Potential of UAS Multispectral Imagery for Predicting Yield Determining Physiological Parameters of Cotton

Amrit Pokhrel

MS Student
Graduate Research Assistant

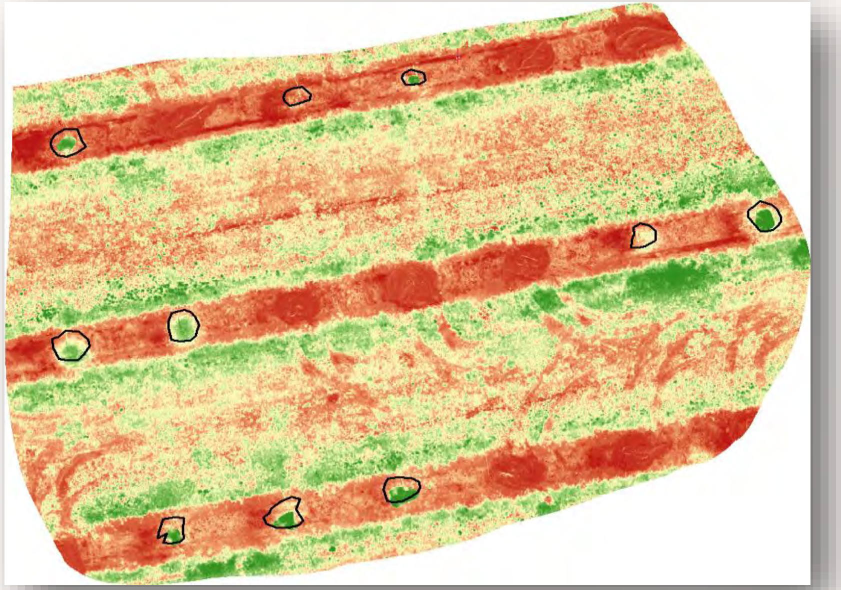
Department of Crop and Soil Sciences
University of Georgia Tifton Campus

15th International Conference on Precision Agriculture
June 26-29, 2022
Minneapolis, Minnesota, United States

Introduction

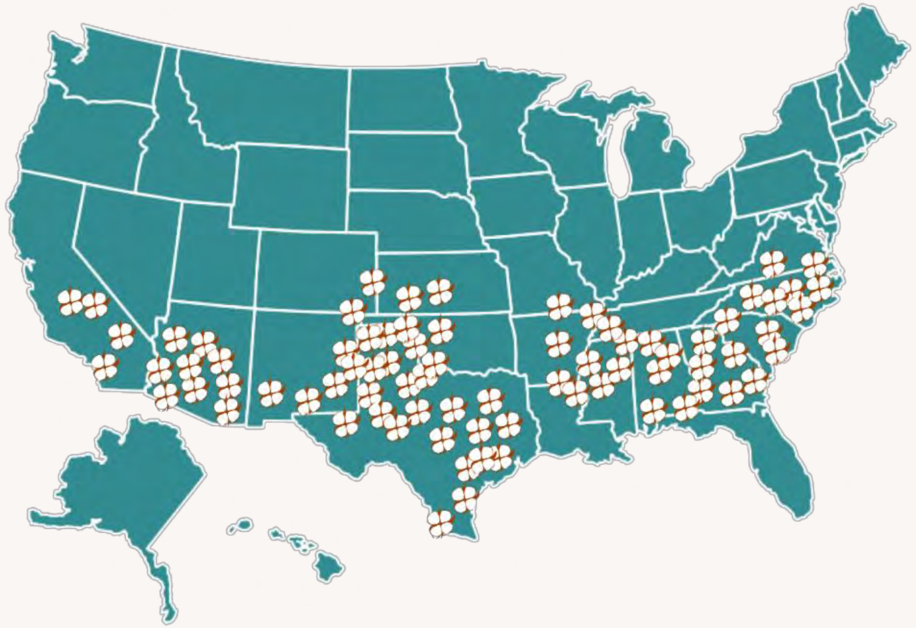
Unmanned Aerial Systems (UAS) application in agriculture:

- Mapping field variability
- Crop species classification
- Growth monitoring
- Stress detection
- Crop phenotyping
- Yield prediction



Importance of Cotton

- Cotton has global importance as a commercial crop and substantial contribution to clothing and textile industry.



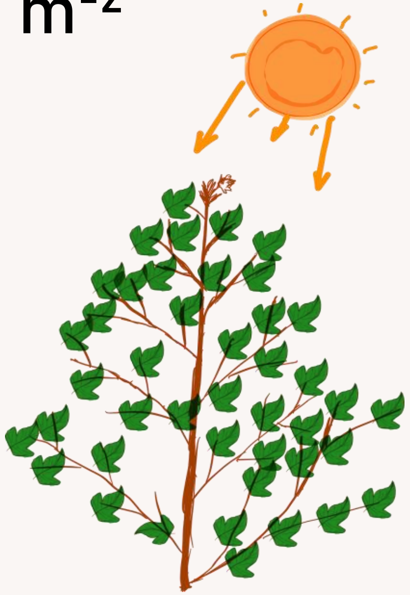
- ❑ Among top 3 cotton-producing countries
- ❑ Contribute 35% of global cotton export (USDA 2021)

Yield Function

$$Yield = IPAR*RUE*HI$$

IPAR

- Intercepted Photosynthetically Active Radiation
- MJ m^{-2}

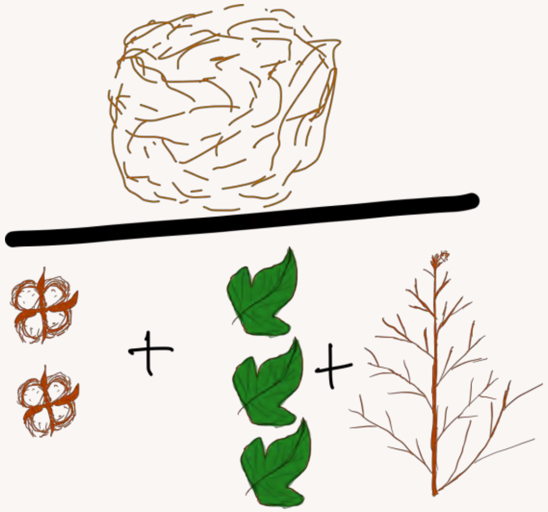


RUE

- Radiation Use Efficiency
- g MJ^{-1}

HI

- Harvest Index
- Ratio



Rationale

- Reports on relationship of multispectral derived vegetation indices with IPAR, RUE and HI are limited.

Objective

- Predict IPAR and RUE from UAS multispectral imagery and derived vegetation indices

Experimental Layout

Cultivar:

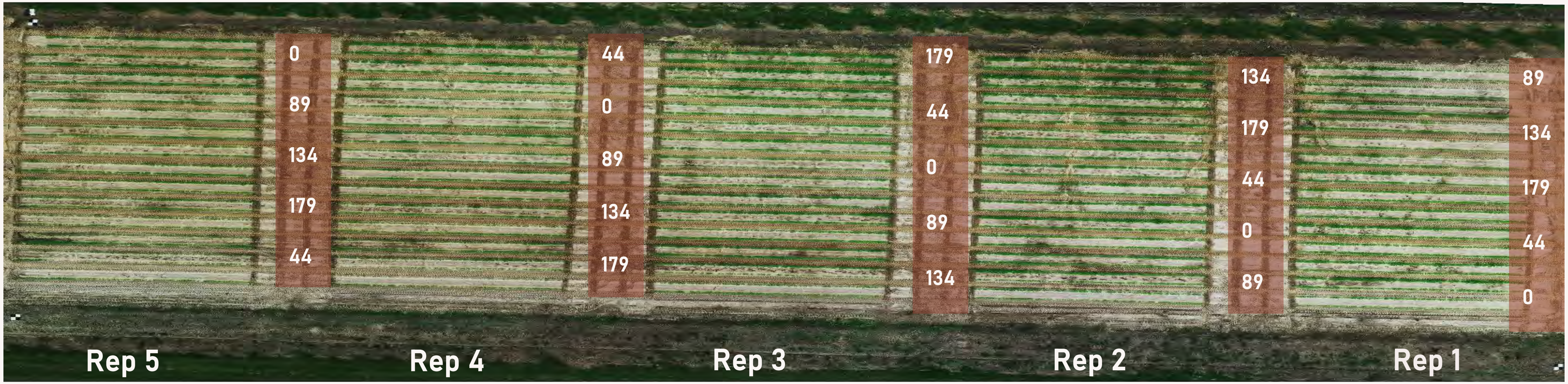
- DP 1646

Nitrogen Treatments:

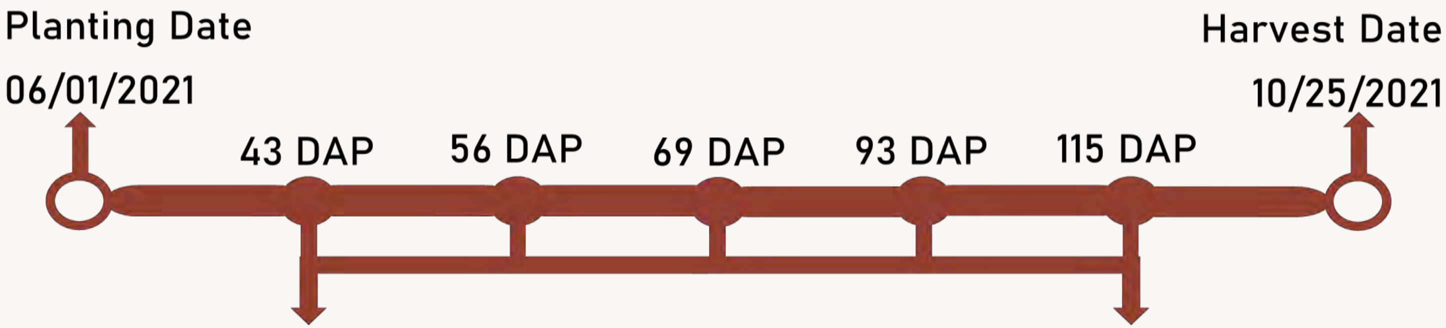
- 0 kg N ha^{-1}
- 44 kg N ha^{-1}
- 89 kg N ha^{-1}
- 134 kg N ha^{-1}
- 179 kg N ha^{-1}

Design:

- RCBD
- 5 replications
- 6 row plots * 15 m in length

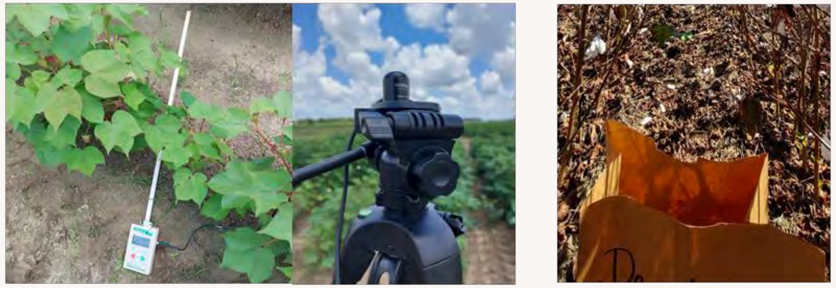


Measurements



1. UAV Imagery

2. Physiological measurements

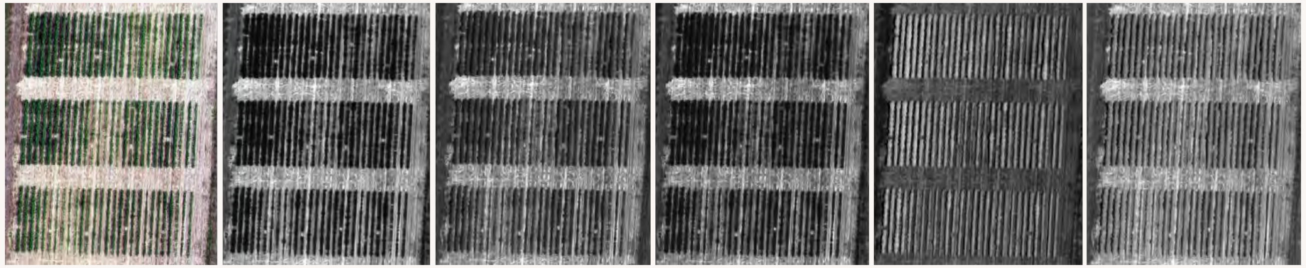


- Multispectral imagery using DJI Inspire 2 and MicaSense RedeEdge™ Camera,
- RGB imagery using DJI Phantom 4 Pro V2.0

- Light Interception using ceptometer
- In season biomass collection
- End of season harvest index
- Lint yield

Image Processing and Analysis

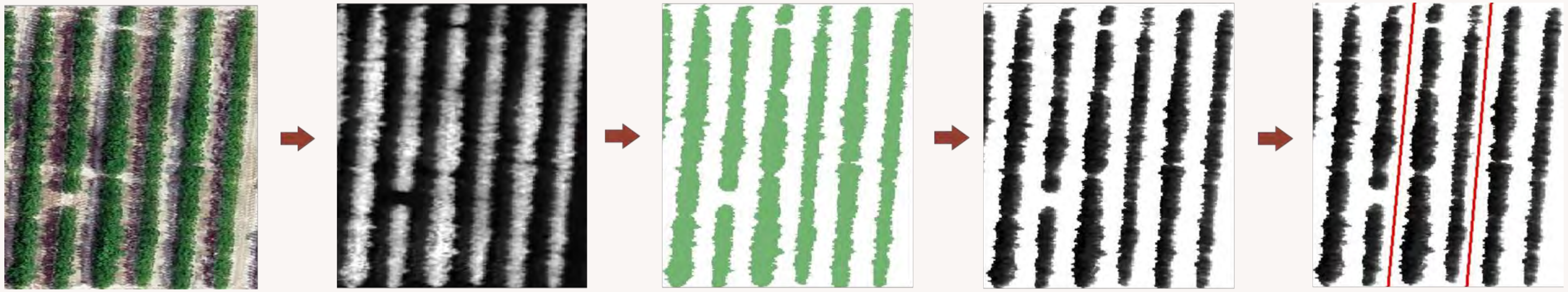
- Image Processing: Pix4D® software was used to obtain mosaic images combining imagery for each sample date.



RGB Red Green Blue NIR Rededge

Sample aerial images at 56 DAP from 45 m height.

- Imagery Analysis: Arc Map 10.7.1® was used to extract reflectance index for vegetation indices (VI's) computation.



RGB Aerial Image → Classified Aerial Image → Binary Mask Layer → Red Band without soil → Region of Interest

Vegetation Indices

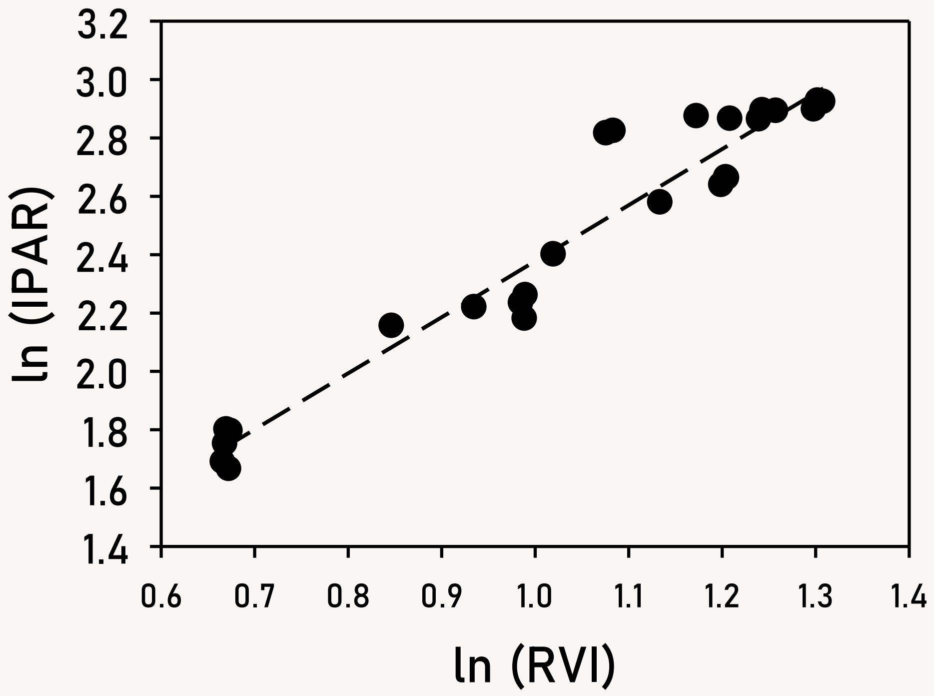
Abbreviated VI's	Nomenclature	Formula
ExG	Excessive Greenness	$2 \times G - R - B$
NDVI	Normalized Difference Vegetation Index	$\frac{NIR - R}{NIR + R}$
ExG*NDVI	ExG multiplied by NDVI (Classification Index)	$(2 \times G - R - B)\left(\frac{NIR - R}{NIR + R}\right)$
GNDVI	Green Normalized Difference Vegetation Index	$\frac{NIR - G}{NIR + G}$
NDRE	Normalized Difference Red Edge Index	$\frac{NIR - RE}{NIR + RE}$
RVI	Ratio Vegetation Index	$\frac{NIR}{R}$
SCCCI	Simplified Canopy Chlorophyll Content Index	$\frac{NDRE}{NDVI}$
RE/R	Red edge and Red Ratio	$\frac{RE}{R}$
GRVI	Green Ratio Vegetation Index	$\frac{NIR}{G}$

Abbreviated VI's	Nomenclature	Formula
VARI	Visible Atmospherically Resistance Index	$\frac{G - R}{G + R - B}$
TCARI	Transformed Chlorophyll Absorption Reflectance Index	$3\left[(RE - R) - 0.2(RE - G) \times \left(\frac{RE}{R}\right)\right]$
OSAVI	Optimized Soil Adjusted Vegetation Index	$(1 + 1.6)\left(\frac{NIR - R}{NIR + R + 0.16}\right)$
TCARI/OSAVI	TCARI normalized by OSAVI	$\frac{TCARI}{OSAVI}$
SAVI	Soil Adjusted Vegetation Index	$(1 + 0.5)\left(\frac{NIR - R}{NIR + R + 0.5}\right)$
RGBVI	Red Green Blue Vegetation Index	$\frac{G - B \times R}{G^2 + (B \times R)}$
RE/G	Red edge and Green Ratio	$\frac{RE}{G}$
GRedVI	Green Red Vegetation Index	$\frac{G - R}{G + R}$
WDRVI	Wide Dynamic Range Vegetation Index	$\frac{0.2 \times NIR - R}{0.2 \times NIR + R}$
MSAVI2	Modified Soil Adjusted Vegetation Index	$\frac{(2NIR + 1) - \sqrt{(2NIR + 1)^2 - 8(NIR - R)}}{2}$
EVI	Enhanced Vegetation Index	$\frac{2.5 \times NIR - R}{(NIR + 6 \times R - 7.5 \times B) + 1}$

Results

IPAR vs VI's

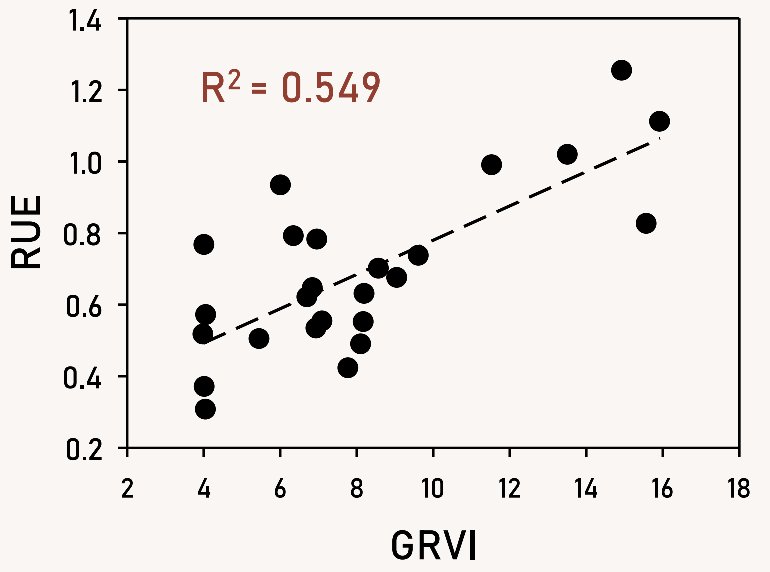
VI's	R^2
RVI	0.9324
NDRE	0.9158
RE/R	0.9121
NDVI	0.9104
SCCCI	0.9083
GNDVI	0.8751
GRVI	0.7923



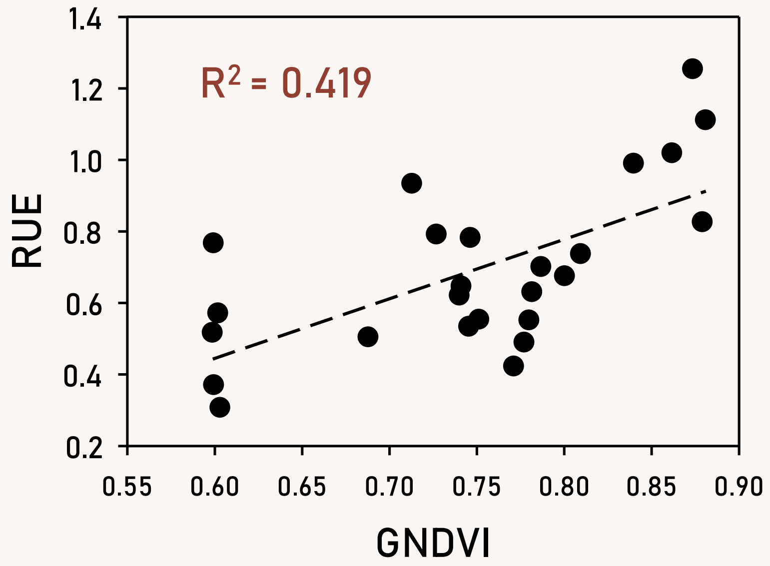
- Ratio VI = NIR/Red
- Power relationship ($y = ax^b$)
- $\ln(IPAR) = 1.048 + 1.922*\ln(RVI)$

RUE vs VI's

- Green Ratio VI = NIR/Green
- Linear function (y = ax + b)
- RUE = 0.048*GRVI + 0.3

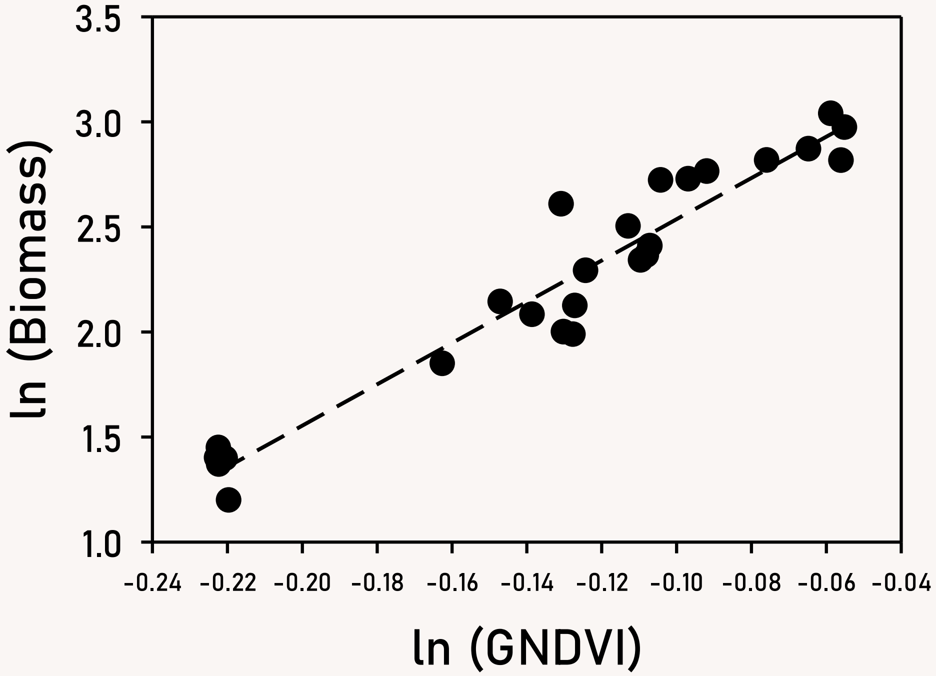


- Green Normalized Difference VI = NIR – Green/NIR + Green
- Linear function (y = ax + b)
- RUE = 1.67*GNDVI – 0.55



Biomass vs VI's

VI's	R^2
GNDVI	0.9297
SCCCI	0.9056
RVI	0.9039
NDRE	0.9016
GRVI	0.8844
NDVI	0.8779
RE/R	0.8678

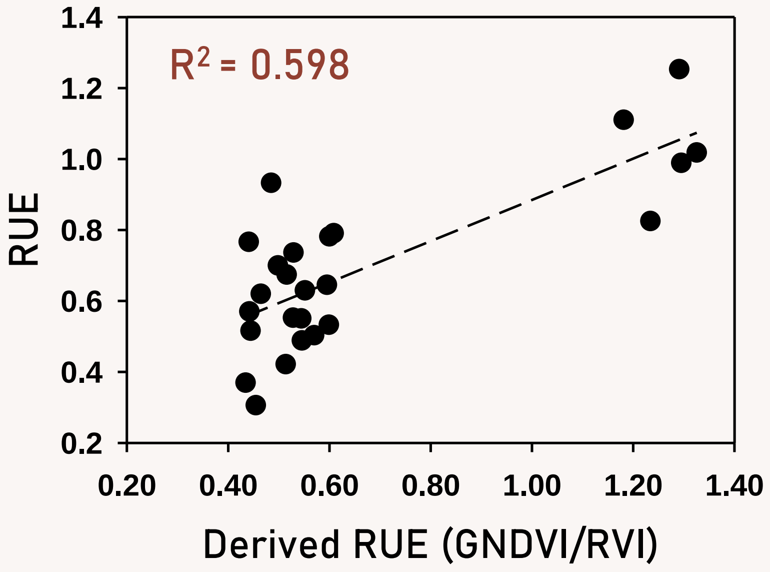


- GNDVI = NIR-Green/NIR-Green
- Power relationship ($y = ax^b$)
- ln(biomass) = 8.105 + 9.834*ln(GNDVI)

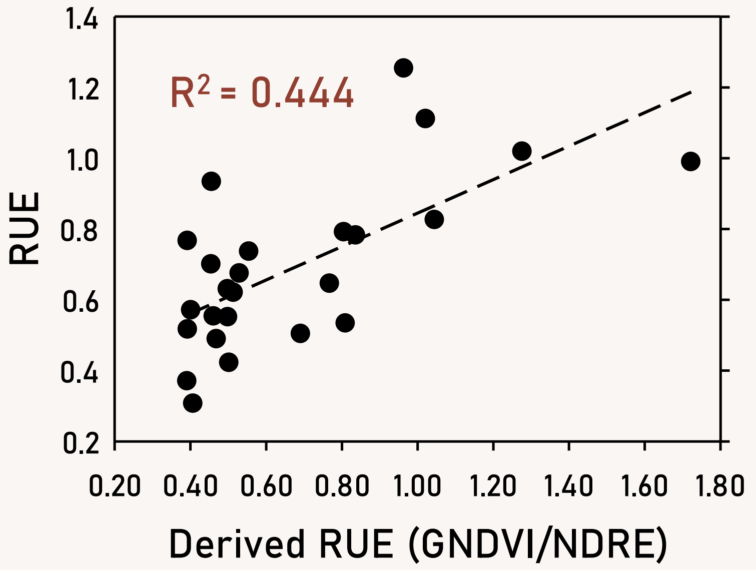
Derived RUE

Biomass = IPAR*RUE

- Predicted IPAR from RVI
- Predicted Biomass from GNDVI



- Predicted IPAR from NDRE
- Predicted Biomass from GNDVI



Conclusions

- IPAR and cotton biomass were highly corelated with the VI's.
- Almost 50% of the variation in RUE can be explained using VI's- GRVI and GNDVI.
- Multispectral Indices such as GNDVI, RVI, and GRVI could potentially be used to predict yield driving cotton physiological parameters within the growing season.
- Future Works:
  - Estimation of end of season HI
  - Yield prediction model

SCAN ME!!

If you want to connect on LinkedIn

OR

Email:
amritpokhrel@uga.edu

Acknowledgement

Simerjeet Virk, John Snider, George Vellidis, Ved Parkash, and Coleman Byers

UNIVERSITY OF GEORGIA
1785

Department of Crop and Soil Sciences

GEORGIA COTTON COMMISSION

cotton

Cotton Incorporated