Use of Remote Sensing in Cotton to Determine Potassium Status and Predict Yield

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Research Objective

- Using Remote Sensing Technologies and Nitrogen-Sensitive Indices to Predict Cotton K Status and Yield

Outline

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- Introduction
  - K in cotton
  - Spatial variability in fields
  - Spectral response to N and K
- Objectives and Hypotheses
- Methods
- Results
  - Leaf K Concentraiton
  - Plant Available K_2O
  - Yield
- Discussion
- Conclusions

Introduction

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- Cotton is less efficient at extracting K from soil than other row crops
- Leaf deficiency symptoms include yellowing, drying of leaf tips, and an overall bronzing of affected leaves
  - Upper leaf deficiencies possibly due to high yielding, short season cultivars and the sink demand of bolls
- Deficiencies can occur unpredictably and under sufficient soil K conditions

Introduction

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Production fields are spatially variable

Introduction

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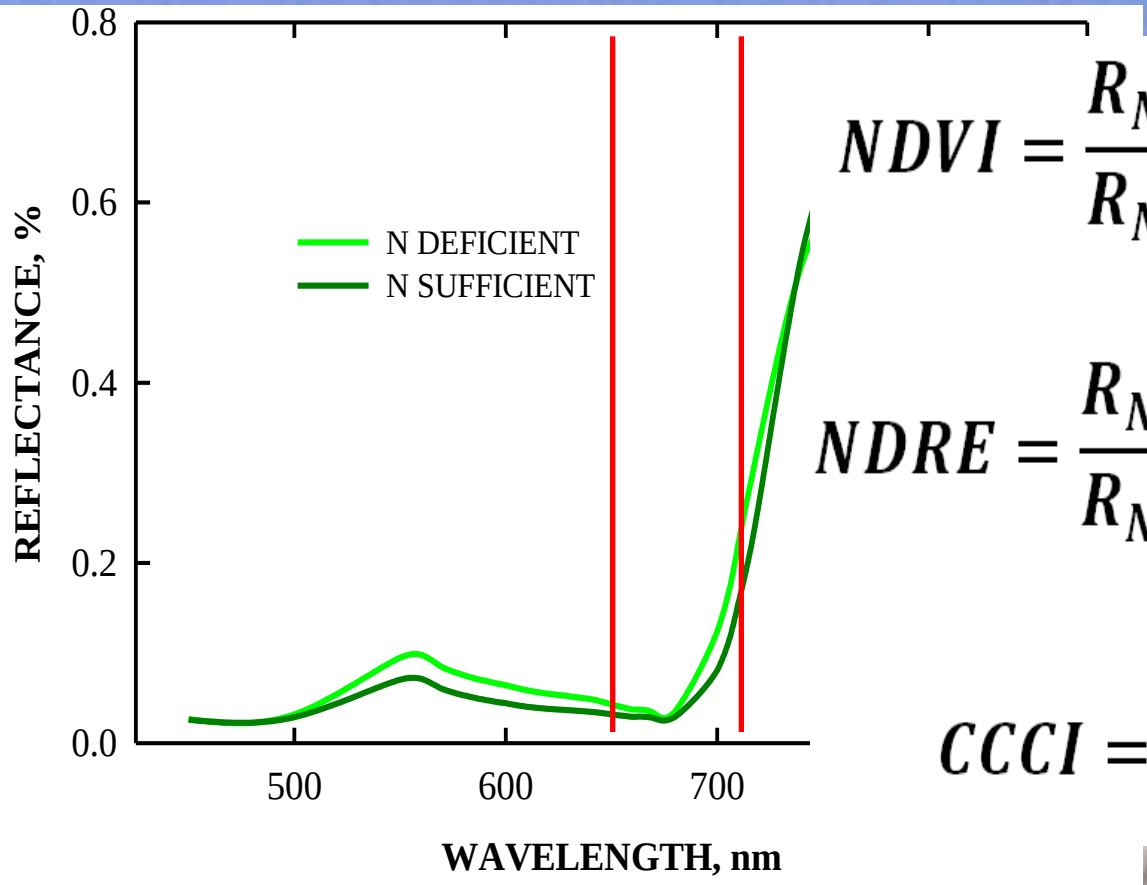

$$NDVI = \frac{R_{NIR} - R_{RED}}{R_{NIR} + R_{RED}}$$

$$NDRE = \frac{R_{NIR} - R_{EDGE}}{R_{NIR} + R_{EDGE}}$$

$$CCCI = \frac{\text{NDRE}}{\text{NDVI}}$$

Introduction

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- Raper et al (2013) tested spectral reflectance indices to remotely sense N deficiency by correlating chlorophyll content with reflectance indices
  - Measure cotton N status in real-time
- Found an average response across the first and third weeks of flowering in several indices to changes in selected cotton growth parameters

Introduction

- Indices may be sensitive to more than N deficiency
  - Water and nutrient stress
- Unnecessary N application environmentally and economically costly
- Goal of remote sensing research to distribute fertilizer N, K based on spatial demand

Objectives

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- Determine if cultivars differ in values from currently available indices formulated for N-status detection from active sensors
- Determine if N-sensitive indices are sensitive to leaf K concentration and available K_2O in the soil
- Evaluate the role of N-sensitive indices in predicting yield

Hypotheses

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- NDVI would more accurately predict leaf K, available K_2O, and yield than NDRE, due to the red-edge band reflecting changes in chlorophyll and the near infrared band reflecting biomass and cell structure.

- Both NDVI and NDRE would more accurately predict parameters than the CCCI due to the strong influence of the red-edge in the index.

Methods

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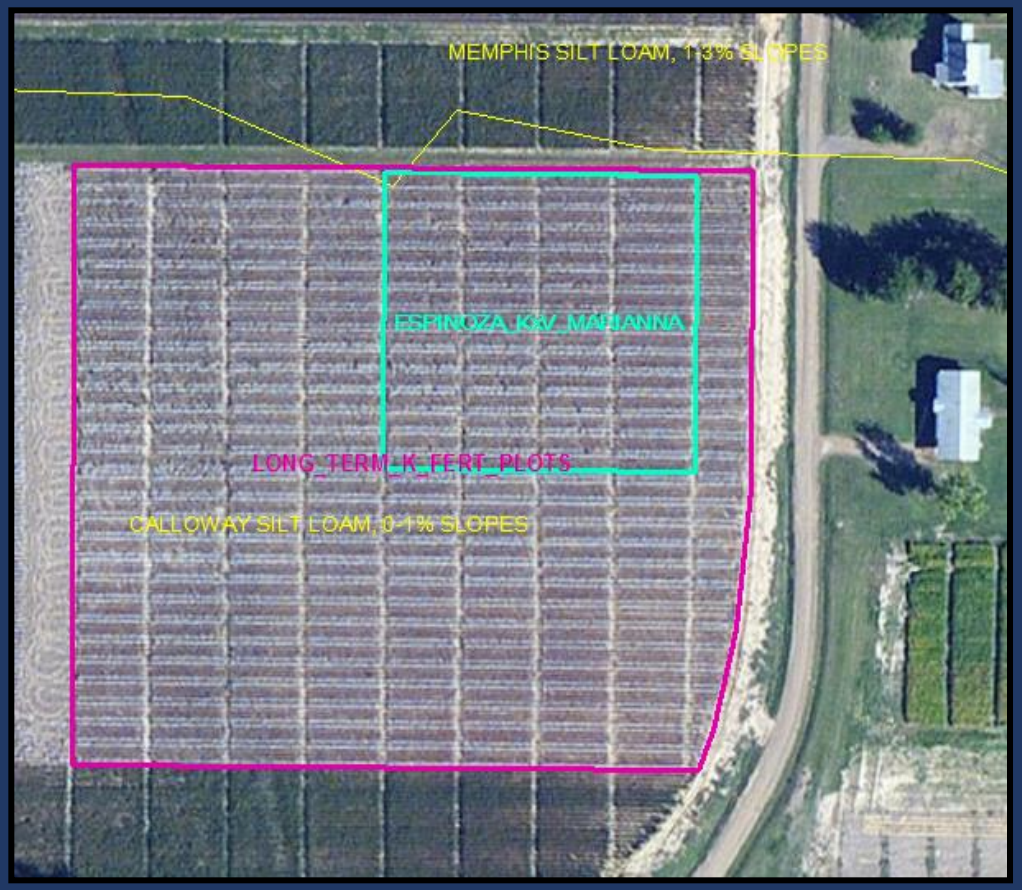
- Location—Lon Mann Cotton Research Station
  - Marianna, AR
  - Long-term cotton K fertility trial plot
  - Calloway Silt Loam



Methods

- Completely Randomized Design
  - 4 row plots, 50’ length
  - Planted 3.5 plants/ft on 38” beds
  - Furrow irrigated as needed
  - Fertilizer N applied uniformly
- Treatments
  - K_2O Rates
    - 0, 30, 60, 90 lb $acre^{-1}$
    - Preplant 0-0-60
  - Cultivars
    - Phytogen 499 WRF
    - Stoneville 5458 B2RF
    - DeltaPine 0912 B2RF

Measurements

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- Soil samples
  - Mehlich 3 extraction
  - For analysis, available K was used instead of K rate due to variability of K in field. This was calculated using the formula:
    - Available K = (Soil Test K x 2 x 1.2) + Fertilizer K
- Tissue
  - Leaf K
- Reflectance
  - Crop Circle ACS-470
    - Active light sensor
    - 10 AM-2 PM
    - First flower (FF) and three weeks post first flower (FF3)
    - 36” height above canopy

Analysis

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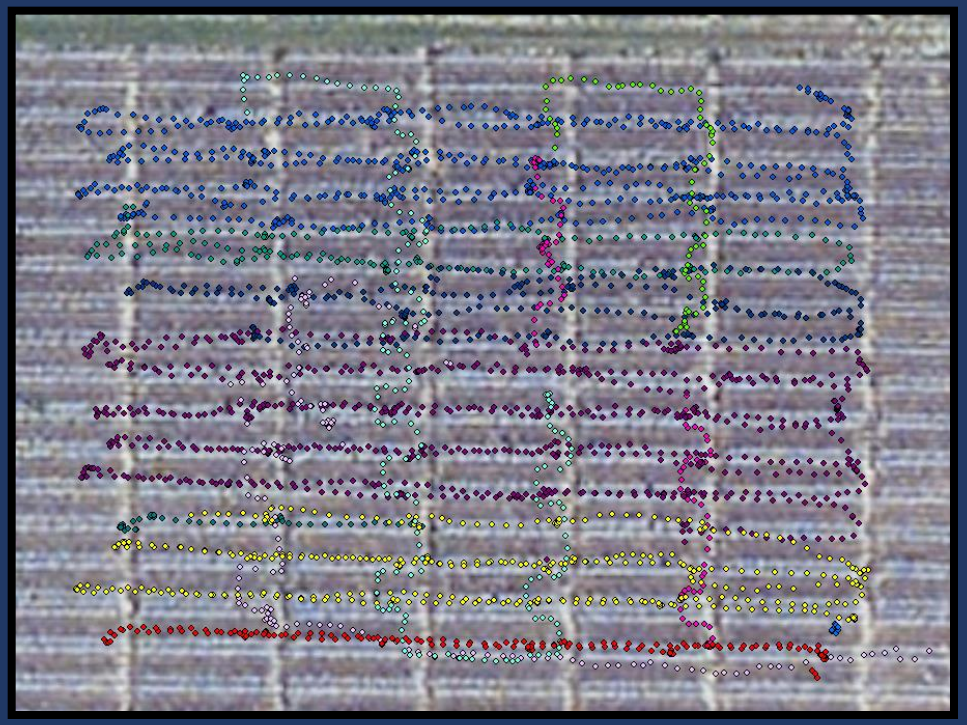
- Data points evaluated and assigned to plots using ArcGIS and ArcMAP 10.2.2
- Regression analysis on JMP Pro 11



Results—Leaf K%

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Growth Stage	Effect	NDVI		NDRE		CCCI	
FF	Cultivar	0.0343	Adjusted R^2=0.815	NS		NS	
	Leaf K%	0.0274		0.0395	Adjusted R^2=0.617	NS	
	Cul * K%	0.0014		0.0087		NS	
FF3	Cultivar	NS		0.0058	Adjusted R^2=0.335	0.0131	Adjusted R^2=0.689
	Leaf K%	NS		NS		NS	
	Cul * K%	NS		NS		NS	

Leaf K %—NDVI

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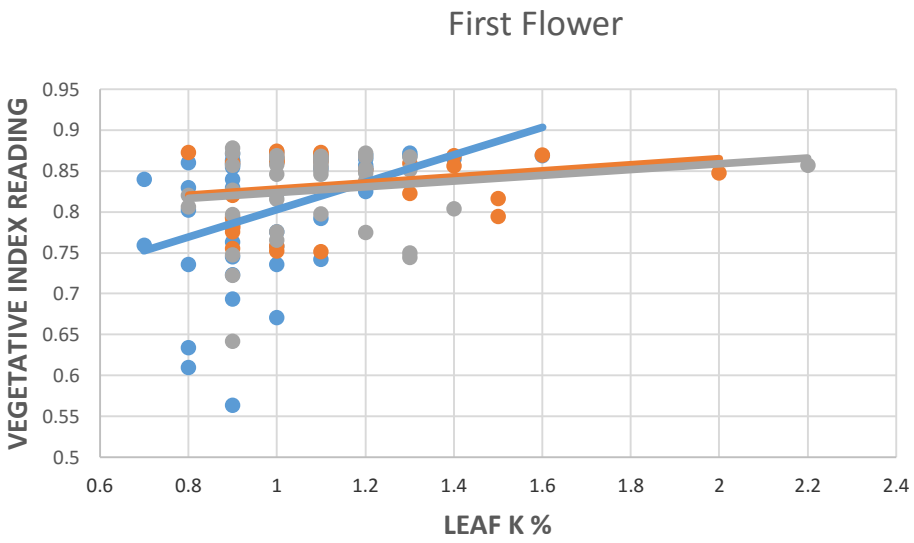

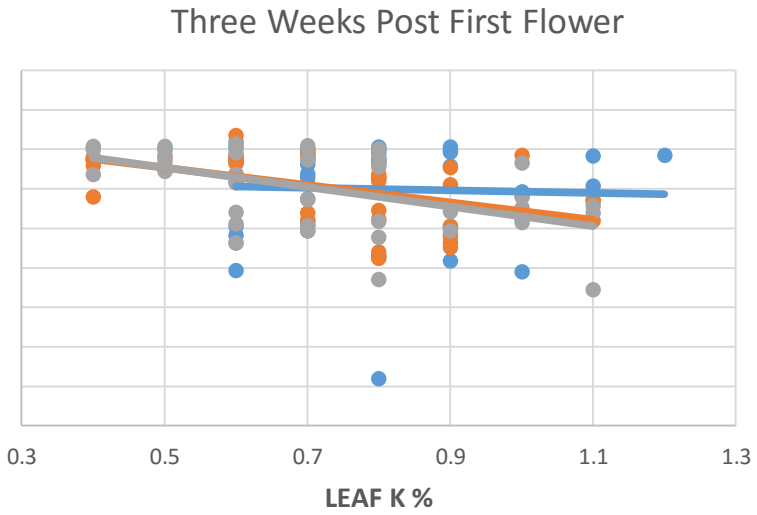

Leaf K %—NDRE

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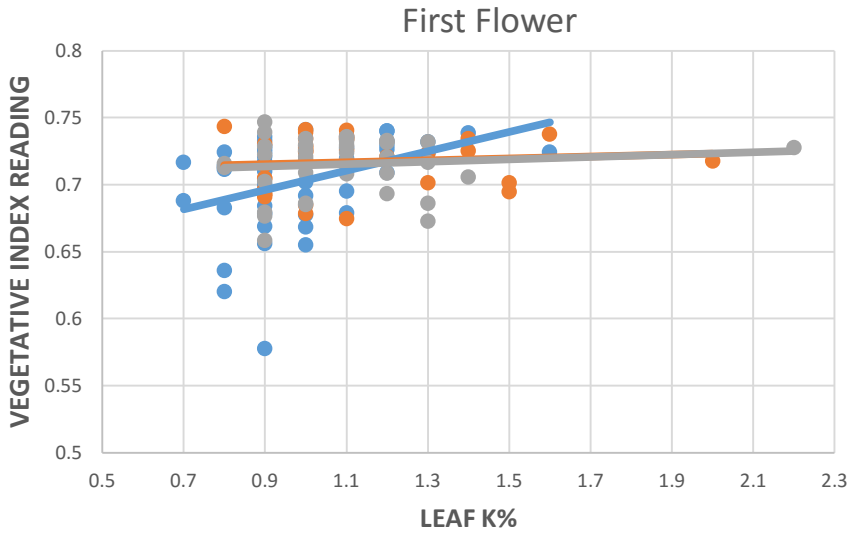

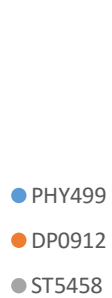

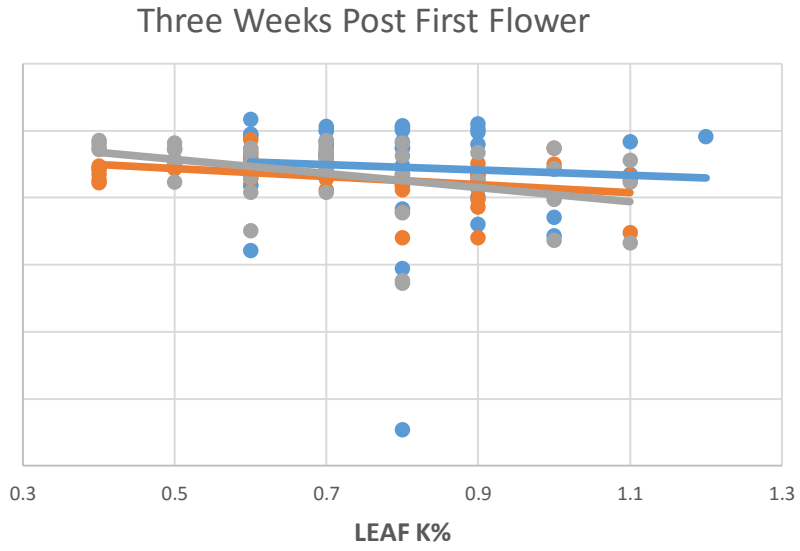

Leaf K %—CCCI

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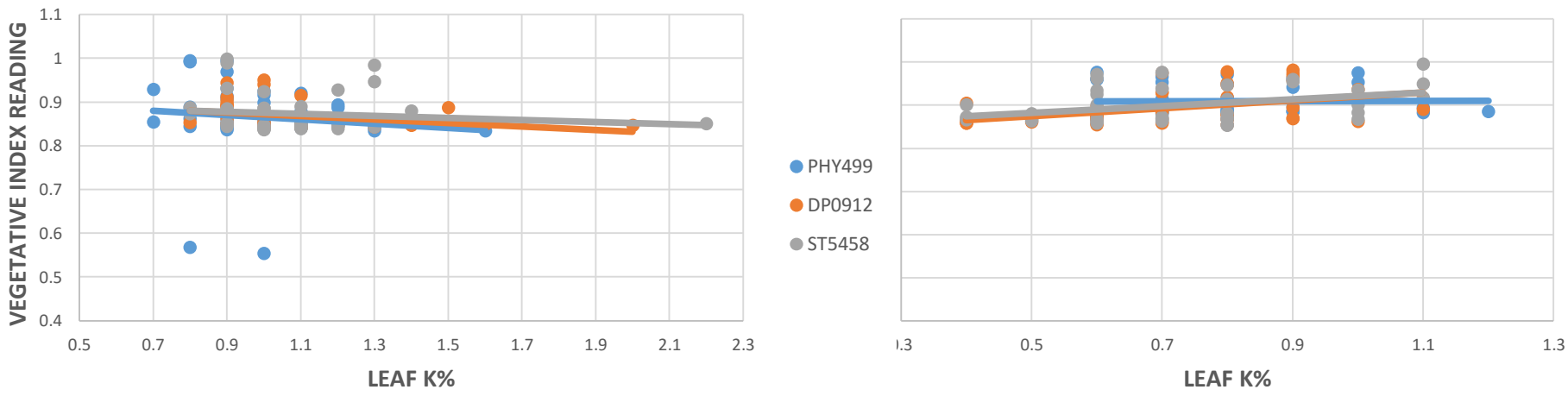

Results—Available K_2O

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Growth Stage	Effect	NDVI		NDRE		CCCI	
FF	Cultivar	0.0472	Adjusted R^2=0.798	NS		NS	
	Avail K_2O	NS		NS		NS	
	Cul * K_2O	NS		NS		NS	
FF3	Cultivar	NS		0.0048	Adjusted R^2=0.344	0.0166	Adjusted R^2=0.690
	Avail K_2O	NS		NS		NS	
	Cul * K_2O	NS		NS		NS	

Available K_2O—NDVI

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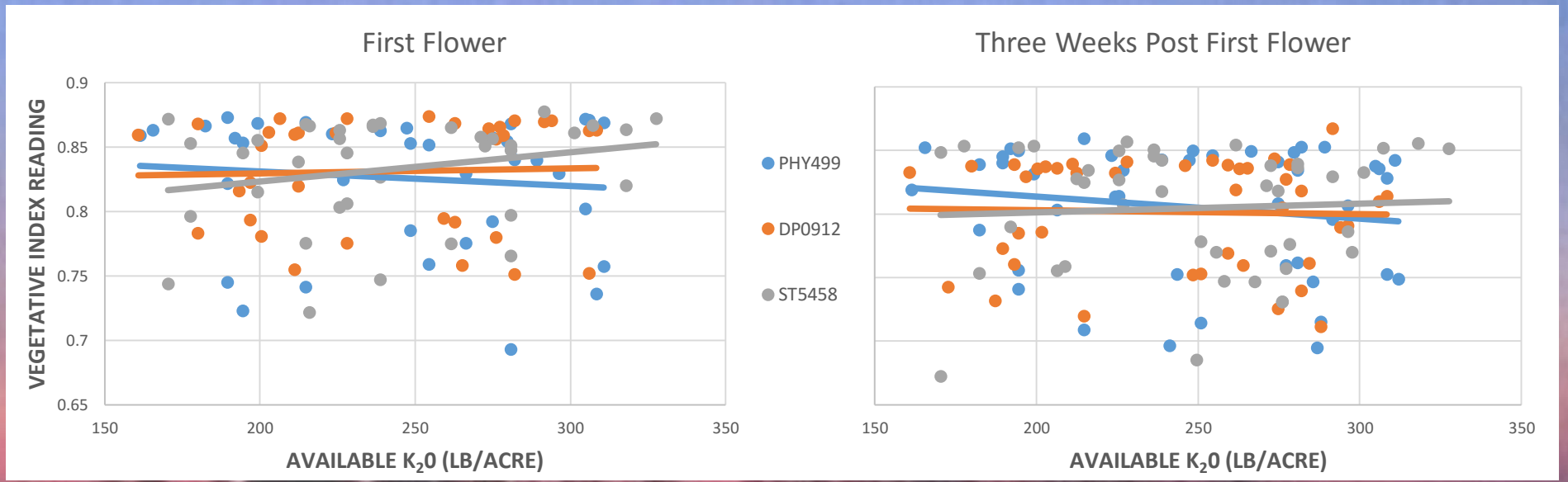

Available K_2O—NDRE

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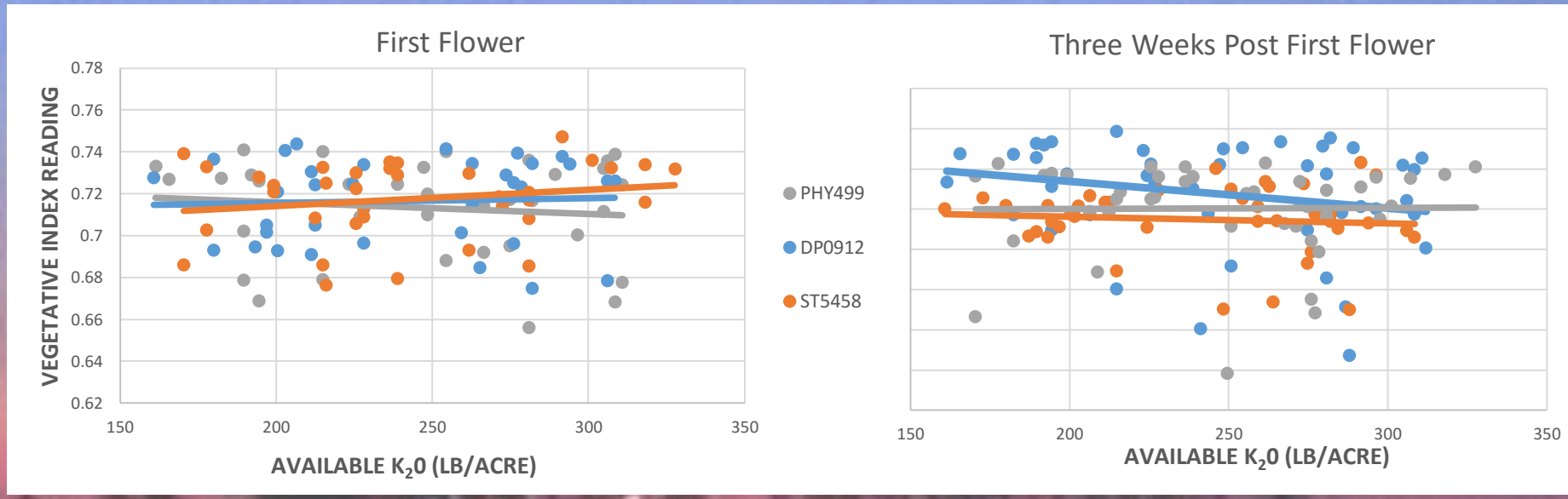

Available K_2O—CCCI

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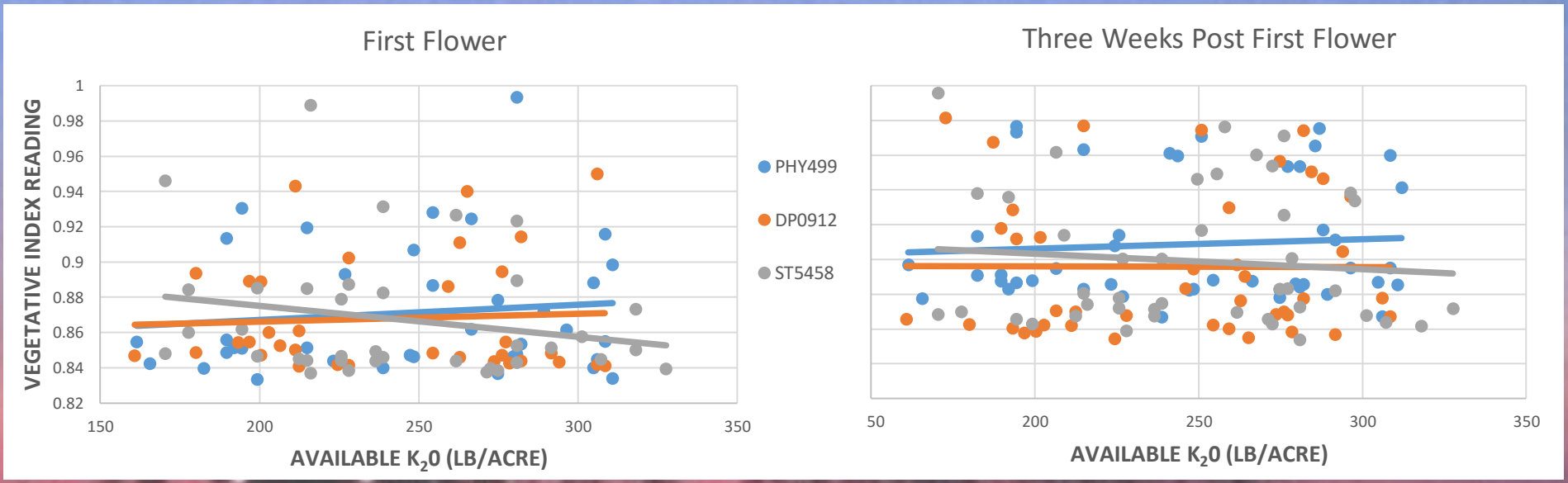

Results—Yield

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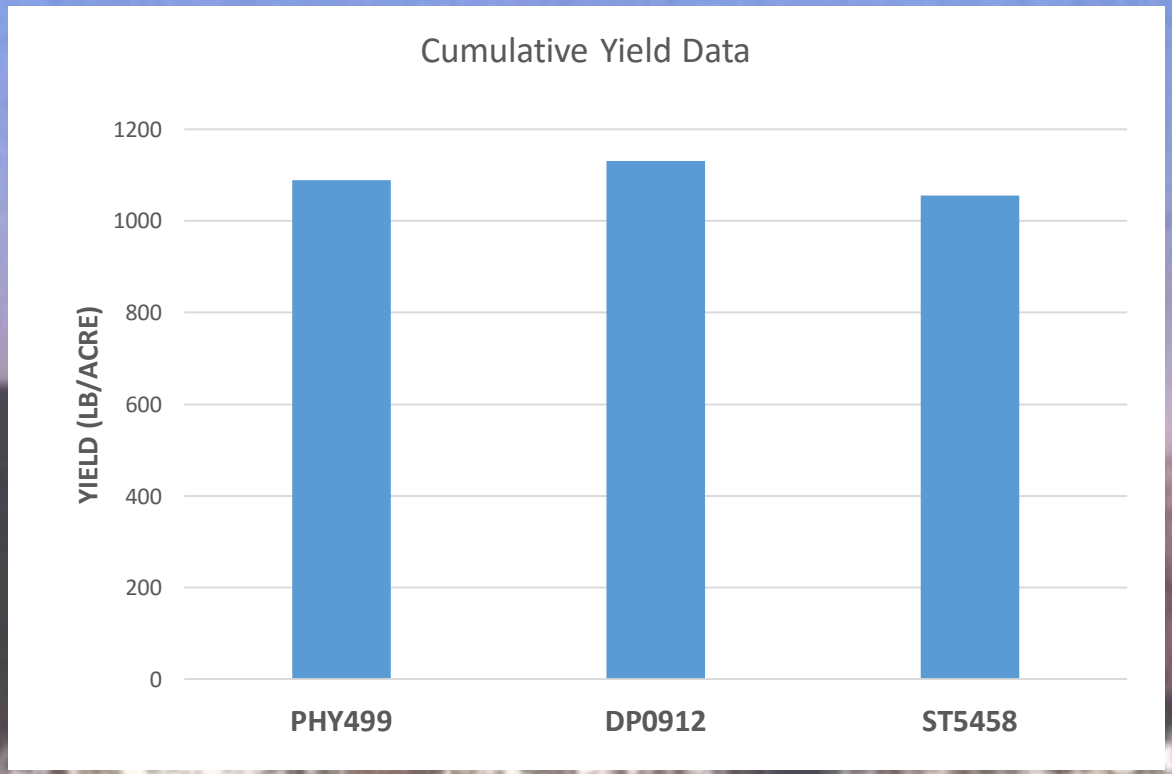

Results—Yield

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Growth Stage	Effect	NDVI		NDRE		CCCI	
FF	Cultivar	NS		NS		NS	
	Yield	<0.0001	Adjusted R^2=0.311	<0.0001	Adjusted R^2=0.339	NS	
	Cul*Yield	0.0009		0.0032		0.0019	Adjusted R^2=0.201
FF3	Cultivar	0.0004	Adjusted R^2= 0.338	0.0003	Adjusted R^2=0.277	0.0036	Adjusted R^2=0.693
	Yield	0.0408		NS		NS	
	Cul*Yield	<0.0001		0.0031		0.0056	

Discussion

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- Early-season NDVI most accurately describes leaf K
  - Red-edge related to chlorophyll whereas near infrared related to cellular structure and intracellular spaces
  - Leaves too deficient later in season to detect differences
    - FF3 leaf K range from 0.4-1.2%
- Available K_2O possibly too low to make a difference in reflectance values
  - Long-term fertility plots
  - Leaf K more efficient in describing plant status

Discussion

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- Yield most accurately predicted by late-season CCCI
  - CCCI relies on both biomass and chlorophyll content
  - Yield related to both biomass and chlorophyll content
- Two-year study, need multiple soil types, locations and cultivars for adoption by producers

Conclusions

- Early-season NDVI most accurately determines leaf K concentration
- Indices chosen were unable to determine plant available K_2O in the soil
- Yield was best predicted using the CCCI late-season

Acknowledgements

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Fluid Fertilizer Foundation

Cotton Incorporated