In-Season Precision Applications of Fluid Fertilizer to Optimize Cotton Productivity and Nitrogen Use Efficiency

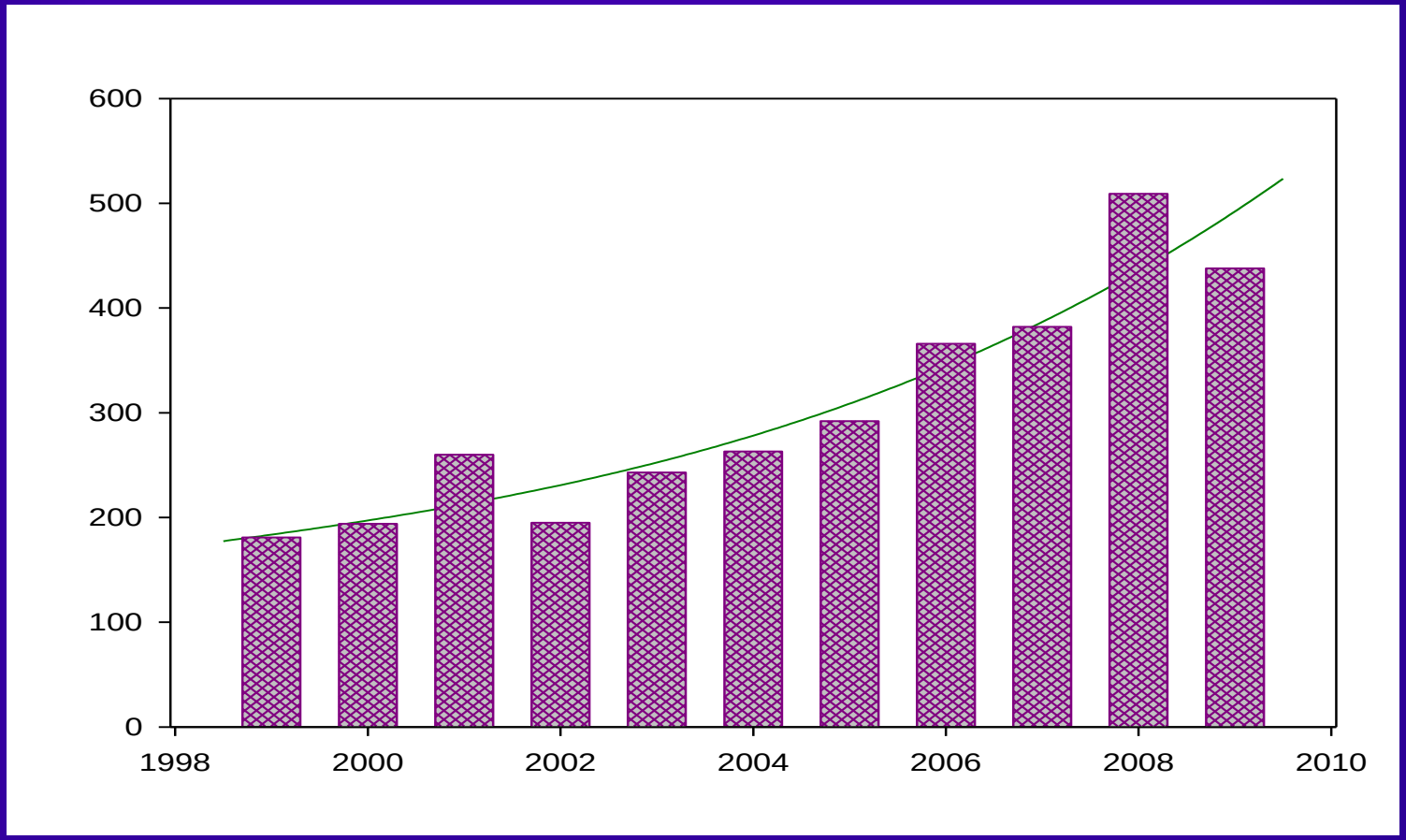
Frank Yin, Chris Main, Owen Gwathmey, Michael Buschermohle, & Don Tyler

University of Tennessee

N Recommendations for Cotton in TN

- **Application Rate:**
  - 30-60 lb N/acre on bottom soils
  - 60-80 lb N/acre on upland soils
- **Application Timing:**
  - Preplanting or at planting
- **Application Scale:**
  - Entire field
- **N Source:**
  - Ammonium nitrate

Ammonium Nitrate Price in U.S. (1999-2009)



Objectives

- ✓ Estimate the spatial variations of lint yield, normalized difference vegetation index (NDVI), leaf N concentration, and soil nitrate within field (2010 & 2011).
- ✓ Investigate the relationship between lint yield and NDVI, and between crop N nutrition status and NDVI (2010 & 2011).
- ✓ Develop algorithms for variable-rate application of fluid N fertilizer, and compare variable-rate N application with the uniform-rate N application in terms of N use and lint yield (2012).

Experimental Design

- **Location:** Gibson
- **Duration:** 2009-2011
- **Pre plant N:** 40 lb N/a
- **Side dress N:** 0, 40, 80, 120, 160 lb N/a
- **Plot size:** 800’ × 40’
- **Design:** Randomized complete block (RCB)
- **Replicate:** 3
- **Sub-plot size:** 100’ × 40’

Sampling and Measurements

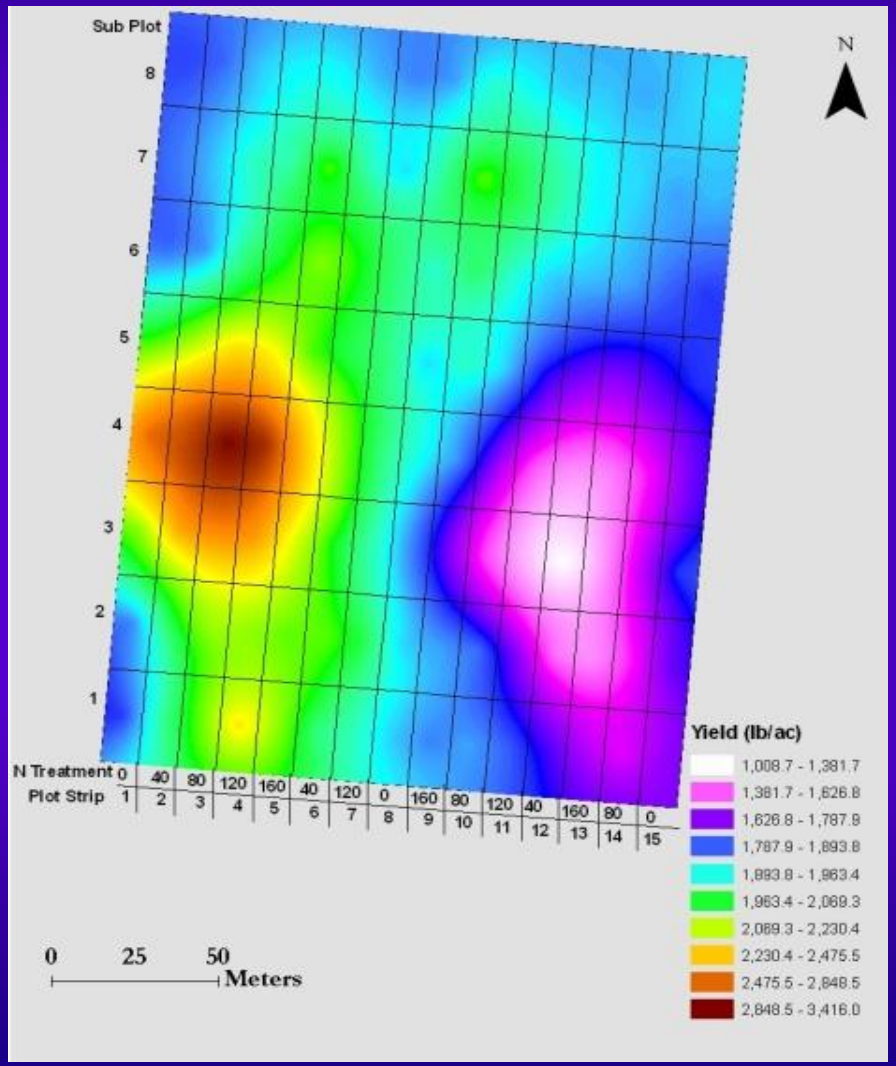
- Soil nitrate before cotton planting
- NDVI readings (early square, early, mid, & late bloom)
- Leaf N concentrations (early square, early, mid, & late bloom)
- Lint yield at harvest using a picker equipped with an automatic yield monitor
- Soil nitrate after cotton harvest
- Relationships among lint yield, NDVI, leaf N, & soil N

Greenseeker RT 2000 NDVI Mapping System

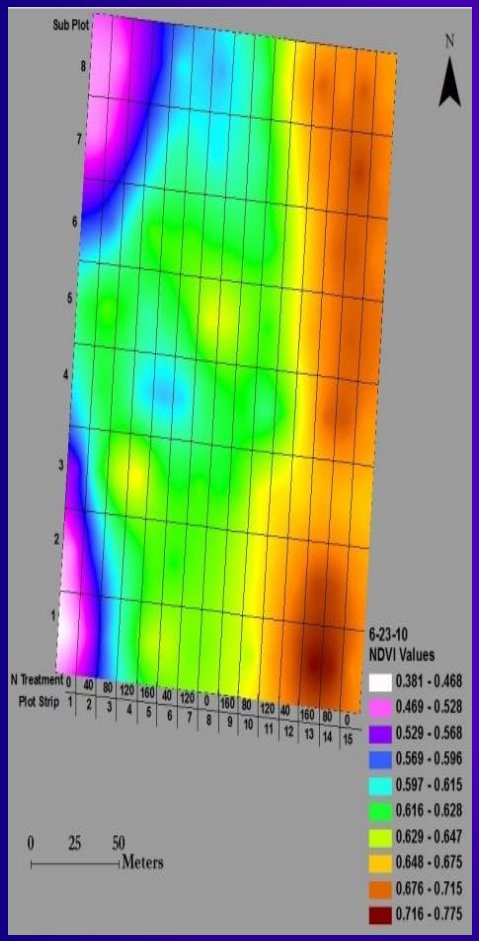
Coefficient of Variation of NDVI, Leaf N, Yield, and Soil N within Strip Plot

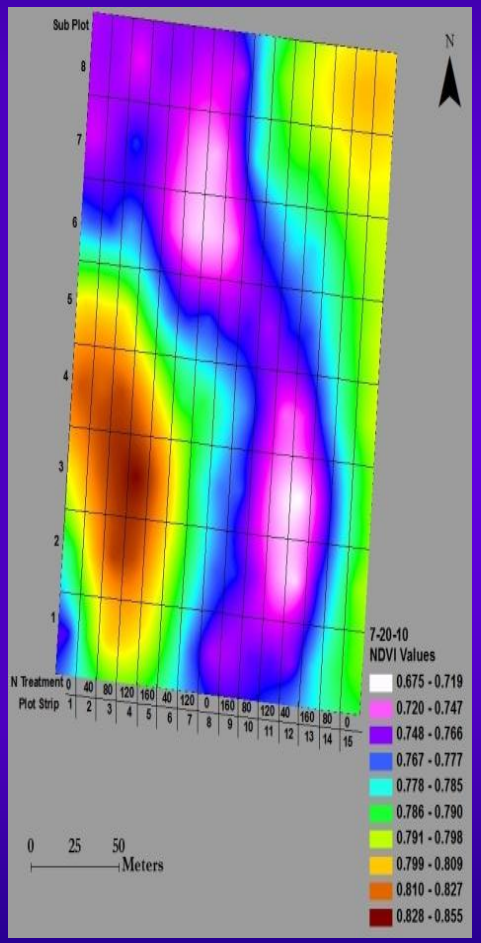
Strip plot	N rate	NDVI 6-23-10	NDVI 7-20-10	NDVI 8-3-10	NDVI 8-16-10	Leaf N 6-23-10	Leaf N 7-15-10	Leaf N 8-3-10	Leaf N 8-16-10	Yield	Post-harvest soil N
1	0	18.4	7	8.2	9.1	14	7.3	8.2	6.7	31.6	18
2	40	17.7	4.7	5.2	8.6	12.7	4.9	5.2	6	47.2	32.3
3	80	9.5	5.7	7	7.9	8.5	8.4	4.9	2.6	44.4	18
4	120	14.3	4	4.3	7.6	7.9	4.2	4.9	4.9	24.7	54.1
5	160	7.3	4.2	4.3	6.5	9.5	3.6	3.8	4	17.3	10.9
6	40	7.6	3.8	4.3	3.8	8.3	4.3	7	4.4	11.5	11.4
7	120	10	4.7	5.4	6.4	6.6	4.6	3.1	5.5	16.2	45.8
8	0	4.4	3.6	2.1	3.4	11.5	2.9	4.2	5.3	14.4	24
9	160	7.3	2.7	1.3	2.1	5.9	2.3	5.7	2.2	20.8	58.2
10	80	8.7	3.7	3.6	3.6	7.7	3.9	4.8	4.5	17.4	9.9
11	120	6.5	4.4	4.2	4.5	6.9	2.1	4.4	3	15	33.9
12	40	5.2	5.4	4.2	6.2	7.4	2.2	6.3	4.8	23.9	20.1
13	160	6.6	2.2	2	4.1	5.3	5.3	3.8	4.1	18.7	67
14	80	4.7	2.1	1.2	1.4	4.9	4	2.2	3.2	42.7	27.5
15	0	2.2	1.3	1.4	2.7	10.9	4.9	6.3	6.8	10.5	17.3

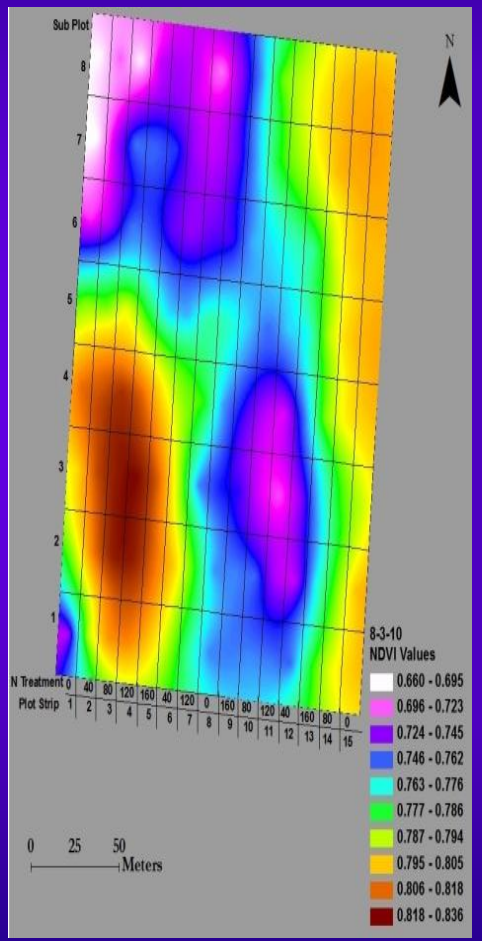
Lint Yield Map

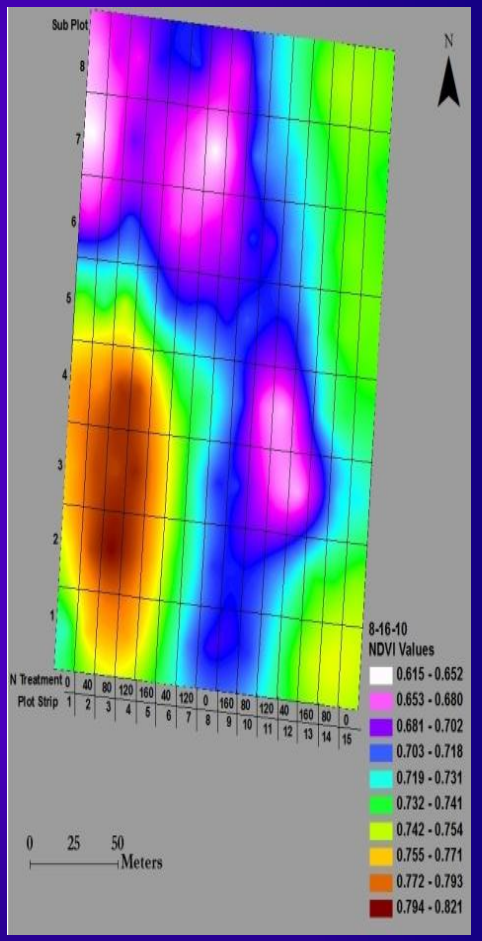


Canopy NDVI Maps

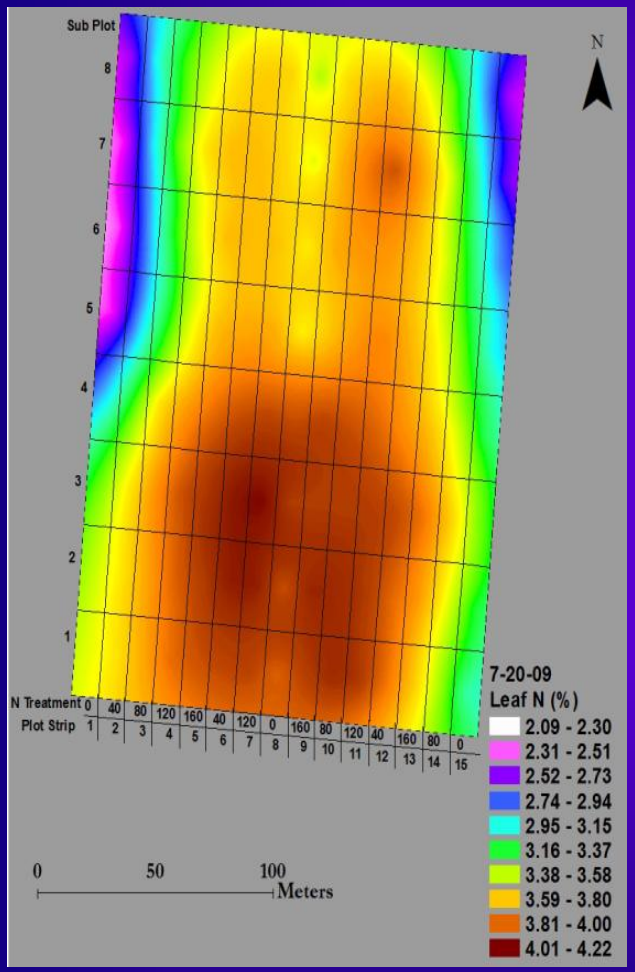


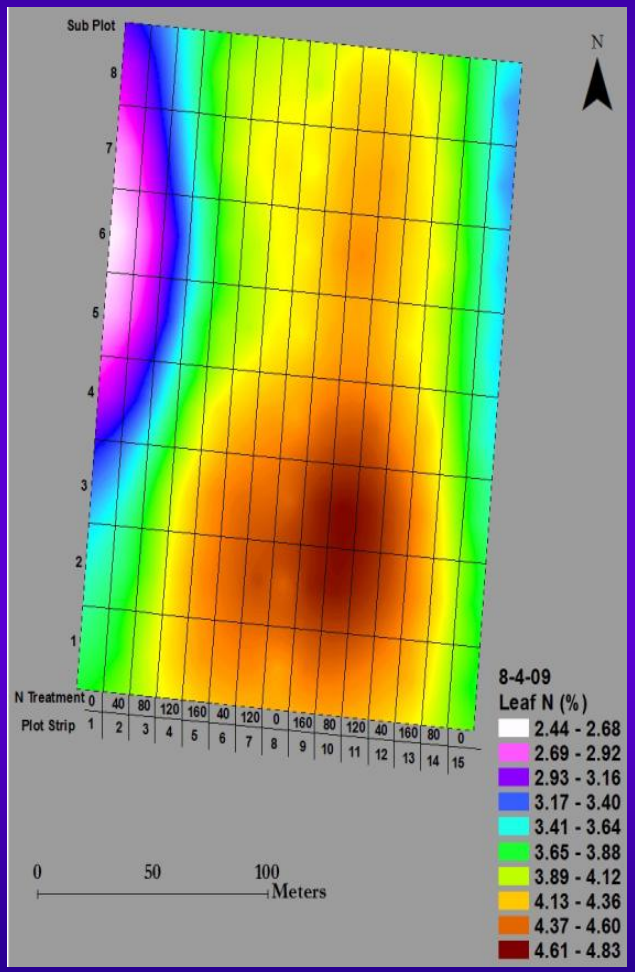


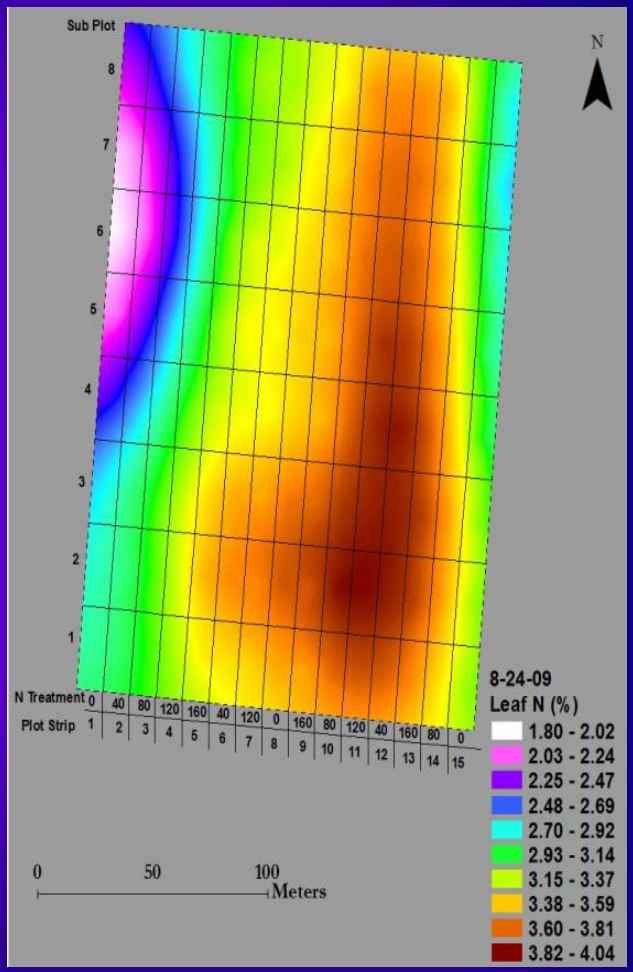




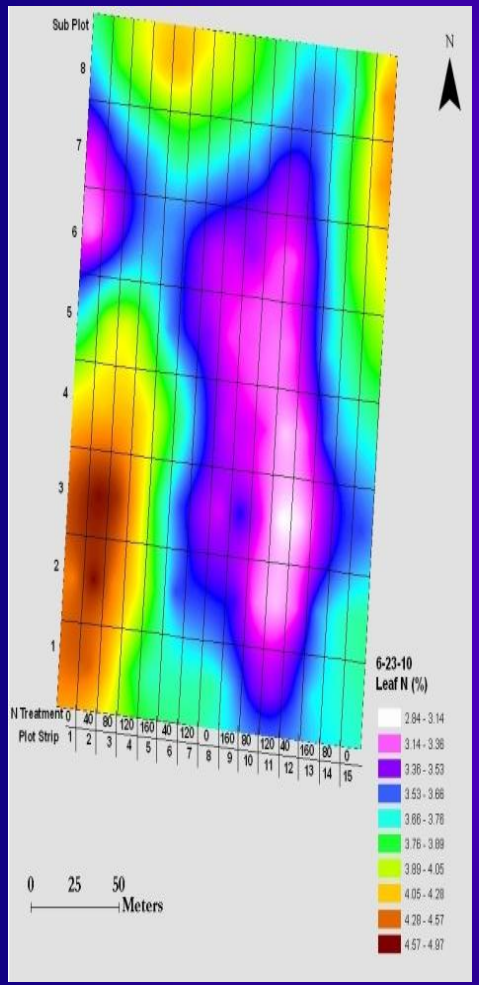
Leaf N Maps

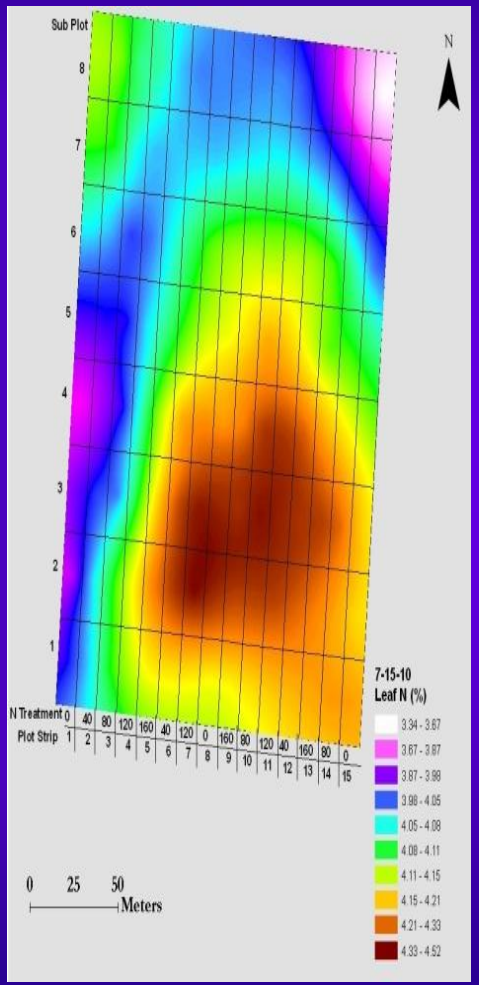

Sub Plot
N
N Treatment 0 40 80 120 160 40 120 0 160 80 120 40 160 80 0
Plot Strip 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
0 50 100
Meters
7-20-09
Leaf N (%)
2.09 - 2.30
2.31 - 2.51
2.52 - 2.73
2.74 - 2.94
2.95 - 3.15
3.16 - 3.37
3.38 - 3.58
3.59 - 3.80
3.81 - 4.00
4.01 - 4.22

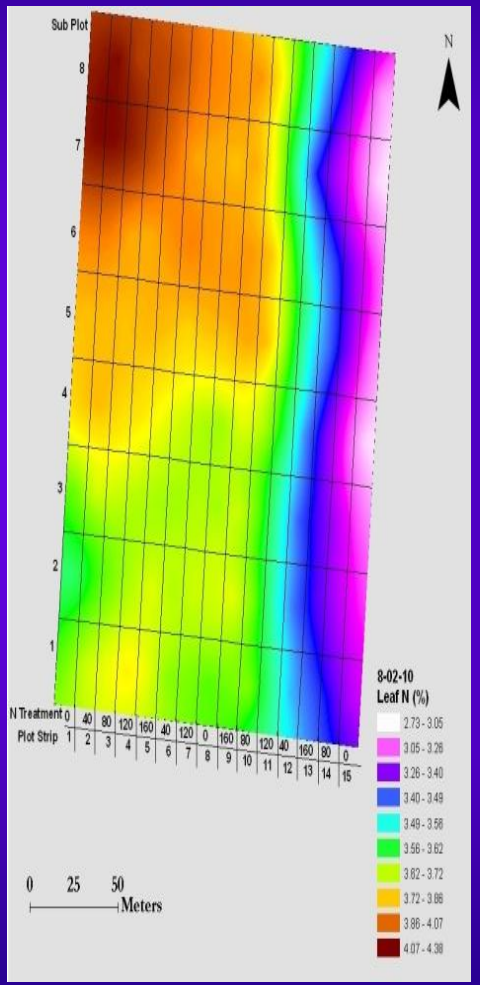

Sub Plot
N
N Treatment 0 40 80 120 160 40 120 0 160 80 120 40 160 80 0
Plot Strip 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
0 50 100
Meters
8-4-09
Leaf N (%)
2.44 - 2.68
2.69 - 2.92
2.93 - 3.16
3.17 - 3.40
3.41 - 3.64
3.65 - 3.88
3.89 - 4.12
4.13 - 4.36
4.37 - 4.60
4.61 - 4.83

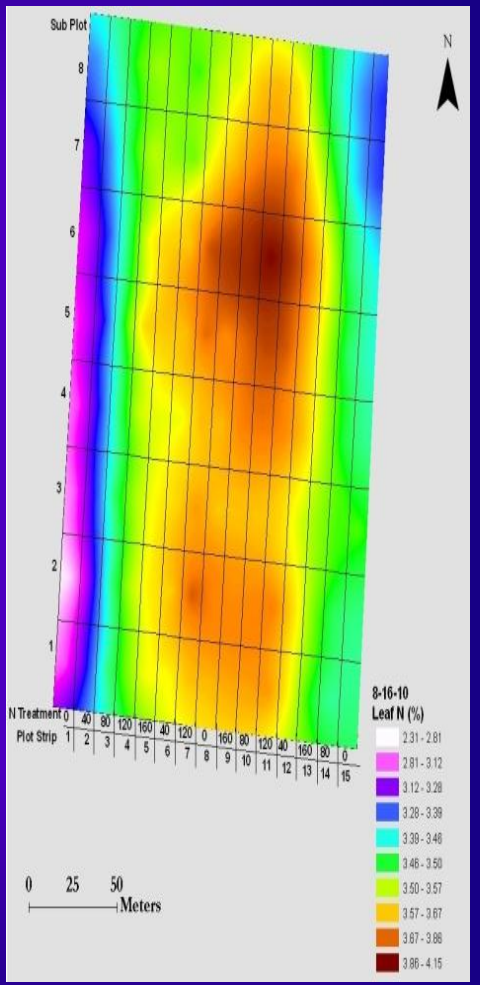

Sub Plot
N
N Treatment 0 40 80 120 160 40 120 0 160 80 120 40 160 80 0
Plot Strip 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
0 50 100
Meters
8-24-09
Leaf N (%)
1.80 - 2.02
2.03 - 2.24
2.25 - 2.47
2.48 - 2.69
2.70 - 2.92
2.93 - 3.14
3.15 - 3.37
3.38 - 3.59
3.60 - 3.81
3.82 - 4.04

Leaf N Maps

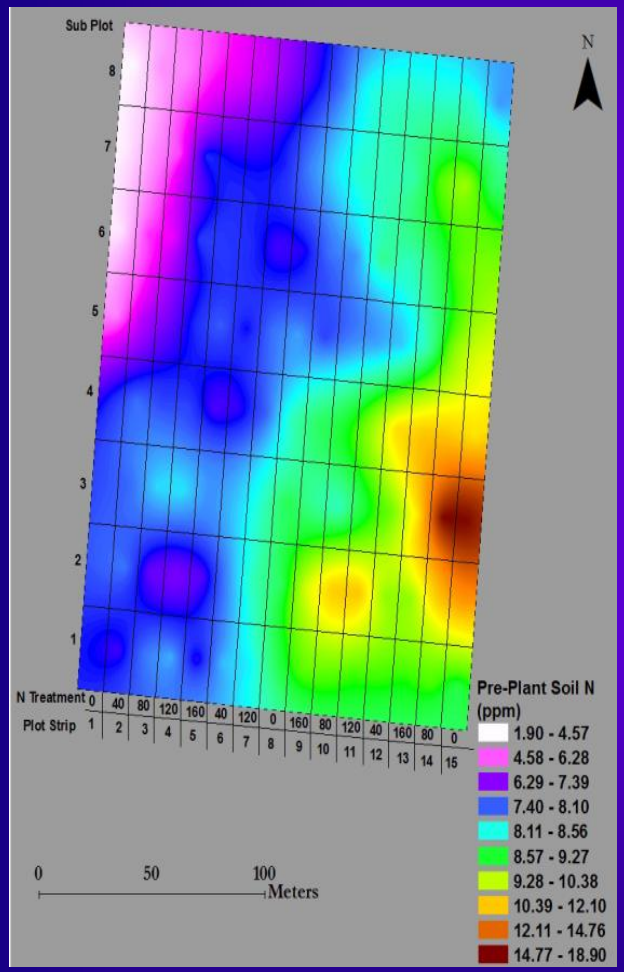

Sub Plot
N
N Treatment
Plot Strip
0 25 50
Meters
6-23-10
Leaf N (%)
2.84 - 3.14
3.14 - 3.36
3.36 - 3.53
3.53 - 3.66
3.66 - 3.76
3.76 - 3.89
3.89 - 4.05
4.05 - 4.28
4.28 - 4.57
4.57 - 4.97

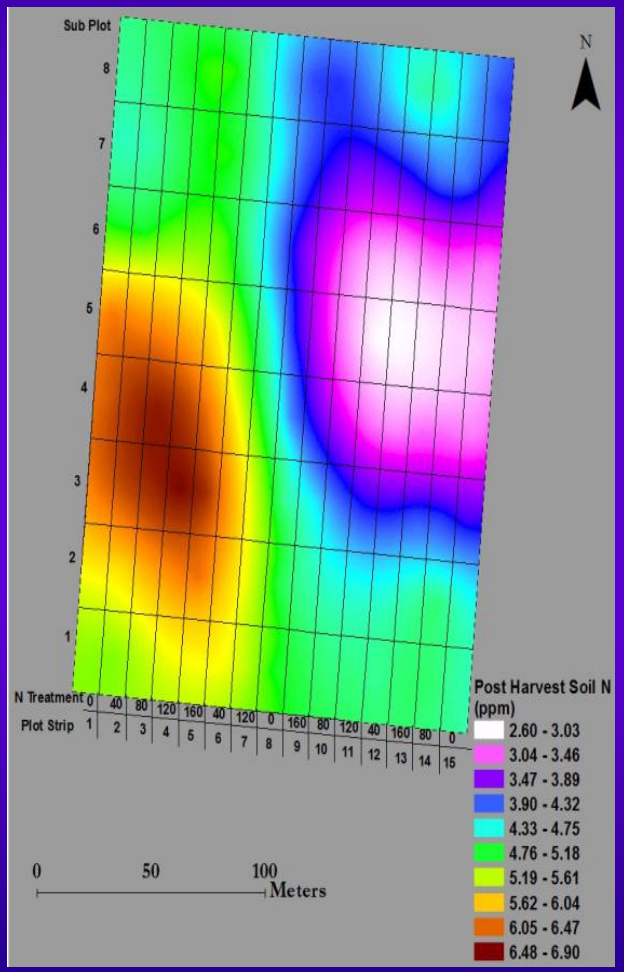

Sub Plot
N
N Treatment
Plot Strip
0 25 50
Meters
7-15-10
Leaf N (%)
3.34 - 3.67
3.67 - 3.87
3.87 - 3.98
3.98 - 4.05
4.05 - 4.08
4.08 - 4.11
4.11 - 4.15
4.15 - 4.21
4.21 - 4.33
4.33 - 4.52

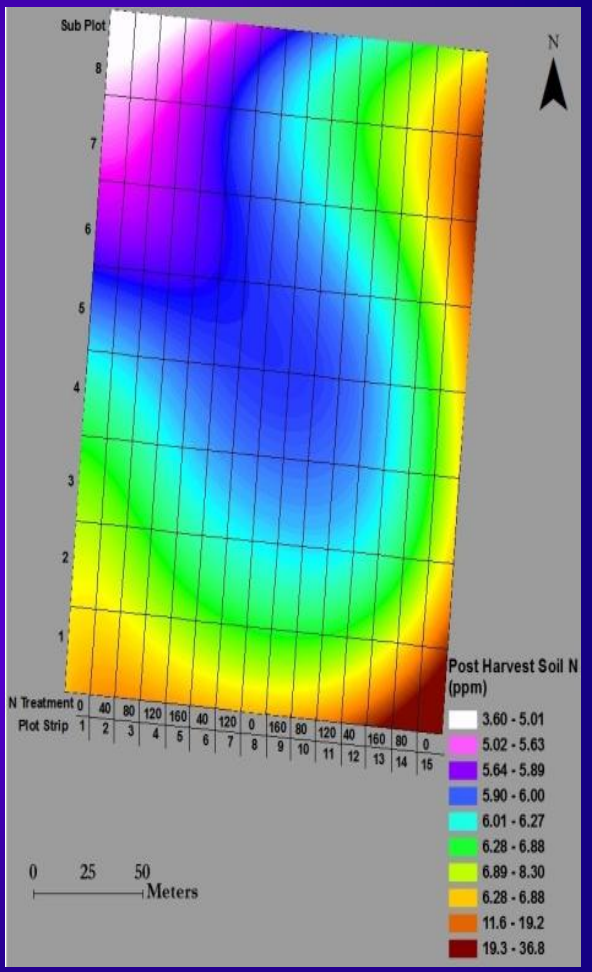

Sub Plot
N
N Treatment
Plot Strip
0 25 50
Meters
8-02-10
Leaf N (%)
2.73 - 3.05
3.05 - 3.26
3.26 - 3.40
3.40 - 3.49
3.49 - 3.56
3.56 - 3.62
3.62 - 3.72
3.72 - 3.86
3.86 - 4.07
4.07 - 4.38


Sub Plot
N
N Treatment
Plot Strip
0 25 50
Meters
8-16-10
Leaf N (%)
2.31 - 2.81
2.81 - 3.12
3.12 - 3.28
3.28 - 3.39
3.39 - 3.46
3.46 - 3.50
3.50 - 3.57
3.57 - 3.67
3.67 - 3.86
3.86 - 4.15

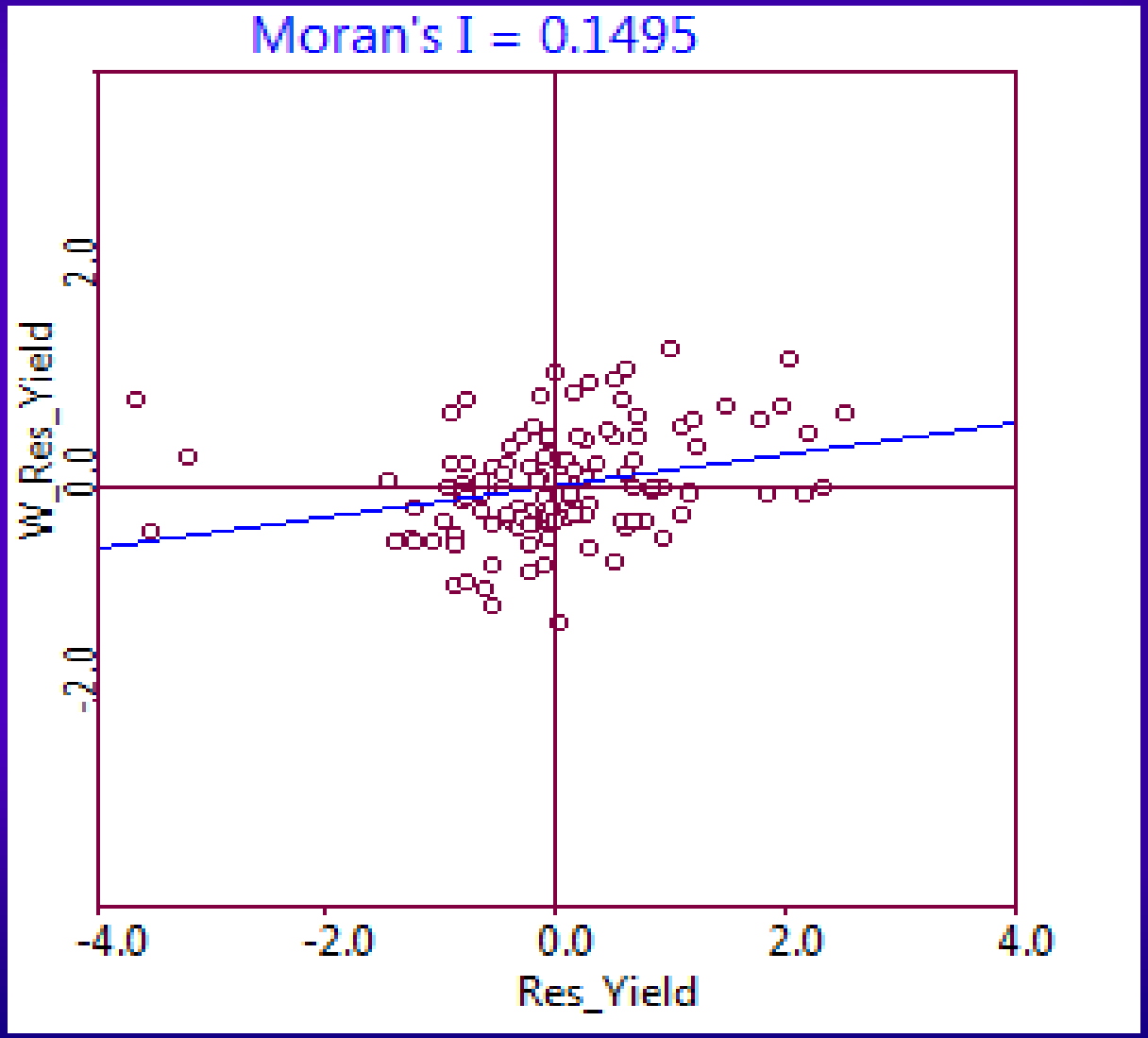
Soil N Maps


Sub Plot
N
N Treatment
Plot Strip
0 40 80 120 160 40 120 0 160 80 120 40 160 80 0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
0 50 100
Meters
Pre-Plant Soil N (ppm)
1.90 - 4.57
4.58 - 6.28
6.29 - 7.39
7.40 - 8.10
8.11 - 8.56
8.57 - 9.27
9.28 - 10.38
10.39 - 12.10
12.11 - 14.76
14.77 - 18.90

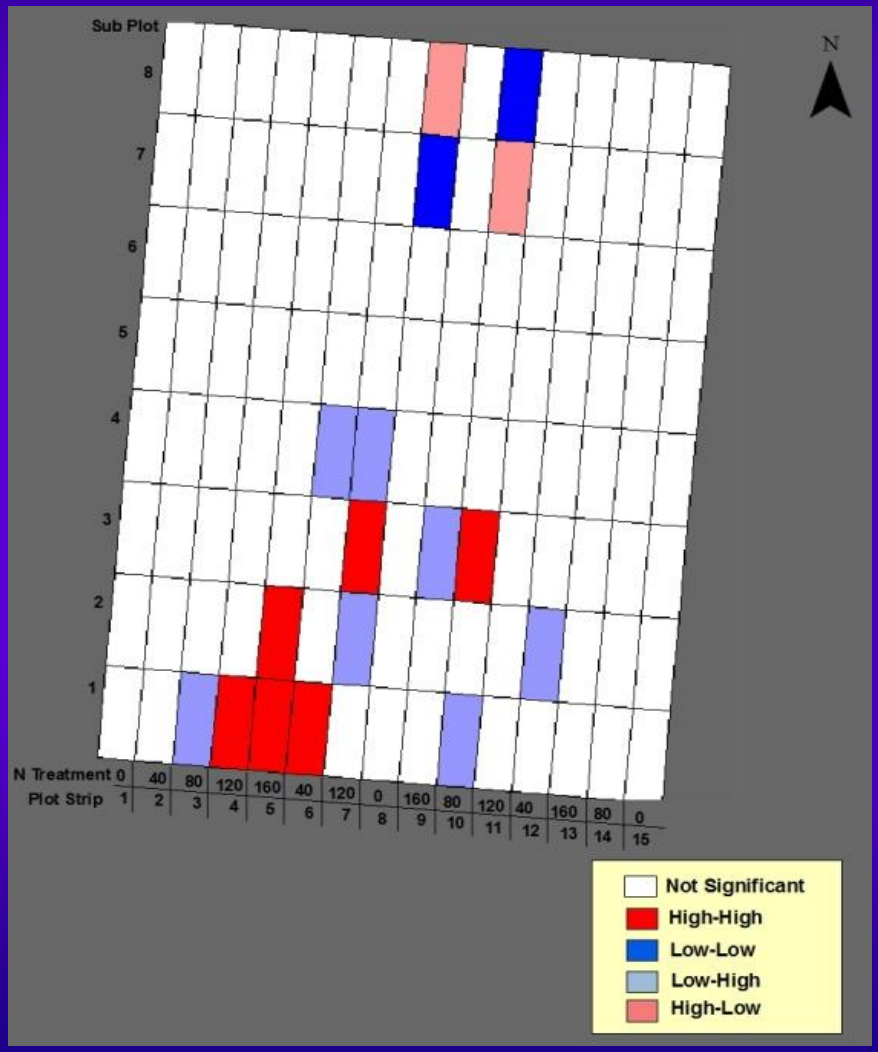

Sub Plot
N
N Treatment
Plot Strip
0 40 80 120 160 40 120 0 160 80 120 40 160 80 0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
0 50 100
Meters
Post Harvest Soil N (ppm)
2.60 - 3.03
3.04 - 3.46
3.47 - 3.89
3.90 - 4.32
4.33 - 4.75
4.76 - 5.18
5.19 - 5.61
5.62 - 6.04
6.05 - 6.47
6.48 - 6.90


Sub Plot
N
N Treatment
Plot Strip
0 40 80 120 160 40 120 0 160 80 120 40 160 80 0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
0 25 50
Meters
Post Harvest Soil N (ppm)
3.60 - 5.01
5.02 - 5.63
5.64 - 5.89
5.90 - 6.00
6.01 - 6.27
6.28 - 6.88
6.89 - 8.30
6.28 - 6.88
11.6 - 19.2
19.3 - 36.8

Moran's I and Scatter Plot of Residual Lint Yield



LISA Cluster Map of Residual Lint Yield



Correlations of Yields with NDVI

Dependent variable	Independent variable	R^2	Significance
Lint yield	NDVI_7-20-09	0.278	**
Lint yield	NDVI_8-4-09	0.427	*
Lint yield	NDVI_8-24-09	0.505	**
Lint yield	NDVI_6-23-10	0.022	ns
Lint yield	NDVI_7-20-10	0.246	**
Lint yield	NDVI_8-03-10	0.137	**
Lint yield	NDVI_8-16-10	0.162	**

Correlations of Leaf N Conc. with NDVI

Dependent variable	Independent variable	R^2	P
Leaf N_7-20-09	NDVI_7-20-09	0.192	**
Leaf N_8-4-09	NDVI_8-4-09	0.355	**
Leaf N_8-24-09	NDVI_8-24-09	0.114	**
Leaf N_6-23-10	NDVI_6-23-10	0.015	ns
Leaf N_7-15-10	NDVI_7-20-10	0.012	ns
Leaf N_8-02-10	NDVI_8-03-10	0.012	ns
Leaf N_8-16-10	NDVI_8-16-10	0.017	ns

Summary

- ✓ Significant correlations of lint yield with canopy NDVI at early, mid, and late bloom stages.
- ✓ Canopy NDVI is not a strong indicator of plant N nutrition during early to late bloom.
- ✓ There was significant global spatial autocorrelation of residual lint yields within the test field based on Moran's I statistic in 2010 but not in 2009.
- ✓ The LISA cluster map shows that there were some significant local clusters of residual lint yields within the test field.

Experiment Design

- **Location:** Milan, Jackson
- **Duration:** 2008-2010
- **N treatment:** 0, 40, 80, 120, 160, 200 lb N/a
- **Plot size:** 30’ × 12.8’
- **Design:** Randomized complete block (RCB)
- **Replicate:** 4

Work Plan

- **Duration:** 2012
- **Pre planting N trt:** 0 lb N/a
  30-50 lb N/a
- **Side dress N trt:** Variable rate N application
  Uniform rate N application

Acknowledgments

Fluid Fertilizer Foundation (FFF)
Cotton Incorporated TN State Committee

Thanks!!!

Questions???