Exploring Nitrogen Dynamics in Cabbage

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[1]**Cornell Cooperative Extension Vegetable Program**

2017 Empire State Producers Expo: Cabbage Session
Syracuse, NY: January 17, 2017

Acknowledgements

- **Funding provided by:**
  - NY Cabbage Research & Development Program
- **Grower Cooperators:**
  - Steve Starowtiz, S.J. Starowitz Farms, North Byron, NY **(trial)**
  - Dean & Joe Brightly, Brightly & Sons, Hamlin, NY **(trial)**
  - Eric Hansen, Hansen Farms, Stanley, NY
  - Mike Riner and Emma Long, CY Farms, Elba, NY
  - John Voelpel, Voelpel Farms, Newfane, NY
  - Colby Homestead Farms, Spencerport, NY
  - Torrey Farms, Elba, NY
  - Star Grower, Elba, NY

Acknowledgements

- **Technical Advisor:**
  - Steve Reiners, NYSAES
- **CVP Program Assistants:**
  - Elizabeth Buck (2014-2015)
  - Cordelia Hall (2014)
  - Missy Call (2015)
  - Amy Celentano (2016)
  - Mariam Taleb (2016)
- **Fertilizer provided by:**
  - Growmark FS, Knowlesville
  - CY Farms
- **Nitrogen stabilizer provided by:**
  - John Boston, Dow AgroSciences

Mariam, Amy & Christy

Nitrogen Dynamics in Cabbage

- CRDP made cabbage fertility with an emphasis on nitrogen as one of their highest research priorities in 2014
- Concerned that too much nitrogen left in fields following harvest of summer cabbage may be causing lodging of following winter wheat crop

Lodging of winter wheat

Cornell Recommendations

Nitrogen:

- Cornell recommends **100 to 120 lb/A**
- 40 lb broadcast and incorporated prior to planting
- 40 lb in the band at planting
- 20 to 40 lb side-dressed 4 weeks after planting

- A lot of variability in rate & timing of N application

Nitrogen Use in Summer Cabbage in New York

Rate (lb/A) and Timing of Nitrogen Application				Ratio		
Total	Pre- & At-Planting	Side-Dress #1 (4 wks)	Side-dress #2 (6 wks)	Planting	Side-dress #1	Side-dress #2
72.5	72.5			**100**	0	
105	105			**100**	0	
150	150			**100**	0	
210	210			**100**	0	
129	89.7	39.1		**69**	31	
152	98.4	53.3		**65**	35	
157	75	82		**48**	52	
185	80	75	30	**43**	41	16
150	60	45	45	**40**	30	30
141	21	120		**15**	85	
185	42.7	142		**23**	77	

All at planting

Two-thirds at planting

50:50 split

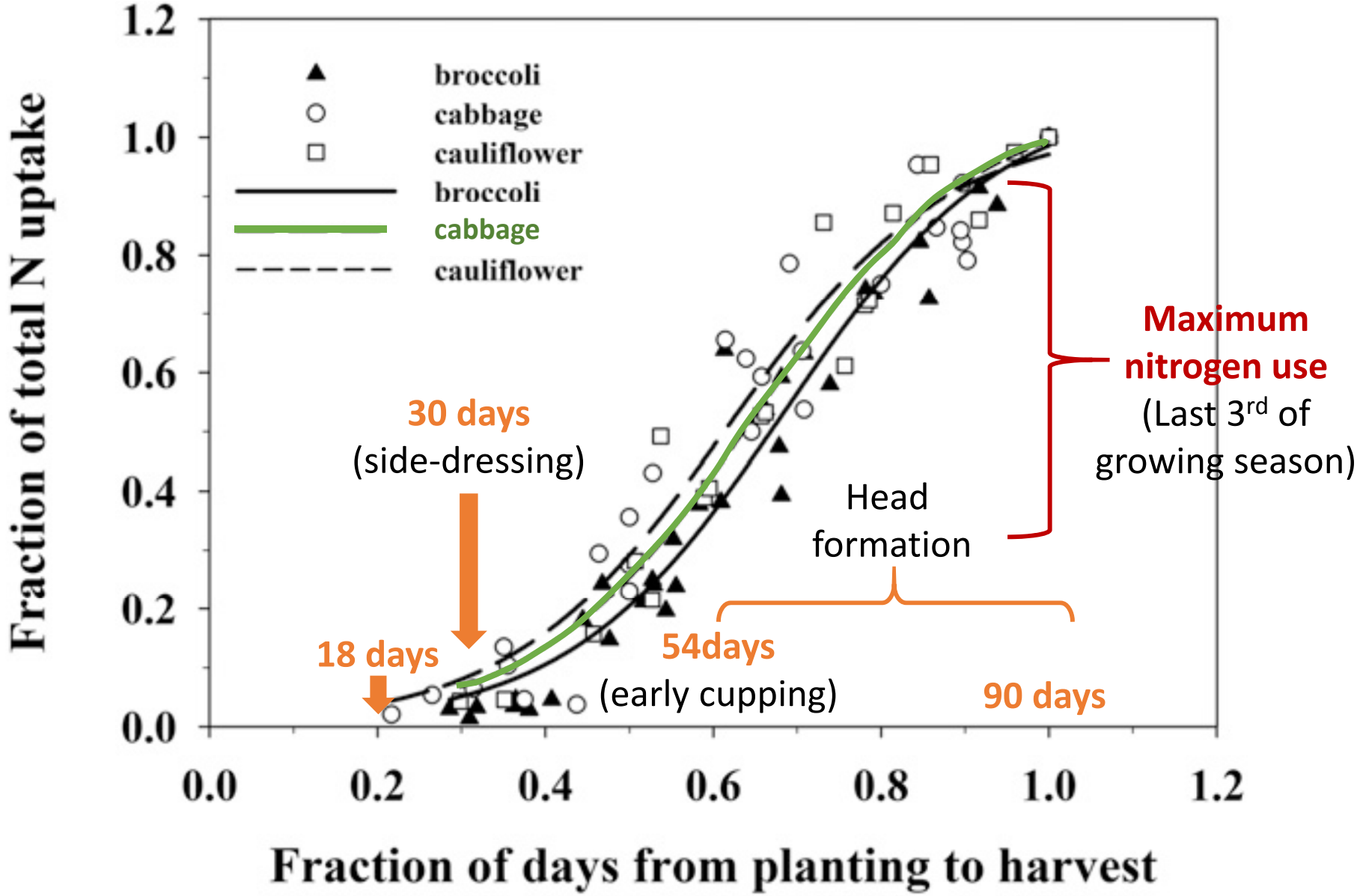
More at side-dress

- Total lb/A: Range; **72.5 to 210 lb/A**; Average: **<u>149 lb/A</u>**
- Ratios of planting to side-dress range from **100:0 to 15:85**

Objectives

- To study nitrogen dynamics in summer cabbage with respect to:
  - total rate applied
  - timing of application (proportion applied pre-plant compared to side-dressed)
  - Use of nitrogen stabilizers
- To refine use of nitrogen in cabbage:
  - To improve efficiency
  - Optimize rates
  - To reduce environmental contamination and/or problems with lodging in following winter wheat crop

Nitrogen Use in Cabbage



Smith et al. 2016

2014 On-Farm Small-Plot Trial

- **5 rates of total applied nitrogen:**
  - 31 lb/A
  - 66 lb/A
  - 132 lb/A
  - 197 lb/A
  - 262 lb/A
- **3 application timings** – ratio at plant: side-dress
  - 100%: 0%
  - 50%: 50%
  - 25%: 75%
- Included no applied nitrogen (= 2.2 lb from MAP)

2015 Case Studies

- **4 Fields** (5 acre sections divided into 4 replicates)
  - 3 summer cabbage (c.v. Transam)
  - 1 storage cabbage, red (c.v. Kilmaro)
- **Soil nutrients:** Available NO_3-N
  - Pre-fertilizer
  - Pre-side-dress
  - Early cupping
  - Heading
  - Harvest)
- **Tissue Analysis:** %N
  - Early Cupping
  - Harvest (head & leaves)
- **Yield: Head & residue**
  - Fresh weight
  - % dry weight
- **Estimate Nitrogen Uptake**

2014 Grower Survey

- 9 fields summer cabbage
- Soil sample at harvest
  - Available NO_3-N

2016 On-farm Small-Plot Trial

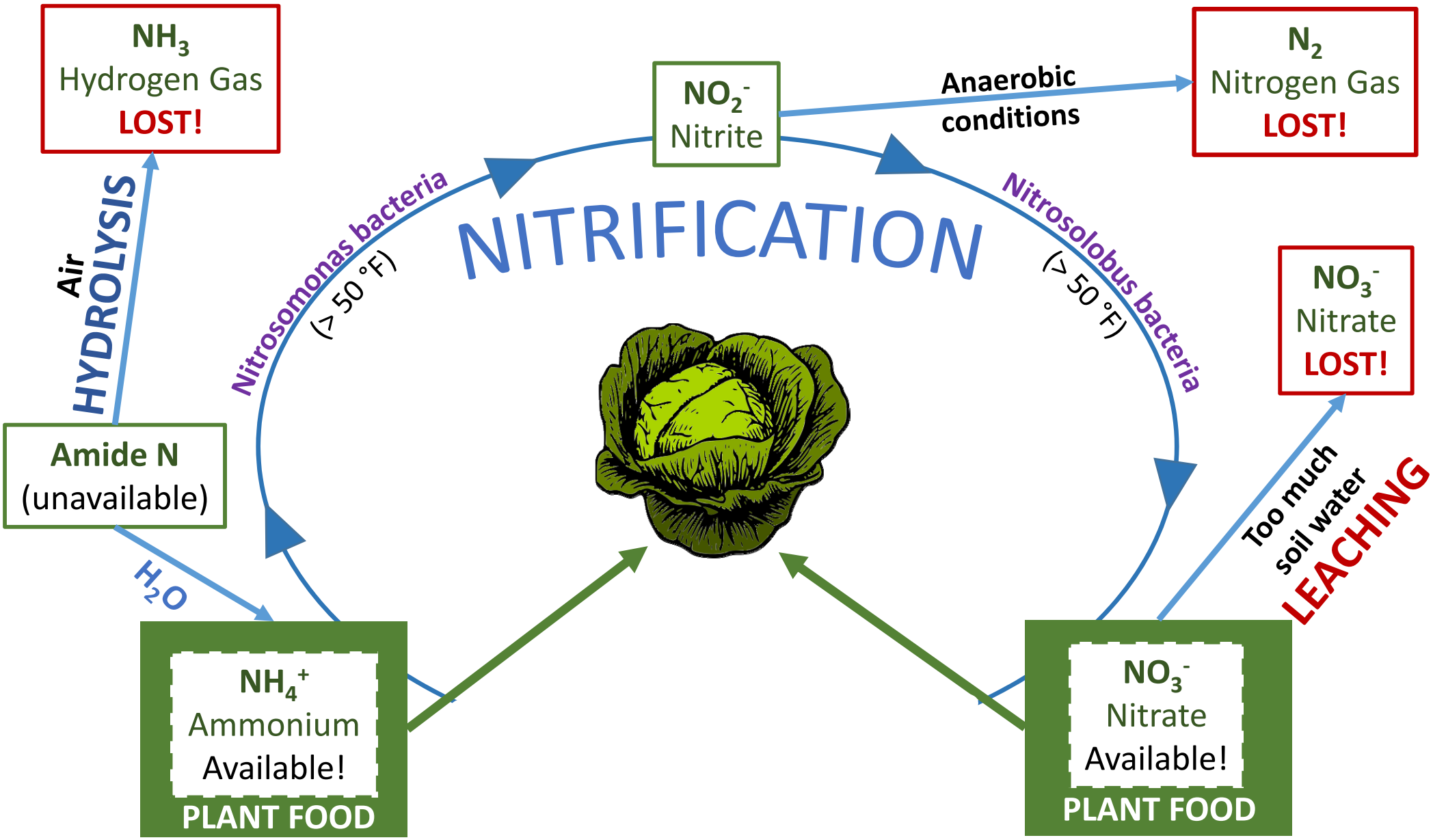
- **3 rates of total applied nitrogen:**
  - 100 lb/A
  - 150 lb/A
  - 200 lb/A
- **2 application timings** – ratio at plant: side-dress
  - 100%: 0%
  - 50%: 50%
- **Nitrogen Stabilizer (a.i. nitrapyrin)**
  - None
  - At planting (surface spray followed by incorporation with fry fertilizer)
  - Side-dress (applied with 30-0-0, knifed in as a liquid)

2016 On-farm Small-Plot Trial

Nitrapyrin

- Instinct II (Dow AgroSciences) @ 37 fl oz/A
- Nitrification inhibitor
- Bactericide of nitrosomonas bacteria (convert ammonium (NH_4^+) into nitrite (NO_2^-)

Nitrogen Cycle



Small-Plot Trial, 5 reps

cv. Constellation (storage cabbage), planted Jun-10

Plot size: 7.5 ft x 19 ft; 3 rows – harvested inside heads of inside row

Side-dress Nitrogen

Nitrogen source: 30-0-0 liquid

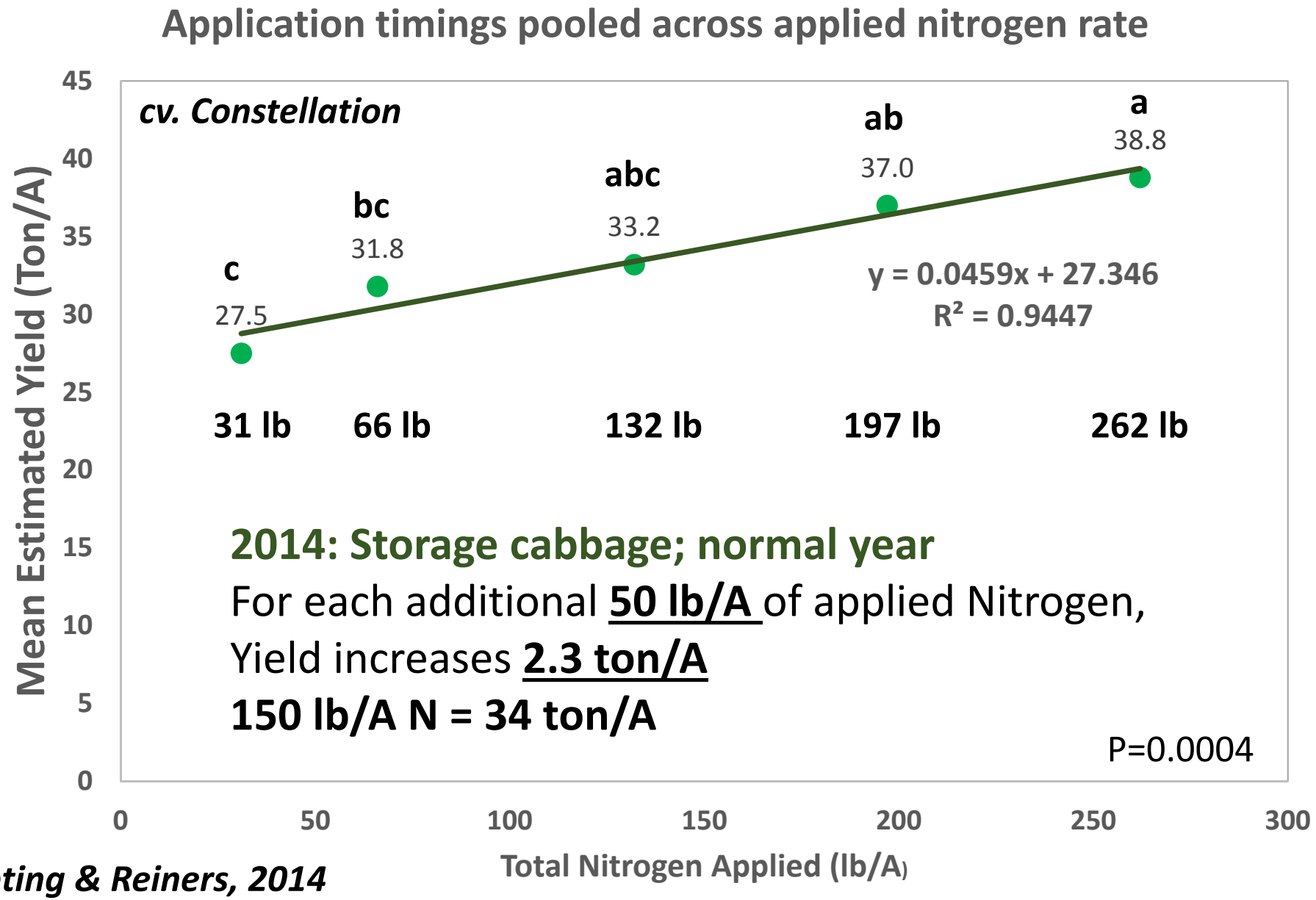
Applied by hand on Jul-10, 5 weeks post-transplanting

Results

The most important factor affecting yield was…

Rate of applied nitrogen!

Effect of Total Applied Nitrogen on Yield (Ton/A) -2014 Trial



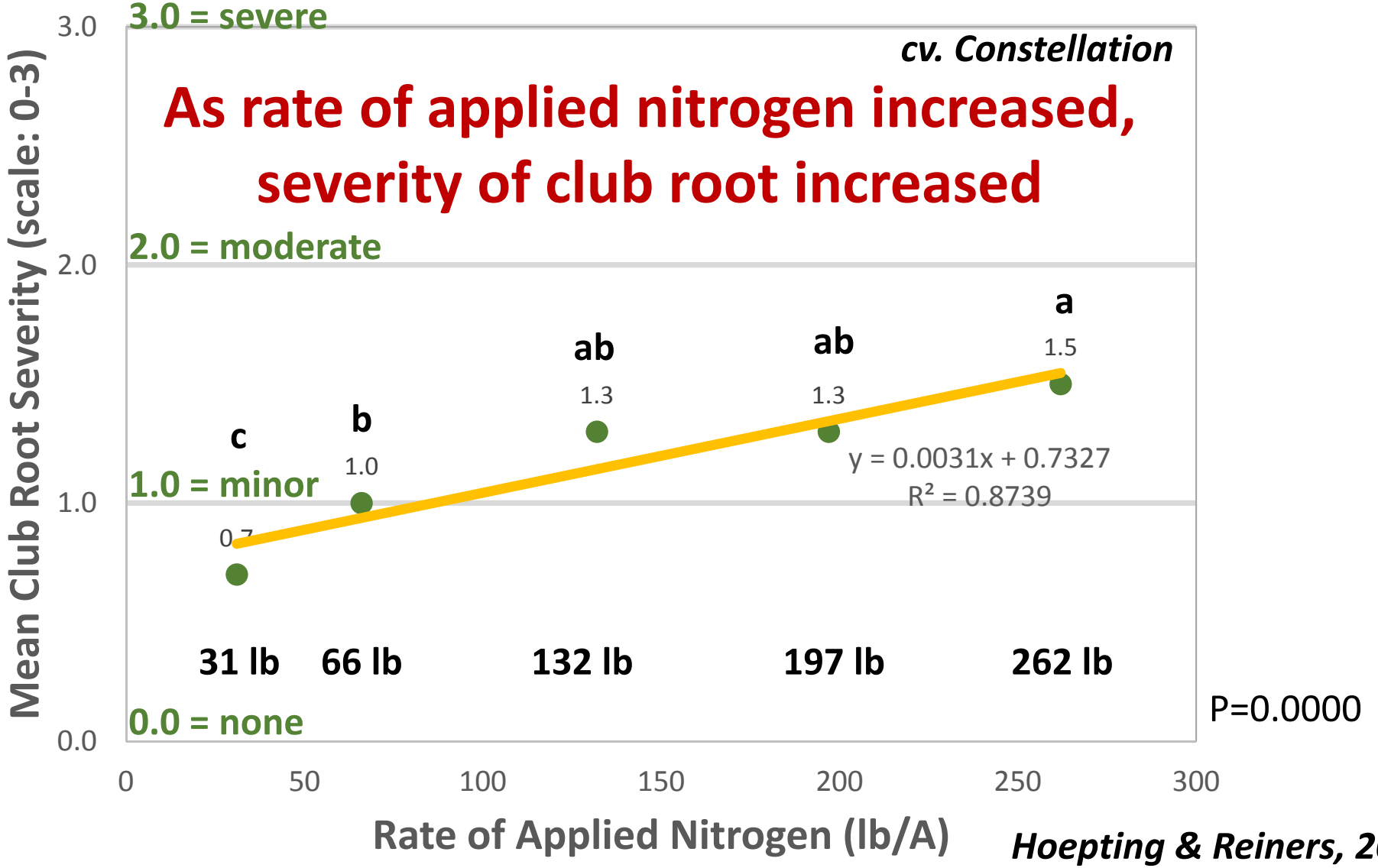
Hoepting & Reiners, 2014

Clubroot Assessment

Each plant rated for clubroot and weighed individually

2014 Trial - Effect of Total Applied Nitrogen on Club Root (Severity Rating)

Application rates pooled across applied nitrogen timings



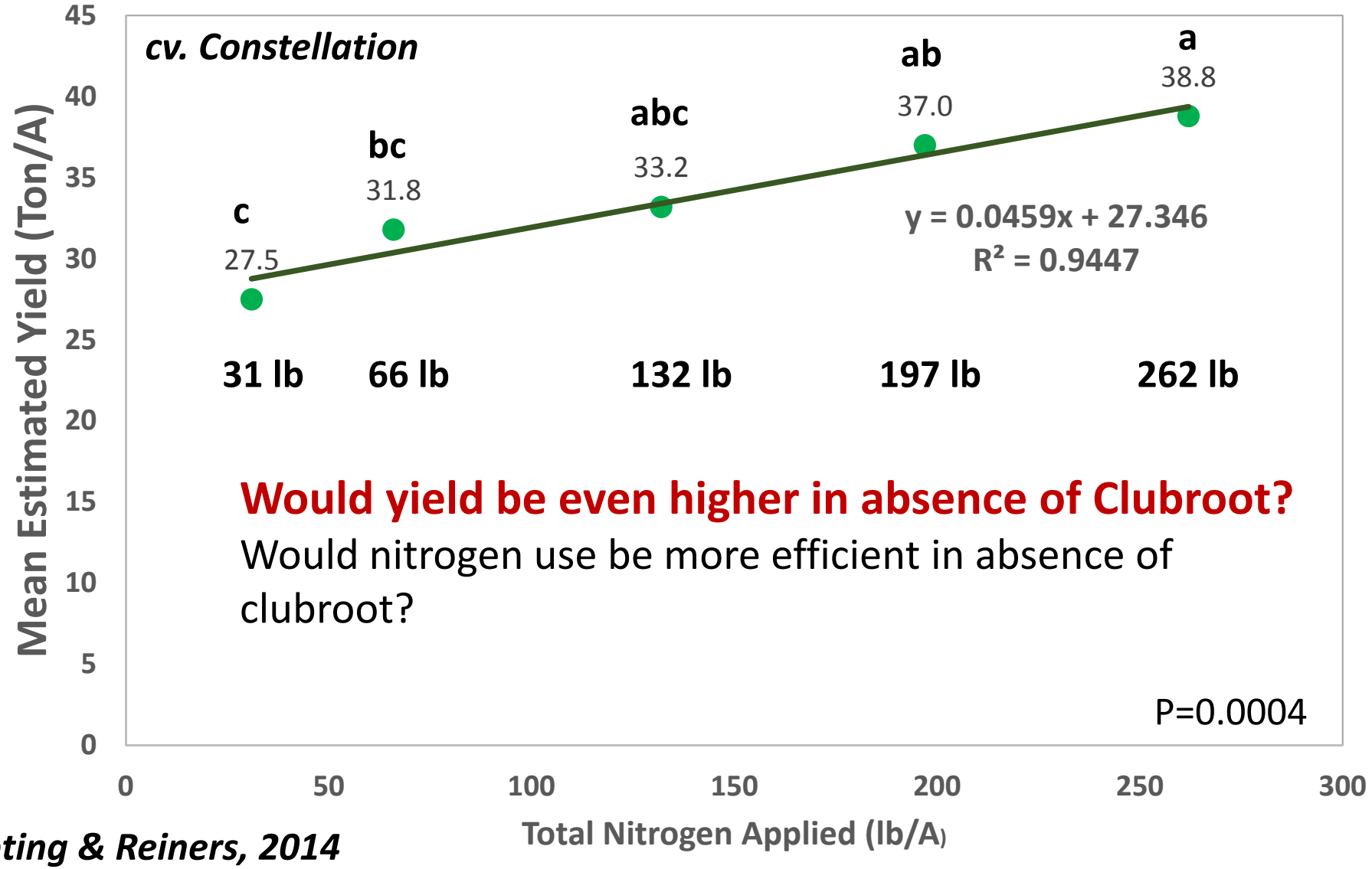
Hoepting & Reiners, 2014

Clubroot Severity: Scale 0-3

None = 0	Minor = 1	Moderate = 2	Severe = 3
			
No club root All healthy roots	Club root starting, mostly healthy roots	A lot of club root Some functioning roots	Virtually no functioning roots

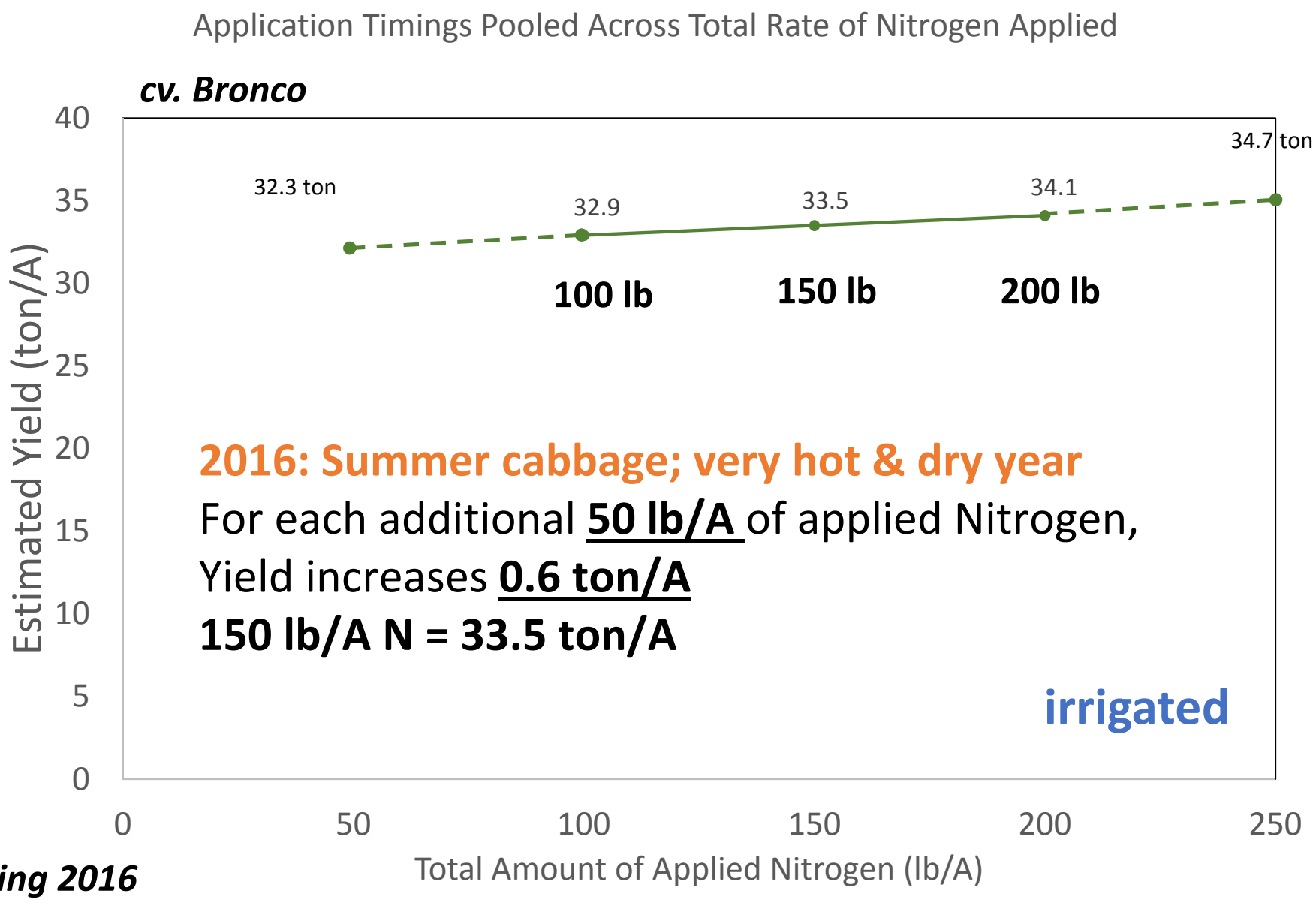
Effect of Total Applied Nitrogen on Yield (Ton/A) -2014 Trial

Application timings pooled across applied nitrogen rate



Hoepting & Reiners, 2014

Effect of Total Applied Nitrogen on Yield (Ton/A) -2016 Trial



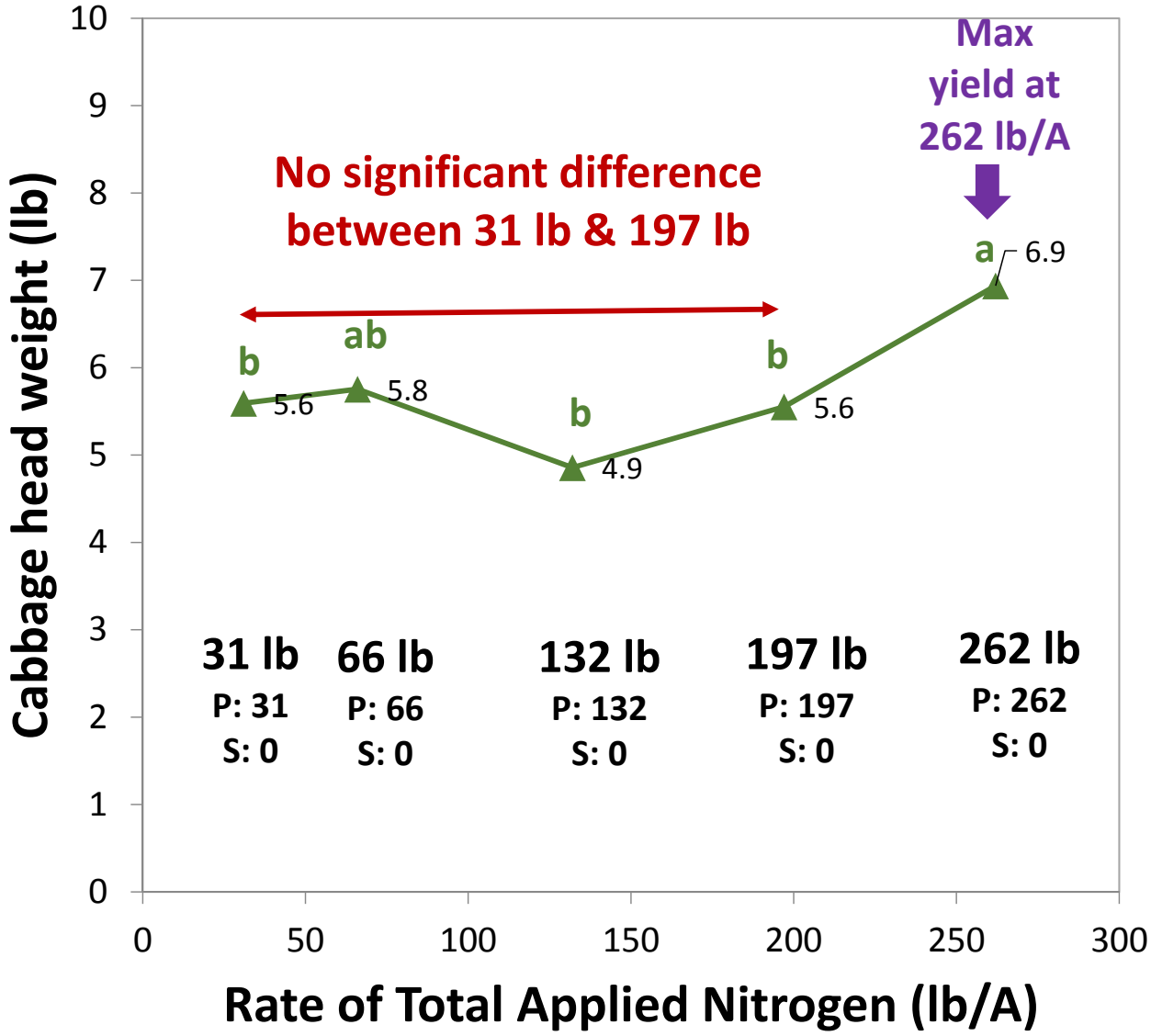
Hoepting 2016

2014 Results: Effect of Total Applied Nitrogen

- According to these results, we did not yet hit the ceiling with respect to the response of applied nitrogen on yield
  - > 262 lb/A in 2014 with club root
  - > 200 lb/A in a hot dry year
  - In a Canadian study, maximum yield reached at **566 lb/A** N
- Significant interaction occurred between applied N rate and application timing for:
  - Head size (lb) = ton/A
- This means that head size responds differently to total N rate applied depending on the application timing

2014 Trial: Effect of Nitrogen Timing on Head Weight (lb)

100% of total Nitrogen applied at planting



cv. Constellation

Ratio of Total Rate Applied At planting: side-dress

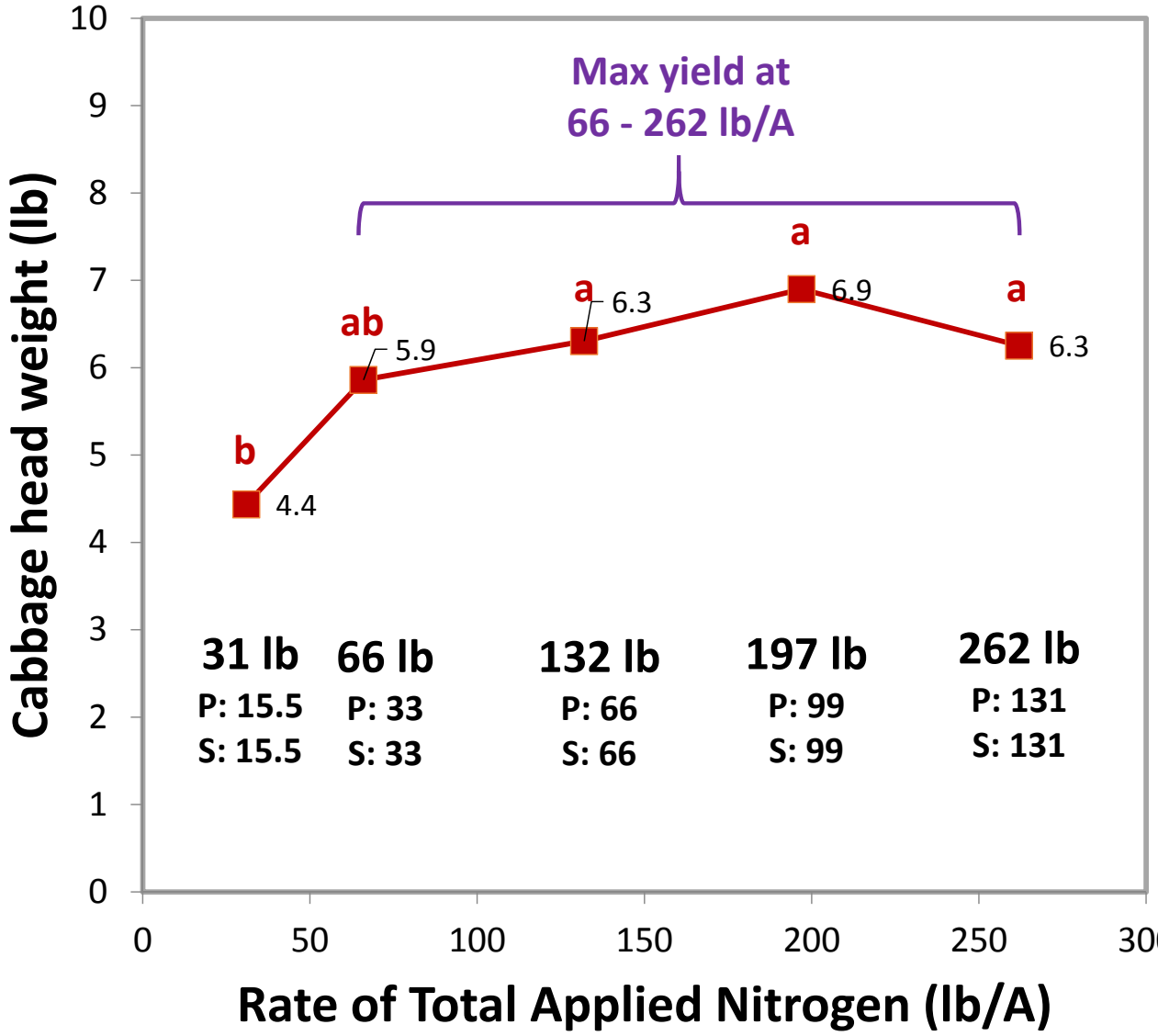
100:0

P=0.0239

Hoepting & Reiners, 2014

2014 Trial: Effect of Nitrogen Timing on Head Weight (lb)

50% of total Nitrogen applied at planting; 50% side-dress



cv. Constellation

Ratio of Total Rate Applied At planting: side-dress

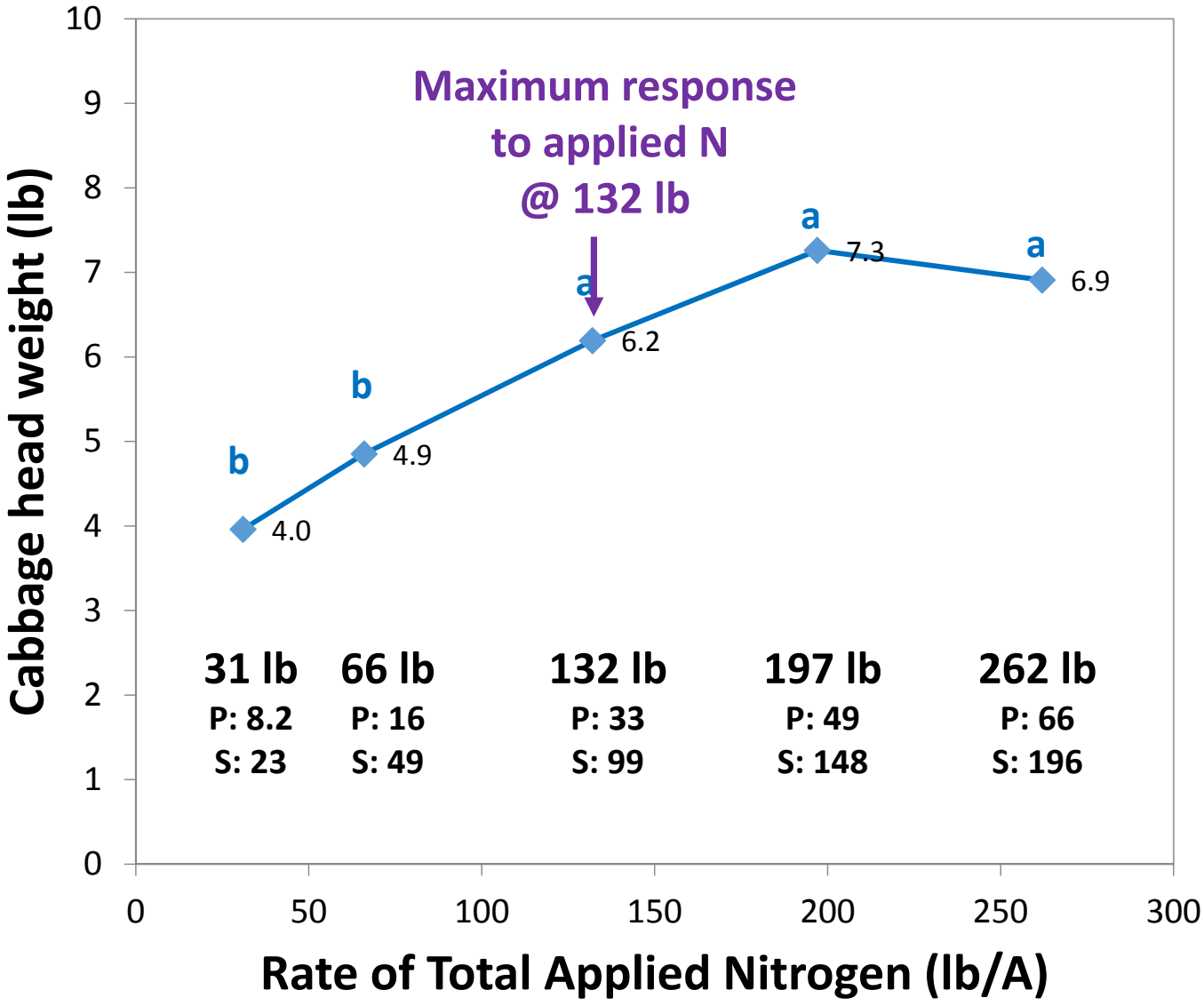
50:50

P=0.0011

Hoepting & Reiners, 2014

2014 Trial: Effect of Nitrogen Timing on Head Weight (lb)

25% of total Nitrogen applied at planting; 75% side-dress



cv. Constellation

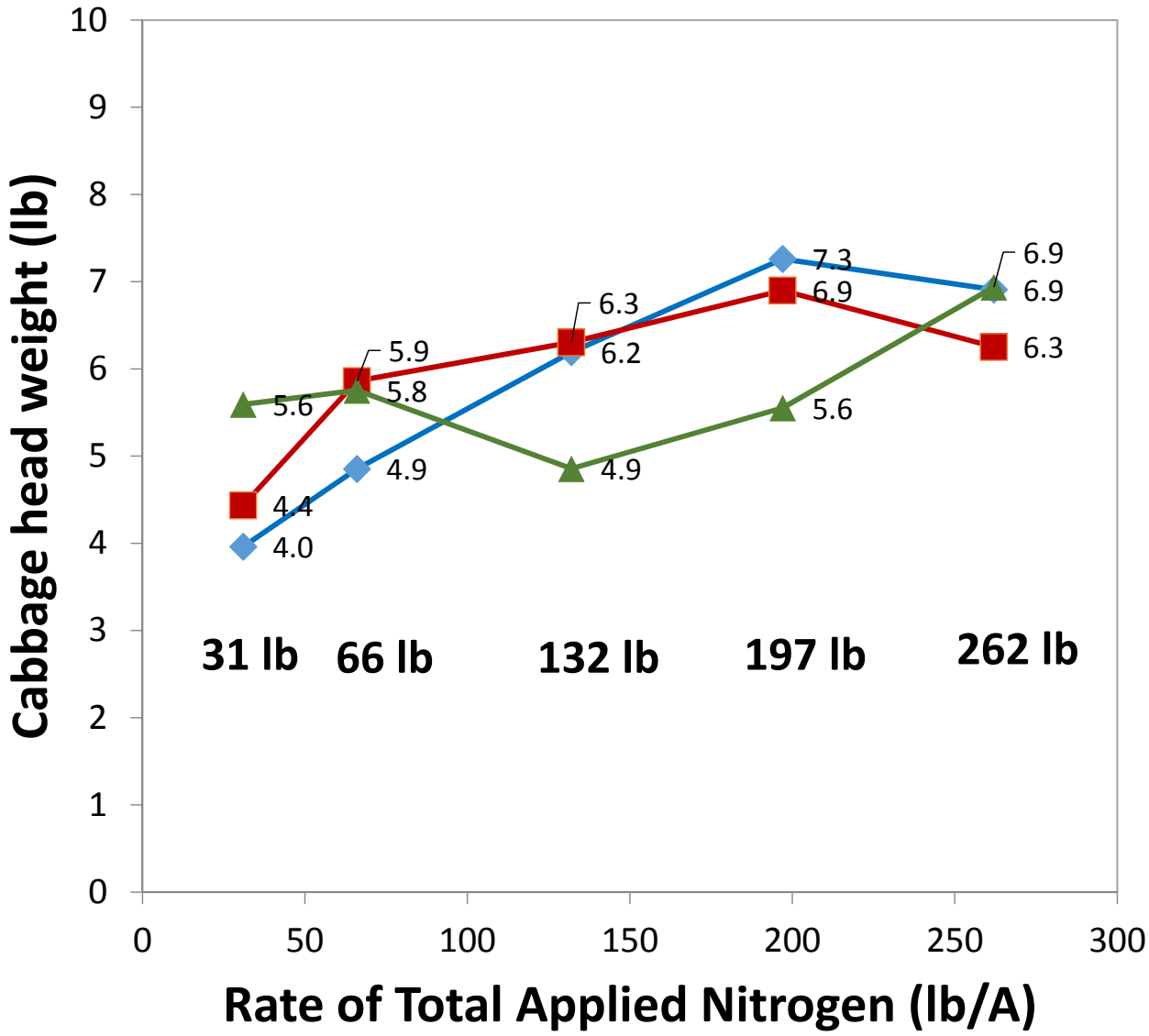
Ratio of Total Rate Applied At planting: side-dress

25:75

P=0.0001

Hoepting & Reiners, 2014

2014 Trial: Effect of Nitrogen Timing on Head Weight (lb)



cv. Constellation

Ratio of Total Rate Applied
At planting: side-dress

- 25:75
- 50:50
- 100:00

Hoepting & Reiners, 2014

2014 Trial: Effect of Nitrogen Timing on Head Weight (lb)

100% of total Nitrogen applied at planting

cv.
Constellation

2014 Trial: Effect of Nitrogen Timing on Head Weight (lb)

50% of total Nitrogen applied at planting; 50% side-dress

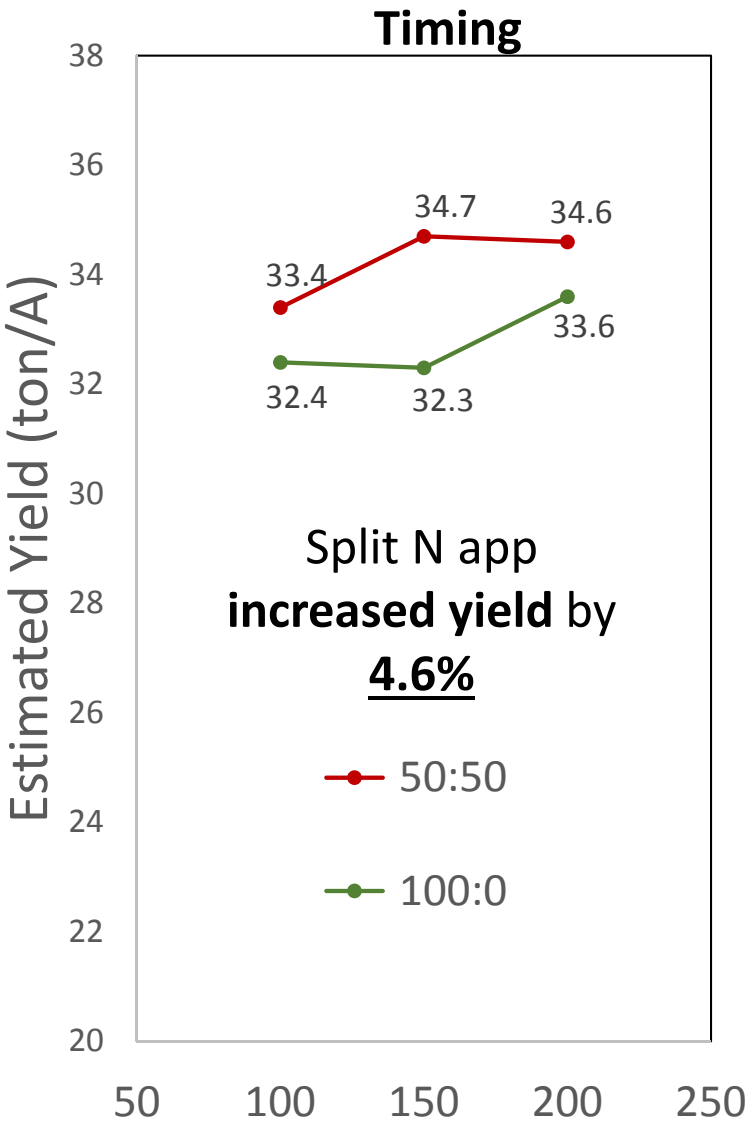
cv. Constellation

2014 Trial: Effect of Nitrogen Timing on Head Weight (lb)

25% of total Nitrogen applied at planting; 75% side-dress

cv. Constellation

2016 Trial: Effect of Nitrogen Timing on Yield (Ton/A)



1 *100: 0*

3 *50: 50*

100

5

7

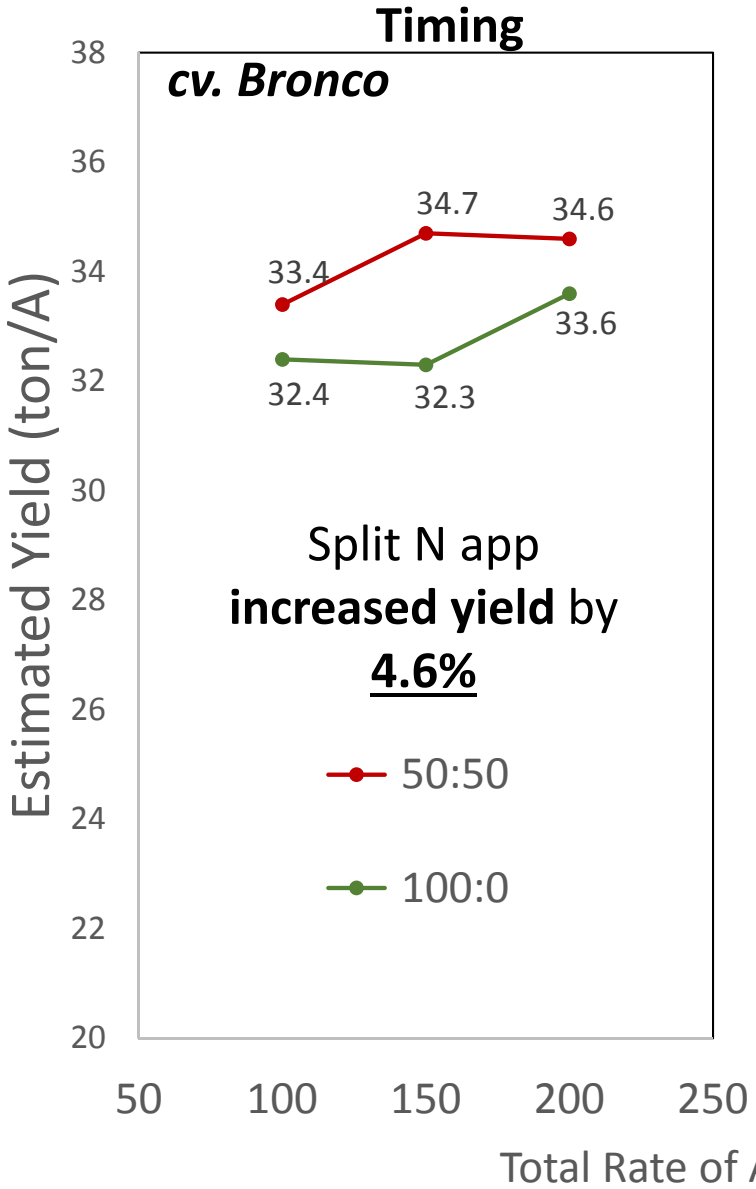
150

9

11

200

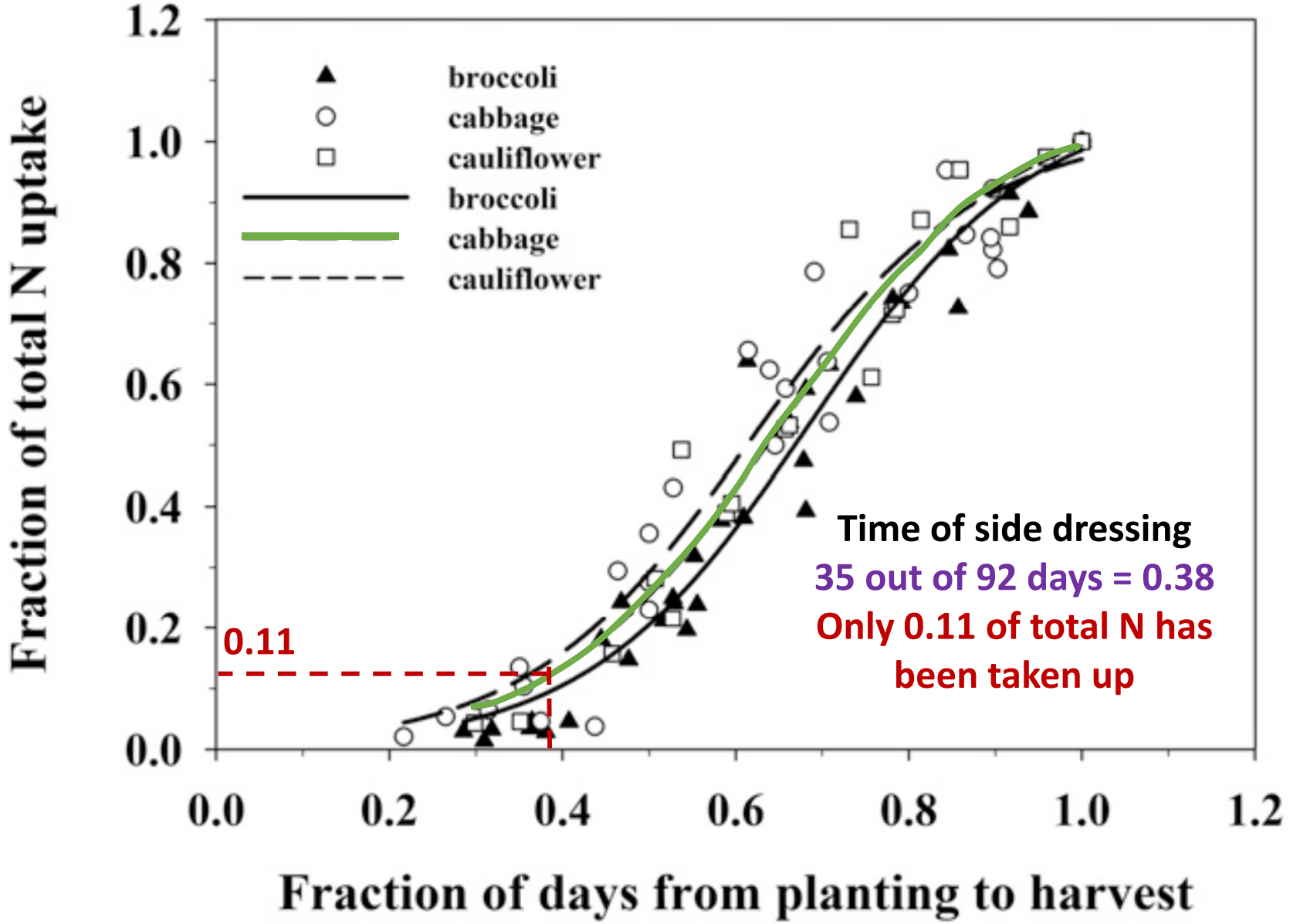
2016 Trial: Effect of Nitrogen Timing on Yield (Ton/A)



- Applying nitrogen in split applications resulted in more efficient use of nitrogen than 100% at planting
- Opportunity to reduce total nitrogen rates

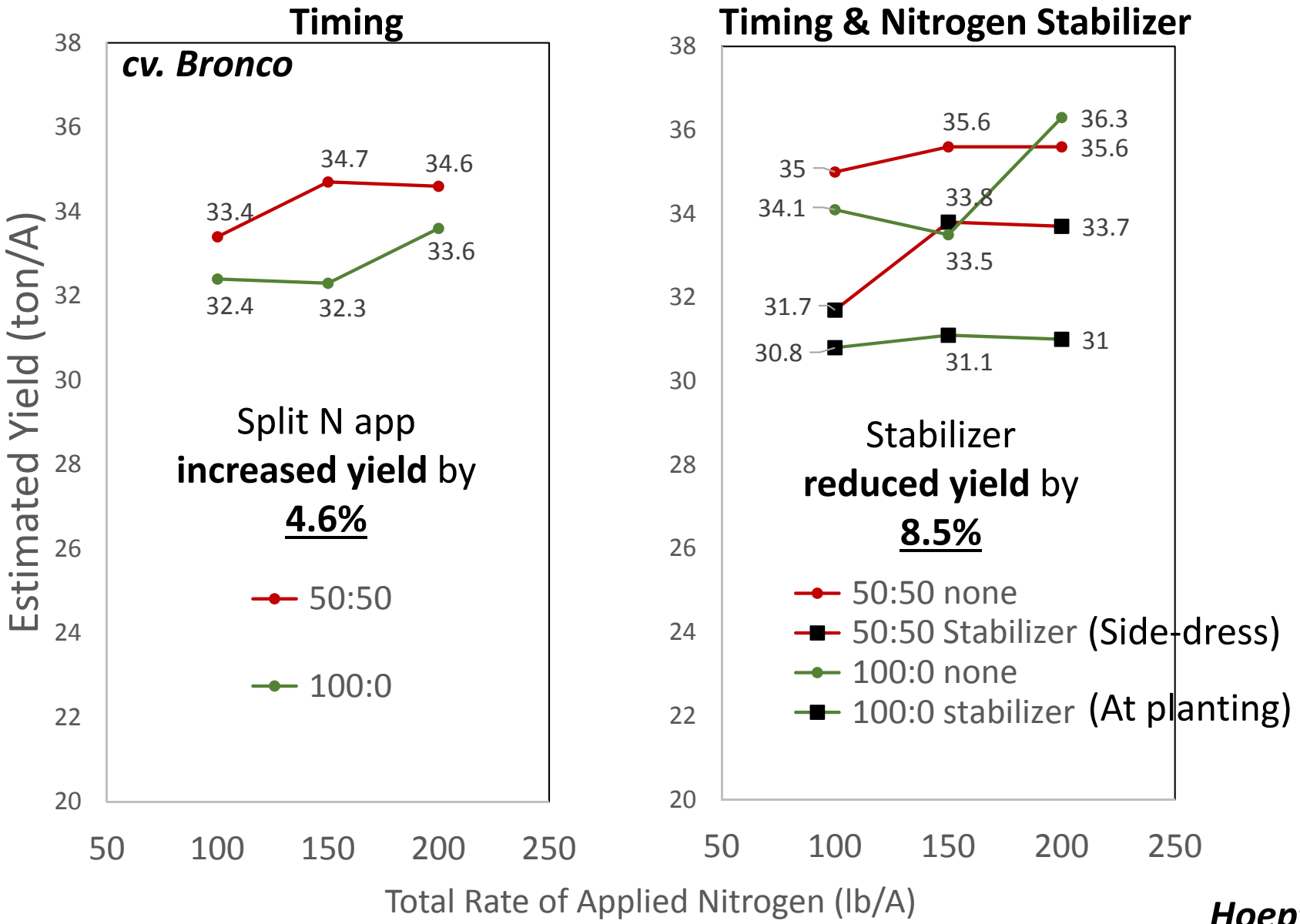
Hoepting 2016

Nitrogen Use in Cabbage



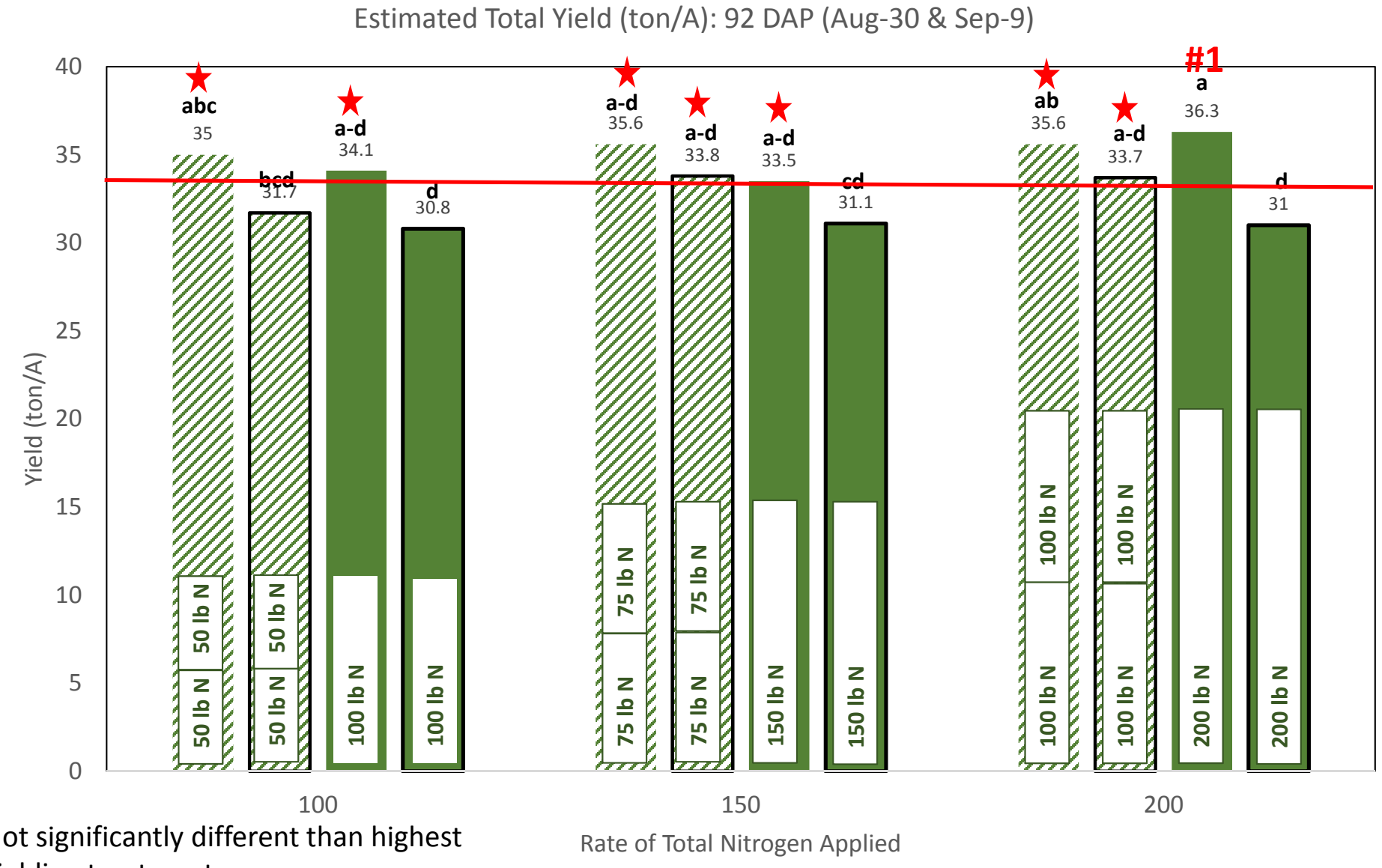
Smith et al. 2016

2016 Trial: Effect of Nitrogen Stabilizer onYield



Hoepting 2016

2016 Trial - Yield (ton/A): Aug-30 to Sep-9 (~92 DAP)



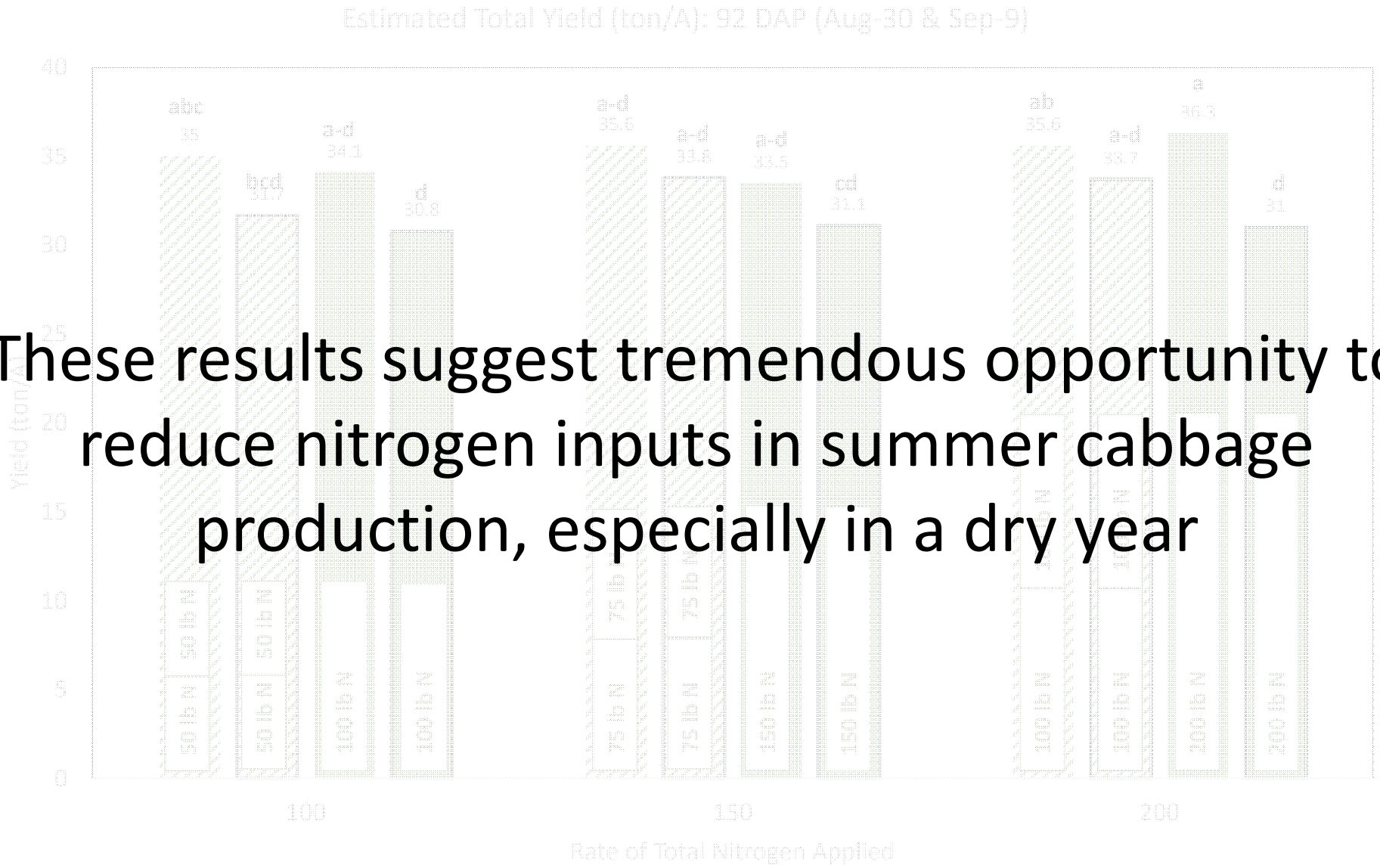
★ Not significantly different than highest yielding treatment

50:50 none | 50:50 Stabilizer | 100:0 none | 100:0 stabilizer

cv. Bronco

Hoepting 2016

2016 Trial - Yield (ton/A): Aug-30 to Sep-9 (~92 DAP)



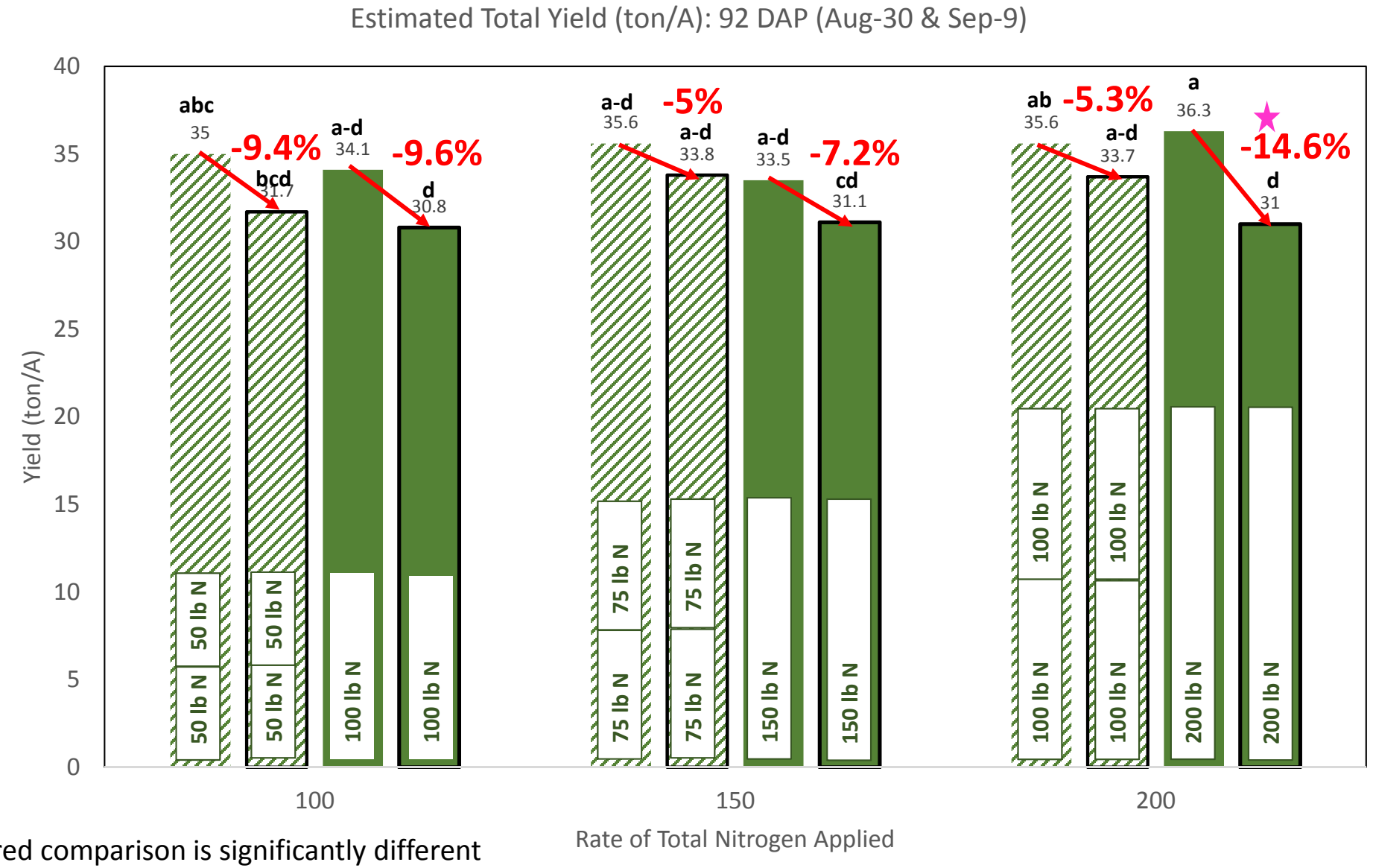
These results suggest tremendous opportunity to reduce nitrogen inputs in summer cabbage production, especially in a dry year

cv. Bronco

50:50 none | 50:50 Stabilizer | 100:0 none | 100:0 stabilizer

Hoepting 2016

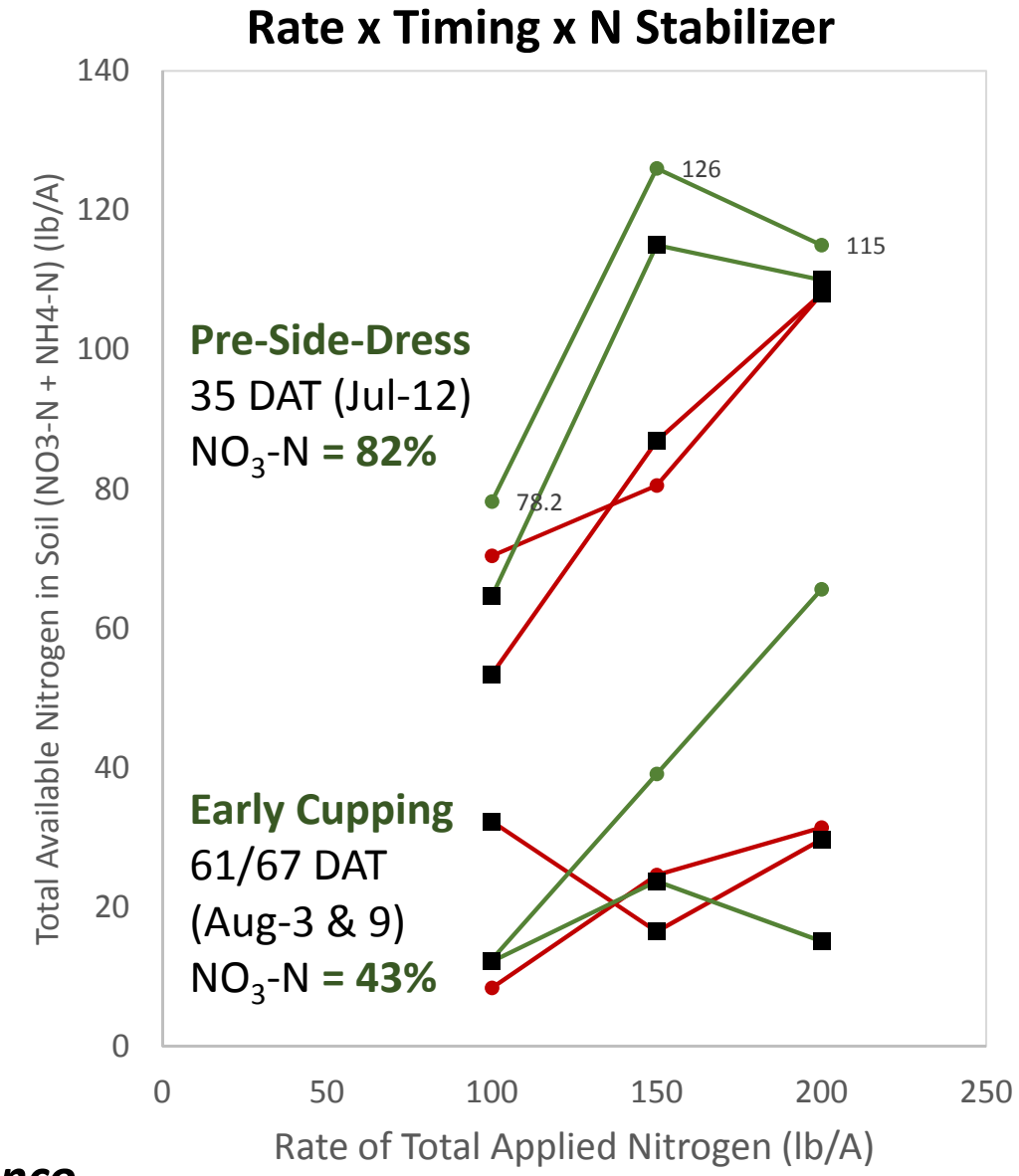
2016 Trial – Effect of Nitrogen Stabilizer on Yield (ton/A)



cv. Bronco

Hoepting 2016

Total Available N (NO_3-N + NH_4-N): Pre-Side-Dress & Early Cupping



Strong correlation:

- Head weight
- Pre-side-dress NO_3-N

(Pearson: R = 0.7515; p = 0.0196)

No correlation:

- Pre-side-dress NO_3-N
- Amount N applied
- Cupping NO_3-N
- Yield

50:50 none
50:50 N stabilizer (side-dress)
100:0 none
100:0 N stabilizer (at planting)

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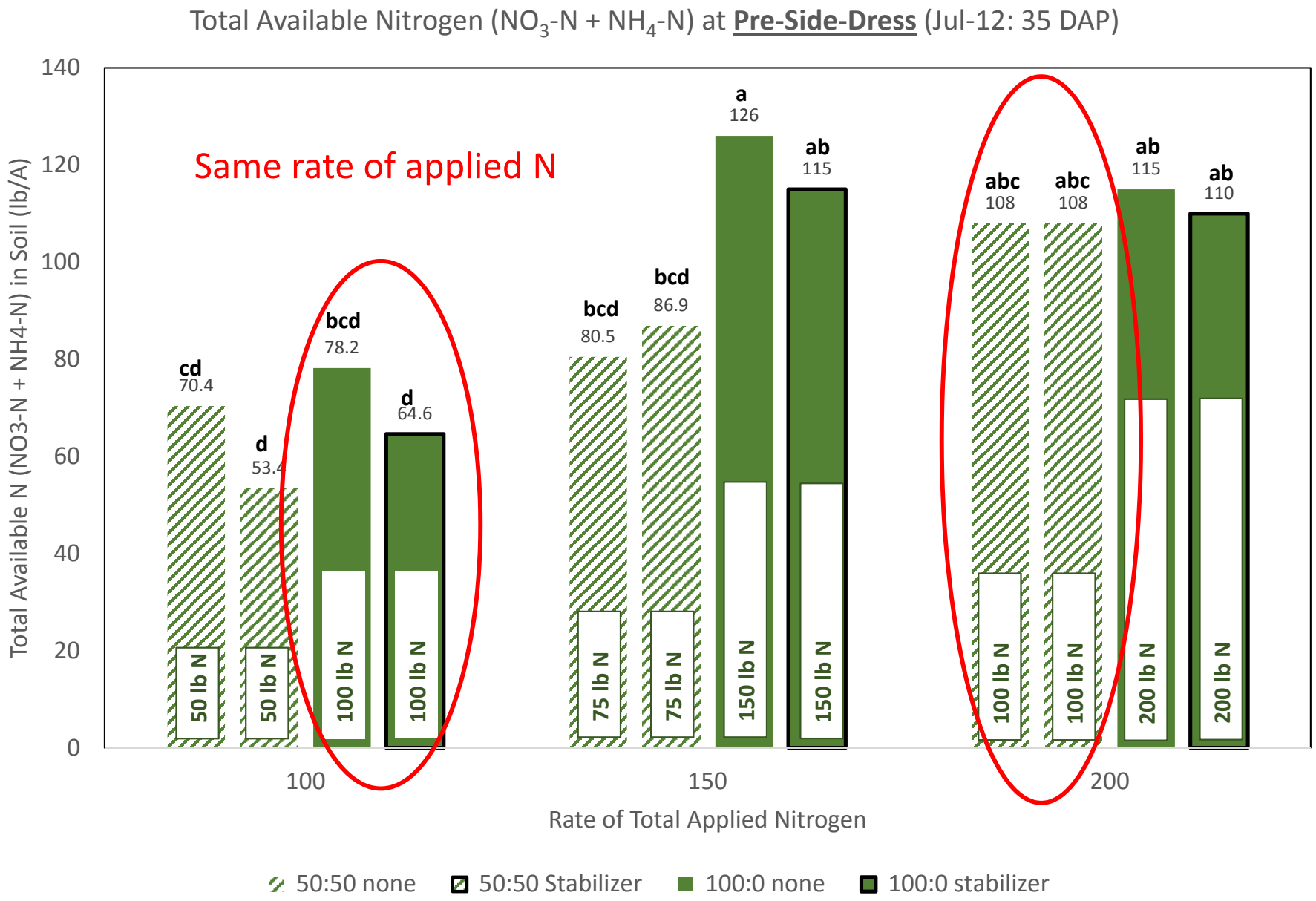
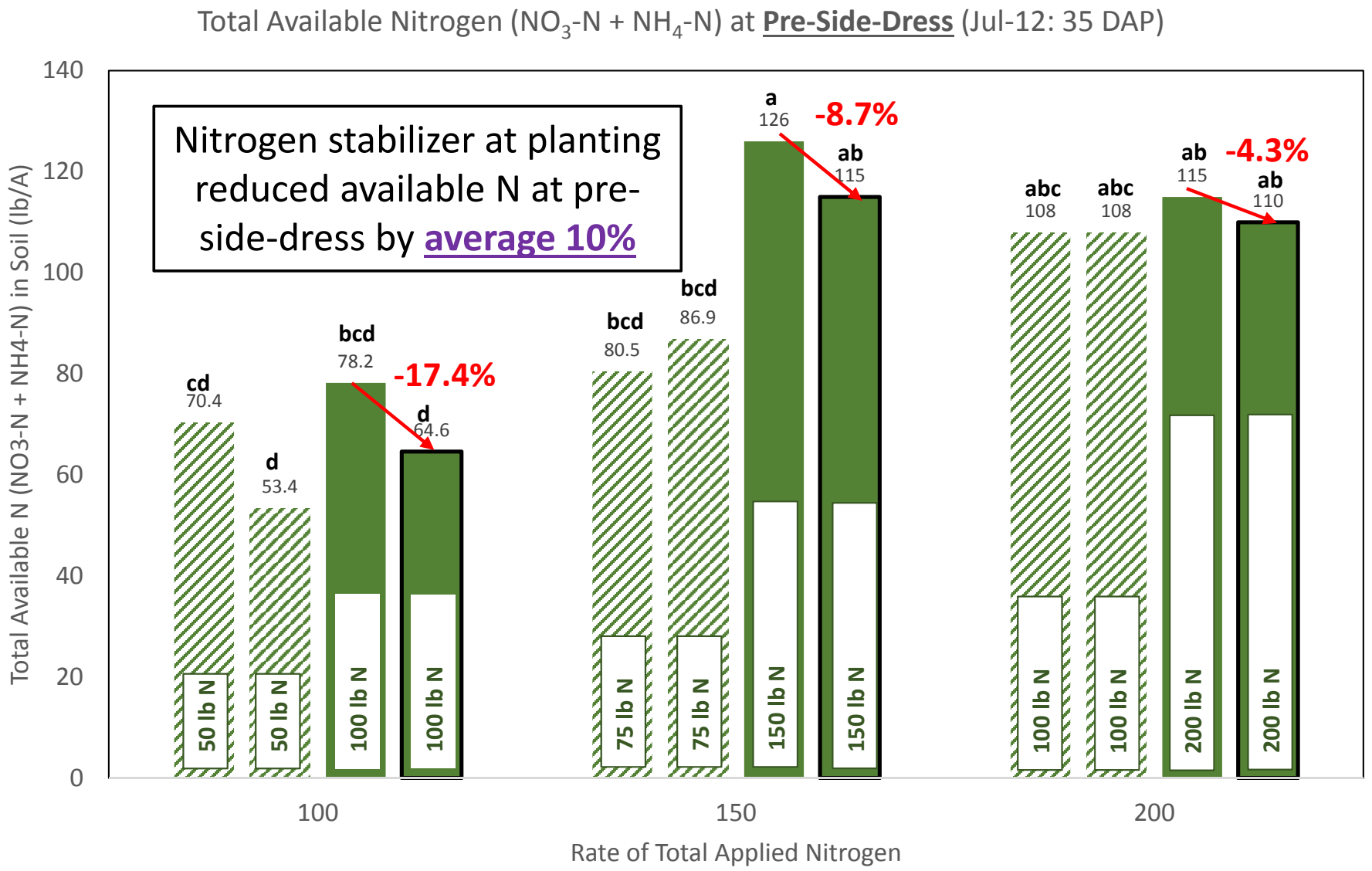
Total Available N (NO_3-N + NH_4-N): Pre-Side-Dress (35 DAT: Jul-12)



Total Available N (NO_3-N + NH_4-N): Pre-Side-Dress (35 DAT: Jul-12)



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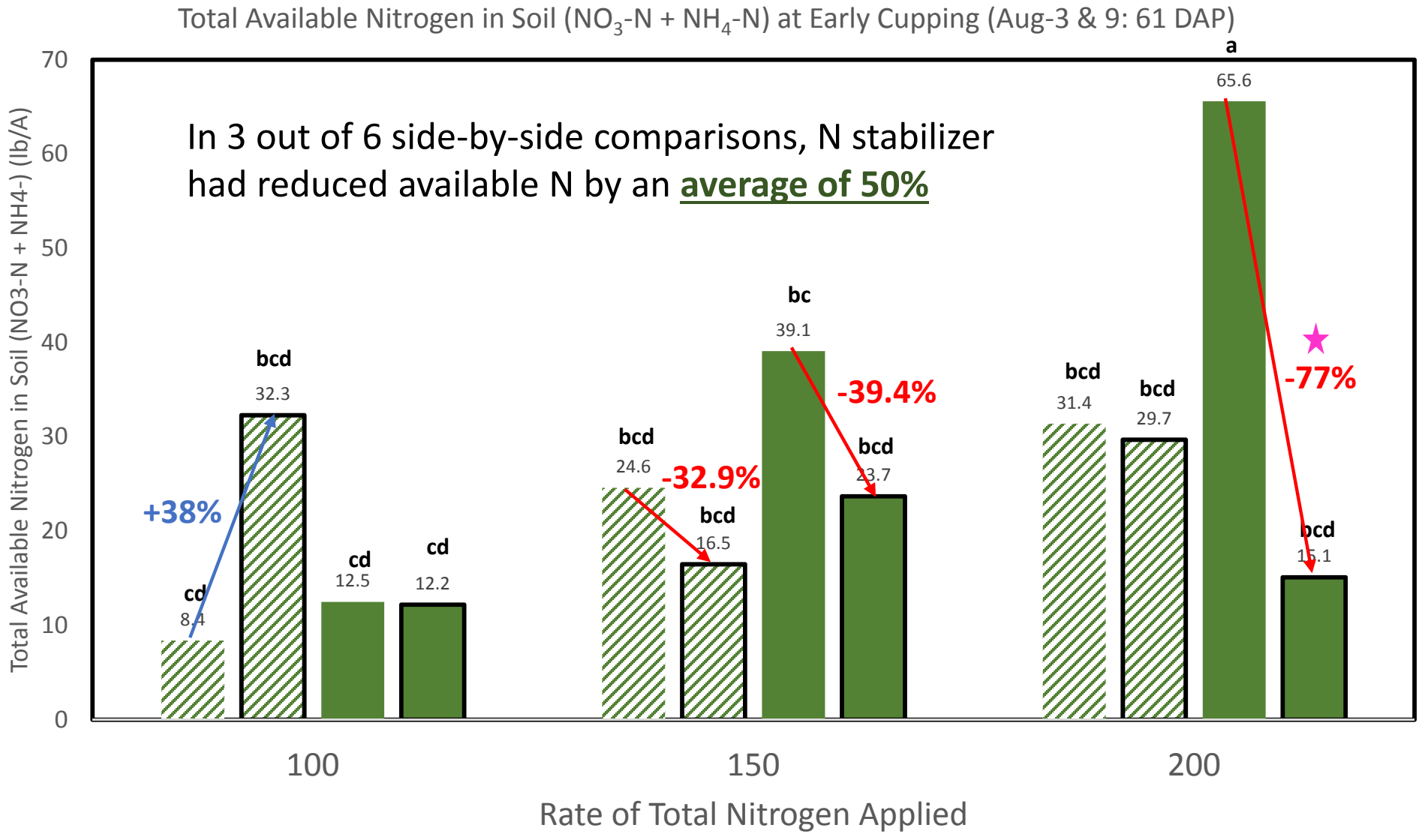
Total Available N (NO_3-N + NH_4-N): Early Cupping (61 DAP: Aug-3 & 9)



Total Available Nitrogen in Soil (NO_3-N + NH_4-N) at Early Cupping (Aug-3 & 9: 61 DAP)

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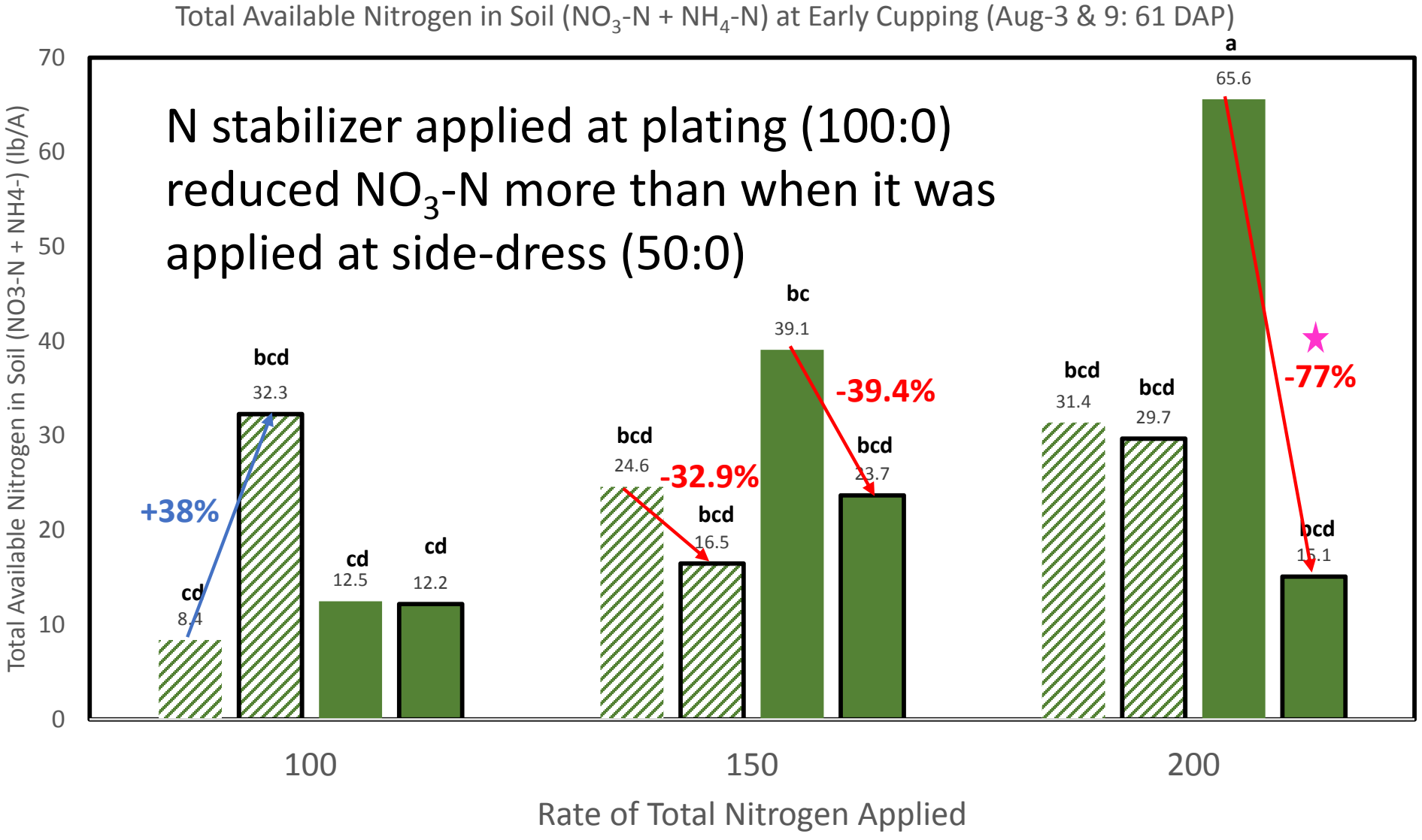
Total Available N (NO_3-N + NH_4-N): Early Cupping (61 DAP: Aug-3 & 9)



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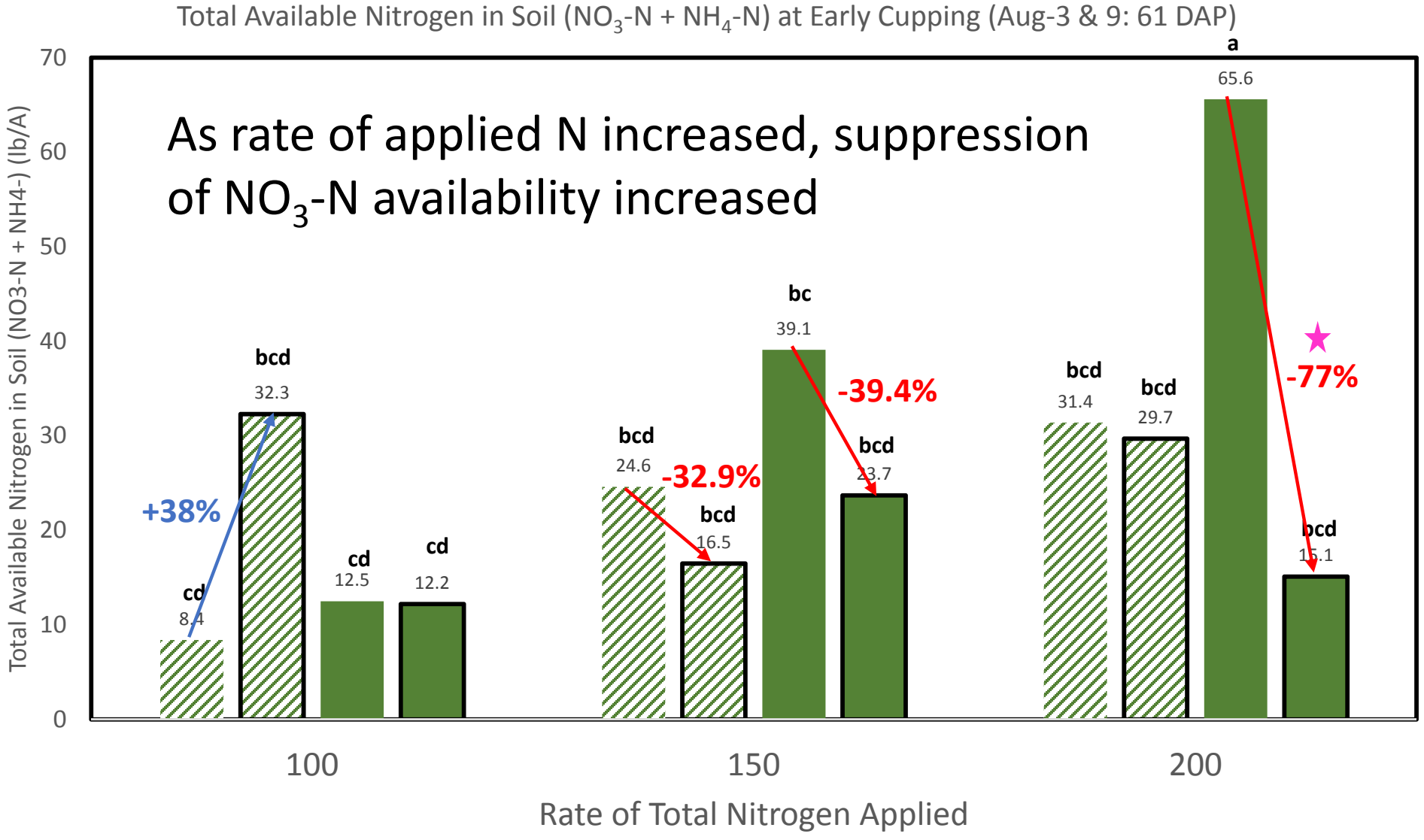
Hoepting 2016

Total Available N (NO_3-N + NH_4-N): Early Cupping (61 DAP: Aug-3 & 9)



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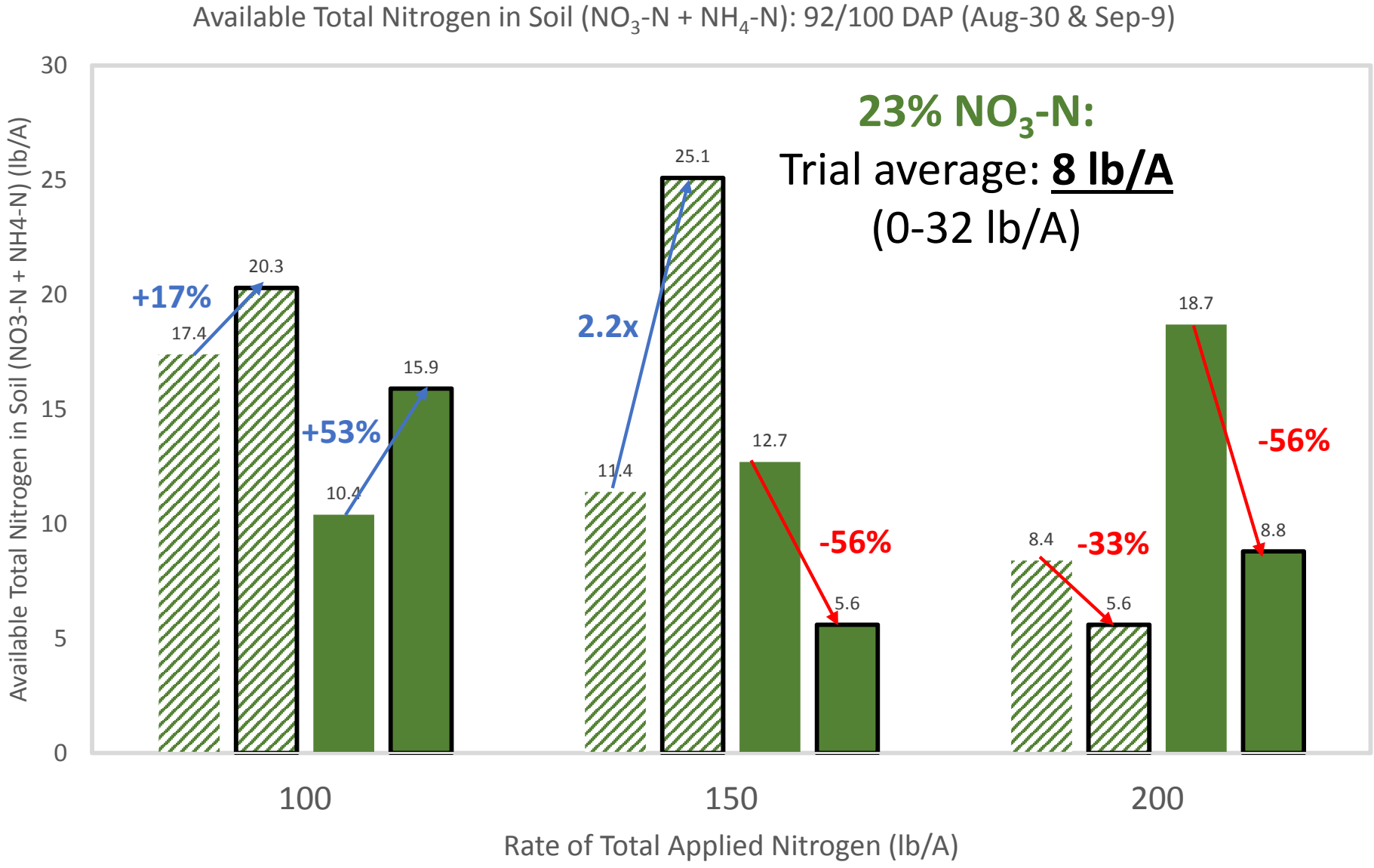
Hoepting 2016

Total Available N (NO_3-N + NH_4-N): Harvest (92/100 DAP: Aug-30 & Sep-9)



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Available NO_3-N Left in Soil at Harvest

Lb/A	Average	Minimum	Maximum
2014 Nitrogen Trial (33-262 lb/A N) Storage cabbage	**7.5**	1.8	29.0
2014 Grower Survey Summer Cabbage	**9.0**	2.1	43.3
2015 4-Field Case Study 3 Summer; 1 storage cabbage	**8.0**	0.0	30
2016 Nitrogen Stabilizer Trial (50-200 lb/A N) Summer cabbage	**8.0**	0	32
Salinas Valley, CA study (30 broccoli, cabbage & cauliflower fields)	**10** (NO_3-N + NH_4-N)	--	--
Canada study (0-446 lb/A N) c.v. Bartolo	**8-10** (0-267 lb/A N)		26.7 (267-446 lb/A)

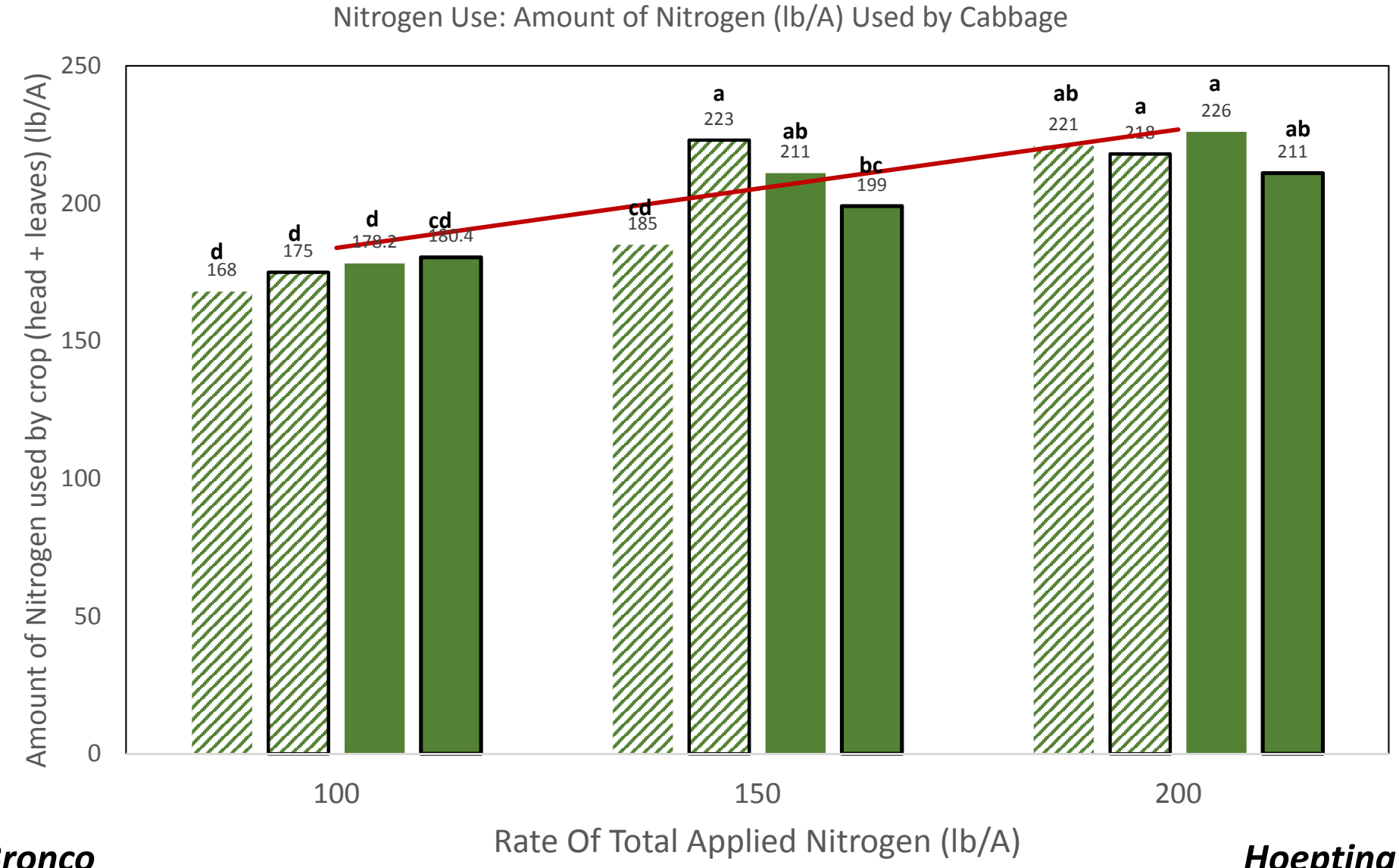
Available NO_3-N Left in Soil at Harvest

< 10 lb/A NO_3-N is low:

- Low risk for leaching and environmental contamination
- Causing winter wheat to lodge
- **Cabbage has a high capacity to scavenge nutrients**

- Highest correlation in 2016 study was between:
  - Head weight
  - Nitrogen Uptake

Nitrogen Uptake in Cabbage: Head & Leaf Residue (2016)



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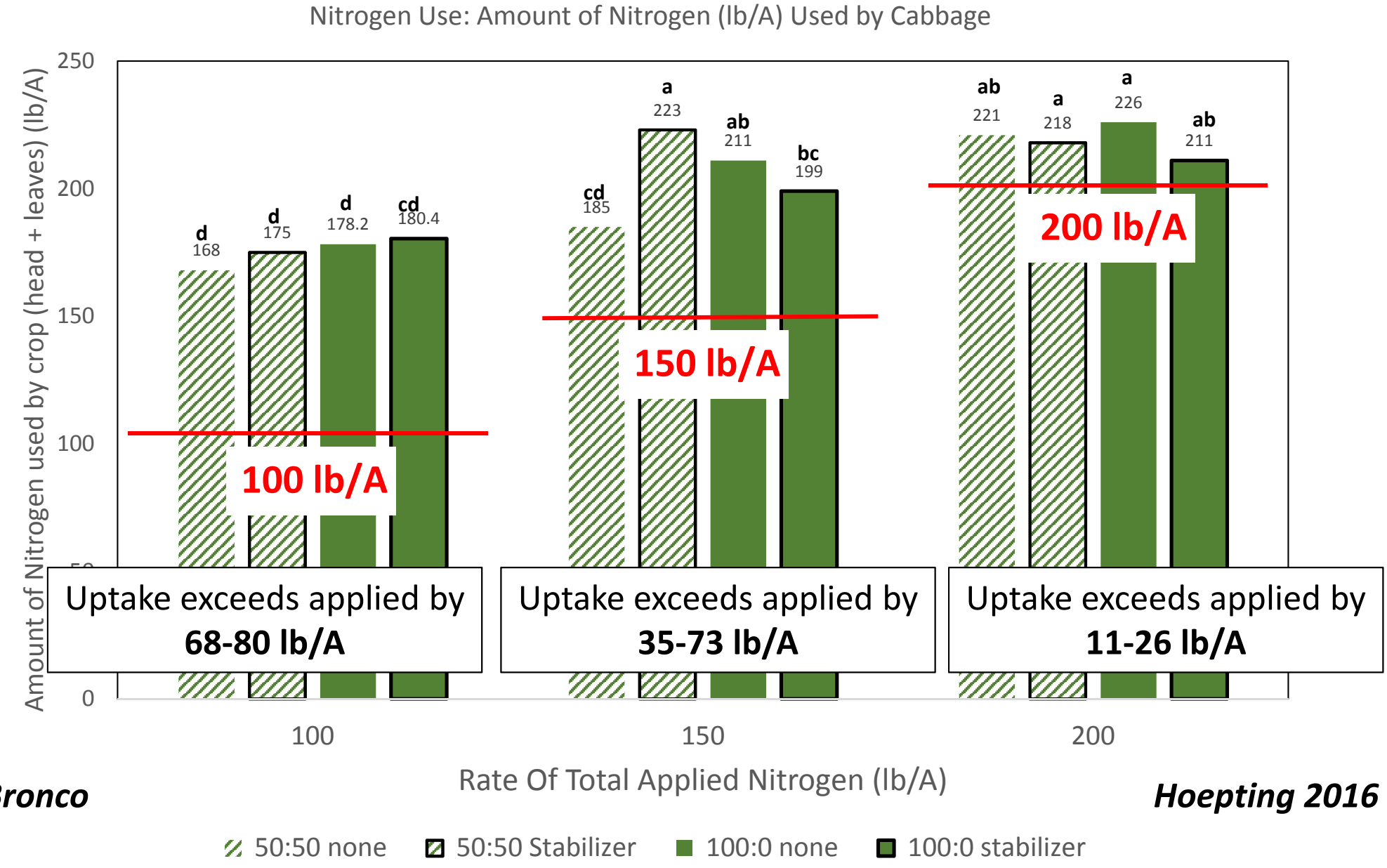
Nitrogen Uptake in Cabbage

Lb/A Nitrogen	Head (Harvested)	Stump & Leaves (Left in Field)	Total N Use
2015 4-Field Case Study **2 Summer;** **1 storage cabbage**	101 (=48%)	109	**210**
2016 Nitrogen Stabilizer Trial (100-200 lb/A N) **Summer cabbage**	96.5 (=48%) (56-143)	103 (78-143)	**200** (168-226)

Cabbage Leaves Behind ~100 lb of Nitrogen in Crop Residue

- Amount of nitrogen left behind in cabbage field in leaf and stump residue is ~ 100 lb/A
- **80 to 120 lb/A** of nitrogen for **winter wheat.**
- **Once crop takes up 150 lb/A it is prone to lodging.**
- Results suggest that the nitrogen left behind in cabbage leaf & stump residue will mineralize and certainly may be a contributing factor to lodging of winter wheat
- Or, may leach into ground water
- **Plan on reducing rate of applied nitrogen when winter wheat (or other crop) follows summer cabbage**
  - On-farm experimentation (e.g. strip trials)
- How to capture 100 lb/A N following storage cabbage?

Nitrogen Uptake in Cabbage: Head & Leaf Residue



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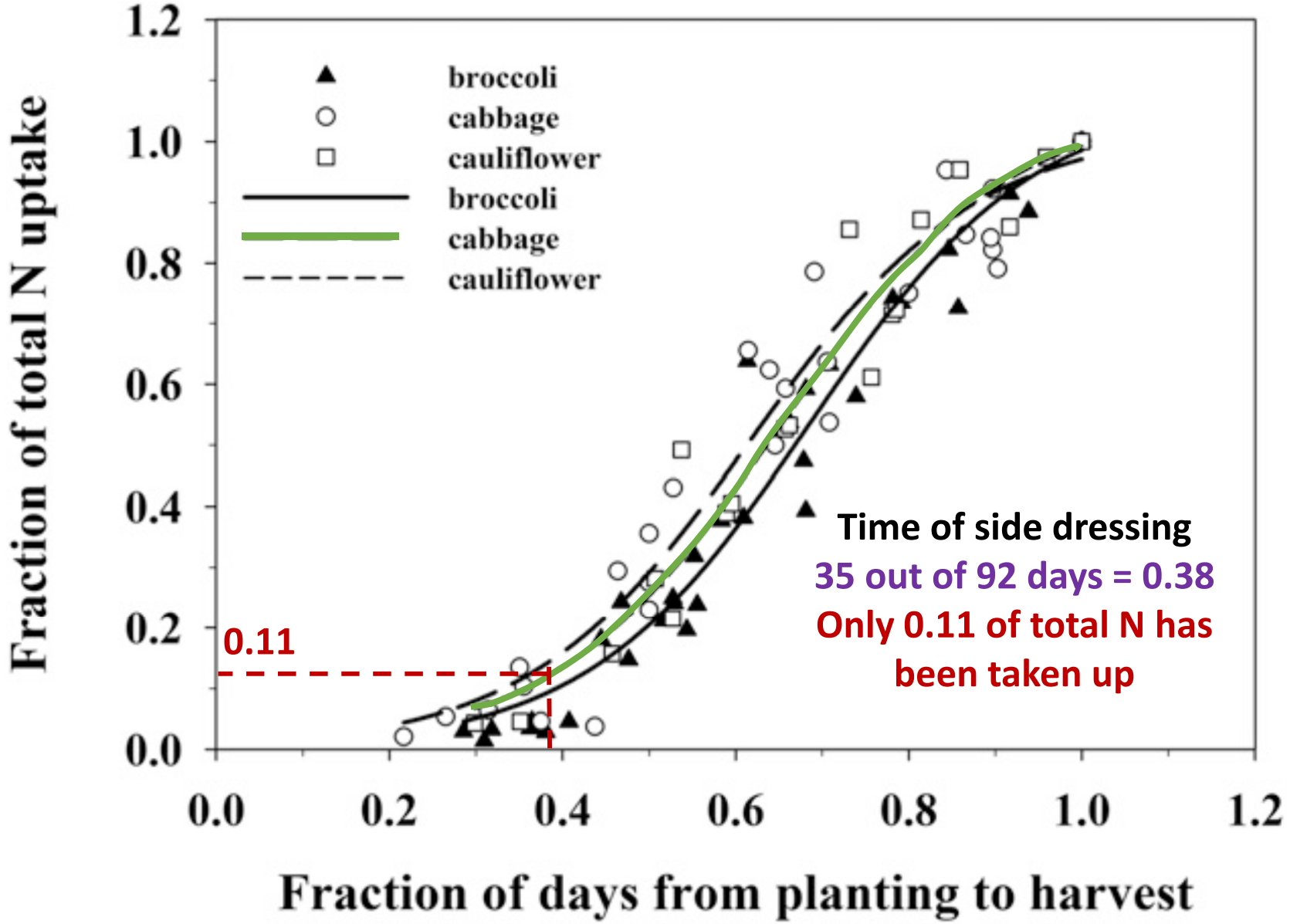
Where Else Does Cabbage Get Nitrogen From?

- Organic matter
  - 10-20 lb/A per 1% OM
  - 20 lb/A for healthy soils; 10 lb/A for poor quality
  - 2016 Study had 2.9% OM = **58 lb/A**
  - At most 150 and 200 lb/A of total applied nitrogen treatments, this would close the gap
- Breakdown of residue from previous crop
  - E.g. corn stubble
- Previous nitrogen-fixing legume crop
- **Can rate of nitrogen be predicted?**
  - Soil test to measure OM
  - Nitrogen credits from manure and legumes
  - PSNT test to determine nitrogen?

Nitrogen Use in Cabbage



Smith et al. 2016

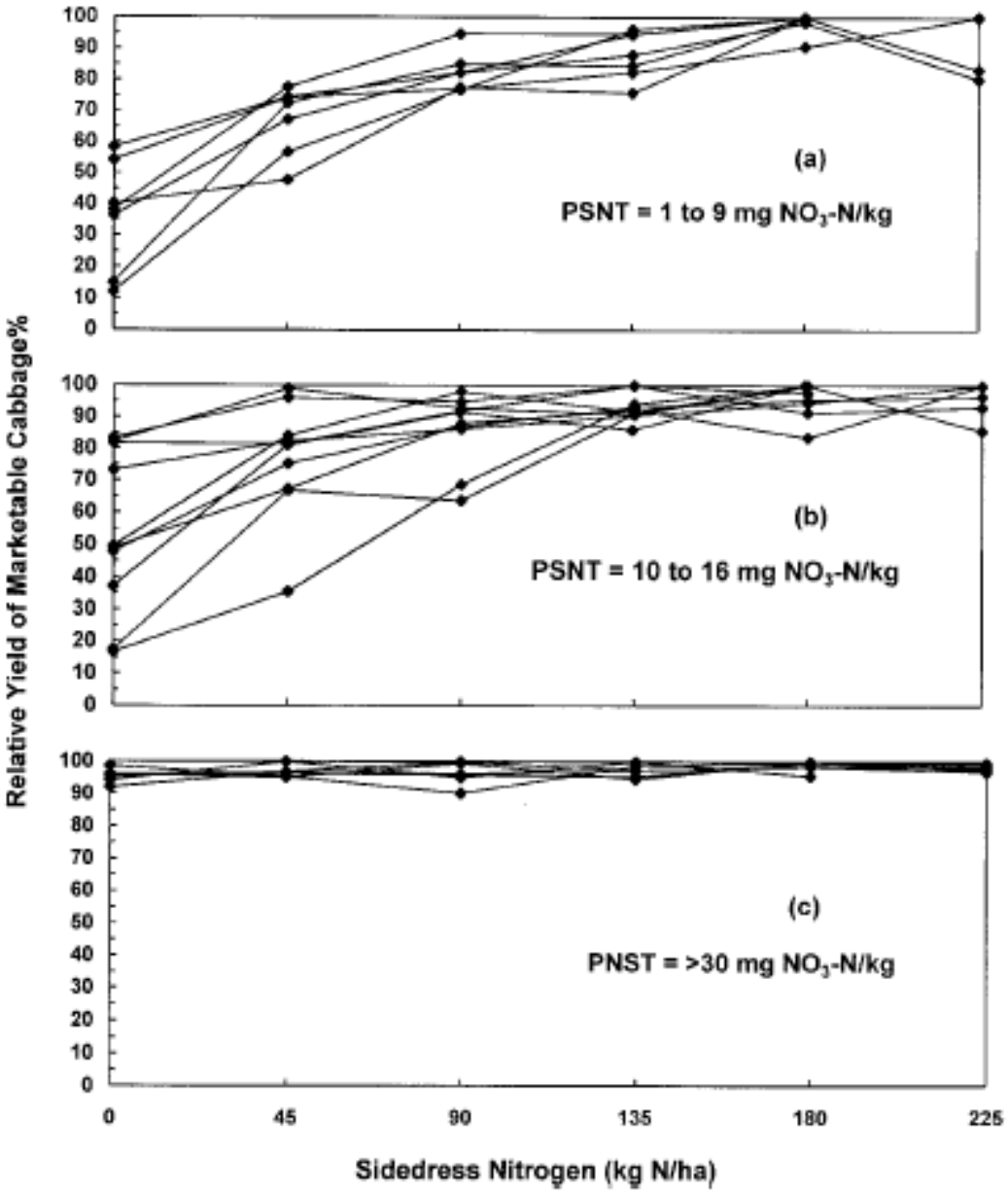
Can Nitrogen Application Be Predicted?

Calculations based on 2016 trial results

Total Cabbage **Uptake**	**~214 lb/A**
Minus nitrogen in soil (58 lb/A)	156 lb/A
Minus nitrogen already taken up by crop (23 lb/A)	133 lb/A
Example: **100 lb/A N applied at planting:** Minus PSNT test (64.6 lb/A)	Add **68 lb/A** **(169 total)**
Example: **100 lb/A N applied at planting:** Minus PSNT test (108 lb/A)	Add **25 lb/A** **(126 total)**
Example: **50 lb/A N applied at planting:** Minus PSNT test (70.4 lb/A)	Add **63 lb/A** **(114 total)**
Example: **75 lb/A N applied at planting:** Minus PSNT test (80.5 lb/A)	Add **55 lb/A** **(129 total)**

Using %OM and pre-side dress test to predict amount of nitrogen to apply at side-dress with varying rates of N applied at planting resulted in 114 to 169 lb/A of total nitrogen used.

PSNT Soil Test for Fall Cabbage: Northeast U.S.



Heckman *et al.* 2002

2 weeks POST-transplanting:

If PSNT: **< 9 ppm (= 18 lb/A)**
Apply **90-160 lb/A N**
=100% standard rates

If PSNT: **10 - 16 ppm (= 20- 32 lb/A)**
Apply **40-120 lb/A N**
(standard rates reduced by 25-50%)

If PSNT: **≥ 24 ppm (= 48 lb/A)**
No response to applied N

Summary

- Most important factor driving cabbage yield is amount of applied nitrogen
- When 100% nitrogen applied at planting, highest rates gave highest yields and climbing
  - 2014 trial: **262 lb/A**
  - 2016 trial: **200 lb/A**
- Rate of increase in yield per 50 lb/A N:
    - Normal year (2014): **2.3 ton/A**
    - Dry year (2016): **0.6 ton/A**

Summary

Split applications of nitrogen between planting resulted in more efficient nitrogen use

- Maximum yields achieved at:
  - 2014 50:50 - **197 lb/A N**
  - 2014 25:75 – **132 lb/A N**
  - 2016 50:50 – **150 lb/A N**
- Nitrogen stabilizer (nitripyran) significantly decreased yield by **8.5%** in a hot dry year
  - Reduced availability of soil nitrogen
    - Demonstrating that it worked!
  - Especially when applied at planting as a surface spray and then incorporated; compared to no stabilizer:
    - **4 – 17%** reduced NO_3-N + NH_4-N at **side-dress**
    - **39-77%** reduced NO_3-N + NH_4-N at **early cupping**
  - How would it perform in a normal or wet year?

Summary

- Cabbage is a very effective scavenger of nitrogen from soil
  - Typically uptake exceeds amount applied
  - <10 lb/A of available nitrogen remains in the ground at harvest
- ~ 100 lb/A of nitrogen is left in the field in crop residue after harvest
- Experiment with reduced rates of nitrogen in crops following harvest of summer cabbage (such as winter wheat)
- Expect a healthy cabbage crop to use ~**215 lb/A** of nitrogen

Recommendations

- **150 lb/A** total applied nitrogen
  - Cornell guidelines are too low
- Split applications:
  - Maximum 50% at planting
  - 50 – 75 lb/A pre-plant & at planting
  - 75 – 100 lb/A at side-dressing
    - Adjust rate according to PSNT, %OM and field history
- Consider a nitrogen stabilizer at planting in a wet spring?

Questions?