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

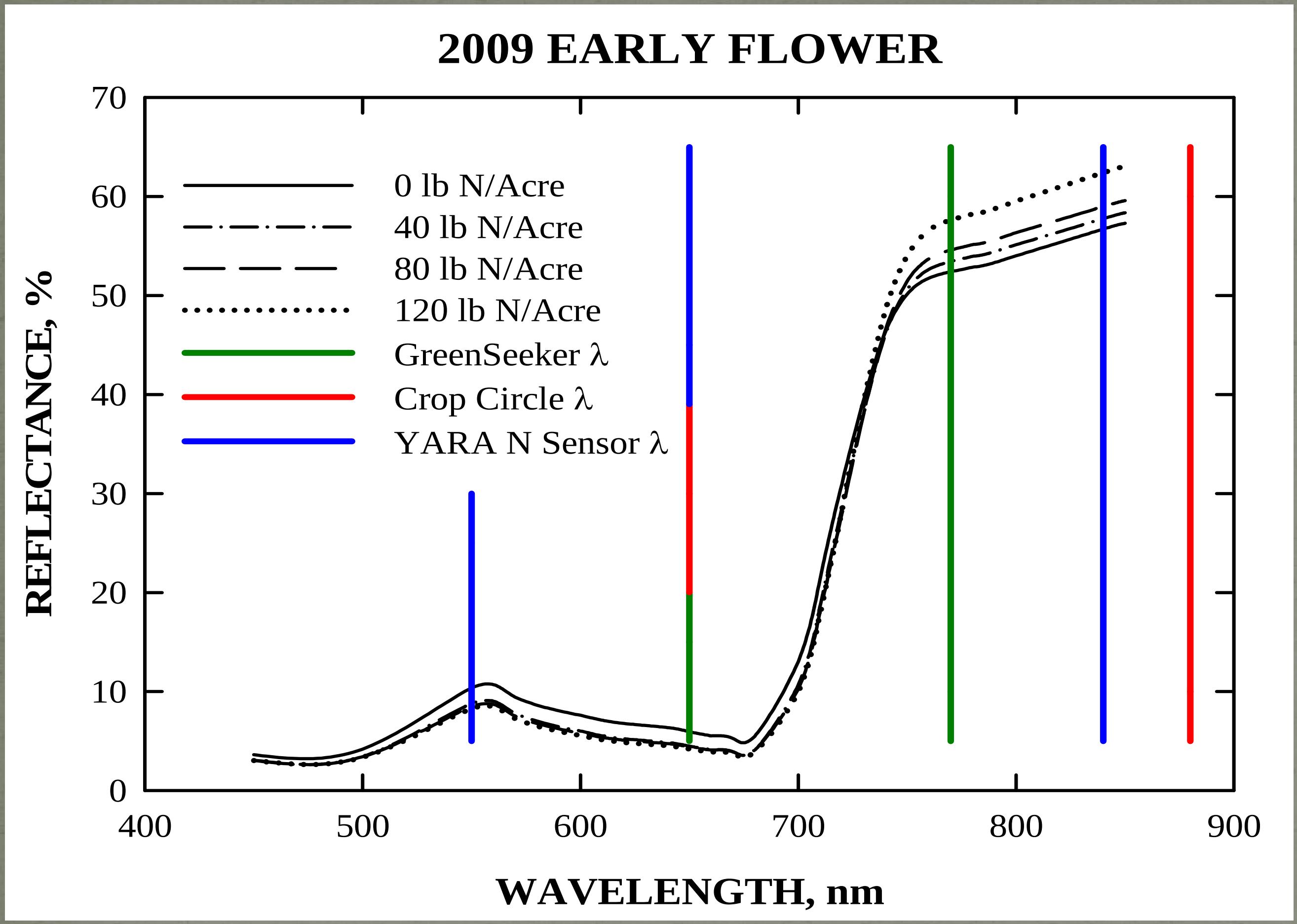
Theoretical Basis for Using Crop Reflectance

- 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

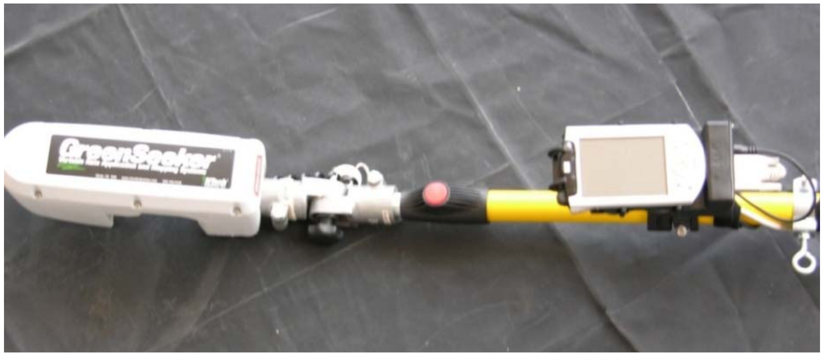


Representative crop reflectance in visible to NIR

Wavelengths used by different sensors indicated in color

Representative cotton canopy reflectance by N rate

Greenseeker 650 nm 770 nm

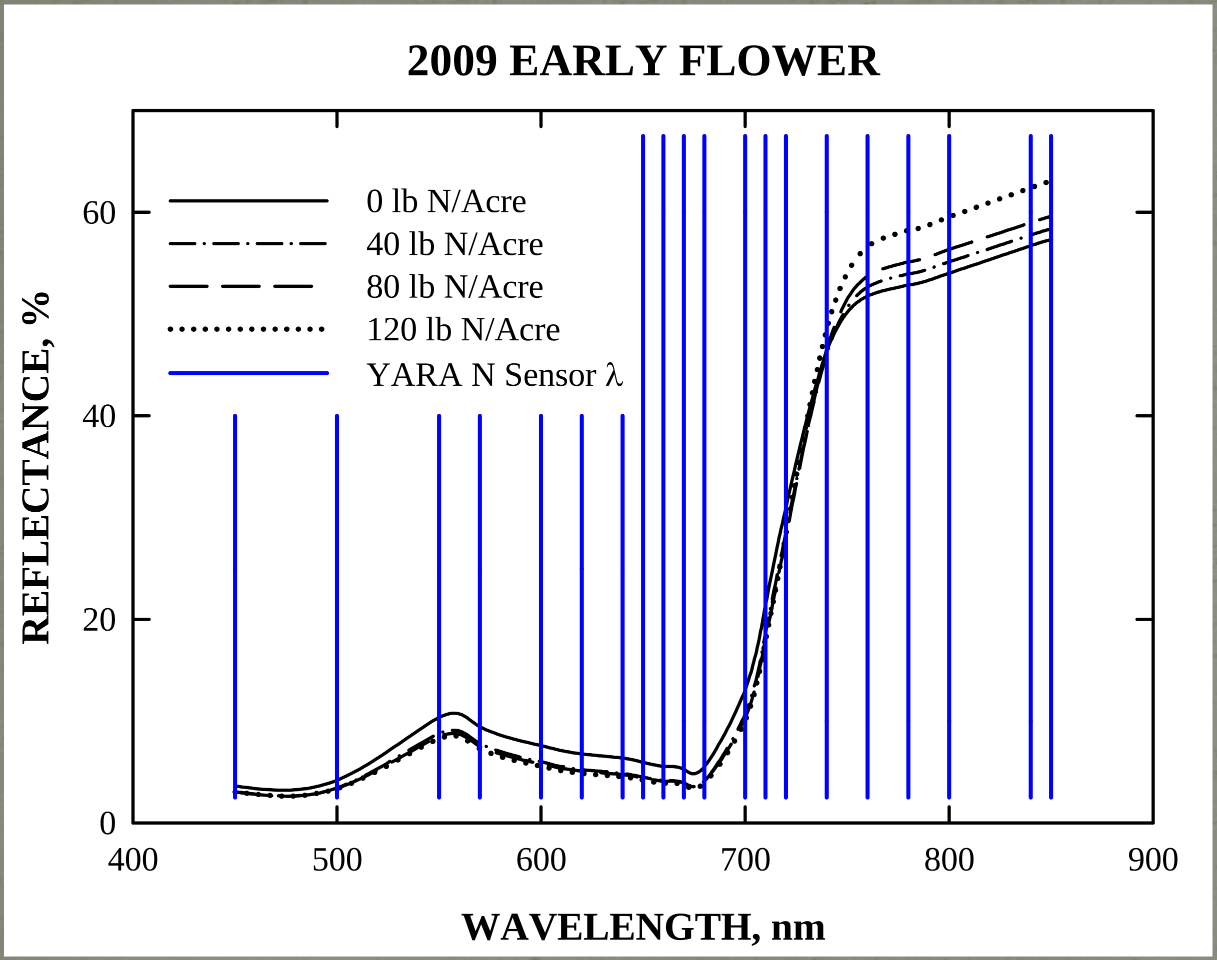


Crop Circle 650 nm 880 nm

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

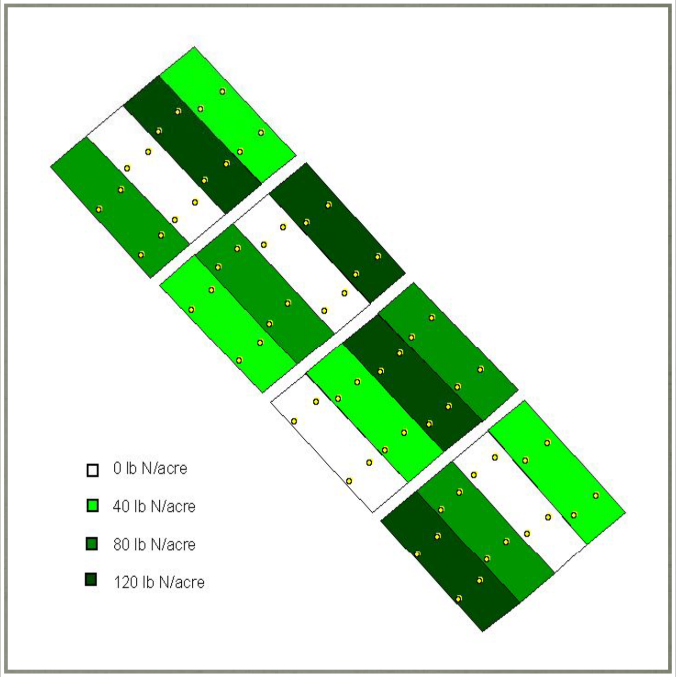
METHODS

- 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.)

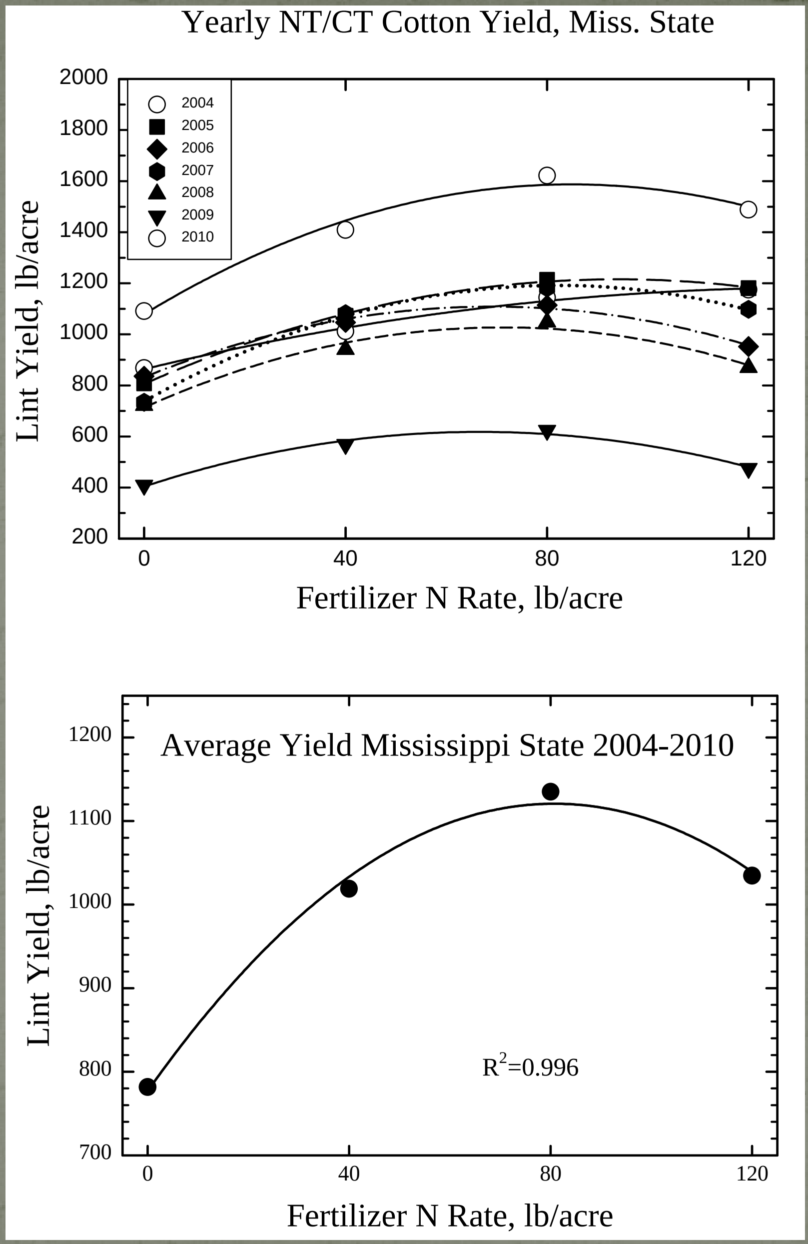
- Treatments
  - 0, 40, 80, and 120 lb N/acre
    - Planting (50%)
    - Early square (50%)
- Cultural practices
  - No-till/CT on beds
  - DPL BG/RR 445, 2010 DPL 1028
  - No growth regulator applied
  - Weed and insect control according to recommendations

Aug. 4, 2010 Late Flowering

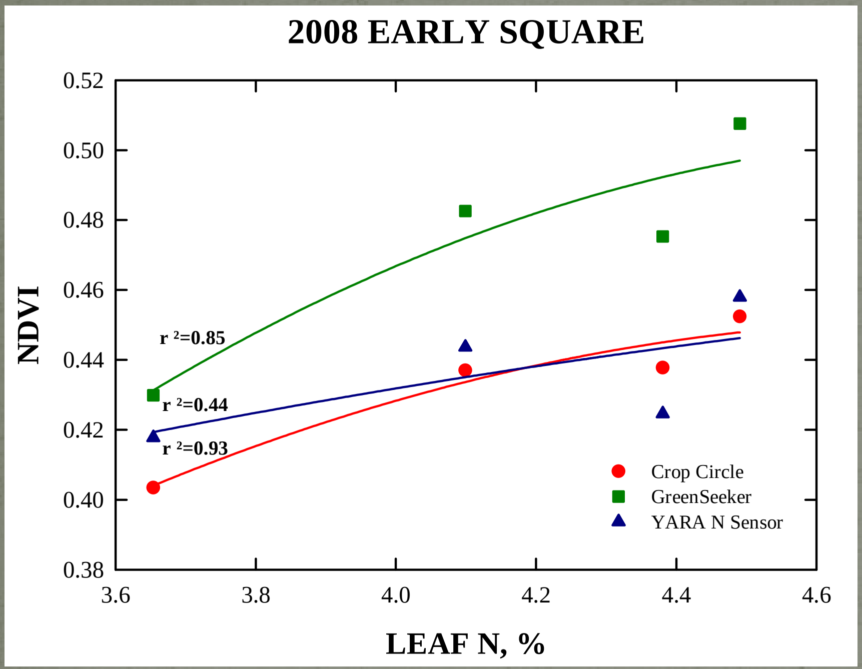


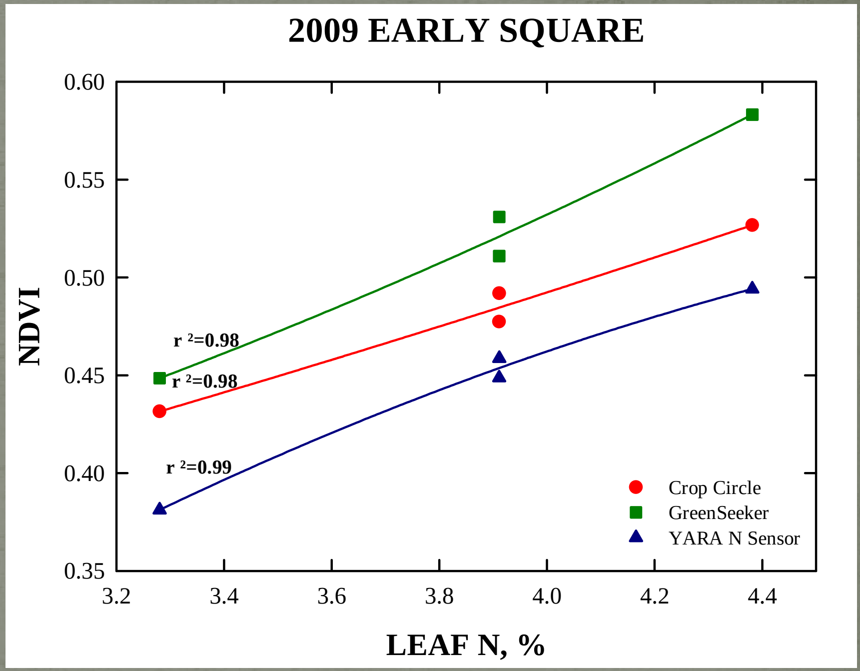
Crop Response to Fertilizer N

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

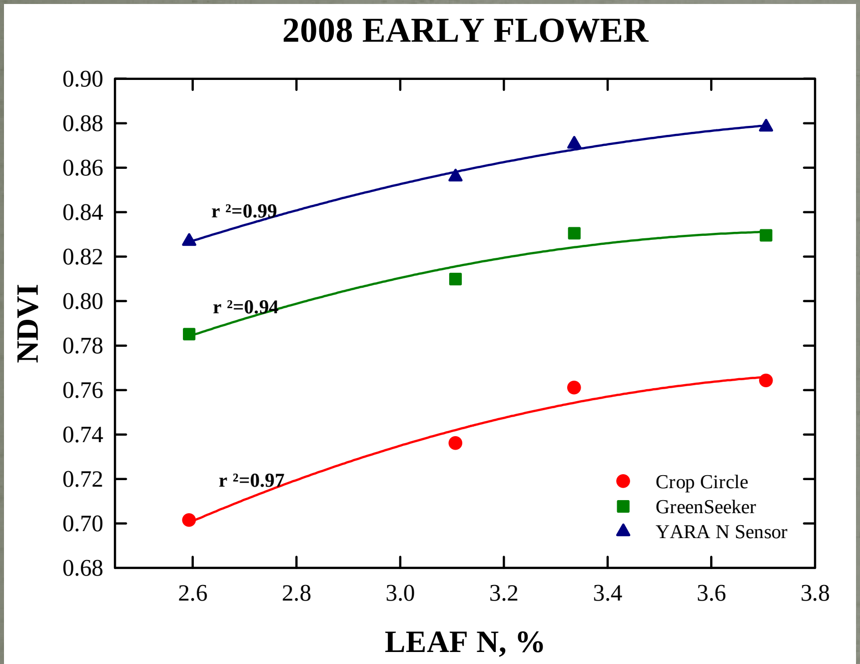


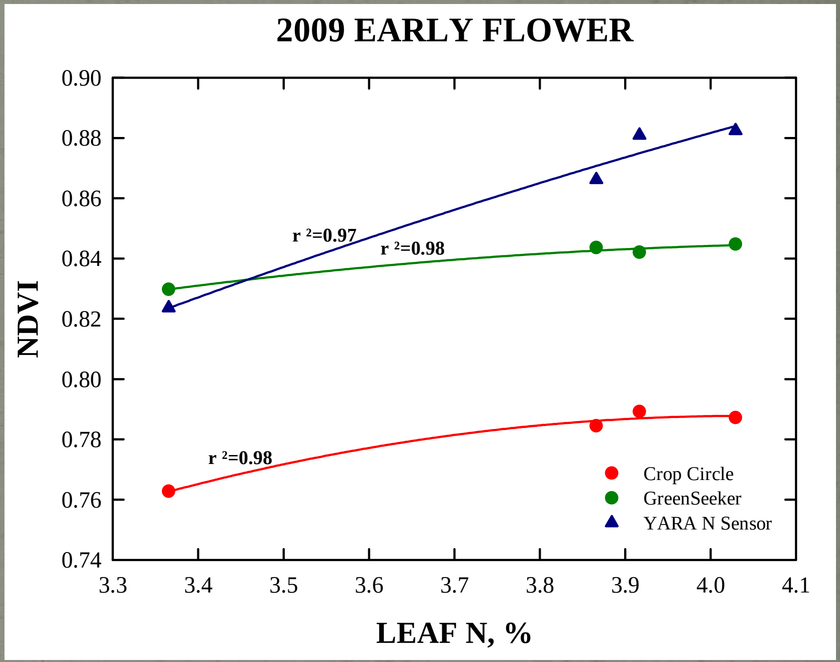
Sensor Comparison Leaf N



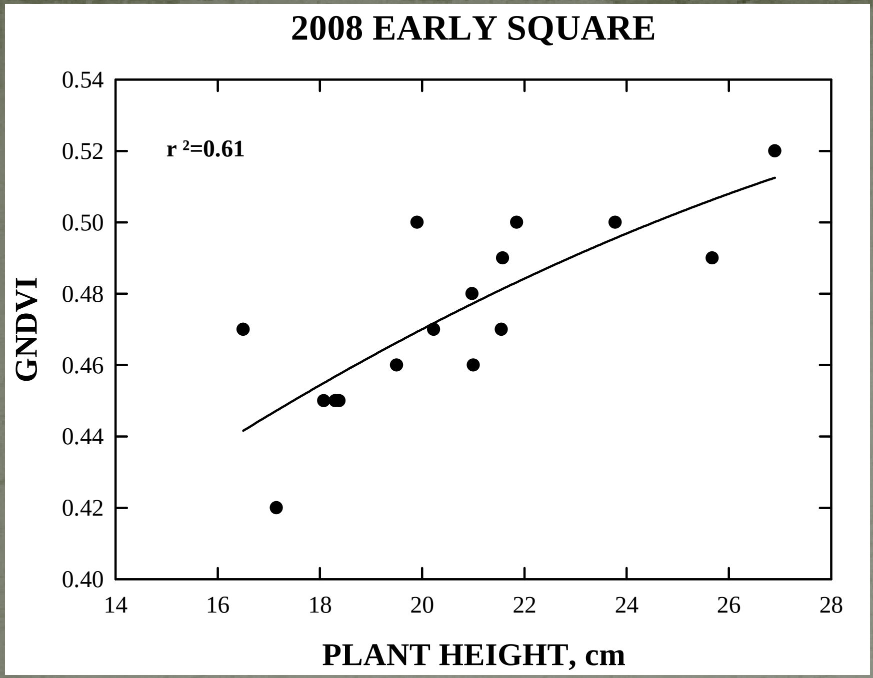


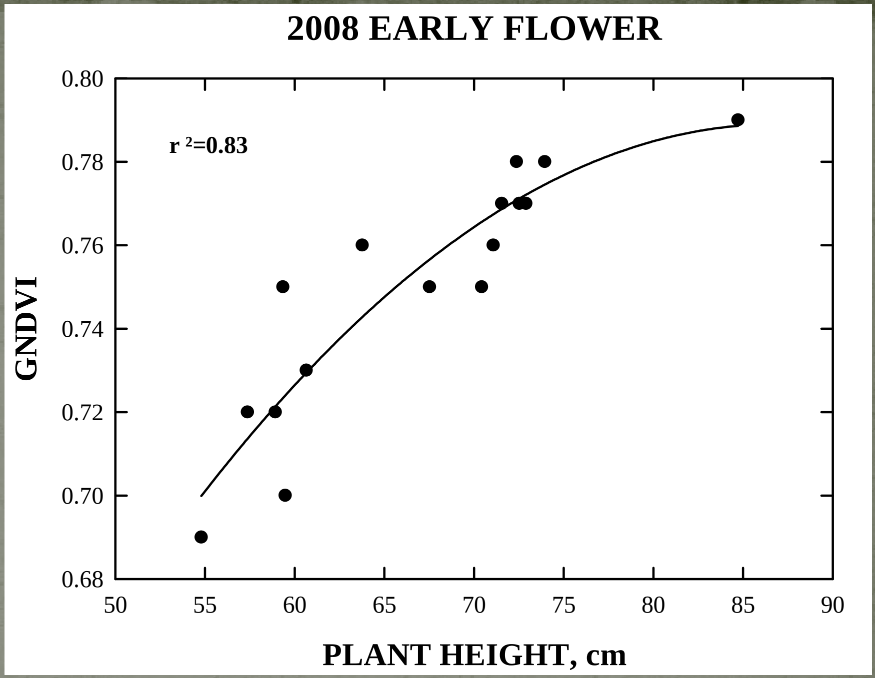
Sensor Comparison-Leaf N

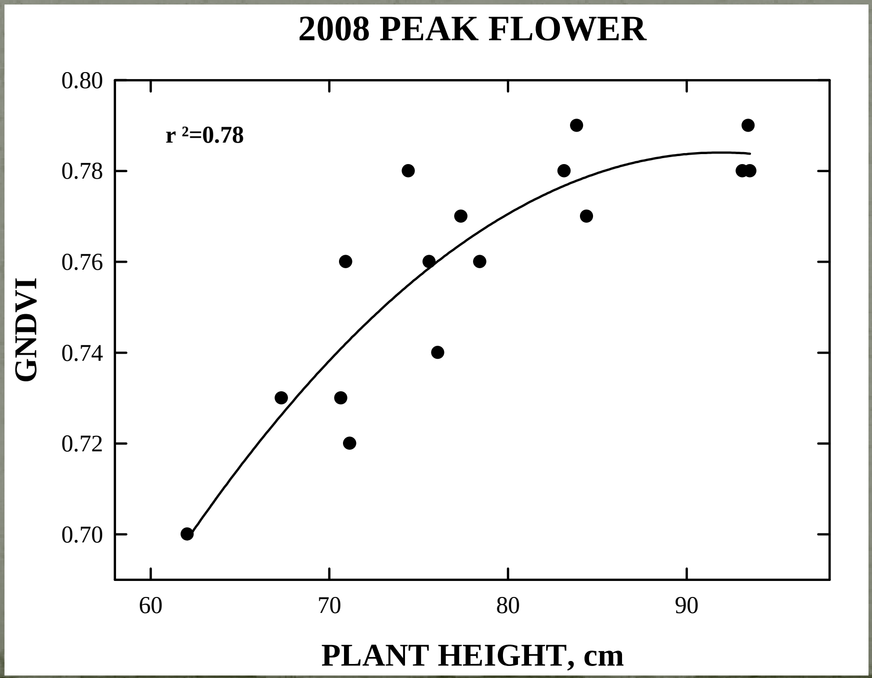


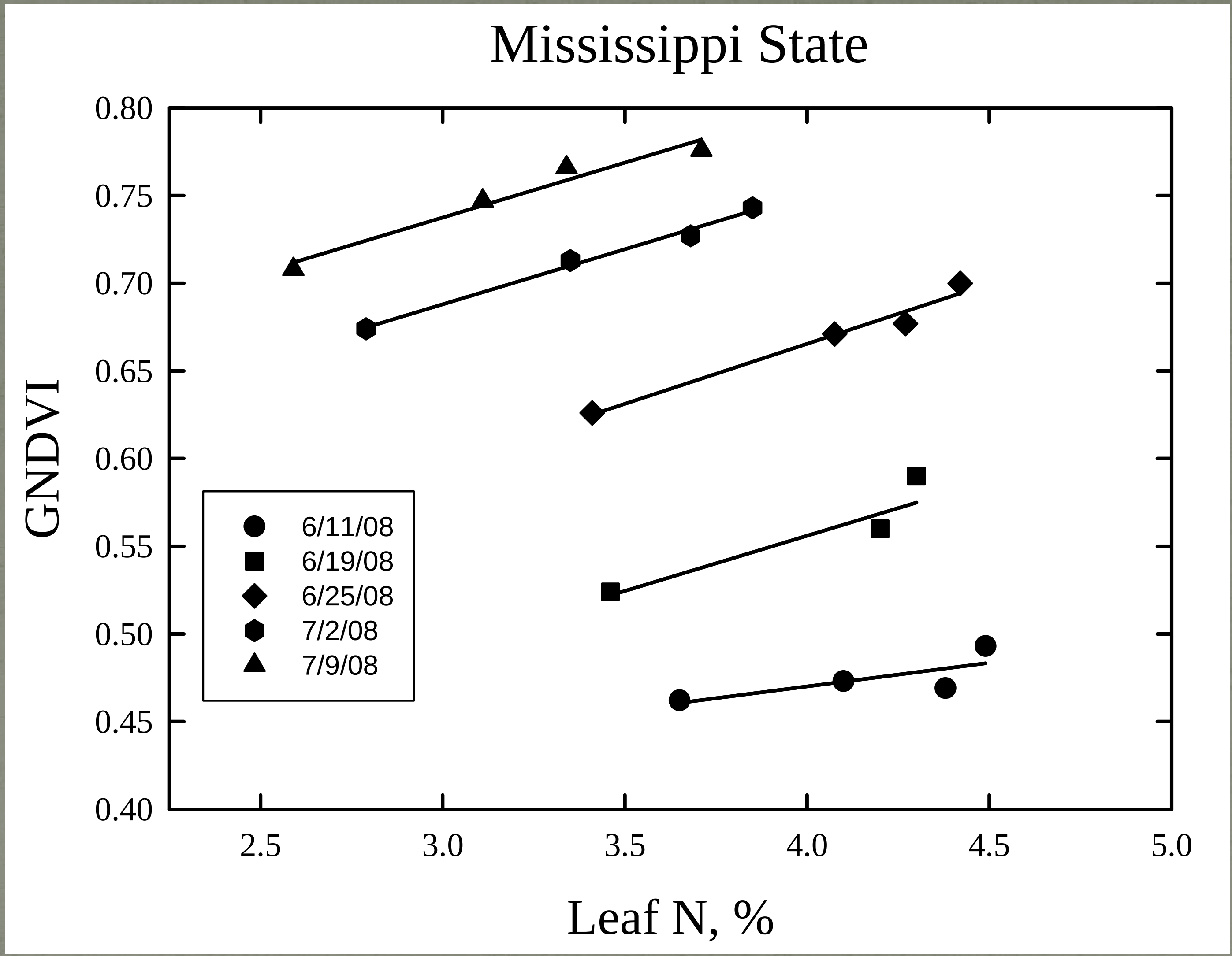


What are we seeing?

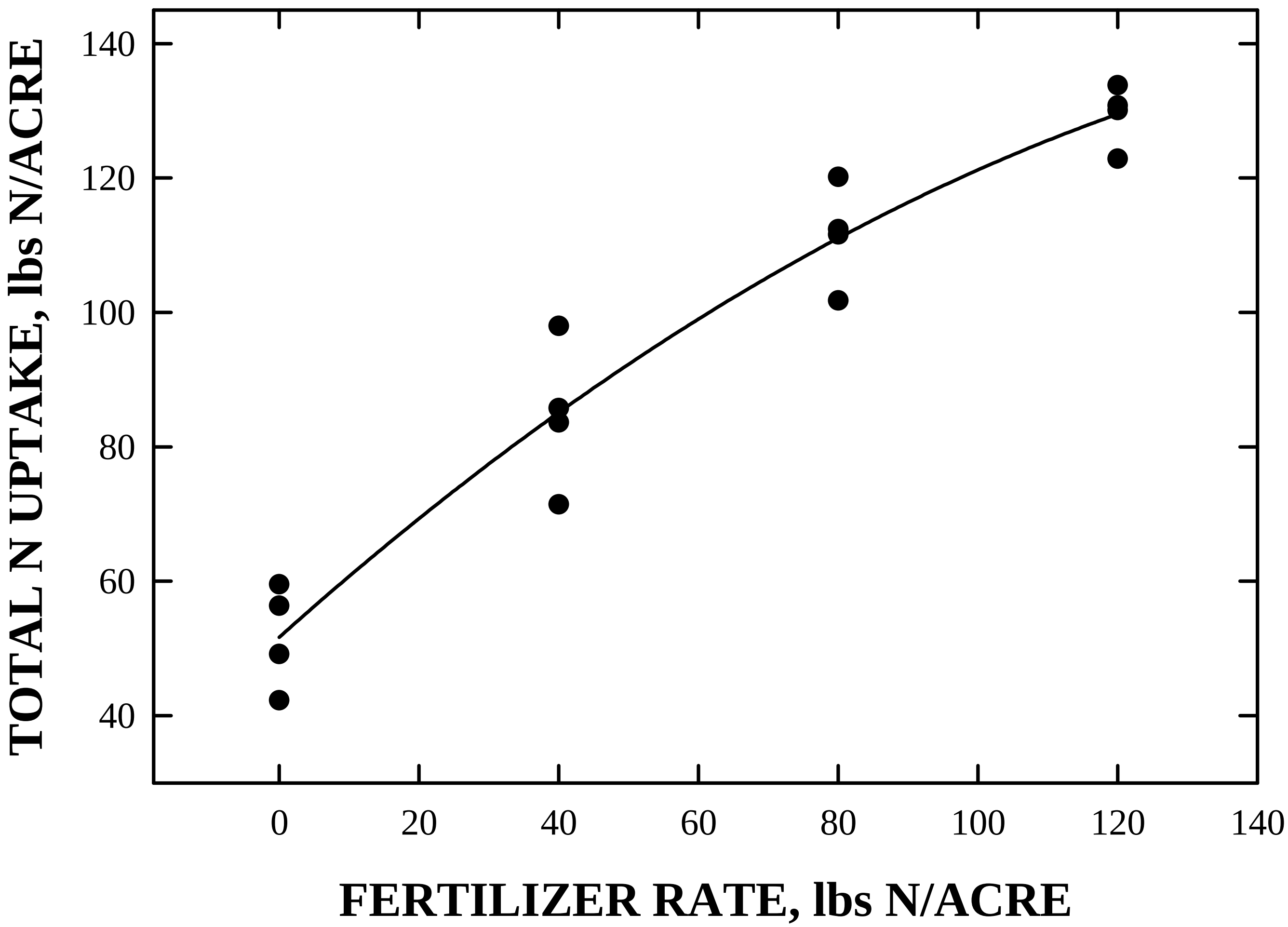

2008 EARLY SQUARE
r ²=0.61
GNDVI
0.54
0.52
0.50
0.48
0.46
0.44
0.42
0.40
14
16
18
20
22
24
26
28
PLANT HEIGHT, cm

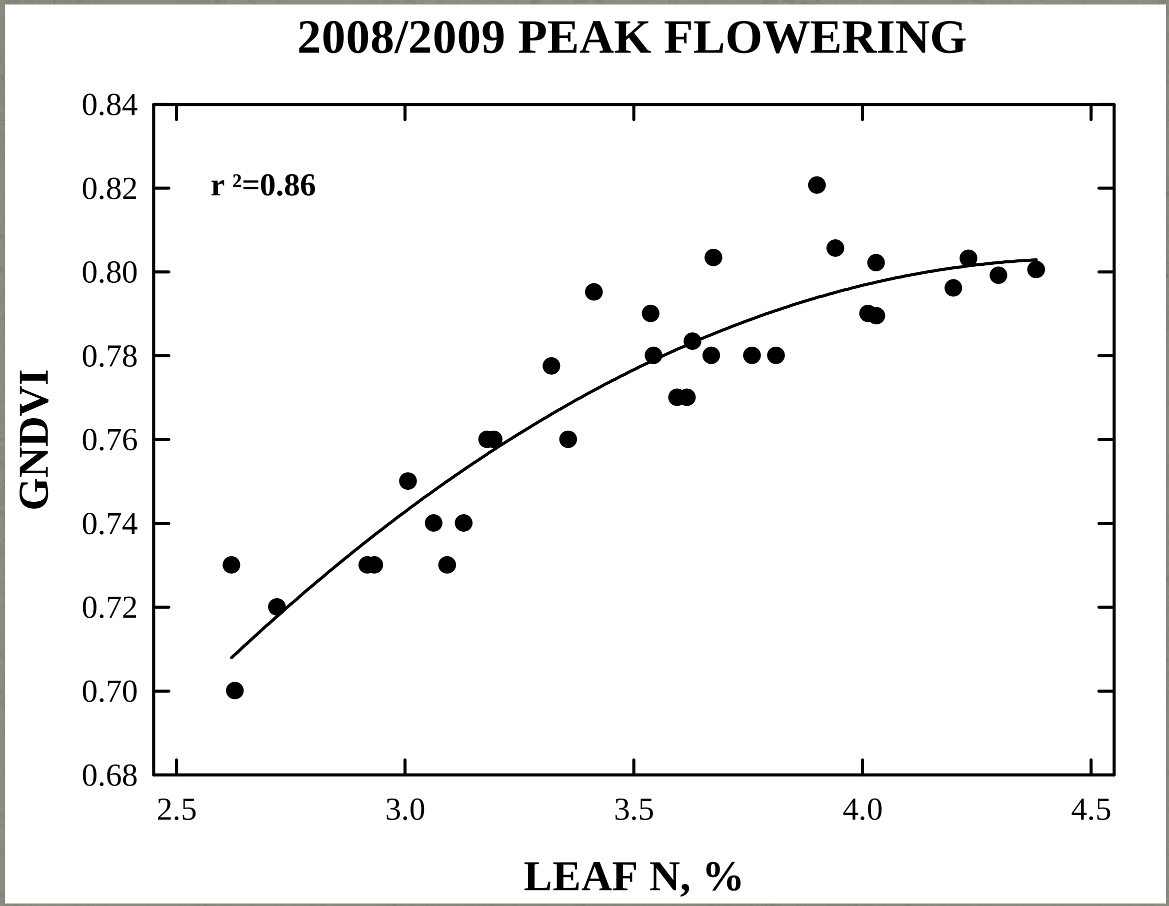

2008 EARLY FLOWER
r ²=0.83
GNDVI
0.80
0.78
0.76
0.74
0.72
0.70
0.68
50
55
60
65
70
75
80
85
90
PLANT HEIGHT, cm


2008 PEAK FLOWER
r ²=0.78
GNDVI
0.80
0.78
0.76
0.74
0.72
0.70
60
70
80
90
PLANT HEIGHT, cm


Mississippi State
GNDVI
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
2.5
3.0
3.5
4.0
4.5
5.0
Leaf N, %
6/11/08
6/19/08
6/25/08
7/2/08
7/9/08

2008 SEASON N UPTAKE

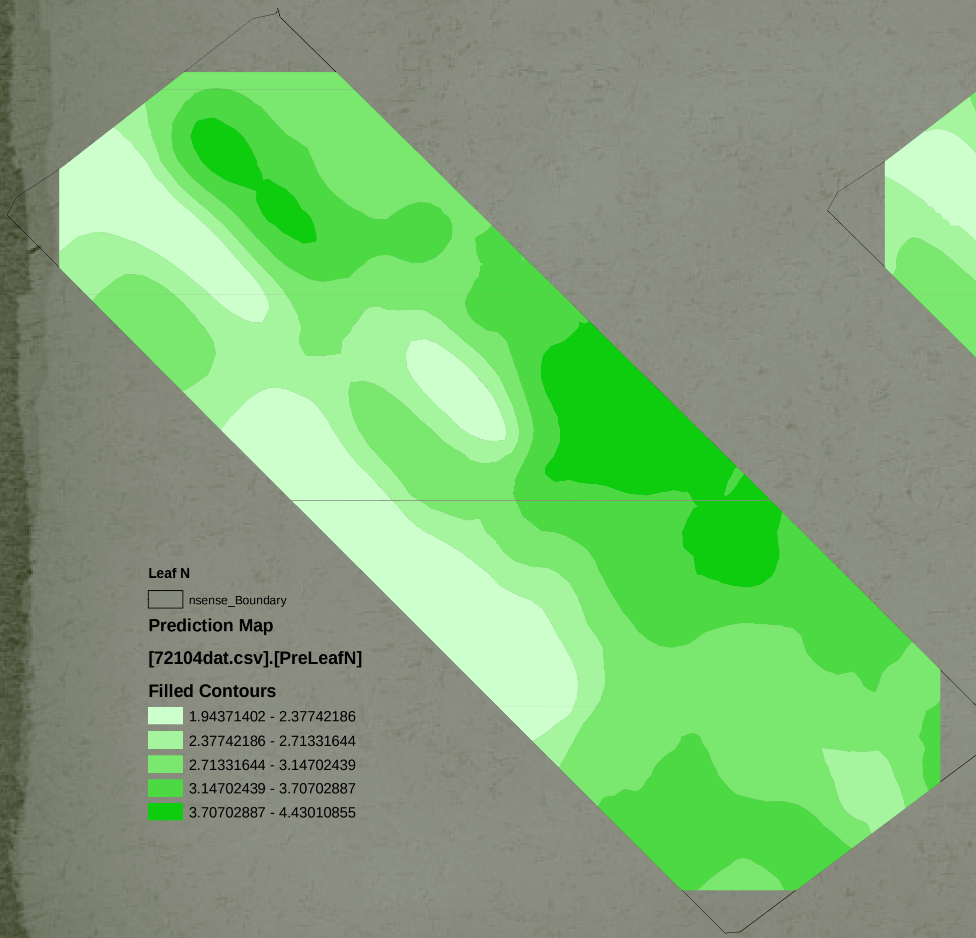


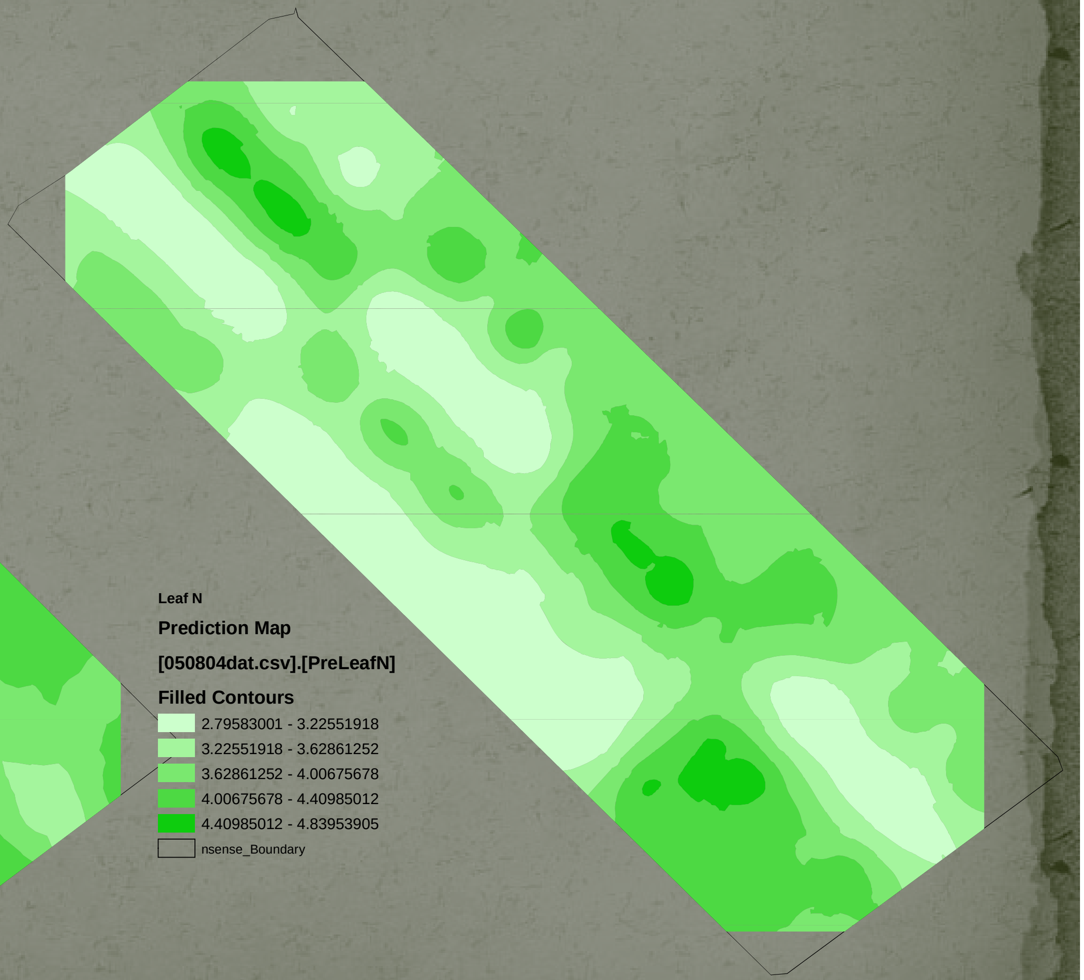

2008/2009 PEAK FLOWERING
r ²=0.86
GNDVI
0.84
0.82
0.80
0.78
0.76
0.74
0.72
0.70
0.68
2.5
3.0
3.5
4.0
4.5
LEAF N, %

Predicted Leaf N Map @ Peak Flowering

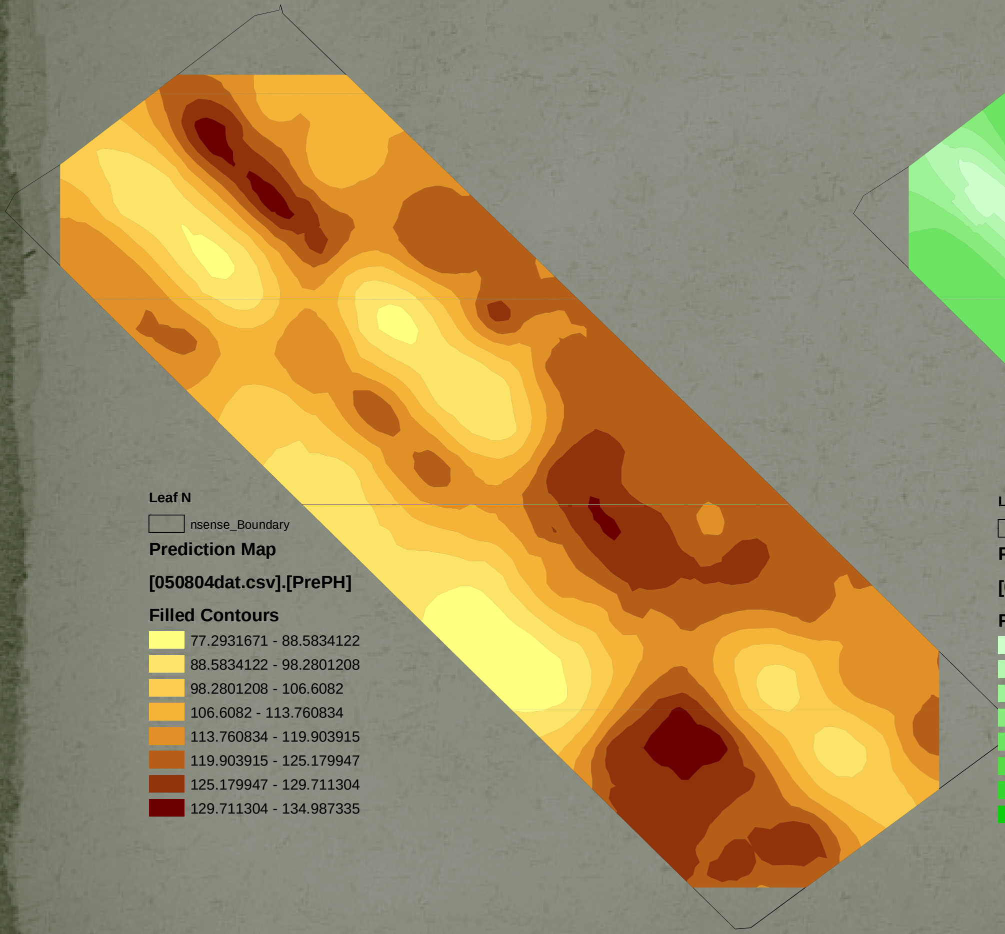
7/21/2004

8/04/2005

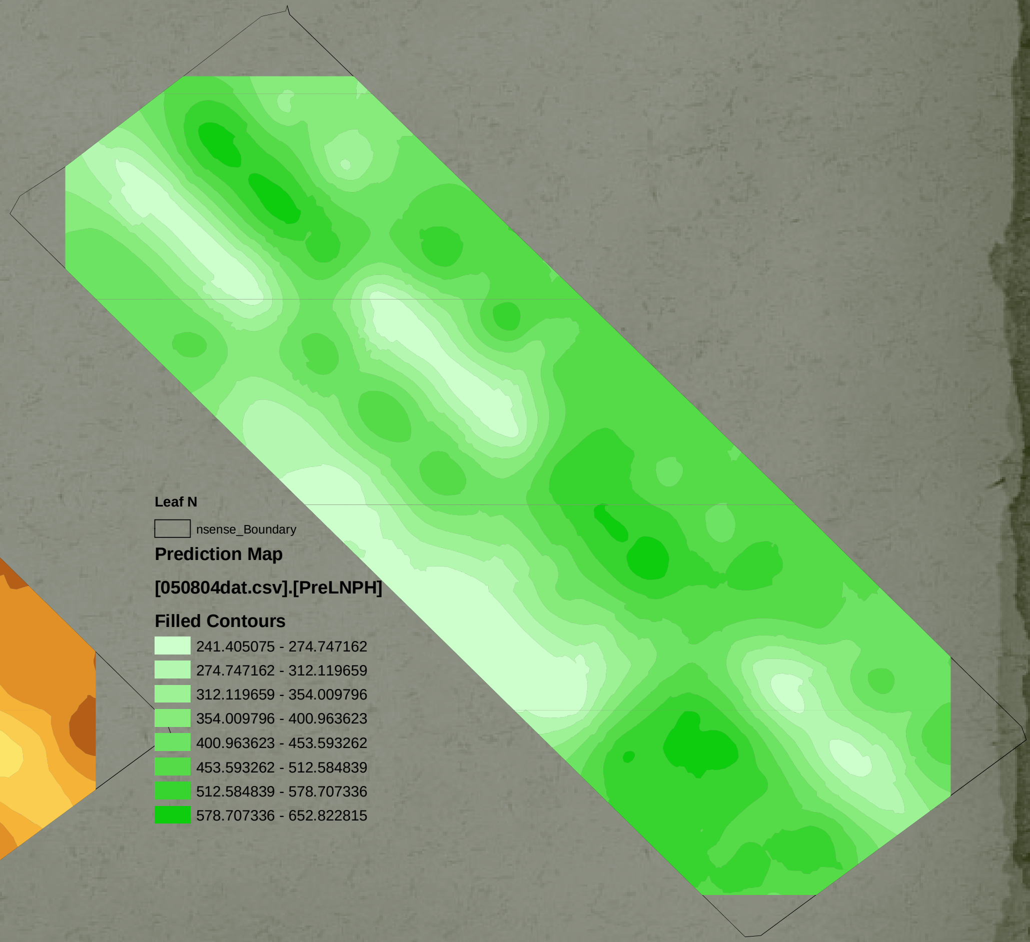




Predicted Plant Height 8/04/2005

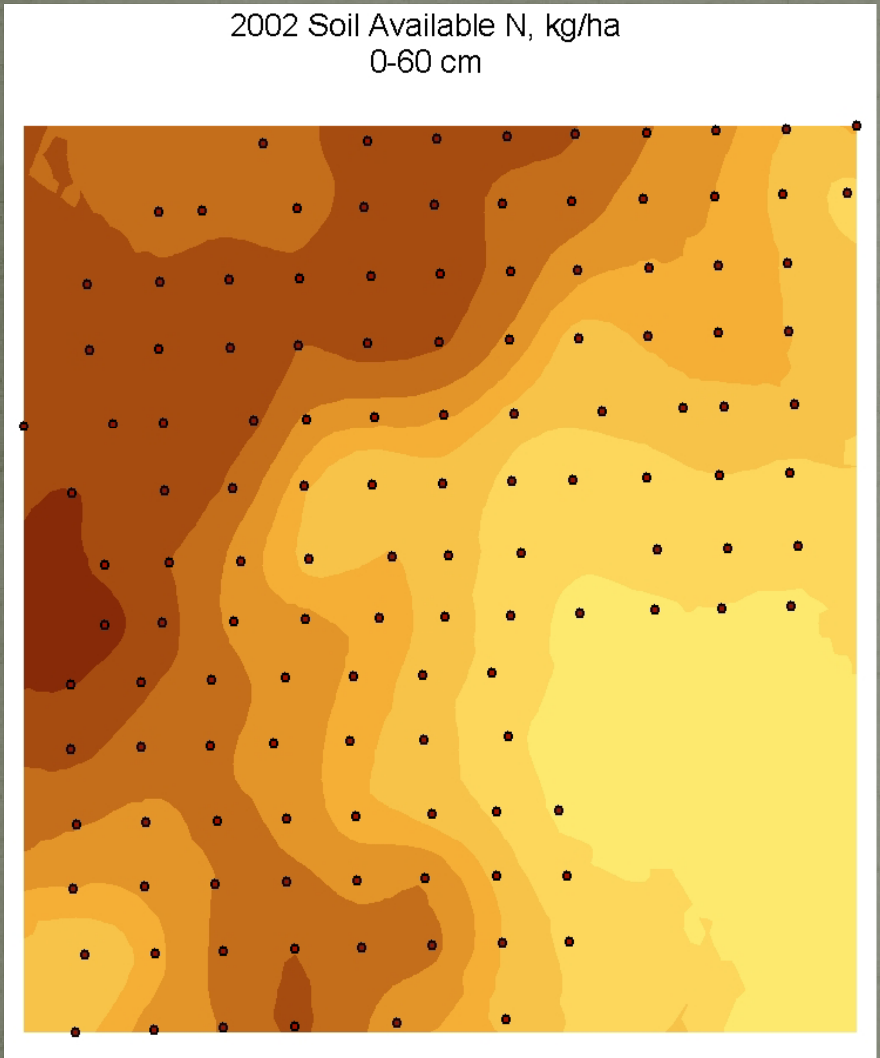


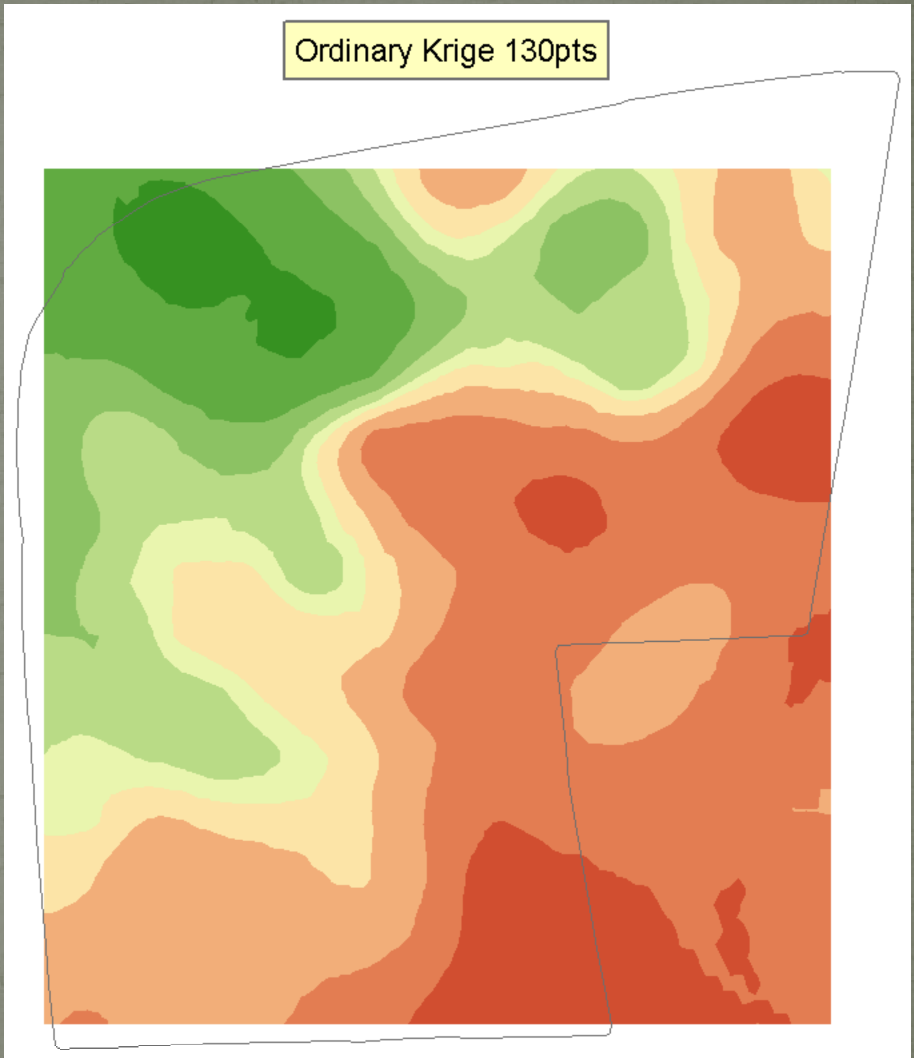
Predicted N Biomass Index 8/04/2005



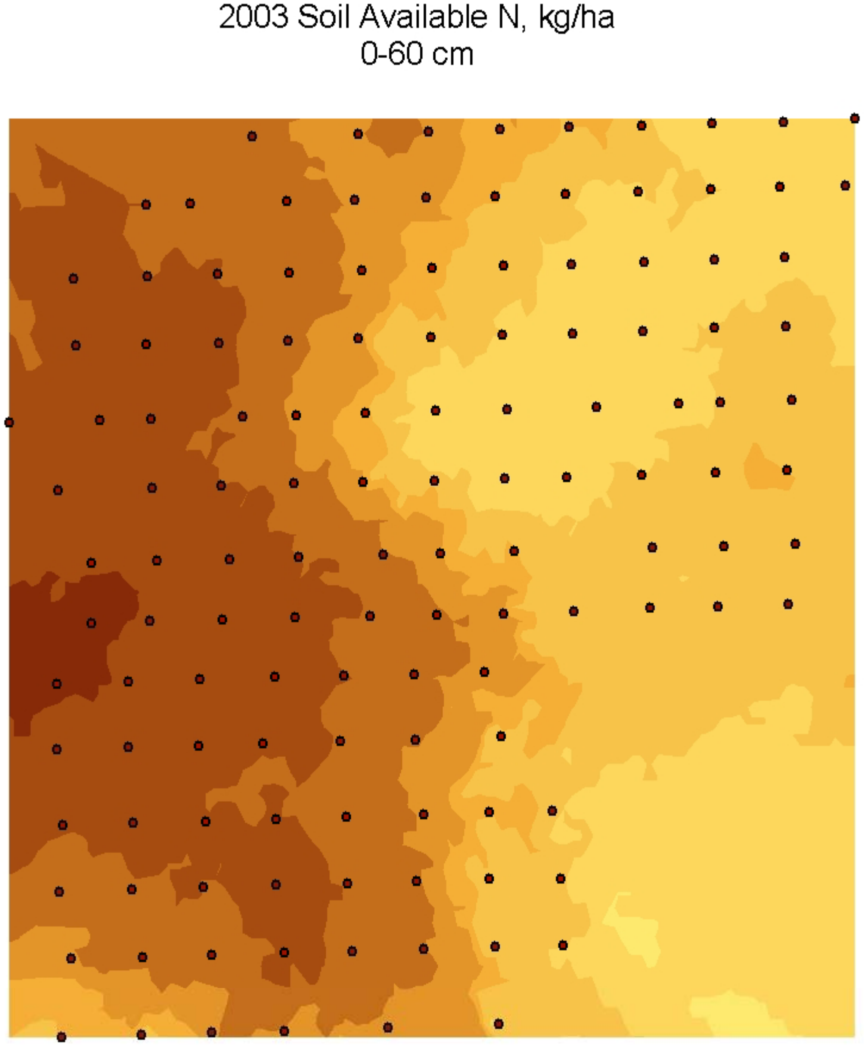
Spatial and temporal detection of N biomass

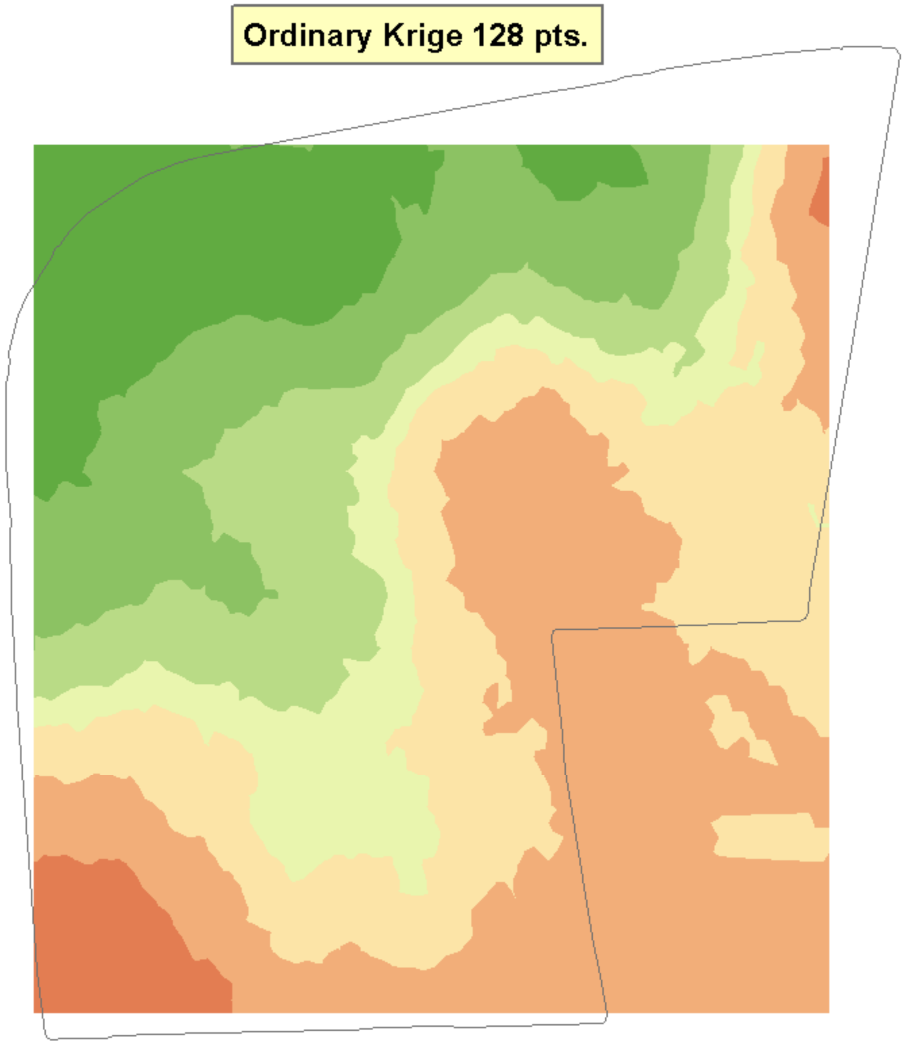
Cotton Leaf N – Early Flowering 2002

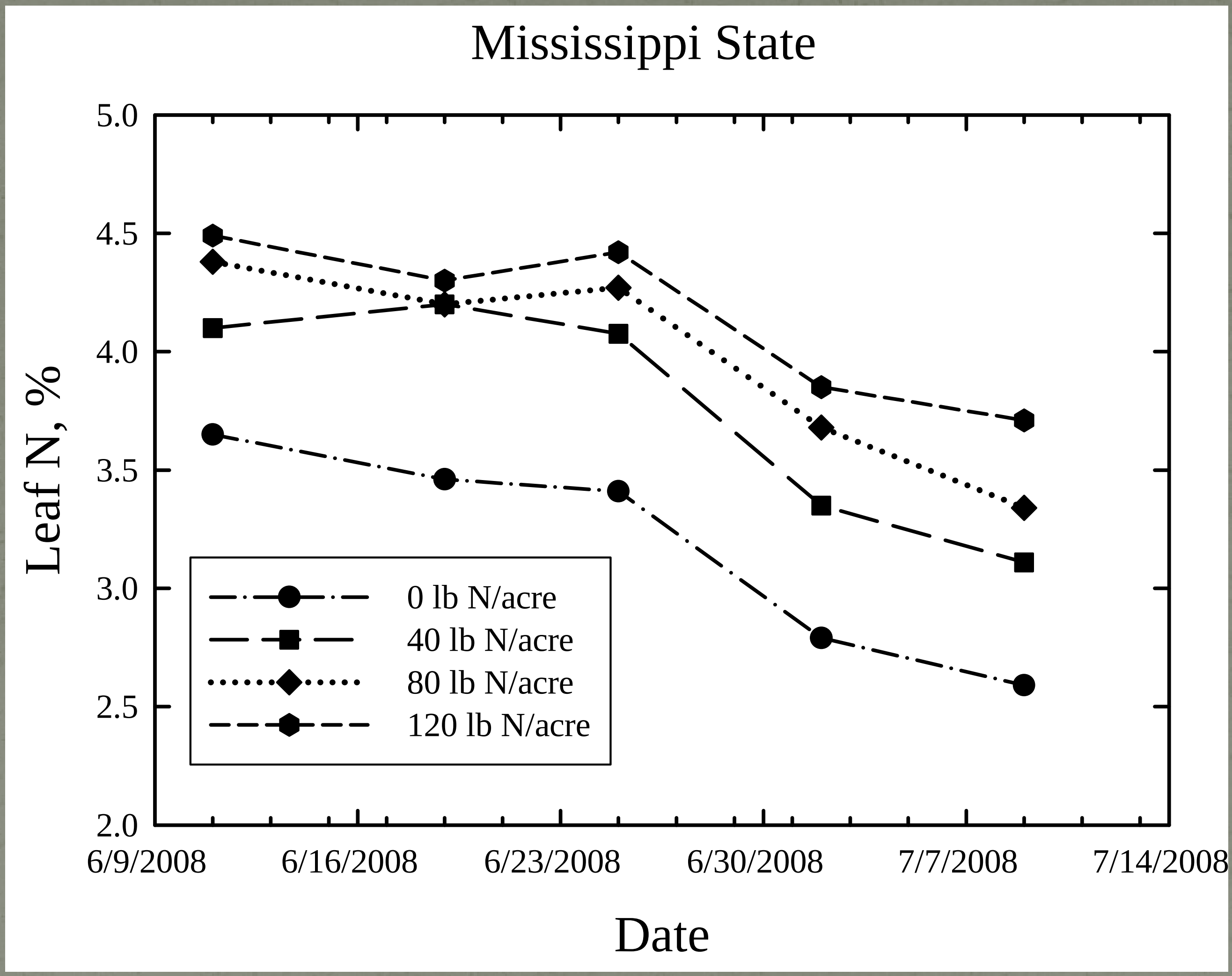




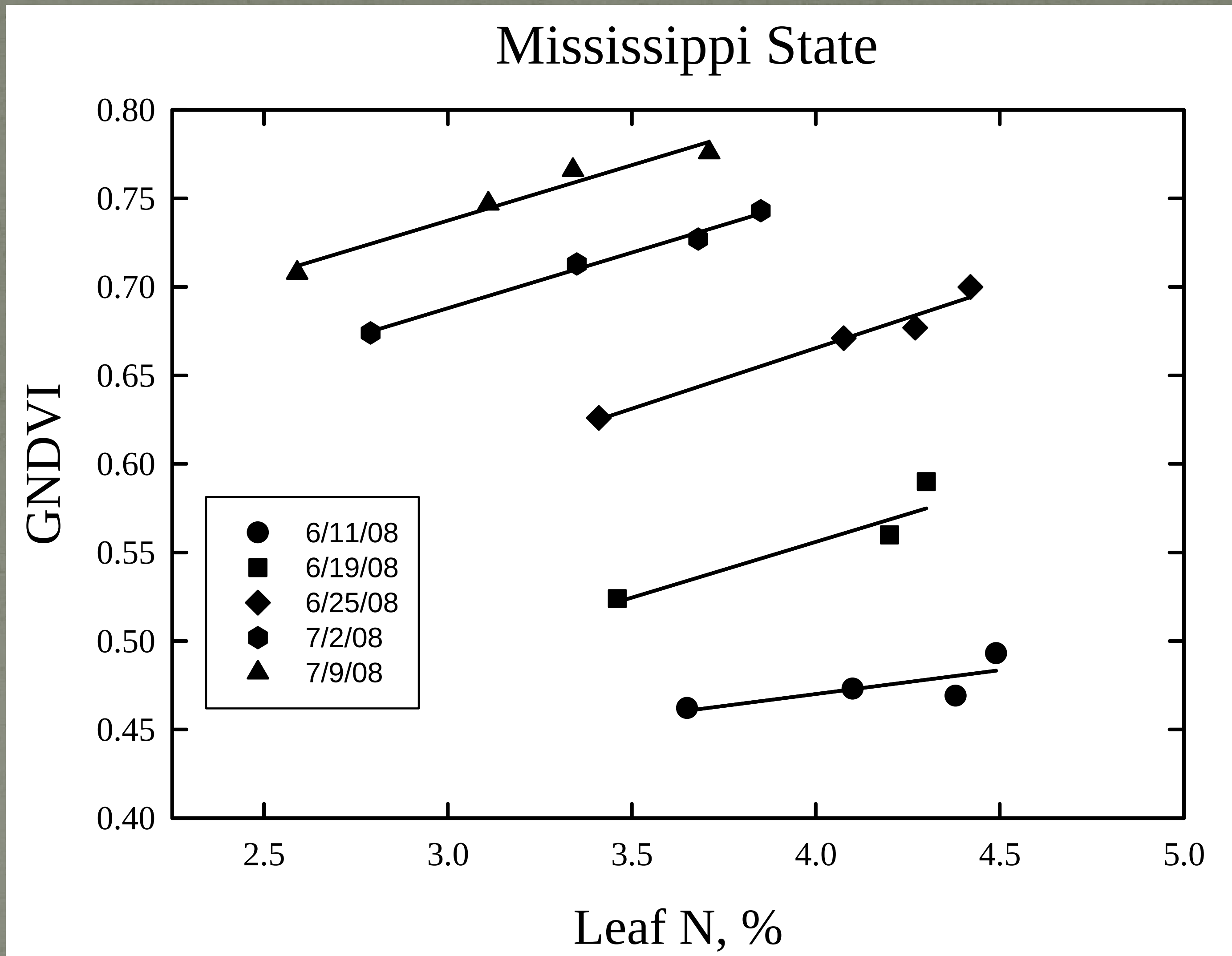
Cotton Leaf N – Early Flowering 2003







Mississippi State
5.0
4.5
4.0
3.5
3.0
2.5
2.0
Leaf N, %
6/9/2008
6/16/2008
6/23/2008
6/30/2008
7/7/2008
7/14/2008
Date
0 lb N/acre
40 lb N/acre
80 lb N/acre
120 lb N/acre



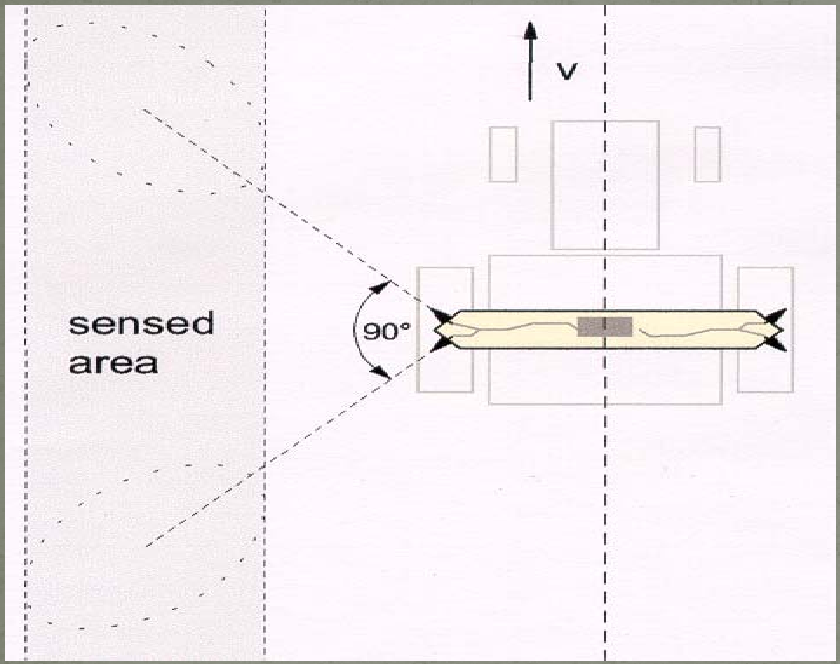
Mississippi State
GNDVI
Leaf N, %
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
2.5
3.0
3.5
4.0
4.5
5.0
6/11/08
6/19/08
6/25/08
7/2/08
7/9/08

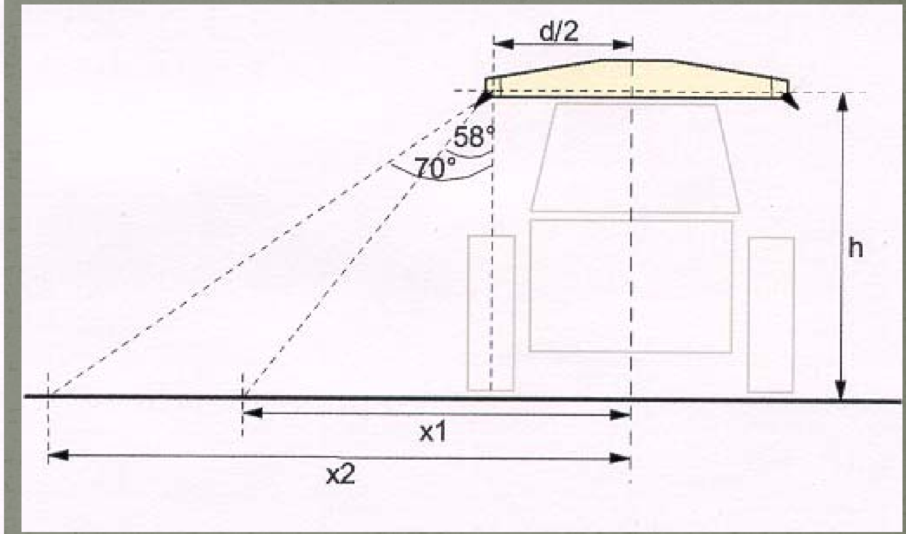
On-The-Go Crop Reflectance

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 m^2/s
Positioning Data: Trimble Pro XR
Speed: 3.5 mph

Viewing Geometry

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

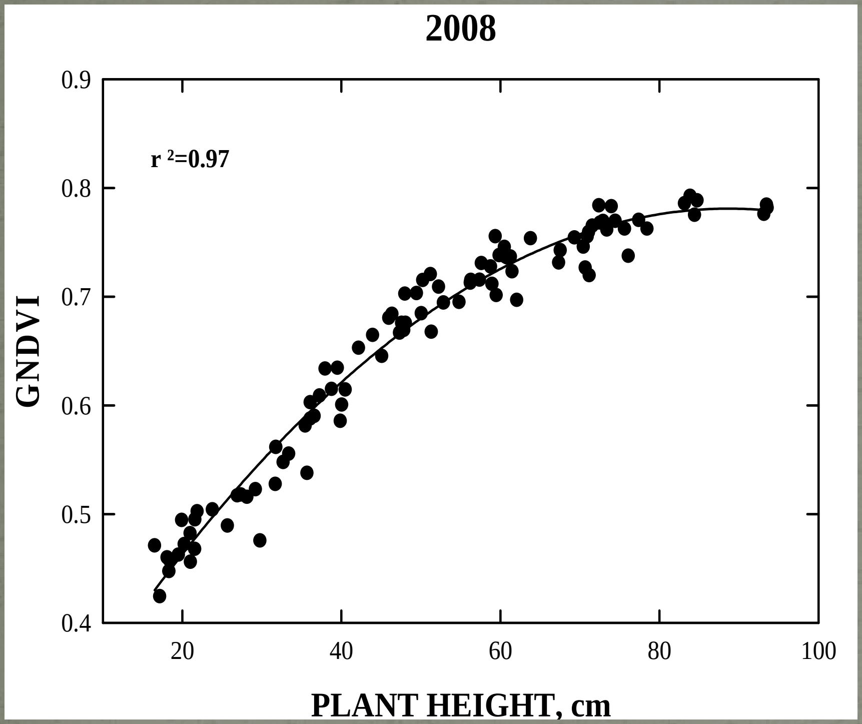


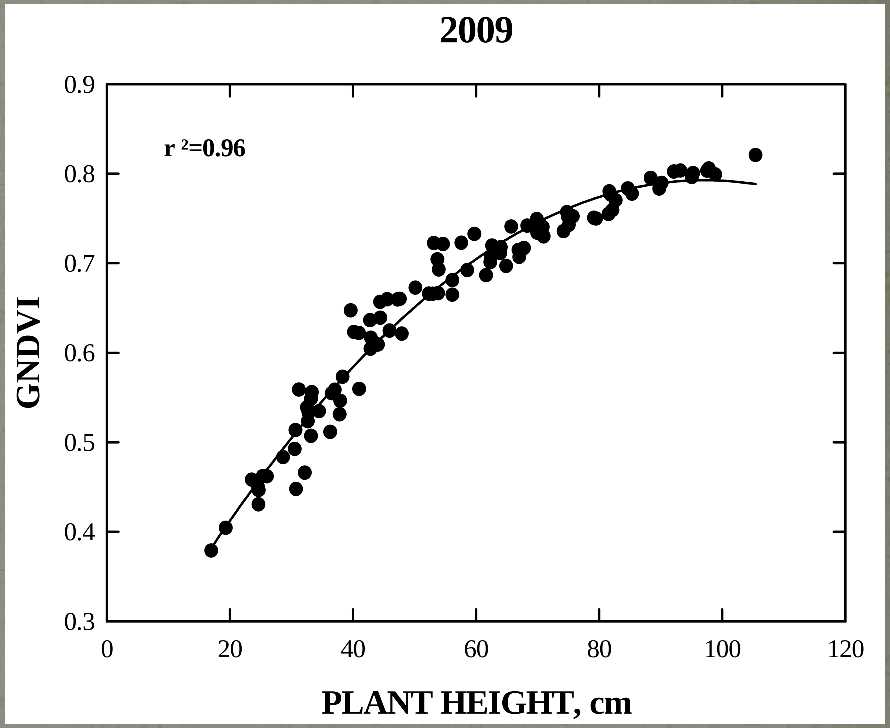


Source: YARA (Hydro Agri), tec5Hellma

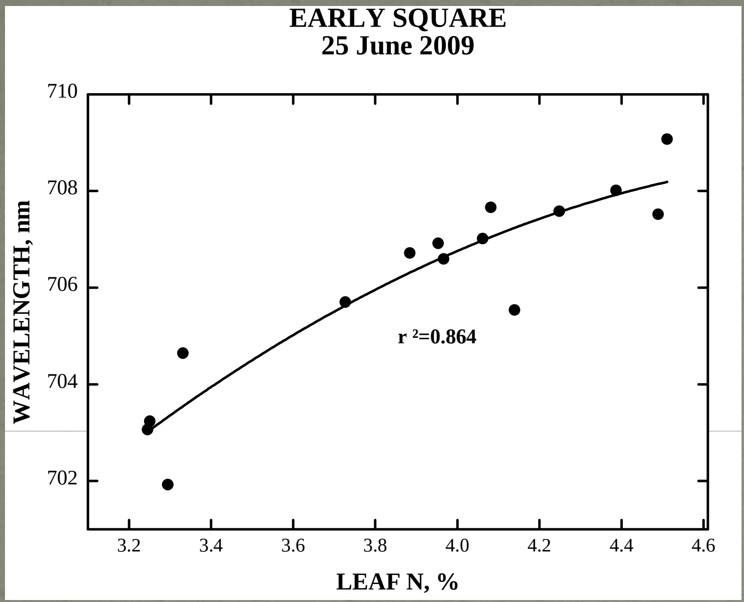
- Wavelengths - 550 (green), 650 (red), 700 (red edge), 710 (red edge), 840 (NIR)
- Currently also collecting 450, 500, 570, 600, 620, 640, 660, 670, 680, 720, 740, 760, 780, 800, and 850

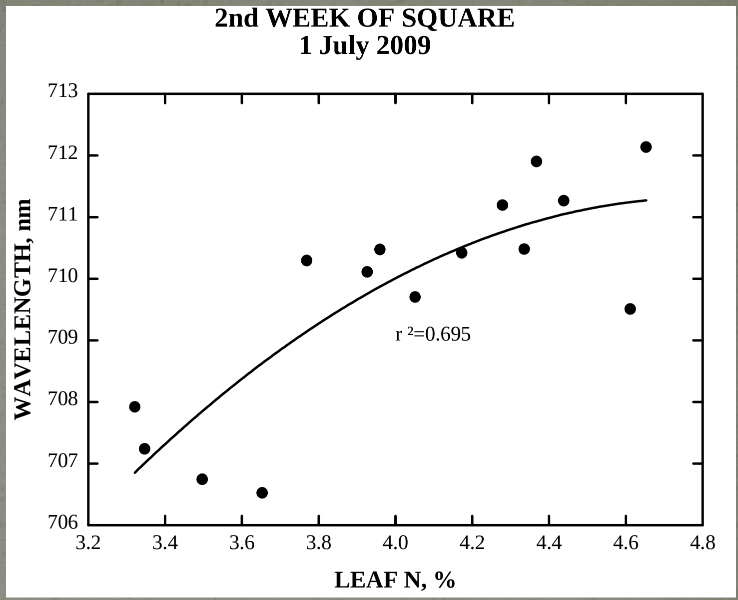
- Green Normalized Vegetation Index GNDVI = (NIR – Green)/(NIR + Green)
- Normalized Vegetation Index NDVI= (NIR – Red)/(NIR + red)

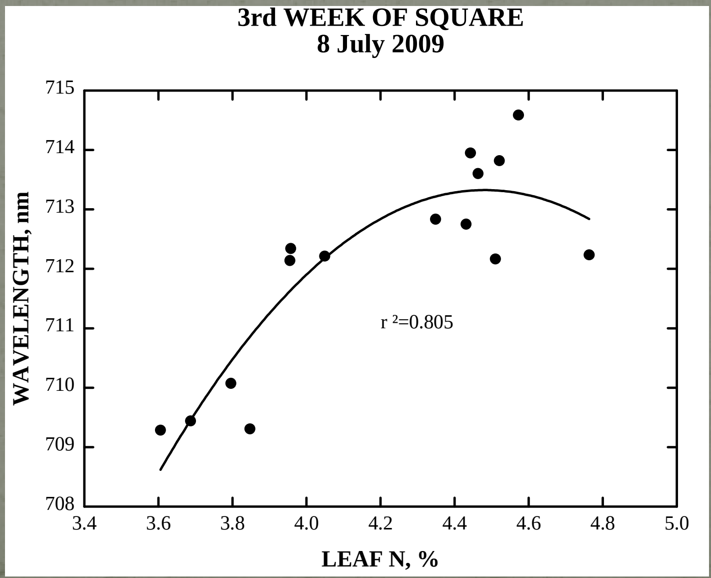

2008
r 2=0.97
GNDVI
PLANT HEIGHT, cm
0.4
0.5
0.6
0.7
0.8
0.9
20
40
60
80
100


2009
r 2=0.96
GNDVI
PLANT HEIGHT, cm
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
20
40
60
80
100
120

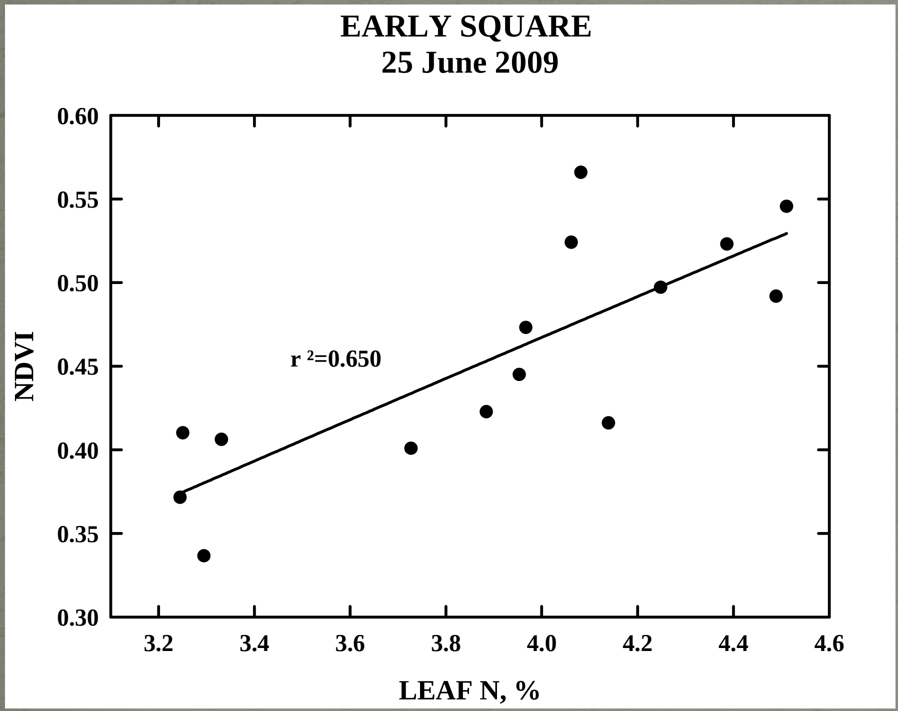
Relationships within Red-Edge Region

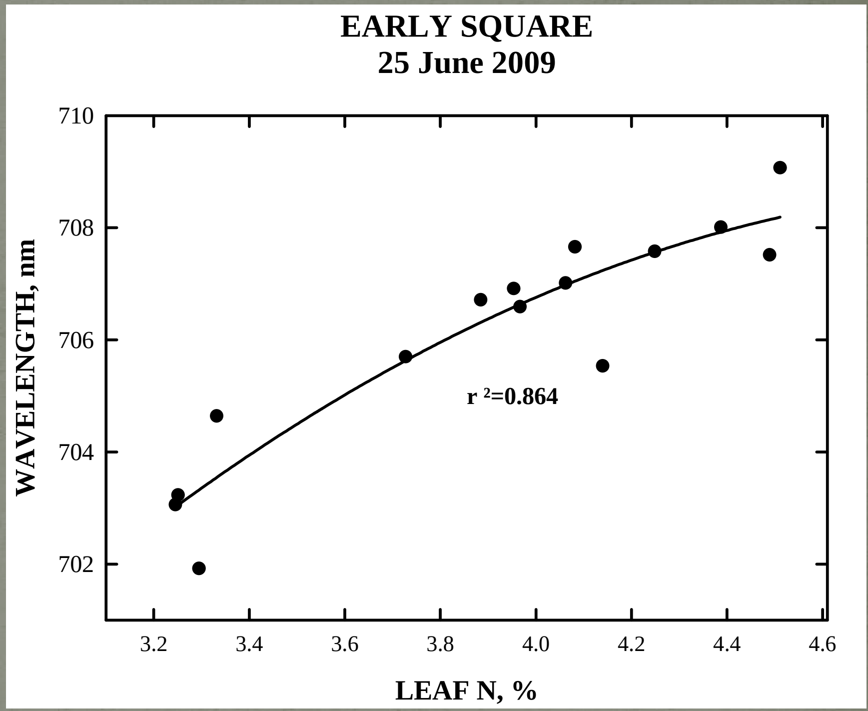




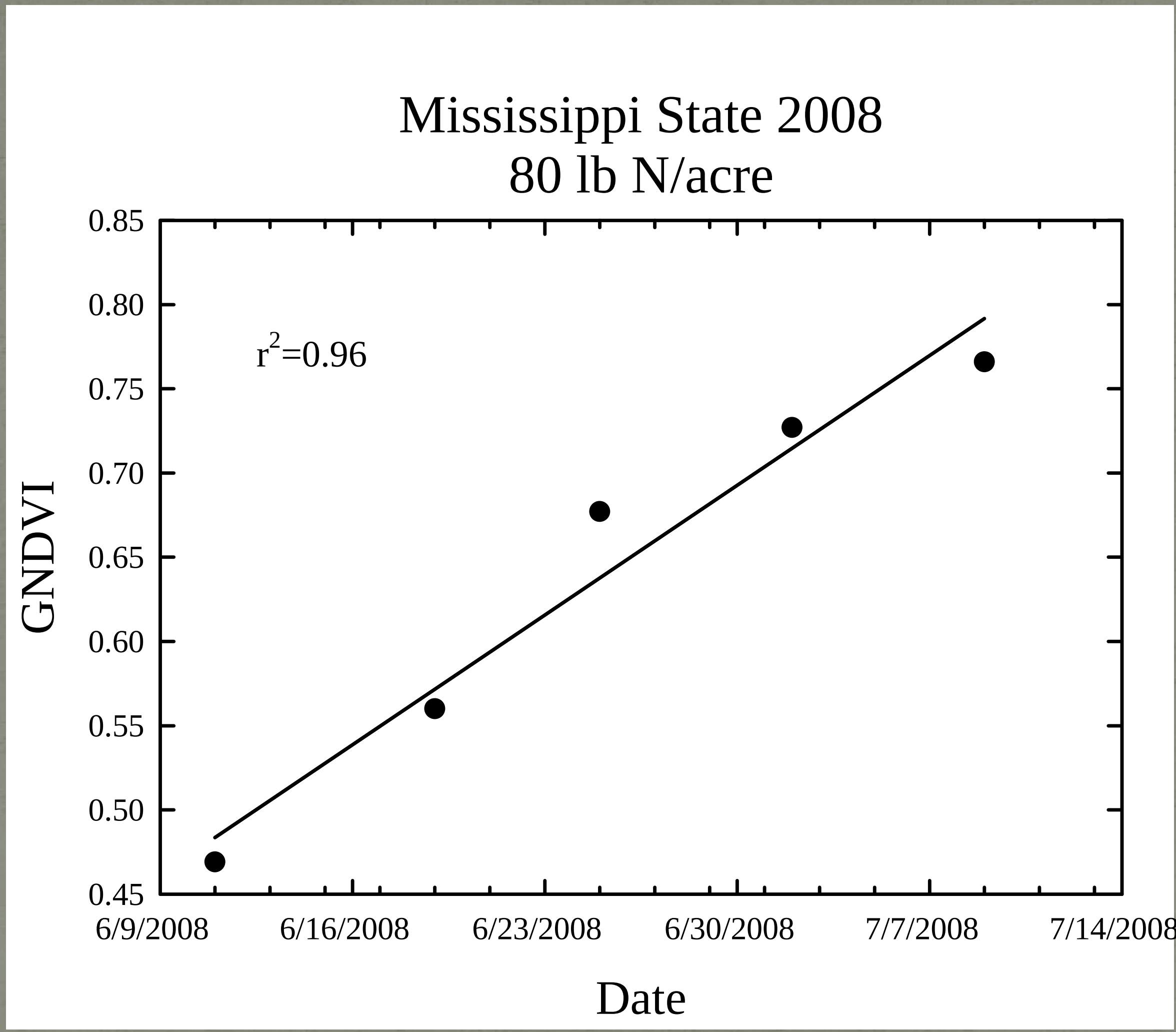


NDVI and REIP

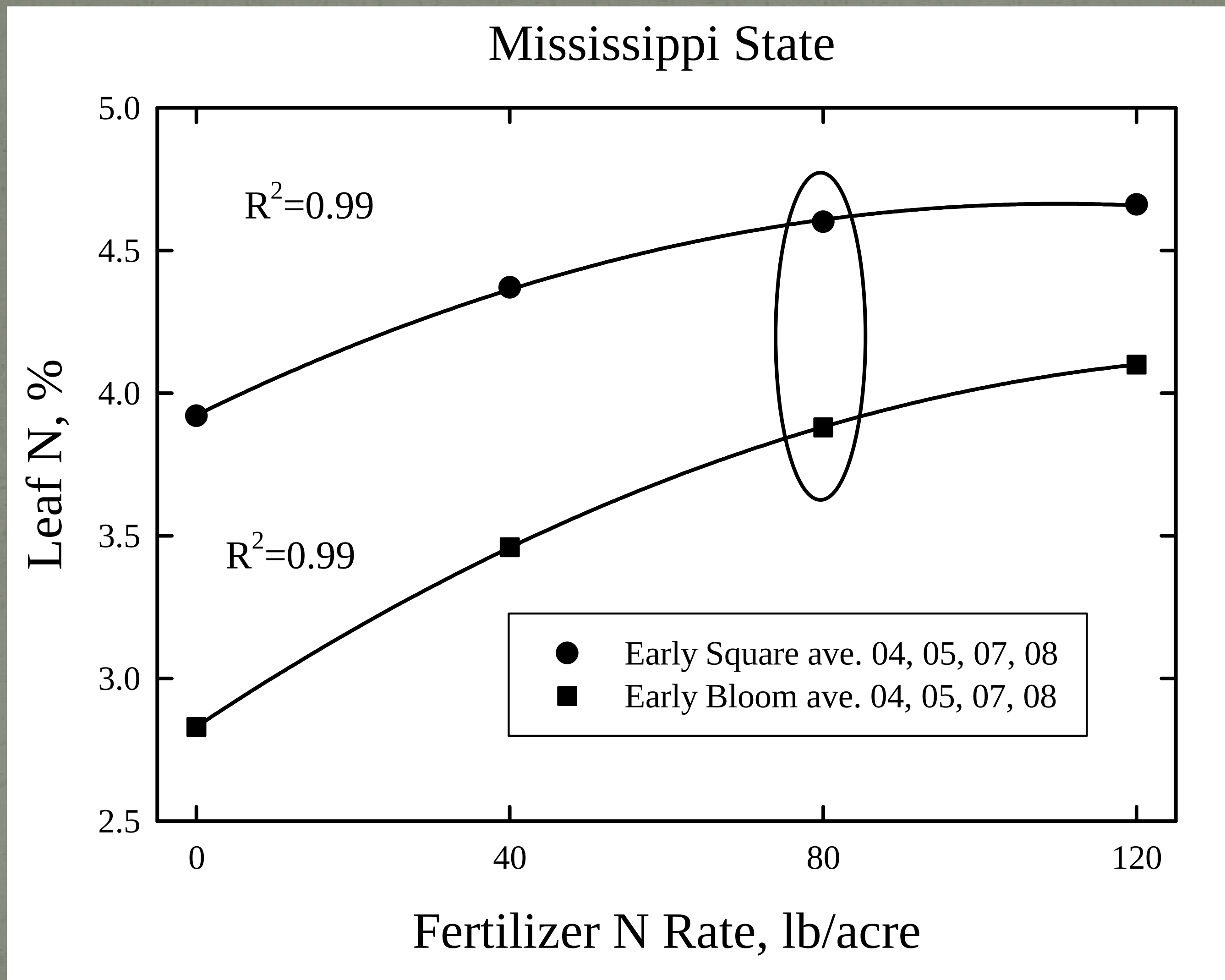




Algorithm Development



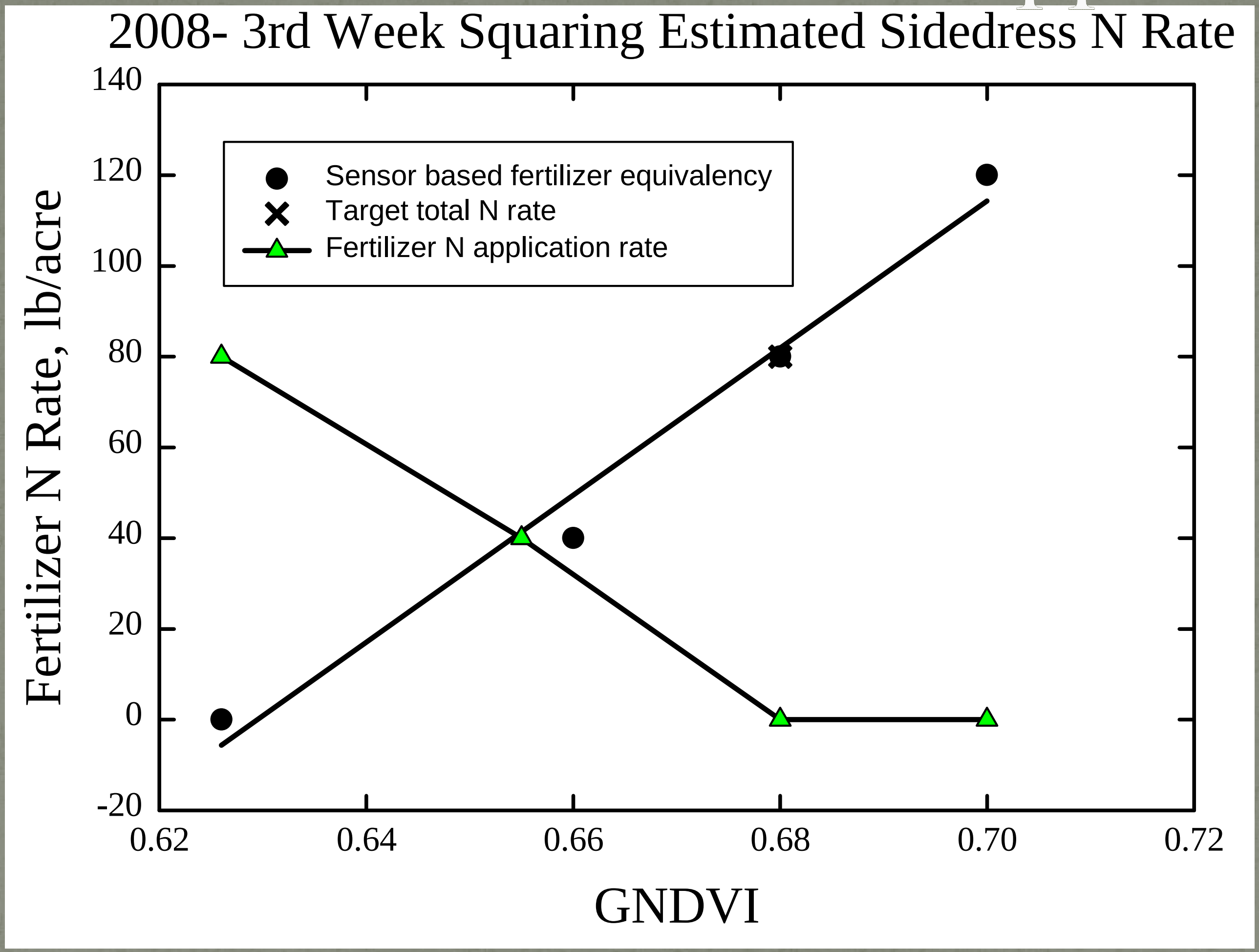
Choosing a Target



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



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?