Foliar Fertilizer Use in Cotton Under Various Fertility Programs

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DEPARTMENT OF
PLANT AND SOIL SCIENCES

Introduction - Foliar Fertilization

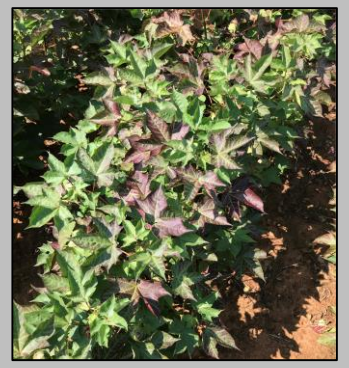
- Defined as the utilization of one or more mineral nutrients via foliar application to supplement traditional soil-applied fertilizers (Oosterhuis and Weir, 2010)
  - Successful fertilizer plan starts with a soil based fertilizer program (Westermann, 1990)
- Utilized in fruit and vegetable production (Oosterhuis and Weir, 2010)
  - Foliar fertilization research limited to high value horticulture crops (Fritz, 1978)
  - McCall and Davis, (1953) reported foliar applications to be more efficient than soil applications based on increased yield per unit of urea-N applied

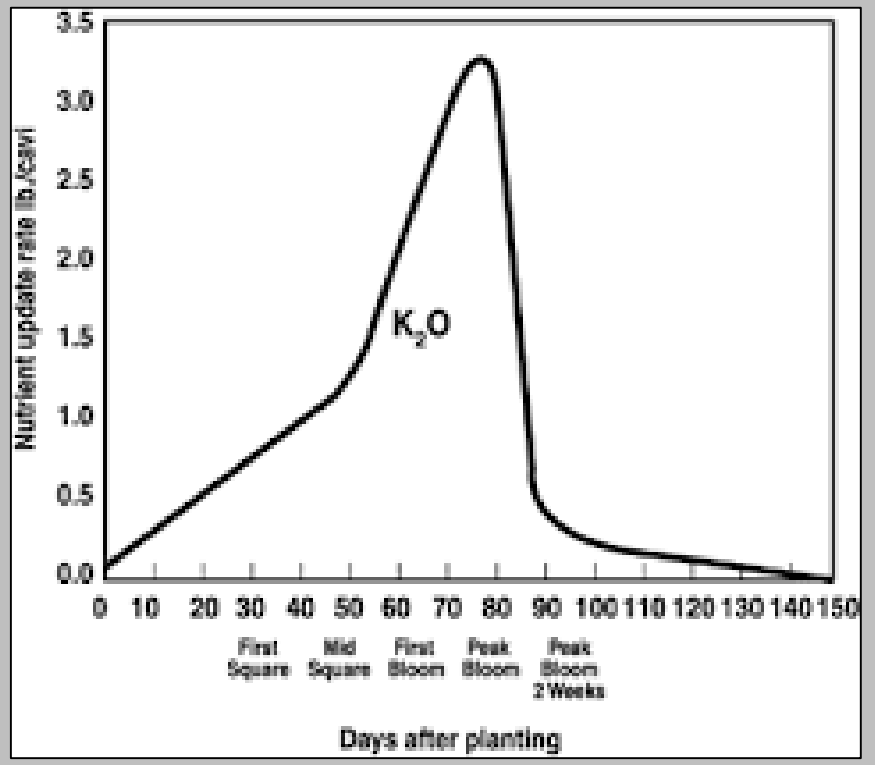
Introduction - Foliar Fertilization Use in Cotton

- Increased interest and use of foliar fertilizer applications over last 2 decades
  - New and improved cotton cultivars
    - Fruiting under shorter time periods (Wells and Meredith, 1984)
    - Growth-stage specific management, allowing for timely remedial applications (McConnell et al., 1995)
- Cotton nutrient uptake follows a seasonal pattern that varies with growth rate and stage (Basset et al., 1970)
  - Nutrient demand at this time may not always be met by the soil
    - Soil applied nutrients subject to losses (Bednarz et al., 1998)
    - Foliar fertilization to relieve physiological stresses has potential (Gray and Akin, 1984)
- Foliar nutrients applied in cotton
  - Traditionally nitrogen and boron foliar application utilized throughout cotton belt (Hake and Kerby, 1988)
  - Potassium foliar applications have become increasingly popular to correct late season deficiencies (Oosterhuis, 1995b)

Plant Nutrition

- Cotton Daily Nutrient Requirements During Peak Demand of K
  - Potassium
    - 1.7 to 4.5 lb K/ac
    - K uptake is dramatically increased as boll set begins (Halevy, 1976)





Mullins and Burmester, 1991

Foliar Fertilization - Cons

- Response to fertilizers is often temporary
  - Multiple applications may be needed (Oosterhuis and Weir, 2010)
- Risk of phytotoxicity
  - Applying large amounts of (N,P, and K) (Havlin et al., 1990)
- Efficacy dependent upon:
  - Environment, crop condition, plant water status (Oosterhuis and Weir, 2010)
- Silvertooth et al., (1998) reported no increased growth, or increased tissue nutrient concentration of mixed foliar fertilizers (S, B, Mg, Mn, Zn, Cu, Fe)

Macronutrient	Maximum Uptake Rate (per day) (lb)
Nitrogen	1.87
Phosphorus	0.62
Potassium	2.86
Sulfur	0.71
Calcium	2.3
Magnesium	0.62
Micronutrient	**Maximum Uptake Rate (per day) (g)**
Iron	9.7
Manganese	2.6
Boron	2.6
Copper	0.36
Zinc	1.5

Rochester et al., 2012

Objectives

- Investigate nutrient uptake in cotton of foliar products under various fertility levels
- Short term impact of foliar applications on cotton growth, and development
- Long term impacts of foliar applications on cotton yield
- Hypothesis – Greater responses to foliar fertilizers under reduced soil-applied fertility programs

Material and Methods - Foliar Products

- Foliar K – (0-0-24)
  - 3.2 lb K/ac
- Foliar P – (4-14-5-0.05Cu-0.7Zn)
  - .20 lb N/ac - .71 lb P/ac - .25 lb k/ac - .0025 lb Cu/ac - .035 lb Zn/ac
- Foliar Mix - (10 - 8 - 8 – 2S - 0.25B - 0.06Cu - 0.25Mn - 0.25Zn)
  - 1.10 lb N/ac - .88 lb P/ac - .88 lb K/ac - .20 lb S/ac - .0025 lb B/ac - .00059 lb Cu/ac
- Foliar Macro/Secondary – 10-0-0-4Ca-0.8Mg-1.2Zn
  - 1.09 lb N/ac - .45 lb Ca/ac - .08 lb Mg/ac - .13 lb Zn/ac
- Foliar Micro - (4 – 0 – 0 – 1S – 0.8B – 1.2Cu – 2Mn – 3Zn)
  - .42 lb N/ac - .10 lb S/ac - .084 lb B/ac - .12 lb Cu/ac - .21 lb Mn/ac - .31 lb Zn/ac

Material and Methods

- Location: Fort Cobb, OK and Lubbock, TX 2019
- Variety: PHY 300 W3FE
  - Irrigated: Center pivot
  - Base Fert. App: 28 May 2019
  - Planting Date: 6 June 2019
  - Soil Type: Binger fine sandy loam
- Application 1: 31 July 2019
- Application 2: 21 Aug 2019
- Spray Volume : 10 gal/ac
- Plant Sample Date 1: Early bloom
  - 7 Aug 2019
- Plant Sample Date 2: 50-60% open
  - 8 October 2019
- Plot Dimensions
  - 4 – 3 ft x 30 ft
  - 4 Replications
  - Randomized Complete Block Design

Treatment	Pre-Plant App. (N/P/K/S) (lb/ac)	Late Squaring App.	Peak Bloom App.
NTC	0/0/0/0	N/A	N/A
Residual Soil Test Levels (RSTL)	120/0/0/0	N/A	N/A
100% Soil Test Levels (STL)	120/50/45/12	N/A	N/A
125% Soil Test Levels (STL)	120/84/68/20	N/A	N/A
100% + Foliar K	120/50/45/12	1.25 gal/ac	1.25 gal/ac
100% + Foliar P	120/50/45/12	0.5 gal/ac	0.5 gal/ac
100% + Macro/Secondary	120/50/45/12	1.0 gal/ac	1.0 gal/ac
100% + Micro	120/50/45/12	1.0 gal/ac	1.0 gal/ac
100% + Mix	120/50/45/12	1.0 gal/ac	1.0 gal/ac
RSTL + Foliar K	120/0/0/0	1.25 gal/ac	1.25 gal/ac
RSTL + Foliar P	120/0/0/0	0.5 gal/ac	0.5 gal/ac
RSTL + Macro/Secondary	120/0/0/0	1.0 gal/ac	1.0 gal/ac
RSTL + Micro	120/0/0/0	1.0 gal/ac	1.0 gal/ac
RSTL + Mix	120/0/0/0	1.0 gal/ac	1.0 gal/ac

Material and Methods

- Location: Fort Cobb, OK and Lubbock, TX 2019
- Variety: DP 1747NR B2XF
  - Irrigated: Furrow
  - Base Fert. App: 13 May 2019
  - Planting Date: 6 June 2019
- Application 1: 17 July 2019
- Application 2: 07 Aug 2019
- Spray Volume : 10 gal/ac
- Plant Sample Date 1: Early bloom
  - 24 July 2019
- Plant Sample Date 2: 50-60% open
  - 8 October 2019
- Plot Dimensions
  - 4 – 3 ft x 30 ft
  - 4 Replications
  - Randomized Complete Block Design

Treatment	Pre-Plant App. (N/P/K/S) (lb/ac)	Late Squaring App.	Peak Bloom App.
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100% + Micro	120/50/45/12	1.0 gal/ac	1.0 gal/ac
100% + Mix	120/50/45/12	1.0 gal/ac	1.0 gal/ac
~~RSTL + Foliar K~~	~~120/0/0/0~~	~~1.25 gal/ac~~	~~1.25 gal/ac~~
~~RSTL + Foliar P~~	~~120/0/0/0~~	~~0.5 gal/ac~~	~~0.5 gal/ac~~
~~RSTL + Macro/Secondary~~	~~120/0/0/0~~	~~1.0 gal/ac~~	~~1.0 gal/ac~~
~~RSTL + Micro~~	~~120/0/0/0~~	~~1.0 gal/ac~~	~~1.0 gal/ac~~
~~RSTL + Mix~~	~~120/0/0/0~~	~~1.0 gal/ac~~	~~1.0 gal/ac~~

Material and Methods

- Data Collection
  - Plant Destructive Sampling data
    - 2 plants per plot sampled 7 – 10 DAA 1st foliar app.
      - Plant Measurements (H, N, NAWF)
      - Plants partitioned into leaf, reproductive structures (squares, flowers, bolls), and reproductive stems
        - Fresh and dry weights collected from each plant part partitioned
        - Plant tissue was ground using forage grinder for tissue nutrient concentration analysis
    - 2 plants per plot sampled after 2nd foliar app. @ 60% open boll
      - Partitioned into leaf, reproductive structures (closed bolls, open bolls), and reproductive stems
      - Open bolls ginned – seed, lint, and bracts & burrs ground for tissue analysis
      - Leaf, and stems – ground and sent for tissue analysis

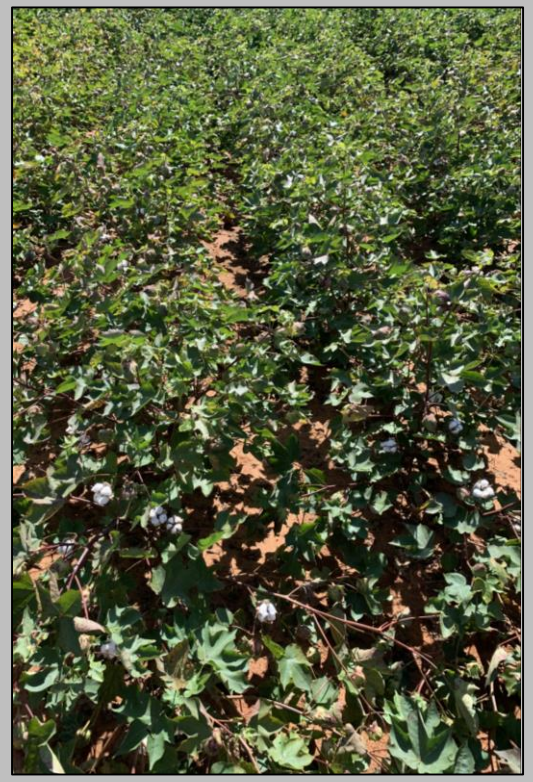
Material and Methods – Harvest Measurements

- Height, NFFB, NUCB, NUHB, and total nodes
  - Open and closed bolls counted in each plot (3.1 m of row)
- Seedcotton yield from each plot
- Whole plot ginned
  - Lint yield

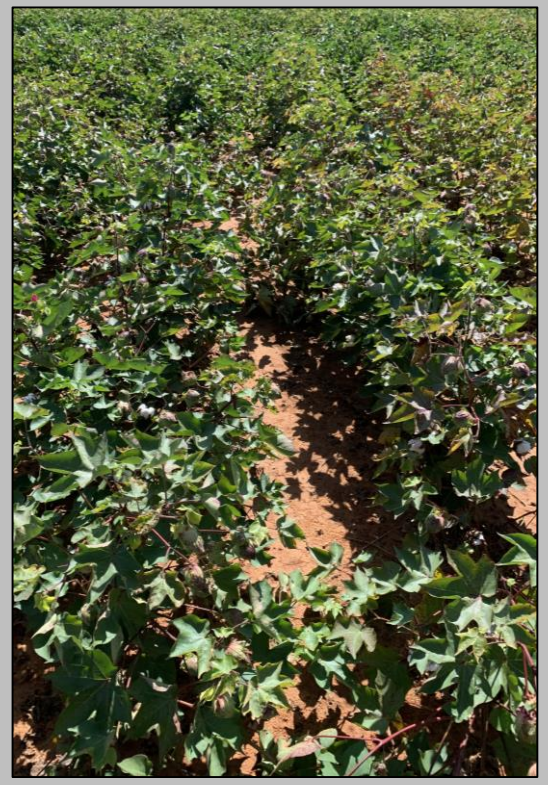
- Data Analysis:
  - Data subjected to ANOVA using PROC MIXED
  - Means were separated using Fisher's Protected LSD at $\alpha = 0.05$
  - SAS v. 9.4

2019 Results – Fort Cobb, OK

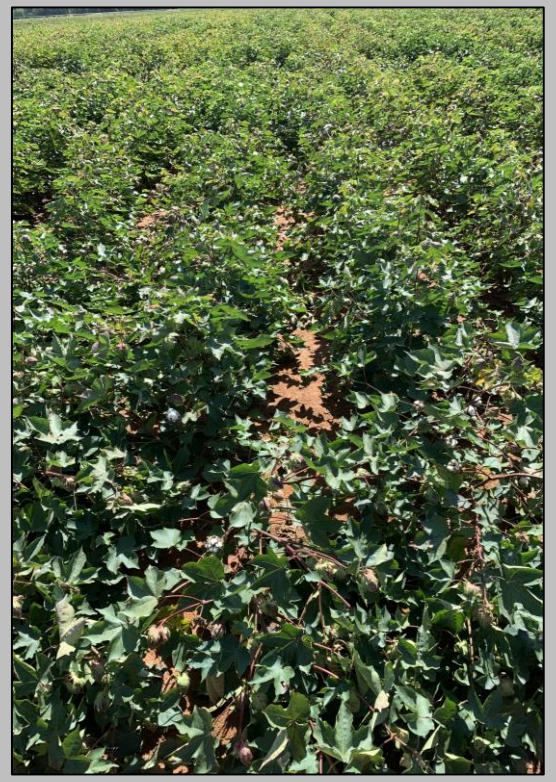
NTC



RSTL

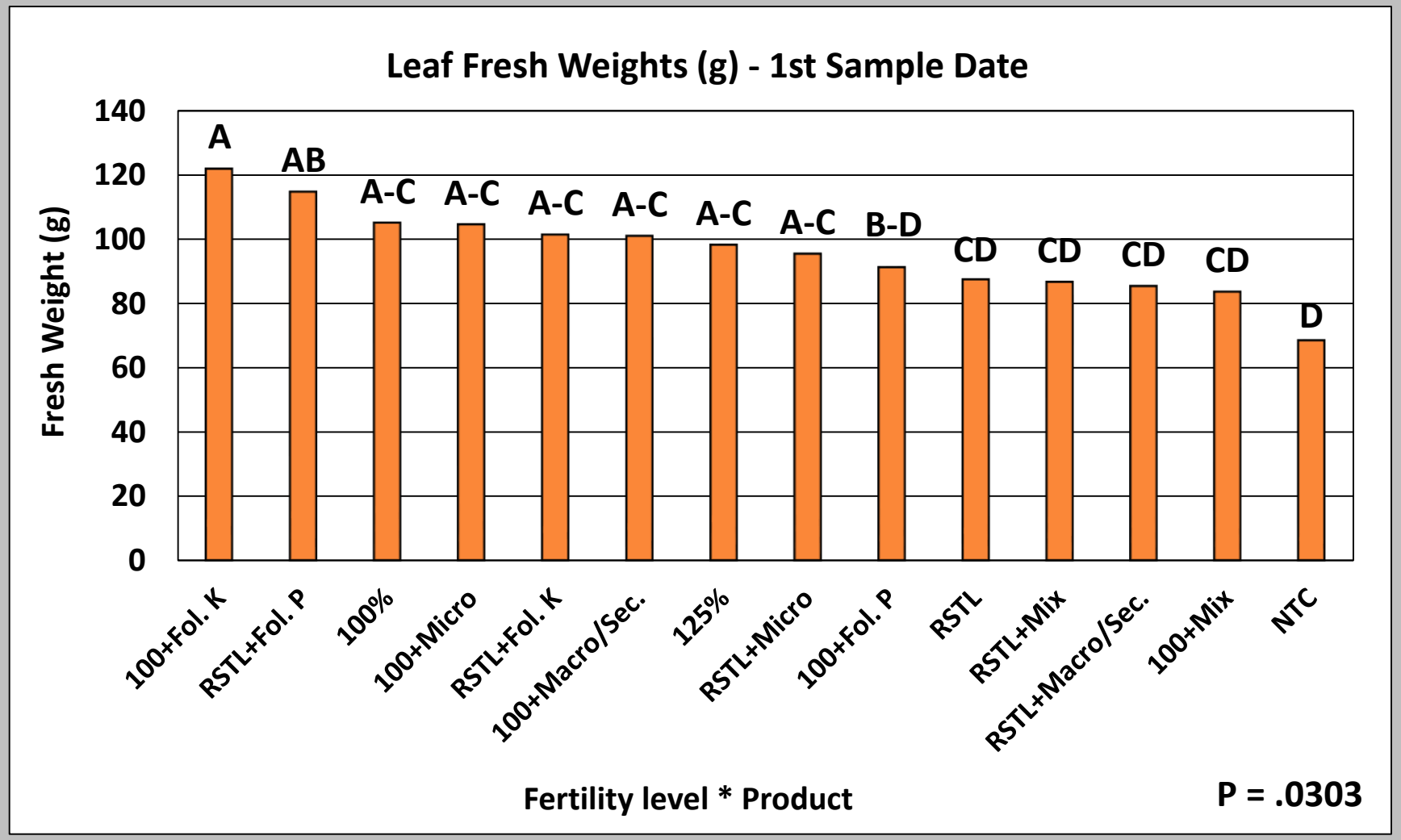


100%

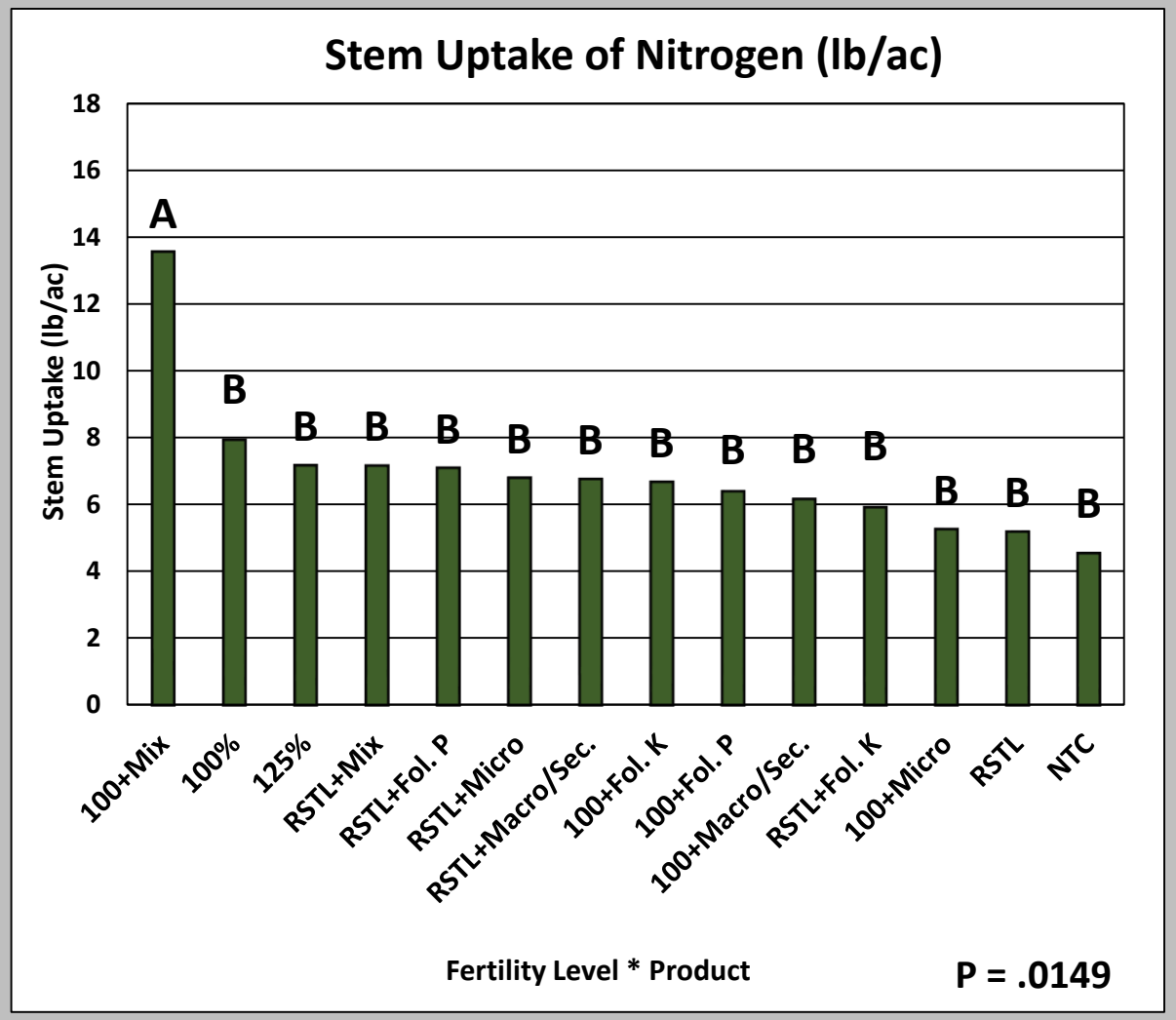


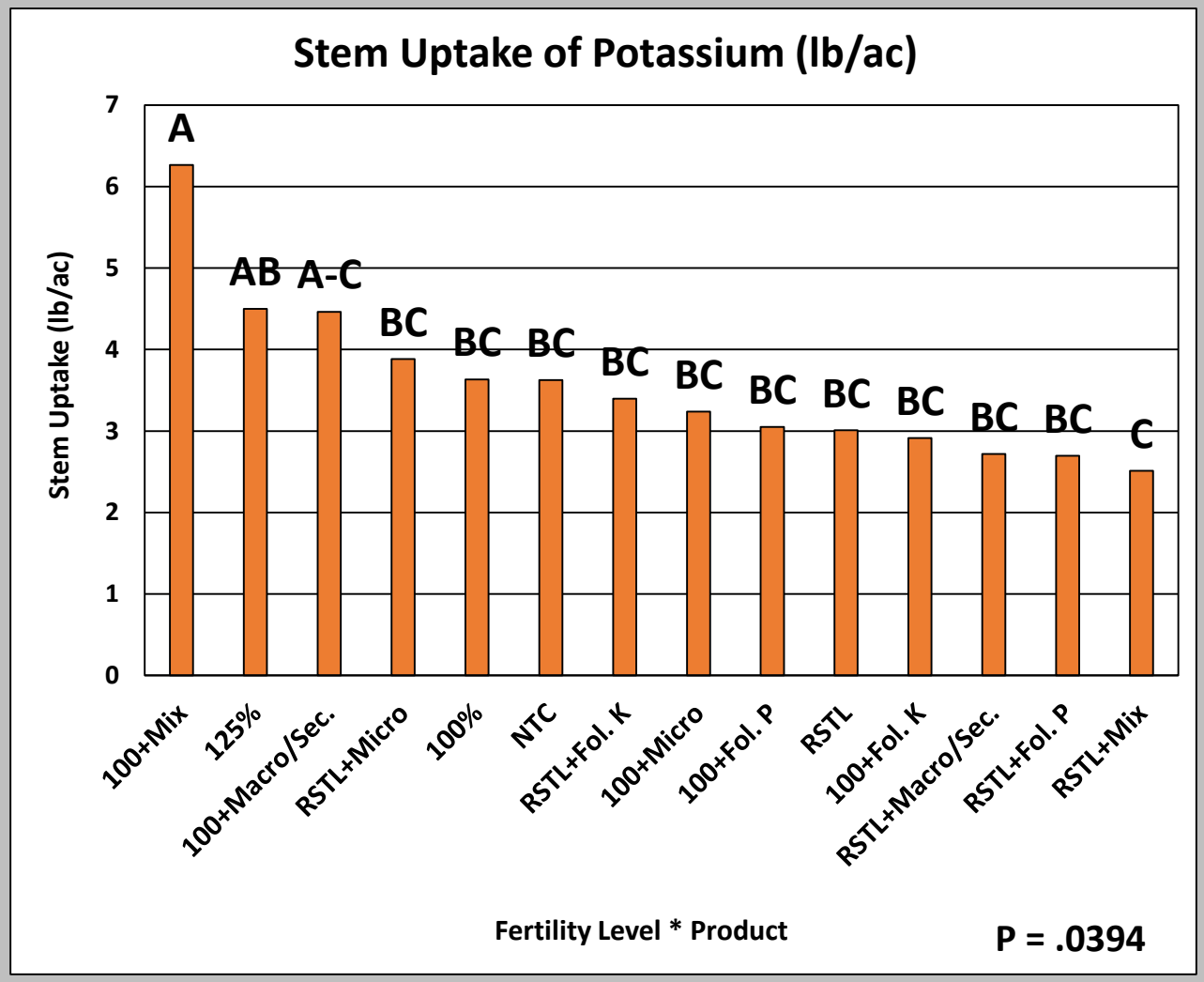
100% + Foliar Mix

1st Plant Destructive Sampling Date



2nd Destructive Sampling Date





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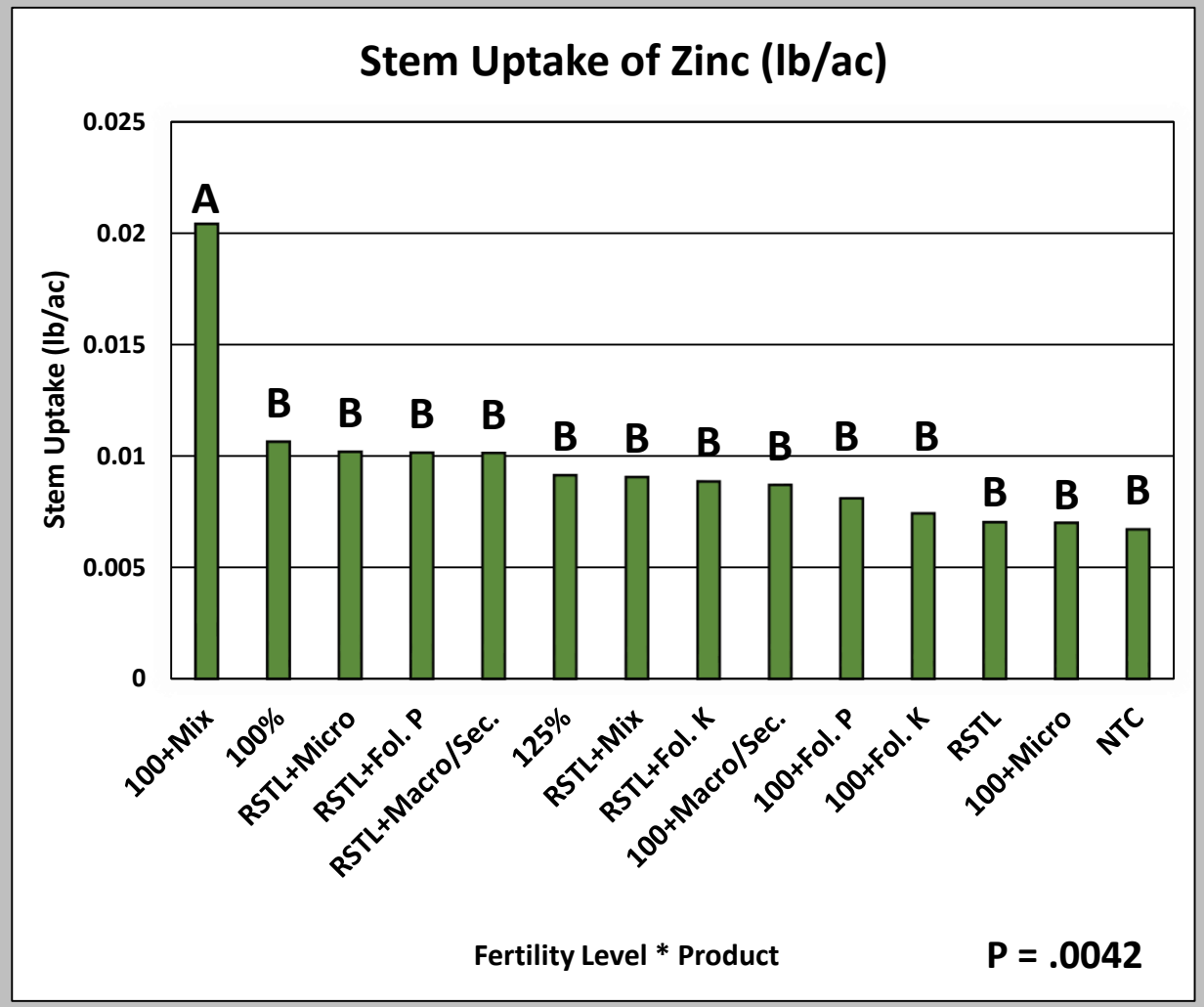
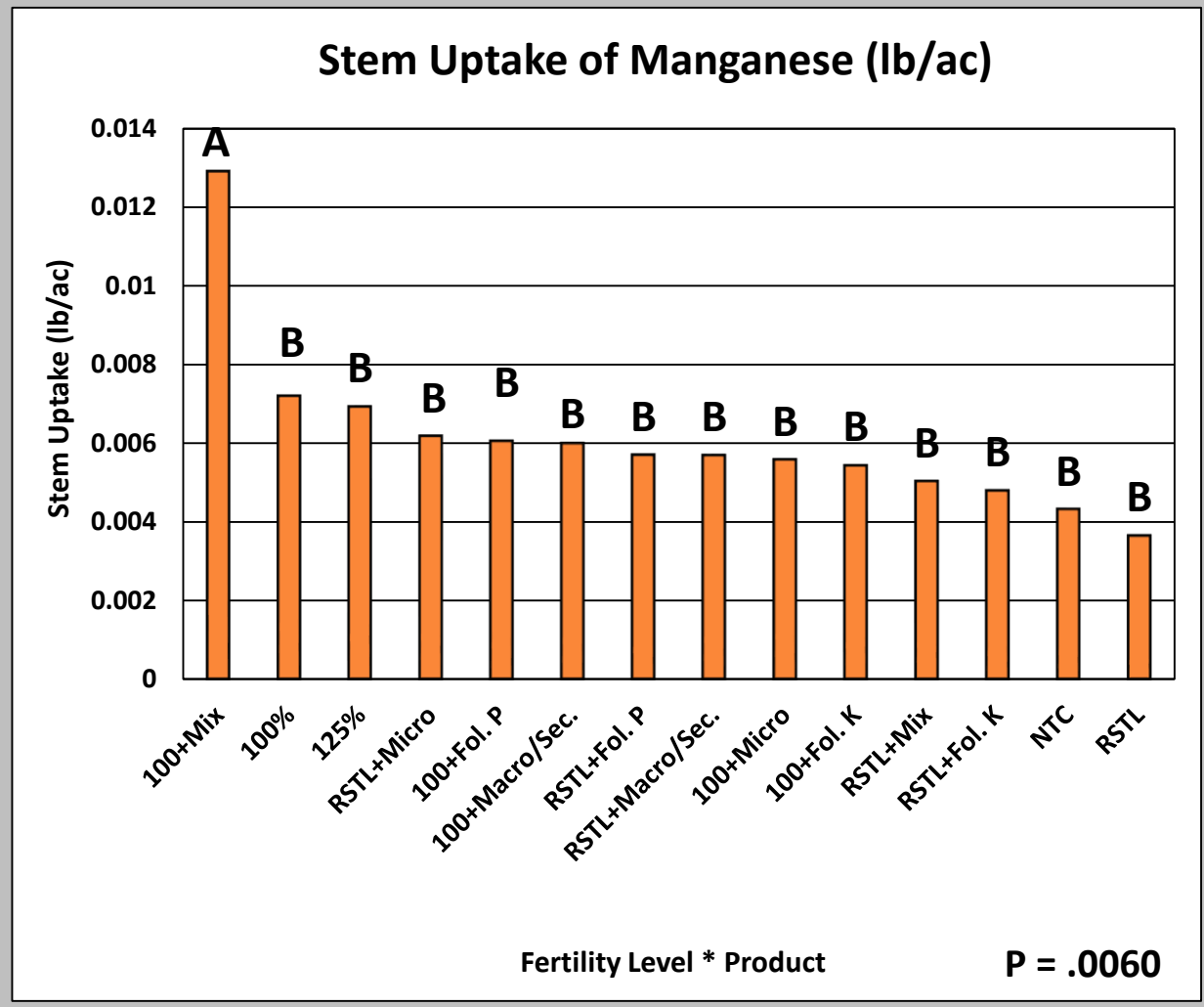
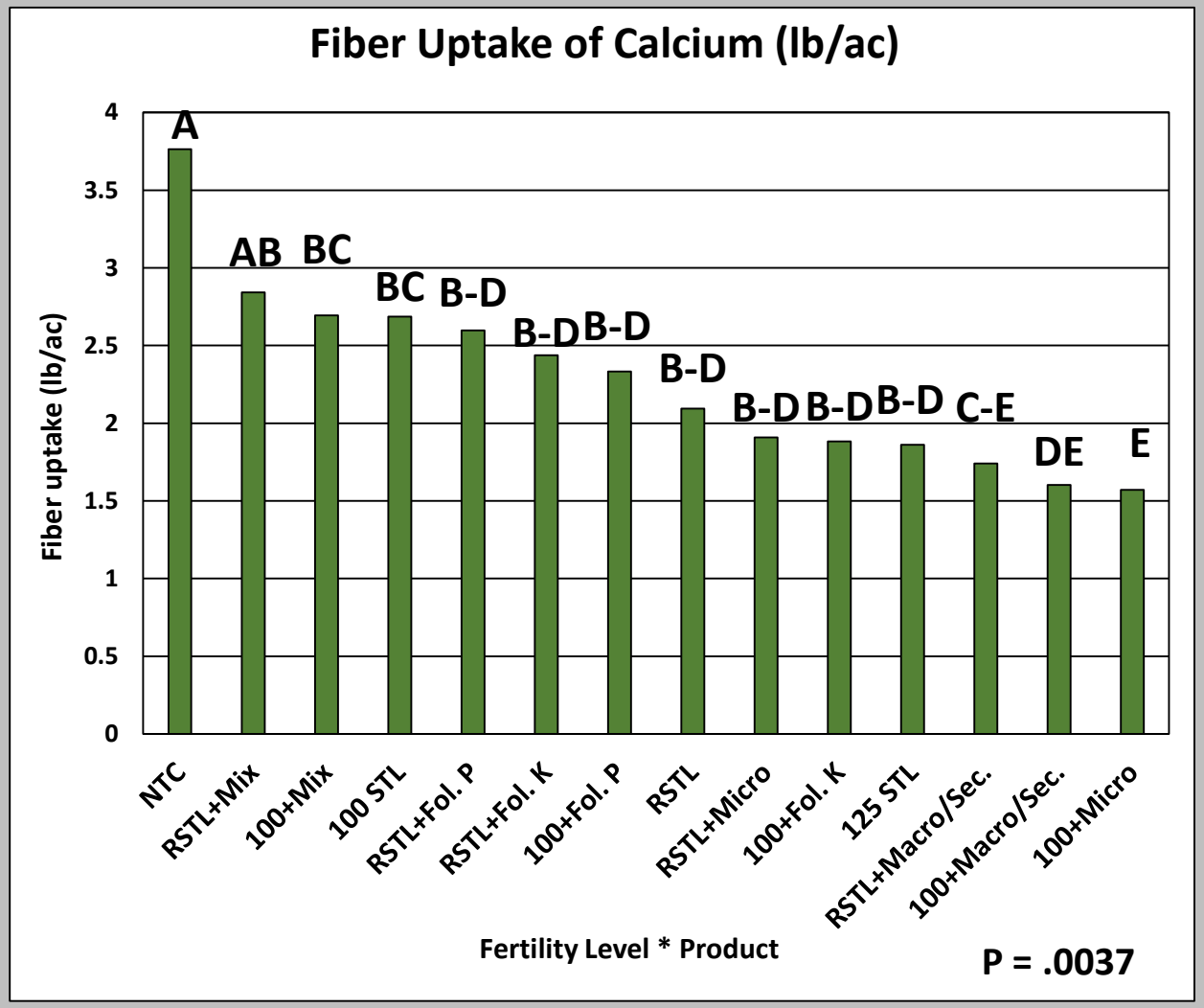
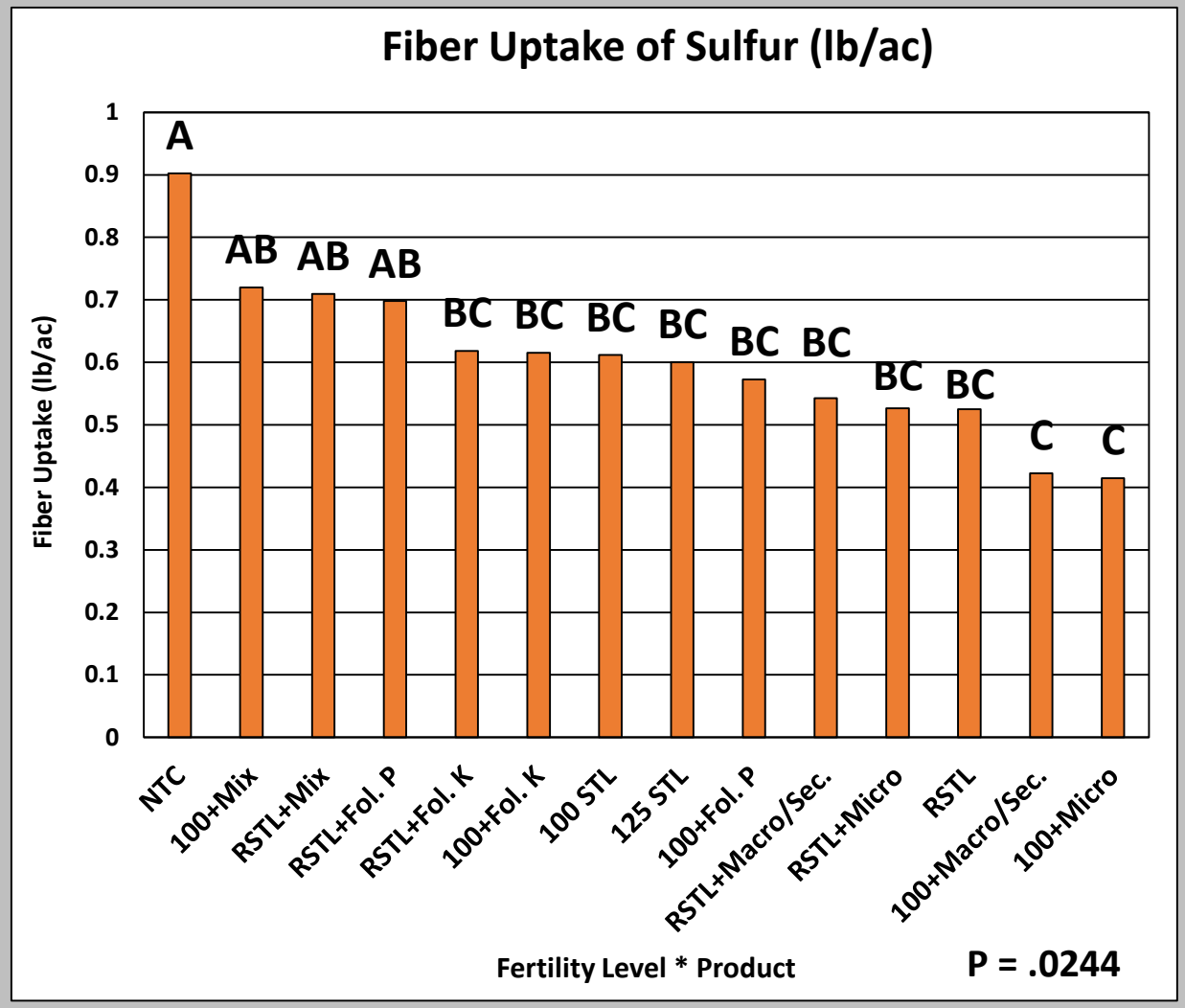


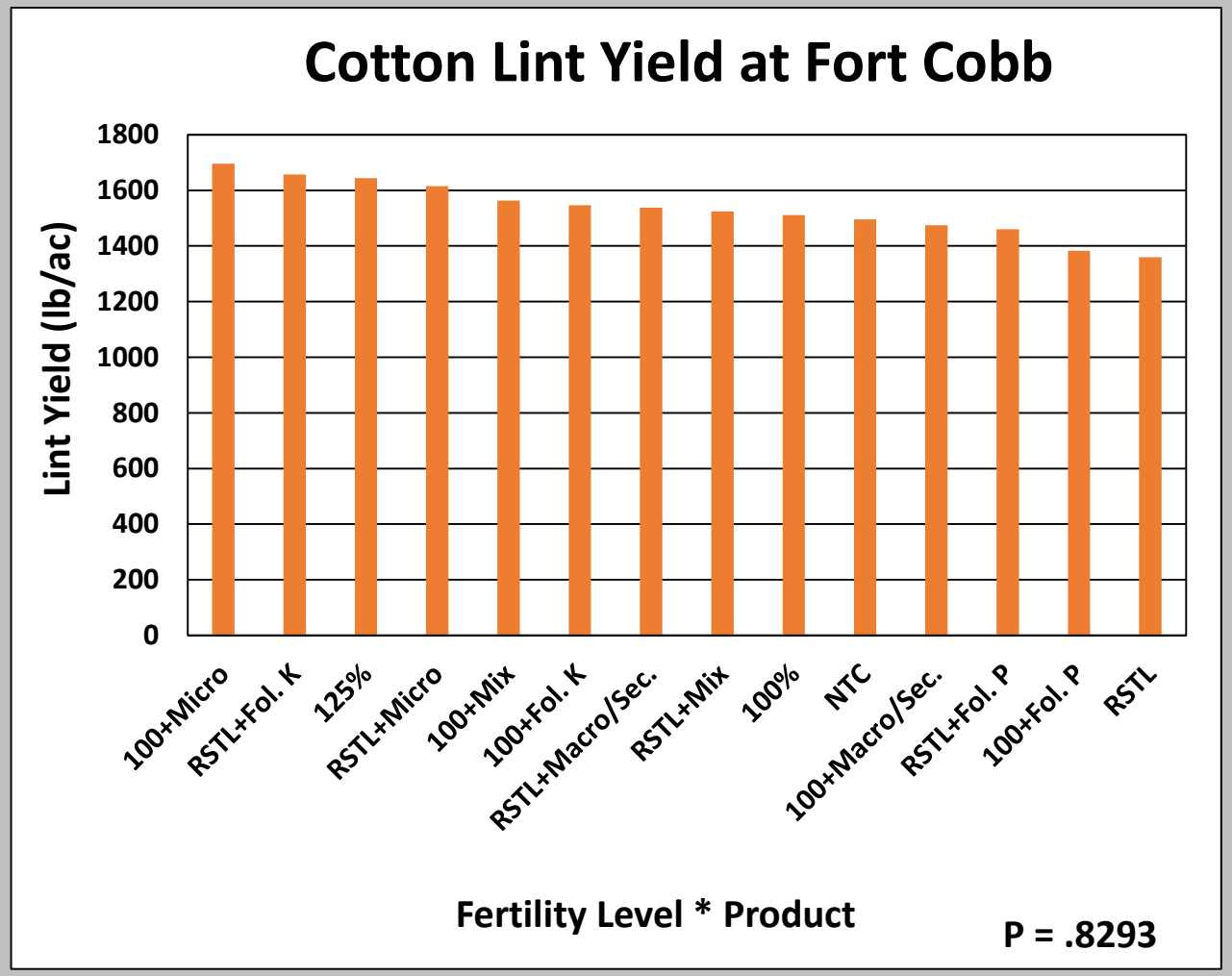


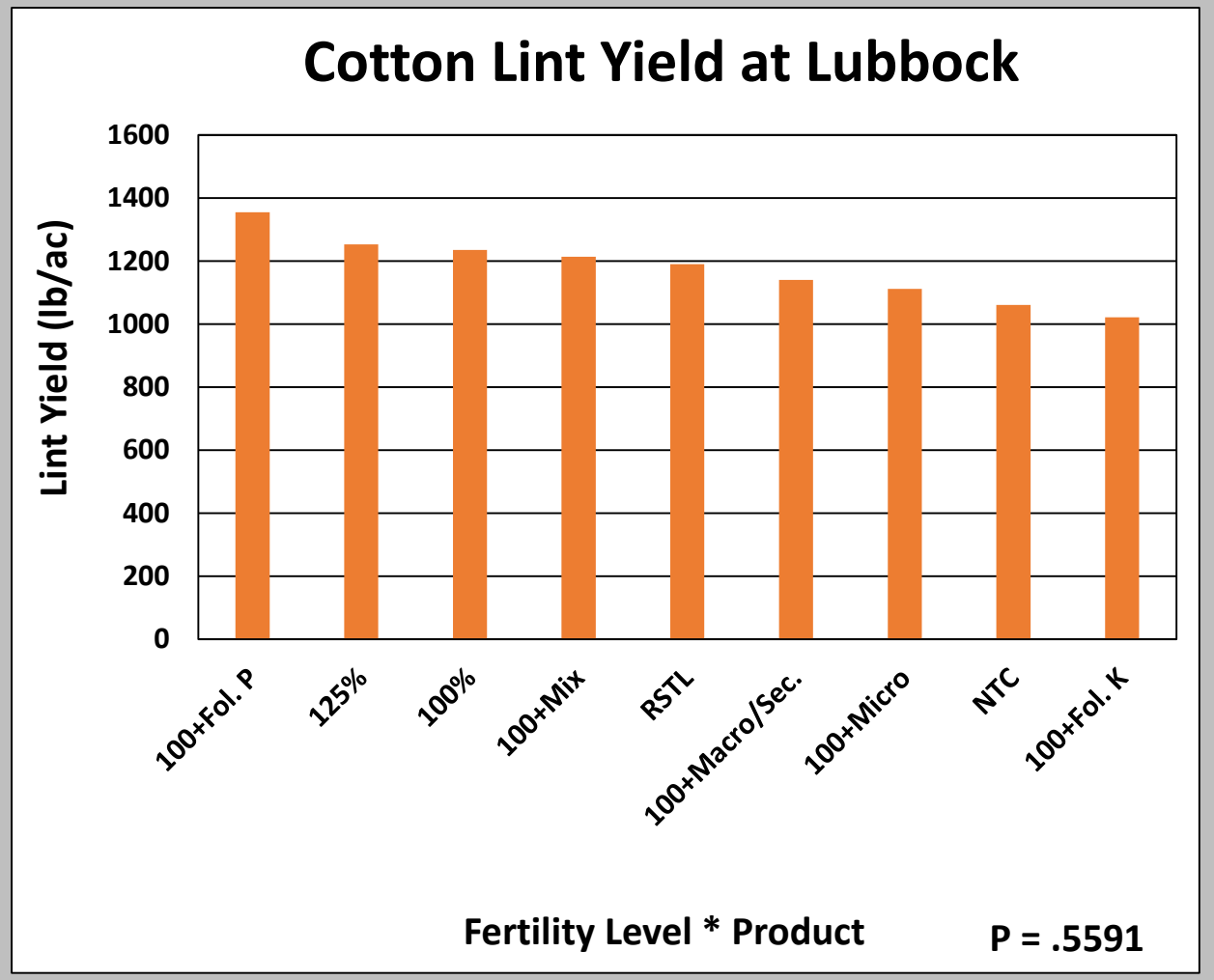
2nd Destructive Sampling Date





Cotton Yield in 2019





Conclusion

- Nutrient uptake effects were observed with few of the foliar treatments in 2019
  - Stem uptake increased with 100% + Foliar Mix (2019)
  - Fiber calcium and sulfur uptake were higher in the NTC compared to foliar products
- Varying levels of fertility programs made no impact on cotton growth, development, and maturity in 2019
- No significant differences among cotton yields at both locations in 2019
  - These data agree with Bednarz et al., 1998 who reported nutrient increases in plant parts but did not correspond to an increase in lint yield

Soil Test Report

- Routine Test -		- Secondary Nutrients -		- Micronutrients -	
pH:	7.4	SO4-S (lbs/A)		Fe (ppm):	5.8
Buffer Index:		Surface:	2	Zn (ppm):	0.4
NO3-N (lbs/A):		Subsoil:		B (ppm):	0.2
Surface:	1	Ca (lbs/A):	2057	Cu (ppm):	0.6
Subsoil:		Mg (lbs/A):	256		
Soil Test P Index:	17 (8 ppm)				
Soil Test K Index:	185 (92 ppm)	- Additional Tests -			

* DL = Detection Limit
INTERPRETATION AND REQUIREMENTS FOR *Cotton* (YIELD GOAL = 3.5)

- Test -	- Interpretation -	- Requirement -	- Recommendations and Comments -
pH	Adequate	No Lime Required	
Nitrogen	Deficient	174 lbs/Acre N	
Phosphorus	79% Sufficient	50 lbs/Acre P2O5 annually	
Potassium	87% Sufficient	45 lbs/Acre K2O annually	
Sulfur	Deficient	13 lbs/Acre	
Calcium	Adequate	None	
Magneisum	Adequate	None	
Iron	Adequate	None	
Zinc	Adequate	None	
Boron	Adequate	None	

Future Research

- Continue to evaluate the effect foliar fertilizer applications at peak nutrient demand timings on cotton growth, development, and yield
    - How does increased levels of nutrients in plant parts benefit cotton growth and development
- Evaluate alternative field locations with reduced fertility levels
- Investigate alternative timings and the effects foliar applications may provide

Acknowledgements

- Dr. Seth Byrd
- Dr. Brian Arnall
- Dr. Katie Lewis
- Fellow Graduate Students
- Student Workers
- Farm crew at Fort Cobb

- Fluid Fertilizer Foundation
- Cotton Inc. Oklahoma State Support

Questions?

Sources

Nutrient	Foliar K	Foliar P	Foliar mix	Foliar macro/secondary	Foliar micro
N		Ammonia Polyphosohate, Ammonia nitrate, Urea	Urea, Triazone, Methylene urea,	Triazone, Methylene urea	Anhydrous Ammonia
P					
K	Potassium acetate	Potassium hydroxide	monopotassium phoshpate, Potassium sulfate		
CA				Calcium nitrate	
S					
MG				Magnesium nitrate	
B			Boric acid		Boric acid
MN			Mn EDTA, Mn IDS		Mn EDTA, Mn sulfate
FE					
ZN		Zinc sulfate	Zinc EDTA, Zinc IDS	Zinc nitrate	Zn EDTA, Zn sulfate
CU		Copper sulfate	Copper EDTA, Copper IDS		Copper EDTA