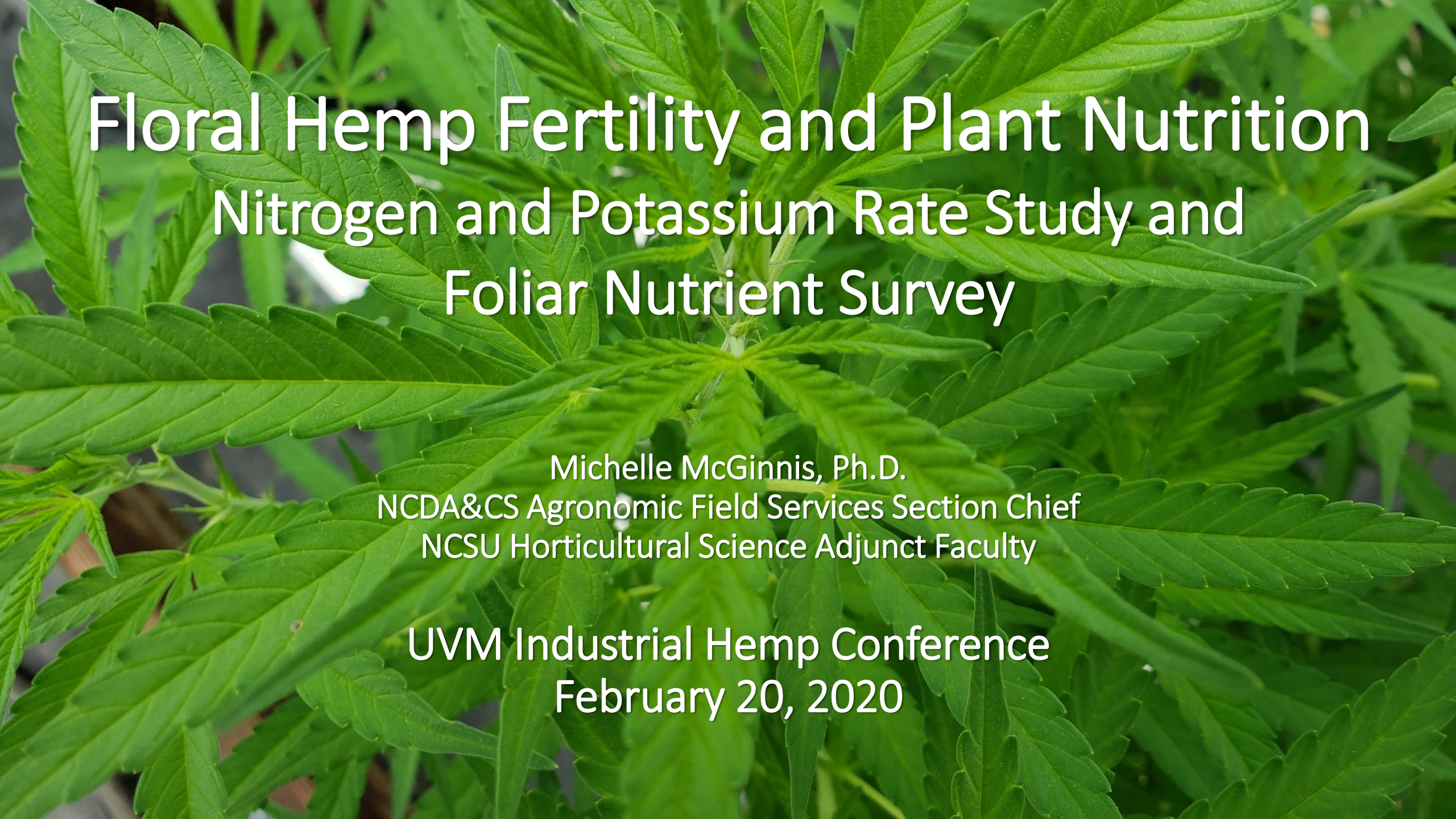


Floral Hemp Fertility and Plant Nutrition

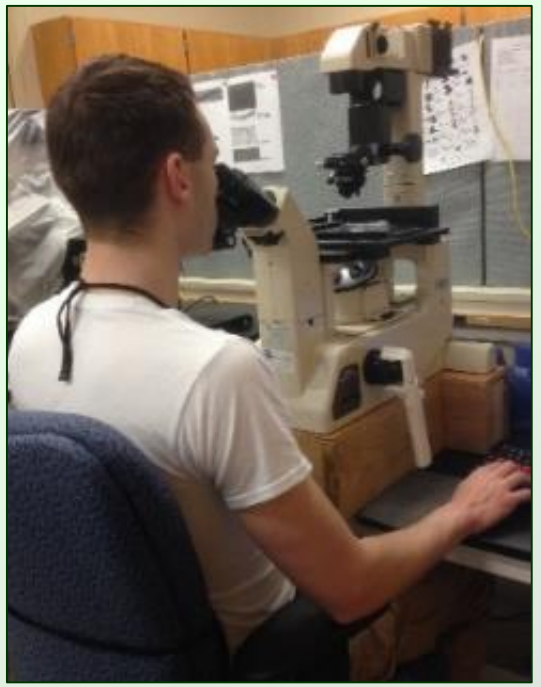
Nitrogen and Potassium Rate Study and Foliar Nutrient Survey

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

UVM Industrial Hemp Conference
February 20, 2020

Agronomic Services Division Laboratory Sections

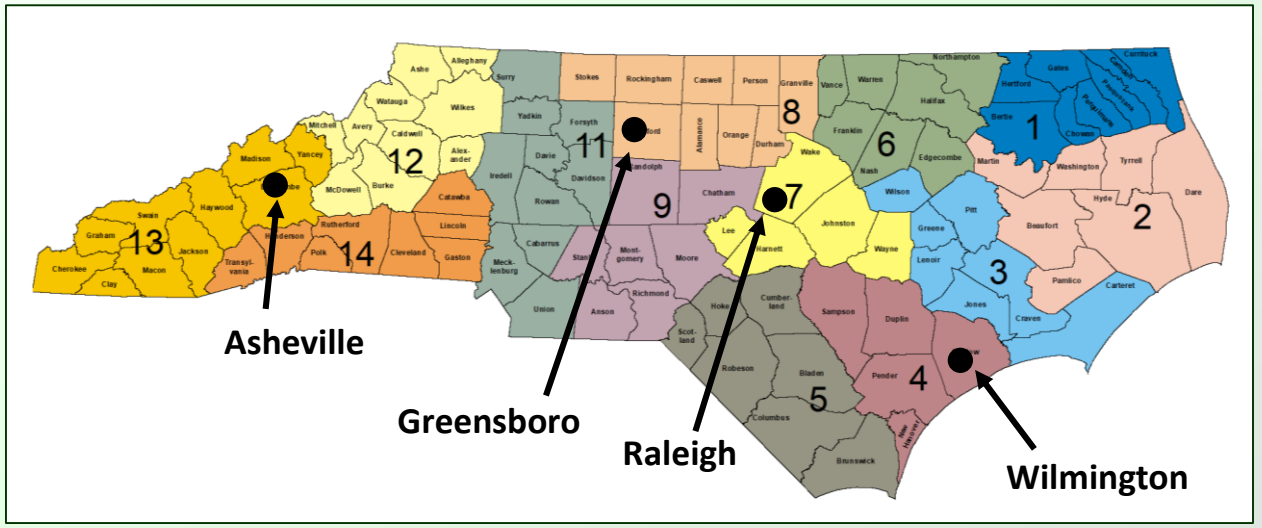
- Soil Testing
- Nematode Assay
- Plant, Waste, Solution, & Media Analysis



Agronomic Services Division
Field Services Section

- Provide on-farm consultations
- Diagnose plant growth problems
- Advise to prevent or correct plant growth problems

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
- And provide economically and environmentally, and scientifically 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)

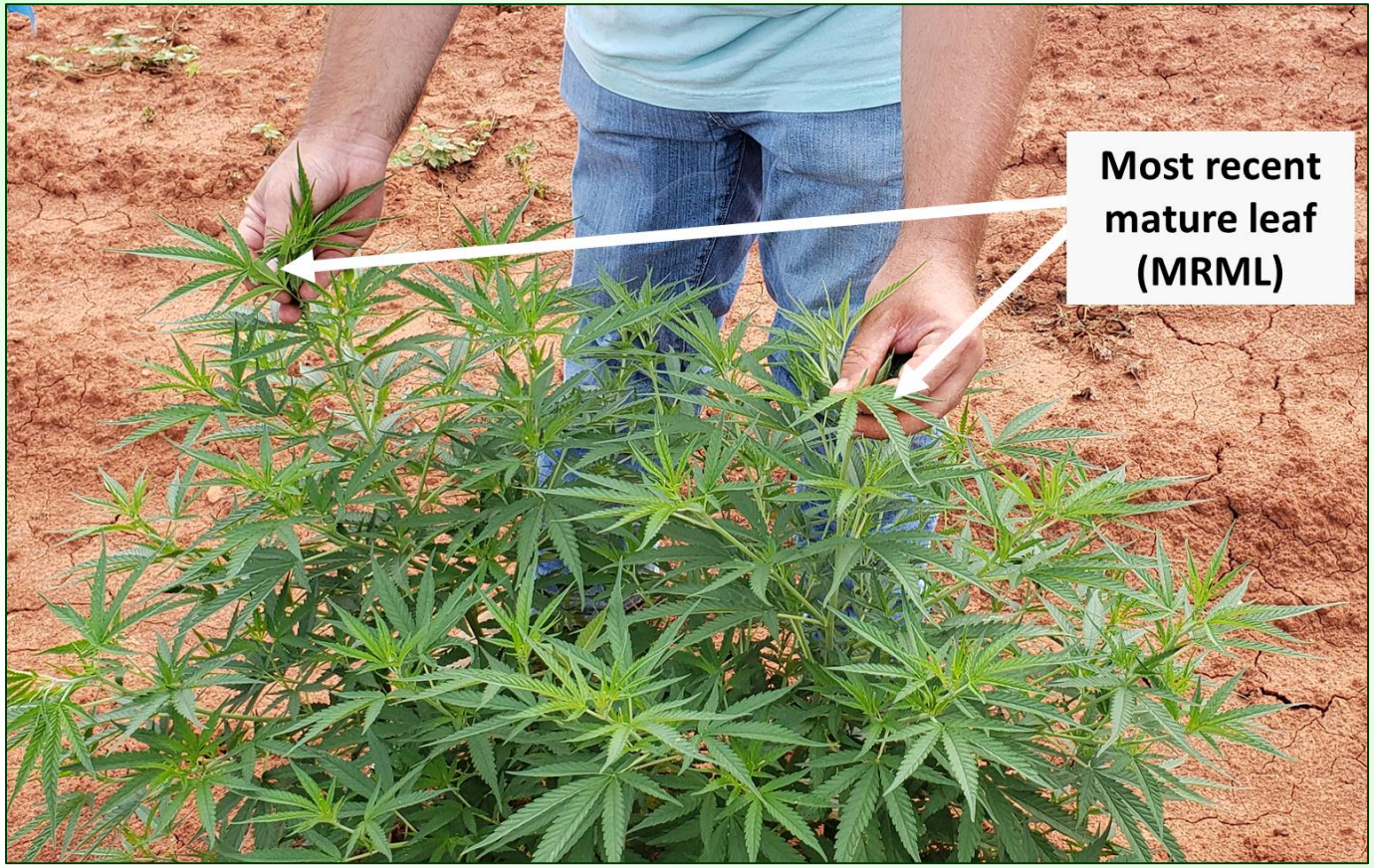
- Phosphorus (P_2O_5)
  - 0 lb/A at P-Index of 70
  - 150 lb/A at P-Index of 0
- Potassium (K_2O)
  - 0 lb/A at K-Index of 80
  - 150 lb/A at K-Index of 0

*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

Representative leaf tissue samples

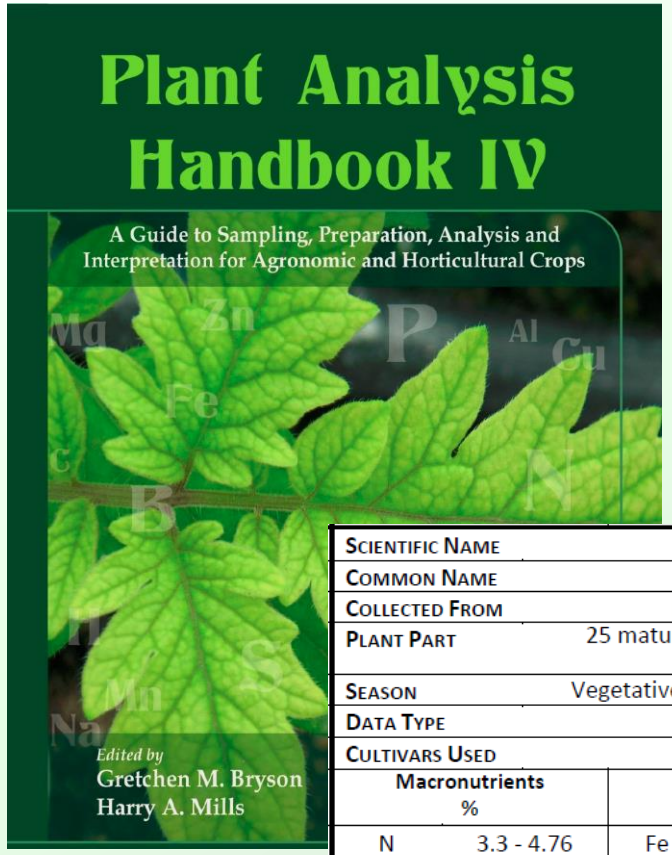


- Collect the most recently mature leaf (MRML)
- Generally the 3rd to 5th leaf down from the growing point
- Collect 1-2 MRMLs from 20-30 from similar environments (30-40 leaves per sample
- Send to lab; lab measures essential plant nutrients

GARBAGE INTO THE LAB – GARBAGE OUT OF THE LAB

Compare lab results to crop specific nutrient ranges

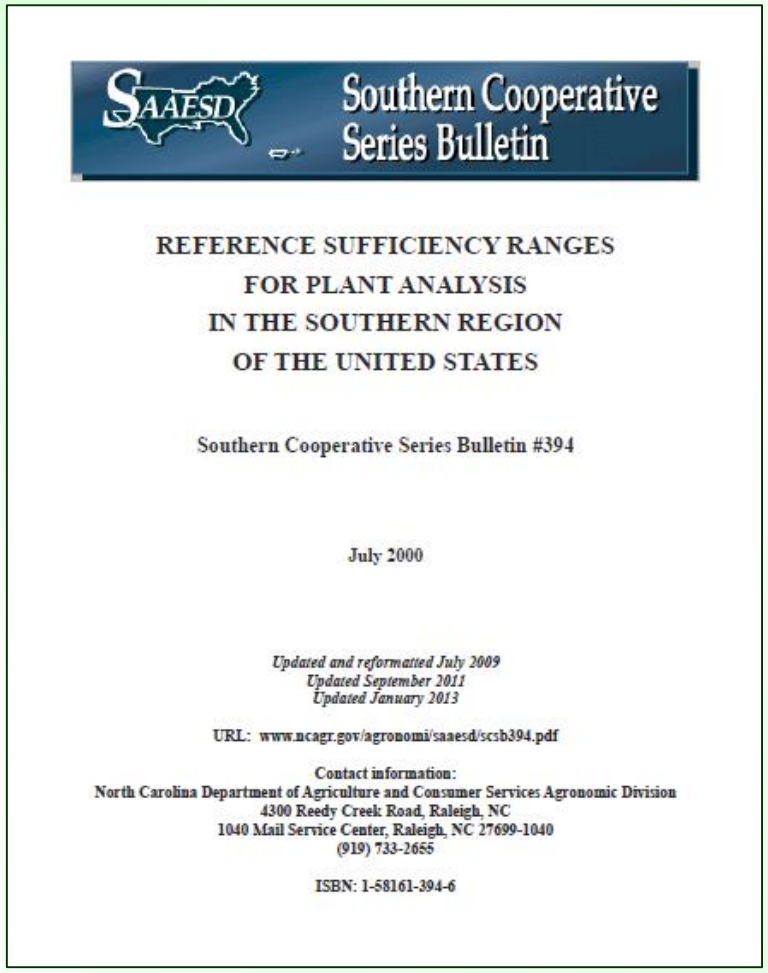
- **Sufficiency Ranges**
  - Established through yield based studies a wide range of growing environments
  - Not established for hemp
- **Survey Ranges**
  - Based on observational data rather than research
  - Published guidelines (Bryson & Mills)*
  - Good framework of nutrient status
- **Lab reports**
  - Indicate if nutrients are sufficient, low, or high



Scientific Name	*Cannabis sativa*		
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**

*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.

Sufficiency Ranges for Plant Analysis



Southern Cooperative Series Bulletin

REFERENCE SUFFICIENCY RANGES
FOR PLANT ANALYSIS
IN THE SOUTHERN REGION
OF THE UNITED STATES

Southern Cooperative Series Bulletin #394

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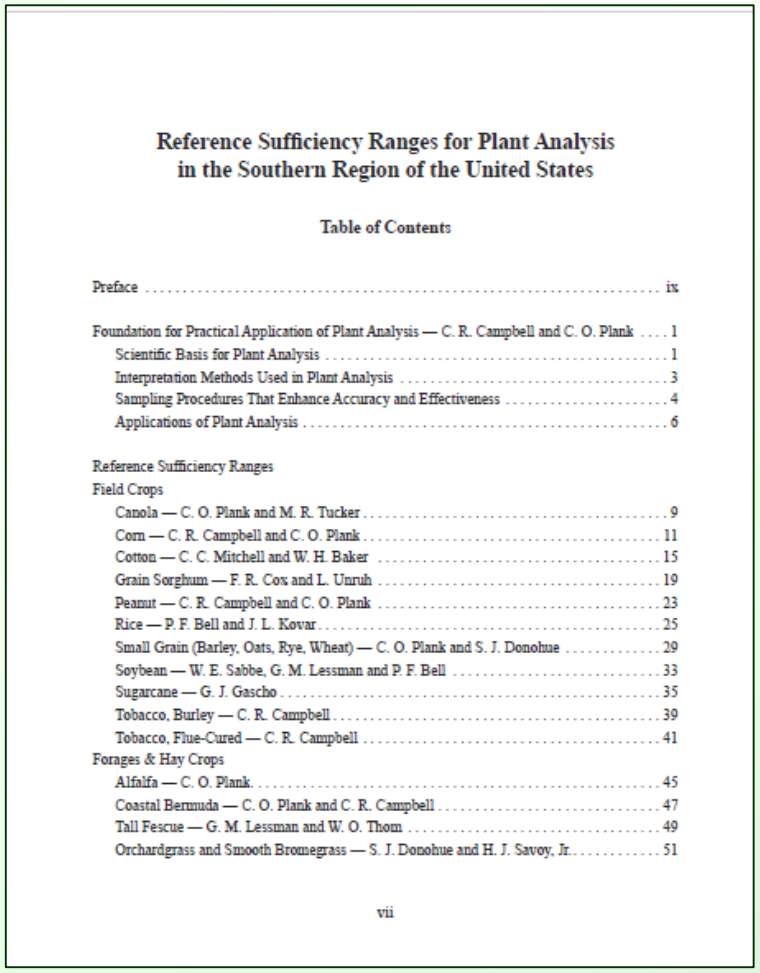

Reference Sufficiency Ranges for Plant Analysis
in the Southern Region of the United States

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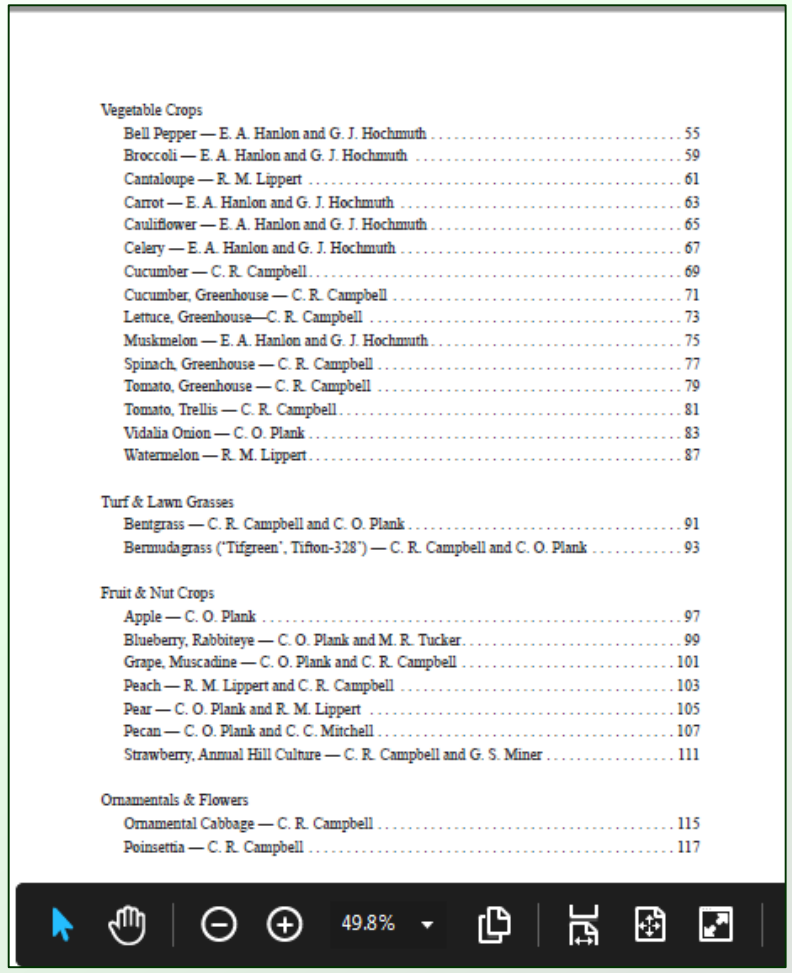


Sufficiency Range Reference for Cotton

Cotton

C. C. Mitchell and W. H. Baker

- **Sufficiency Levels and Critical Values**

Sufficiency ranges for cotton have often been used based upon observations and ranges of analyses of plant tissue from healthy or normal cotton crops. For this reason, ranges may be broad and too inclusive. Therefore, use of a sufficiency range for cotton and the implied critical concentration (lower end of sufficiency range) of a nutrient for deficiencies or toxicities are not absolute.

- **Sampling Procedures**

Petiole analysis
Sample petioles from the most recently matured leaf on the vegetative stem at intervals beginning the week before first bloom and continuing for 7 or 8 weeks after bloom. Samples should be taken at weekly intervals and compared for the results to be meaningful. Interpret petiole analysis for NO3-N, total P, and total K only. Nitrate analysis is the most meaningful and the primary reason for sampling.

Leaf blade at early bloom
Sample the uppermost, mature cotton leaf blade on the vegetative stem. Discard the petiole. (Note: some research has included both leaf blade and petiole.] This is usually the 3rd to 5th leaf from the terminal. Sample during the period of one week before to one week after first bloom.

- **Sufficiency Ranges**

Petioles
The petioles from the most recently matured leaf on the vegetative stem at intervals beginnin "Arkansas Intepretation" may be more appropriate for loess and other fine-textured soils of the mid-South whereas the "Georgia Interpretation" was developed for the coarser textured soils of the Atlantic and Gulf Coastal Plain.

Problem-solving Samples
These samples can be taken at any time during the growing season. Comparative samples from "good" and "bad" areas should be taken according to guidelines at the stage of growth.

Monitoring Samples
These samples should be taken at full tillering (Zadoks 30; Feekes 5) to predict nutritional status and additional nitrogen required to optimize yield. Final monitoring samples should be taken at flag leaf emergence (Zadoks 45; Feekes 10) to evaluate nutrient program.

- **Sufficiency Ranges**

Important Ratios
The N:S ratio should be between 10 and 15 for optimum yields. N:S ratios greater than or equal to 18 indicate that sulfur is limiting in relation to nitrogen.

Seedling to Tillering; Jointing to Flag Leaf Emergence

Macronutrients					
N	P	K	Ca	Mg	S
4.0–5.0%	0.2–0.5%	2.5–5.0%	0.2–1.0%	0.14–1.0%	0.15–0.65%

Micronutrients					
Fe	Mn	Zn	Cu	B	Mo
30–200 ppm	20–150 ppm	18–70 ppm	4.5–15 ppm	1.5–4 ppm	0.1–2.0 ppm

Flag Leaf Maturity

Macronutrients					
N	P	K	Ca	Mg	S
4.0–5.0%	0.2–0.5%	2.0–4.0%	0.2–1.0%	0.14–1.0%	0.15–0.65%

Micronutrients					
Fe	Mn	Zn	Cu	B	Mo
30–200 ppm	20–150 ppm	18–70 ppm	4.5–15 ppm	1.5–4.0 ppm	0.1–2.0 ppm

Youngest, Mature Leaf Blade
The following sufficiency ranges were compiled from several sources (Anderson and others 1971; Hodges and Hadden 1992; Mullins and Burmester 1990, 1992, 1993; Plank 1988; Reeves and Mullins 1993; Sabbe and Mackenzie 1973; Sabbe and others 1972).

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

Micronutrients (ppm)					
	Fe	Mn	Zn	Cu	B
early bloom	50–250	25–350	20–200	5–25	20–80
late bloom / maturity	50–300	10–400	50–300		15–200

- **References**

Anderson OE, Perkins HF, Carter RL, Jones JB Jr. 1971. Plant nutrient survey of selected plants and soils of Georgia. Athens (GA): Georgia Agricultural Experiment Station. Research Report 102.

Bassett DM, MacKenzie AJ. 1976. Plant analysis as a guide to cotton fertilization. In: Reisenauer HM, editor. Soil and plant-tissue testing in California. Davis (CA): University of California Cooperative Extension Service. p 16–7.

Benton ME, Maples R, May RD, Miley WN, Sabbe WE. 1979. A computerized system for cotton nitrate monitoring with program listings and descriptions. Fayetteville (AR): University of Arkansas Agricultural Experiment Station. Report Series 244.

Hodges SC, Hadden J. 1992. Late season soil and plant nutrient status in Georgia cotton soils. In: Proceedings 1992 beltwide cotton conferences. Memphis (TN): National Cotton Council. p 1126–7.

Lutrick MC, Peacock HA, Cornell JA. 1986. Nitrate monitoring for cotton lint production on a Typic Paleudult. Agron J 78:1041–6.

"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

"California" Petiole K Interpretation (Bassett and MacKenzie 1976)

Time of sampling	*% Potassium (K)*
Week of first bloom	4.0–5.5
Bloom + 4 weeks	3.0–4.0

Miley WN, Maples R. 1988. Cotton nitrate monitoring in Arkansas. Fayetteville (AR): University of Arkansas Cooperative Extension Service. Cotton Comments 2-88.

Mitchell CC, Pate G, Burmester CH, Edmisten KL, Gazaway W. 1992. Fertility status of Alabama cotton soils. In: Proceedings 1992 beltwide cotton conferences. Memphis (TN): National Cotton Council. p 1120–5.

Mullins GL, Burmester CH. 1990. Dry matter, nitrogen, phosphorus, and potassium accumulation by four cotton varieties. Agron J 82:729–36.

Mullins GL, Burmester CH. 1992. Uptake of calcium and magnesium by cotton grown under dryland conditions. Agron J 84:564–9.

Mullins GL, Burmester CH. 1993. Accumulation of copper, iron, manganese and zinc by four cotton cultivars. Field Crops Res 32:129–40.

Plank CO. 1988. Plant analysis handbook for Georgia. Athens (GA): University of Georgia Cooperative Extension Service.

Reeves DW, Mullins GL. 1993. Subsoiling and K placement: effects on cotton water relations. In: Proceedings 1993 beltwide cotton conferences. Memphis (TN): National Cotton Council. p 1322–5.

Sabbe WE, Keogh JL, Maples R, Hileman LH. 1972. Nutrient analysis of Arkansas cotton and soybean leaf tissue. Arkansas Farm Res 21:2.

Sabbe WE, MacKenzie AJ. 1973. Plant analysis as an aid to cotton fertilization. In: Walsh LM, Beaton JD, editors. Soil testing and plant analysis. Madison (WI): Soil Science Society of America, Inc. p 299–313.

Sufficiency Range Reference for Small Grains

Small Grain —Barley, Oats, Rye, Wheat

C. O. Plank and S. J. Donohue

- **Critical Values**

The values given here are best estimates based on extensive experience. They apply to all samples and growth stages.

Macronutrients					
N	P	K	Ca	Mg	S
3.0%	0.15%	2.0%	0.15%	0.10%	0.10%

Micronutrients					
Fe	Mn	Zn	Cu	B	Mo
25 ppm	15 ppm	15 ppm	3 ppm	1 ppm	0.05 ppm

- **Sampling Procedures**

Seedling to Tillering
Whole plants should be collected by cutting 1 inch above the soil surface. Samples can be taken by grasping existing growth at a given site and cutting at the recommended level above the soil with a small knife. Dead leaves should be avoided as much as possible. After **collecting subsamples from several locations in a field, clippings should be combined for a** representative sample.

Jointing to Flag Leaf Emergence
Break the top two to three leaves (growing point) from representative plants in several locations of the field. Combine for a representative sample. Stems should be included.

Flag Leaf to Maturity
Flag leaves from representative plants in the field should be collected randomly. A minimum of 15 to 20 leaves should be collected from a given field or area.

- **Remarks**

Sufficiency ranges are based on available literature and experience interpreting plant samples.

Results are less reliable as crop approaches maturity. Comparative "good" and "bad" samples should be used when sampling at various stages of maturity.

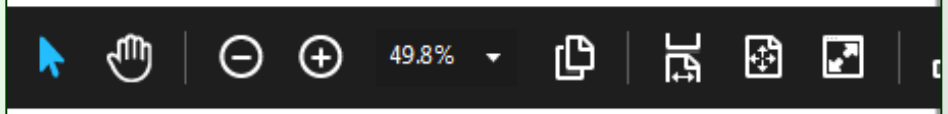
Sufficiency ranges can generally be applied for wheat, oats, rye, and barley although most of the research has been done on wheat.

- **References**

Mills HA, Jones JB Jr. 1996. Plant analysis handbook II: a practical sampling, preparation, analysis, and interpretation guide. Athens (GA): Micro-Macro Publishing.

Plank CO. 1989. Plant analysis handbook for Georgia. Athens (GA): University of Georgia Cooperative Extension Service. p 37–8.

Westfall DG, Whitney DA, Brandon DM. 1990. Plant analysis as an aid in fertilizing small grains. In: Westerman RL, editor. Soil testing and plant analysis. 3rd ed. Madison (WI): Soil Society of America, Inc. p 495–519. (SSSA book series; 3).



NCDA Plant Analysis Report

Crop with established sufficiency ranges

Sample Information

ID: WHEAT
Crop: Wheat
Growth Stage: E
Week: 16
Plant Part: W
Plant Position: U
Plant Appearance:

Nutrient Measurements are given in units of parts per million (ppm or mg/L) unless otherwise specified.

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

Na (%)	Cl (%)	C (%)	DW (g)	Al
0.01	-	-	-	86.9

Nutrient Ratios

N:S	N:K	Fe:Mn
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

ID: RAT
Crop: Hemp, Field
Growth Stage: M
Week: 0
Plant Part: M
Plant Position: 0

Nutrient Measurements are given in units of parts per million (ppm or mg/L) unless otherwise specified.

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

Na (%)	Cl (%)	C (%)	DW (g)	Al
0.00	-	-	0.62	22.4

Nutrient Ratios

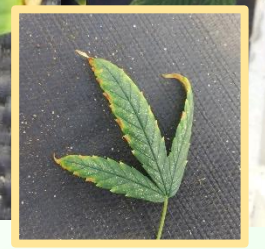
N:S	N:K	Fe:Mn
19.4 : 1	2.65 : 1	0.77 : 1

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

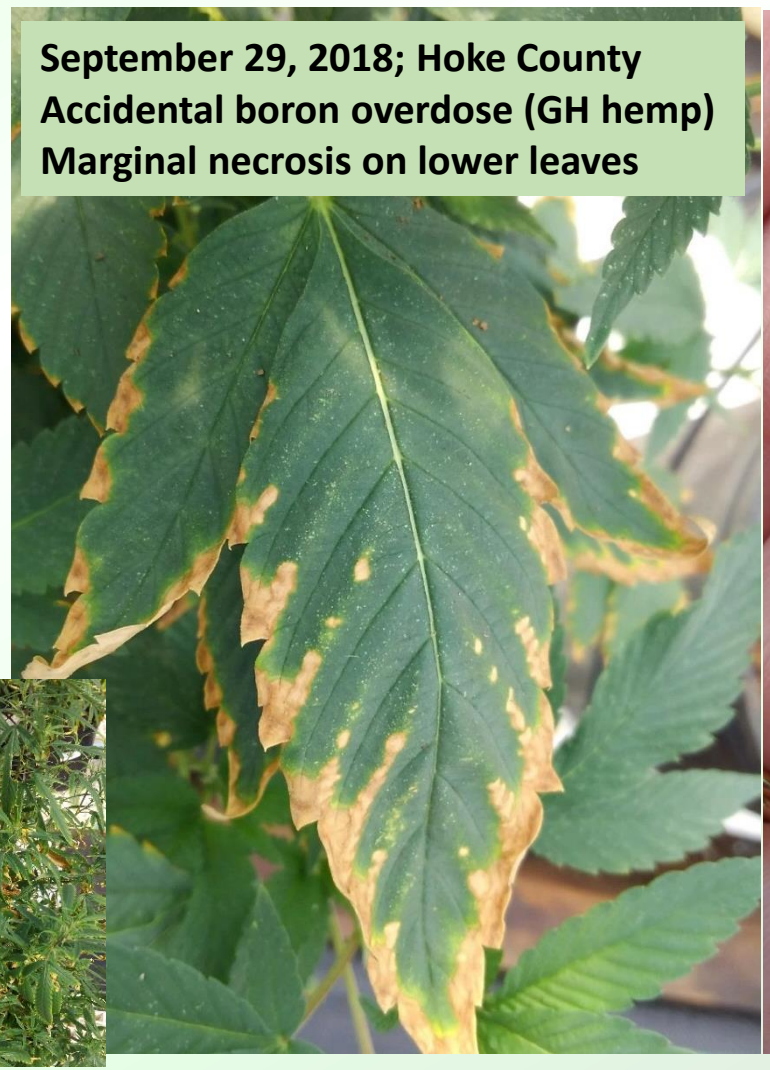
- No indexes for hemp b/c no sufficiency ranges or NC based survey ranges
- Compare results to Bryson & Mills survey ranges listed in Agronomist's Comments

August 24, 2018; Guilford
Low plant tissue P
Stunting; mottling, dark green new and/or purpling

Sample Information	Nutrient Measurements are given in units of parts per million (ppm or mg/L) unless otherwise specified.										
GH1	N (%) 3.97	P (%) 0.42	K (%) 1.87	Ca (%) 1.90	Mg (%) 0.34	S (%) 0.21	Fe 311	Mn 154	Zn 27.3	Cu 7.67	B 16.8
FS1	N (%) 1.22	P (%) 0.19	K (%) 1.01	Ca (%) 1.52	Mg (%) 0.19	S (%) 0.08	Fe 125	Mn 60.2	Zn 11.3	Cu 4.13	B 44.3
Lower end of target range	3.3%	0.24%	1.8%	1.5%	0.40%	0.17%	100 ppm	41 ppm	24 ppm	5 ppm	56 ppm



September 29, 2018; Hoke County
Accidental boron overdose (GH hemp)
Marginal necrosis on lower leaves



Sample Information	Nutrient Measurements are given in units of parts per million (ppm or mg/L) unless otherwise specified.										
ID: hemp1 Crop: Hemp, G.H.	N (%) 5.43	P (%) 0.49	K (%) 2.64	Ca (%) 1.77	Mg (%) 0.30	S (%) 0.67	Fe 140	Mn 80.2	Zn 50.3	Cu 3.75	B 961
Lower end of target range	**3.3%**	**0.24%**	**1.8%**	**1.5%**	**0.40%**	**0.17%**	**100 ppm**	**41 ppm**	**24 ppm**	**5 ppm**	**56 ppm**

August 9, 2018; Guilford
Iron deficiency
Interveinal chlorosis of new growth

Sample Information	Nutrient Measurements are given in units of parts per million (ppm or mg/L) unless otherwise specified.										
GOOD	N (%) 3.05	P (%) 0.47	K (%) 1.84	Ca (%) 3.06	Mg (%) 0.42	S (%) 0.21	Fe 50.6	Mn 53.0	Zn 35.3	Cu 7.90	B 61.1
BAD	N (%) 2.53	P (%) 0.35	K (%) 1.83	Ca (%) 2.83	Mg (%) 0.32	S (%) 0.17	Fe 110	Mn 42.8	Zn 31.1	Cu 6.70	B 71.8
Lower end of target range	3.3%	0.24%	1.8%	1.5%	0.40%	0.17%	100 ppm	41 ppm	24 ppm	5 ppm	56 ppm

July 25, 2018; Guilford
Deficient K confirmed with plant tissue analysis
Chlorosis and mottling of lower leaf margins

NCDA and NCSU – Two Projects

1) Nitrogen and Potassium Rates for Floral Hemp
2) Foliar Nutrient Survey for Floral Hemp

Nitrogen and Potassium Rates for Floral Hemp Objective

- Evaluate the effect
  - Yield (dry floral weight)
  - Cannabinoid concentrations (CBD, THC, etc)
- Establish
  - Soil test K recommendation
  - Optimal N recommendation
  - N and K foliar sufficiency ranges

Nitrogen and Potassium Rates for Floral Hemp Experimental Design

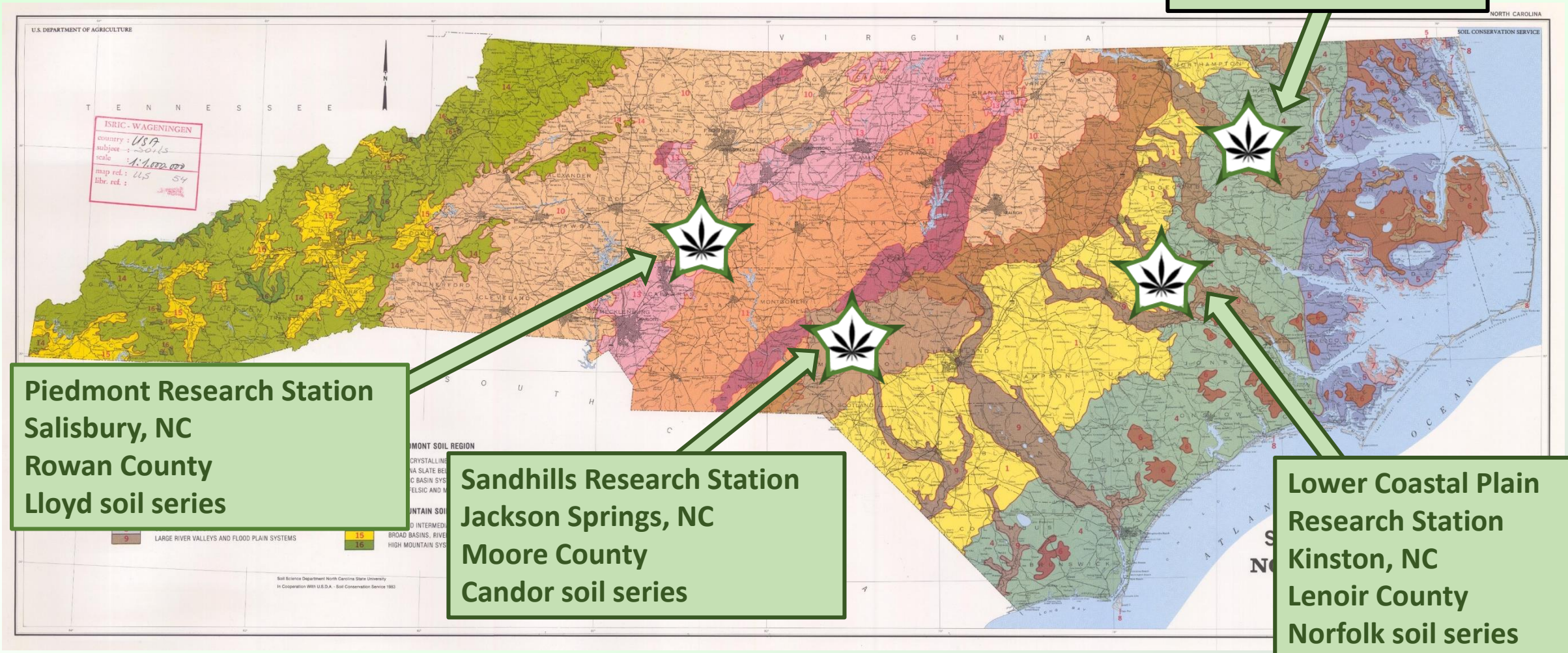
Nitrogen Rate Studies

- 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 K_2O/A
- RCBD with 4 reps
- Potassium: Applied with K_2SO_4 (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 – 4 Locations

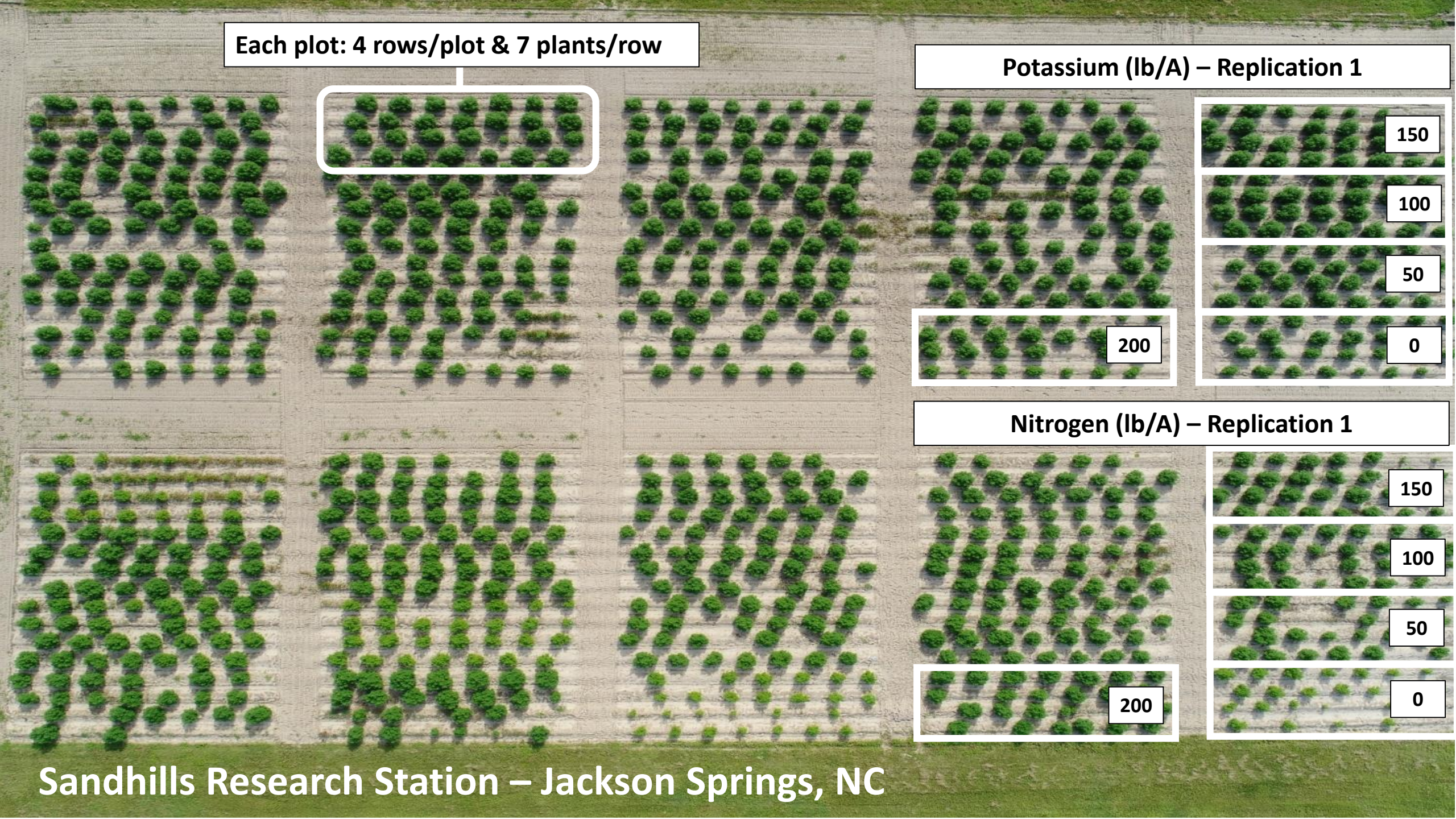


On-Farm
Windsor, NC
Bertie County
Wickham soil series &
Dogue soil series

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
150
100
50
200
0
Nitrogen (lb/A) – Replication 1
150
100
50
200
0
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)

Nitrogen Test at Harvest (Sandhills)

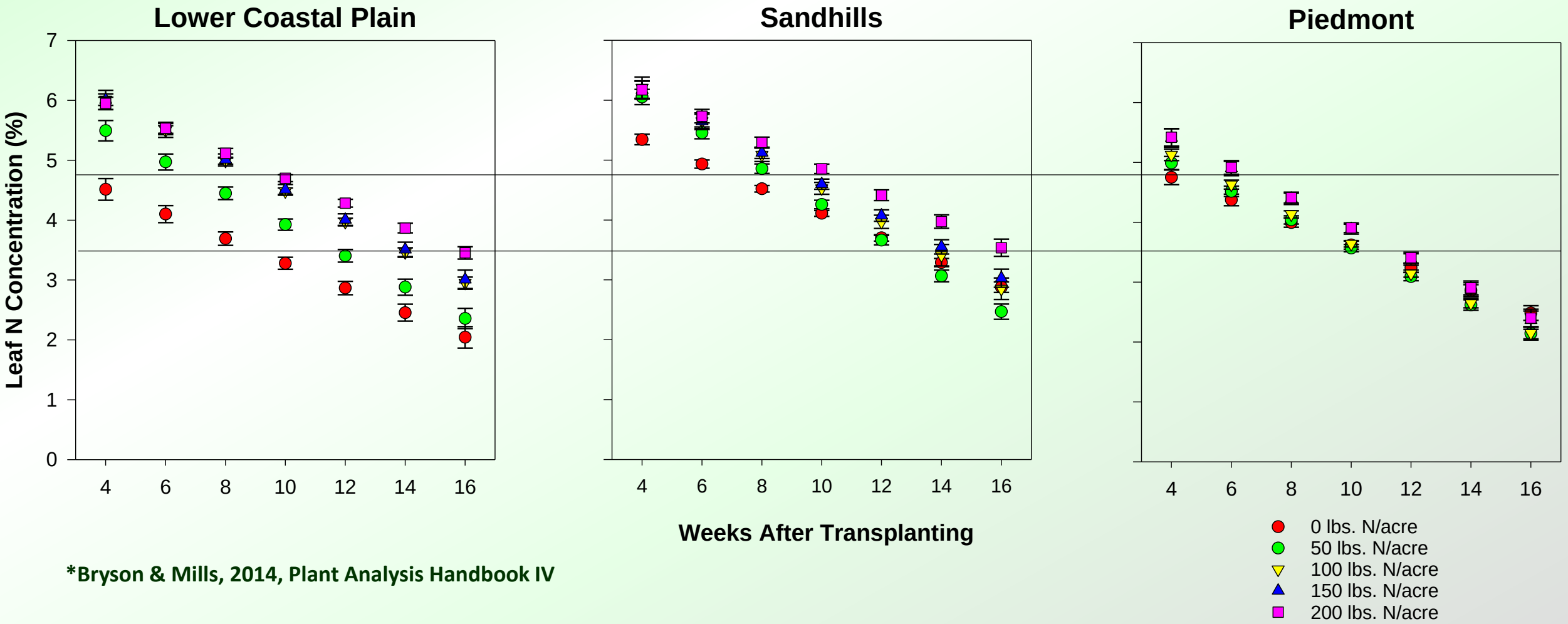
0 lbs N/acre

100 lbs N/acre

200 lbs N/acre

Foliar N Concentration (N Rate Study)

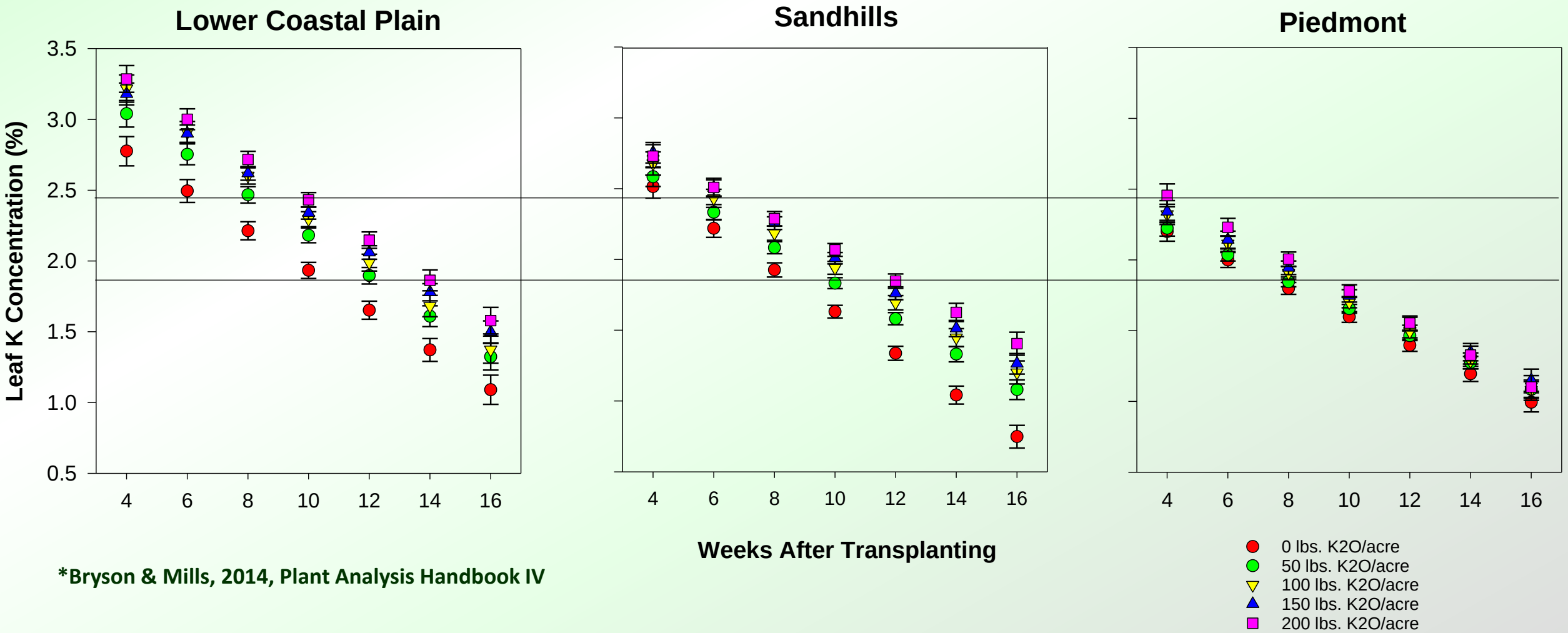
Nitrogen survey range 3.3-4.8%*



*Bryson & Mills, 2014, Plant Analysis Handbook IV

Foliar K Concentration (K Rate Study)

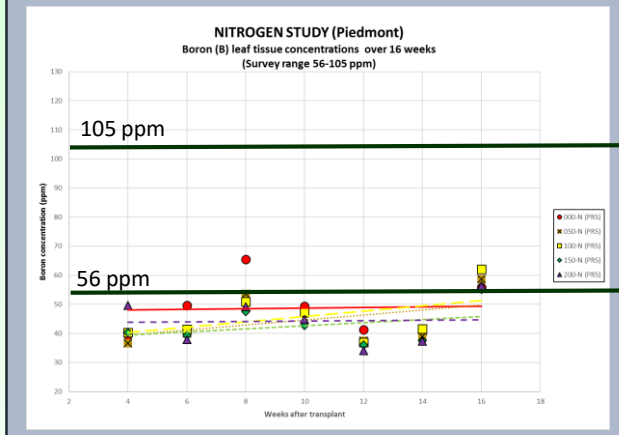
Potassium survey range 1.8-2.4%

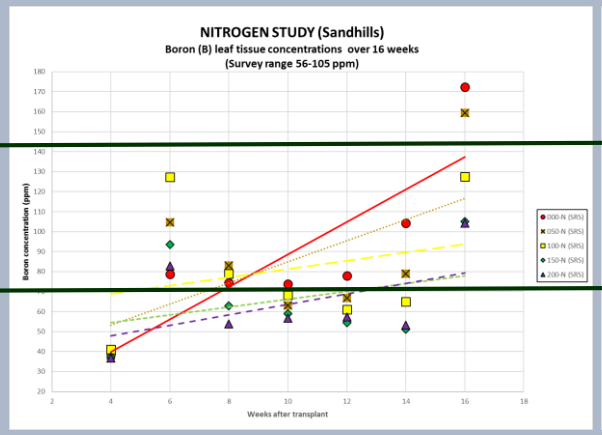


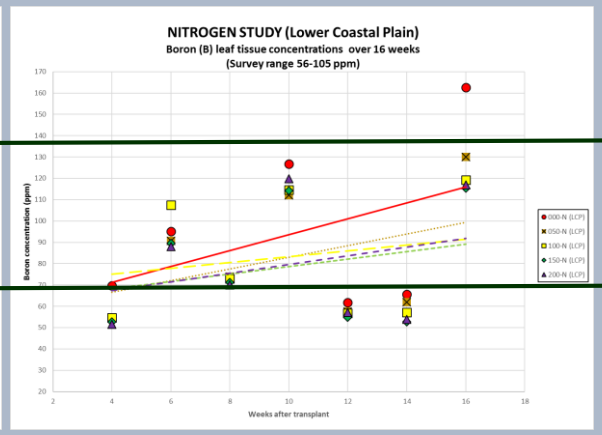
*Bryson & Mills, 2014, Plant Analysis Handbook IV

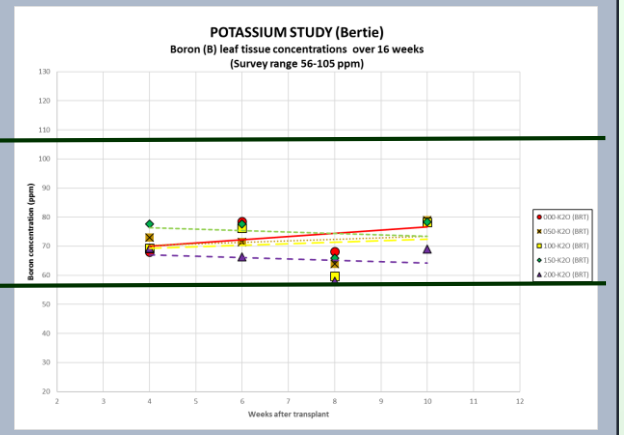
Foliar boron concentrations

Nitrogen rate studies

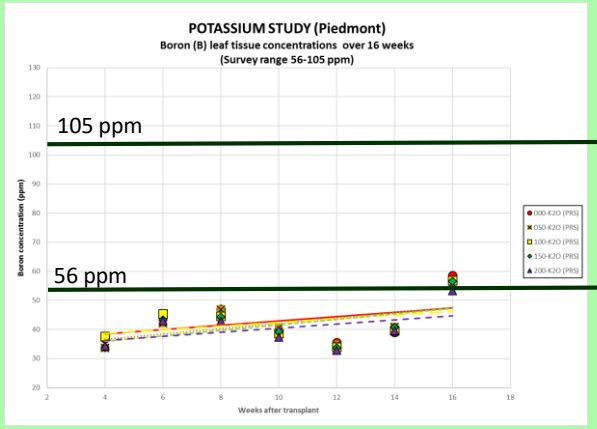


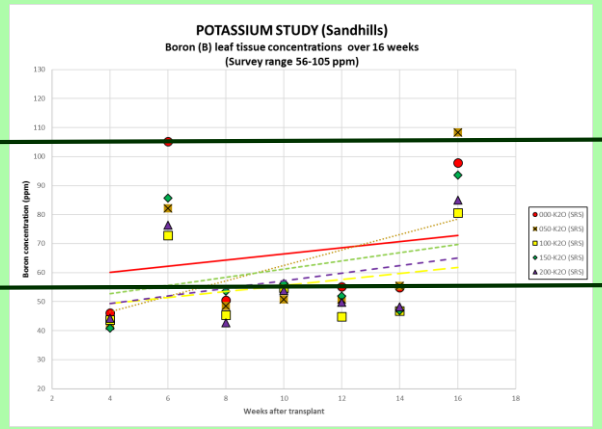


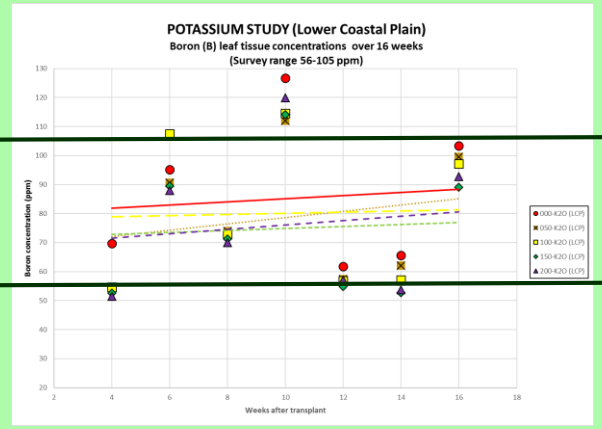


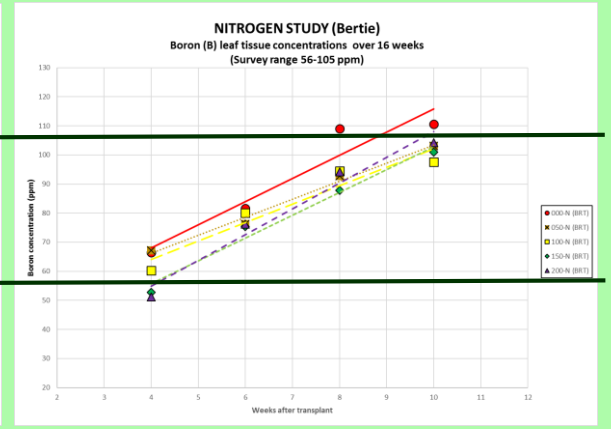


Potassium rate studies



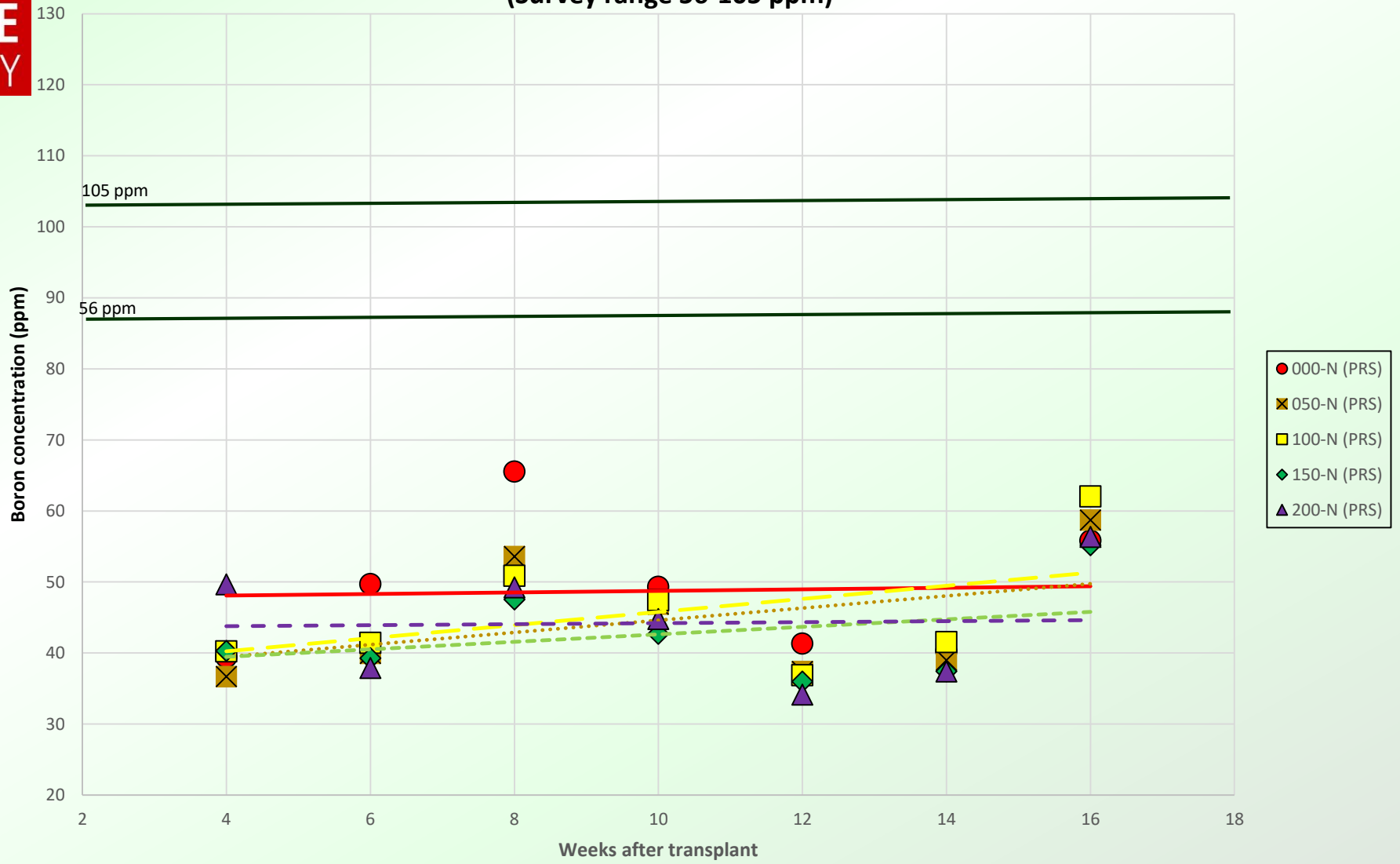






NITROGEN STUDY (Piedmont)

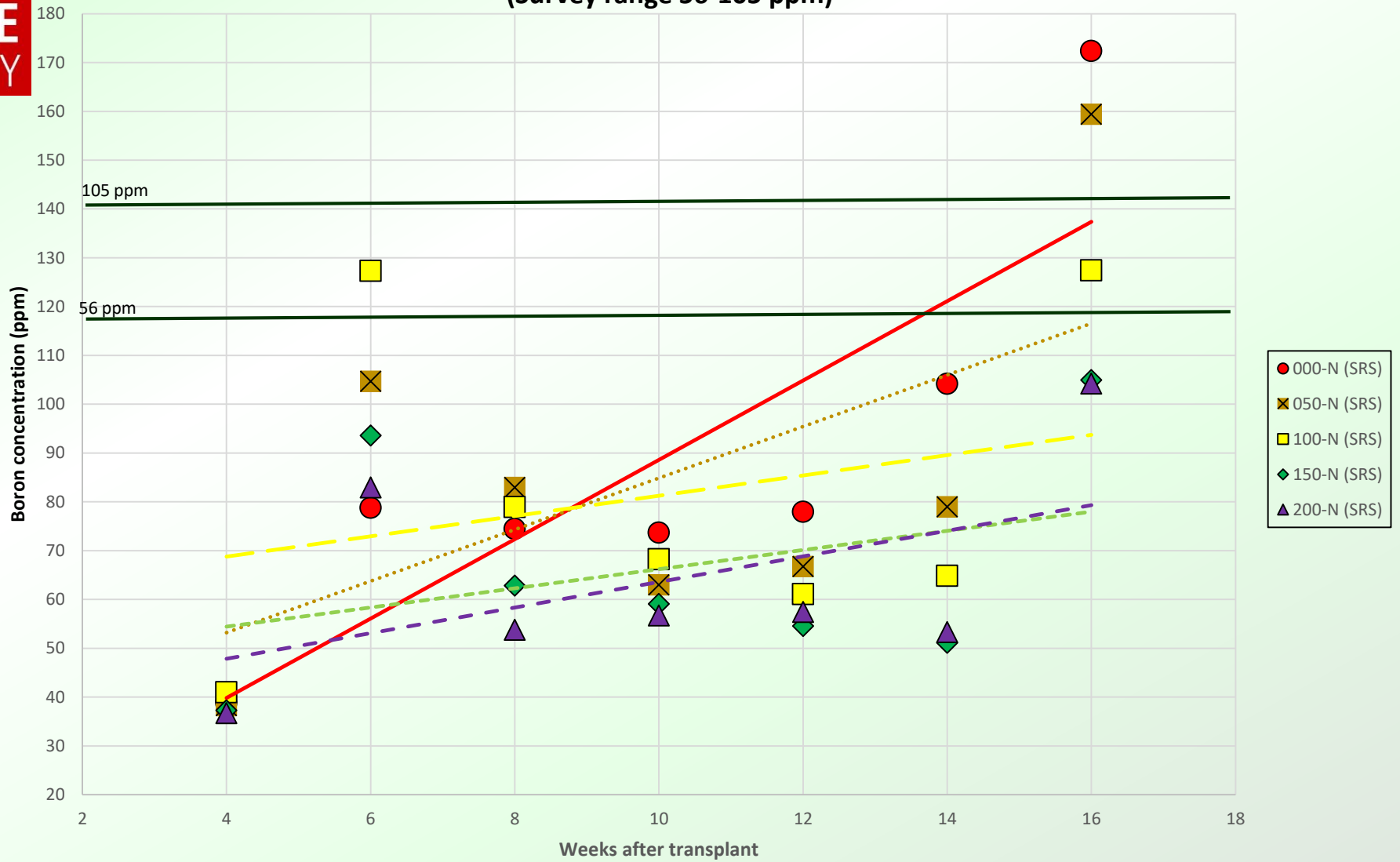
Boron (B) leaf tissue concentrations over 16 weeks
(Survey range 56-105 ppm)



NITROGEN STUDY (Sandhills)

Boron (B) leaf tissue concentrations over 16 weeks

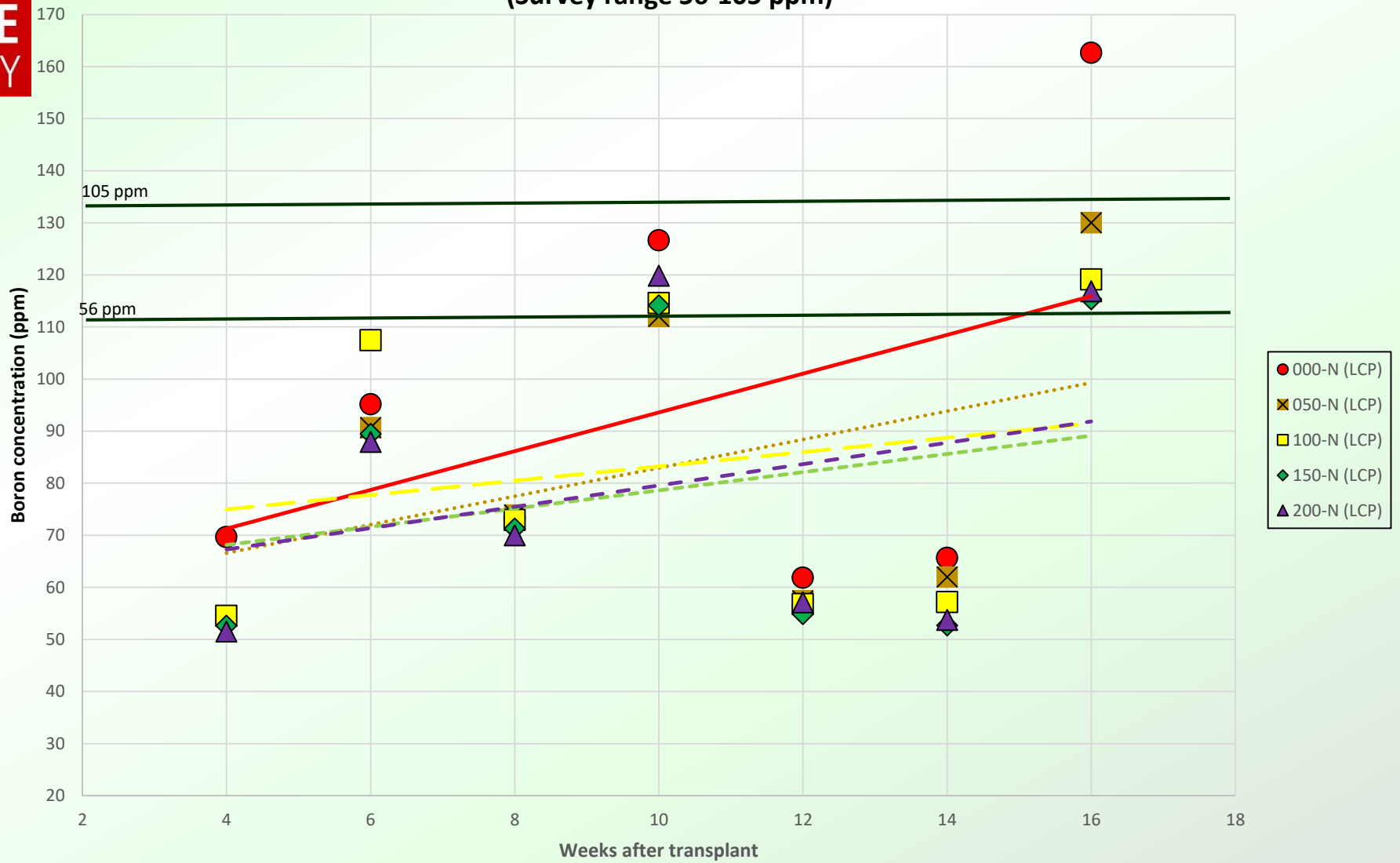
(Survey range 56-105 ppm)



NITROGEN STUDY (Lower Coastal Plain)

Boron (B) leaf tissue concentrations over 16 weeks

(Survey range 56-105 ppm)



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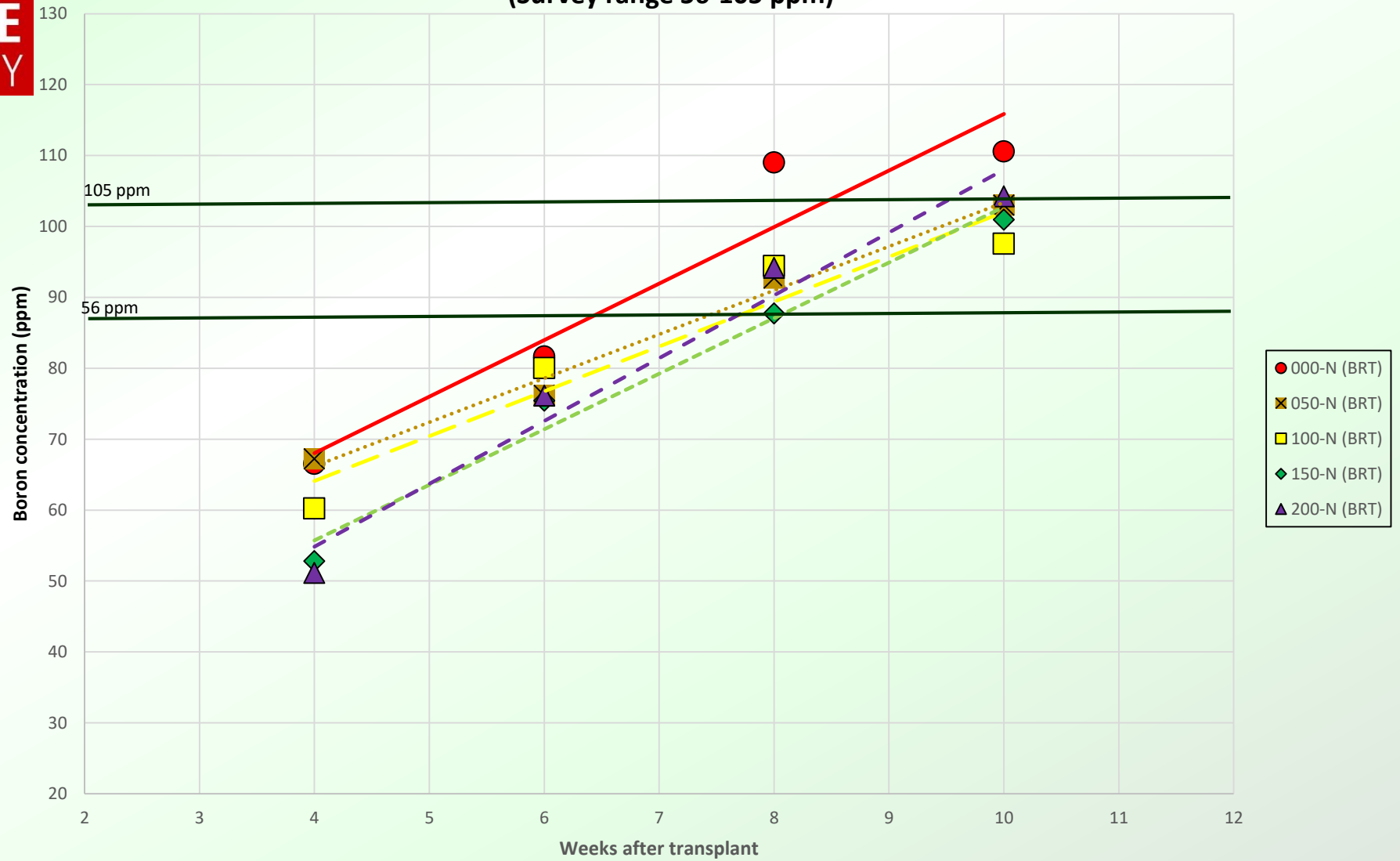
NITROGEN STUDY (Bertie)

Boron (B) leaf tissue concentrations over 16 weeks

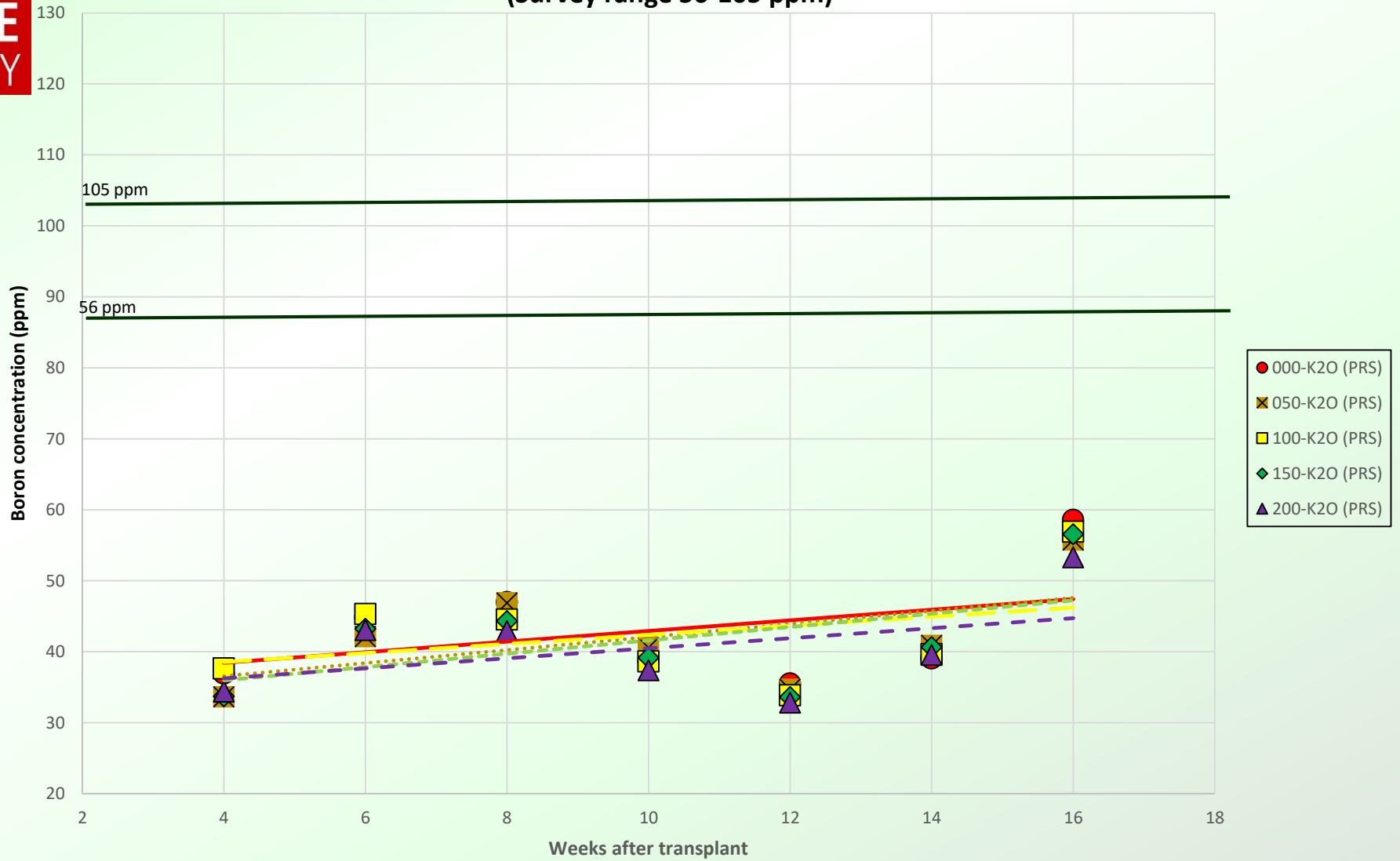
(Survey range 56-105 ppm)



POTASSIUM STUDY (Piedmont)

Boron (B) leaf tissue concentrations over 16 weeks

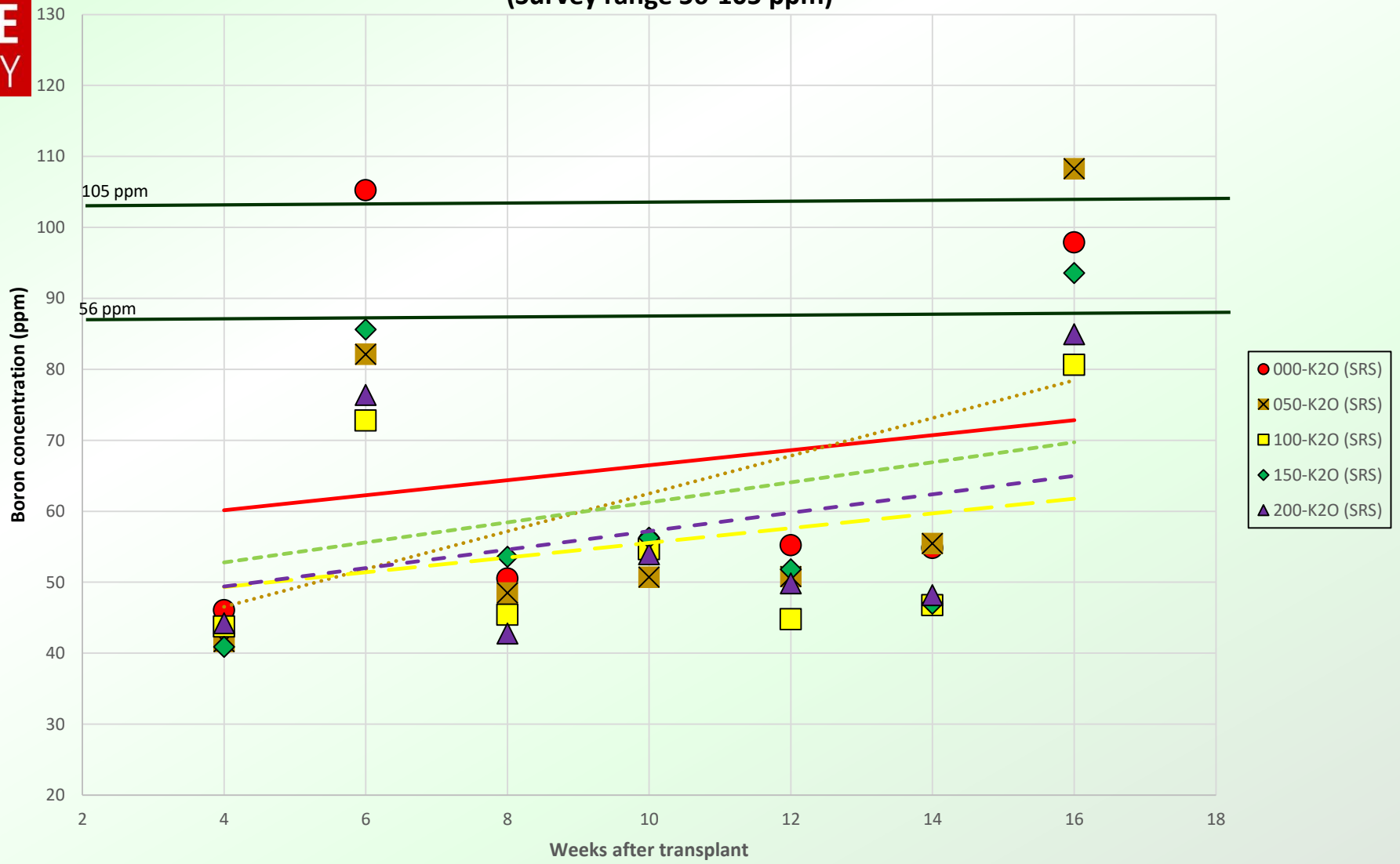
(Survey range 56-105 ppm)



POTASSIUM STUDY (Sandhills)

Boron (B) leaf tissue concentrations over 16 weeks

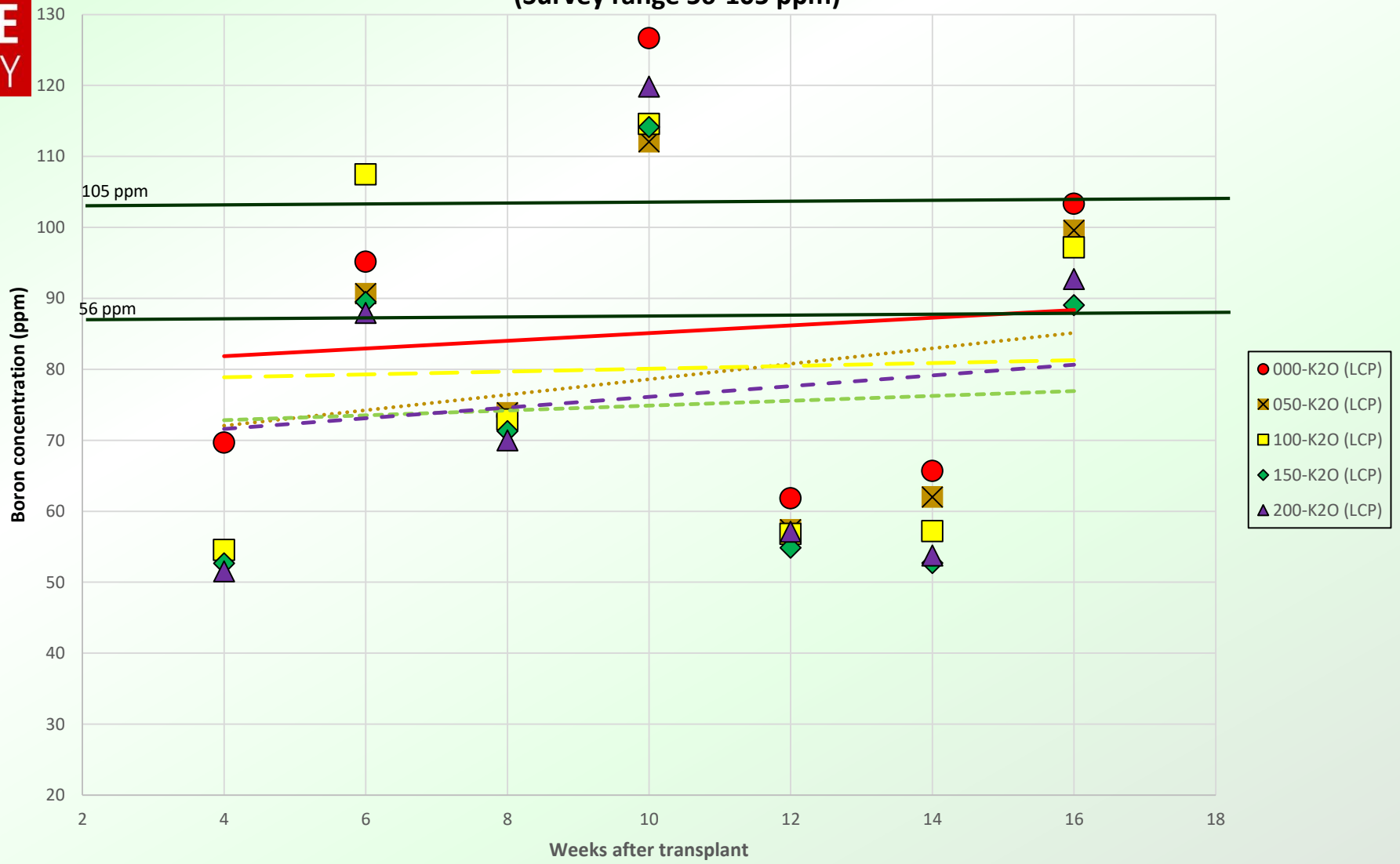
(Survey range 56-105 ppm)



POTASSIUM STUDY (Lower Coastal Plain)

Boron (B) leaf tissue concentrations over 16 weeks

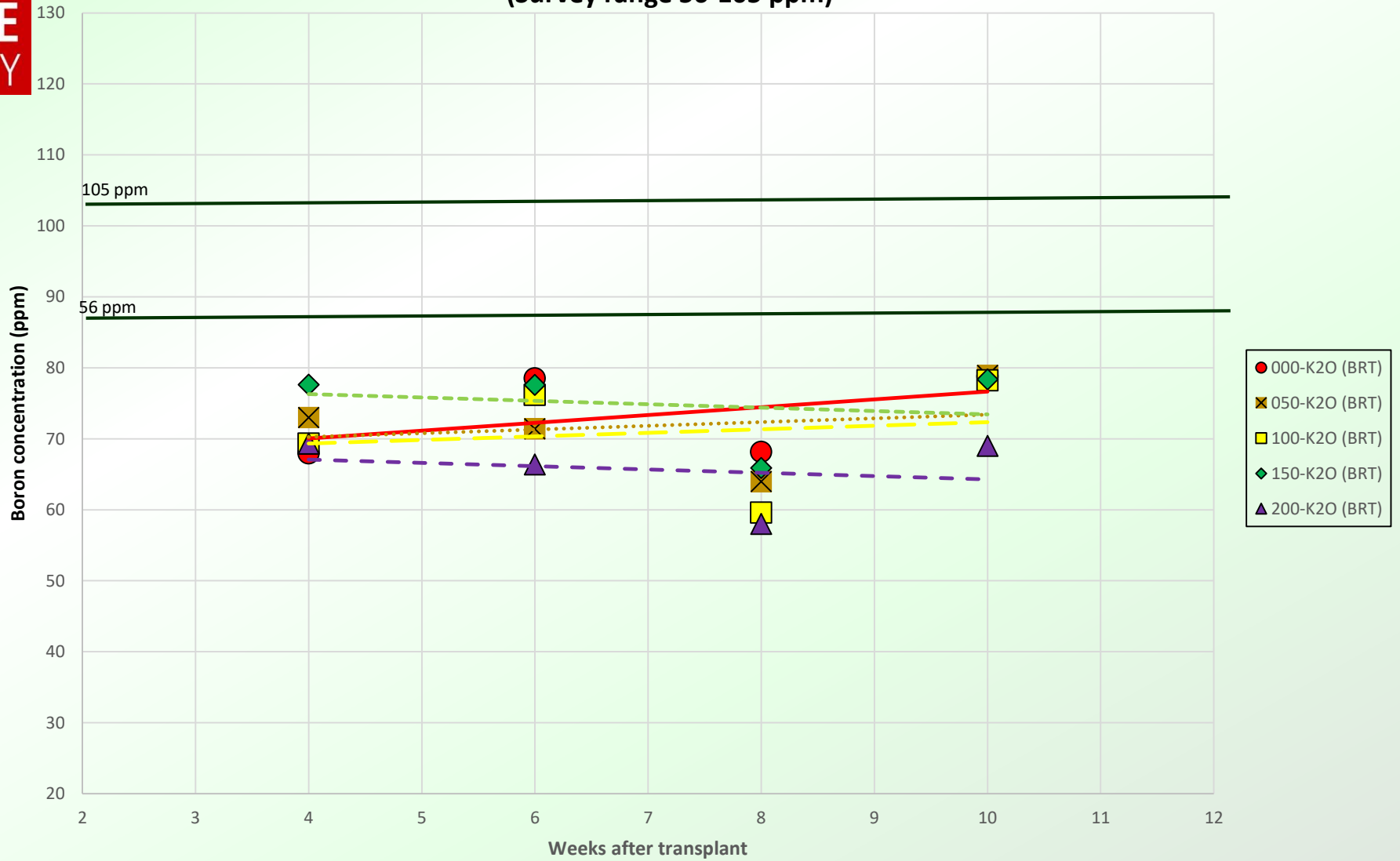
(Survey range 56-105 ppm)



POTASSIUM STUDY (Bertie)

Boron (B) leaf tissue concentrations over 16 weeks

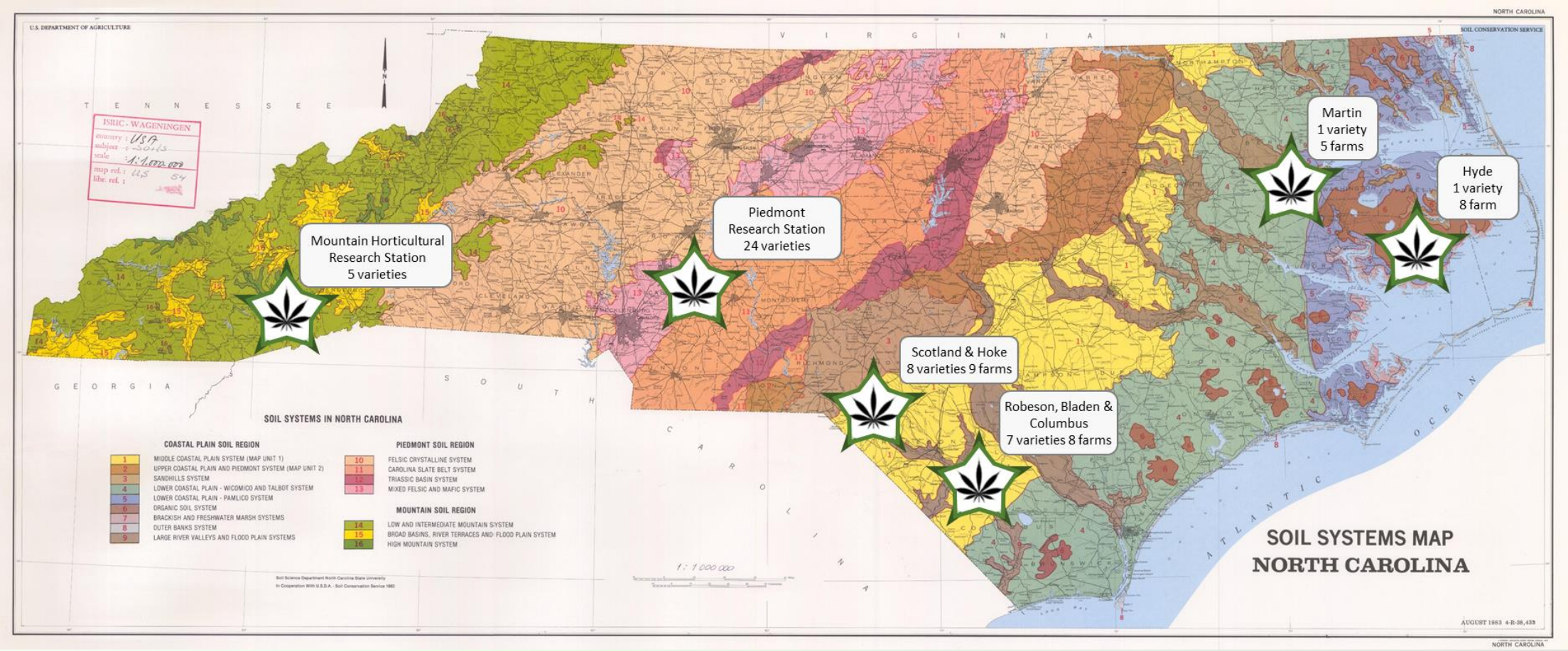
(Survey range 56-105 ppm)



Foliar Nutrient Survey for Floral Hemp Objectives

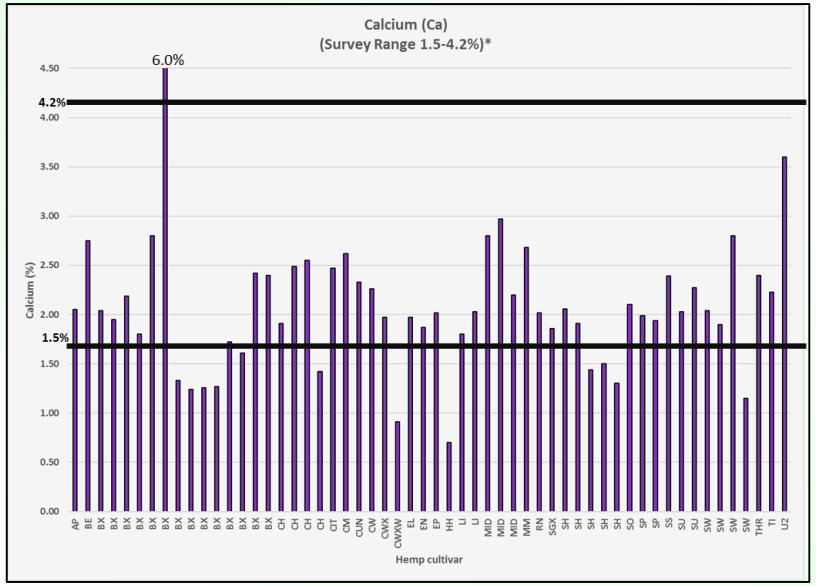
- **Ground-truth Bryson & Mills nutrient survey ranges to cultivars and environments specific to North Carolina**
- Conducted 2019; Again 2020
- Multiple cultivars (NCSU trials)
- Transplant sources (producer and clones/seeds)
- Fertility management / irrigation management
- Across the state

Leaf Tissue Nutrient Survey Sample Locations

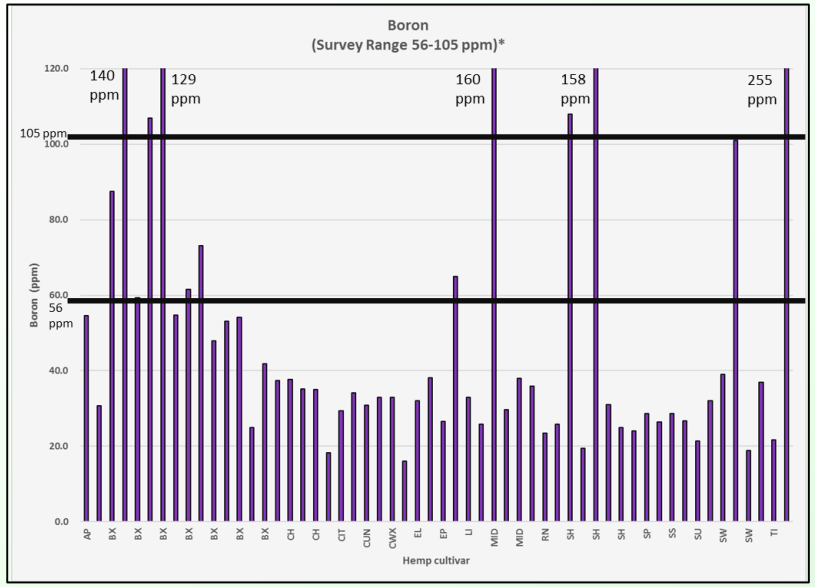


Leaf Tissue Nutrient Survey

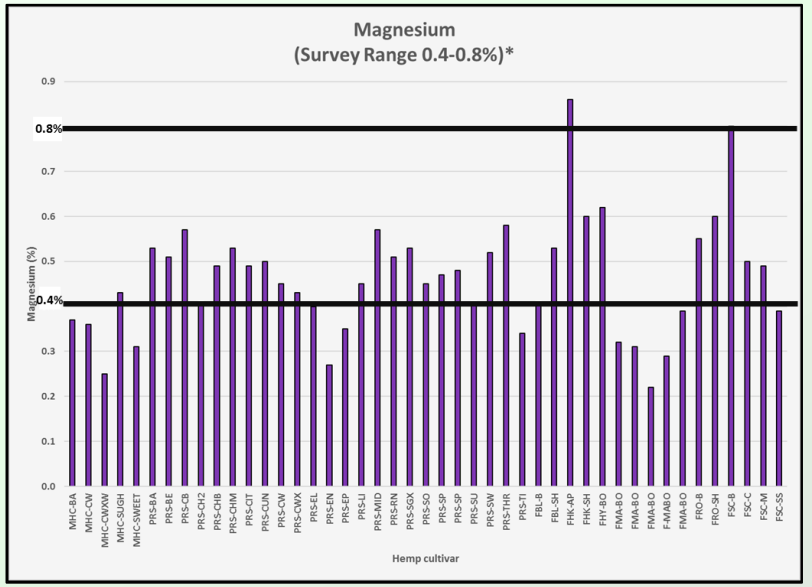
Calcium survey range 1.5-4.4%



Boron survey range 56-105 ppm



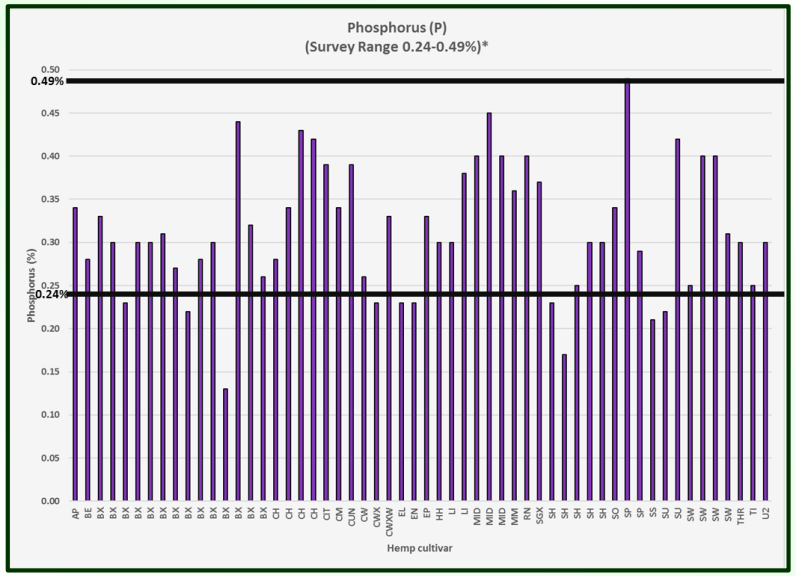
Magnesium survey range 0.4-0.8%



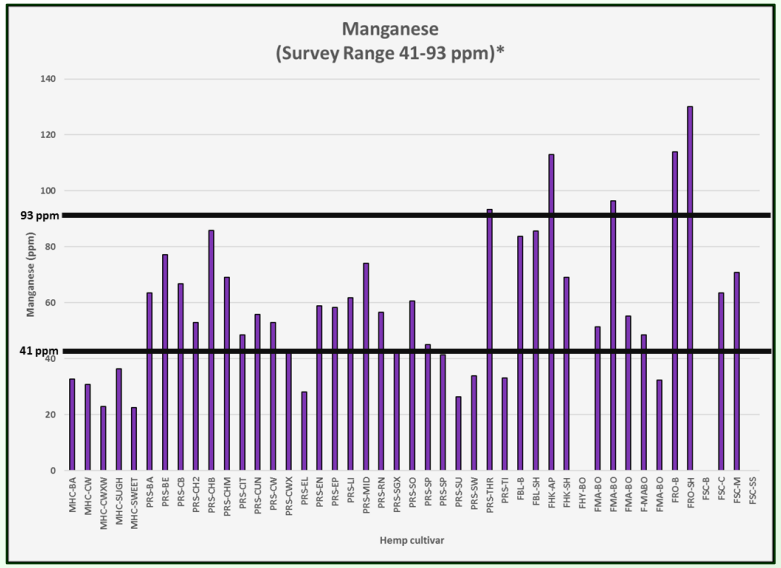
Ranges too high??

Leaf Tissue Nutrient Survey

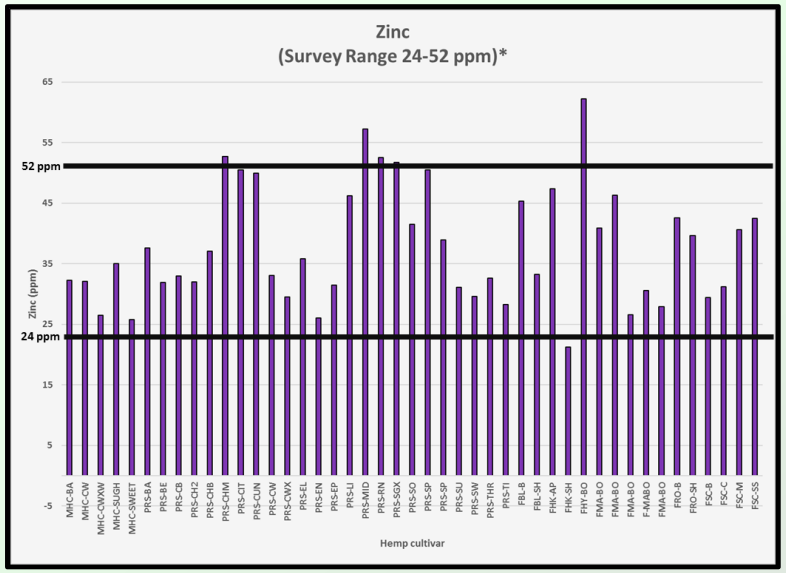
Phosphorus survey range 0.24-0.49%



Manganese survey range 41-93 ppm



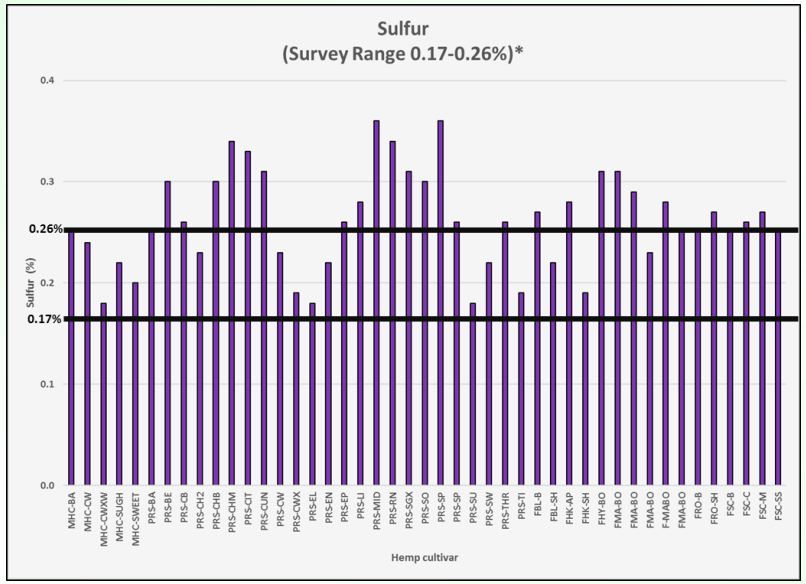
Zinc survey range 24-52 ppm



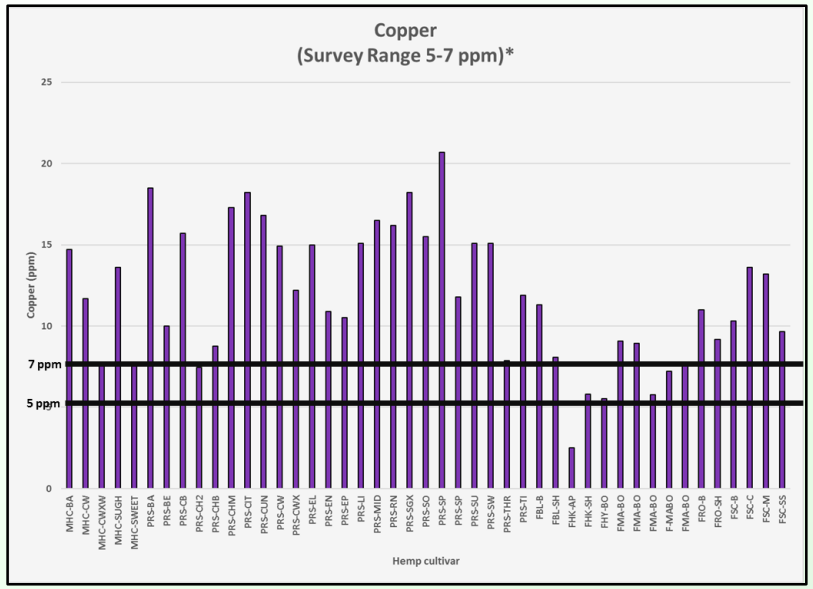
Ranges reasonable??

Leaf Tissue Nutrient Survey

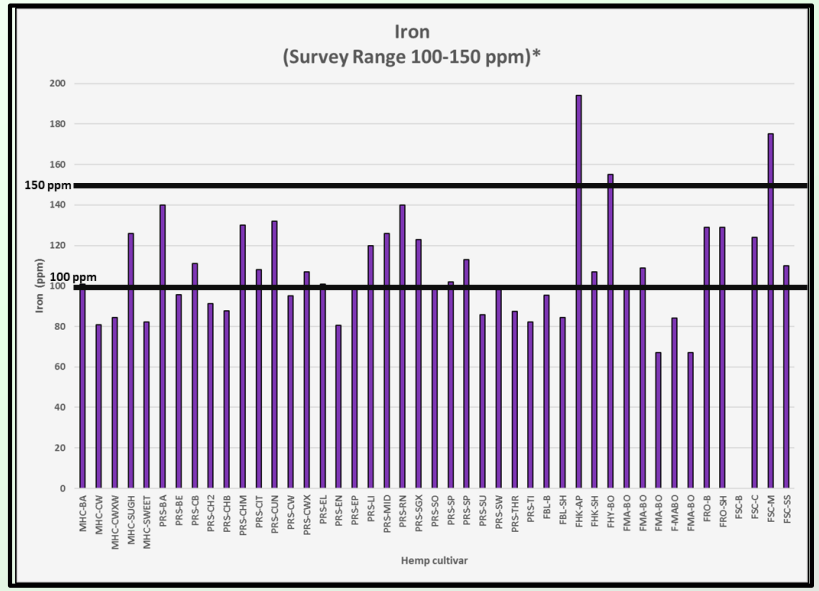
Sulfur survey range 0.17-0.26%



Copper survey range 5-7 ppm



Iron survey range 100-150 ppm



Ranges too narrow??

Establishing Hemp Leaf Tissue Nutrient Sufficiency and Survey Ranges for North Carolina Production

- Results of N and K rate study will contribute to establishing N and K sufficiency ranges
- Observational data from the survey study will contribute to establishing survey ranges for the rest of the nutrients
- Also to be considered when establishing these ranges
  - Data collected by Dr. Kristin Hicks, Agronomic Plant Lab Section Chief
  - Data reported in Cockson, P.; Landis, H.; Smith, T.; Hicks, K.; Whipker, B.E. Characterization of Nutrient Disorders of *Cannabis sativa*. *Appl. Sci.* **2019**, *9*, 4432 https://www.mdpi.com/2076-3417/9/20/4432

Super Team

- Maggie Short – MS Student
- Matthew Vann
- Keith Edmisten
- David Suchoff (welcome!)
- NCSU Tobacco Team
- Agronomic Field Services Team
- Research Stations
- Extension Agents













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