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Use of Remote Sensing in Cotton to Accurately Predict the Onset of Nutrient Stress

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OUTLINE

- Intro
  - N in cotton
  - K in cotton
  - Spatial, temporal variability in production fields
  - Spectral response to N, K
- Objective
- Methods
- Results
- Conclusions

INTRODUCTION

Nitrogen in Cotton Production

- Overall most yield restricting nutrient
  - Limits yield, lowers quality
- Excessive N Causes-
  - Rank growth, boll rot, harvesting difficulties
  - Increased need for growth regulators, insecticides, and defoliants
  - Carryover N environmental hazard
- Applied in the largest quantities
  - Composes a large % of input costs
  - Coupled to energy costs

INTRODUCTION

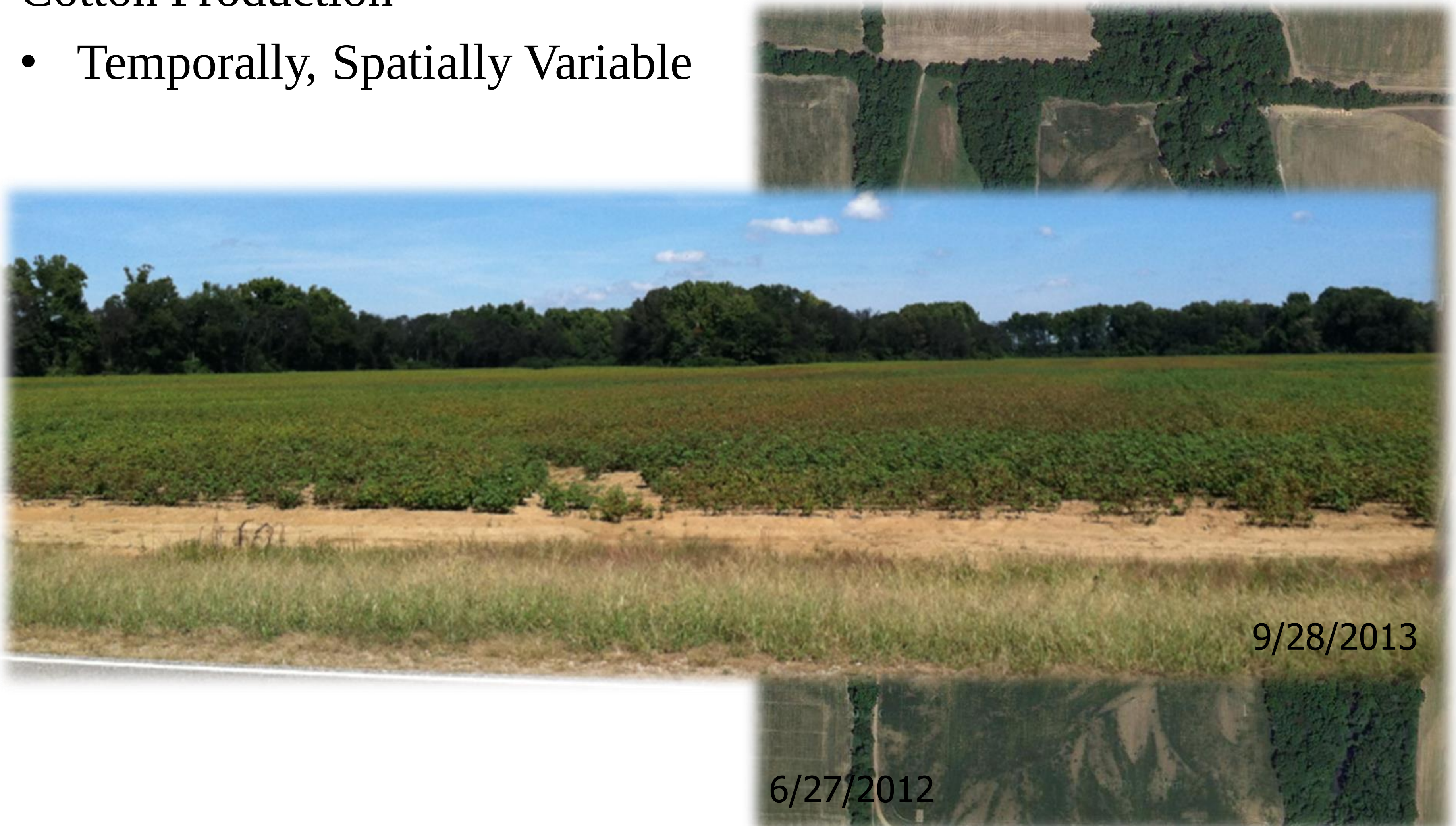
Cotton and K

- Relatively less efficient at extracting K from soil than several other row crops
- Deficiencies often in upper leaves
  - Possibly due to higher yielding, short-season varieties
  - Sink demand of bolls
- Deficiencies often occur:
  - Under sufficient soil conditions
    - Cassman et al. (1986)
    - Cope (1981)
  - Unpredictably
    - Oosterhuis and Weir (2010)

INTRODUCTION

Cotton Production

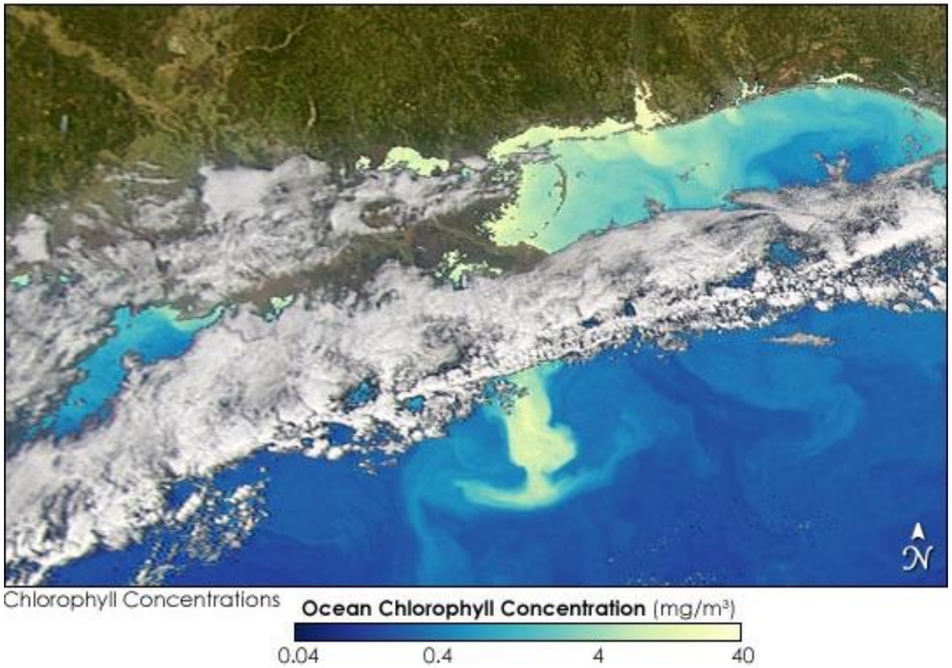
- Temporally, Spatially Variable



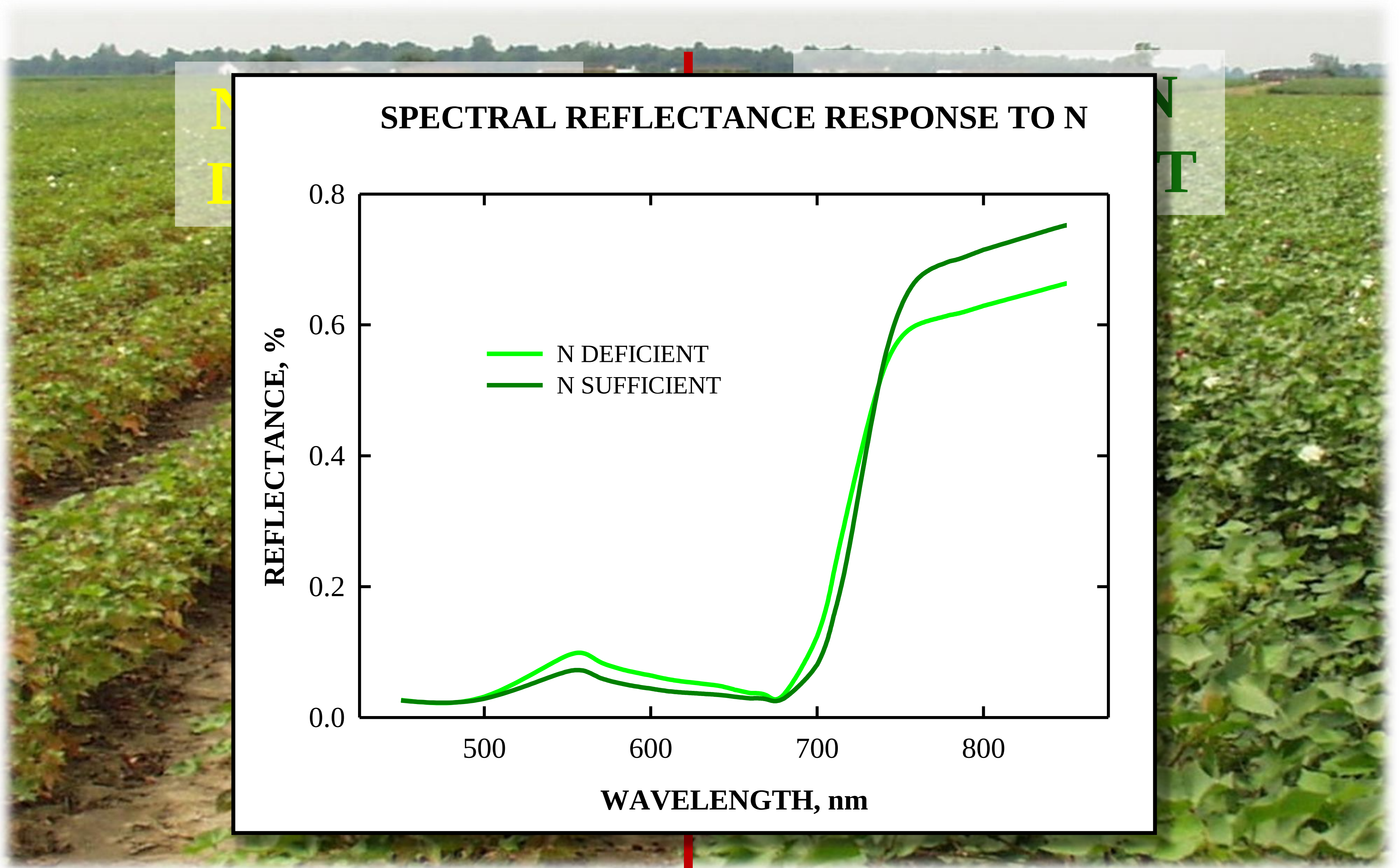
INTRODUCTION

NASA defines remote sensing as, "the art of identifying, observing, and measuring an object without coming into direct contact with it."

- Remote Sensing
  - If we can correlate reflectance with chlorophyll content, N status
  - Measure cotton N status in real-time
    - Advantages over soil and tissue testing
  - Distribute fertilizer N, K based on spatial demand

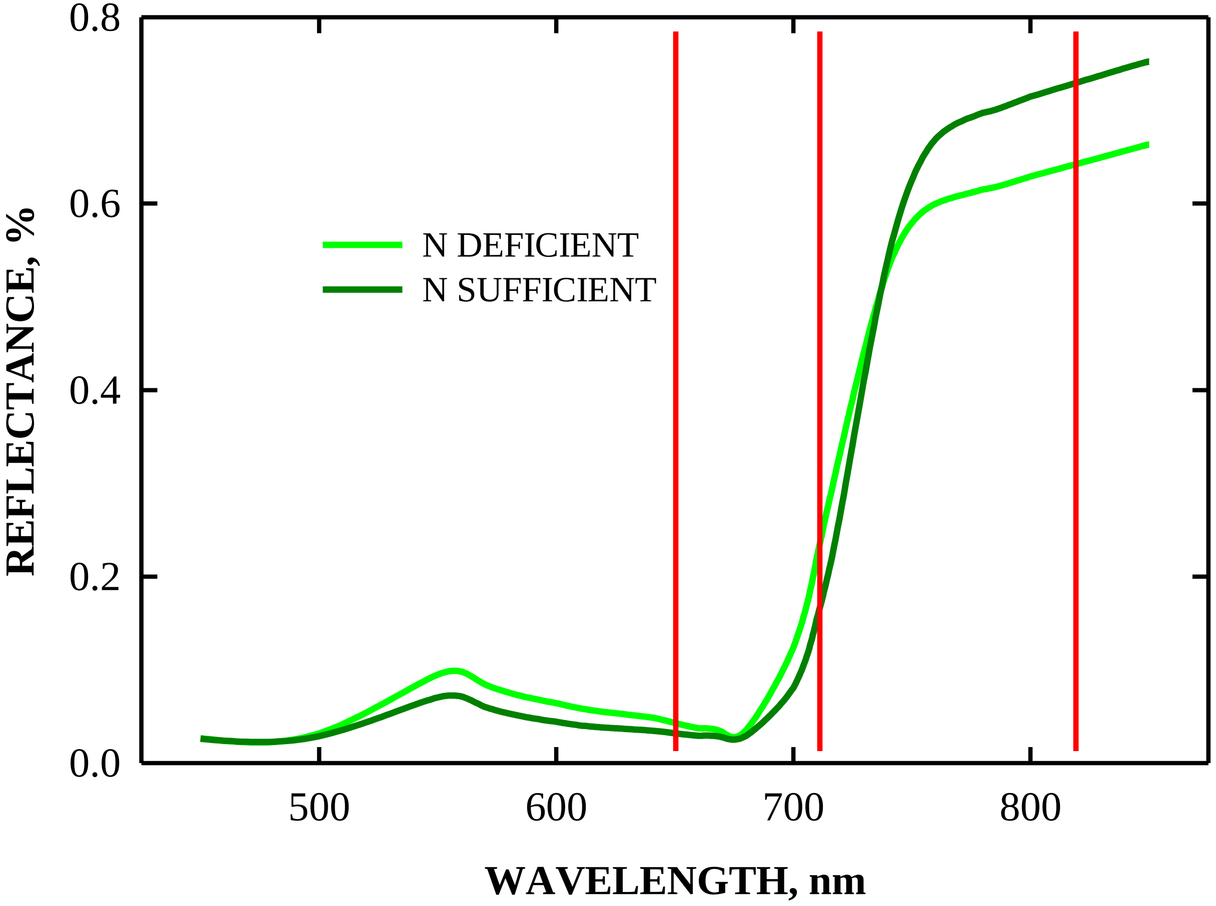


BACKGROUND



SPECTRAL REFLECTANCE RESPONSE TO N
REFLECTANCE, %
0.0
0.2
0.4
0.6
0.8
WAVELENGTH, nm
500
600
700
800
N DEFICIENT
N SUFFICIENT

BACKGROUND



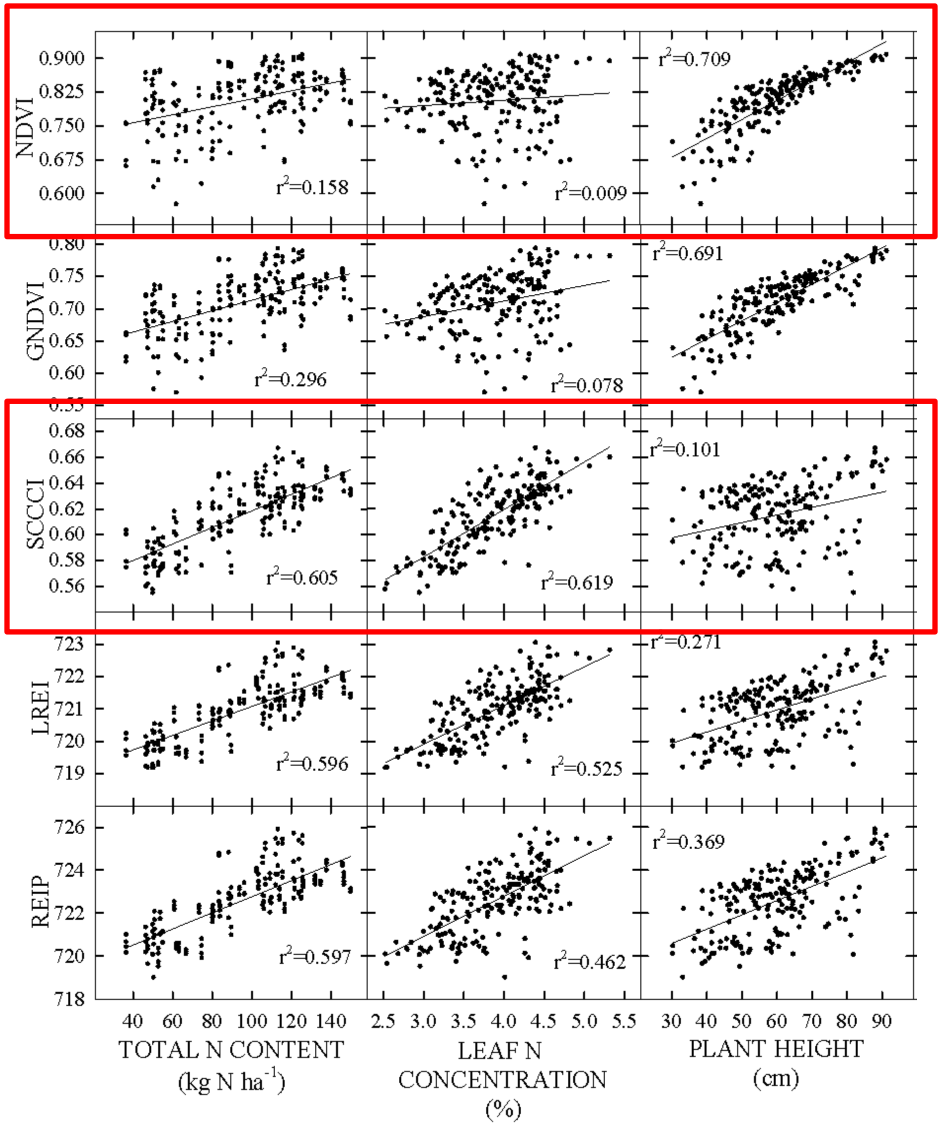
$$NDVI = \frac{R_{NIR} - R_{RED}}{R_{NIR} + R_{RED}}$$

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

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

BACKGROUND

- Index Development/Testing
  - Raper et al. (submitted)
    - Average over three years of data, physiological periods
      - N=190
    - Examine relationships between indices and parameters of interest



Average response across the 3rd week of flower bud formation and first week of flowering (end of timely fertilizer application period) in several selected indices to changes in selected cotton growth parameters.

OBJECTIVE

Determine if currently available, N-sensitive indices calculated from active sensors are sensitive to:

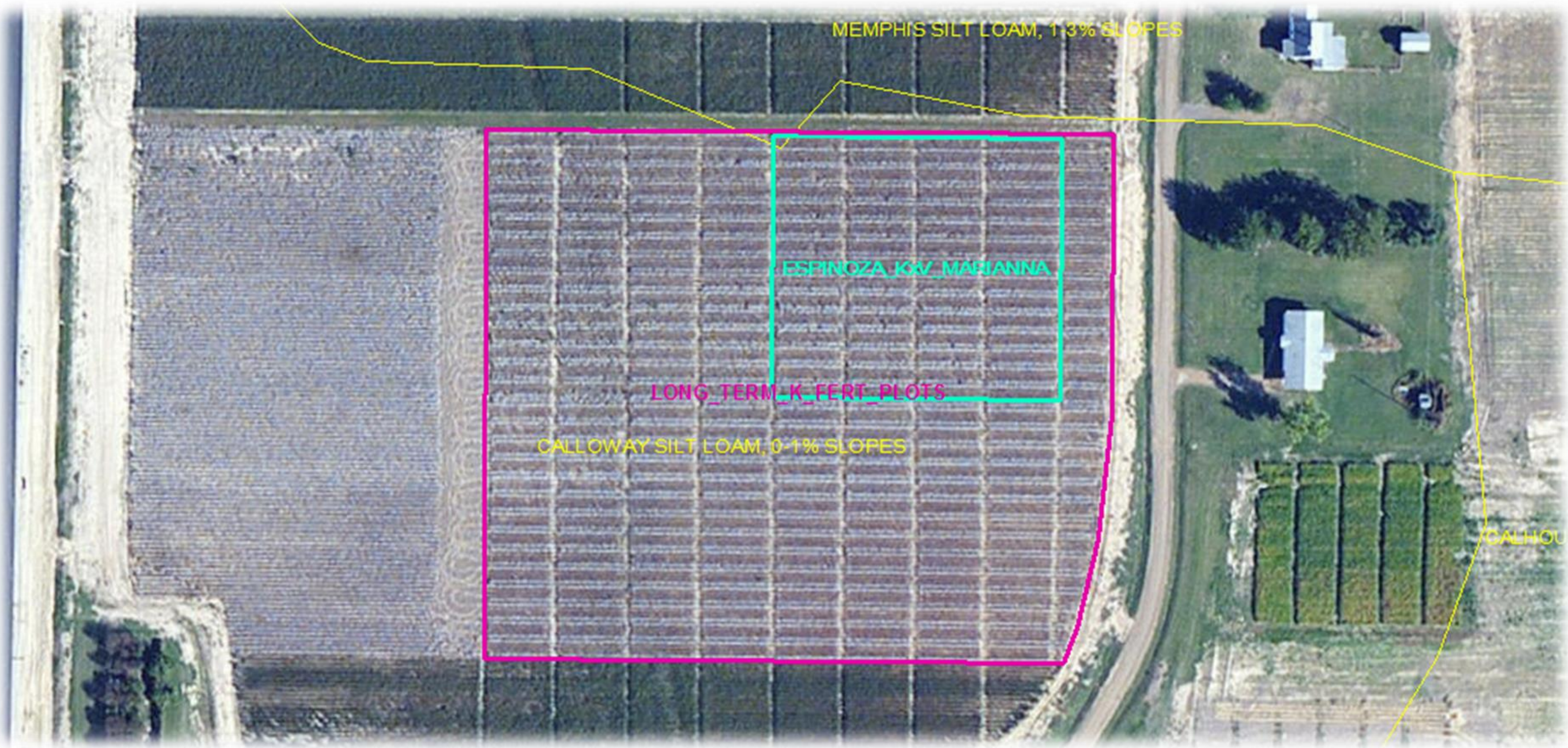
- K deficiencies
- Differences in popular cotton cultivars

METHODS

- Location
  - Lon Mann Cotton Research Station
    - Marianna, AR

METHODS

- Location
  - Long-term cotton fertility trail, maintained by Dr. Leo Espinoza

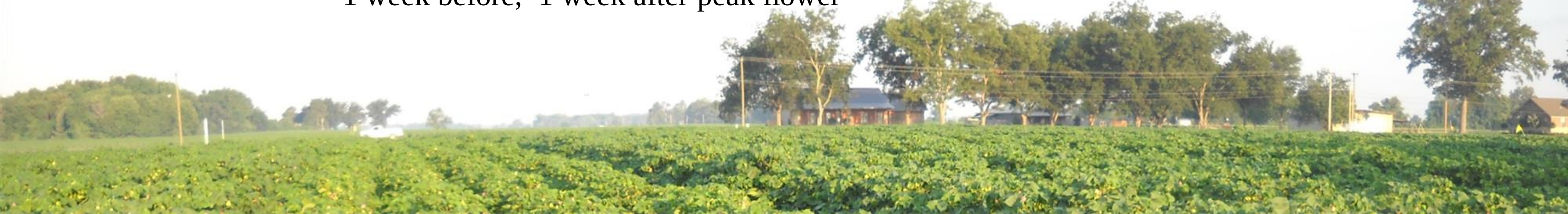


METHODS

- Cultural
  - Strip trial
  - 4 row plots, 50’ length
  - Planted @ 3.5 plants/ft, 38” beds
  - Furrow irrigated, as needed (generally on a weekly basis)
  - Fertilizer N applied uniformly
    - Split, 60/40 @ emergence/first square
- Treatments
  - K_2O rate
    - 0, 30, 60, 90 lb K_2O/acre
  - Cultivar
    - Phytogen 499 WRF
    - Stoneville 5458 B2RF
    - DeltaPine 0912 B2RF

METHODS

- Measurements
  - Soil samples
    - Bed shoulder at 6” depth
    - Mehlich 3 extraction
    - Processed and analyzed by the University of Arkansas Soil Testing Laboratory
      - Marianna, AR
  - Tissue
    - Leaf N, K
    - Petiole N, K
    - Flower N,K
  - Reflectance
    - Crop Circle ACS-470
      - Single unit
      - Height of 36”
      - First sensing by hand
      - Second sensing using Spider Sprayer
      - If visual deficiencies present, starting at Early Flower
      - 1 week before, 1 week after peak flower



RESULTS

RESULTS

- Analysis
  - Available K_2O was calculated in lieu of applied K_2O due to differences in initial K concentrations
  - Available K_2O was defined as:

    [(ppm soil test K × 2 × 1.2) + lb K_2O fertilizer/acre]

  - Regression analysis was conducted in JMP 10 (SAS Institute Inc., Cary, NC)
    - Independent variables in model included block, available k, cultivar, and interaction between available k and cultivar

RESULTS

Table 1: Soil test K (Mehlich 3) results and calculated available K_2O concentrations from soil samples in Marianna, AR .

	Mehlich-3-extractable soil potassium (ppm)		
	Min	Mean	Maximum
Rep			
1	63	86	135
2	67	95	133
3	96	122	139
4	80	109	147
	Calculated available soil potassium (lb K_2O/acre)[a]		
	Min	Mean	Maximum
Rep			
1	181	259	349
2	160	258	349
3	260	341	391
4	232	316	442

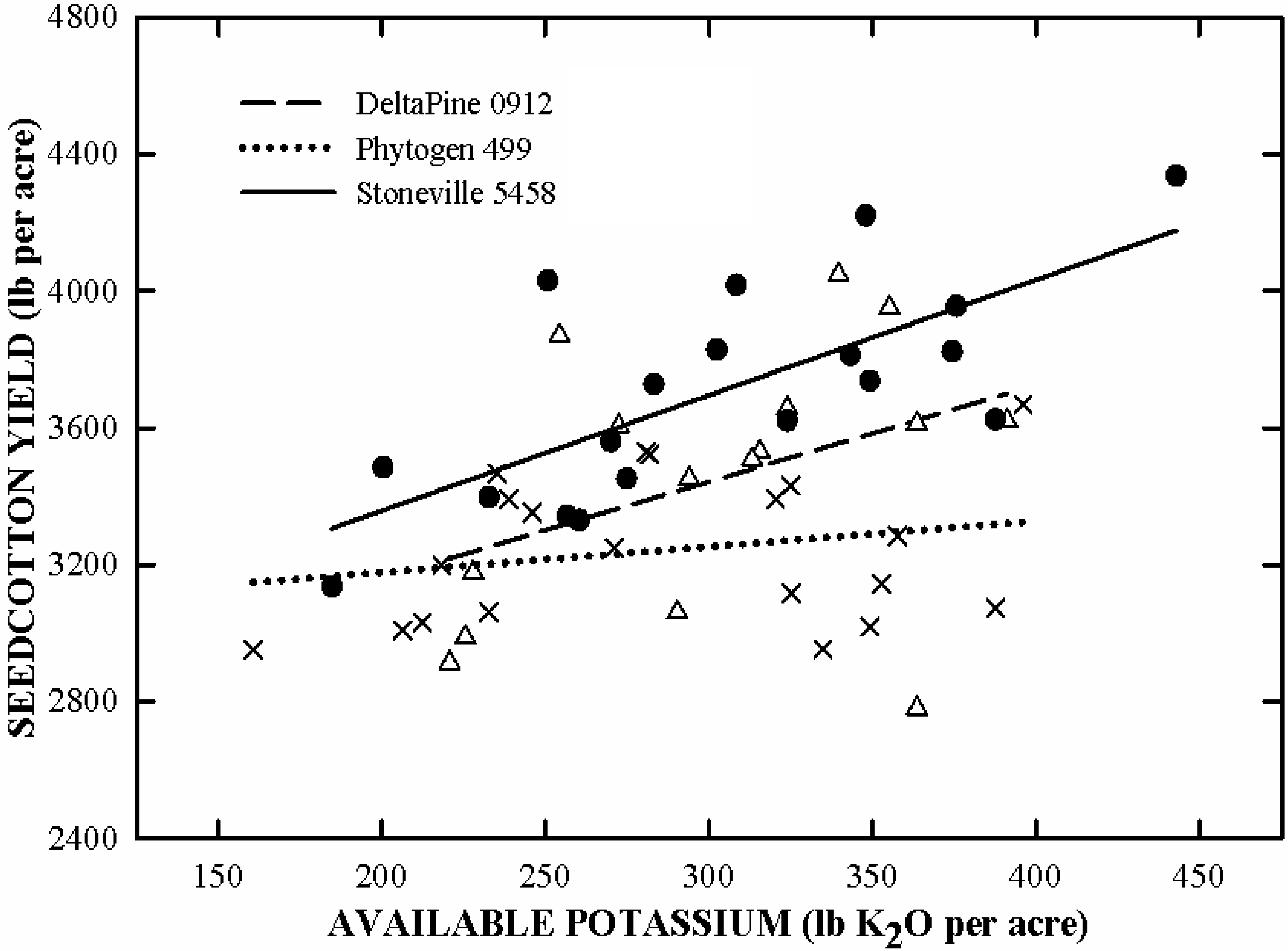
TABLE 1. Interpretation of soil-nutrient concentrati most row crops and forages. The interpretati

Soil Test Level	Expected Yield Potential[†]	P	K [Most Crops]
		- - - - - - -	- - - - - - - -
Very Low[§]	<65%	<16	<61
Low[§]	65 - 85%	16 - 25	61 - 90
Medium[§]	85 - 95%	26 - 35	91 - 130
Optimum	100%	36 - 50	131 - 175
Above Optimum (High)	100%	>50	>175

[†]Expected yield potential without fertilization.
[‡]Recommendations are not provided for these nutrients. The listed v
[§]The soil test levels of "Very Low," "Low" and "Medium" are consider

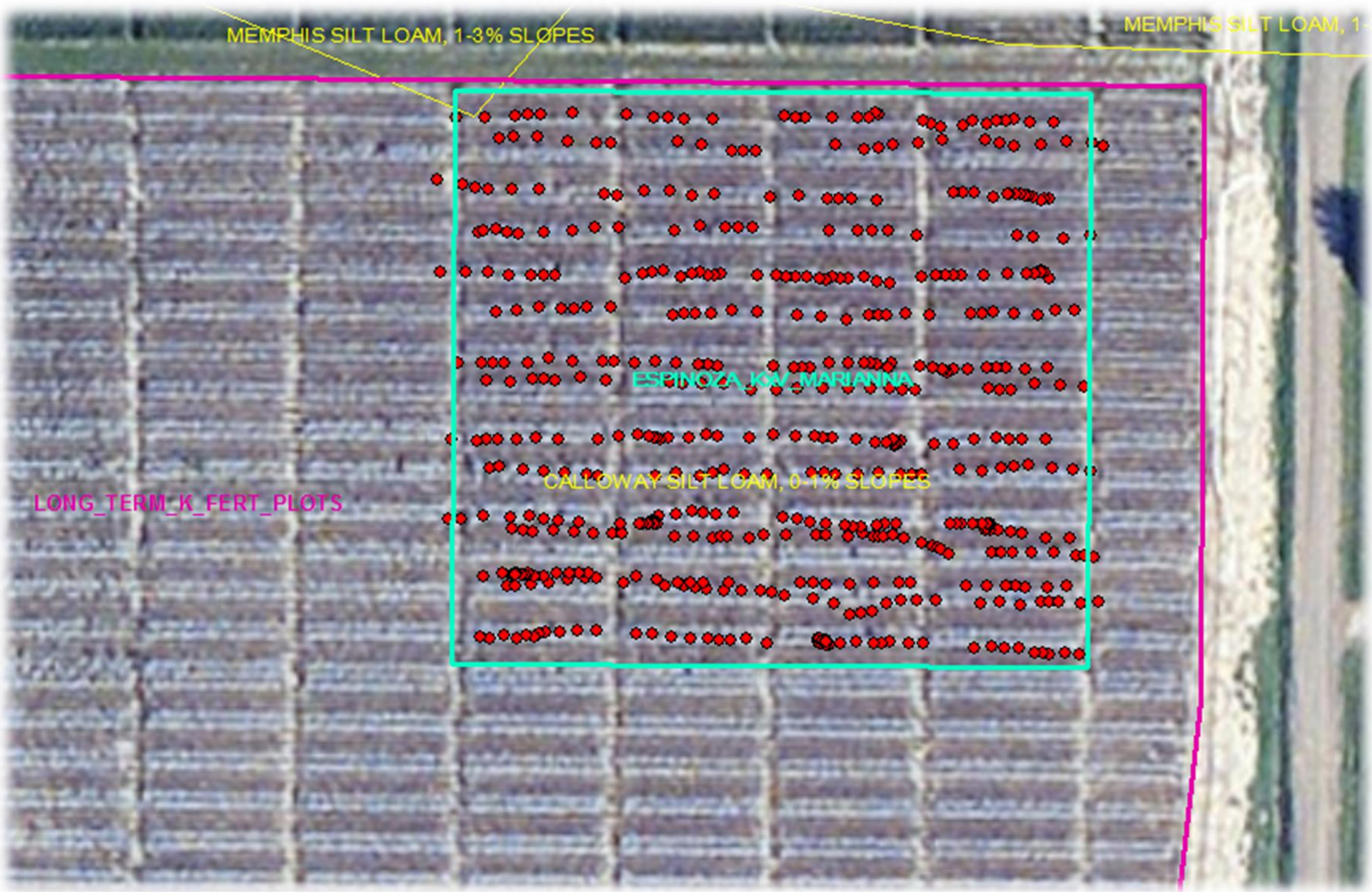
RESULTS

RESULTS



DeltaPine 0912
Phytogen 499
Stoneville 5458
SEEDCOTTON YIELD (lb per acre)
AVAILABLE POTASSIUM (lb K_2O per acre)
4800
4400
4000
3600
3200
2800
2400
150
200
250
300
350
400
450

RESULTS



MEMPHIS SILT LOAM, 1-3% SLOPES
MEMPHIS SILT LOAM, 1-
ESPINOZA_KV_MARIANNA
CALLOWAY SILT LOAM, 0-1% SLOPES
LONG_TERM_K_FERT_PLOTS

RESULTS

NDVI=0.85
CCCI=0.82

NDVI=0.87
CCCI=0.82

RESULTS

NDVI=0.84
CCCI=0.84

NDVI=0.87
CCCI=0.83

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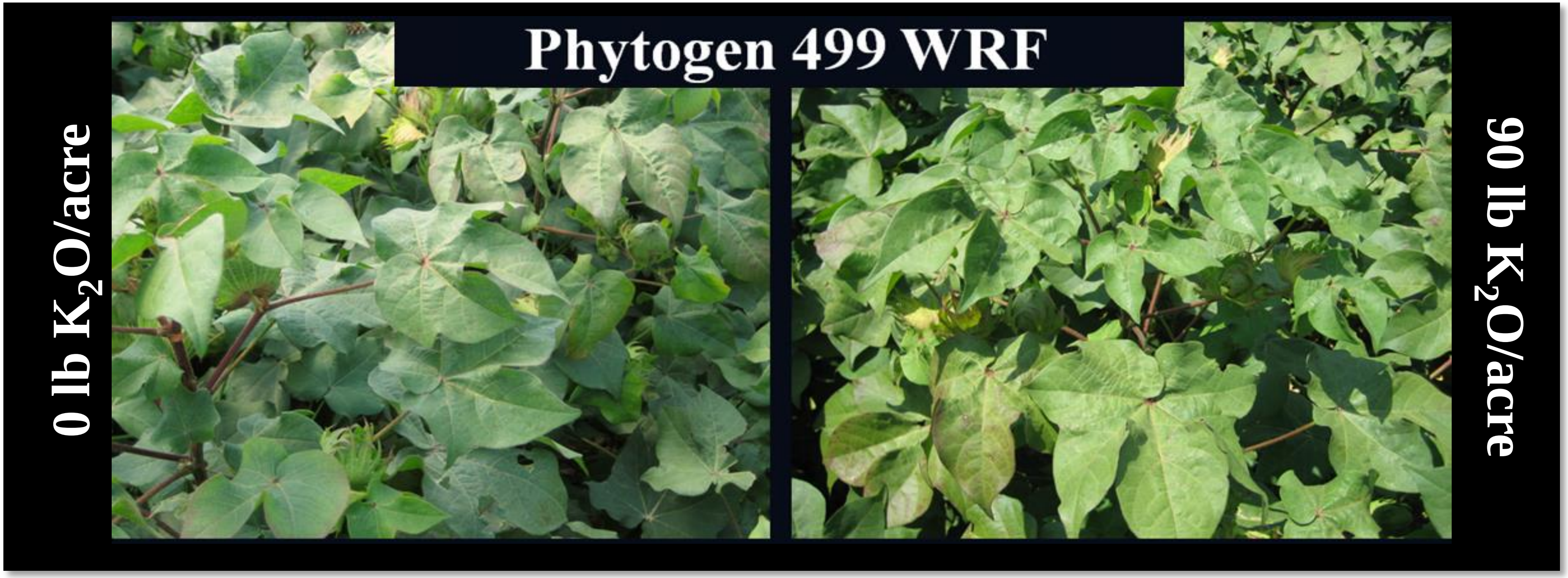
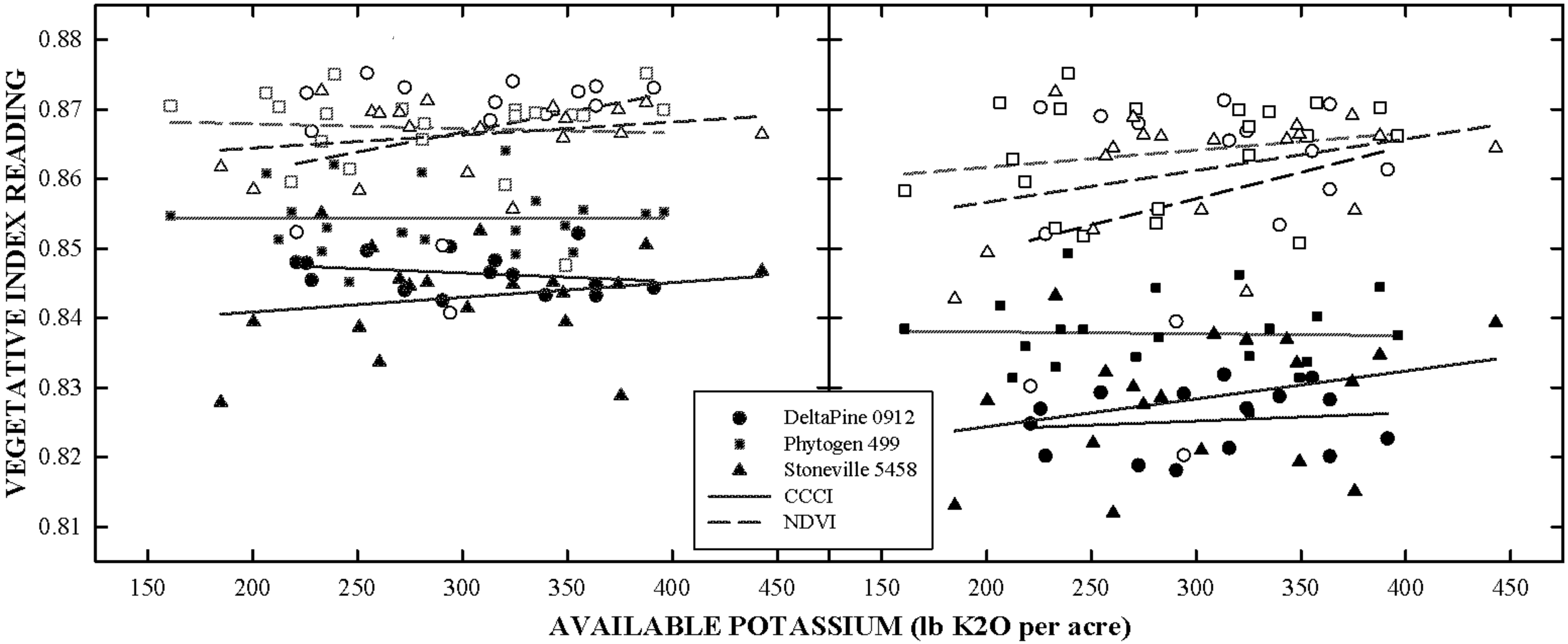
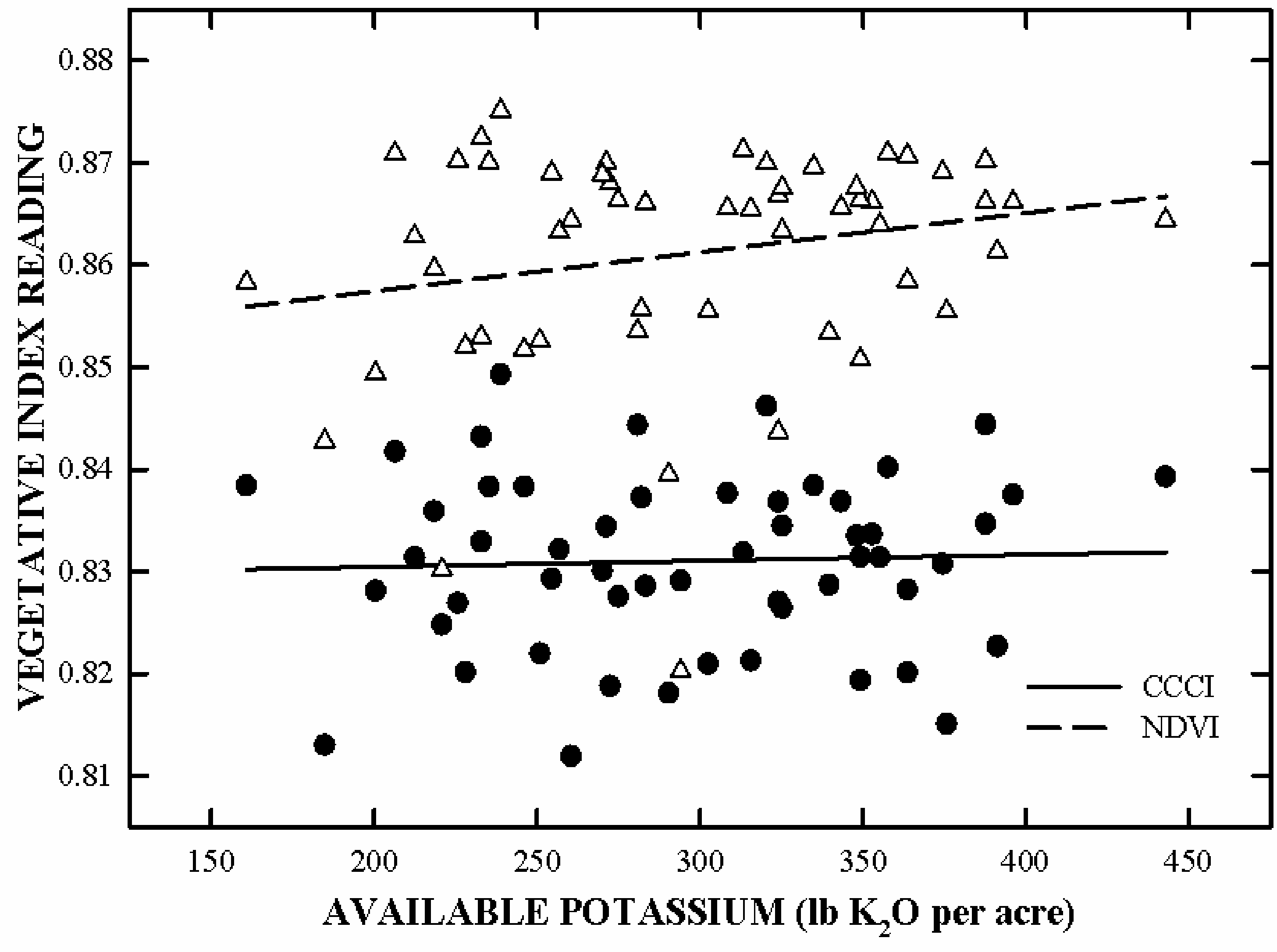


RESULTS


VEGETATIVE INDEX READING
0.88
0.87
0.86
0.85
0.84
0.83
0.82
0.81
150
200
250
300
350
400
450
AVAILABLE POTASSIUM (lb K2O per acre)
DeltaPine 0912
Phytogen 499
Stoneville 5458
CCCI
NDVI

RESULTS



0.88
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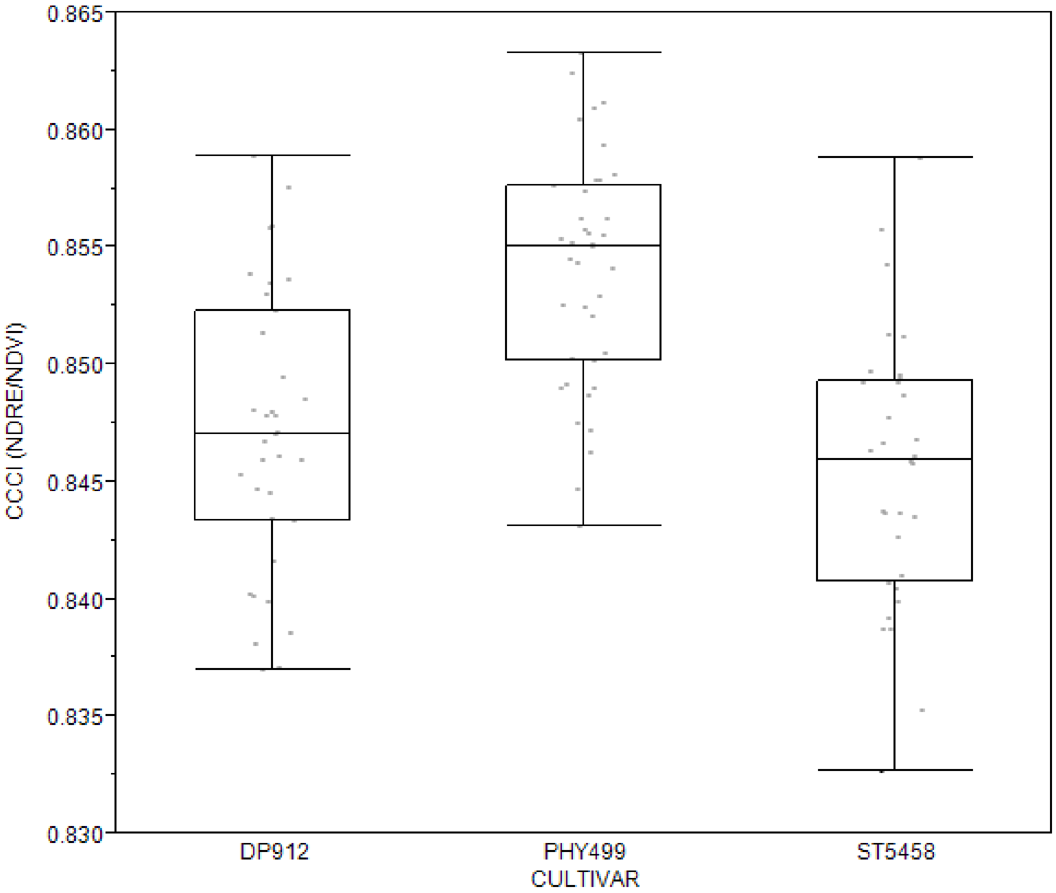
0.83
0.82
0.81
VEGETATIVE INDEX READING
150
200
250
300
350
400
450
AVAILABLE POTASSIUM (lb K_2O per acre)
CCCI
NDVI

RESULTS



0.865
0.860
0.855
0.850
0.845
0.840
0.835
0.830
CCCI (NDRE/NDVI)
DP912
PHY499
ST5458
CULTIVAR

CONCLUSIONS

- K and Reflectance
  - Decrease in NDVI with K deficiency
    - Potential to drive foliar K applications
  - Limited response of CCCI with K deficiency
- Cultivar and Reflectance
  - PHY499 had sig higher NDVI, CCCI values
  - ST5458 and DP0912 very similar
- CCCI
  - Significant response to cultivar

ACKNOWLEDGEMENTS

- Fluid Fertilizer Foundation
- Cotton Incorporated
- Western Laboratories

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