

Sensor Based Fertilizer Nitrogen Management

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Nitrogen in Cotton Production

- Increased costs linked to energy costs
- Deficiency limits yield and lowers quality
- Excess – rank growth, boll rot, difficulty in harvesting, and increased need for growth regulators, insecticides, and defoliants

- N availability is a determinant of
 - Biomass
 - Leaf area
 - Greenness
 - Physiological processes
 - Yield



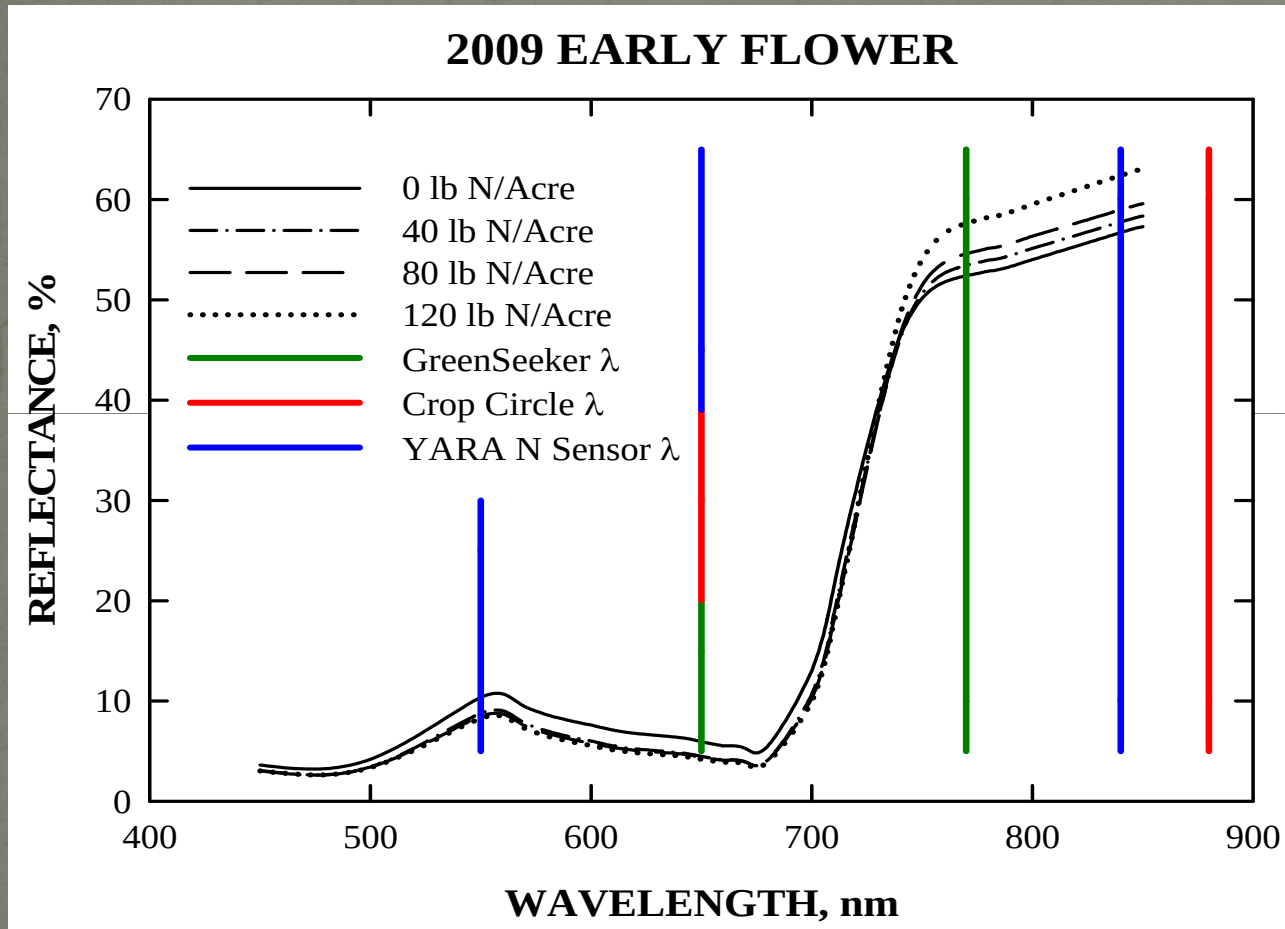
Theoretical Basis for Using Crop Reflectance

- Crop growth is a result of an integration of all factors influencing growth including the size of the available soil N pool, available water, and climatic conditions
- Remote sensing/crop reflectance is an indication of growth
- Selected crop reflectance indices can be used as surrogate measurements for leaf N and N content
- Spatial variances in crop reflectance are an indication of growth potential and at least a partial indication of the relative differences in the utilization of and/or size of the available soil N pool

Crop Reflectance Based Fertilizer N Management

- What we know:
 - Green band indices-effective for determining N status cotton (Buscalia and Varco, 2002; Peterson, 2002; Bronson et al., 2003)
 - Leaf N and K concentrations can be predicted utilizing crop reflectance, especially in green and red edge spectral regions (Fridgen and Varco, 2004)
 - Vegetative indices from aerial imagery most highly correlated with leaf N at peak bloom (Emerine, 2004)
 - Structural indices (e.g. NDVI, SAVI etc.) related to canopy scattering and growth are better indicators of field variability at earlier growth stages, while chlorophyll related indices are better related at later stages (e.g. Green Index or GI) (Zarco-Tejada et al., 2005)

Use of Crop Sensors for Growth and N Detection

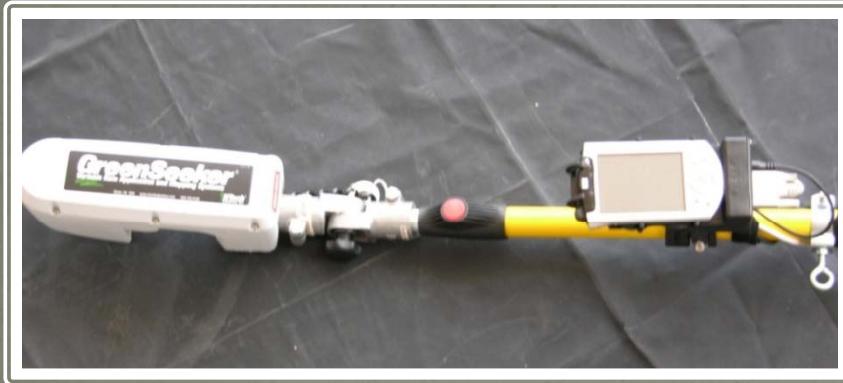


Representative crop
reflectance in visible
to NIR

Wavelengths used by
different sensors
indicated in color

Representative cotton
canopy reflectance by
N rate

Greenseeker 650 nm 770 nm



Crop Circle 650 nm 880 nm



YARA N Sensor five user selected
20 research mode



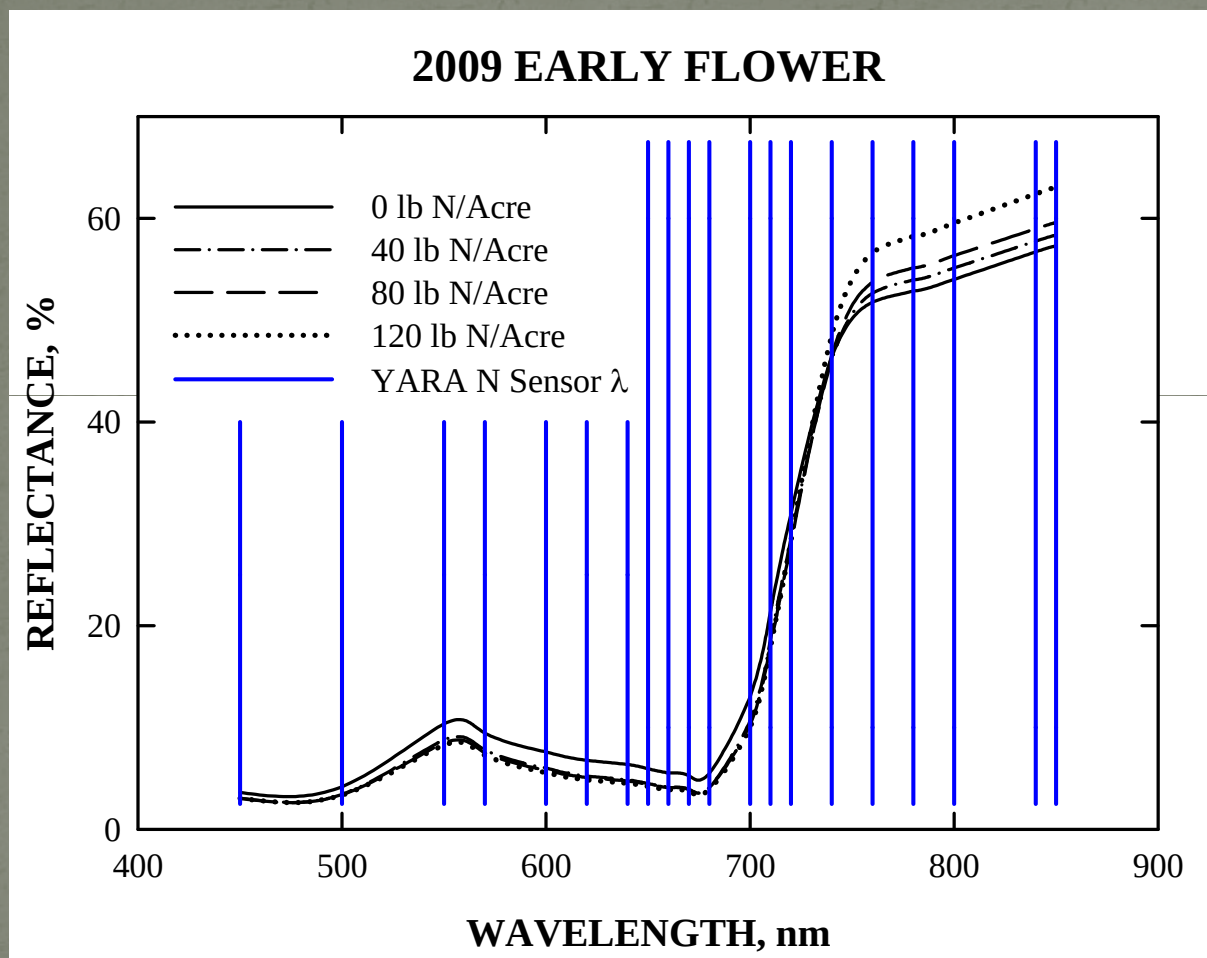
YARA ALS 730 nm 760 nm



Topcon Cropscan
735 nm and 808 nm
calibrated to YARA ALS

YARA N Sensor Cotton Canopy Scan

Wavelengths collected
in research mode
shown in blue



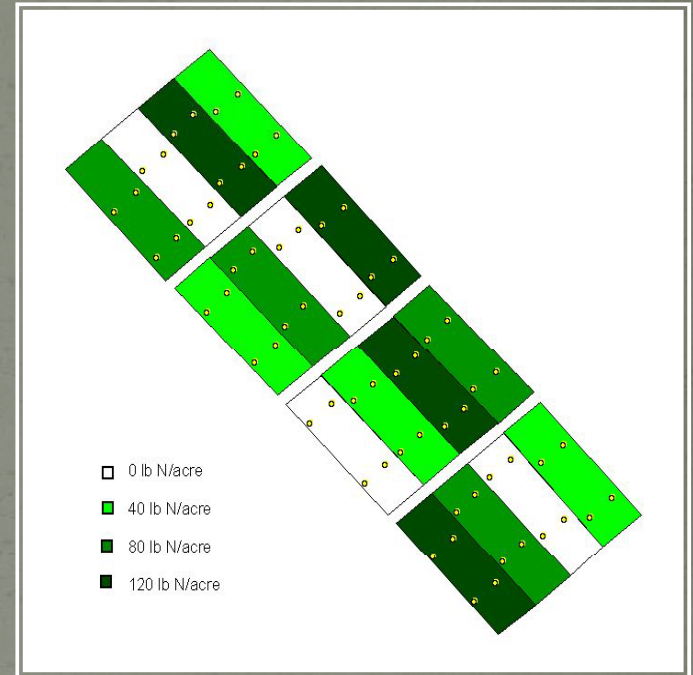
METHODS

- Plant Science Research Unit, Mississippi State, MS
- Randomized complete block design
- 4 Fertilizer N rates w/4 Reps
 - 12 rows wide @ 38" row spacing
 - 125' long
 - 4 sub-locations for sampling

METHODS (CONT.)

- Treatments
 - 0, 40, 80, and 120 lb N/acre
 - Planting (50%)
 - Early square (50%)
- Cultural practices
 - No-till/CT on beds
 - DPL BG/RR 445, 2010 DPL 1028
 - No growth regulator applied
 - Weed and insect control according to recommendations

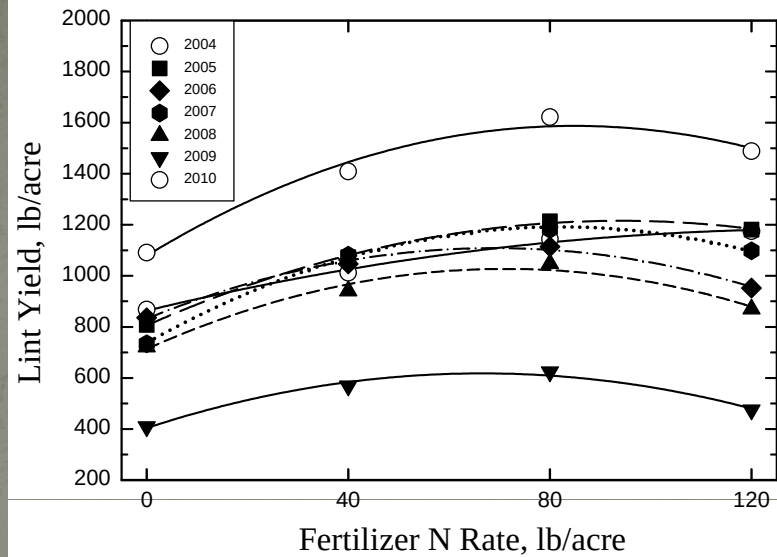
Aug. 4, 2010 Late Flowering



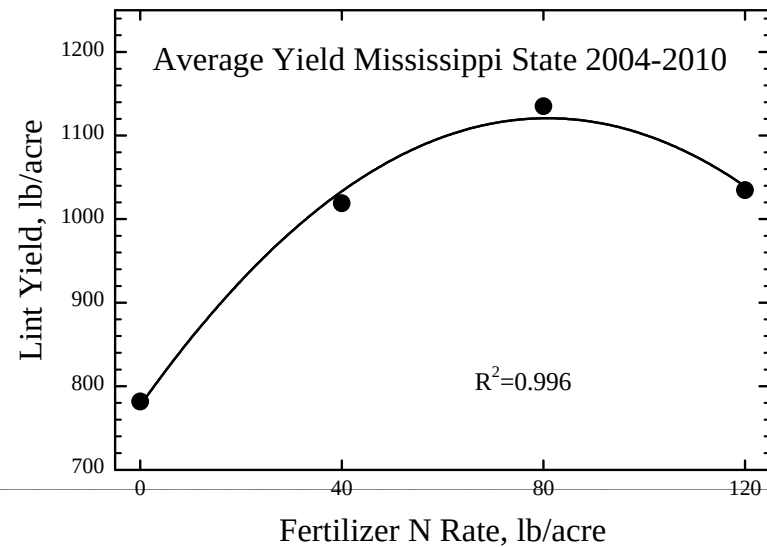
Crop Response to Fertilizer N

UAN 32%, 50% after planting
50% @ early square, 8-9" to one side
of row, 3" deep

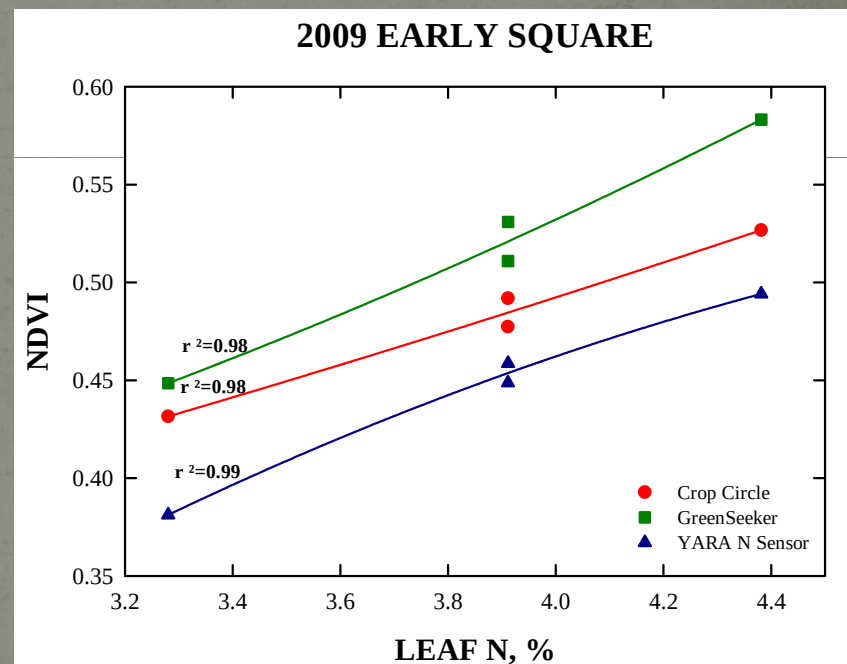
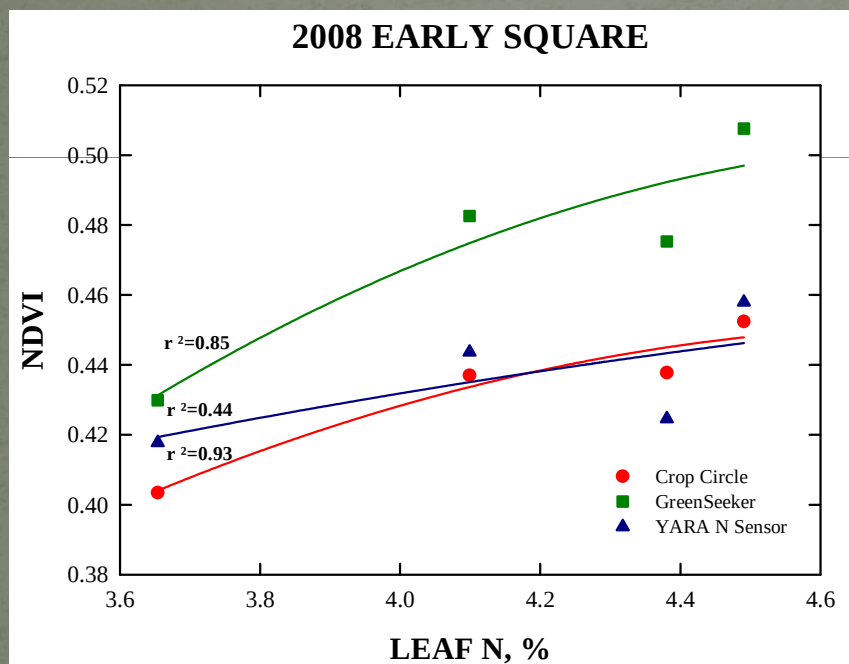
Yearly NT/CT Cotton Yield, Miss. State



Average Yield Mississippi State 2004-2010

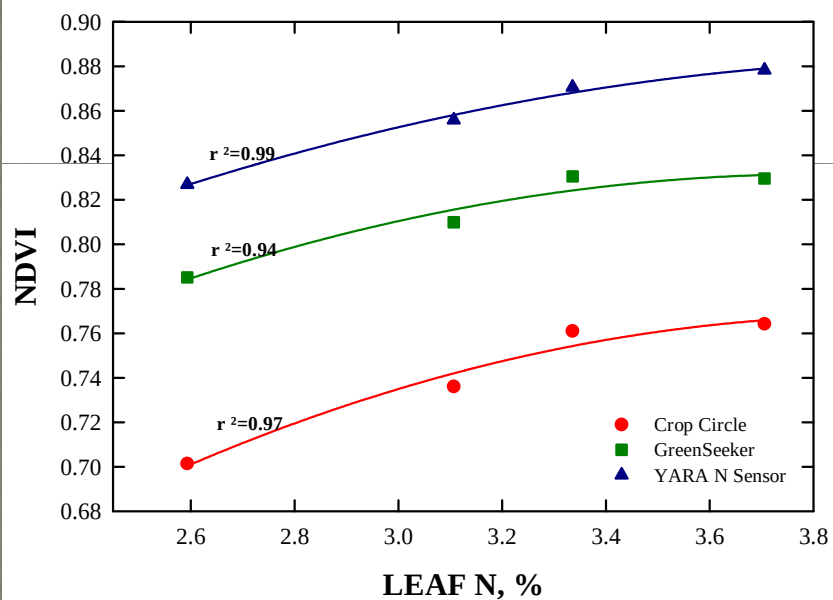


Sensor Comparison Leaf N

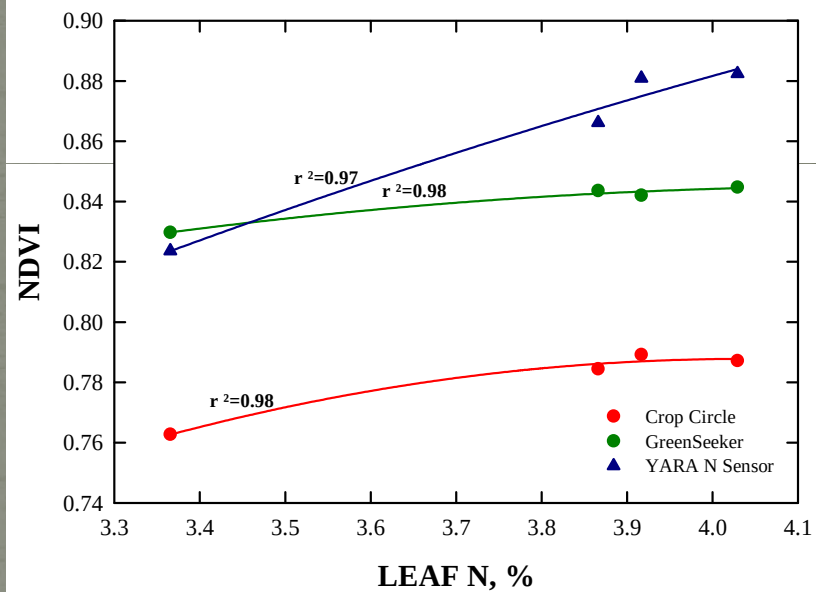


Sensor Comparison-Leaf N

2008 EARLY FLOWER

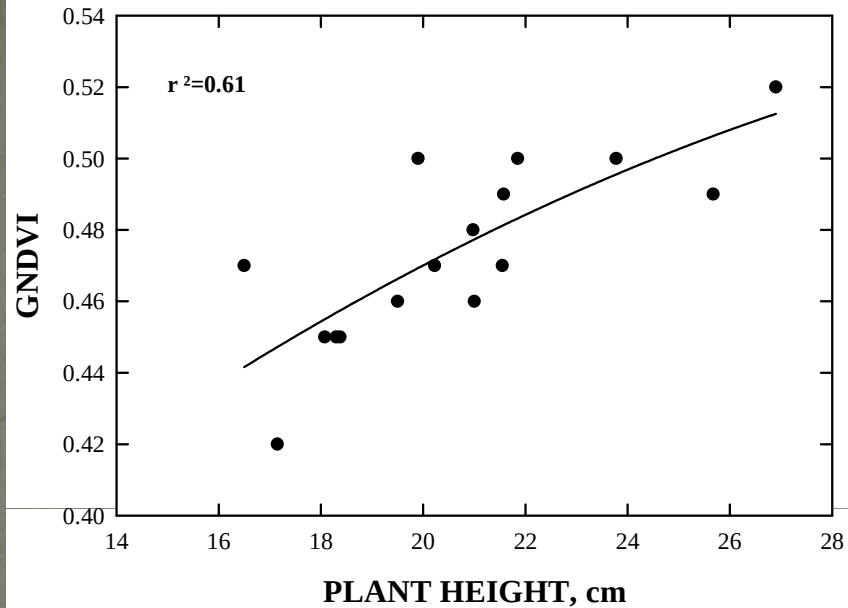


2009 EARLY FLOWER

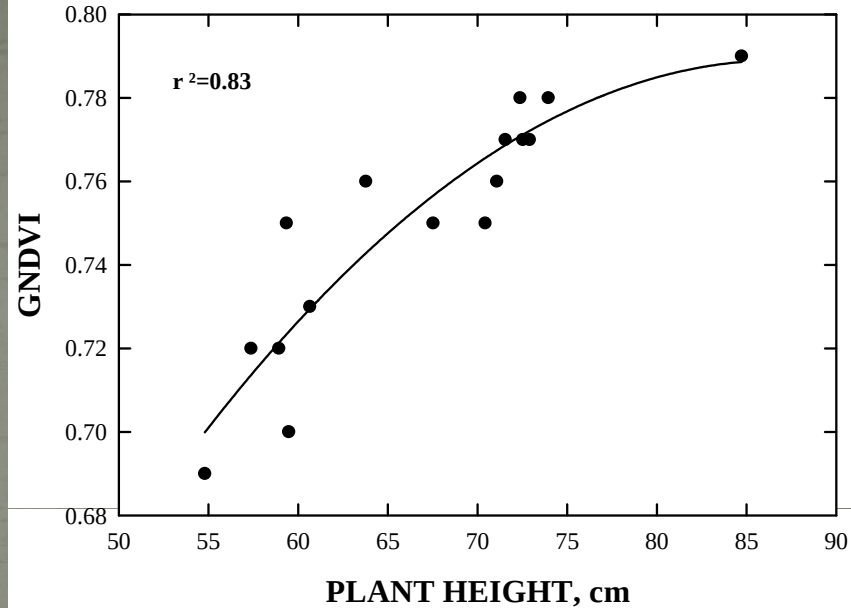


What are we seeing?

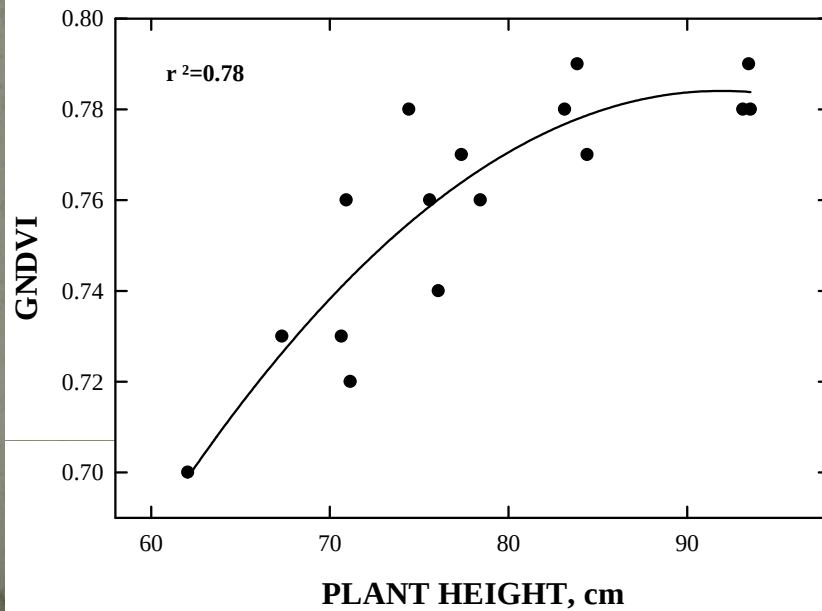
2008 EARLY SQUARE



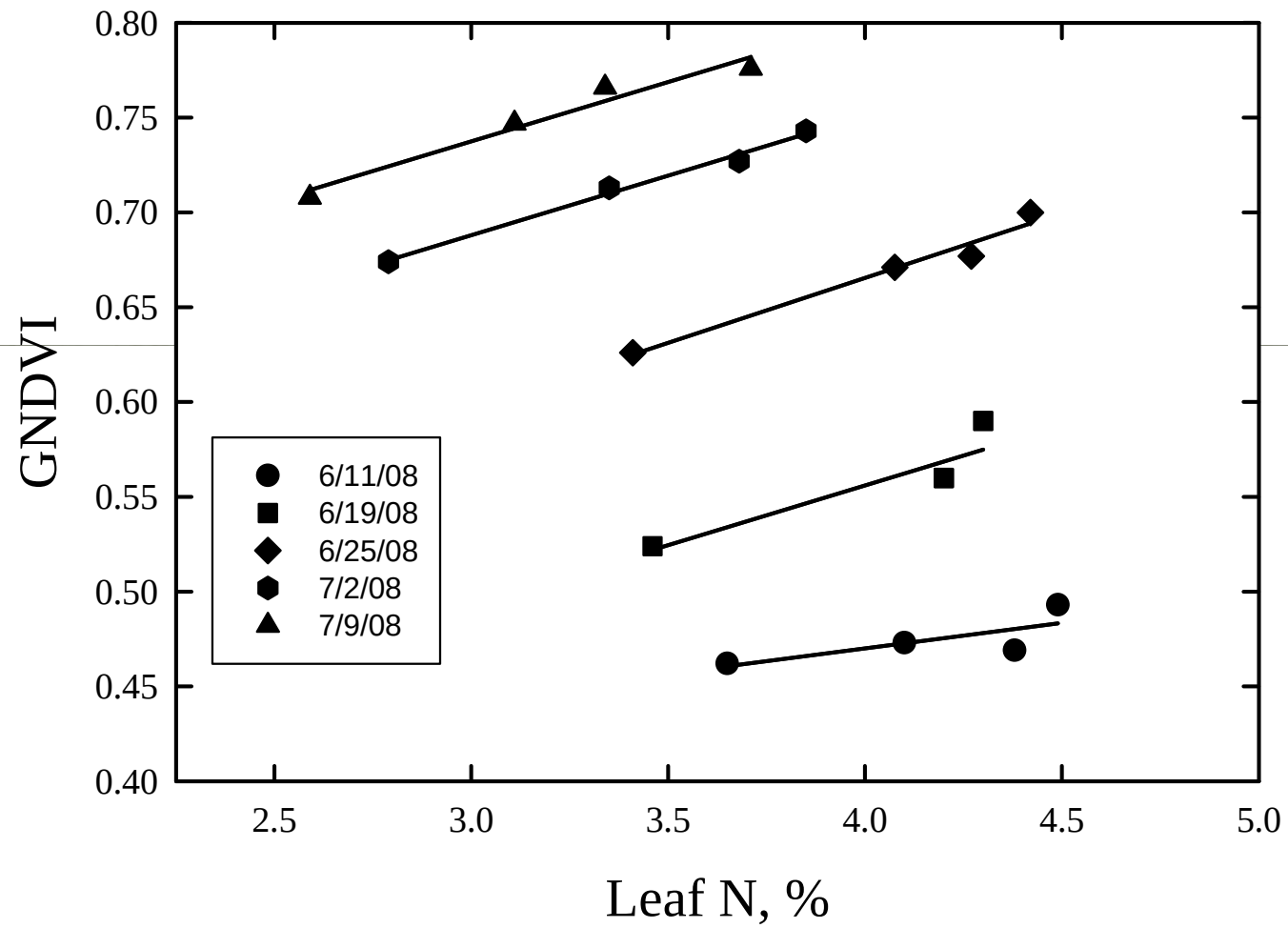
2008 EARLY FLOWER



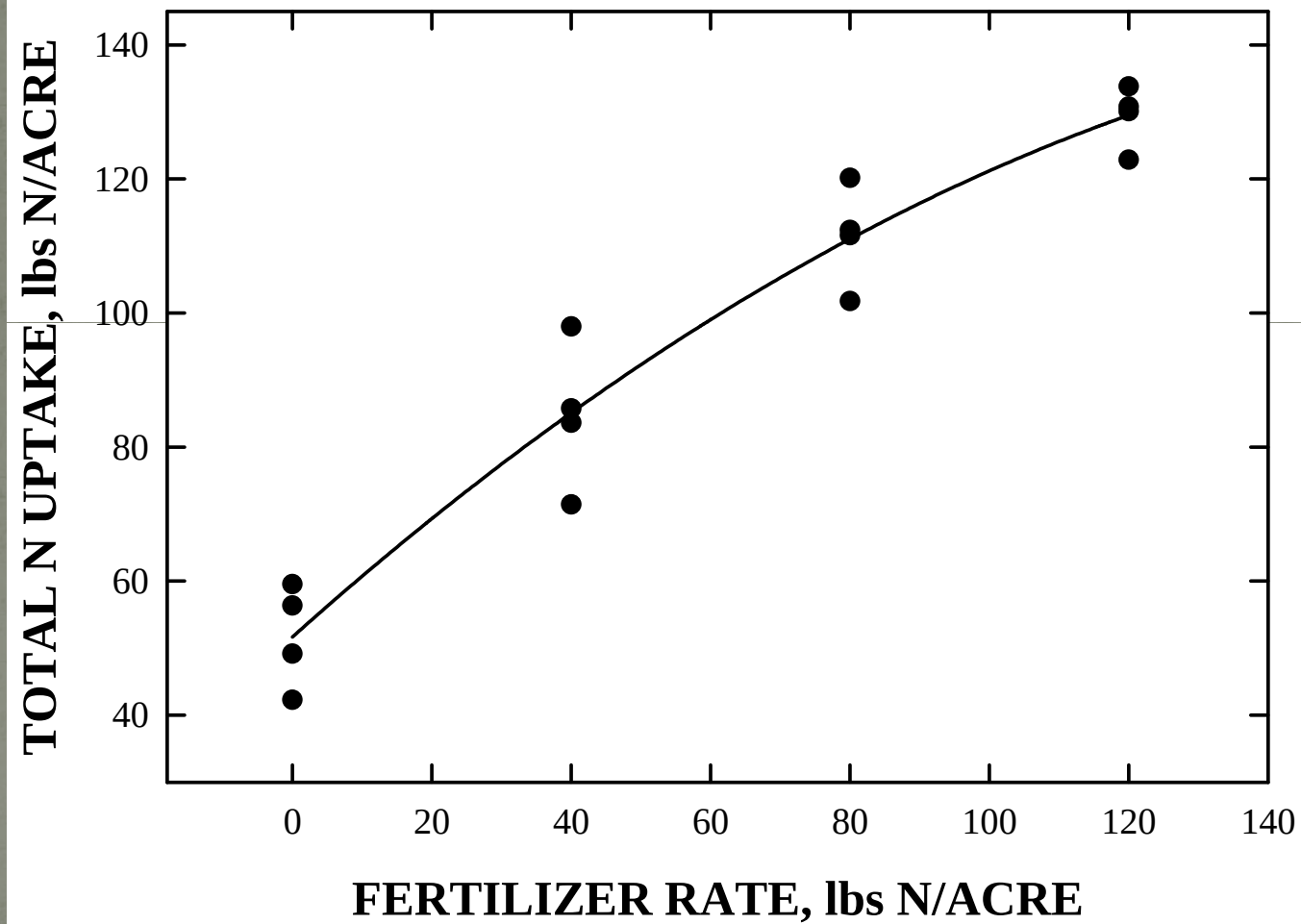
2008 PEAK FLOWER



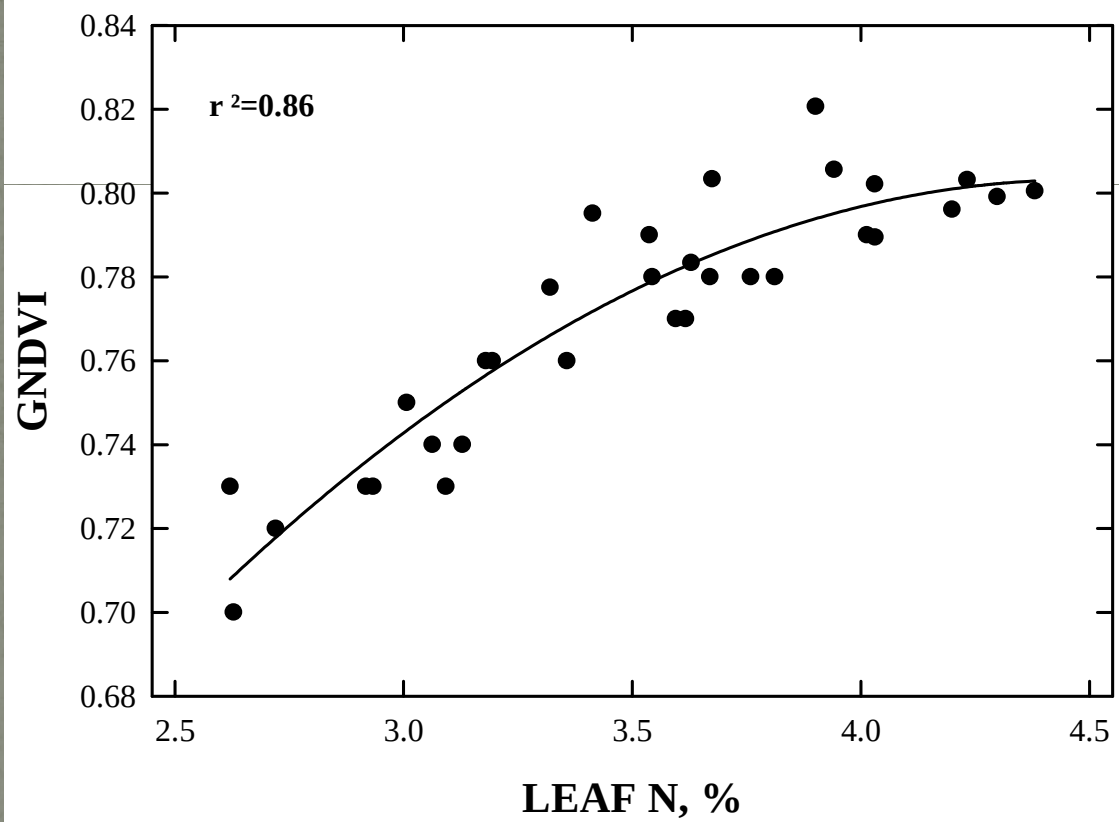
Mississippi State



2008 SEASON N UPTAKE



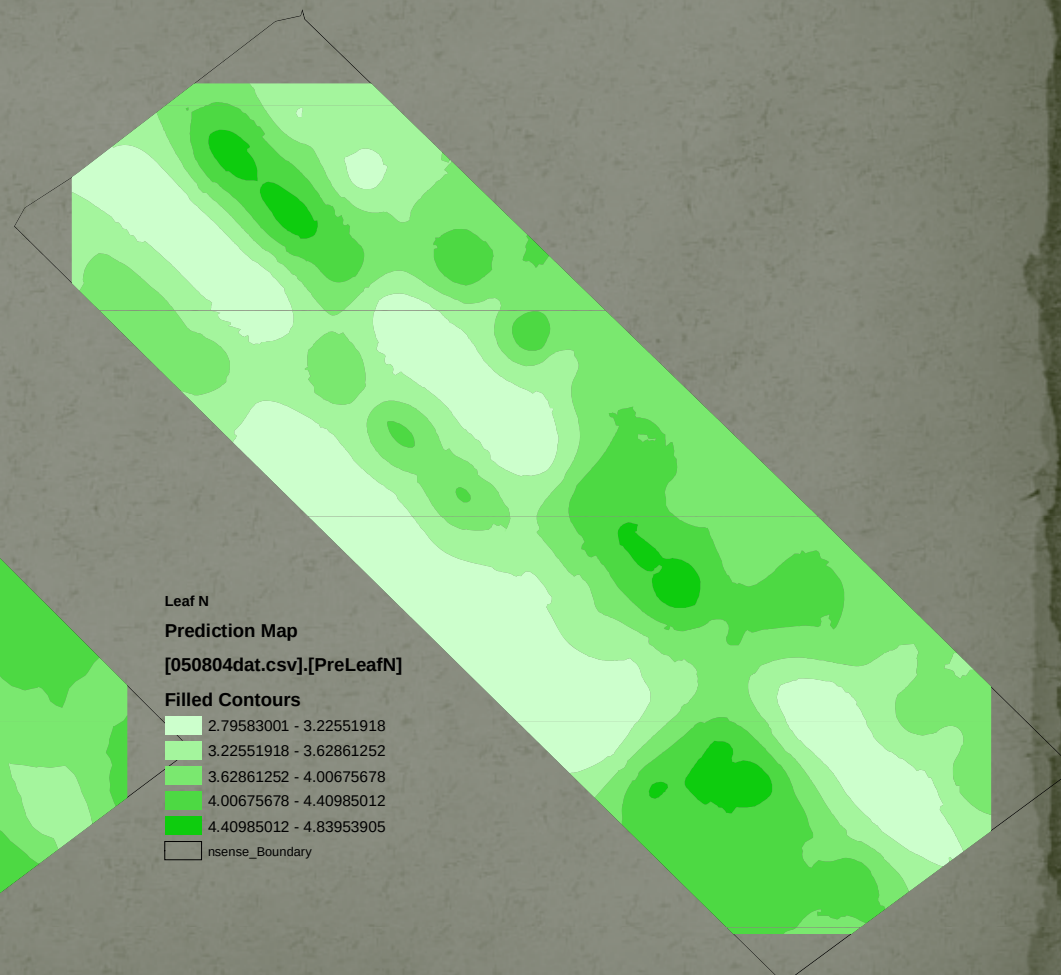
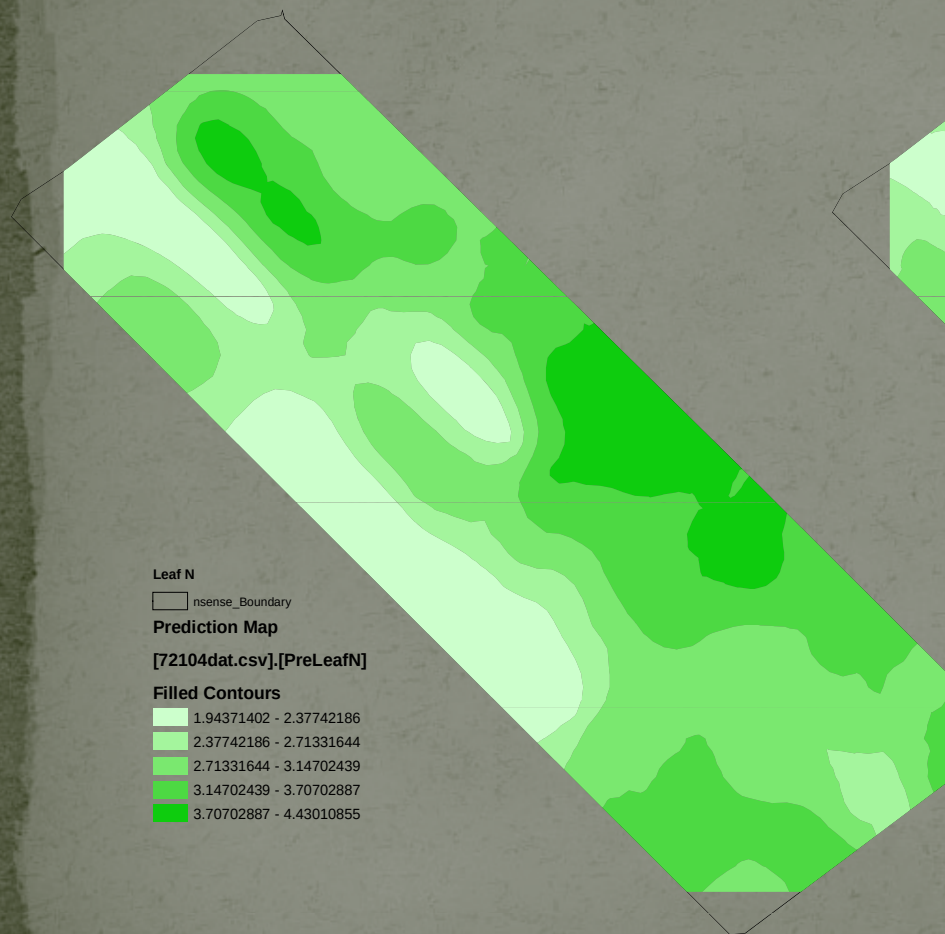
2008/2009 PEAK FLOWERING



Predicted Leaf N Map @ Peak Flowering

7/21/2004

8/04/2005



Predicted Plant Height 8/04/2005

Predicted N Biomass Index 8/04/2005

Leaf N

nsense_Boundary

Prediction Map

[050804dat.csv].[PrePH]

Filled Contours

77.2931671 - 88.5834122
88.5834122 - 98.2801208
98.2801208 - 106.6082
106.6082 - 113.760834
113.760834 - 119.903915
119.903915 - 125.179947
125.179947 - 129.711304
129.711304 - 134.987335

Leaf N

nsense_Boundary

Prediction Map

[050804dat.csv].[PreLNPH]

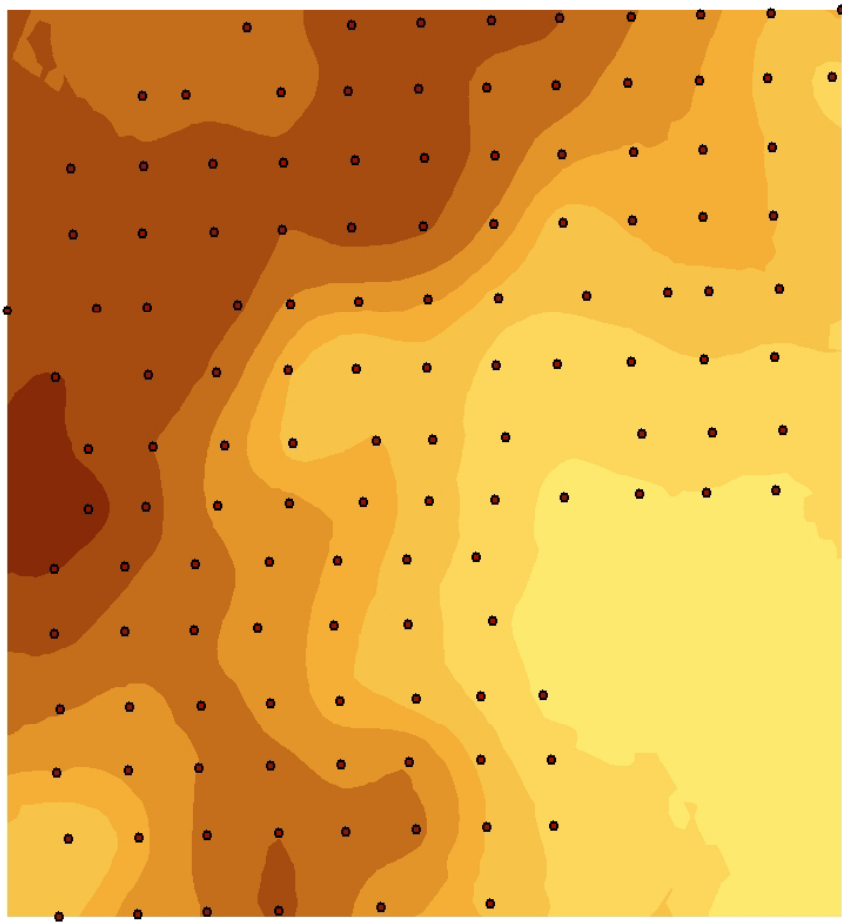
Filled Contours

241.405075 - 274.747162
274.747162 - 312.119659
312.119659 - 354.009796
354.009796 - 400.963623
400.963623 - 453.593262
453.593262 - 512.584839
512.584839 - 578.707336
578.707336 - 652.822815

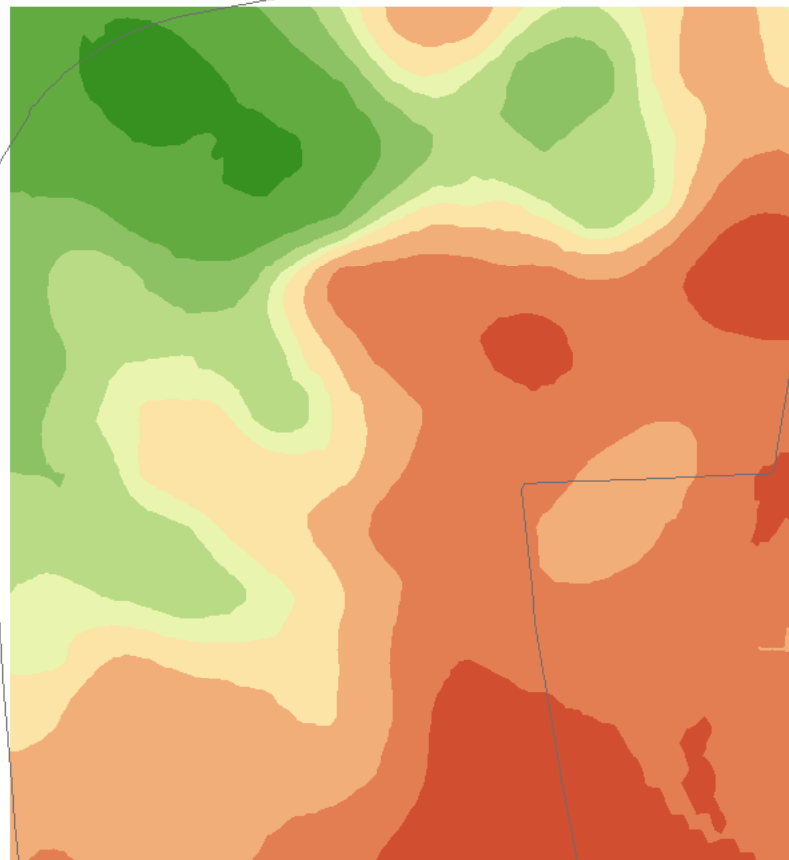
Spatial and temporal detection of N biomass

Cotton Leaf N – Early Flowering 2002

2002 Soil Available N, kg/ha
0-60 cm



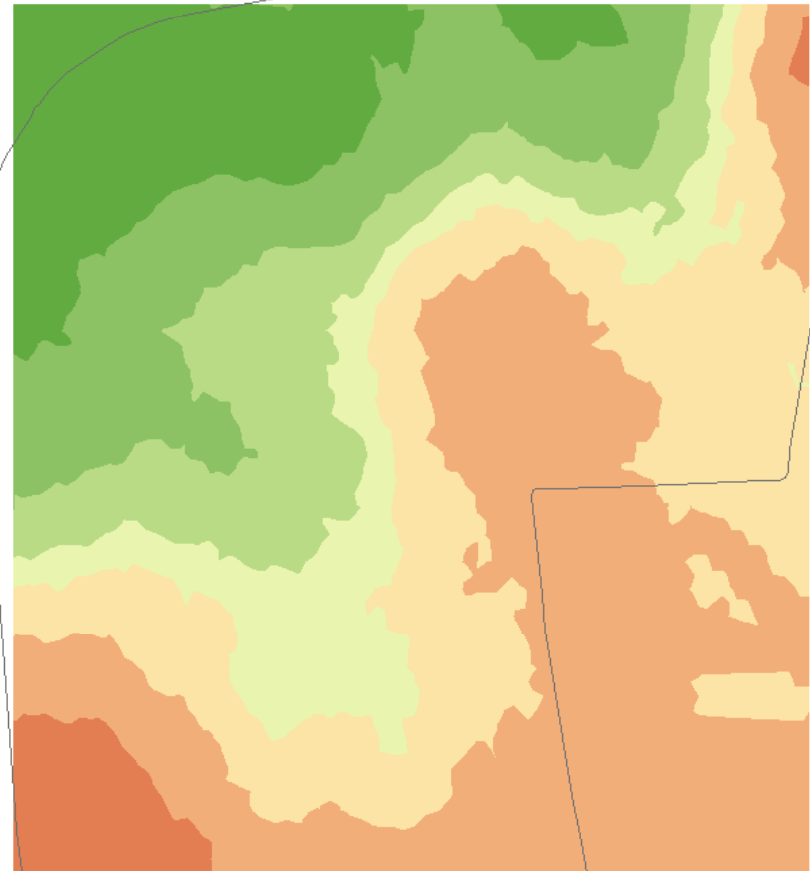
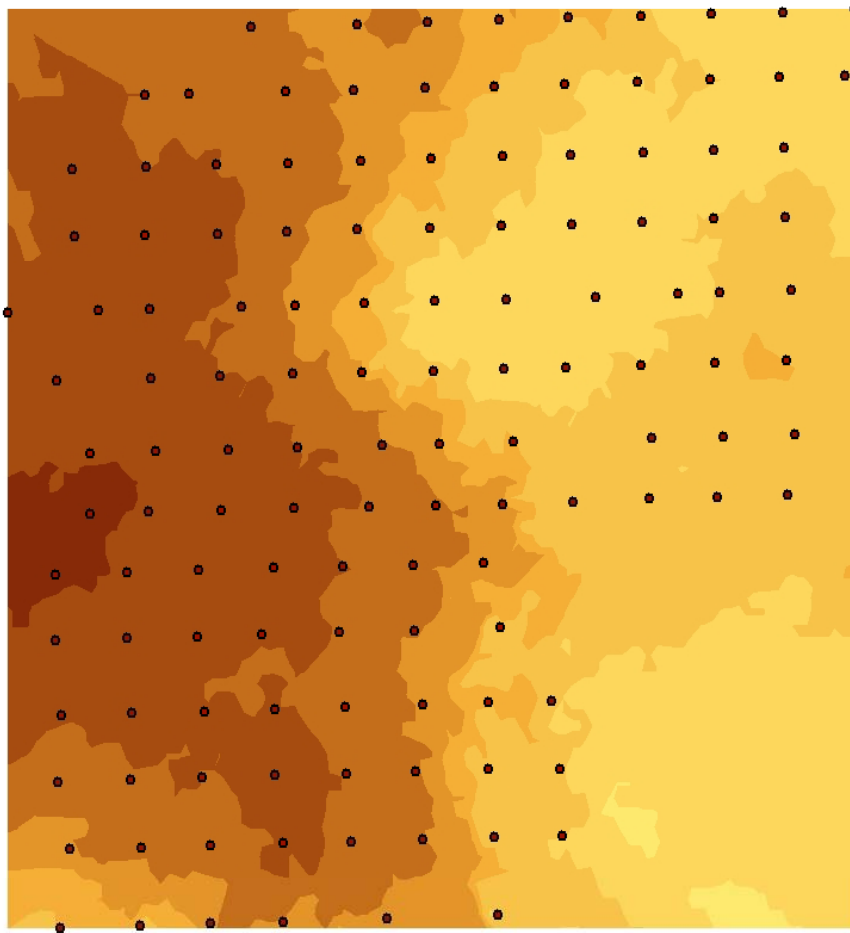
Ordinary Kriging 130pts



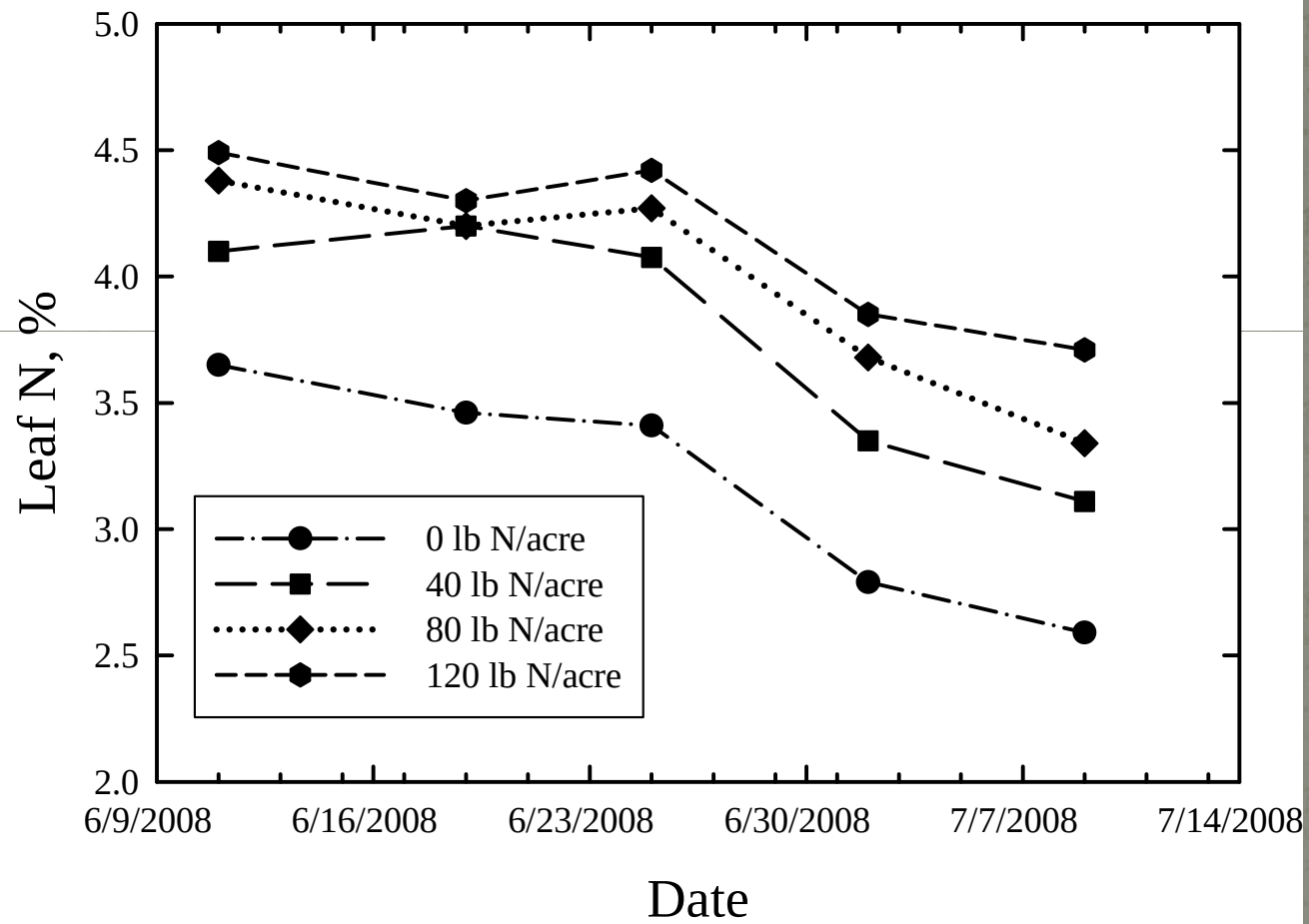
Cotton Leaf N – Early Flowering 2003

2003 Soil Available N, kg/ha
0-60 cm

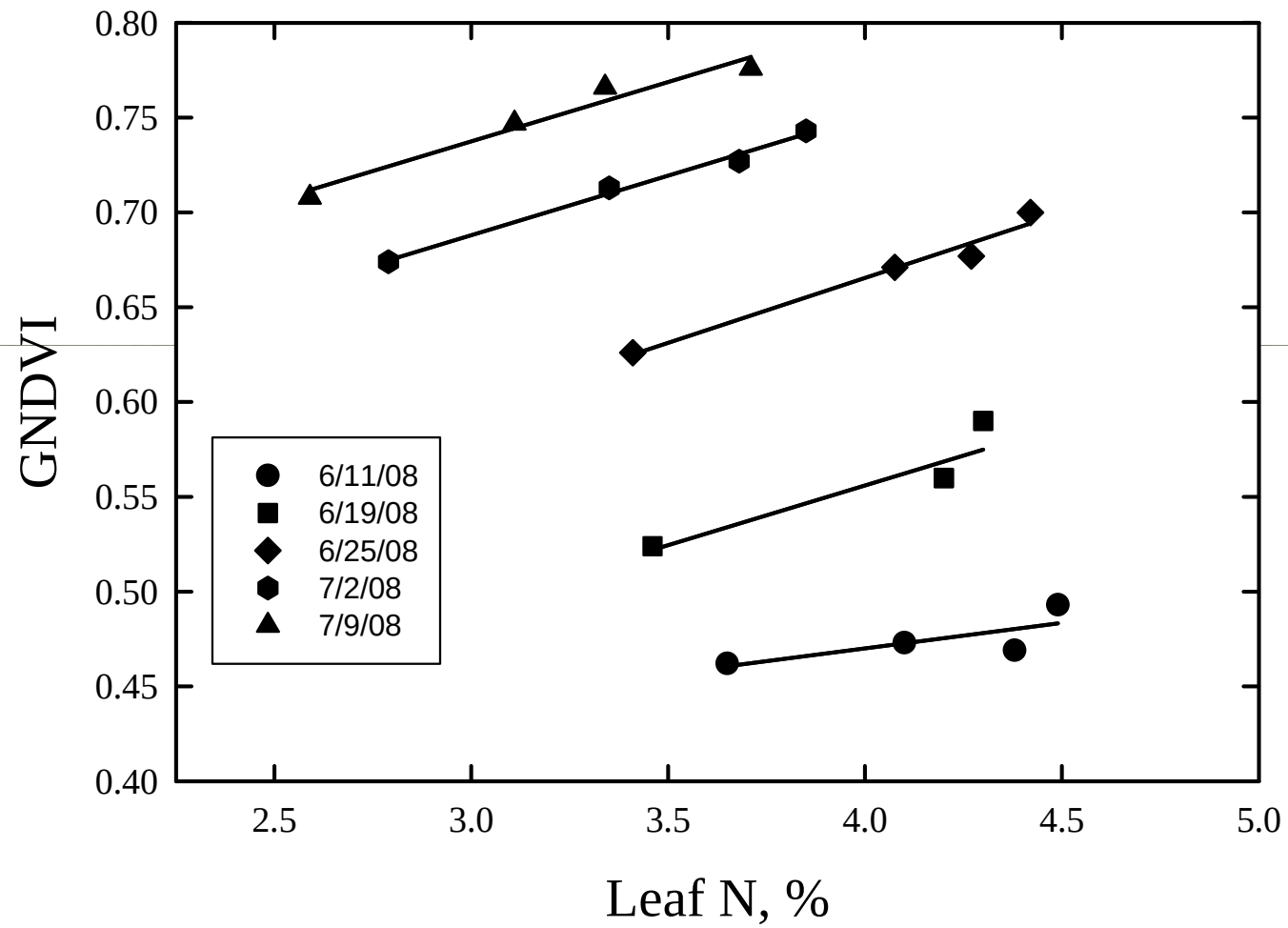
Ordinary Kriging 128 pts.



Mississippi State



Mississippi State



On-The-Go Crop Reflectance

YARA N Sensor

Wavelength Channels: 20 user selectable

Wavelength range: 450 to 900 nm, ± 5 nm

Optical inputs: 4 reflectance, 1 irradiance

Acquisition interval: 1 second

Area scanned: 50-100 m²/s

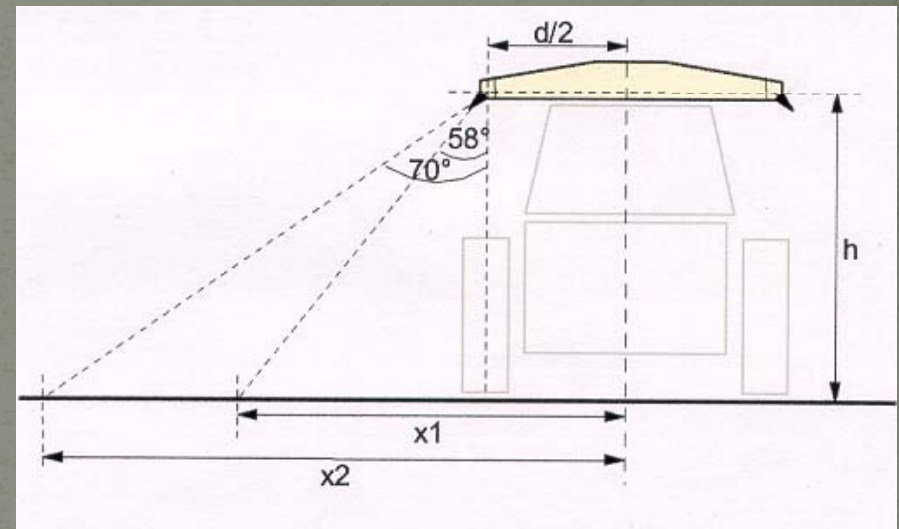
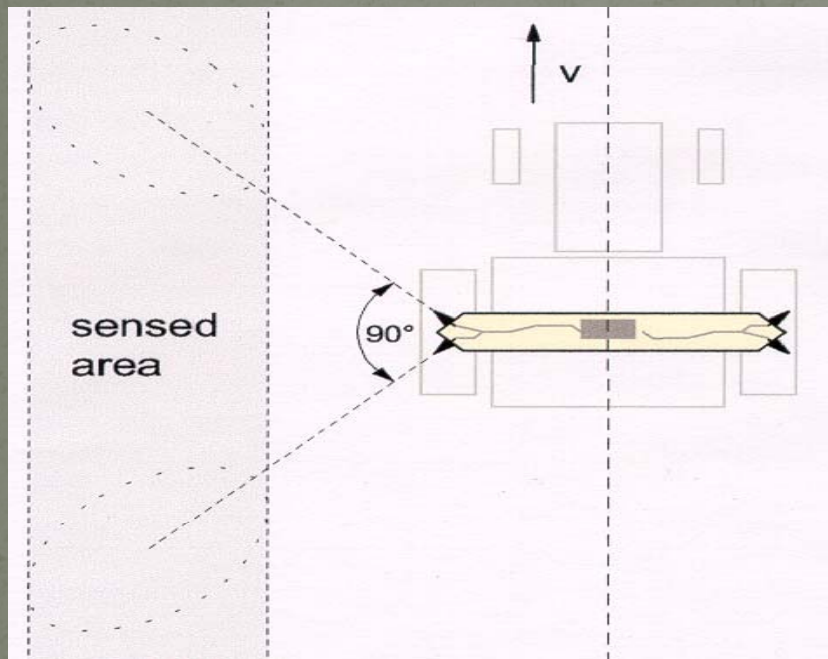
Positioning Data: Trimble Pro XR

Speed: 3.5 mph



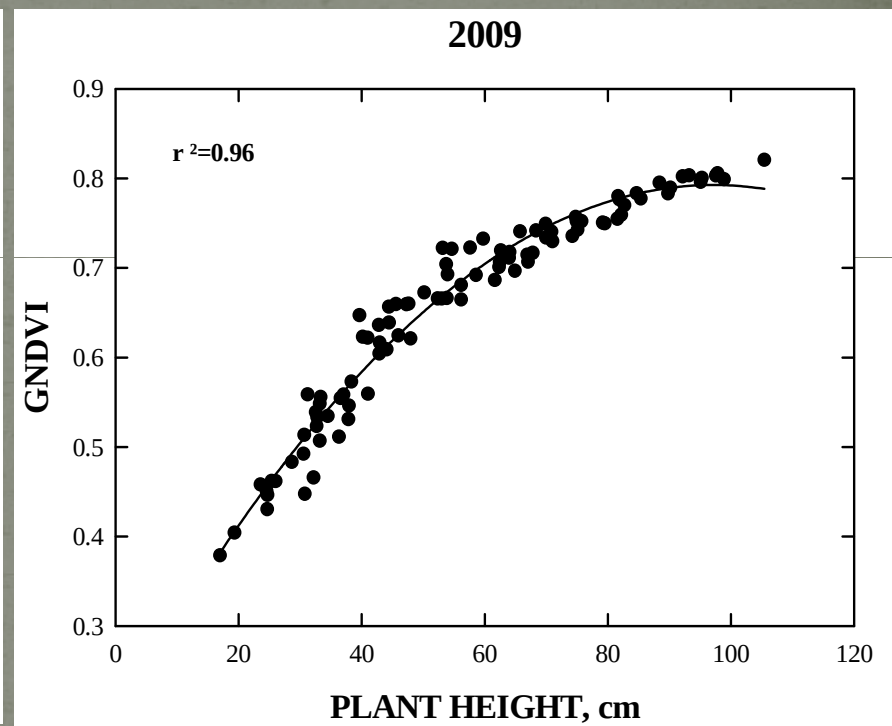
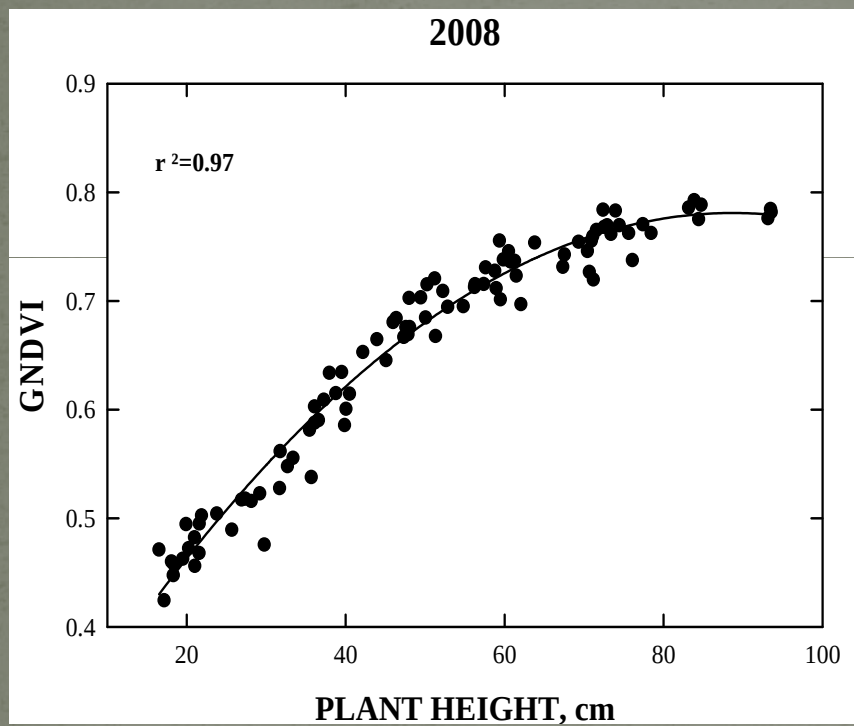
Viewing Geometry

Positioning of optical inputs as viewed from overhead and from behind.

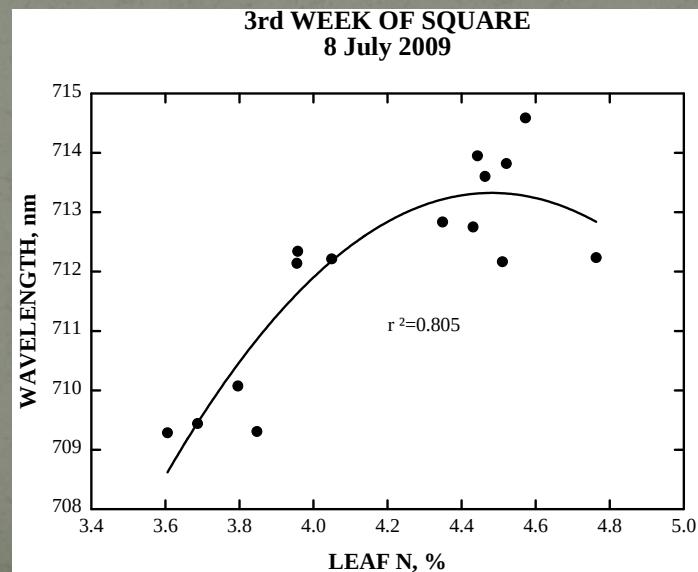
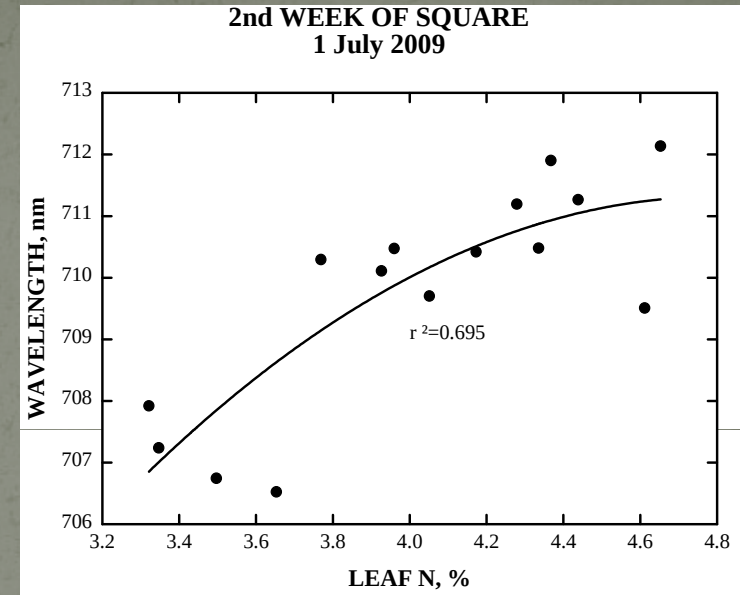
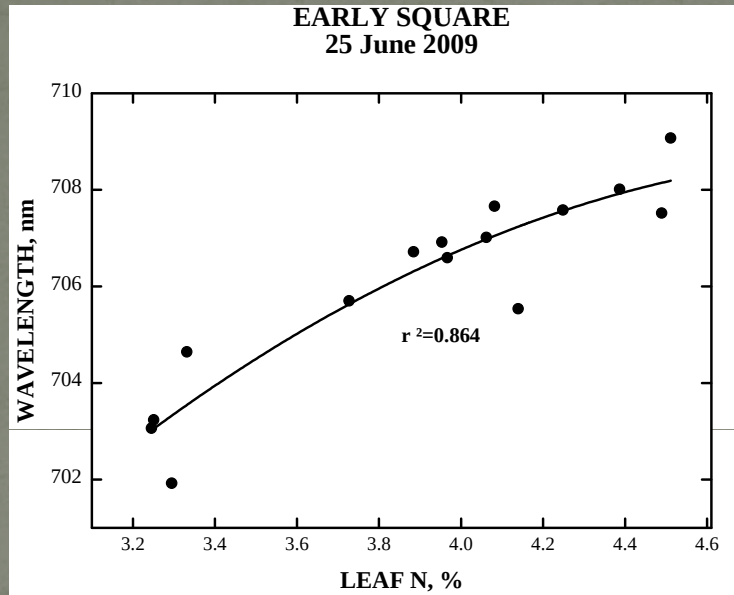


Source: YARA (Hydro Agri),
tec5Hellma

- Wavelengths - 550 (green), 650 (red), 700 (red edge), 710 (red edge), 840 (NIR)
- Currently also collecting 450, 500, 570, 600, 620, 640, 660, 670, 680, 720, 740, 760, 780, 800, and 850
- Green Normalized Vegetation Index $GNDVI = (NIR - Green) / (NIR + Green)$
- Normalized Vegetation Index $NDVI = (NIR - Red) / (NIR + red)$

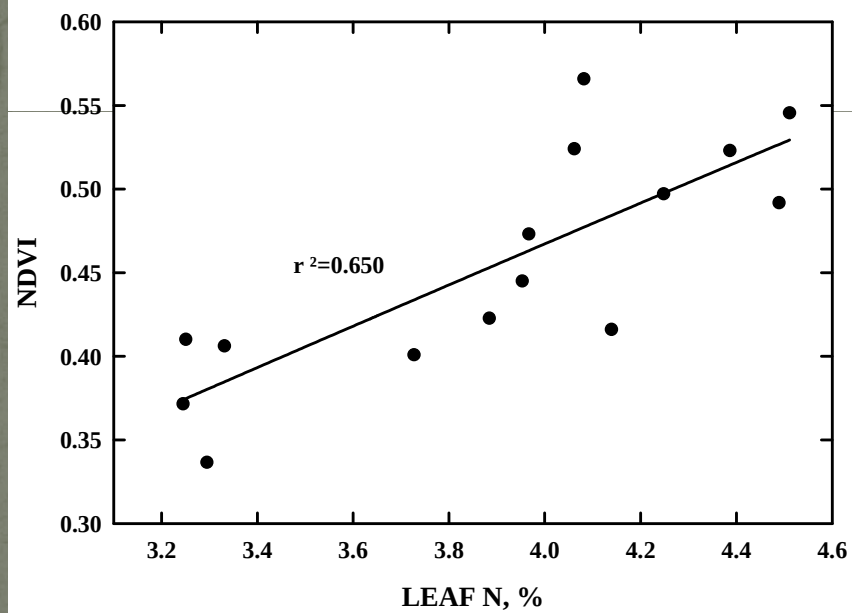


Relationships within Red-Edge Region

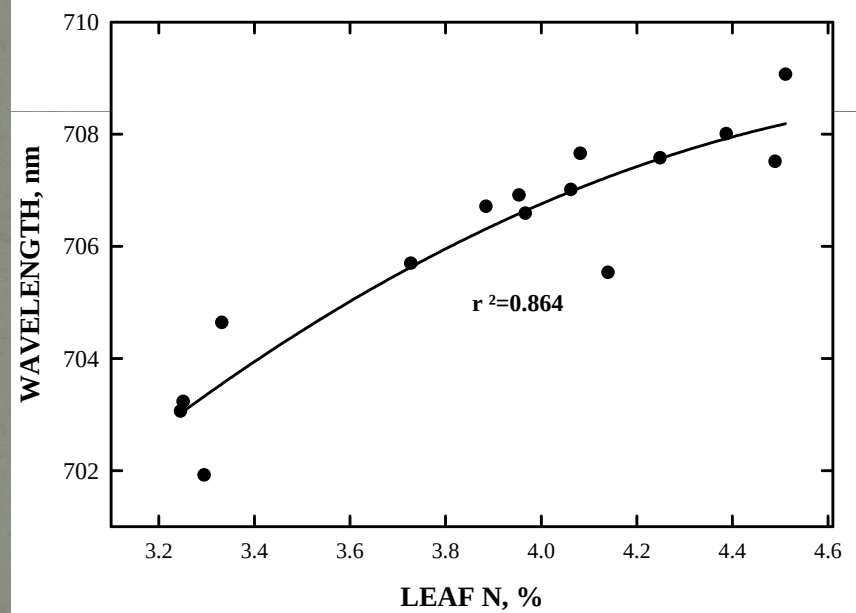


NDVI and REIP

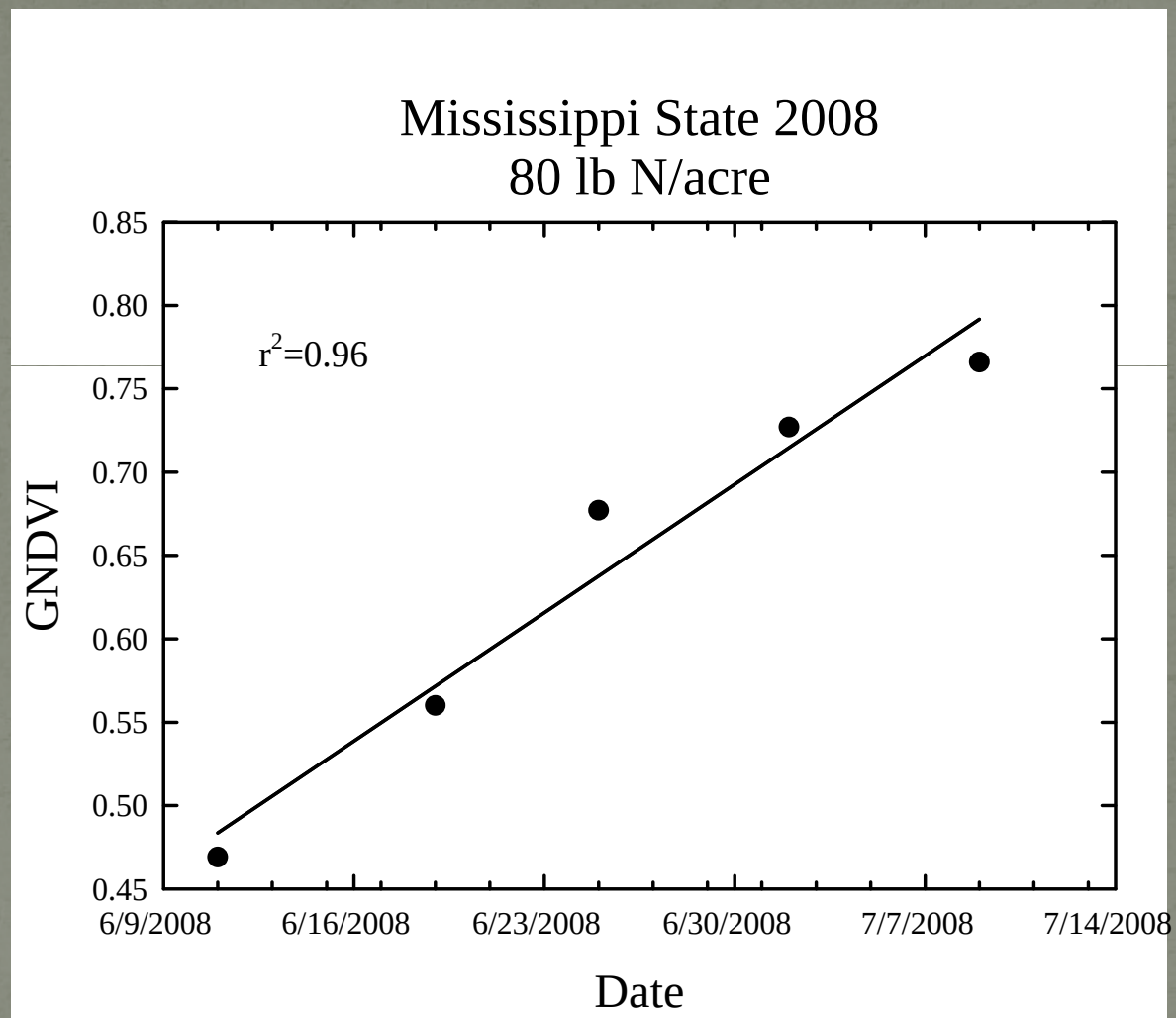
EARLY SQUARE
25 June 2009



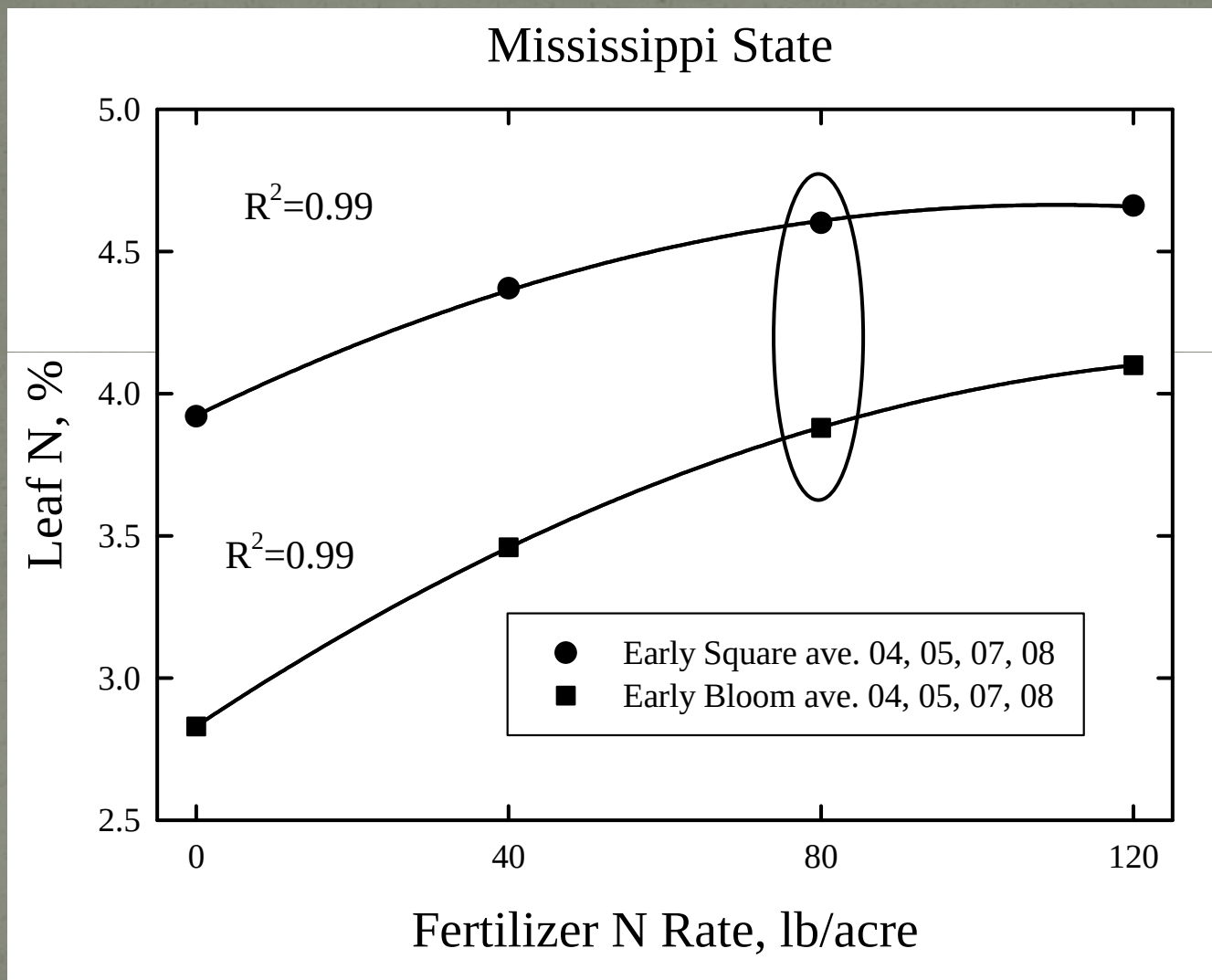
EARLY SQUARE
25 June 2009



Algorithm Development



Choosing a Target

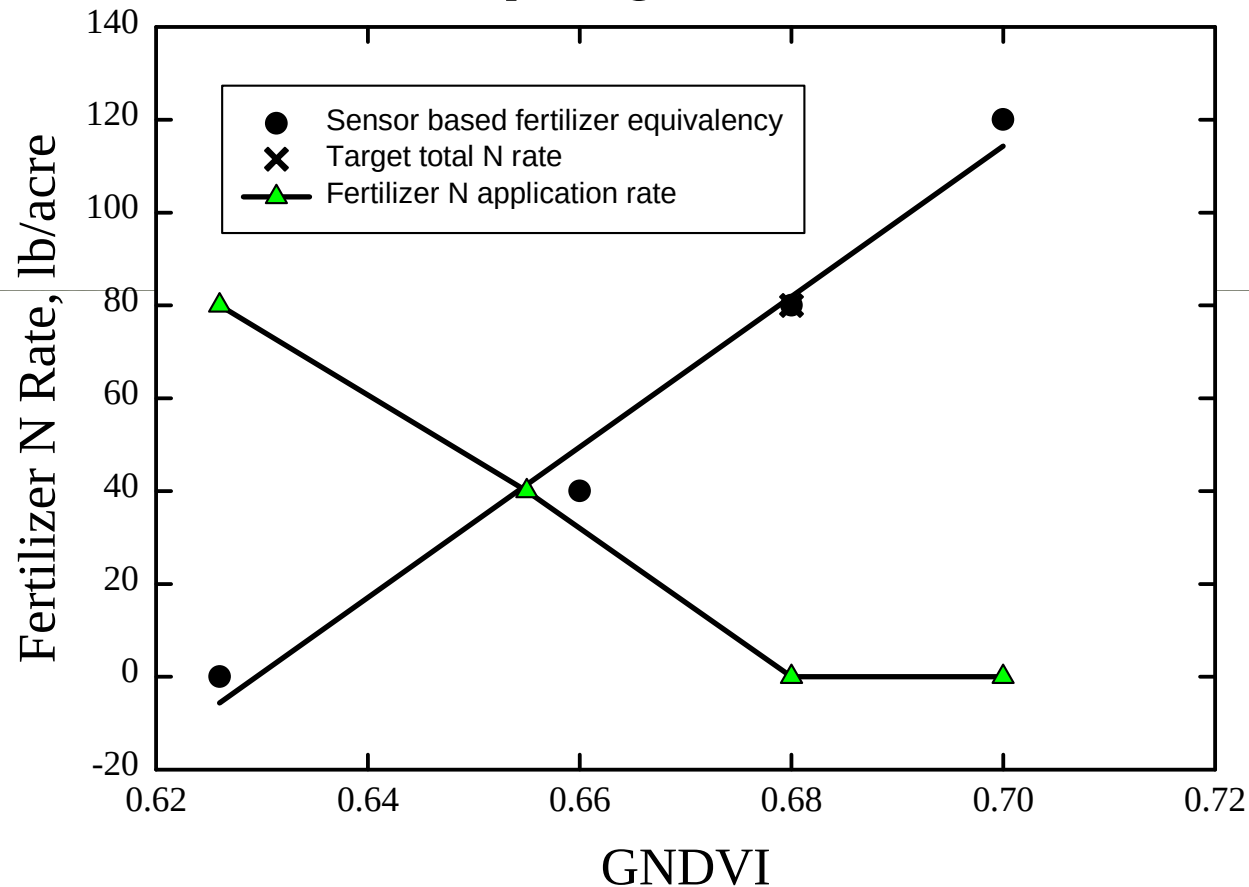


Sensor based N fertilization example

1. Apply initial fertilization @ a rate which will promote favorable growth say 40 lb N/acre.
2. Allow cotton growth to progress to point where spatial variability is evident and N related and backed up by some sampling and tissue analyses.
3. Decide on side dress N rate which in combination w/initial application is a good field average rate. This will require some experience w/the field and grower input. In this case let's use 40 lb N/acre for a total applied of 80 lb N/acre.
4. Use the sensor to collect readings to establish a two point or more calibration curve or use a robust algorithm.
5. On-the-sensing establishes fertilizer equivalency of the standing crop and N rate is adjusted accordingly.

Sensor Based Side Dress N Application

2008- 3rd Week Squaring Estimated Sidedress N Rate



SUMMARY

- On-the-go sensors can assist in the mapping of spatial and temporal variations in growth and N nutrition
- Real time crop reflectance can assist in the application of fertilizer N to account for spatial differences in N availability, but systematic calibration is necessary to maximize accuracy
- The profit maximizing fertilizer N rate should continue to be pursued as the desired target

Questions/Comments?

