Retrieved from: http://www.agmrc.org/commodities__products/vegetables/sweet-corn/

Retrieved from: http://www.funpub.net/funny-pictures/Various/218/agriculture

Nitrogen and Sulfur Management in Cotton


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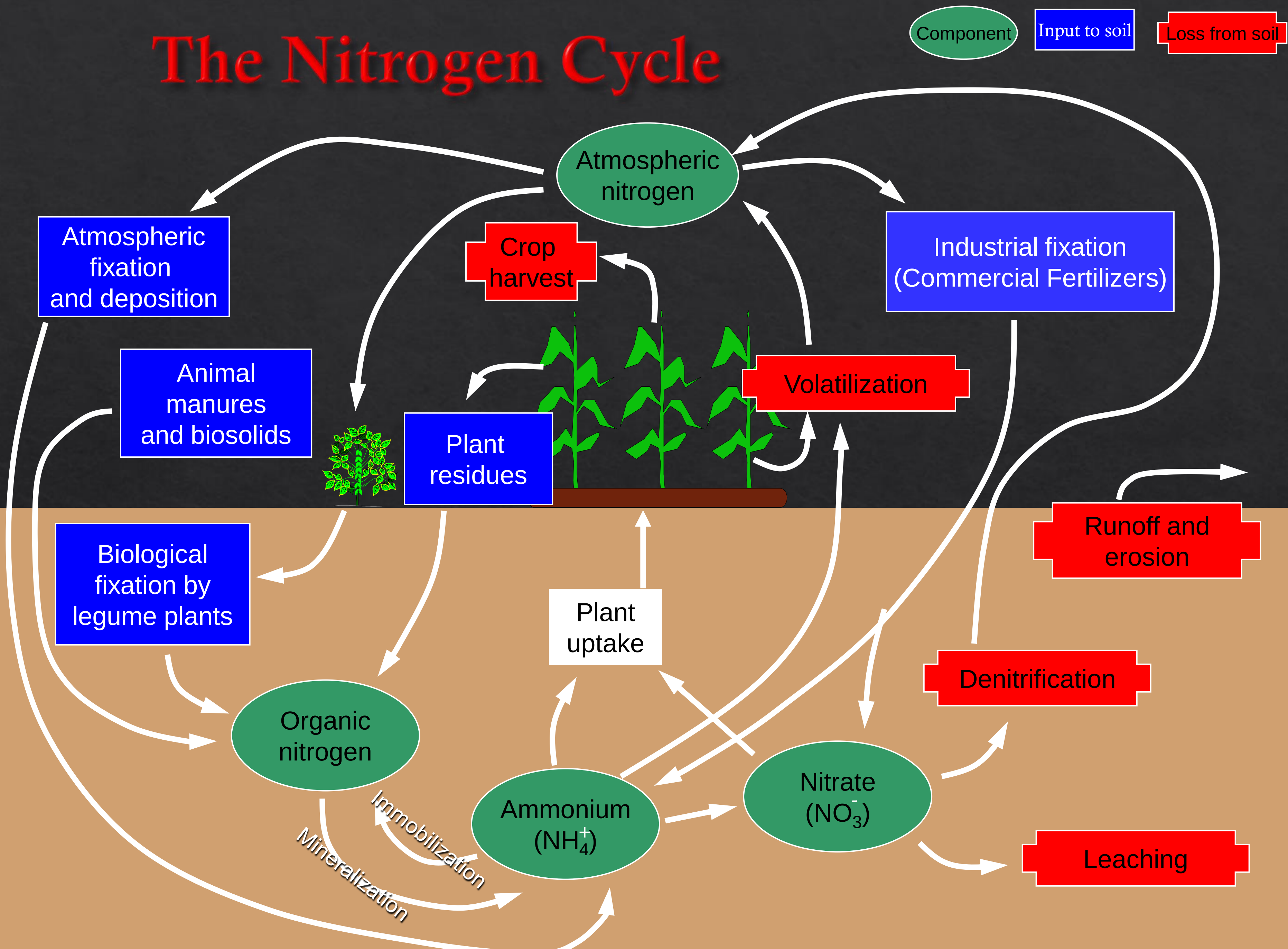
Virginia Tech TAREC
March 16, 2017

The Nitrogen Cycle



Source: http://www.ipni.net/ppiweb/ppibase.nsf/$webindex/article=C2452786852569B5005AB164B438D5E8

Loss Pathways for Nitrogen

- Ammonia Volatilization
  - Ammonia can be converted to greenhouse gases
  - Contributes to formation of particulate matter
- Nitrate Leaching
  - Groundwater pollution
- Denitrification
  - NO_x gases which are greenhouse gases
- Runoff and Erosion
  - Pollution of surface waters
  - Contributes to Eutrophication (Chesapeake Bay)
- Crop harvest
  - Global NUE is 33%
  - Probably between 40-50% in US

Savings from Improving Nitrogen Use Efficiency

- Global Nitrogen Use Efficiency (NUE) = **33%***

- 1,275,516 tons N
  - N savings if NUE is increased by 1% (constant yields)

- $892,861,200 savings at $0.35/lb N

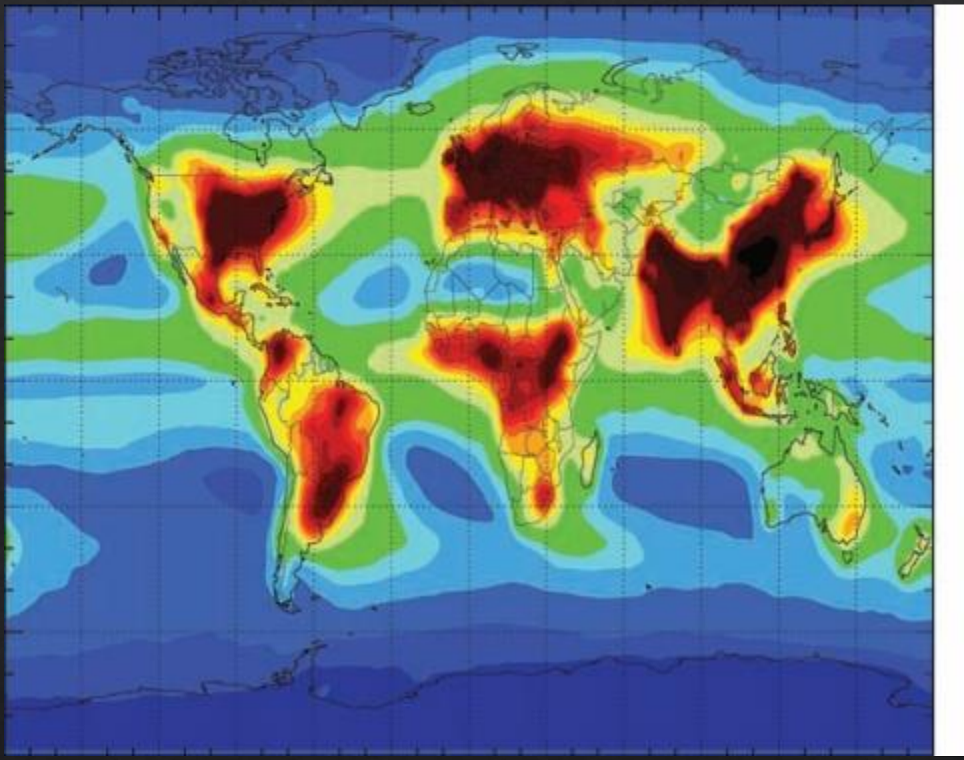


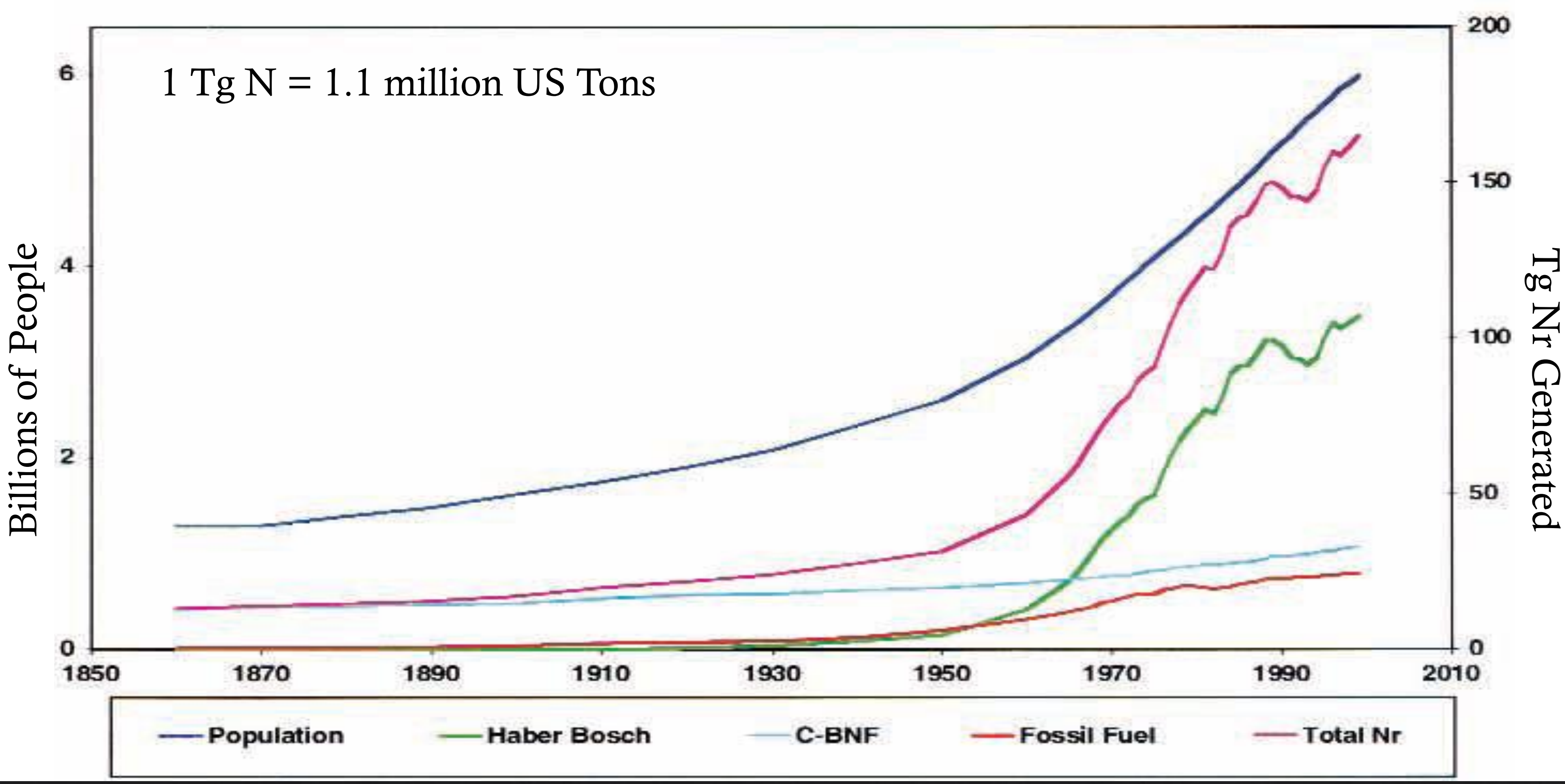
Fig. 2. Estimated N deposition from global total N (NOy and NHx) emissions, totaling 105 Tg N y^{-1}. The unit scale is kg N ha^{-1} y^{-1}, modified from the original units (mg m^{-2} y^{-1}).

(F. Dentener et al. 2006. Global Biogeochem. Cycles 20,GB4003)

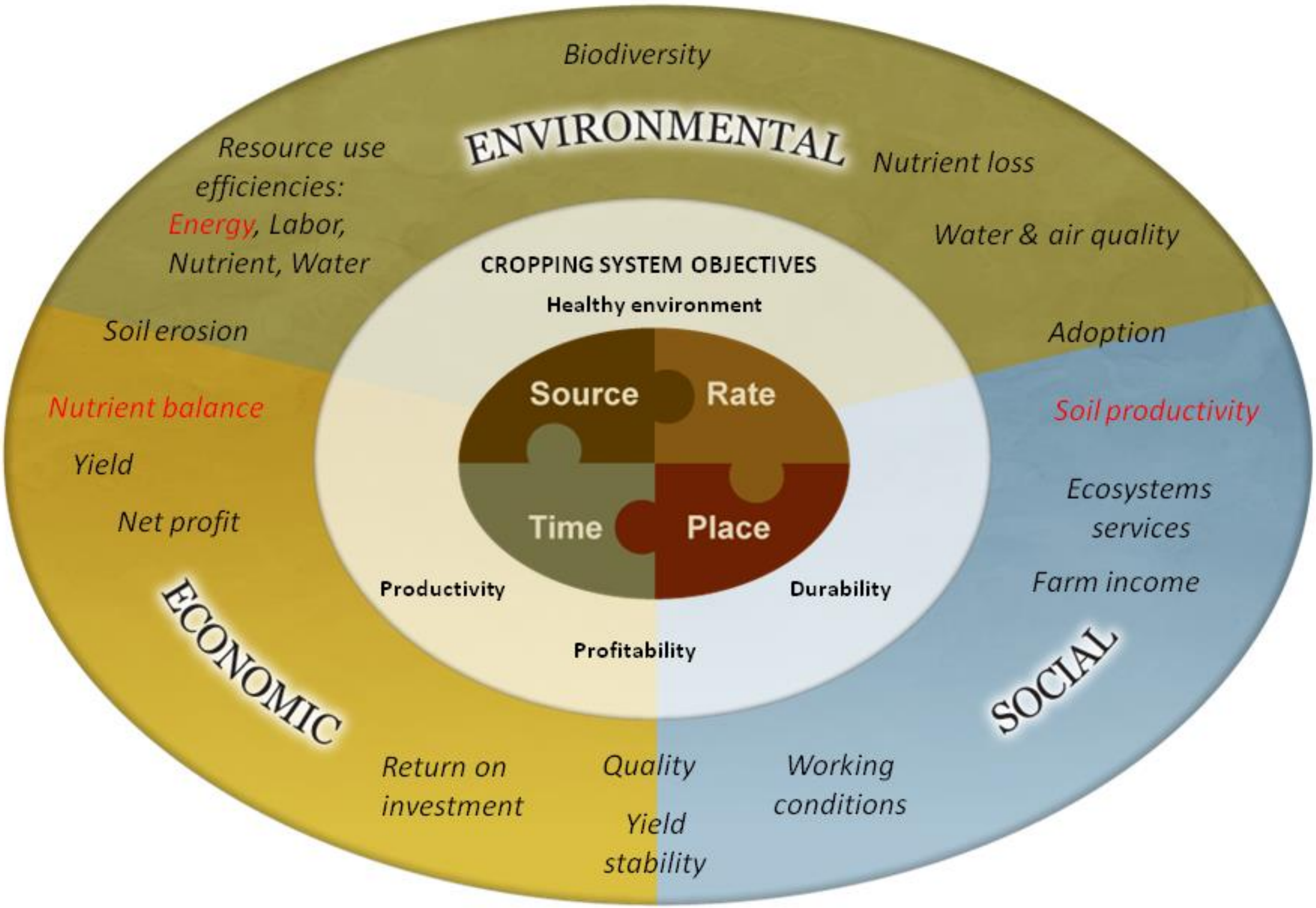
105 Tg = 231 billon pounds N = $81 billion

*Raun, W.R and G.V. Johnson, 1999

Reactive Nitrogen Generation



Global population trends from 1860 to 2000 (billions, left axis) and reactive nitrogen (Nr) creation (teragrams nitrogen [Tg N] per year, right axis). (Galloway et al., 2003)



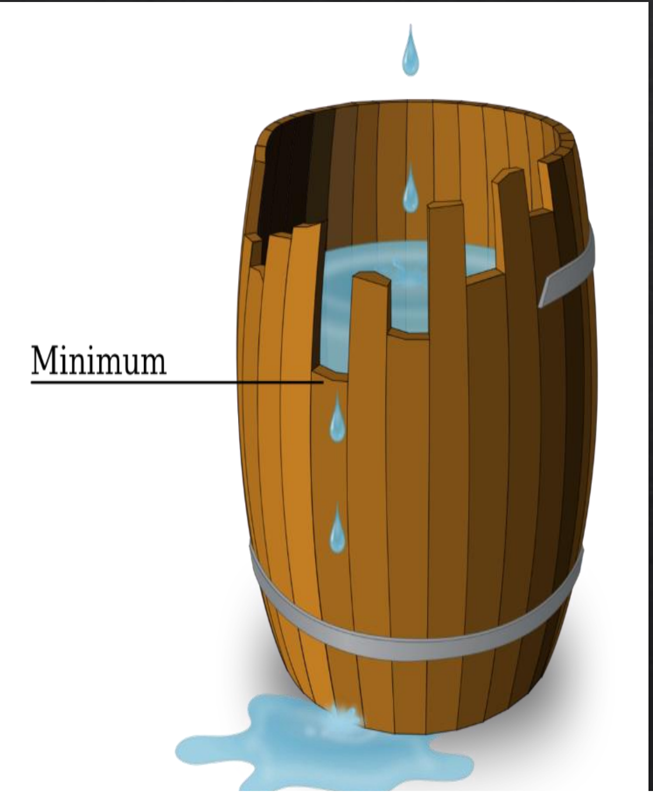
IPNI. 4R Diagram. 4R Nutrient Stewardship Portal. International Plant Nutrition Institute. June 2009. http://www.ipni.net/4r

Common Sources of Nitrogen

- Anhydrous Ammonia (82-0-0)
- Granular Urea (46-0-0)
- Urea Ammonium Nitrate Solutions
  - 28-32% Nitrogen
- Ammonium Sulfate
- Ammonium Nitrate
- Organic N Sources
  - Poultry Litter
  - Dairy Slurry/Manure
  - Bio-solids

Liebig's Law of the Minimum

- Yield will be limited by the amount of the most limiting nutrient!!!



Courtesy of © Wikimedia Commons

Current Soil Fertility Recommendations for Cotton

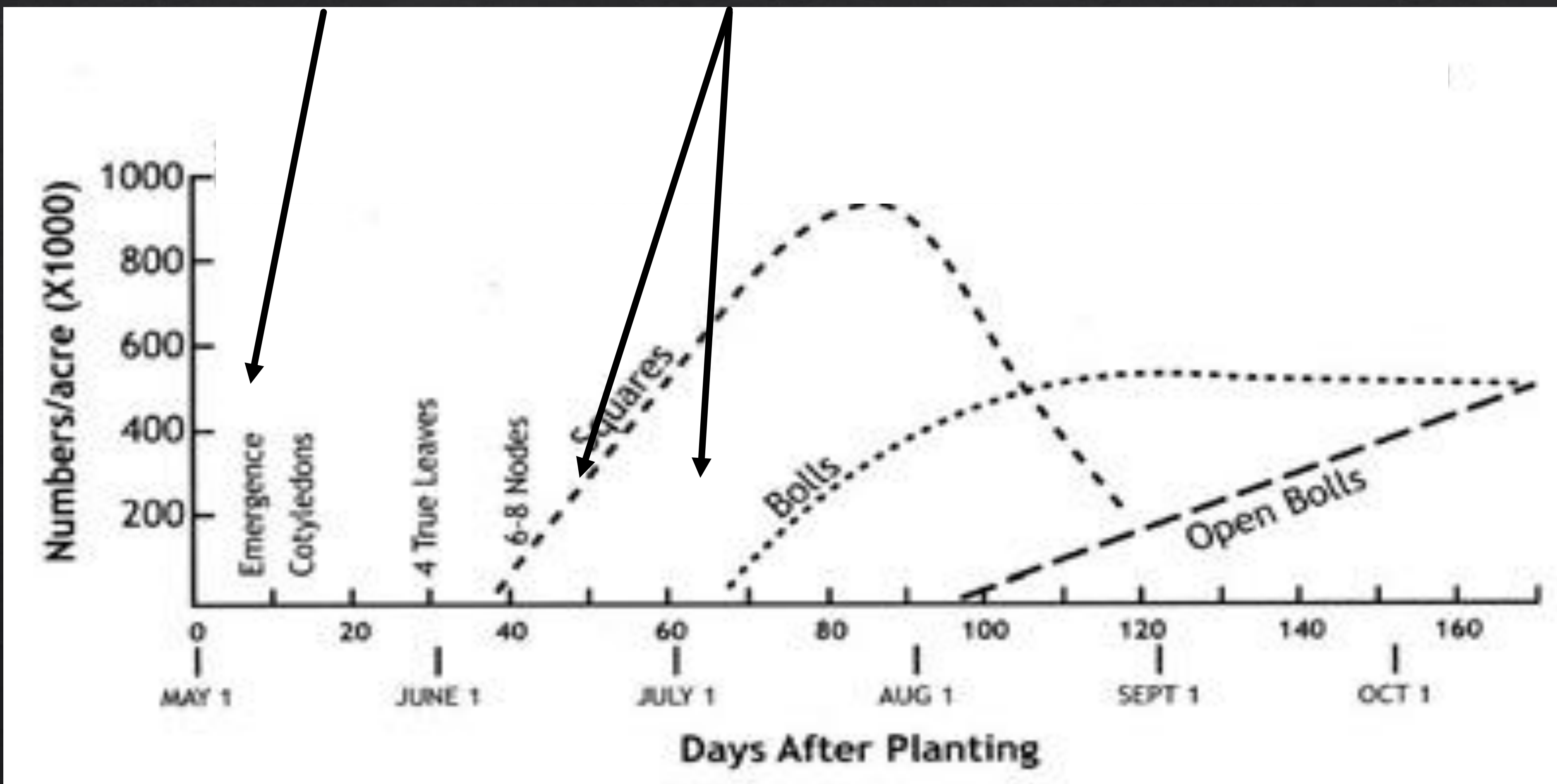
- Nitrogen
  - Current recommendations: 50 lbs N/acre per bale expected yield
    - 2 bale = 100 lb N per acre uptake
    - 3 bale = 150 lb N per acre uptake
  - 20-30% applied pre- or at planting
  - 70-80% applied in-season (1 or 2 applications??????)
  - In-season monitoring with tissue testing

- Sulfur
  - Current Recommendations: Apply 20 lbs S per acre
  - Easy time to put that out is with side-dress N
  - Want to use a source containing sulfate as elemental S needs time to break down and become plant available

Current Nitrogen Management in Cotton

Pre-plant Fertilizer
20-30% N

Side-dress N application
70-80% N
Single or Split Applications



Summary of N, K, and S Uptake

- Nitrogen Uptake
  - 20-30 lb N ac^{-1} between planting and 1st square
  - From 1st square to harvest cotton needed an additional 100 lb N ac^{-1}
  - 120-140 lb N ac^{-1} total uptake at defoliation
  - Substantial N can be supplied by soil ~80 lb N ac^{-1}
    - Depends on soil typed and residual N available
  - Largest sink for N at harvest was cottonseed
- Sulfur Uptake
  - 2.5 - 6 lb S ac^{-1} between planting and 1st square
    - Uptake at 1st square can be as high as 8-10 lb S ac^{-1}
  - 15 lb S ac^{-1} total uptake at cutout at normal S application rates
    - As high as 25 lb S ac^{-1}
  - 18-22 lb S ac^{-1} total uptake at defoliation
  - Majority of S uptake occurs prior to cutout and major sink were leaves
- Potassium Uptake
  - 30-35 lb K2O ac^{-1} between planting and 1st square
  - From 1st square to harvest cotton need an additional 100 lb K2O ac^{-1}
  - 120-140 lb K2O ac^{-1} total uptake at cutout

In-Season Monitoring of Nitrogen Status in Cotton

University Recommended Petiole Nitrate and Phosphorus Concentrations

"Arkansas" Interpretation (Benton and others 1979)

Time of sampling	*Nitrate nitrogen (ppm)*	*Phosphorus (ppm)*
Week of bloom	10,000–35,000	>800
Bloom + 1 week	9,000–30,000	*
Bloom + 2 weeks	7,000–25,000	*
Bloom + 3 weeks	5,000–20,000	*
Bloom + 4 weeks	3,000–13,000	*
Bloom + 5 weeks	2,000–8,000	
Bloom + 6 weeks	1,000–5,000	
Bloom + 7 weeks	0–5,000	
Bloom + 8 weeks	0–5,000	

* A decrease in P concentration of more than 300 ppm from the previous week usually indicates moisture stress

"Georgia" Interpretation (Lutrick and others 1986; Plank, personal communication)

Time of sampling	*Nitrate nitrogen (ppm)*	*Phosphorus (ppm)*
Week before first bloom	7,000–13,000	>800
Week of bloom	4,500–12,500	>800
Bloom + 1 week	3,500–11,000	*
Bloom + 2 weeks	2,500–9,500	*
Bloom + 3 weeks	1,500–7,500	*
Bloom + 4 weeks	1,000–7,000	*
Bloom + 5 weeks	1,000–6,000	*
Bloom + 6 weeks	500–4,000	
Bloom + 7 weeks	500–4,000	
Bloom + 8 weeks	500–4,000	

* A decrease in P concentration of more than 300 ppm from the previous week usually indicates moisture stress

Adapted from Mitchell and Baker (2009)

North Carolina Sufficiency Ranges for Petiole Nitrate-N throughout the Growing Season

Table 4. Desired range of petiole nitrate-nitrogen (ppm) by growth stage and week

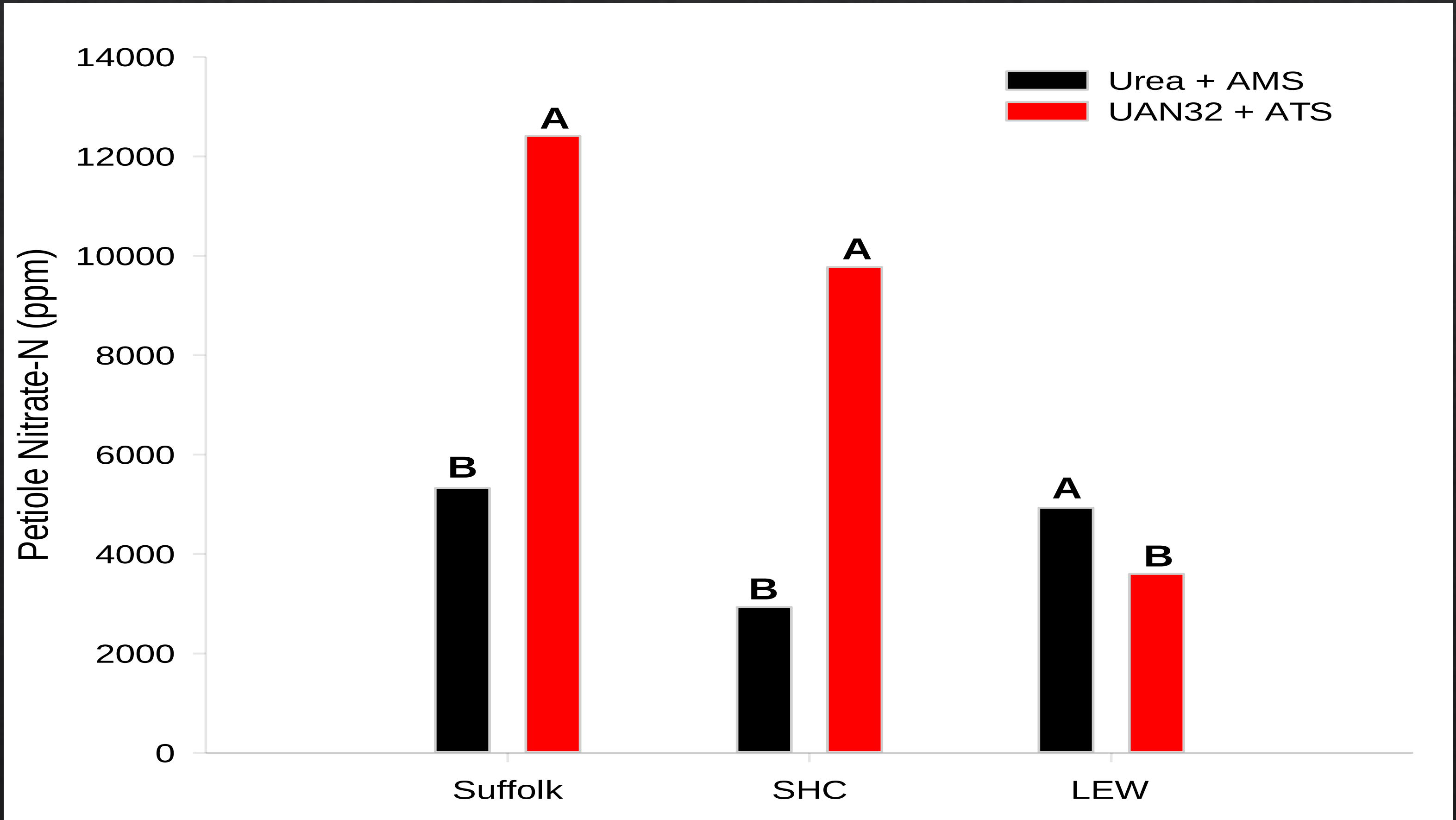
Week	Seedling (S)	Early (E)	Bloom (B)	Fruit (F)	Mature (M)
1	16,000–30,000	12,000–18,000	6,000–12,000	1,000–6,000	200–2,500
2	15,000–25,000	10,000–16,000	5,000–11,000	500–5,000	150–2,000
3	14,000–22,500	8,000–14,000	3,500–10,000	250–4,000	100–1,500
4	13,000–20,000	7,500–13,000	2,000–8,000	100–3,000	50–1,000

Table 1. Consecutive growth stage and week designations for cotton tissue samples

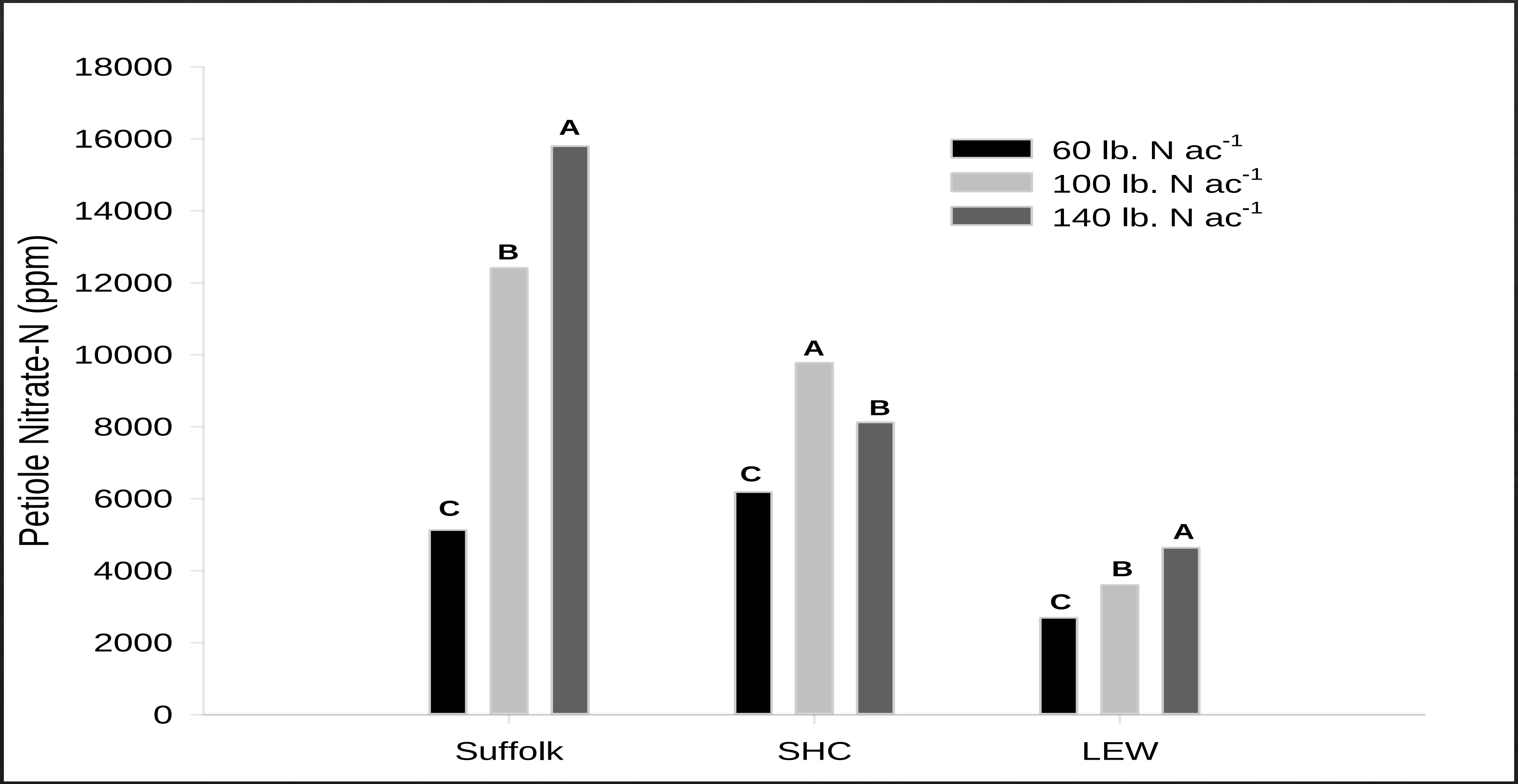
S = SEEDLING, 4 WKS 1–4				E = EARLY VEGETATIVE GROWTH, 4 WKS 1–4				B = BLOOM, 4 WKS 1–4				F= FRUIT, 4 WKS 1–4			
S1	S2	S3	S4	E1	E2	E3	E4	B1	B2	B3	B4	F1	F2	F3	F4

Adapted from Cleveland (2012)

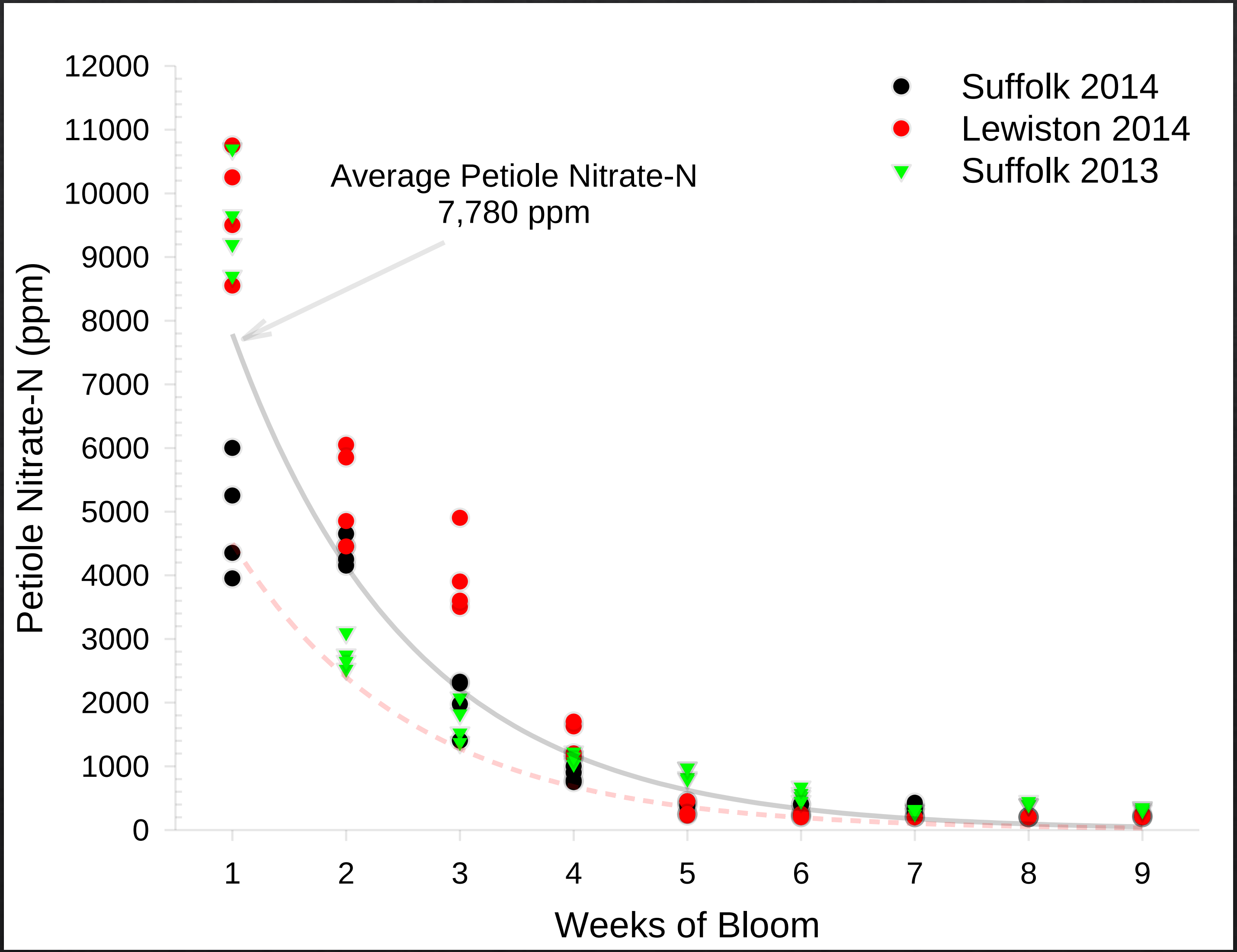
Fertilizer Source and petiole Nitrate-N at 100 lb N acre^{-1}



Petiole Nitrate-N and Nitrogen Rate



Combined Nitrate-N Concentrations during Bloom in Virginia



Leaf Tissue Nutrient Concentrations at TAREC from 2013-2015

Nutrient Systems	Leaf Nutrient Concentrations							
	1st‡				5th			
	N	P	K	S	N	P	K	S
	------------------------------ % ------------------------------							
Unfertilized Control	3.41 c*	0.34	1.57	0.54 b	2.76 c	0.26	1.29	0.71
Broadcast Agronomic Control	4.32 a	0.32	1.77	0.76 a	3.49 ab	0.24	1.47	0.77
Liquid Starter Control	4.23 a	0.32	1.67	0.68 a	3.45 ab	0.23	1.44	0.75
100% 2X2 N-P-K-S	4.29 a	0.31	1.76	0.77 a	3.46 ab	0.23	1.44	0.78
100% Deep Placement N-P-K-S	4.16 b	0.31	1.66	0.76 a	3.56 a	0.23	1.47	0.77

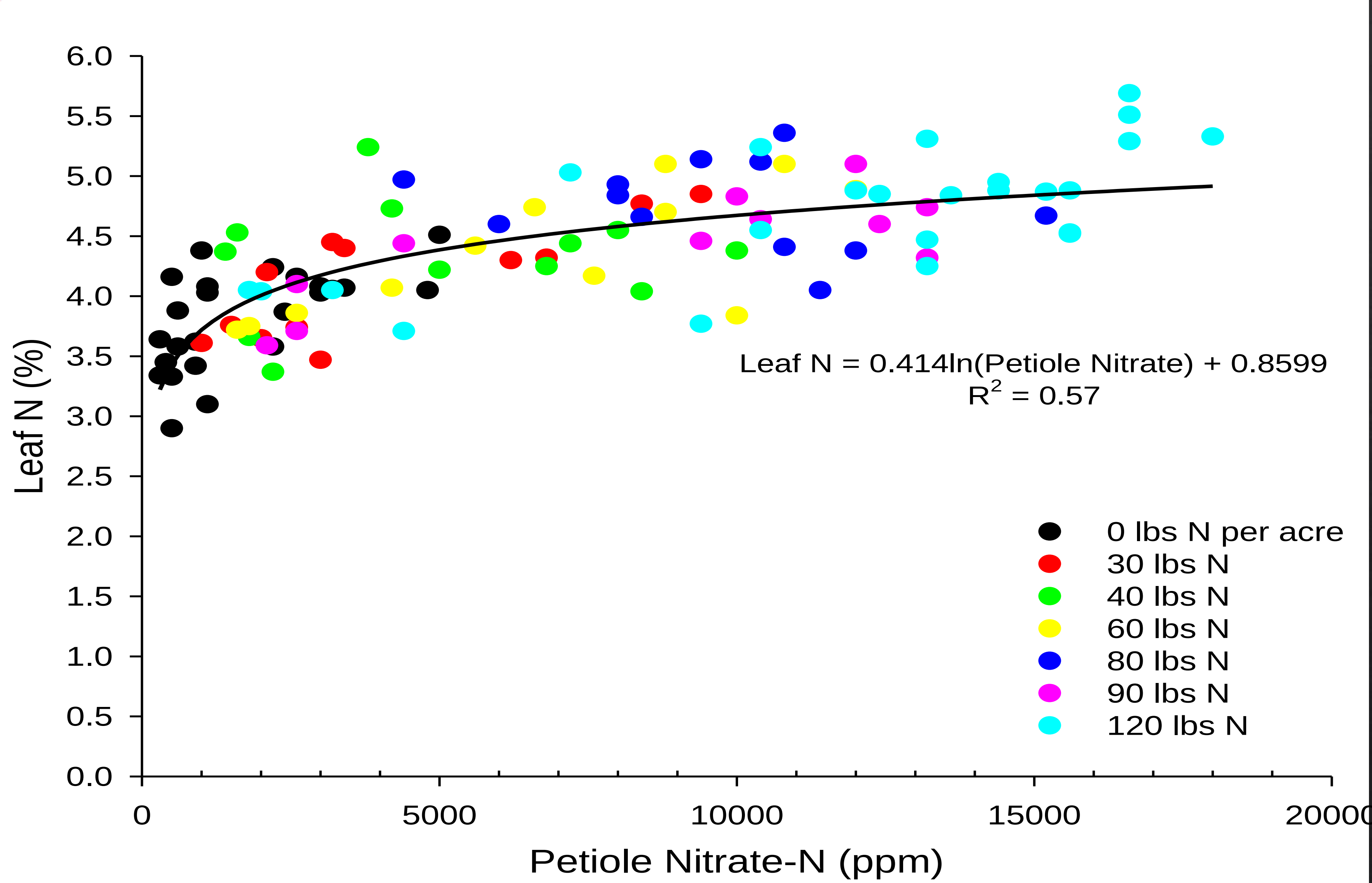
*Values with the same letter are not significantly different at $\alpha = 0.05$

‡ Week of bloom

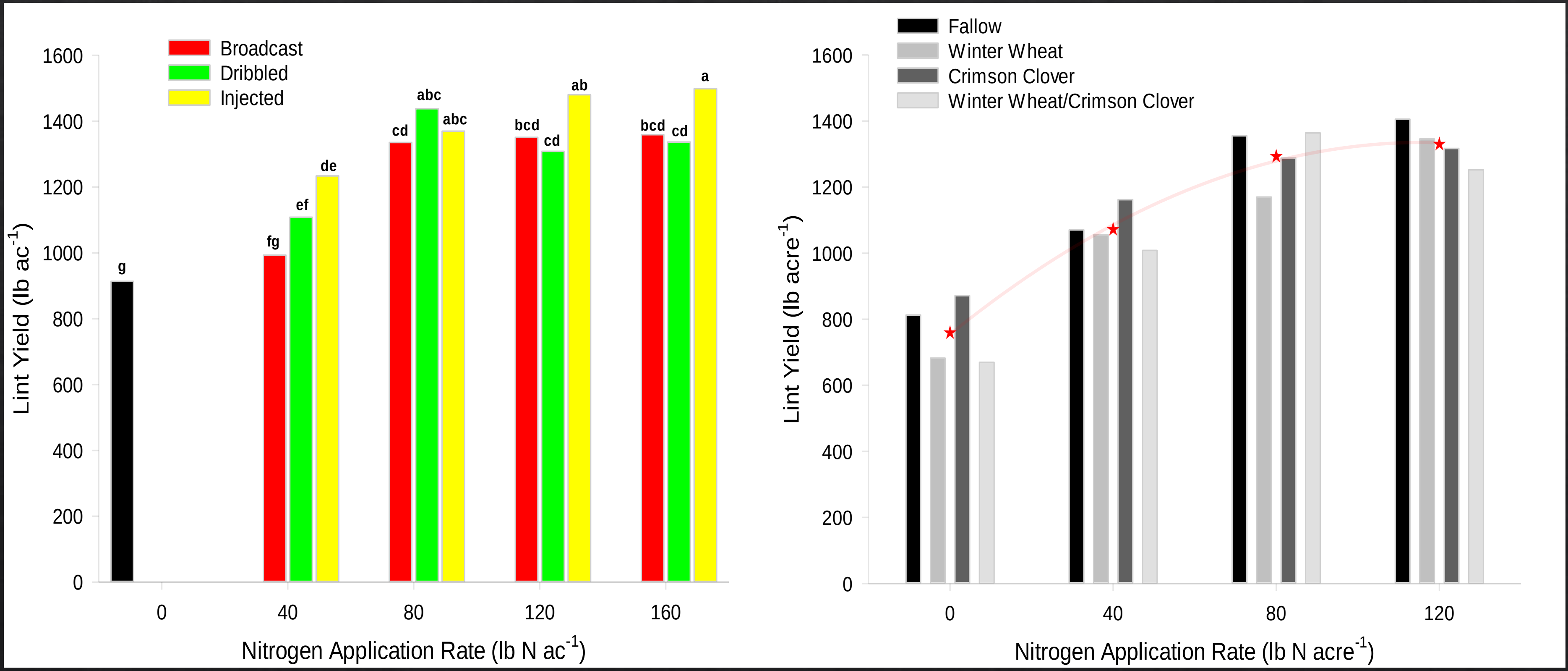
Macronutrients (%)						
	N	P	K	Ca	Mg	S
early bloom	3.0–4.5	0.2–0.65	1.5–3.0	2.0–3.5	0.3–0.9	0.25–0.8
late bloom / maturity	3.0–4.5	0.15–0.6	0.75–2.5	2.0–4.0	0.3–0.9	0.3–0.9

Adapted from Mitchell and Baker (2009)

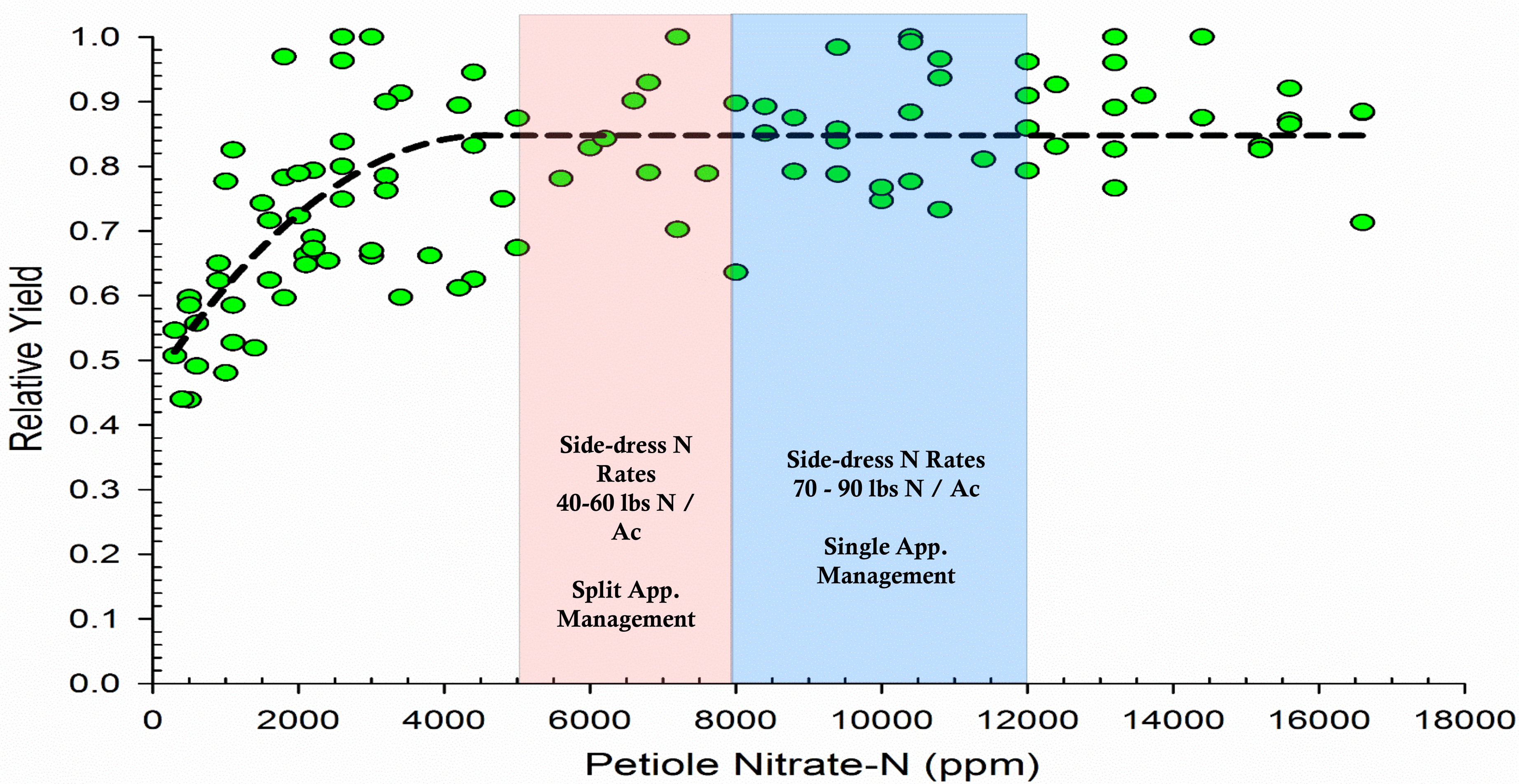
Combined Leaf Nitrogen and Petiole Nitrate-N
1st Week of Bloom



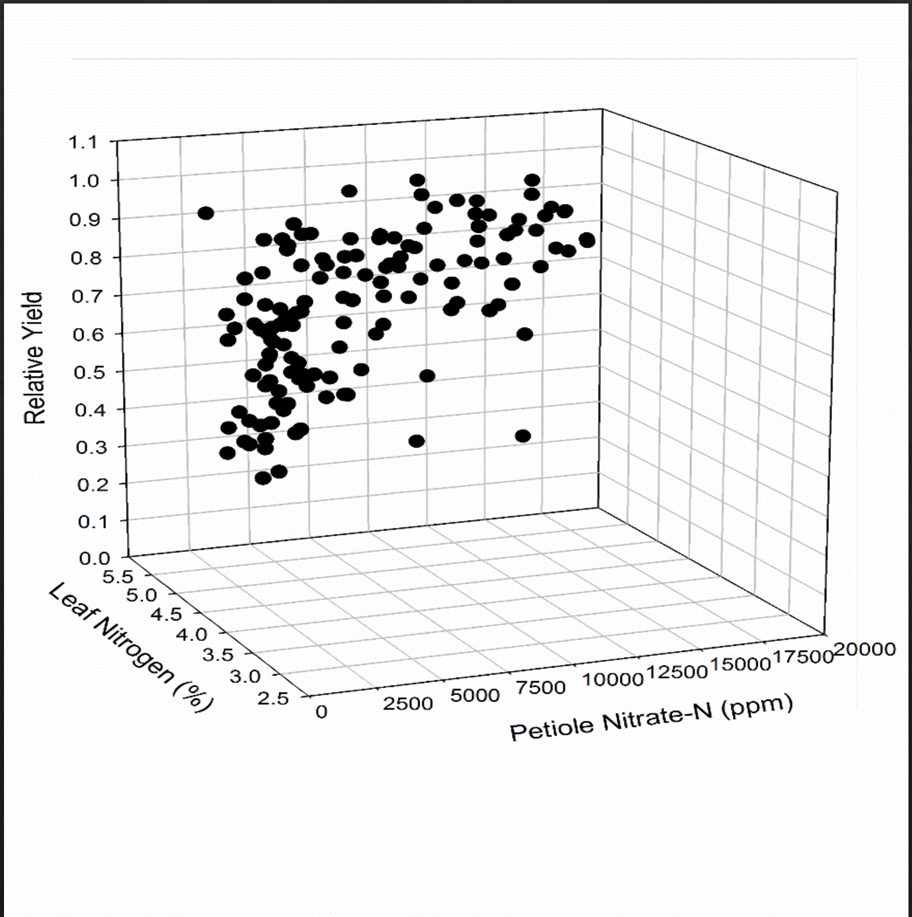
Nitrogen Management in Cotton at TAREC

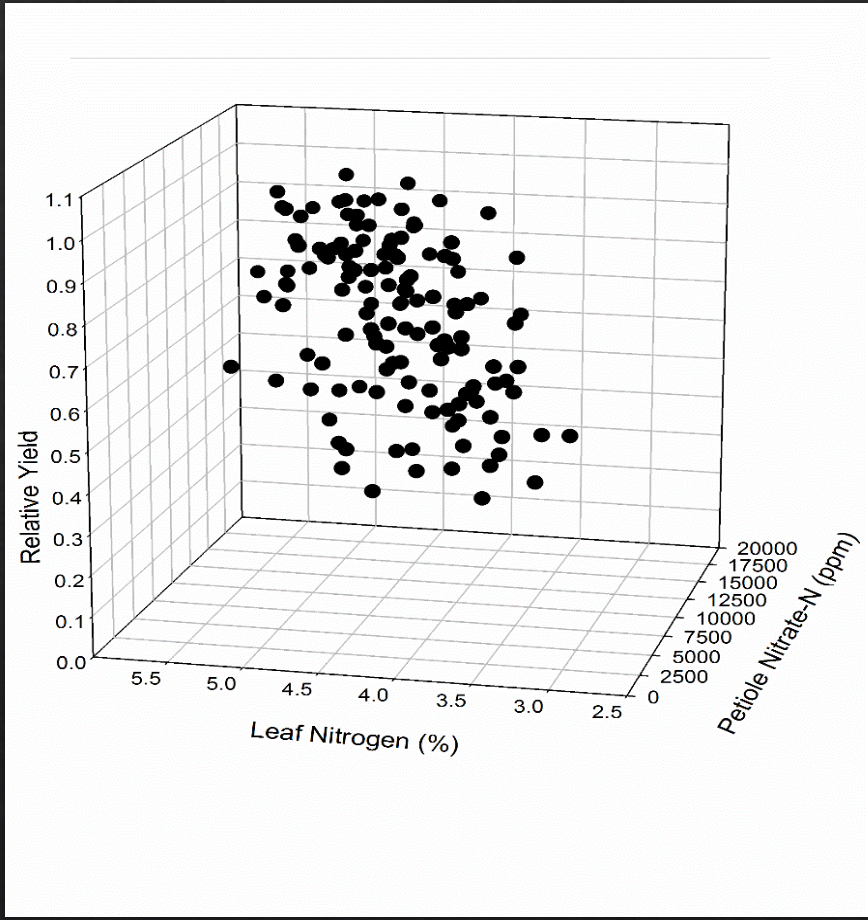


Using Tissue Testing For Nitrogen to Predict Lint Yield



Relative Yield, Petiole Nitrate-N, and Leaf Nitrogen during the 1st week of Bloom





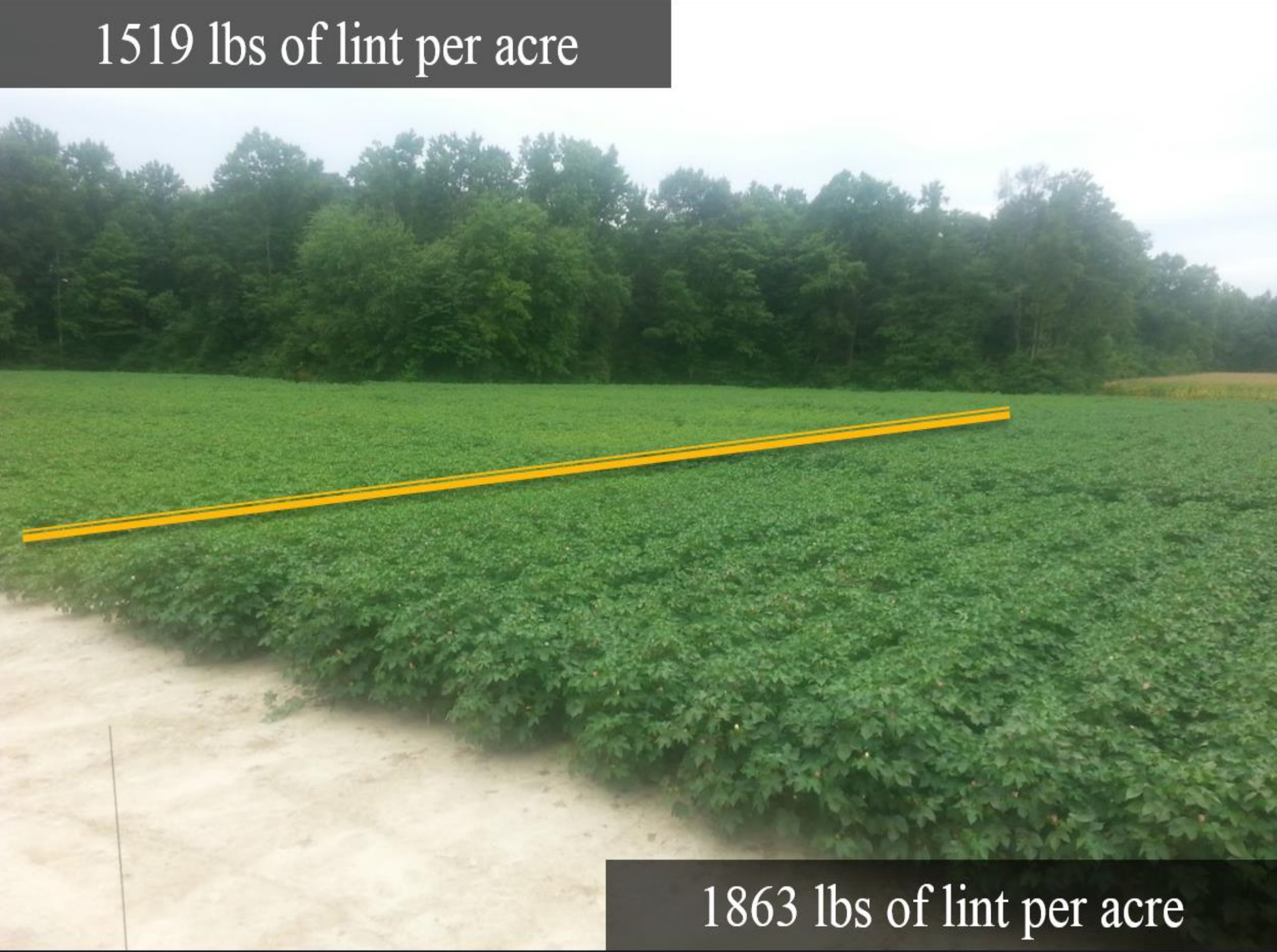
In-Season Management Scenarios

1. N Management System
   - Split vs Single Side-dress Application
   - Recommend 50 lbs N per acre per bale of expected yield
2. How much N has been applied at side-dressing?
   - 40-60 lbs N
   - 70+ lbs N
3. What were the results of the petiole and leaf analysis?
   - Leaf N?
     - 0 - 3.75%
     - 3.75 - 5.00%
   - Petiole Nitrate-N?
     - 0 - 4,500 ppm nitrate
     - 4,500 - 8,000 ppm
     - 8,000 + ppm

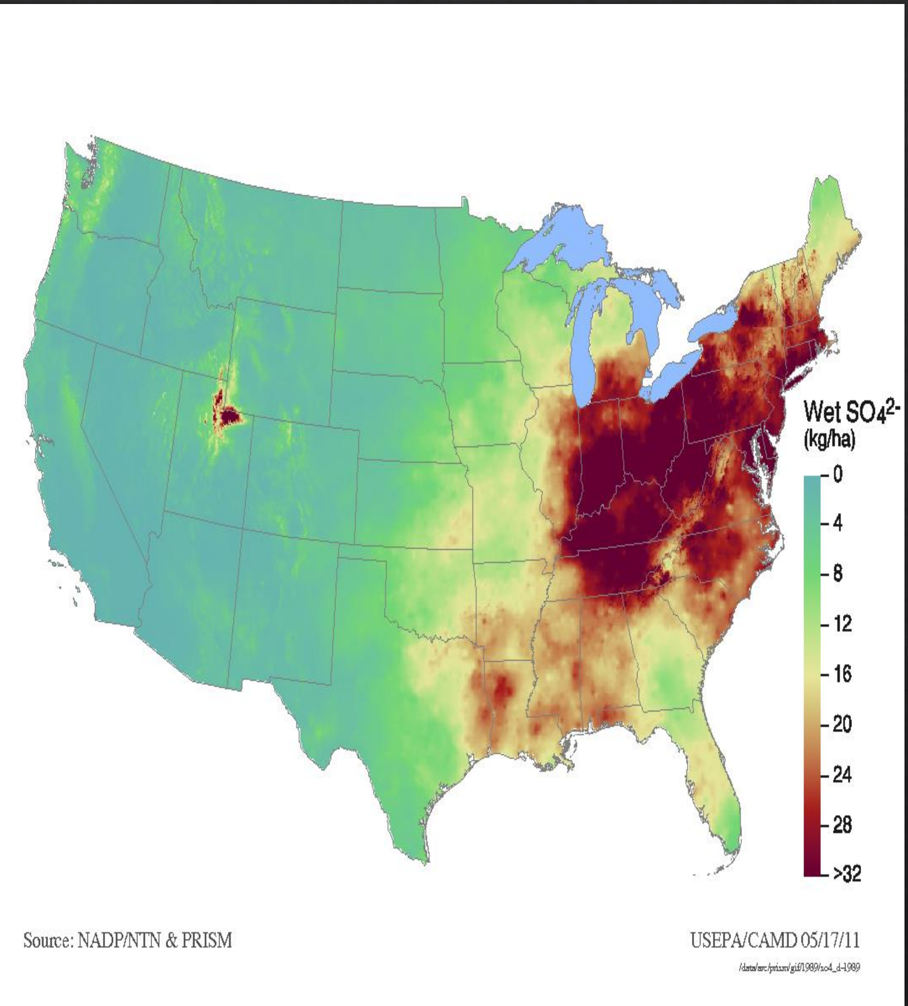
Making the Appropriate N Decisions

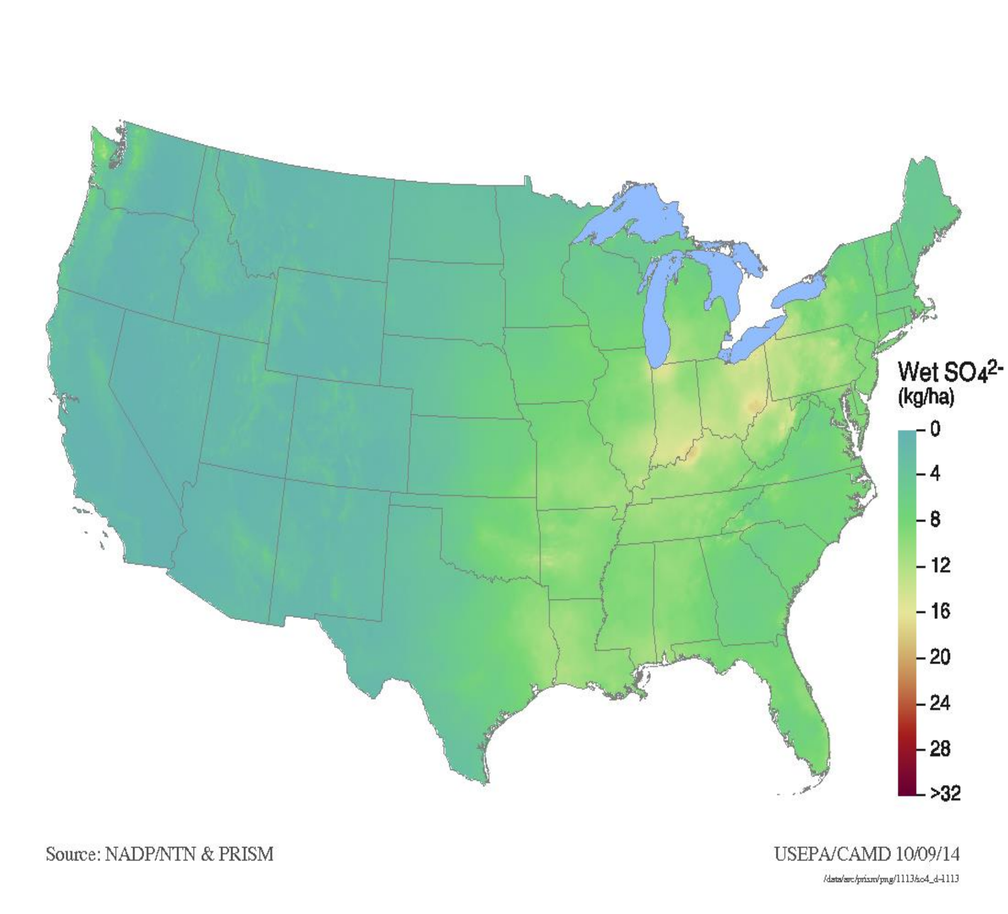
- Single Side-dress N Application System
  - 60 lbs N applied at MHS
  - Leaf N @ 1st bloom = 4.00%
  - Petiole Nitrate = 7,000 ppm
- This scenario is in the "gray area",
  - Take into account total applied N
    - 25 lbs or less = Apply an extra 20-30 lbs addition N per acre
    - 30 lbs or more = Most likely have enough N available to achieve yield goal.
- Weather conditions and early season stress will influence tissue analysis results
- Maybe not a "Two" Prong Approach… More like a 4-5!
- The earlier in the bloom period the better correlation to yield and gives more time to correct N problems!!!

Sulfur Management in Cotton


1519 lbs of lint per acre
1863 lbs of lint per acre

Apply Sulfur? Why?





1989

2014

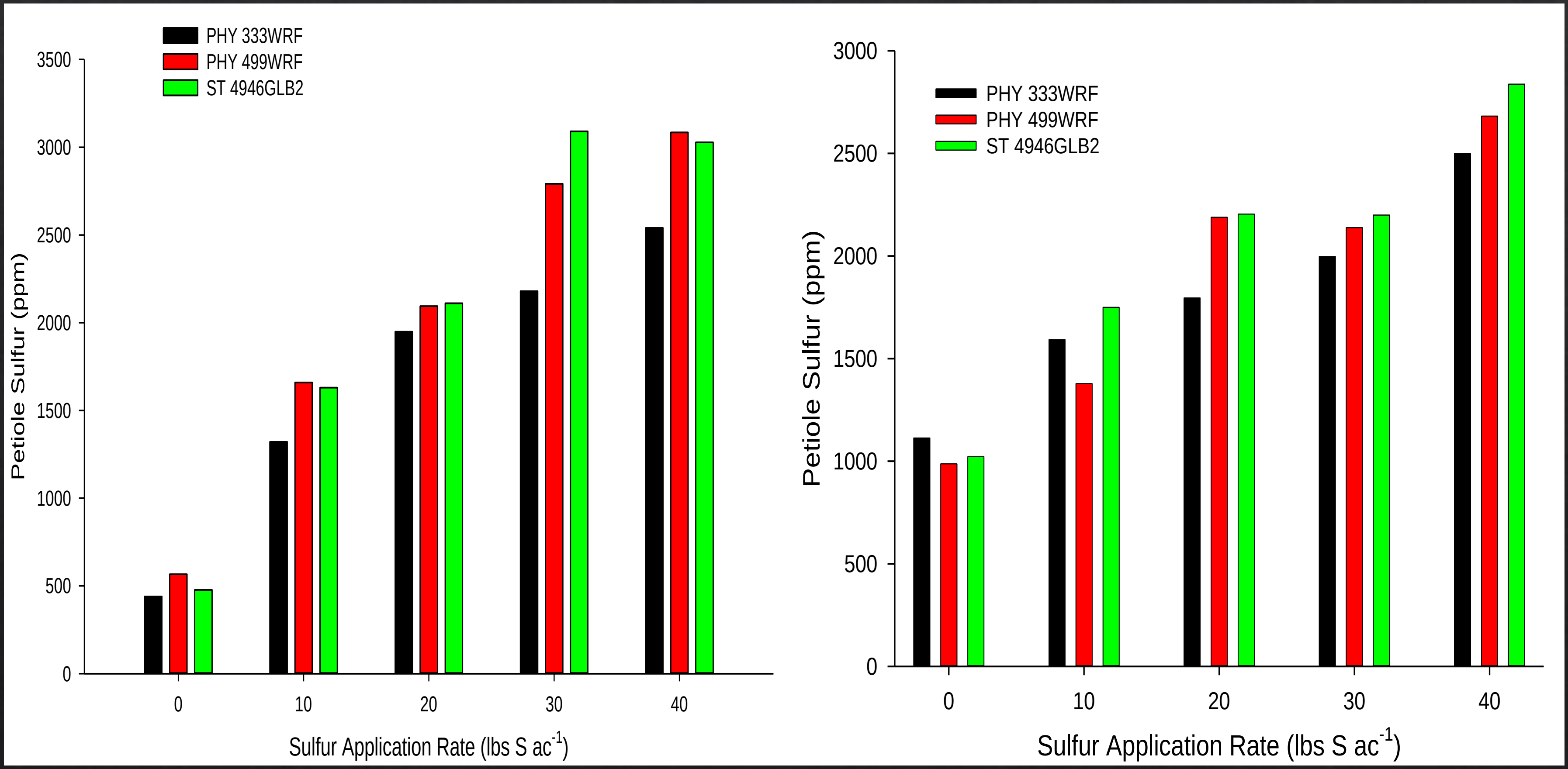
Retrieved from :http://www3.epa.gov/castnet/maps/prism/1113/so4_d-1113.png

Spatial Variability in Soil Testing For Sulfur

Petiole Sulfur Concentration, Application Rate, and Variety During the 1st Week of Bloom

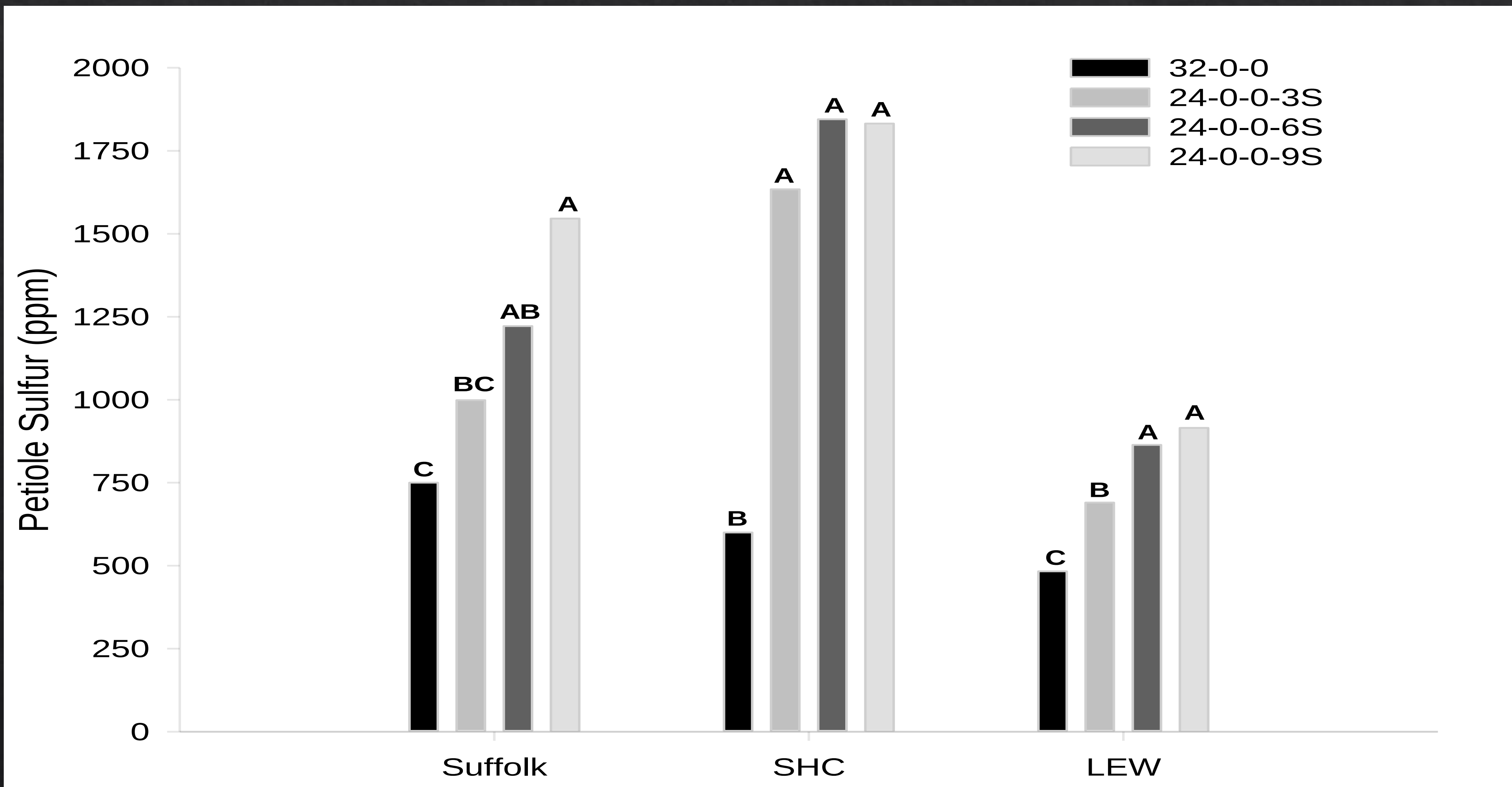
Location 1

Location 2

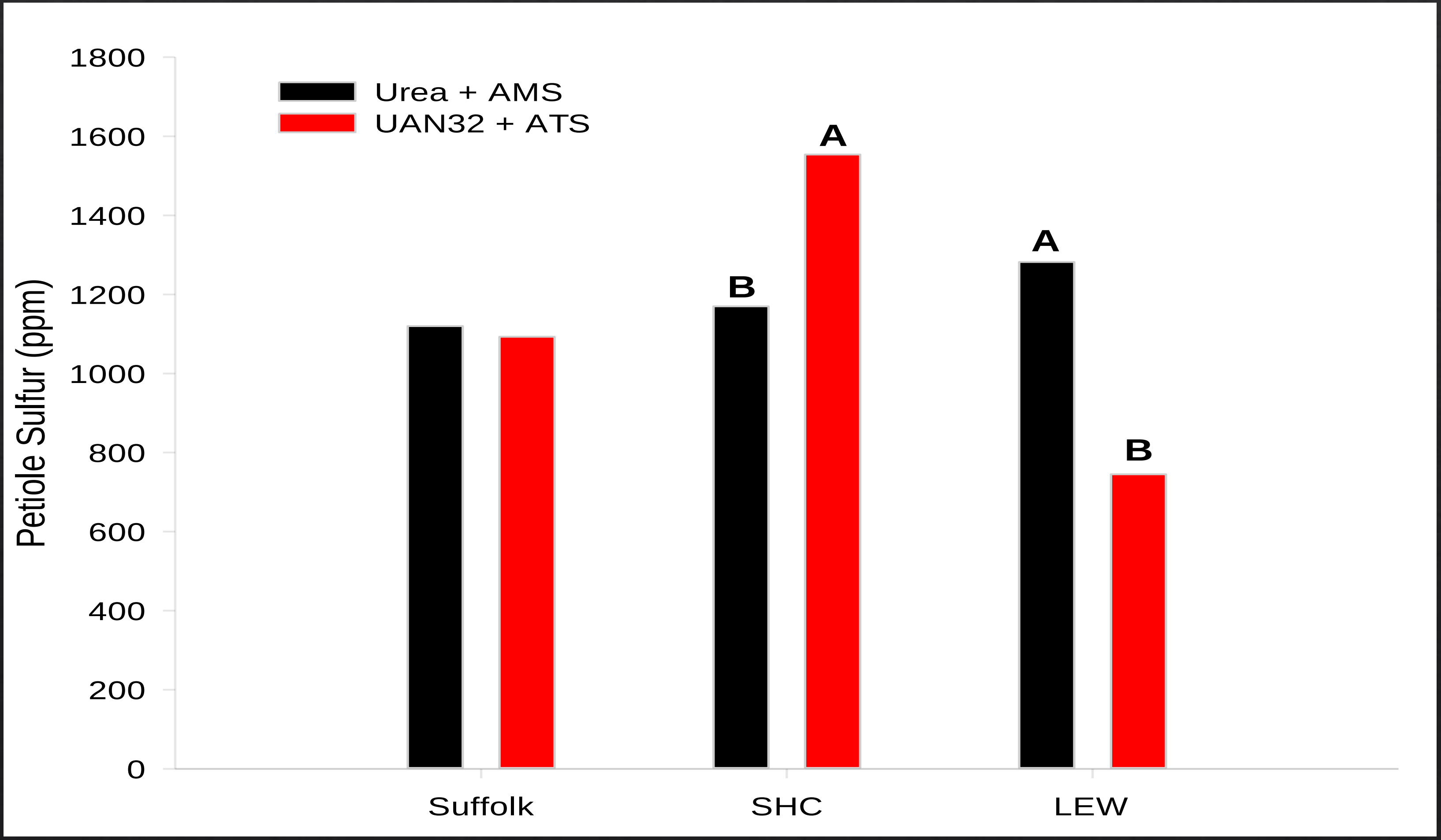


2016 Beltwide Cotton Conferences

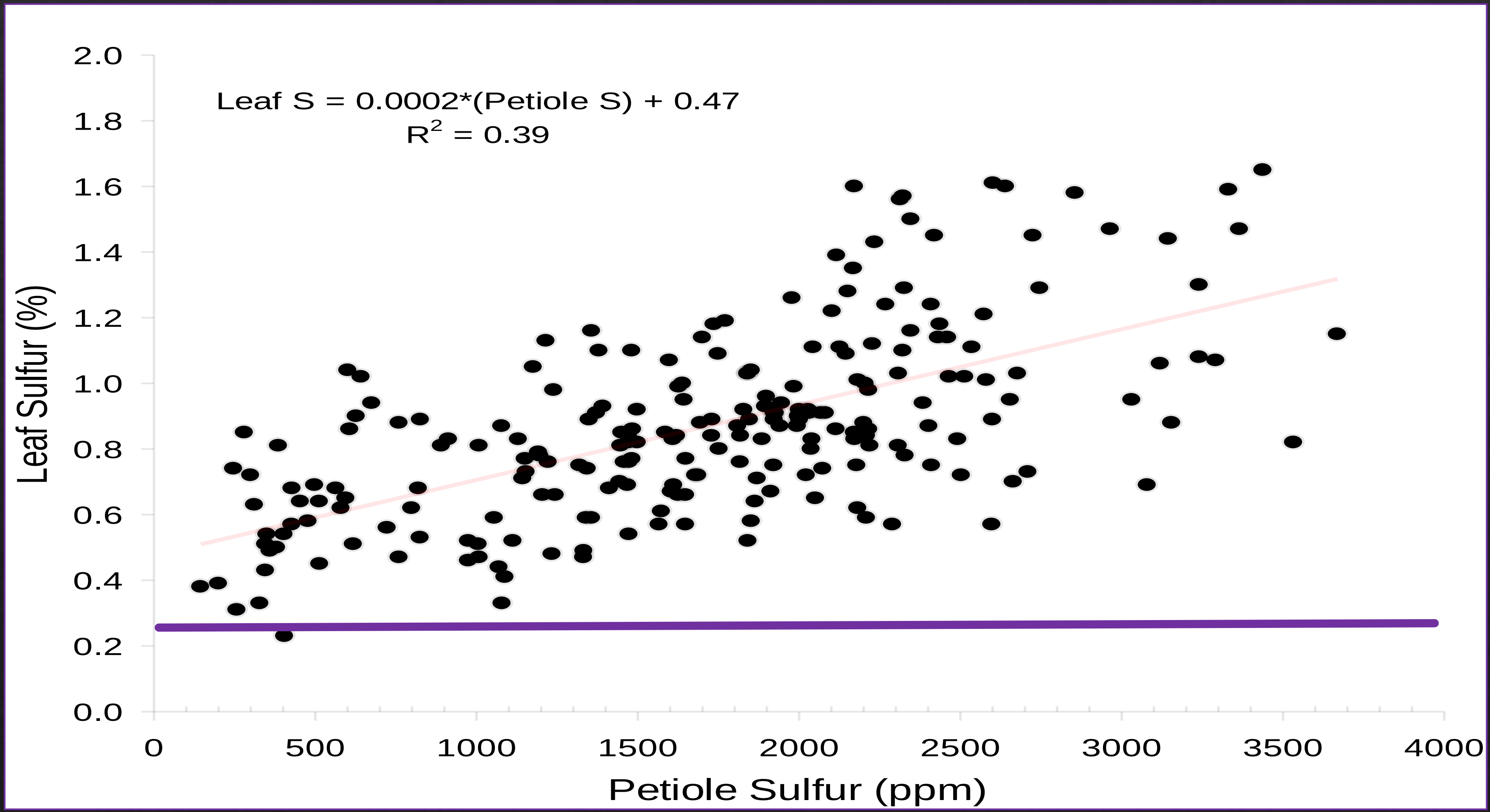
Petiole Sulfur for Fluid N/S Formulations



Petiole S concentration and Fertilizer Source

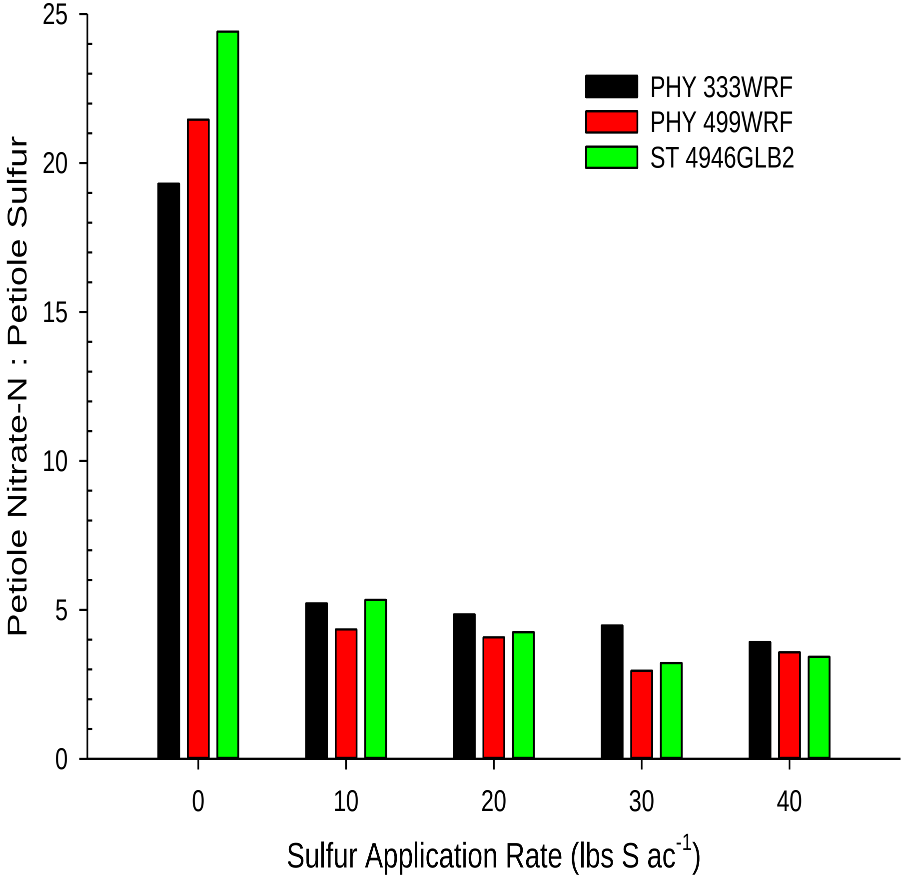


Sulfur Fertilization of Virginia Cotton

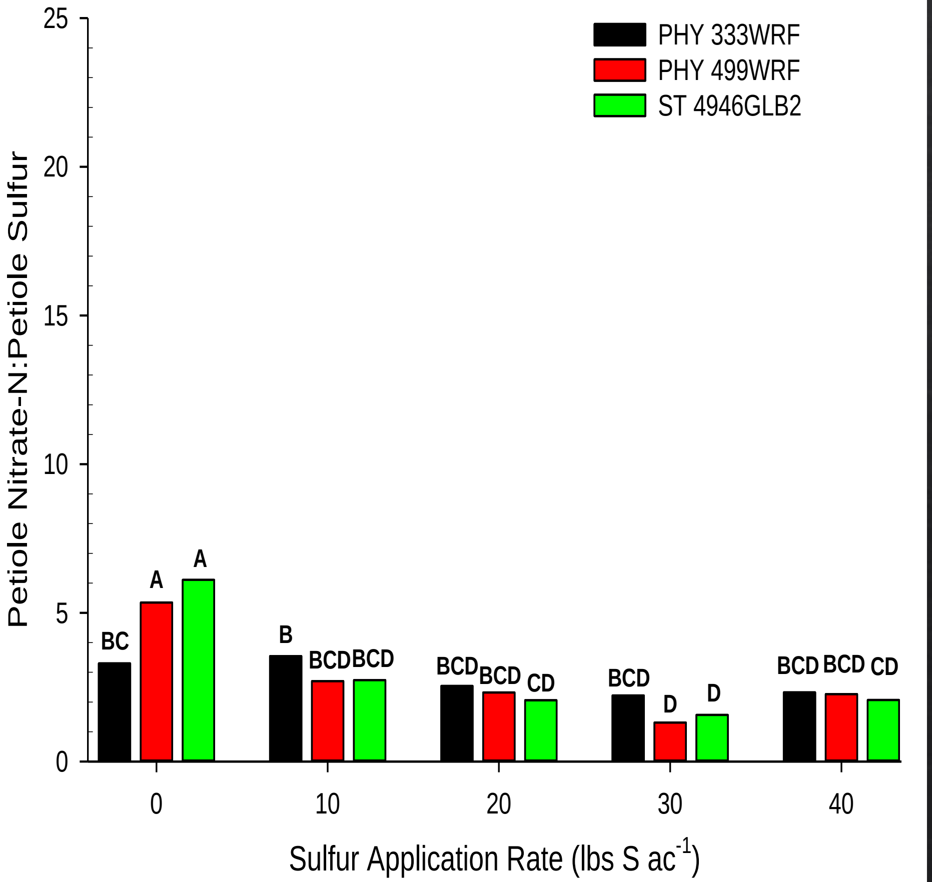


Ratio of Petiole Nitrate-N to Petiole S Concentrations

Location 1

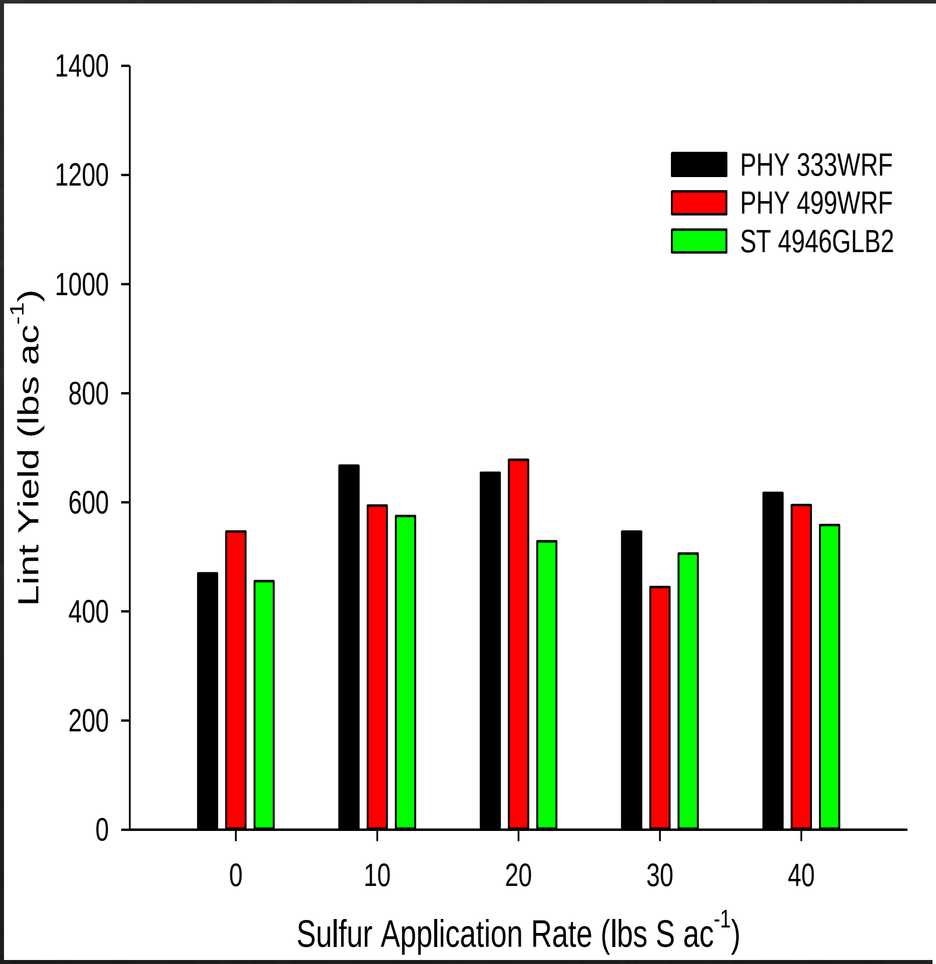


Location 2

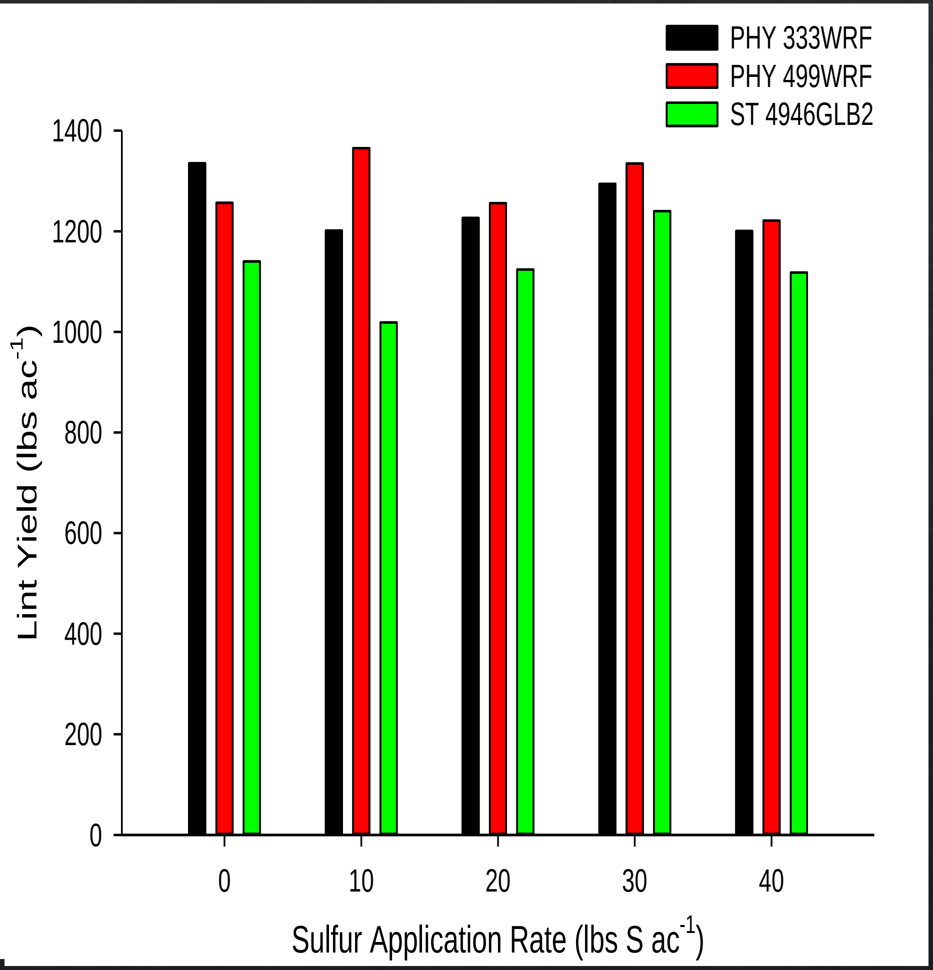


Variety and Sulfur Application Rate on Lint Yield in 2015

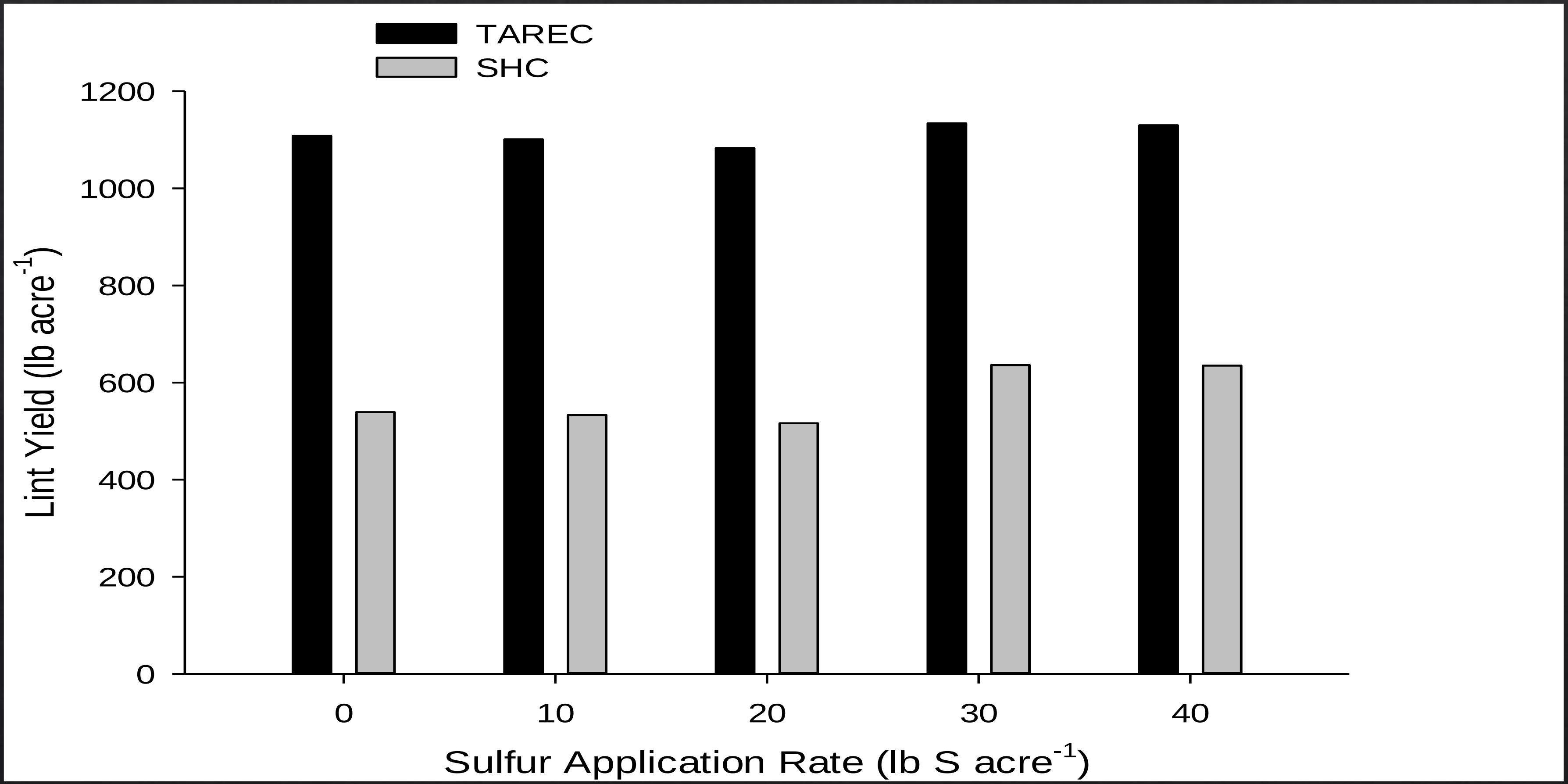
Location 1



Location 2

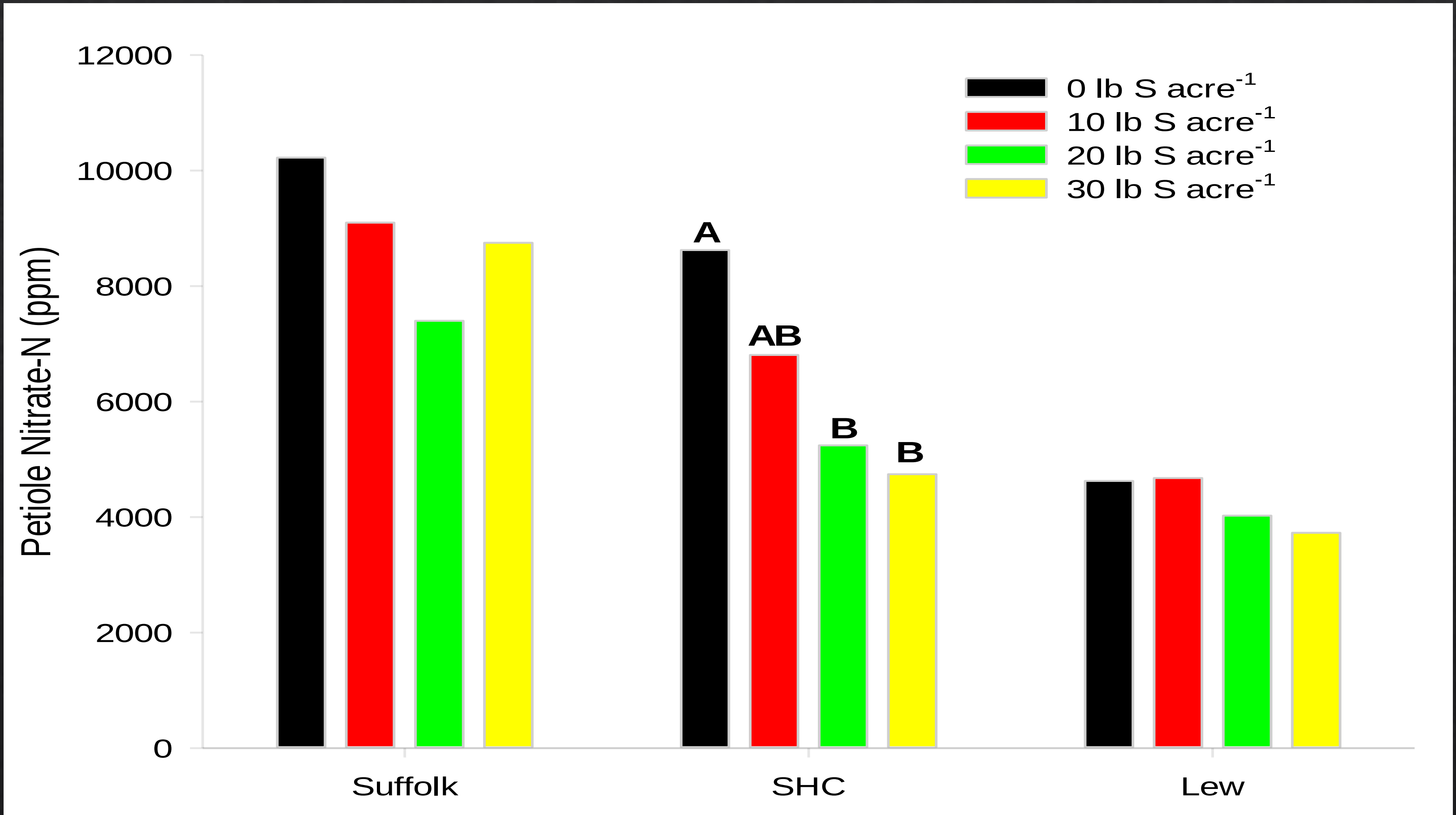


Variety and Sulfur Application Rate on Lint Yield in 2016

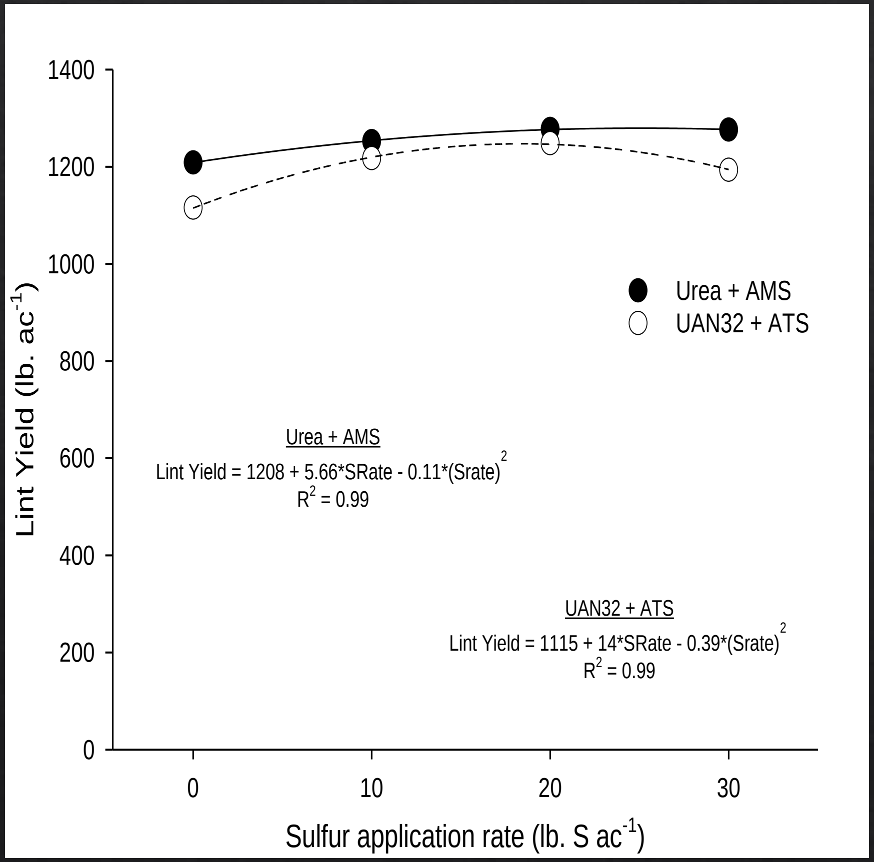


Nitrogen and Sulfur Interactions in Cotton…

Petiole Nitrate-N and Sulfur Rate During The 1st Week of Bloom

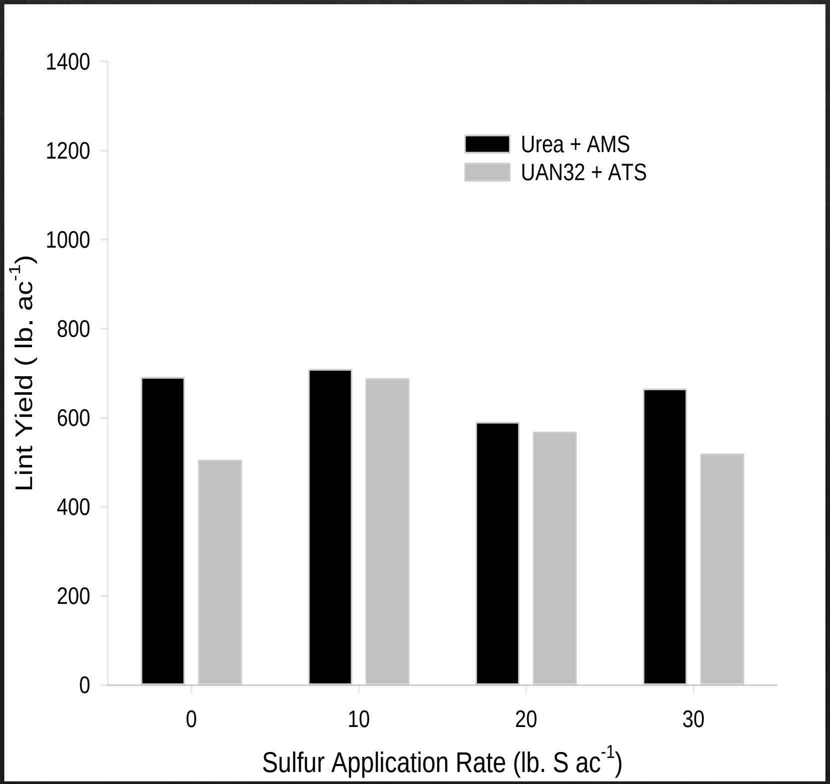


Lint yield and N/S Source
Suffolk, vA

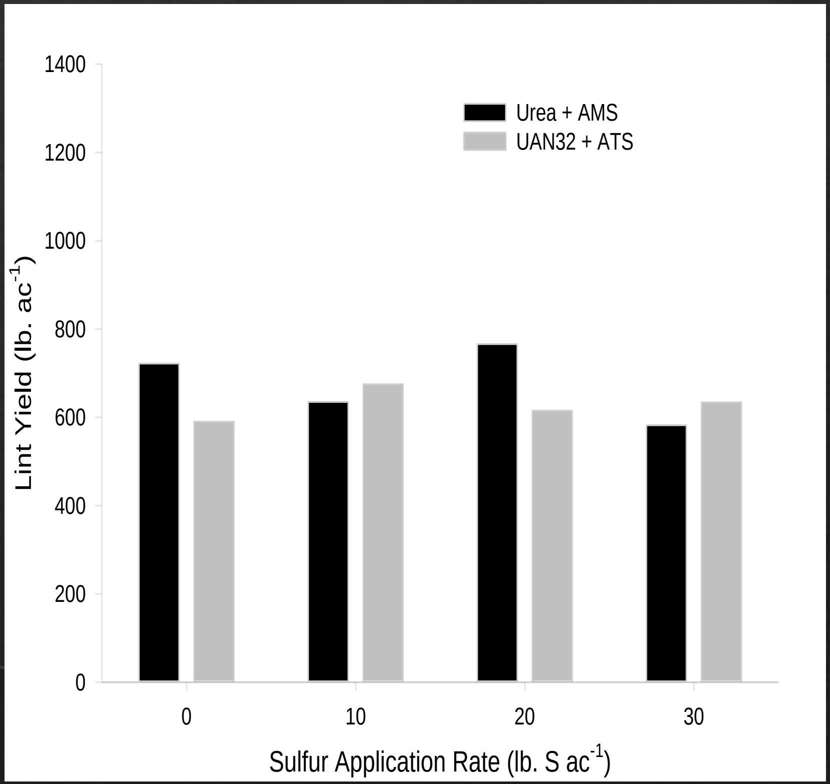


Lint yield and N/S Source

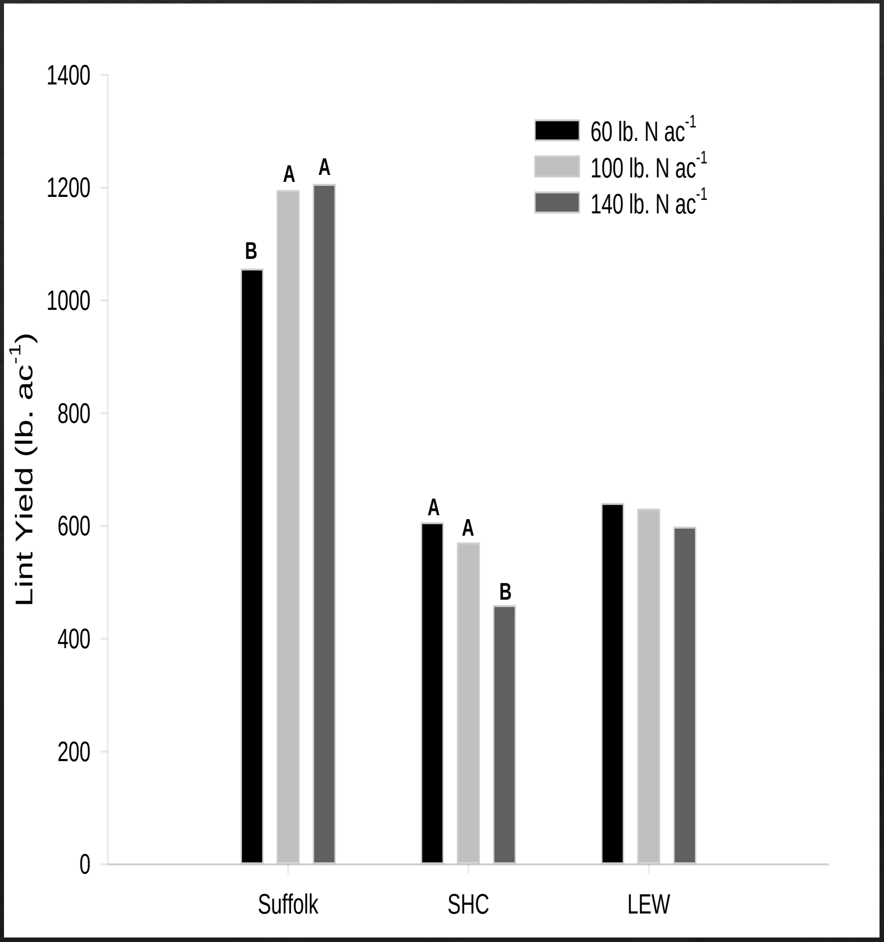
Southampton, VA

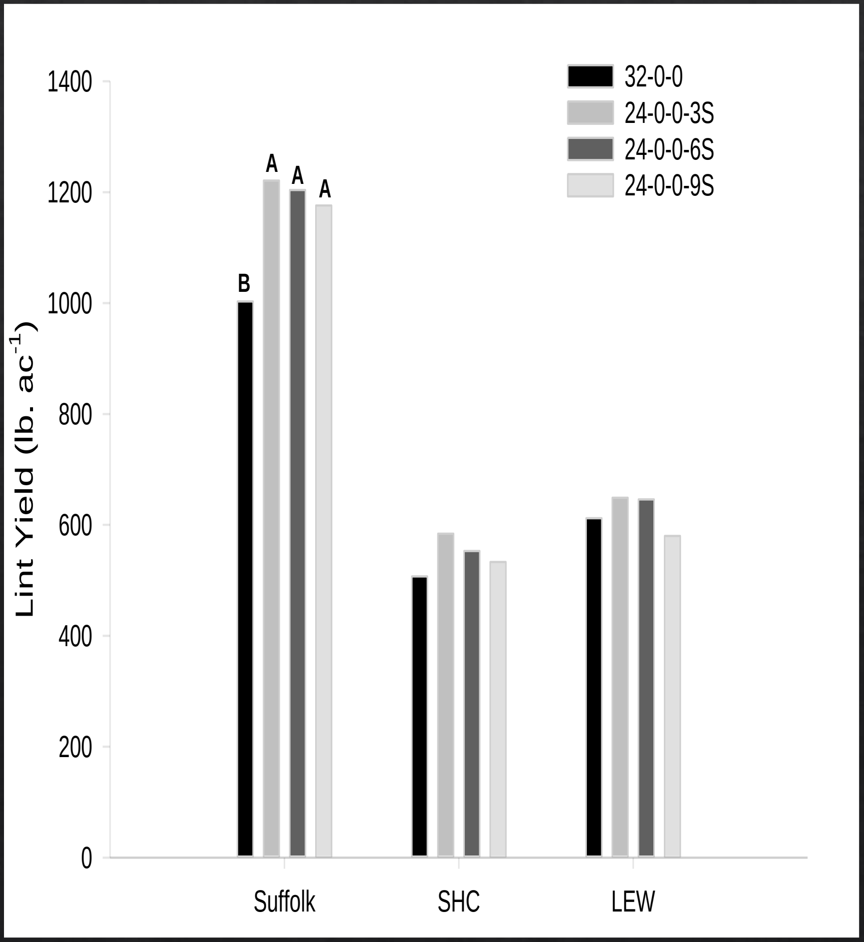


Lewiston, NC

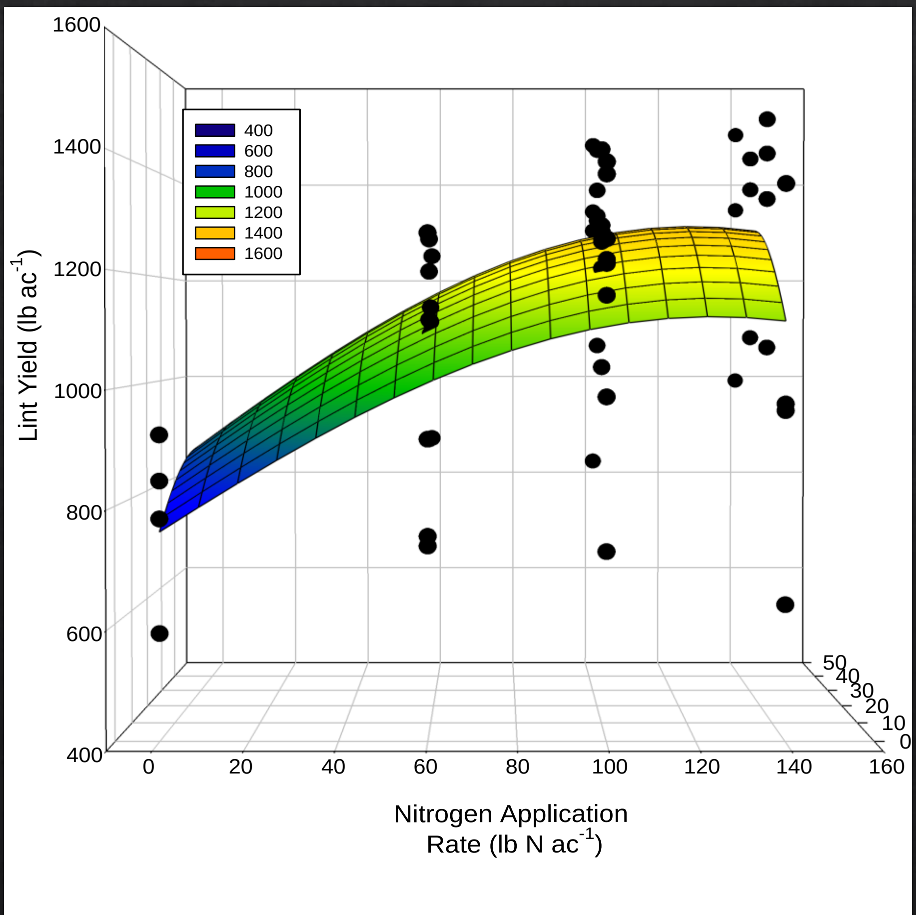


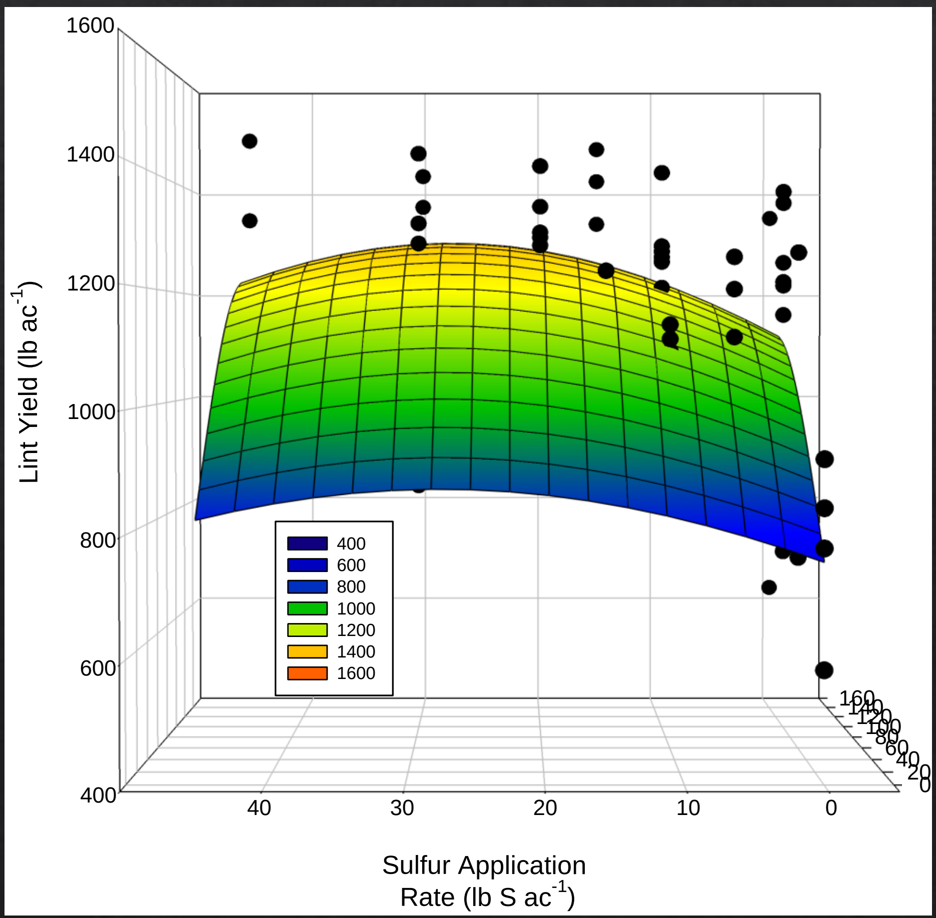
Fluid N/S Formulations and Lint Yield



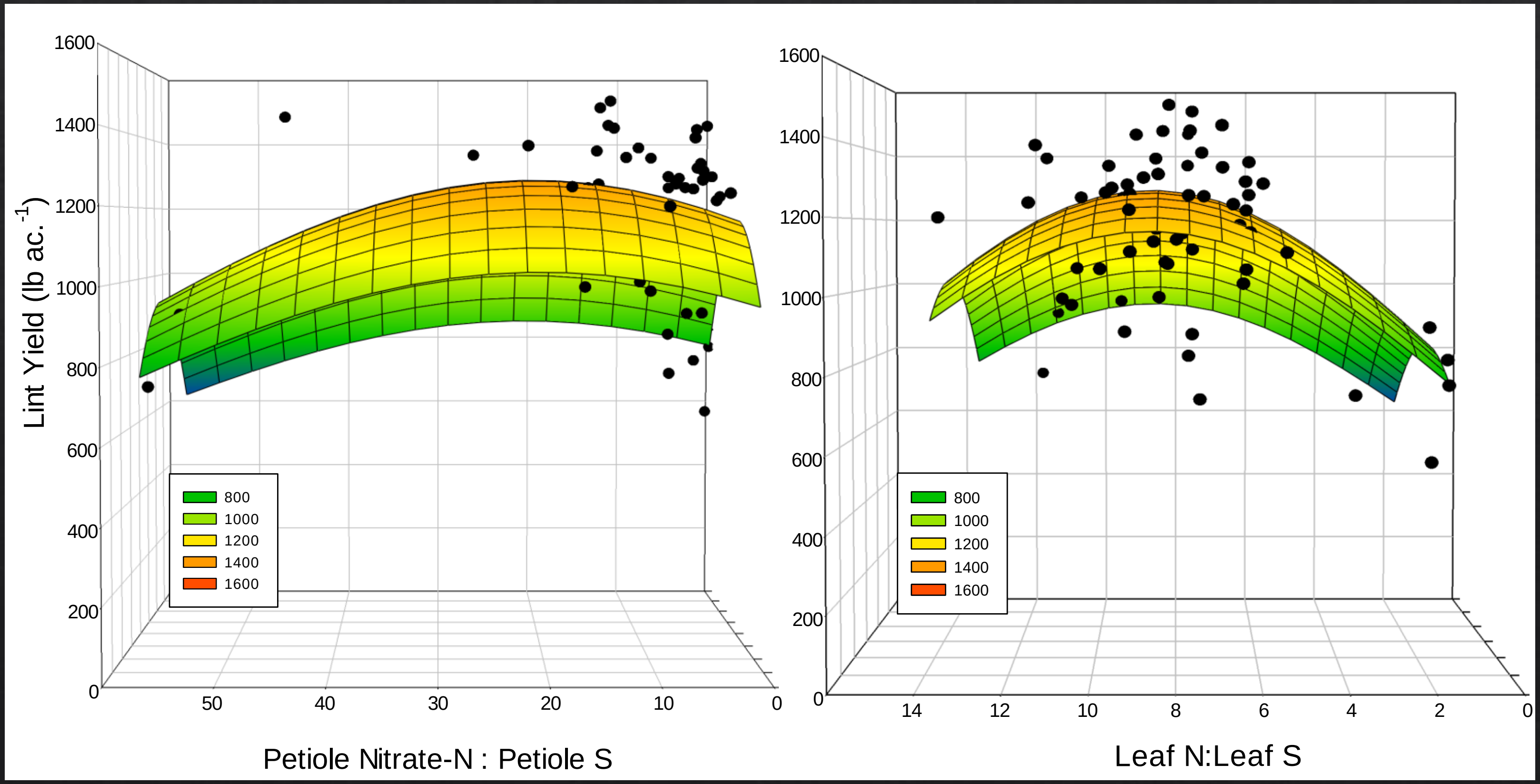


Nitrogen and sulfur Rates explaining Lint Yield at Tarec





Leaf and Petiole N:S and Lint Yield at TAREC



Summary

- High nitrogen application rates increased yields at high yielding locations and was detrimental to lint yields at low yielding sites.
  - When high N rates and high S rates were applied together excess growth made defoliation difficult.
  - N rate s between 80 -120 lb N per acre optimized lint yields at responsive sites
  - Critical petiole nitrate-N level of 4,500 ppm nitrate-N
- Petiole nitrate-N, petiole sulfur, leaf nitrogen, and leaf sulfur concentrations increased with increasing application rates.
- No current sufficiency range is documented for petiole sulfur concentrations
- Leaf Sulfur concentrations were above current critical levels of 0.25% during the first week of bloom even when no S was applied.
- 20 lb. S ac^{-1} maximized yield at the high yielding responsive site.
- At all locations 24-0-03S increased lint yields above 32-0-0 when averaged over nitrogen rates.
- Petiole Nitrate:S ratio was optimum between 10-20 and Leaf N:S was optimum at 8 at TAREC
- Differences in N/S source and application method
- Interactions between N and S in petiole nitrate-N and lint yield.