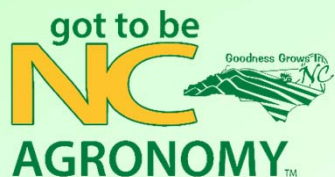


A close-up photograph of vibrant green hemp leaves with serrated edges, filling the background of the slide.

Floral Hemp Fertility and Plant Nutrition

Michelle McGinnis, Ph.D.
NCDA&CS Agronomic Field Services Section Chief
NCSU Horticultural Science Adjunct Faculty

NCA&T Hemp Conference
February 11, 2020



Agronomic Services Division

➤ Soil Testing Lab

- David Hardy, Ph.D., Section Chief
- Jagathi Kamalakanthan, Agronomist

➤ Plant, Waste, Solution & Media Analysis Lab

- Kristin Hicks, Ph.D., Section Chief
- Jessica Long, Agronomist

➤ Nematode Assay Lab

- Weimin Ye, Ph.D., Section Chief

➤ Field Services

- Michelle McGinnis, Ph.D., Section Chief
- 13 regional agronomists



Dr. David Hardy



Dr. Kristin Hicks



Dr. Weimin Ye



Dr. Colleen
Hudak-Wise
Director



Jagathi
Kamalakanthan



Jessica Long



Dr. Michelle McGinnis and 13 Regional Agronomists

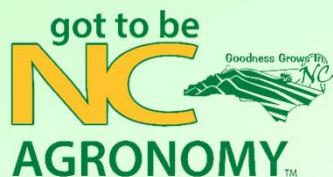


Purpose of this presentation

Tell you about the work we're doing to

- Obtain scientifically valid information
- To be incorporated into our lab's interpretations and recommendations
- So we can provide scientifically and economically and environmentally sound nutrient advice.

NCDA Agronomic Services, NCSU Crop & Soil Science, NCSU Horticultural Science



Soil Test Recommendations for Hemp

Based on University of Kentucky guidelines for seed and fiber hemp

Target pH

- 6.2 for mineral soil
- 5.5 for mineral-organic soil
- 5.0 for organic soil

Nitrogen rate

- 50 lb/A for fiber
- 100-150 lb/A for seed/grain
- No recommendation for flower*
(100-150 lb/A typical grower rate)

Phosphorus and potassium rates (based on soil test results)

- Phosphorus (P_2O_5)
 - 0 lb/A at P-Index of 70
 - 150 lb/A at P-Index of 0
- Potassium (K_2O)
 - 0 lb/A at K-Index of 80
 - 150 lb/A at K-Index of 0

*NCDA/NCSU research underway to determine optimal N and K rates for floral hemp



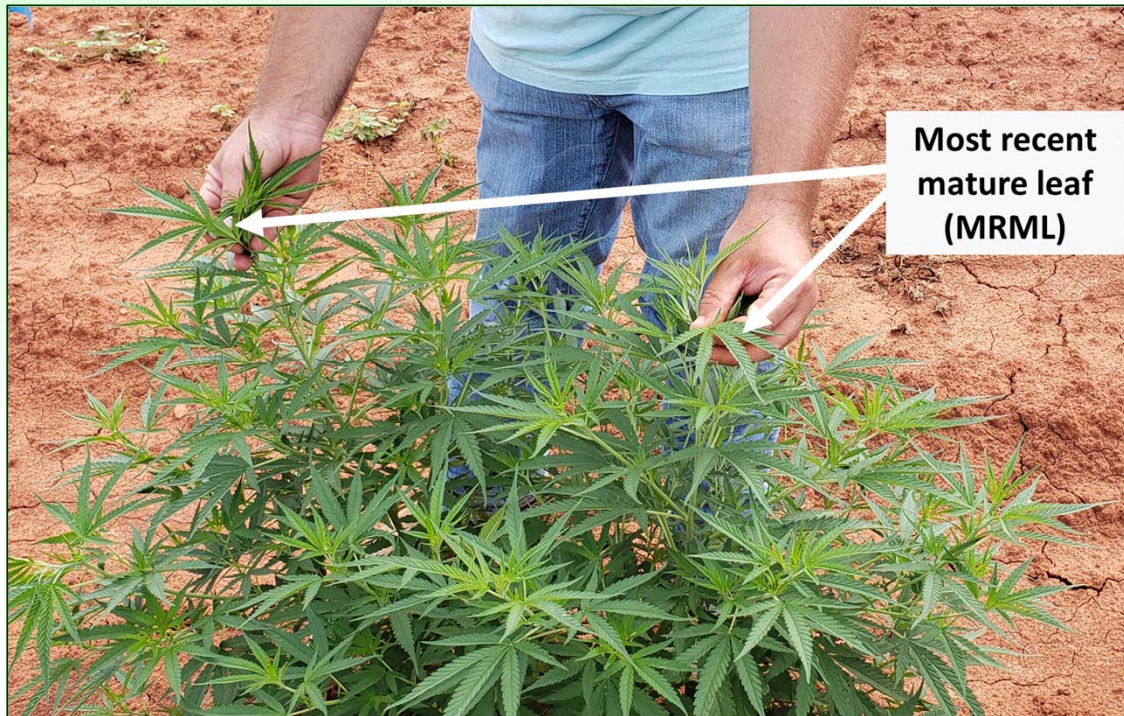
Plant Tissue Analysis

Tool to manage in-season fertility and help identify cause(s) of plant growth problems





Collecting representative plant leaf tissue samples



- Collect the most recently mature leaf (MRML)
- Generally the 3rd to 5th leaf down from the growing point
- Collect 1-2 MRMLs from 20-30 from similar environments (30-40 leaves per sample)
- Send to lab; lab measures essential plant nutrients



Plant Tissue Analysis

- Compare results to crop specific nutrient ranges
 - Sufficiency ranges – Established through yield based studies a wide range of growing environments (not established for hemp)
 - Survey ranges – Based on observational data under fewer growing environments; good approximation of deficient and toxic critical levels; additional info needed (published general guidelines)
- Lab reports indicate if nutrients are sufficient, deficient, or high



Compare lab results to crop specific nutrient ranges

- **Sufficiency Ranges**

- Established through yield based studies a wide range of growing environments
- Not established for hemp

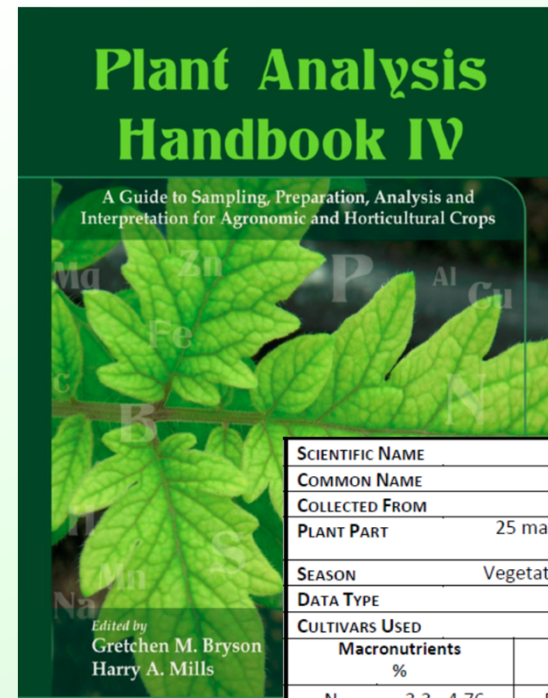
- **Survey Ranges**

- Based on observational data rather than research
- Published guidelines (Bryson & Mills)*
- Good framework of nutrient status

- **Lab reports**

- Indicate if nutrients are sufficient, low, or high

*Bryson, G.M, and H.A. Mills (Eds). 2014. *Plant analysis handbook IV e-edition. A guide to sampling, preparation, analysis, and interpretation for agronomic and horticultural crops.* Athens, GA: Macro-Micro Publishing Inc.



SCIENTIFIC NAME		<i>Cannabis sativa</i>	
COMMON NAME		Cannabis	
COLLECTED FROM		Production nursery	
PLANT PART		25 mature leaves from new growth	
SEASON		Vegetative prior to flowering	
DATA TYPE		Survey Range	
CULTIVARS USED			
	Macronutrients	Micronutrients	
	%	ppm	
N	3.3 - 4.76	Fe	100 - 150
P	0.24 - 0.49	Mn	41 - 93
K	1.83 - 2.35	B	56 - 105
Ca	1.47 - 4.42	Cu	5 - 7.1
Mg	0.4 - 0.81	Zn	24 - 52
S	0.17 - 0.26	Mo	0.5 - 1.5



NCDA Plant Analysis Report

Crop with established sufficiency ranges

Sample Information	Nutrient Measurements are given in units of parts per million (ppm or mg/L) unless otherwise specified.												
ID: WHEAT Crop: Wheat Growth Stage: E Week: 16 Plant Part: W Plant Position: U Plant Appearance:	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Fe	Mn	Zn	Cu	B	Mo	NO ₃ -N
	5.57	0.48	3.07	0.17	0.04	0.55	93.7	83.6	26.0	5.81	2.96	-	-
	Interpretation Indexes												
	N	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo	
	89-H	73-S	56-S	38-L	12-D	69-S	59-S	62-S	54-S	53-S	51-S	-	
	Other Results					Nutrient Ratios							
	Na (%)	Cl (%)	C (%)	DW (g)	Al	N:S	N:K	Fe:Mn					
	0.01	-	-	-	86.9	10.1 : 1	1.81 : 1	1.12 : 1					

Plant indexes based on crop specific sufficiency ranges

- 50-75 – Nutrients within sufficiency range
- <50 – Nutrients low or deficient
- >75 – Nutrients high

Crop w/o established sufficiency ranges

Sample Information	Nutrient Measurements are given in units of parts per million (ppm or mg/L) unless otherwise specified.												
ID: BAT Crop: Hemp, Field Growth Stage: M Week: 0 Plant Part: M Plant Position: 0	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Fe	Mn	Zn	Cu	B	Mo	NO ₃ -N
	5.45	0.29	2.06	1.93	0.29	0.28	118	154	41.1	17.3	53.9	-	-
	Interpretation Indexes												
	N	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo	
	-	-	-	-	-	-	-	-	-	-	-	-	-
	Other Results					Nutrient Ratios							
	Na (%)	Cl (%)	C (%)	DW (g)	Al	N:S	N:K	Fe:Mn					
	0.00	-	-	0.62	22.4	19.4 : 1	2.65 : 1	0.77 : 1					

- No indexes for hemp b/c no sufficiency ranges or NC based survey ranges
- Compare results to Bryson & Mills survey ranges listed in Agronomist's Comments

Agronomist's Comments: Plant sufficiency ranges for hemp have not yet been established. The following are survey ranges for Cannabis in production nurseries at the vegetative stage prior to flowering reported in the Plant Analysis Handbook: N (3.3-4.76%); P (0.24-0.49%); K (1.83-2.35%); Ca (1.47-4.42%); Mg (0.4-0.81%); S (0.17-0.26%); Fe (100-150 ppm); Mn (41-93 ppm); B (56-105 ppm); Cu (5-7.1 ppm); Zn (24-52 ppm); Mo (0.5-1.5 ppm). Kristin A. Hicks 7/30/2019 9:29 AM



NCDA and NCSU – Two Projects

- **Floral hemp nitrogen and potassium rate study**
- **Floral hemp foliar nutrient survey**



Nitrogen and Potassium Rates for Floral Hemp Experimental Design

Nitrogen Rate Studies

- 0, 50, 100, 150, 200 lb N/A
- RCBD with 4 reps
- Nitrogen: Split-applied with 28% UAN
 - 50% ~10 days after transplanting
 - 50% ~28 days after transplanting

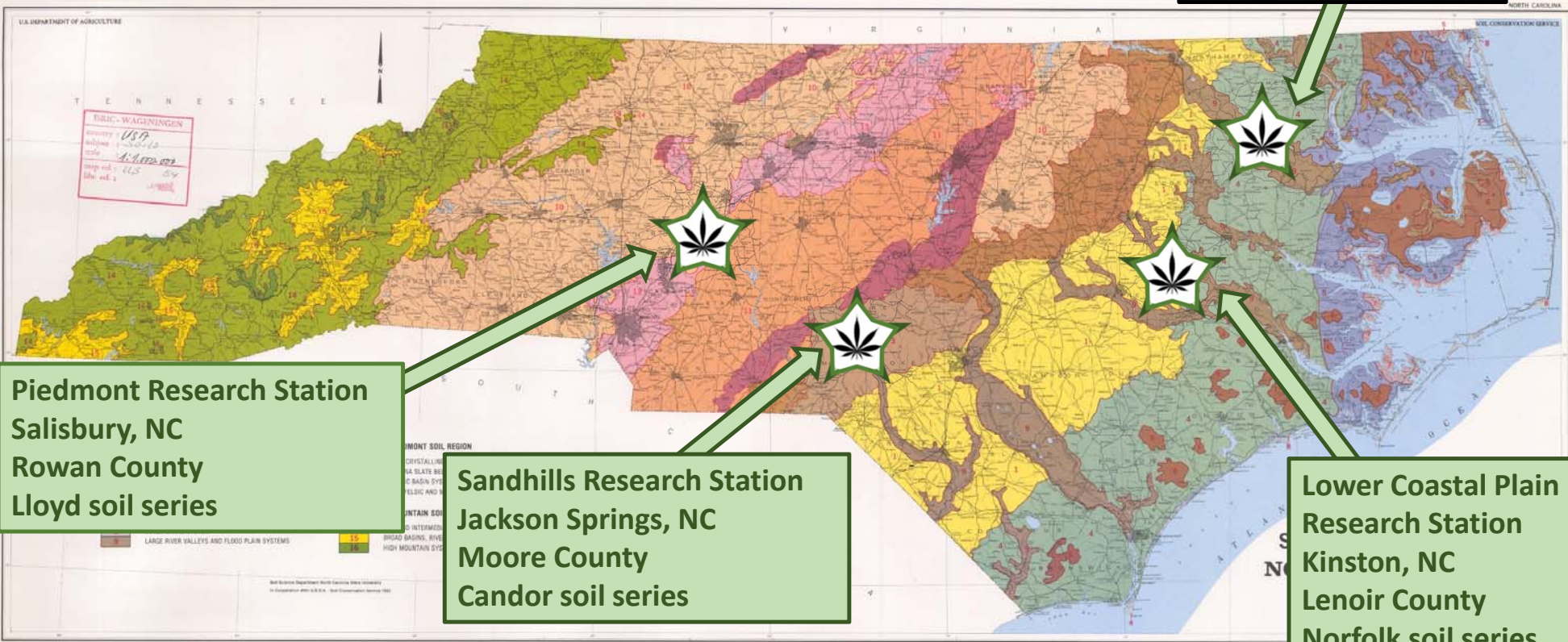
Potassium Rate Studies

- 0, 50, 100, 150, 200 lb K₂O/A
- RCBD with 4 reps
- Potassium: Applied with K₂SO₄ (0-0-50, 17%S) ~10 days after transplant
- Fields had NCDA soil test K-I <40



N and K Rates for Floral Hemp Experimental Design

On-Farm
Windsor, NC
Bertie County
Wickham soil series &
Dogue soil series



Piedmont Research Station
Salisbury, NC
Rowan County
Lloyd soil series

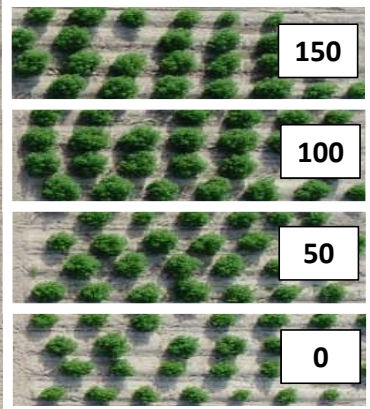
Sandhills Research Station
Jackson Springs, NC
Moore County
Candor soil series

Lower Coastal Plain
Research Station
Kinston, NC
Lenoir County
Norfolk soil series

Each plot: 4 rows/plot & 7 plants/row




Potassium (lb/A) – Replication 1



Nitrogen (lb/A) – Replication 1



Sandhills Research Station – Jackson Springs, NC



Nitrogen (lb/A) – Replication 1

0

50

100

150

200

Piedmont Research Station – Salisbury, NC

N and K Rates for Floral Hemp Materials & Methods (Planting)

- BaOx clones transplanted
 - Mid-May at research stations
 - Late-June at farm locations
- Mechanical transplanting
- Open beds
- 60" in-row spacing
- Variable between row spacing





N and K Rates for Floral Hemp Materials & Methods (Data Collection)

- Foliar tissue samples (nutrients)
 - Every other week from Week 4-16
- Growth index measures
 - Every other week from Week 4-16
- Floral tissue samples (cannabinoids)
 - Clear, milk, amber trichome stage (100 lb treatments)
 - Harvest (all treatments)
- Soil samples
 - Pre-plant, Week 8, Harvest

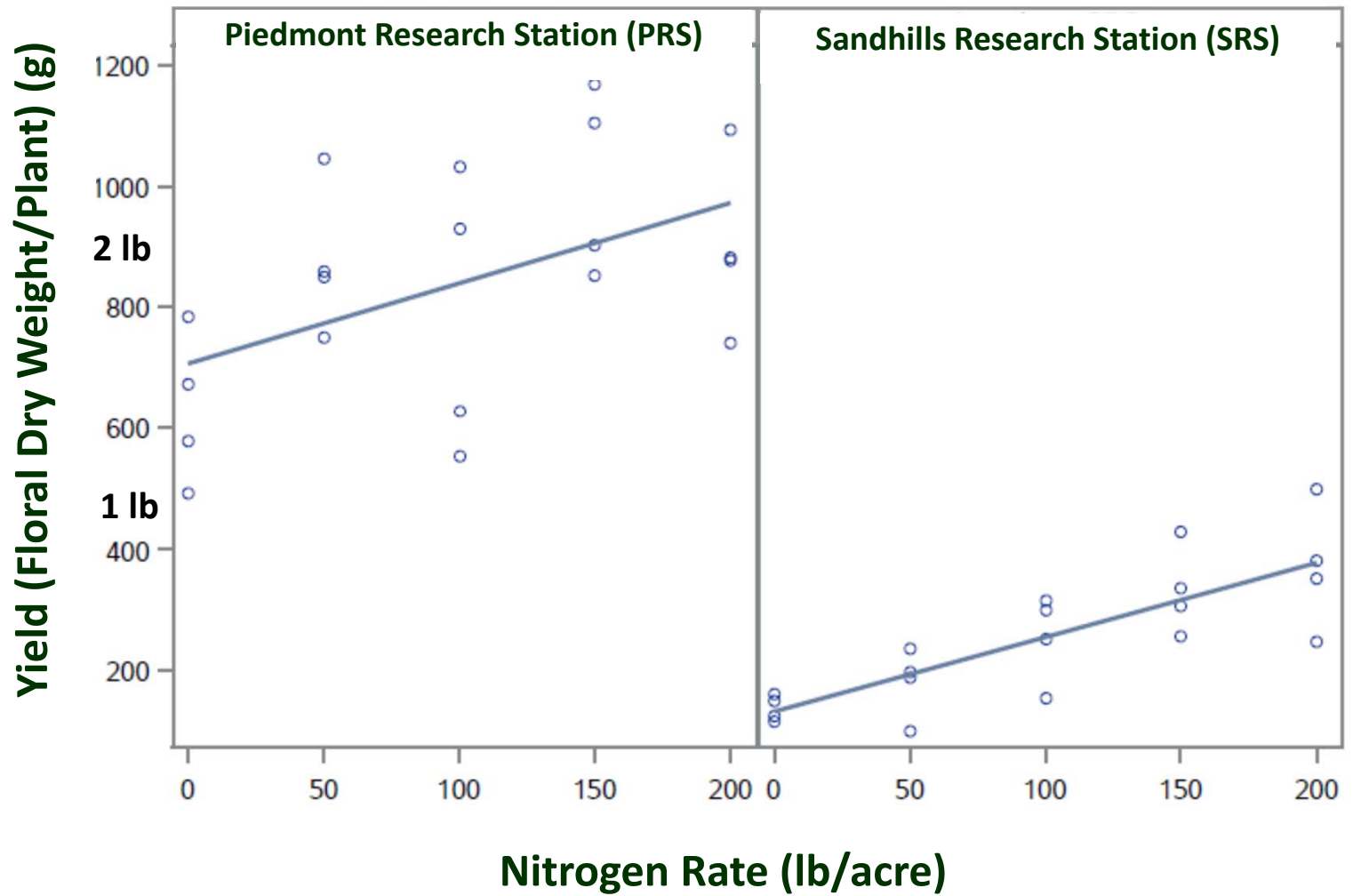
N and K Rates for Floral Hemp Materials & Methods (Harvesting)

- Three plants per plot
- Tobacco barn at 150°F for 2-3 days (in bags)
- Floral tissue removed from stems
- Placed in dryer until constant weight
- Weighed dry floral material (yield)





Yield (Floral Dry Weight) vs Nitrogen Rate



Nitrogen Test at Harvest (Sandhills)



0 lbs N/acre



100 lbs N/acre



200 lbs N/acre



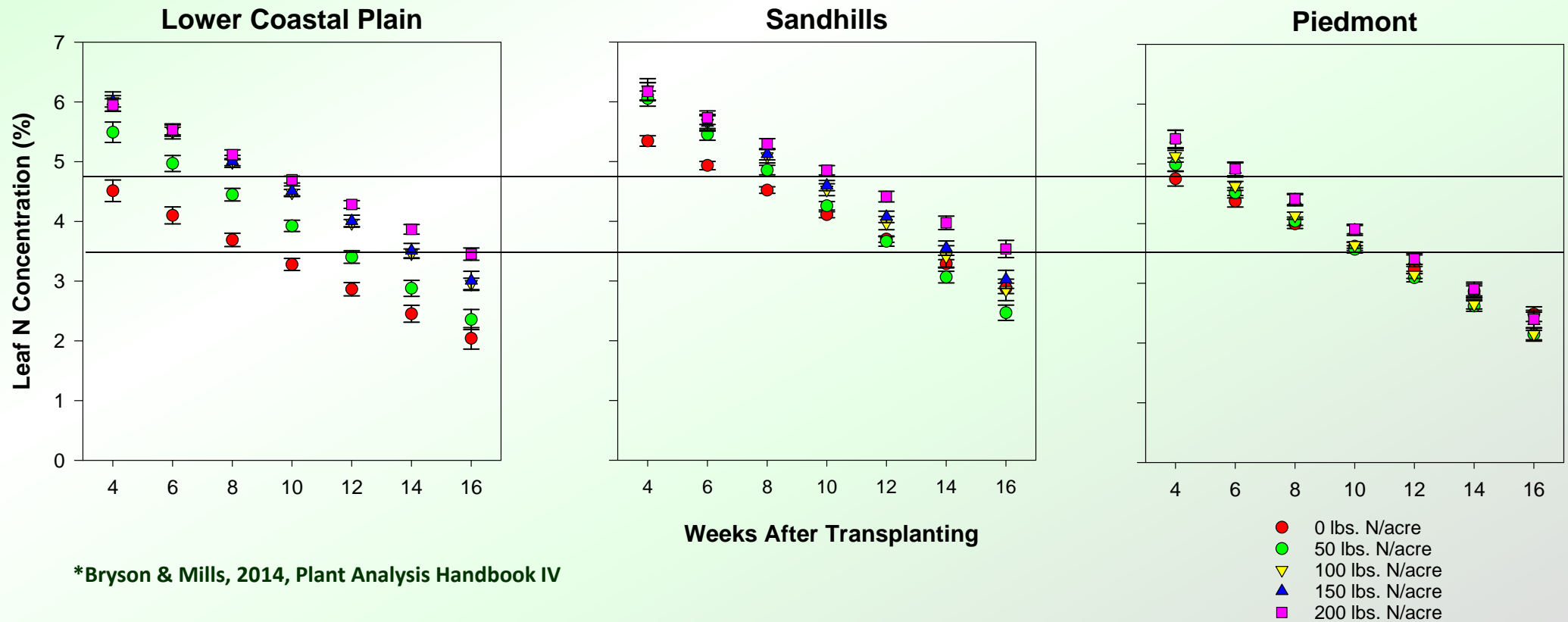
N and K Rates for Floral Hemp Results

- Linear yield response to increasing N rate
 - Sandhills and Piedmont
- Quadratic yield response to increasing N rate
 - Lower Coastal Plain
- No yield response to N rate
 - Bertie Farm
- No yield response to K rate
 - All locations



Foliar N Concentration (N Rate Study)

Nitrogen survey range 3.3-4.8%*



*Bryson & Mills, 2014, Plant Analysis Handbook IV



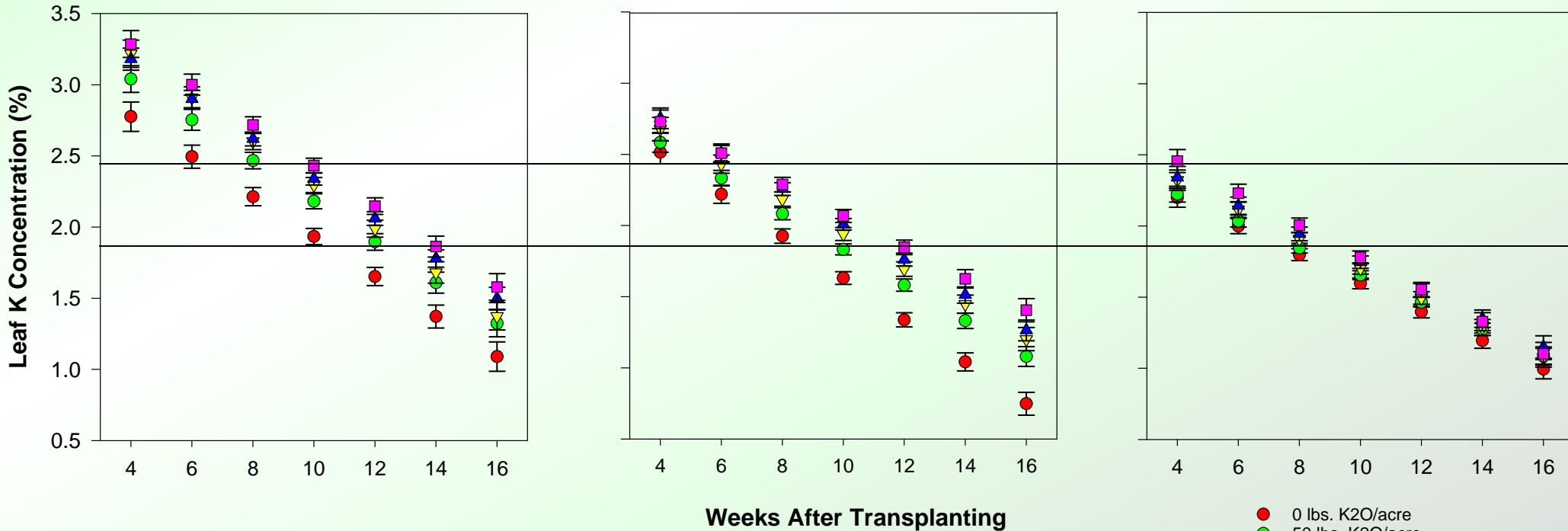
Foliar K Concentration (K Rate Study)

Potassium survey range 1.8-2.4%

Lower Coastal Plain

Sandhills

Piedmont



*Bryson & Mills, 2014, Plant Analysis Handbook IV

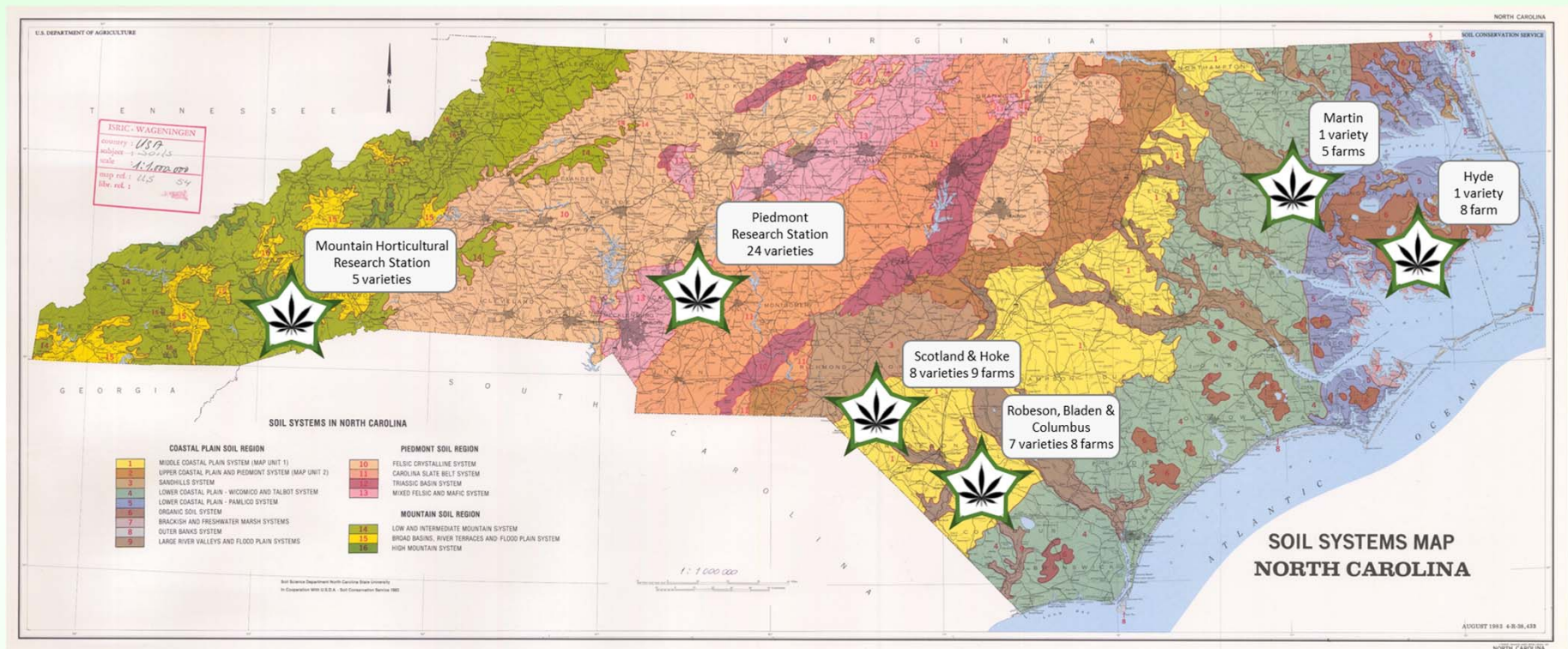
- 0 lbs. K₂O/acre
- 50 lbs. K₂O/acre
- ▼ 100 lbs. K₂O/acre
- ▲ 150 lbs. K₂O/acre
- 200 lbs. K₂O/acre



Leaf Tissue Nutrient Survey

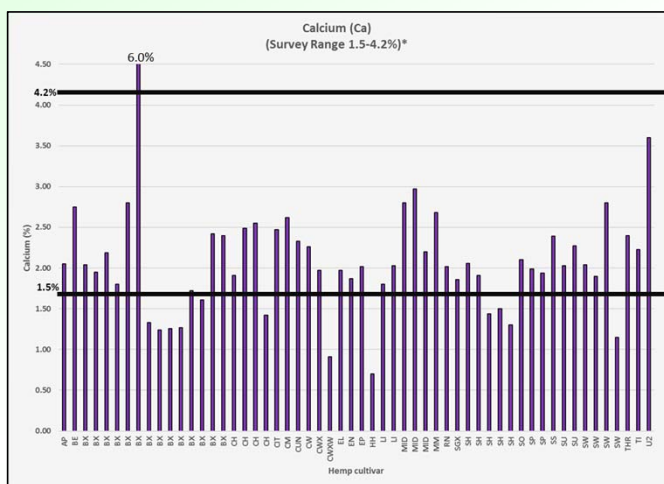
- **Ground-truth Bryson & Mills nutrient survey ranges to cultivars and environments specific to North Carolina**
- 2019 and 2020
- Multiple cultivars (NCSU trials)
- Transplant sources (producer and clones/seeds)
- Fertility management / irrigation management
- Across the state

Leaf Tissue Nutrient Survey Sample Locations

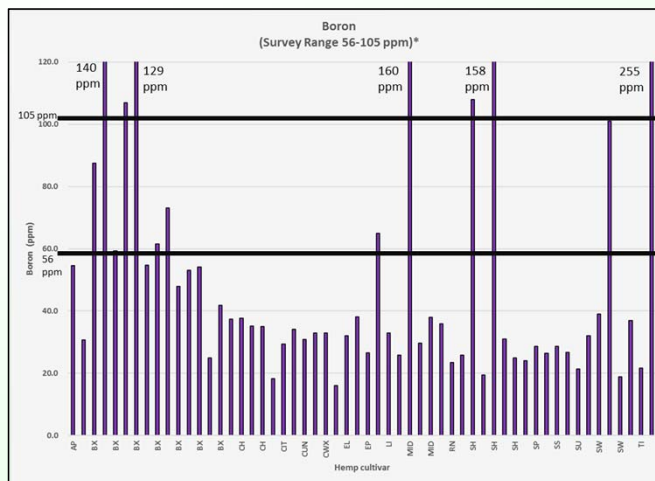


Leaf Tissue Nutrient Survey

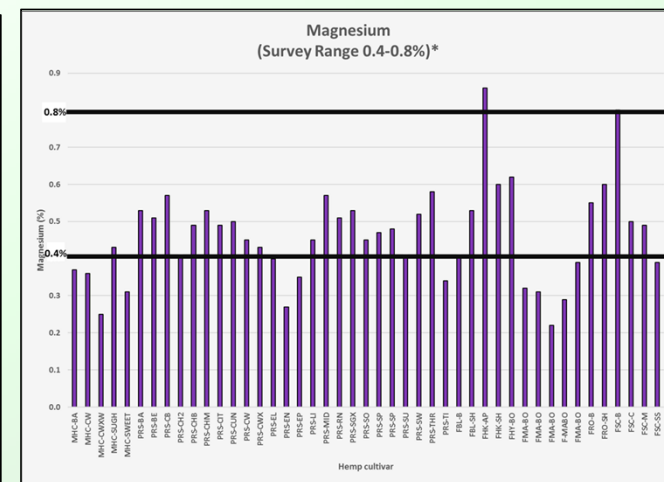
Calcium survey range 1.5-4.4%



Boron survey range 56-105 ppm



Magnesium survey range 0.4-0.8%



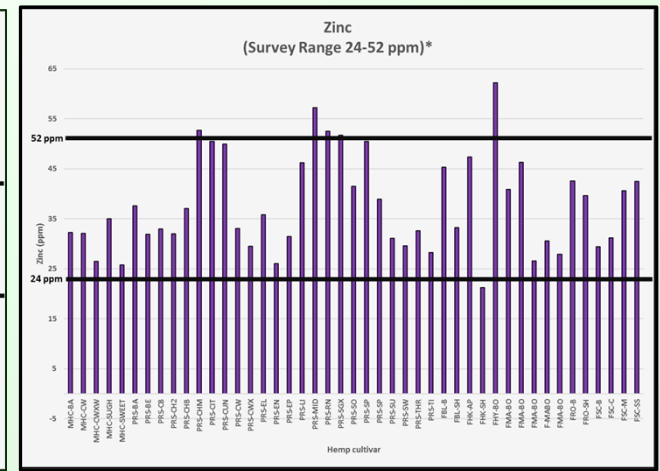
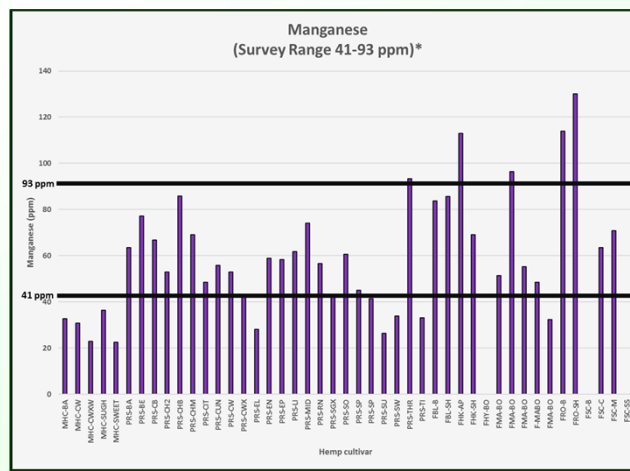
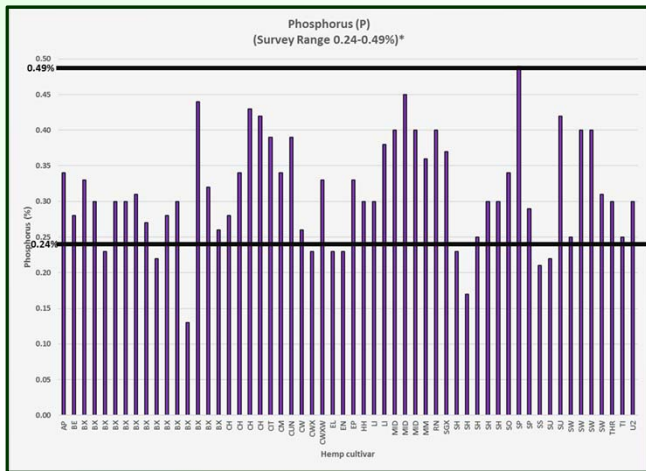
Ranges too high??

Leaf Tissue Nutrient Survey

Phosphorus survey range 0.24-0.49%

Manganese survey range 41-93 ppm

Zinc survey range 24-52 ppm



Ranges reasonable??

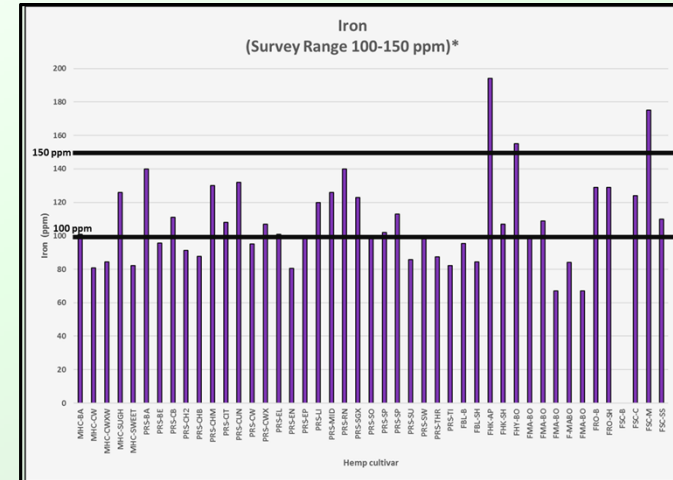
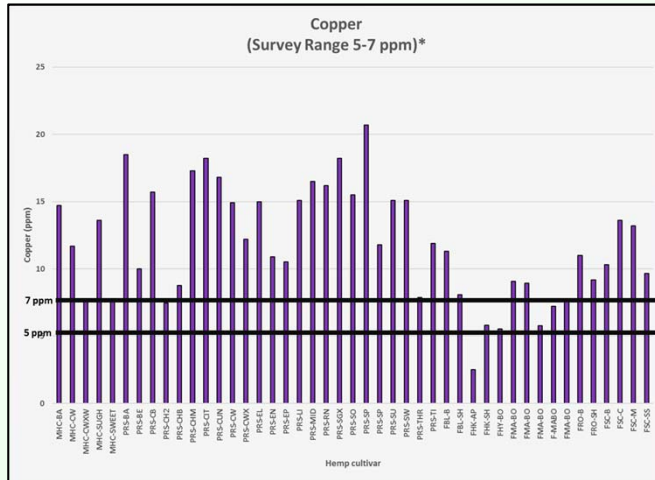
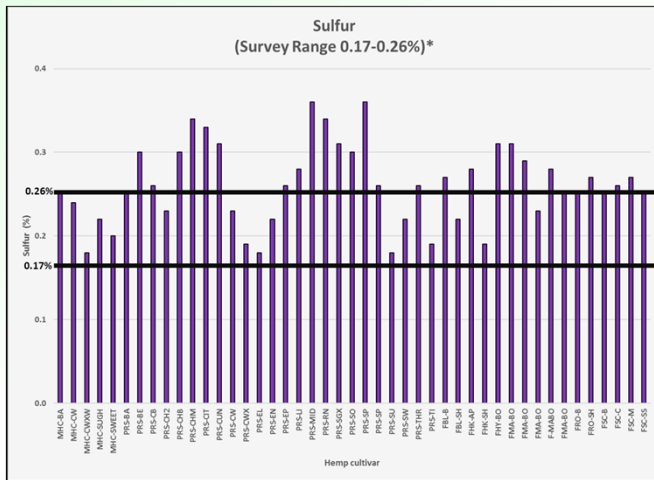


Leaf Tissue Nutrient Survey

Sulfur survey range 0.17-0.26%

Copper survey range 5-7 ppm

Iron survey range 100-150 ppm



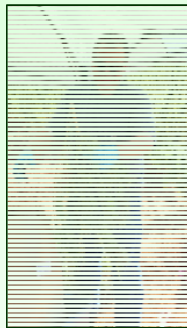
Ranges too narrow??



Super Team

- Maggie Short – MS Student
- Matthew Vann
- Keith Edmisten
- NCSU Tobacco Team
- Agronomic Field Services Team
- Research Stations
- Extension Agents







Thank you for funding and support!

