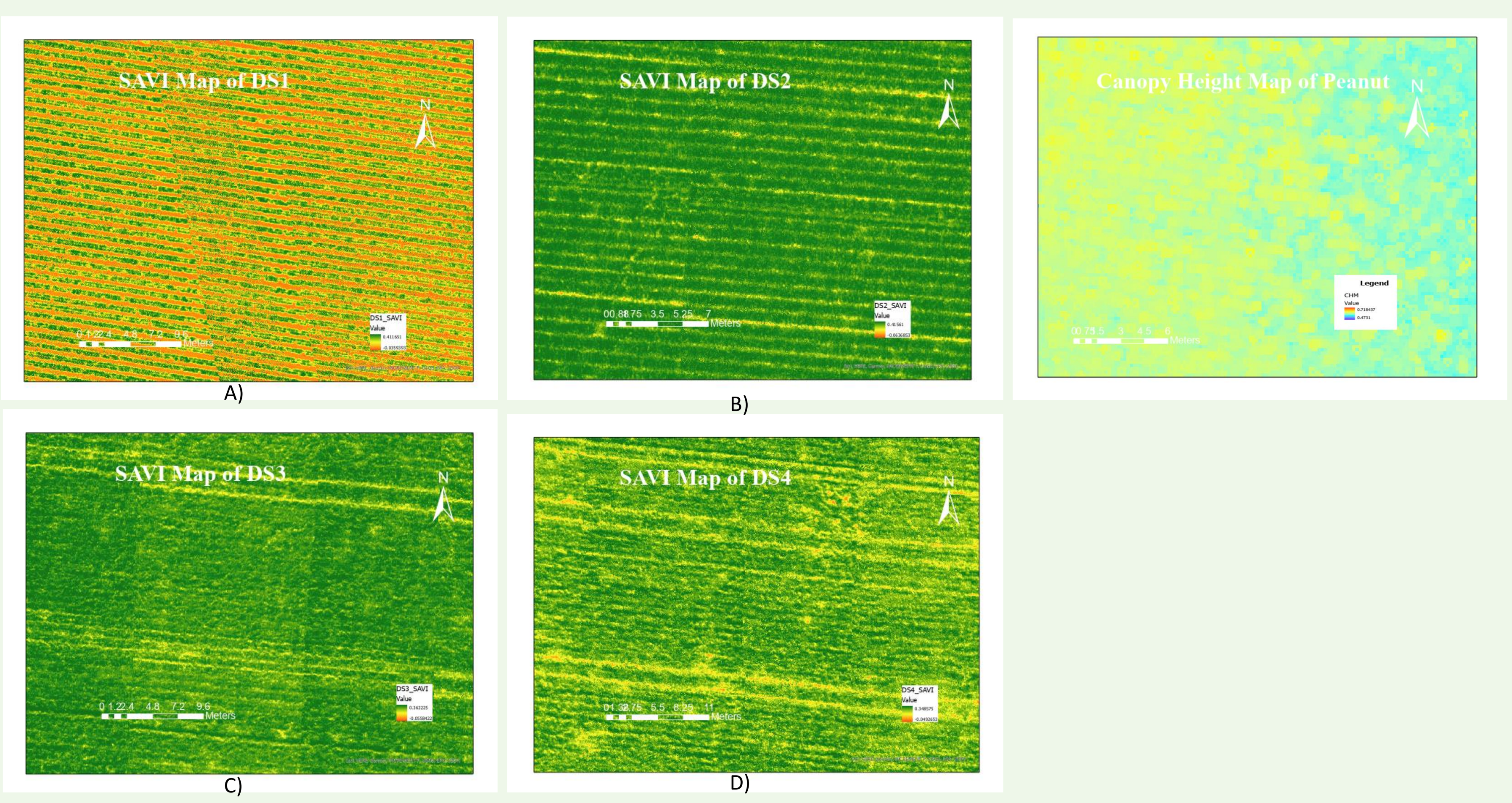
Results

- The correlation analyses indicated that SAVI is highly correlated (r=0.63) with canopy height at the late development stage (approx. one month before harvesting), whereas NDVI, NDRE, and IRVI show low significant correlations. For the last development stage, only a few days before harvesting, VI, SAVI, and IRVI showed low but significant correlations. All the VIs showed very low correlations with the CHM at the early stages of the crop development.

Table 2: Pearson correlation values between all vegetation indices and CHM mean pixel values for the n=1000 sample polygons randomly distributed across the field. Significance was at p-value=0.5.

Pearson Correlation Coefficients for VI in relation to CHM				
VI	DS1	DS2	DS3	DS4
NDVI	-0.02	0.02	-0.17**	0.18***
NDRE	-0.05	0.00	-0.15**	-0.09
SAVI	-0.02	0.08	0.63***	0.17***
IRVI	0.01	-0.02	0.20***	0.20***

Fig. 5: Subset of the peanut field of approx. 0.34 ha SAVI Vegetation Index for A) development stage 1, B)development stage 2, C)development stage 3, D)development stage 4, and CHM Map



Conclusion

- Statistically significant correlations between optical sensor-based vegetation indices and lidar-derived heights could be further utilized to generate models to predict crop productivity. More research will be done to examine differences across development stages.

Acknowledgement

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