

Potential of UAV Imagery to Estimate Cotton Harvest-Aids Efficacy for Different Application Methods and Carrier Volumes

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(C. Byers, S. Virk, J. Snider, C. Hand)



Cotton Harvest Aids

□ Cotton harvest aids - mixture of **defoliation agents** to enhance **boll opening** (Cavalaris et al., 2022)

□ Considered as fundamental component for mechanized harvesting (Chen et al., 2022)

Importance: (Cavalaris et al., 2022)

- Improved harvest efficiency
- Enhanced fiber quality
- Reduced boll rot and disease

Challenges: (Chen et al., 2022)

- Application timing
- Application method and rate
- Environmental factors

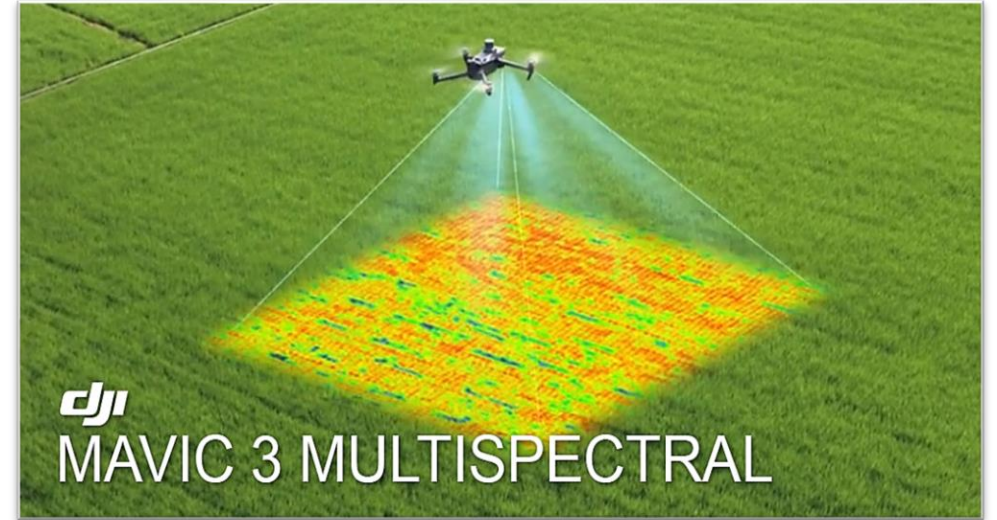


Unmanned Aerial Vehicle (UAV)

□ Benefits of UAV over traditional method

Potential (Pokhrel et al., 2023; Yi et al., 2019)

- ❖ Estimate the efficacy of harvest aid
 - Defoliation monitoring
 - Boll opening detection
- ❖ Stress detection
- ❖ Crop phenotyping
- ❖ Yield Estimation
- ❖ Growth monitoring throughout the season etc.



Source: https://www.vertigodrones.com/DJI-Mavic-3M-Multispectral-with-Enterprise-Care-Basic-2-Year_p_2514.html



Hypothesis

- ❑ UAV-based multispectral and visual imagery (Vegetative Indices) can help in determining differences in defoliation efficacy between different application methods and/or volumes

Objective

- ❑ To evaluate the potential of UAV-based multispectral and visual imagery for estimating cotton defoliation efficacy among different application methods and carrier volumes

Materials and Methods

- **Study Treatments:**
 - Drone Sprayer
 - 3 GPA & 5 GPA
 - Ground Sprayer
 - 5 GPA & 10 GPA
- Each treatment (sprayer and volume) was replicated four times (RCBD design)
- Each plot measured 8 rows wide (24 ft) and 100 ft long
- Three-way defoliant mix – Folex, Dropp and Prep – was used for all applications

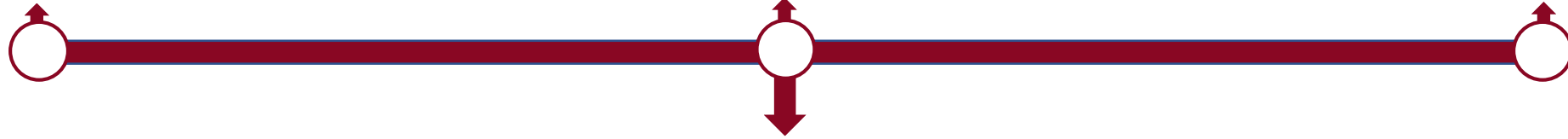


Data Collection

On day of application (0 DAA)
10/10/2023

Seven days after application (7 DAA)
10/17/2023

Fourteen days after application (14 DAA)
10/24/2023



1. Physiological measurements



10-Consecutive plants from two adjacent rows

- Green Leaf Number
- Light Interception using Ceptometer
- Open boll Number
- Closed boll Number

2. UAV Imagery



Multispectral and RGB Imagery using DJI Mavic 3M

- RGB Camera: 20MP, 4/3 CMOS,
- Multispectral Camera: 4 x 5MP, G/R/RE/NIR

- Height: 50ft.
- Speed: 2.4 mph
- Front overlap: 80%
- Side overlap: 60%

Data Extraction & Workflow



1st: Flight Plan

- Created in DJI Mavic 3M
- Raw image tiles obtained



2nd: Pix4D Field/Mapper

- Multispectral Bands: Nir-R-G-RE
- Visual Orthomosaic : RGB



3rd: ArcMap

Multispectral Bands

Visual Orthomosaic

Vegetation Indices Values

Vegetation Indices Map

Cotton Fiber Index Computation

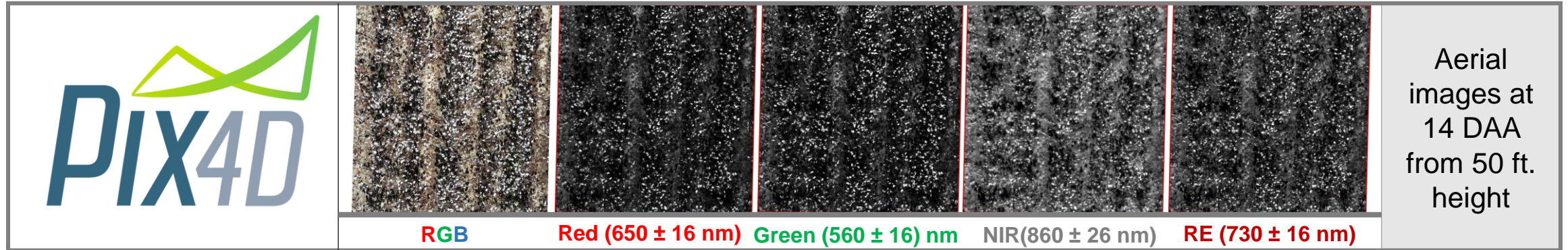
Indicator of Defoliation

Indicator of Boll Opening

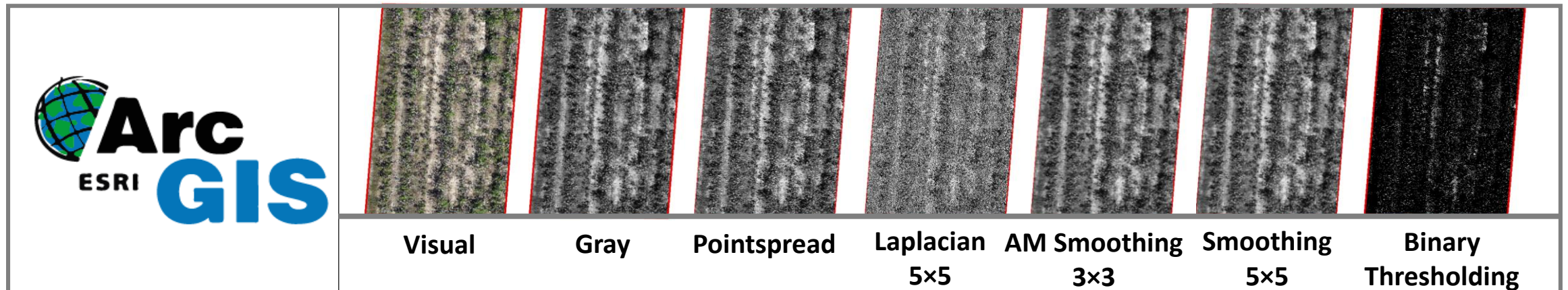


Image Processing and Analysis

- ❖ **Image Processing:** Pix4D Mapper software was used to create mosaic image combining raw imagery tiles from UAV for each date



- ❖ **Imagery Analysis:** ArcMap 10.7.1 and ArcGIS Pro Mapper software was used to extract reflectance index for vegetation indices (VI's) and CFI computation (pixel value > 150 was used as white pixels).



Data Analysis

- Statistical Analysis was performed using **JMP**[®] Pro 17.2.0 ($\alpha = 0.05$)
- Data was subjected to **mixed-effect ANOVA** for each parameter ($p \leq 0.05$)
- Correlation between aerial imagery data and ground measurements was conducted
- Formula's used for computing open bolls (%), Defoliation (%) and CFI:

$$\text{Open Boll (\%)} = \frac{\text{Number of open bolls on the sample spots}}{\text{Total number of bolls on the sample plots}} \times 100$$

(Yang & Zhou, 2010)

$$\text{Defoliation (\%)} = \frac{(\text{No. of green leaves before application} - \text{No. of Green leaves after application})}{\text{Number of green leaves before application}} \times 100$$

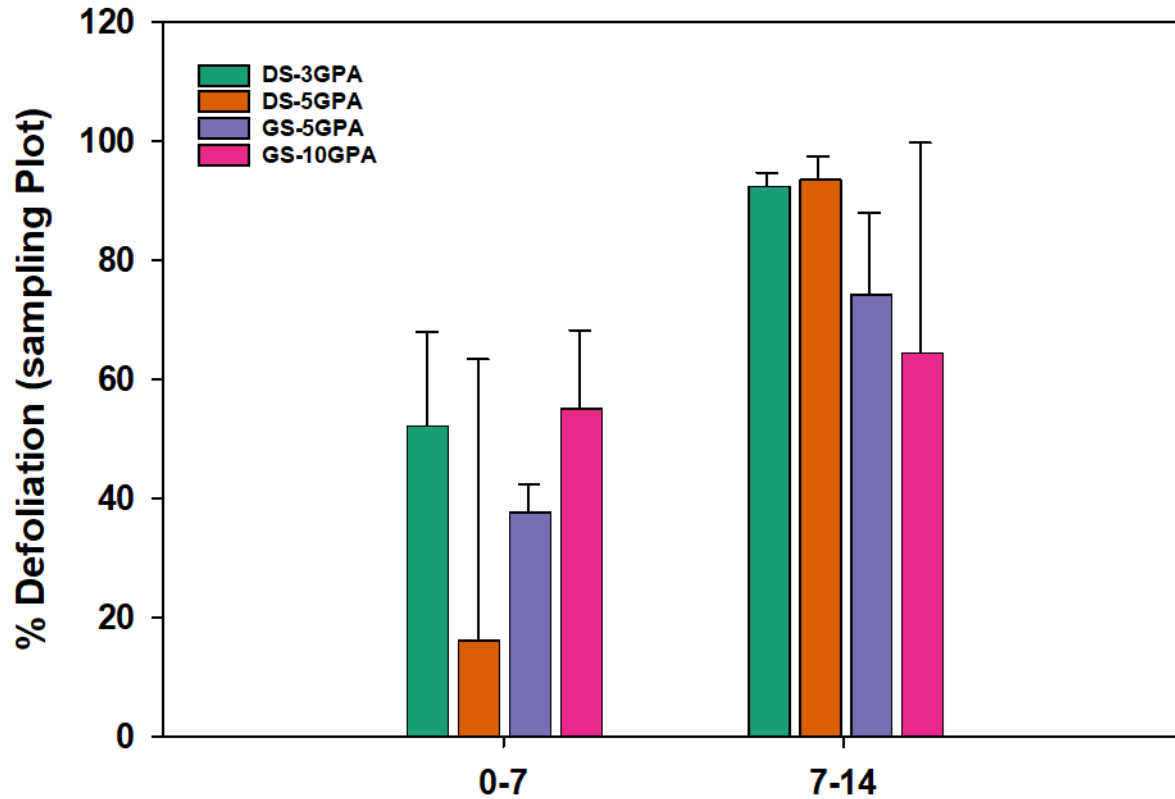
(Chen et al., 2022; Meng et al., 2019)

$$\text{Cotton Fiber Index(CFI)} = \frac{\text{Number of white pixels classified as cotton in sampling spot}}{\text{Total number of pixels in sampling spot}}$$

(Cavalaris et al., 2022)

RESULTS: Harvest-Aid Efficacy

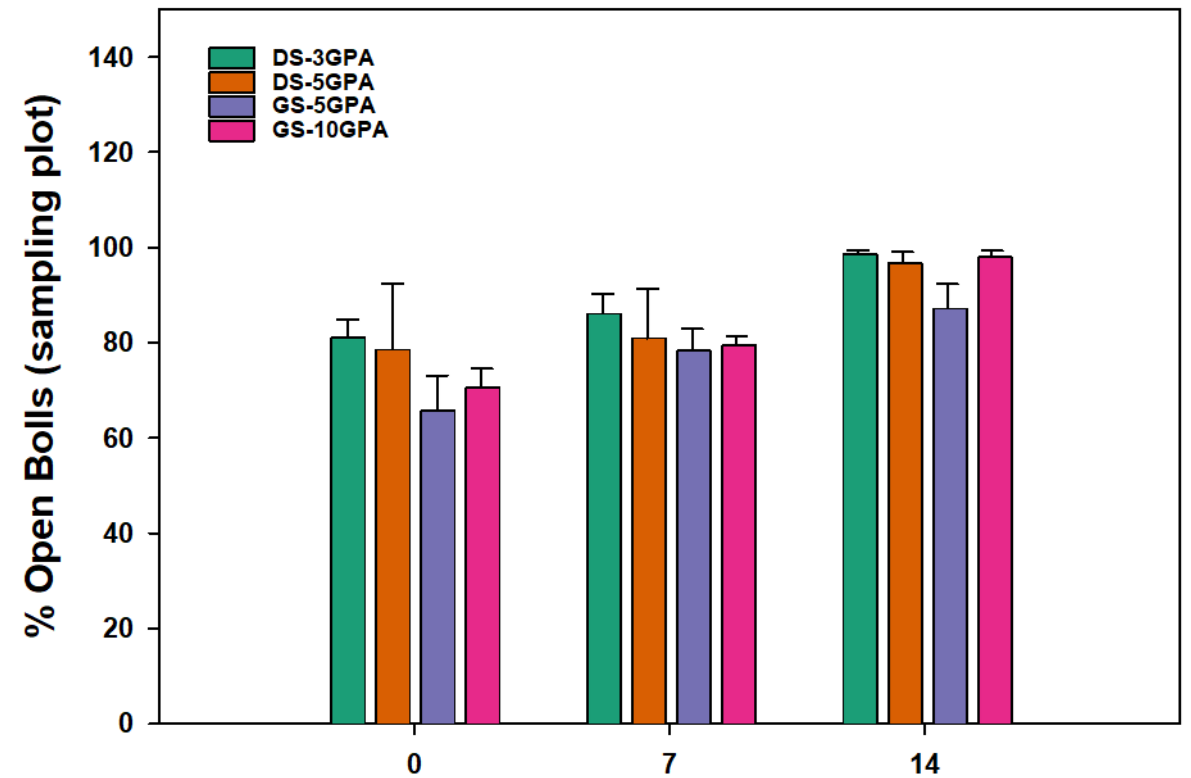
Defoliation (%)



Time Interval

DAA	P-value	Significance
0-7	0.3954	Ns
7-14	0.8205	Ns

Open bolls (%)

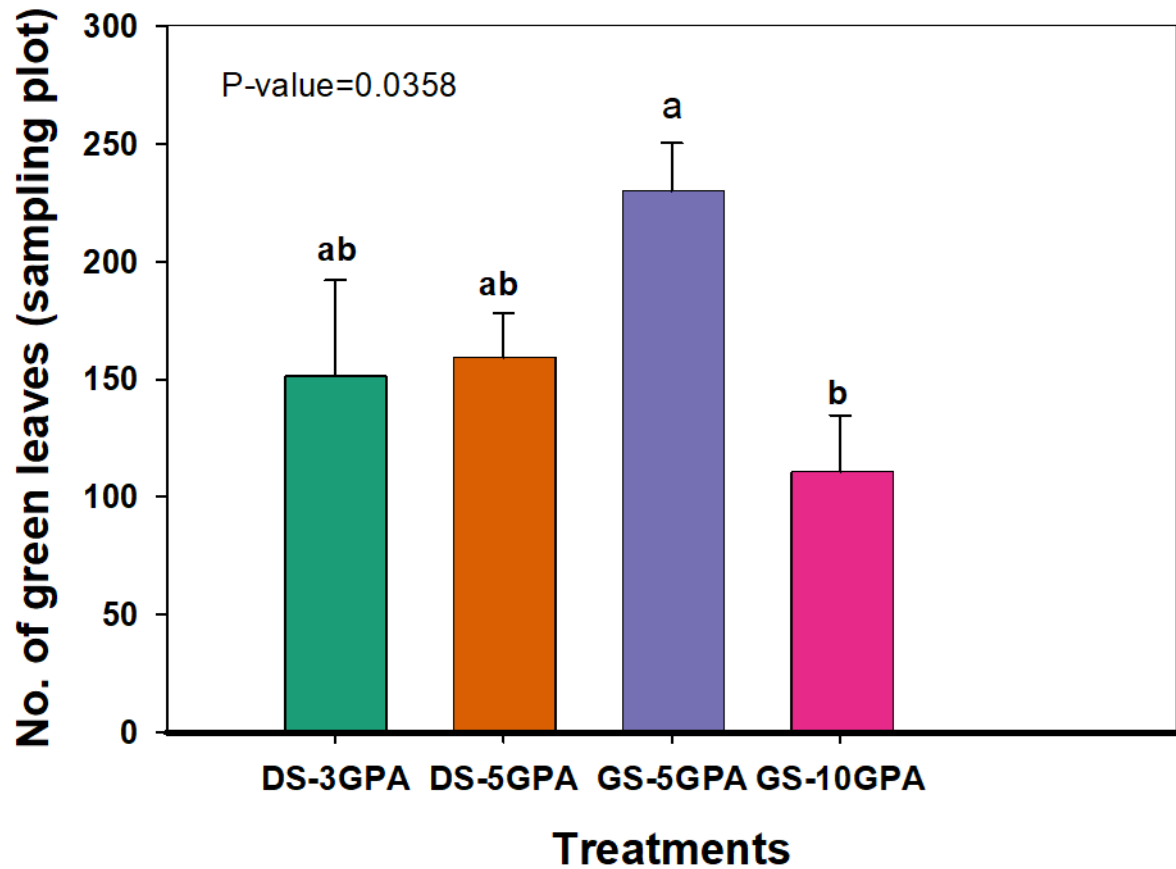


Days After Application (DAA)

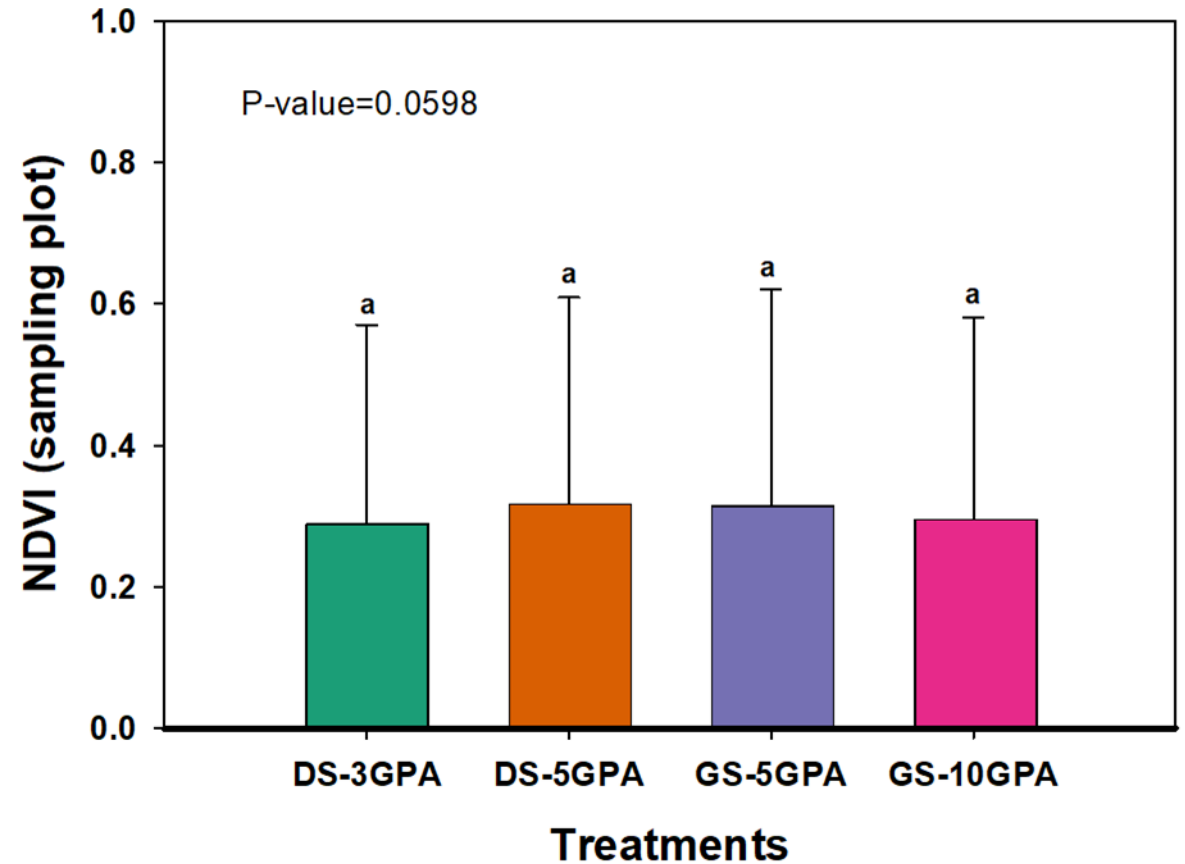
DAA	P-value	Significance
0	0.5123	Ns
7	0.7593	Ns
14	0.1152	Ns

No. of Green Leaves and NDVI at 7 DAA

No. of Green Leaves with treatments at 7 DAA

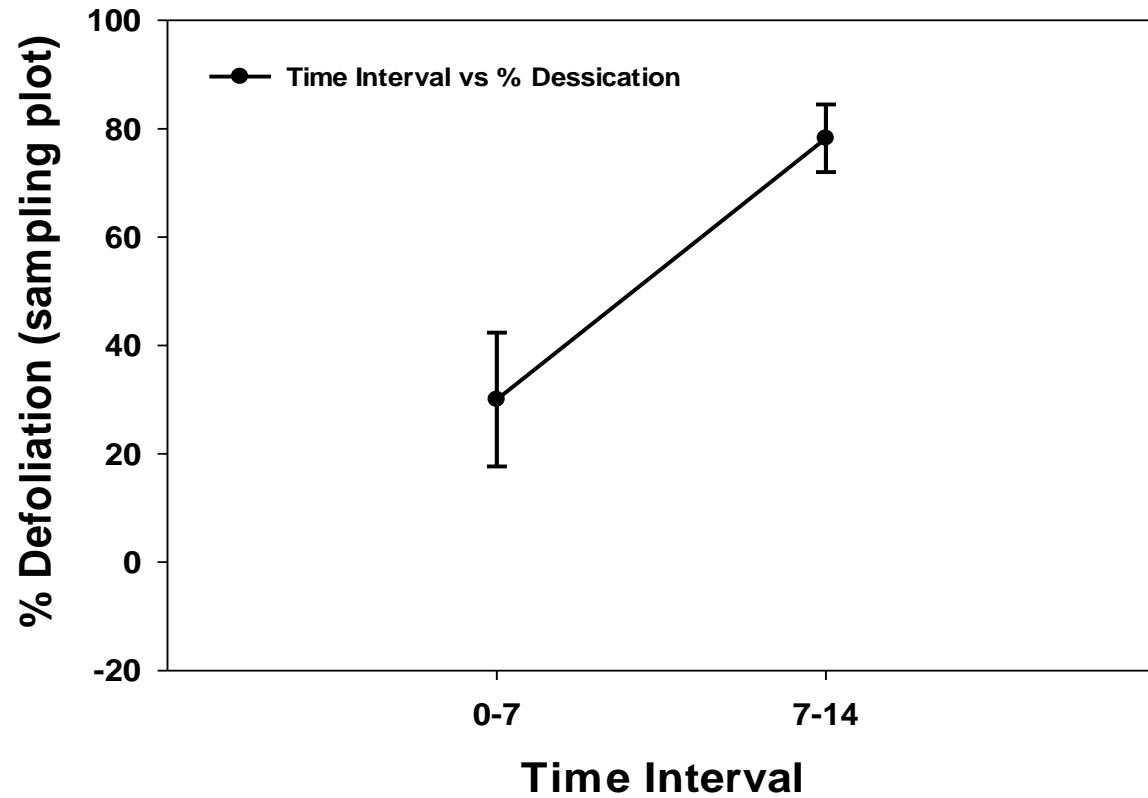


NDVI with treatment at 7 DAA



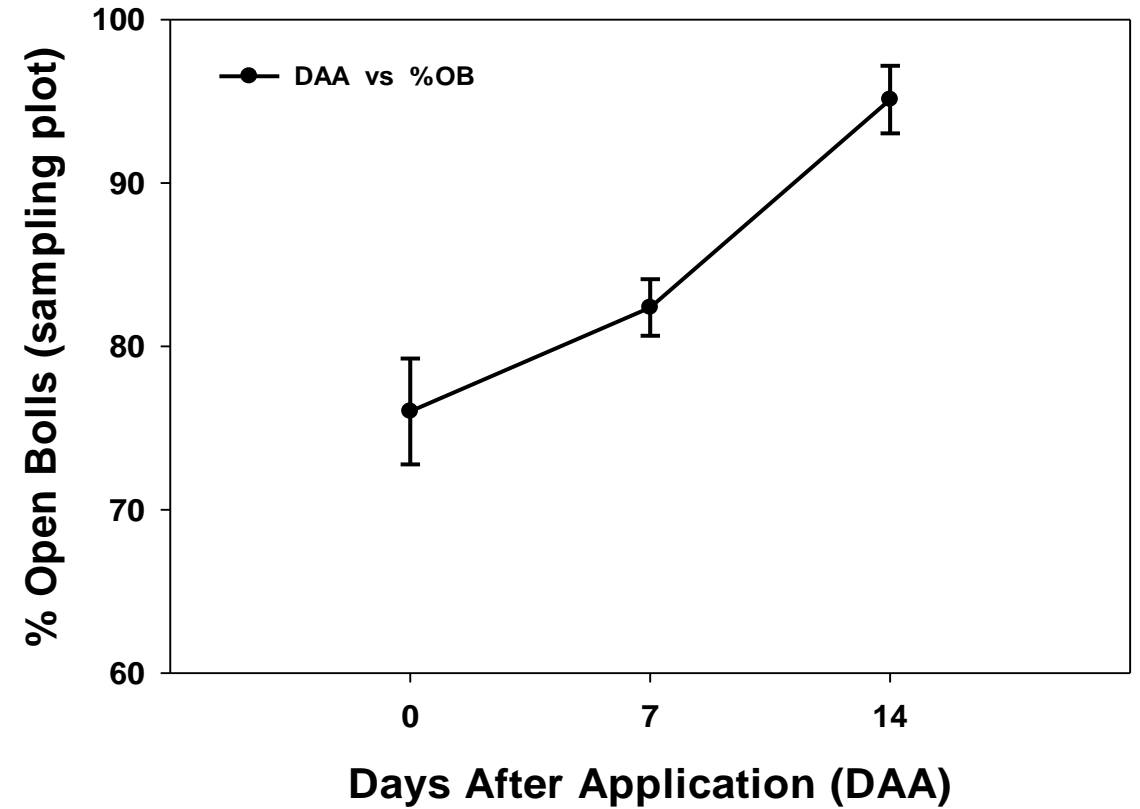
RESULTS: Harvest Aid Efficacy

Defoliation (%)



Source	P-Value	Significance
Time Interval	0.0043	*

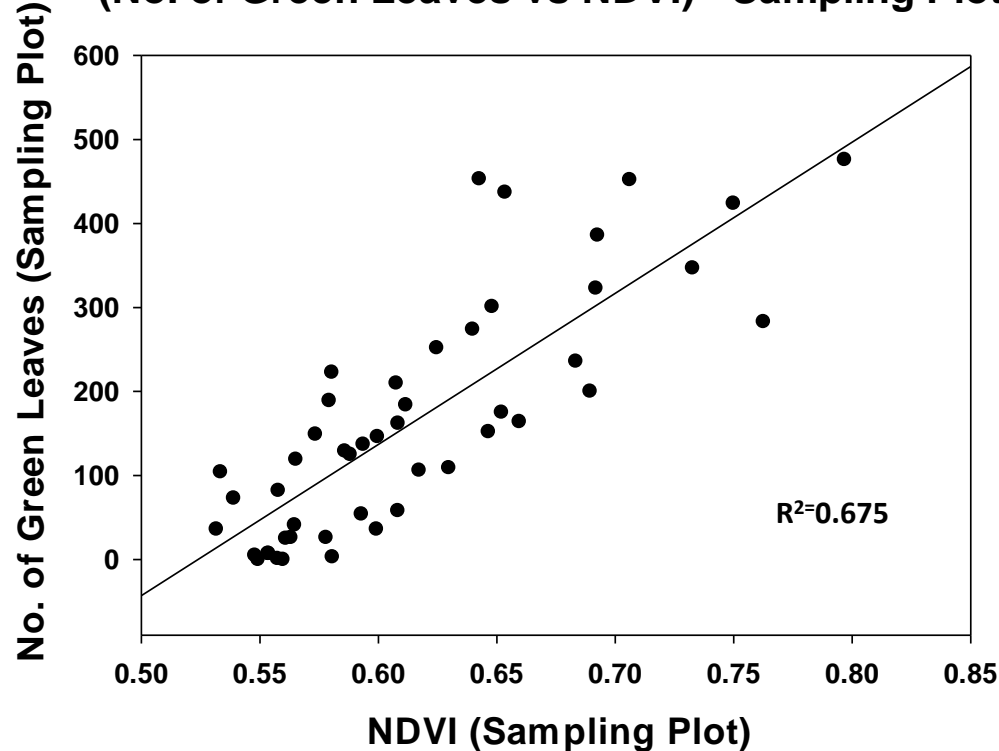
Open bolls (%)



Source	P-Value	Significance
DAA	<0.001	*

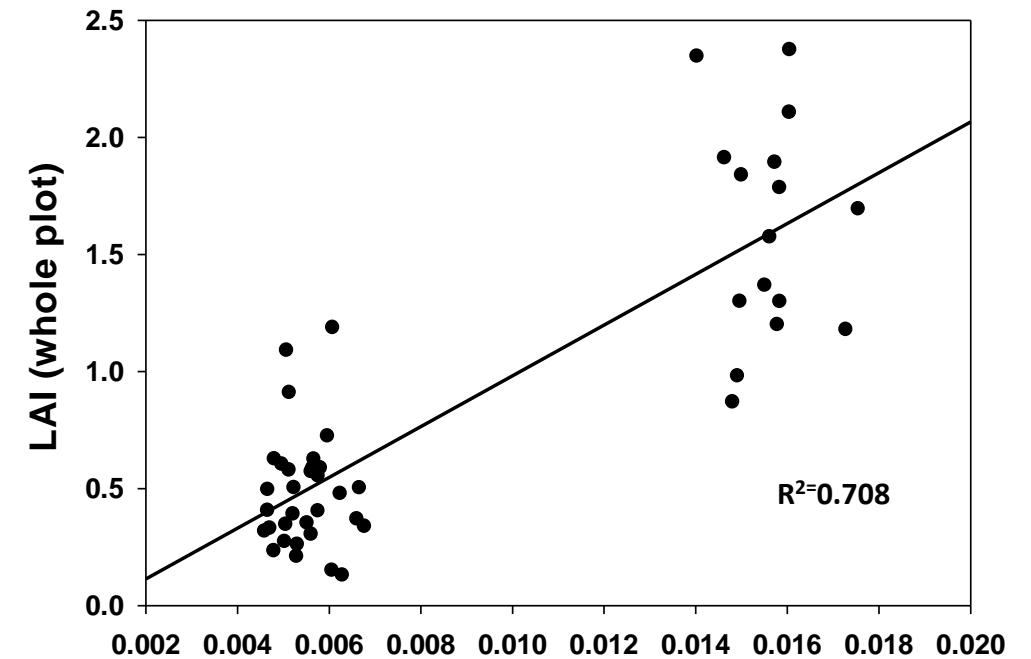
Defoliation-(Ground measurement vs Aerial Data)

(No. of Green Leaves vs NDVI) - Sampling Plot



Green Leaf Number vs VI's - Sampling plot	
VI's	R ²
NDVI	0.675
GNDVI	0.665
MSAVI	0.628
SAVI	0.467
EVI2	0.29
NDRE	0.144

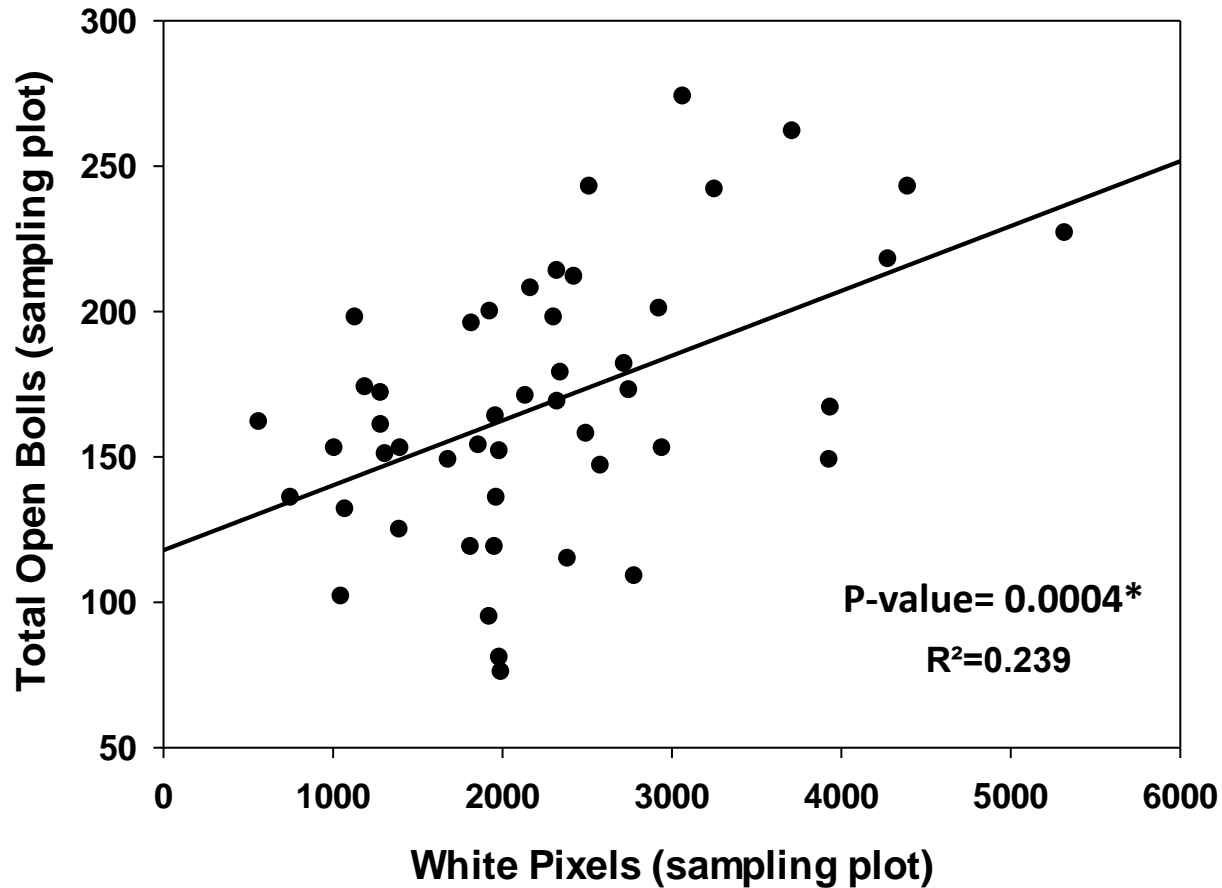
(Leaf Area Index vs SAVI) - whole plot



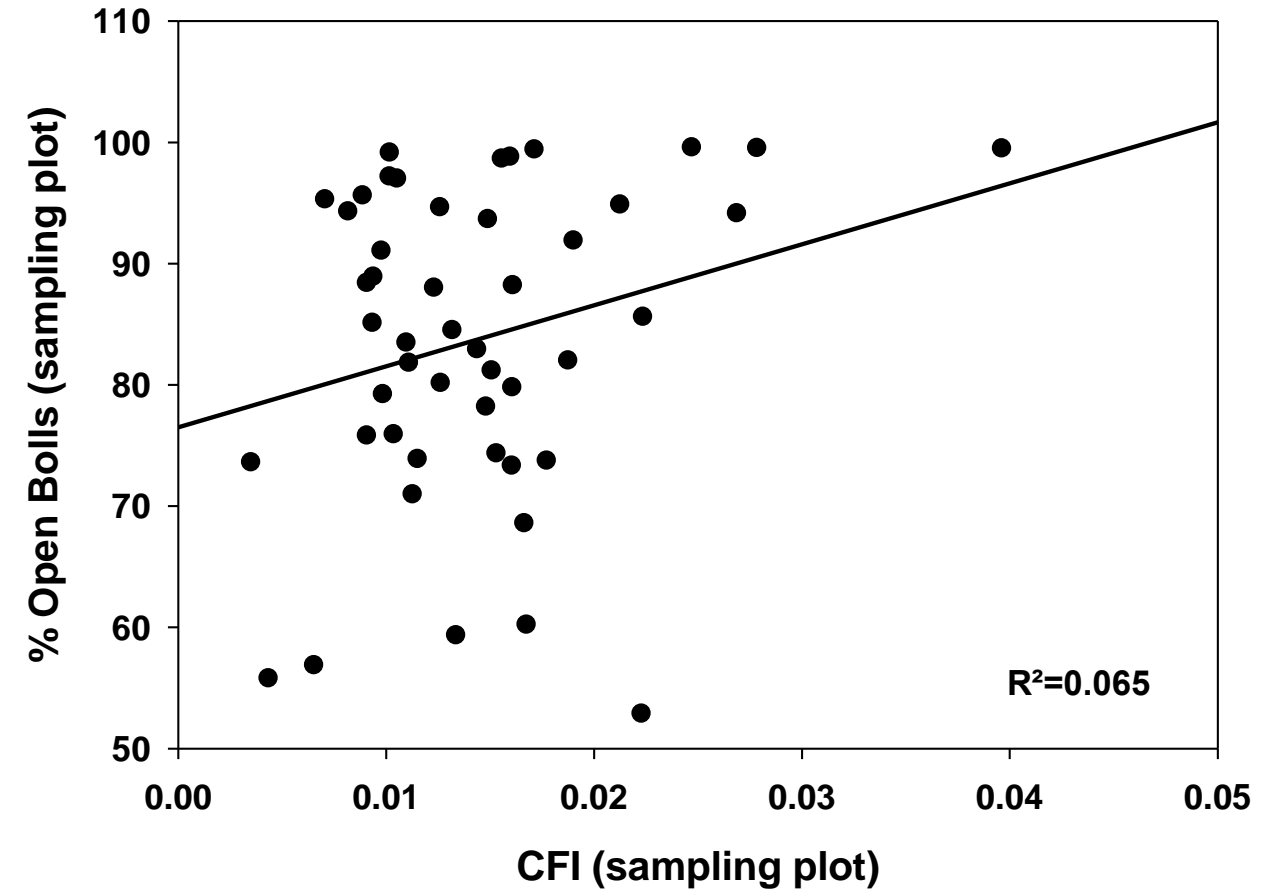
LAI vs VI's - Whole plot	
VI's	R ²
SAVI	0.708
MSAVI	0.624
NDVI	0.505
GNDVI	0.501
EVI2	0.495
NDRE	0.144

Boll Opening-(Ground measurement vs Aerial Data)

Total no. of Open Bolls vs White Pixels



Percent Open Bolls vs Cotton Fiber Index



Summary

- ❖ No significant differences among treatments for %Defoliation and %Open boll at each date.
- ❖ %Defoliation and %Open bolls were significantly increased with time interval and DAA respectively.
- ❖ No. of green leaves at 7 DAA was significantly different whereas VIs at 7 DAA were not significantly different with treatment.
- ❖ Strong Correlation between LAI and No. of green leaves with different VI's.
- ❖ Total Open Boll and white pixels were poorly correlated, similarly, correlation between %Open boll and CFI was very low.
- ❖ Multispectral Indices and Visual imagery were poorly correlated with ground measurements.

Future Research :

Hyperspectral imagery will be used to evaluate the correlation between ground measurements and aerial data.

Thanks!

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Cotton
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