Optimum Nitrogen Management for Modern Corn Hybrids in Manitoba

AGVISE Soil Fertility Seminar

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Research Justification - Corn Production in MB is Increasing

- By Acres
  - 85 000 grain acres in 1990
  - 185 000 grain acres in 2010
  - 370 000 grain acres in 2018
  - 416 000 grain acres in 2019
  - Provincial 10 year average 263 000 acres
- By Yield
  - With better, earlier maturing hybrids, plus longer growing season
  - 76 bu/ac provincial average 1990
  - 110 bu/ac 2006
  - 145 bu/ac 2016
  - 134 bu/ac 2017
  - 126 bu/ac 2019
  - Provincial 10 year average is 121 bu/ac

Source: Manitoba Agriculture Services Corporation

Research Justification – Nitrogen management is of greater interest then ever before

- MB recommendations are outdated
  - much higher yields
  - US studies show that modern hybrids have higher N use efficiency (require less N/bu)

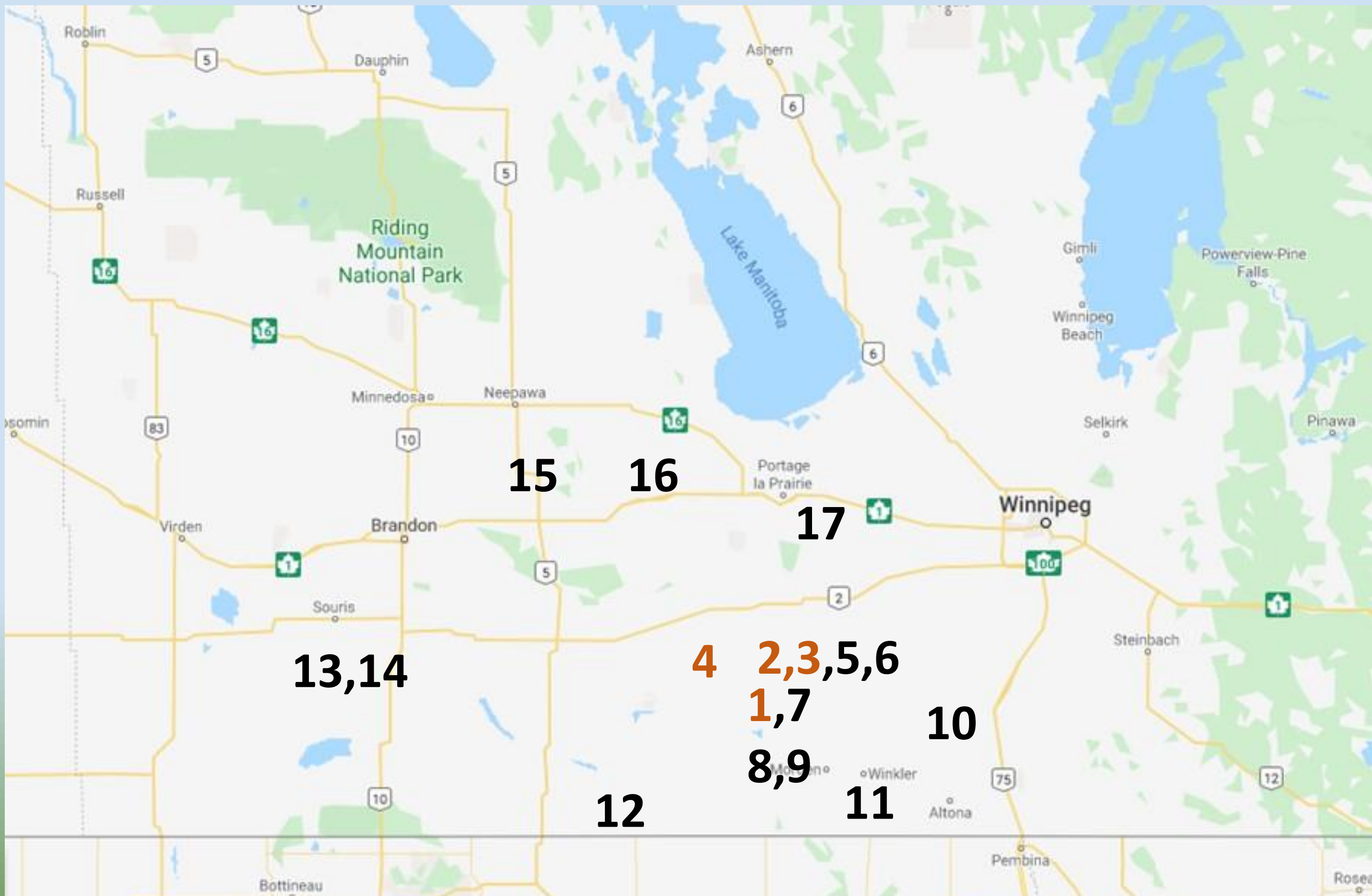
- Agronomic, economic and environmental factors
  - margins for corn price vs. cost of N fertilizer
  - availability of enhanced efficiency fertilizers (EEF)
  - equipment for in-season applications
  - excess residual N after corn increases risk of nitrate leaching, nitrous oxide emissions (GHG)

Project Objectives - Improve upon matching N supply with plant demand

- More precise N rate (lb/acre & lb/bu)
  - Our climate and soils are much different than other areas ... therefore different N demands
  - Ability to adapt and adjust to each year
- Evaluate pre plant EEF products
- Determine best combination of time and placement for split applications
- Better predict N supplying power of soil - mineralization
- Evaluate accuracy of in-season decision tools

Methods

- 17 site years of data (2018 & 2019)
- 4 were “gold” level sites with the source (EEF) treatments



Site Name (year)	
1	Graysville18
2	Stephenfield18
3	CarmanNorth19
4	St.Claude19
5	CarmanWest18
6	CarmanSouth19
7	Graysville19
8	Rosebank18
9	Rosebank19
10	Morris19
11	Winkler18
12	Clearwater19
13	Elgin18
14	Elgin19
15	Wellwood18
16	Macgregor18
17	Portage18

Treatments

0
40 lb/ac **broadcast**
80 lb/ac **post-plant**
120 lb/ac
160 lb/ac
200 lb/ac

Rate

80 & 120 lb/ac Urea **broadcast &**
80 & 120 SuperU **incorporated**
80 & 120 eNtrench treated urea
80 & 120 ESN 1:1 Urea blend
80 & 120 SuperU **broadcast post-plant**

Source (Gold Sites Only)

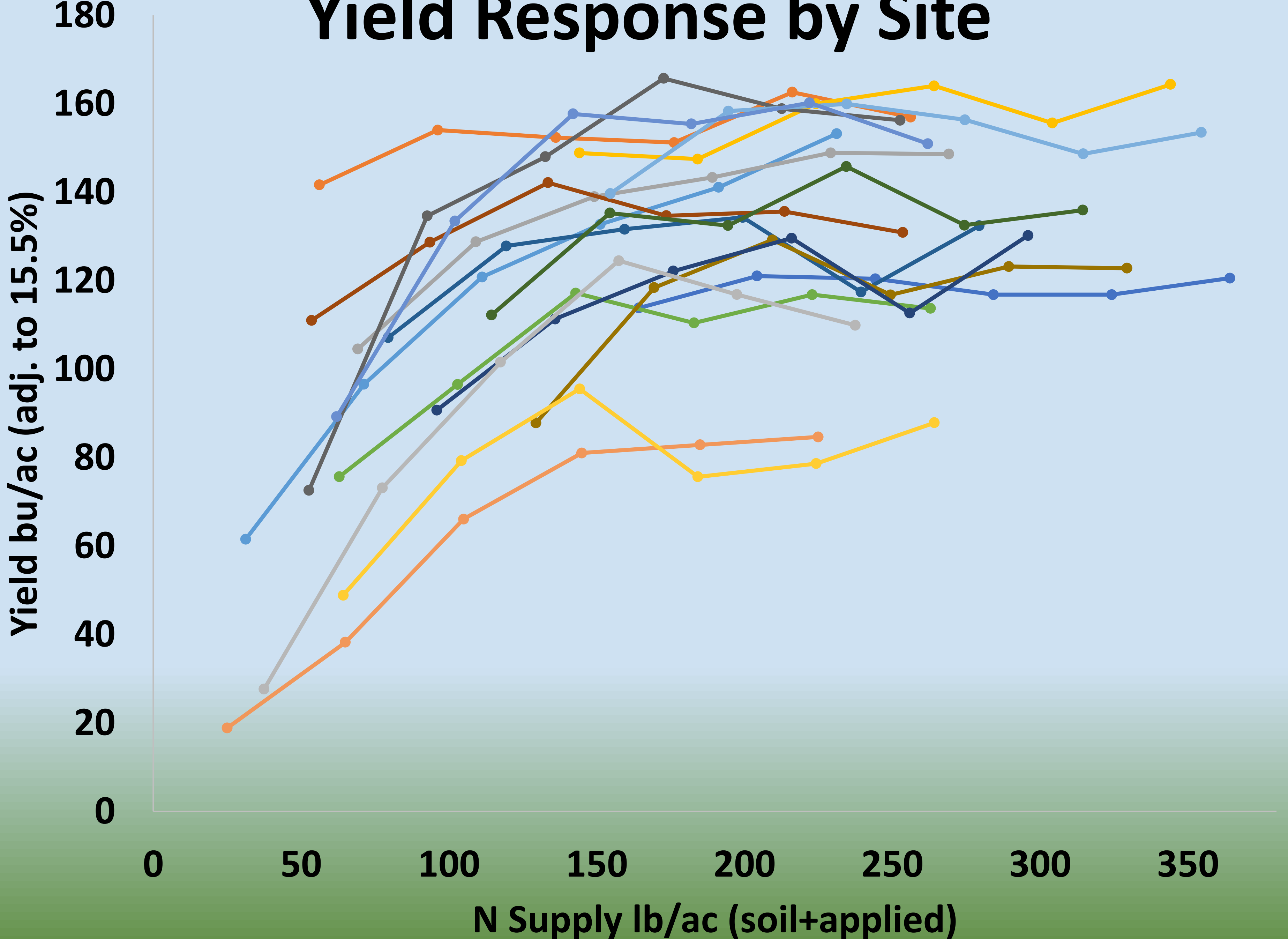
80 SuperU
40 SpU + 40 UAN Side-dress@V4
40 SpU + 40 UAN Y-drop@V8
40 SpU + 40 UAN w/ Agrotain Y-drop@V8
120 SuperU
40 SpU + 80 UAN Side-dress@V4
40 SpU + 80 UAN Y-drop@V8
40 SpU + 80 UAN w/ Agrotain Y-drop@V8

Time & Place

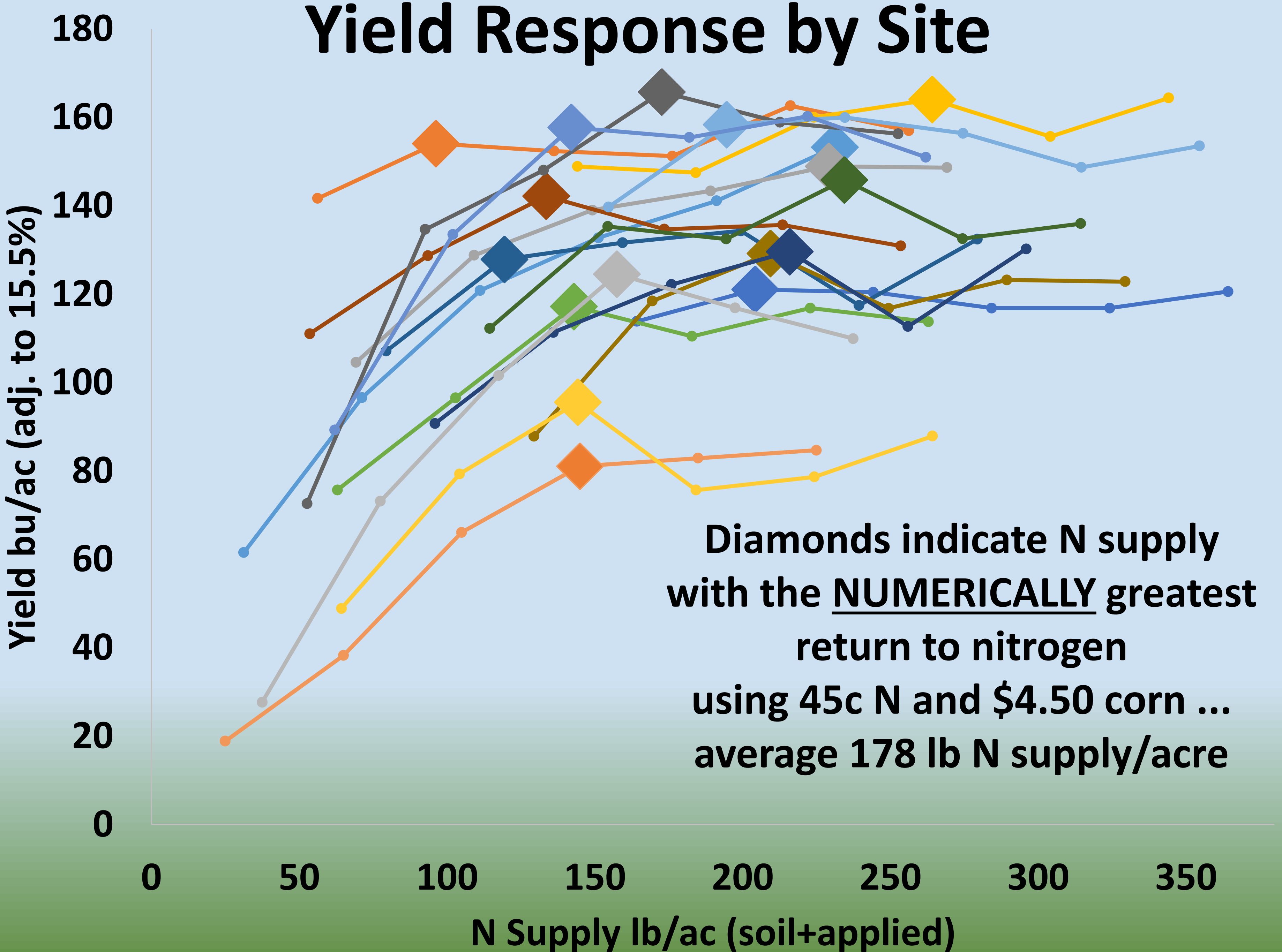
Measurements

- preplant soil nitrate
- pre-sidedress nitrate
- estimated mineralizable soil N
- leaf reflectance
- biomass yield, N content (control (0 N) plots only)
- grain yield, moisture, N content
- stalk nitrate content
- post harvest soil nitrate
- estimated mineralized soil N
- rainfall, temperature, solar radiation, & soil temperature
- soil moisture & texture

Yield Response by Site



Yield Response by Site



Diamonds indicate N supply with the <u>NUMERICALLY</u> greatest return to nitrogen using 45c N and $4.50 corn ... average 178 lb N supply/acre

N supply for the numerically greatest return to nitrogen using 45c N and $4.50 corn

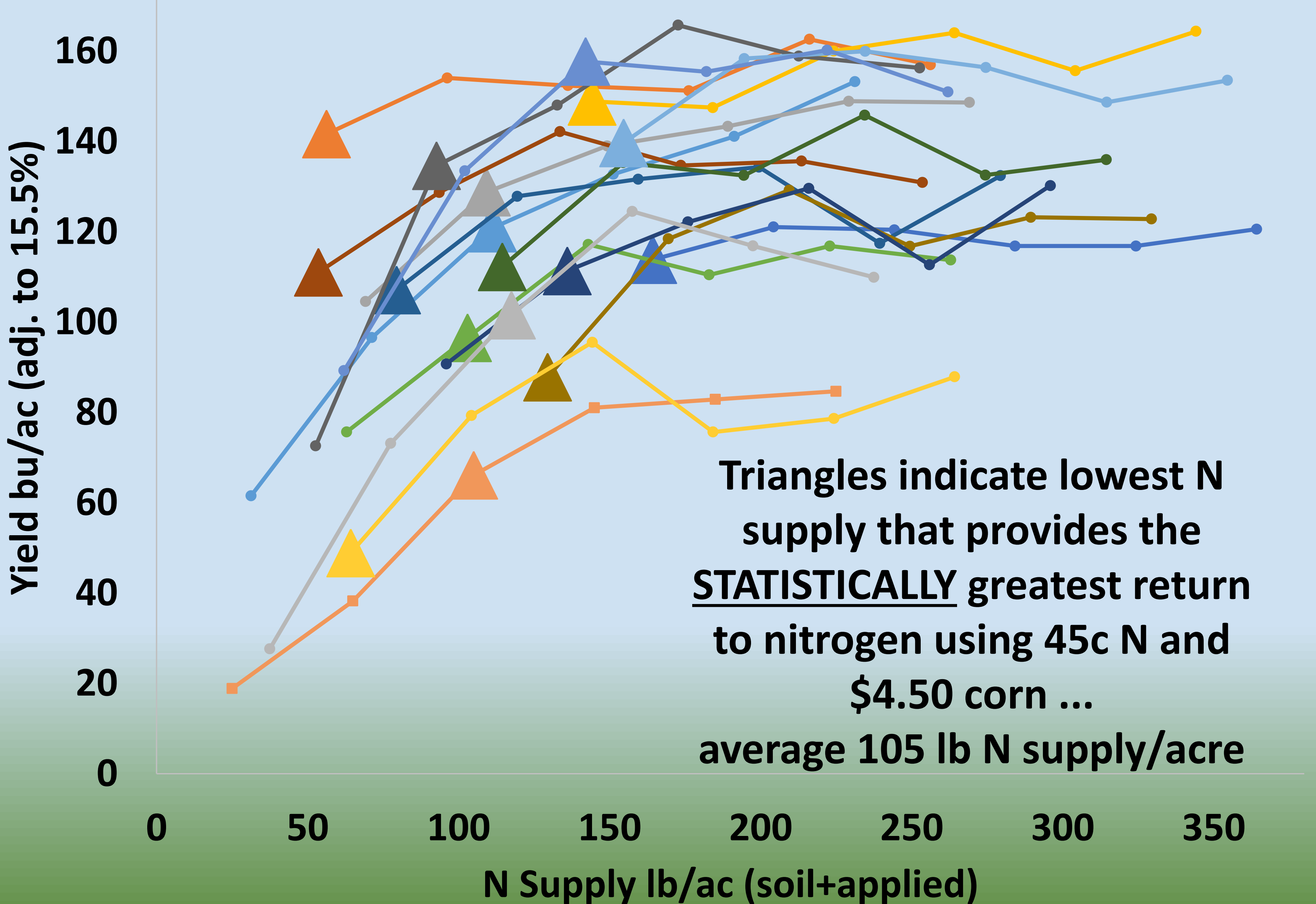
Yield potential <130 bu/ac

Site Year	N supply at greatest profitability (lb/ac)	Yield at greatest profitability (bu/ac)	lb of N supply /bu yield
St.Claude19	145	81	1.79
Wellwood18	145	96	1.51
Elgin19	143	117	1.22
Elgin18	204	121	1.69
Stephenfield18	157	124	1.26
Morris19	210	129	1.62
mean	167	111	1.52

Yield potential >130 bu/ac

Site Year	N supply at greatest profitability (lb/ac)	Yield at greatest profitability (bu/ac)	lb of N supply /bu yield
Graysville18	120	128	0.94
Portage18	216	130	1.67
Graysville19	134	142	0.94
Rosebank18	235	146	1.61
Macgregor18	172	148	1.16
Rosebank19	195	149	1.31
CarmanWest18	229	149	1.54
CarmanNorth19	231	153	1.51
CarmanSouth19	96	154	0.63
Winkler18	142	158	0.90
Clearwater19	264	164	1.61
mean	185	147	1.26

Yield Response by Site

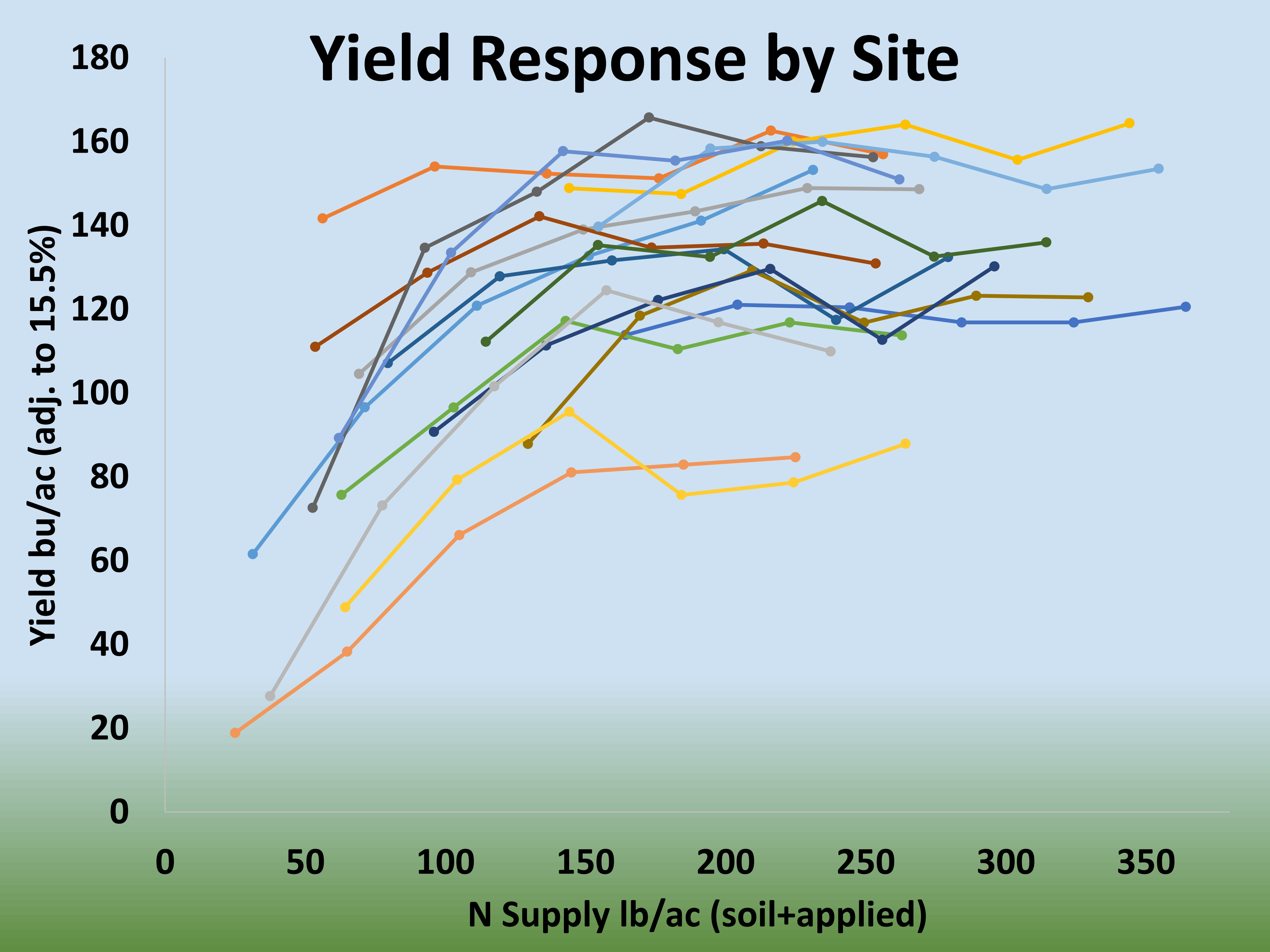


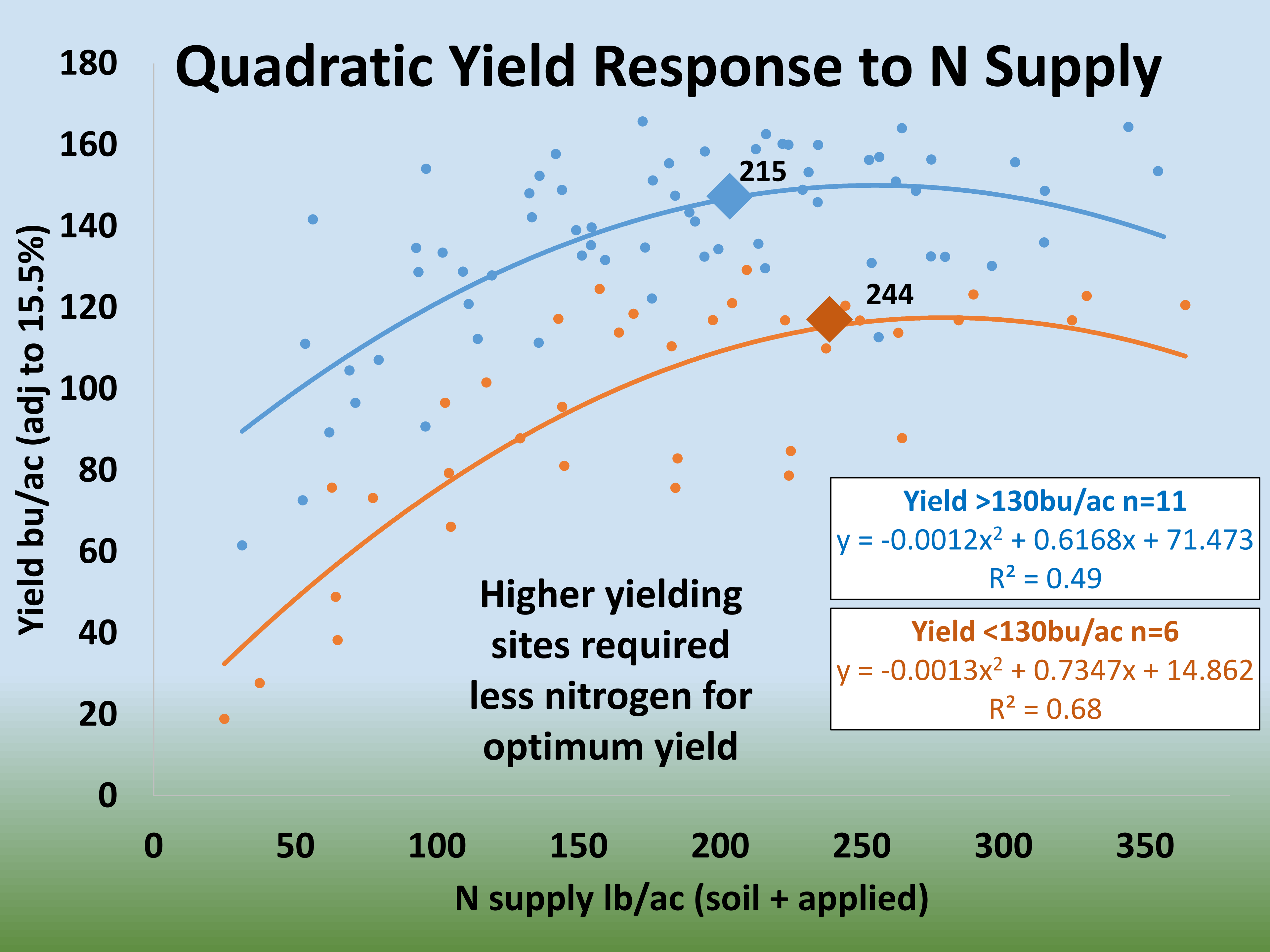
Yield potential <130 bu/ac

N supply for the statistically greatest return to nitrogen using 45c N and $4.50 corn

Yield potential >130 bu/ac

Siteyr	N Supply at statistically MRTN (lb/ac)	Yield at MRTN (bu/ac)	lb of N supply /bu yield
Wellwood 18	55	49	1.32
StClaude 19	105	66	1.59
Morris19	129	88	1.48
Elgin19	93	97	1.07
Stephenfield18	117	102	1.16
Elgin18	130	114	1.44
mean	105	86	1.34
Graysville 18	80	107	0.74
Graysville 19	54	111	0.48
Portage18	131	111	1.22
Rosebank 18	109	112	1.02
Carman North19	111	121	0.92
Carman West18	104	129	0.85
Macgregor 18	88	135	0.69
Rosebank 19	150	140	1.11
Carman South19	57	142	0.40
Clearwater 19	139	149	0.97
Winkler 18	132	158	0.90
mean	105	129	0.85


Yield Response by Site
Yield bu/ac (adj. to 15.5%)
0
20
40
60
80
100
120
140
160
180
0
50
100
150
200
250
300
350
N Supply lb/ac (soil+applied)


Quadratic Yield Response to N Supply
Yield bu/ac (adj to 15.5%)
0
20
40
60
80
100
120
140
160
180
0
50
100
150
200
250
300
350
N supply lb/ac (soil + applied)
215
244
Higher yielding sites required less nitrogen for optimum yield
Yield >130bu/ac n=11
y = -0.0012x² + 0.6168x + 71.473
R² = 0.49
Yield <130bu/ac n=6
y = -0.0013x² + 0.7347x + 14.862
R² = 0.68

Optimum N Supply Predicted from Quadratic Response

Optimum rate is where yield increase from the added N fertilizer = cost of adding the N fertilizer

Using $4.50 corn and 45c nitrogen

Sites yielding >130 bu/ac

Optimum rate =215 lb/ac N yielding 148 bu/ac

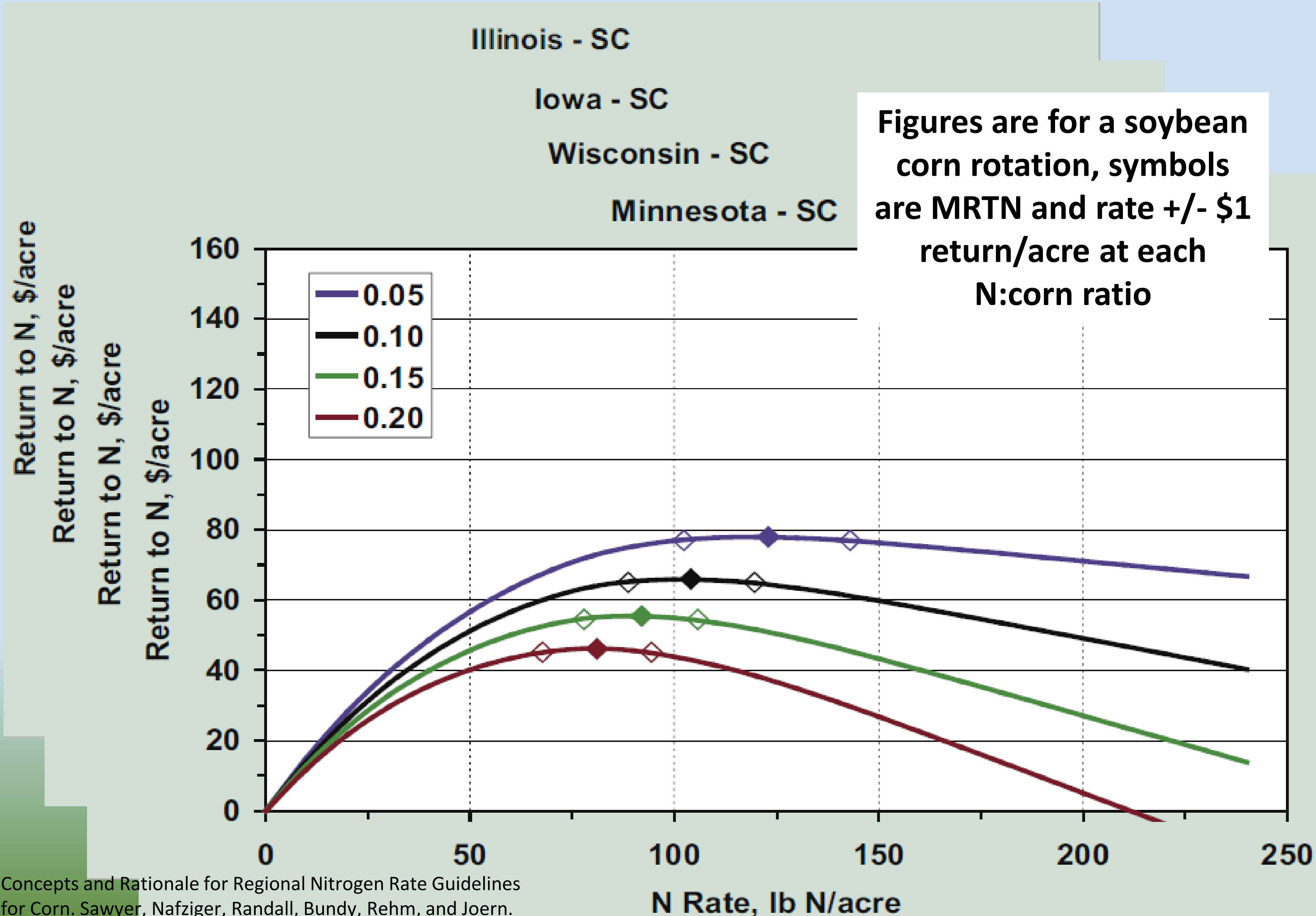
=1.45 lb N /bu

Sites yielding <130 bu/ac

Optimum rate =244 lb/ac N yielding 117 bu/ac

=2.08 lb N /bu

What is the right rate in other places?



Figures are for a soybean corn rotation, symbols are MRTN and rate +/- $1 return/acre at each N:corn ratio

Concepts and Rationale for Regional Nitrogen Rate Guidelines for Corn. Sawyer, Nafziger, Randall, Bundy, Rehm, and Joern.

What is the right rate in other places?

- Maximum Return To Nitrogen application rate at 0.1:1, corn: N ratio
- Non responsive sites not included

States listed from South to North

State	N application rate (lb/ac) at MRTN	Yield (bu/ac) at MRTN rate	lb of N applied/ bu yield
Illinois	163	174	0.94
Iowa	123	179	0.69
Wisconsin	107	169	0.63
Minnesota	101	168	0.60

Concepts and Rationale for Regional Nitrogen Rate Guidelines for Corn. Sawyer, Nafziger, Randall, Bundy, Rehm, and Joern.

Why does optimum N rate decrease as we move North?

Yield Potential ↓

Soil Supply ↑

N use efficiency ↑

What do my data say about N rate?

Most American studies consider only N application rate, whereas we use spring nitrate + applied N = N supply

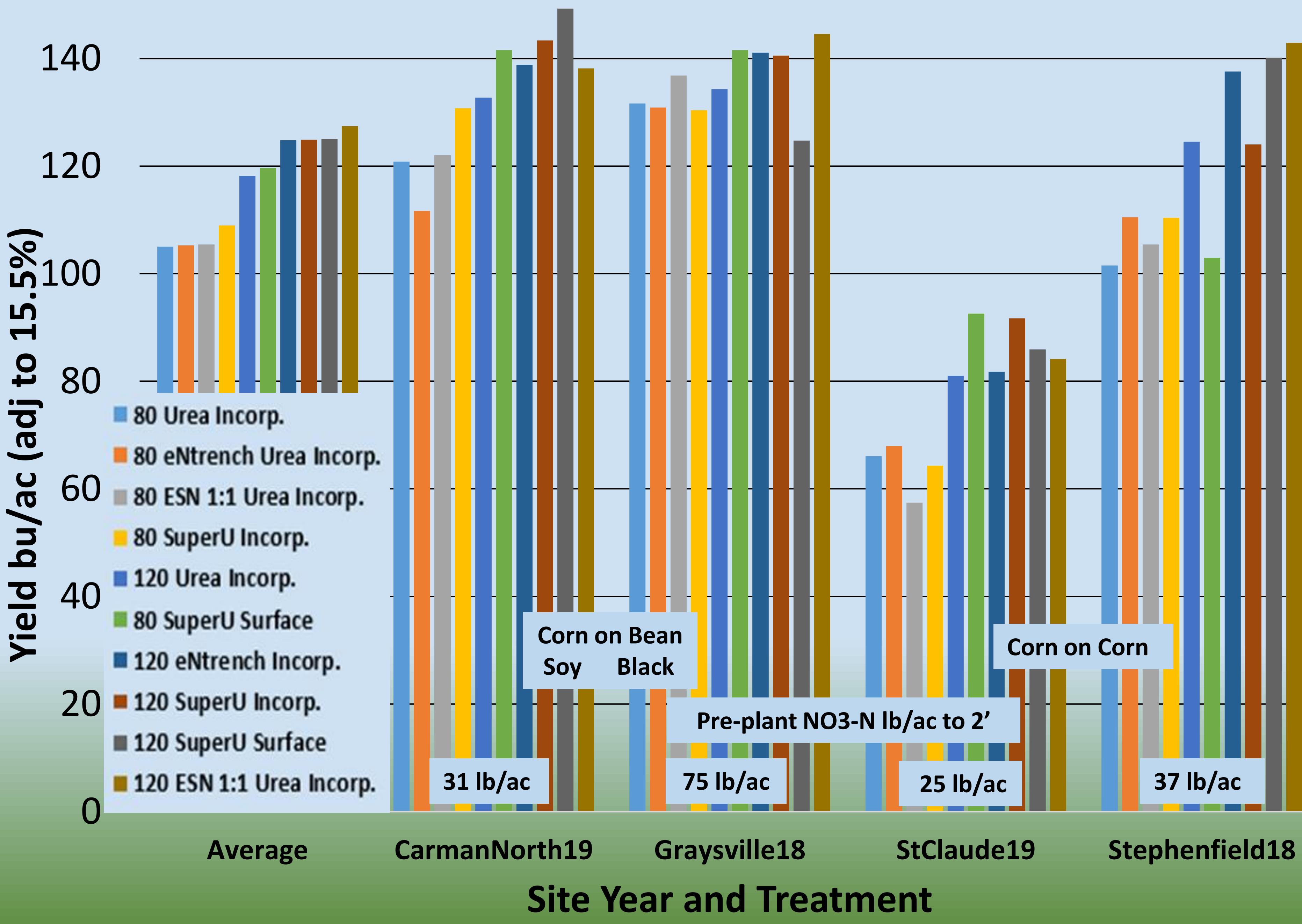
The <u>NUMERICALLY</u> optimum N supply for each site averaged 178 lb N/ac

The <u>STATISTICALLY</u> optimum N supply for each site averaged 105 lb/ac

The optimum N supply for the <u>QUADRATIC</u> response for sites with yields >130 bu/ac was 215 lb/ac

Method of Analysis	lb N supply/bu – yielding <130 bu/ac	lb N supply/bu – yielding >130 bu/ac
Numerical	1.52 lb/bu	1.26 lb/bu
Statistical	1.34 lb/bu	0.85 lb/bu
Quadratic	2.08 lb/bu	1.45 lb/bu

Yield of EEF Treatments at Gold Sites by Site Year



Statistically Significant Differences for N Sources and Placements

Global ANOVA

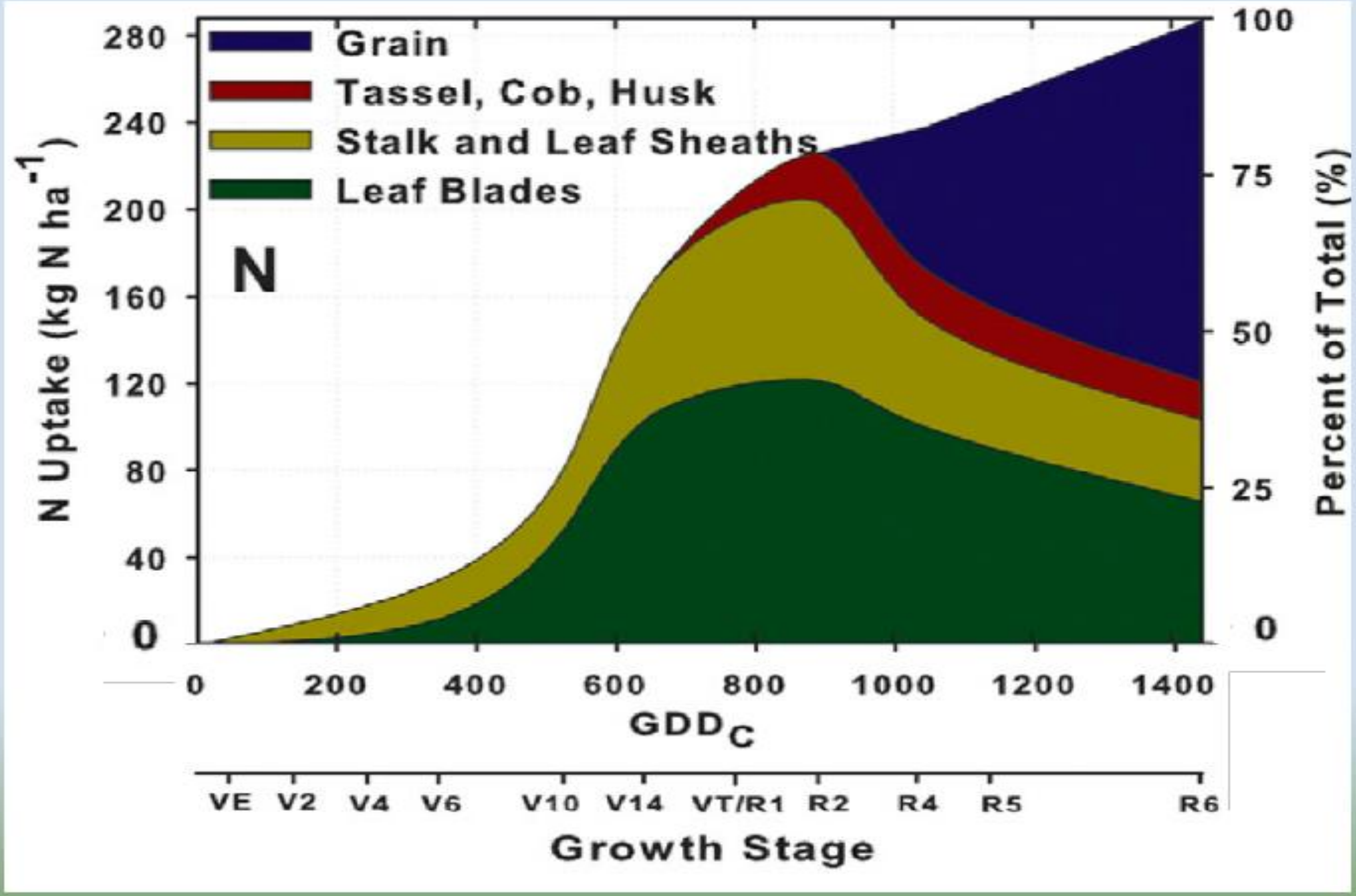
4 gold site years

Effect	p-value
Treatment	<0.0001
Siteyear	0.0002
Siteyear*Treatment	0.1216
c.v.	27%

Rate	Source	Placement	Yield (bu/ac)	
80 lb/ac	ESN 1:1 Urea	Broadcast & incorp	105	C
	eNtrench treated urea		105	C
	Urea		105	C
	SuperU		109	BC
	SuperU	Post plant broadcast	120	ABC
120 lb/ac	Urea	Broadcast & incorp	118	ABC
	eNtrench treated urea		125	AB
	SuperU		125	AB
	SuperU	Post plant broadcast	125	AB
	ESN 1:1 Urea	Broadcast & incorp	127	A

- Many examples of statistically similar yields for different combinations of N rate and source, but high variability may limit detection of differences.

Matching N supply with plant demand



*Bender et al. 2013. Agronomy J. 105:161-170

Post-Plant/In-Season N Timing and Placement

- Sites analyzed independently, statistically significant differences at 2/17 sites and statistically similar at 15/17 sites

	Post-plant SuperU broadcast + in-season application					
Site year	Rate (lb/ac)	Time	Source	Place	Yield (bu/ac)	
Carman North19 p <0.0001 c.v. 17%	80	Planting	SuperU	Surface B'cast	142	a
	40 + 40	V4	UAN	Side-dress	124	ab
		V9	UAN	Y-drop	100	b
		V9	UAN w/Agrotain	Y-drop	100	b
	120	Planting	SuperU	Surface B'cast	149	a
	40 + 80	V4	UAN	Side-dress	145	a
		V9	UAN w/Agrotain	Y-drop	125	ab
		V9	UAN	Y-drop	127	ab
Stephen-field 18 p=0.0006 c.v. 27%	80	Planting	SuperU	Surface B'cast	103	B
	40 + 40	V4	UAN	Side-dress	94	B
		V10	UAN	Y-drop	74	B
	40 + 53	V7	UAN	Y-drop	93	B
		V7	UAN w/Agrotain	Y-drop	95	B
	120	Planting	SuperU	Surface B'cast	140	A
	40 + 80	V4	UAN	Side-dress	89	B
	40 + 106	V7	UAN w/Agrotain	Y-drop	92	B
		V7	UAN	Y-drop	99	B

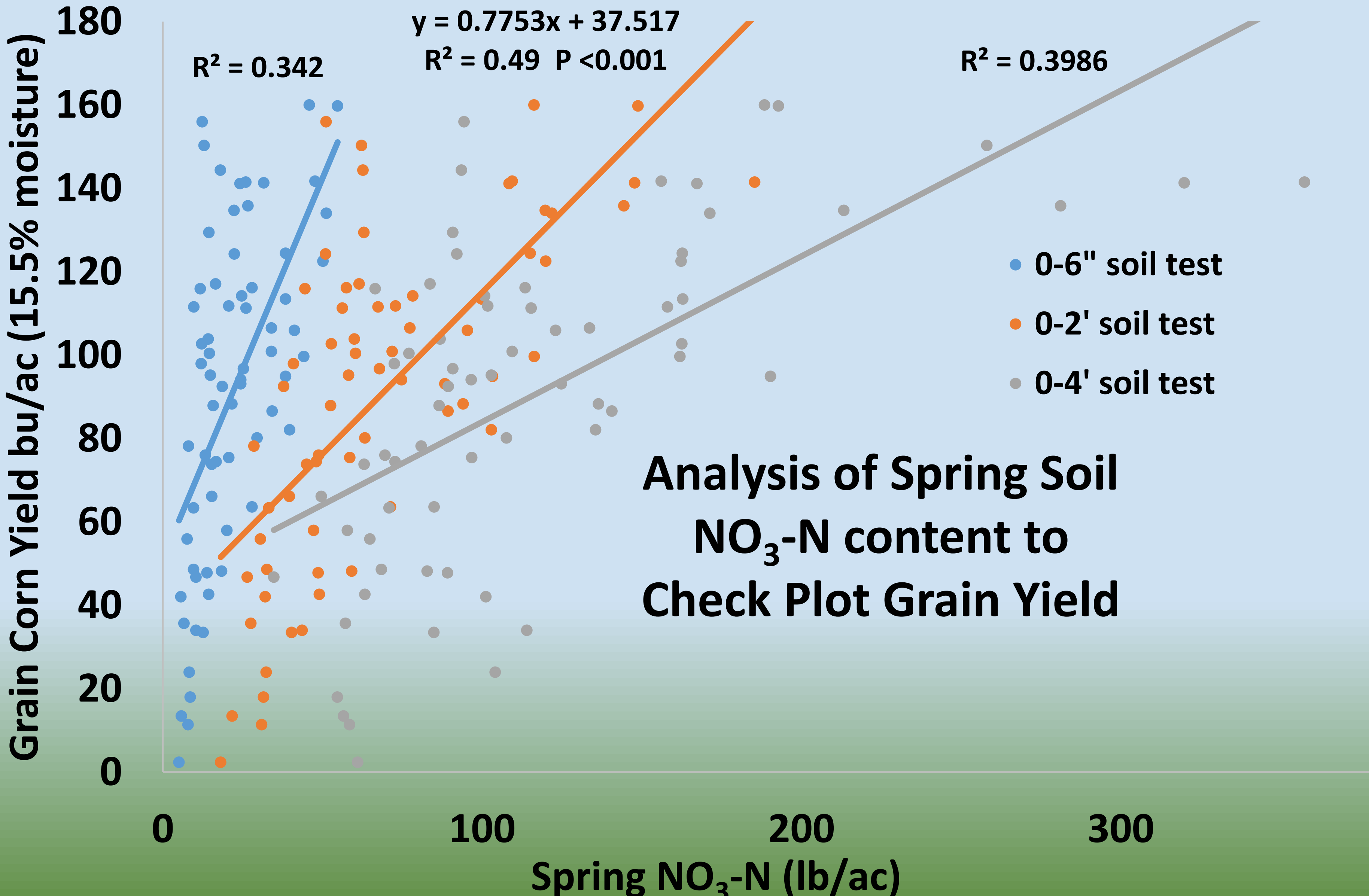
Stephenfield 2018

- Pre plant NO_3-N 37 lb/ac

Carman North 2019

- Pre plant NO_3-N 31 lb/ac
- Can see the blue flag dividing plots
- Bottom leaves deficient on right hand plot
- Dark coloured leaves on left and pale on the right

Soil testing for nitrate – N, it works



Beyond Soil Testing

Canopy Sensing

- Many instruments using red and near-infrared wavelengths to measure the canopy chlorophyll content, and quantify the nitrogen status of the plant.
- Hand held, mounted on equipment, or flown
- Adjust N applications based on N status of the crop

Growing Season Modeling

- Using past database and growing season probabilities to predict the yield potential and nitrogen demand
- Some use up to date weather and soil parameters to predict crop N status and yield potential throughout the season

An important part of modeling is to predict the timing and size of N mineralization – release of soil organic N to plant available N

Mineralization at each site

Quantified mineralization that occurred on each of the control (zero N) plots for 13 sites

pre plant soil nitrate – post harvest soil nitrate
= change in soil mineral nitrogen

N in above ground biomass - change in soil nitrogen
= mineralization

This assumes no environmental losses and neglects N in root biomass

The average mineralization at a site was 53 lb N/ac

High 93 lb/ac at Carman South19

Low of 13 lb/ac at Stephenfield 18

Those sites were only 6 miles apart

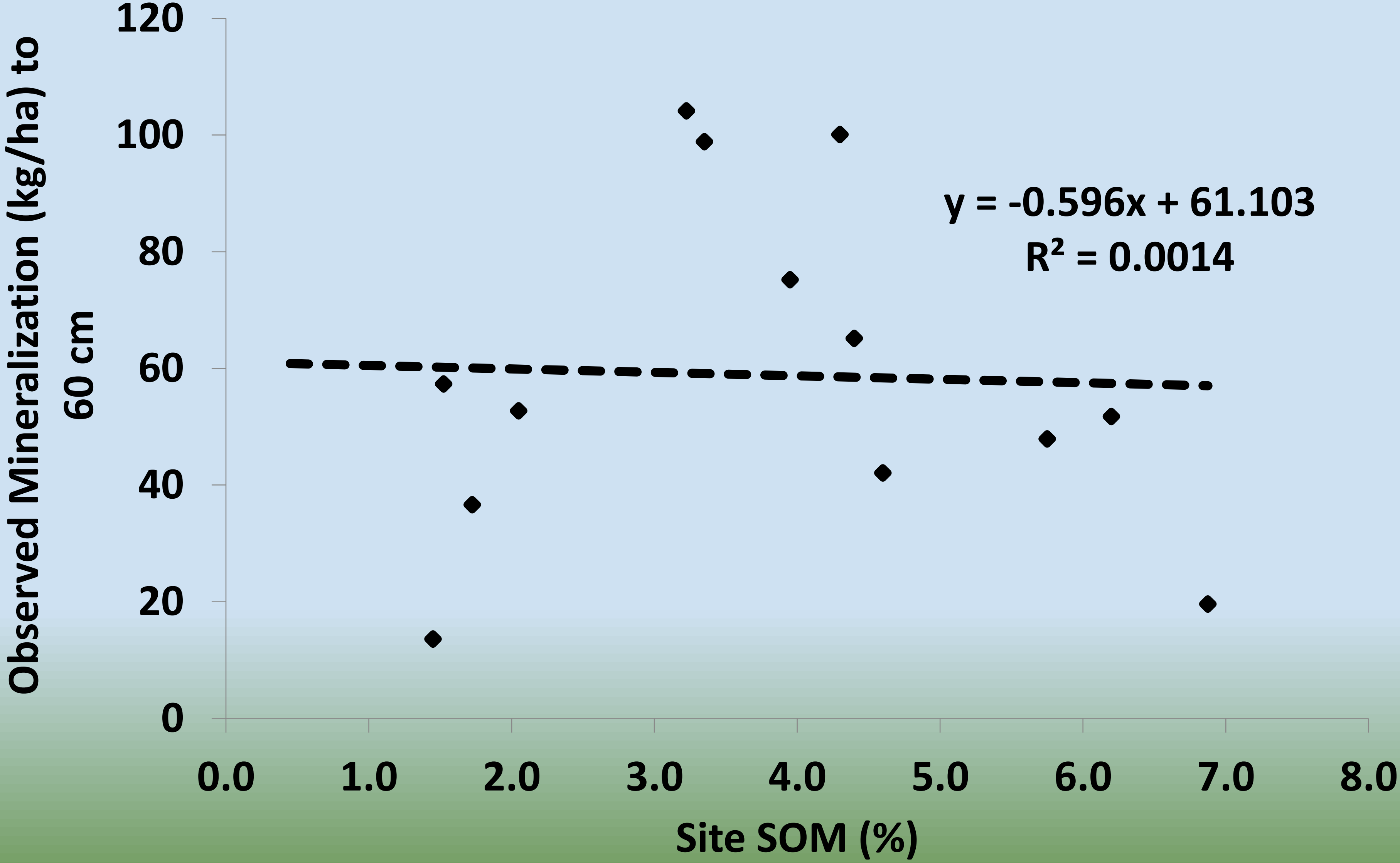
50% of the sites were between 38 and 67 lb/ac

Estimating mineralization

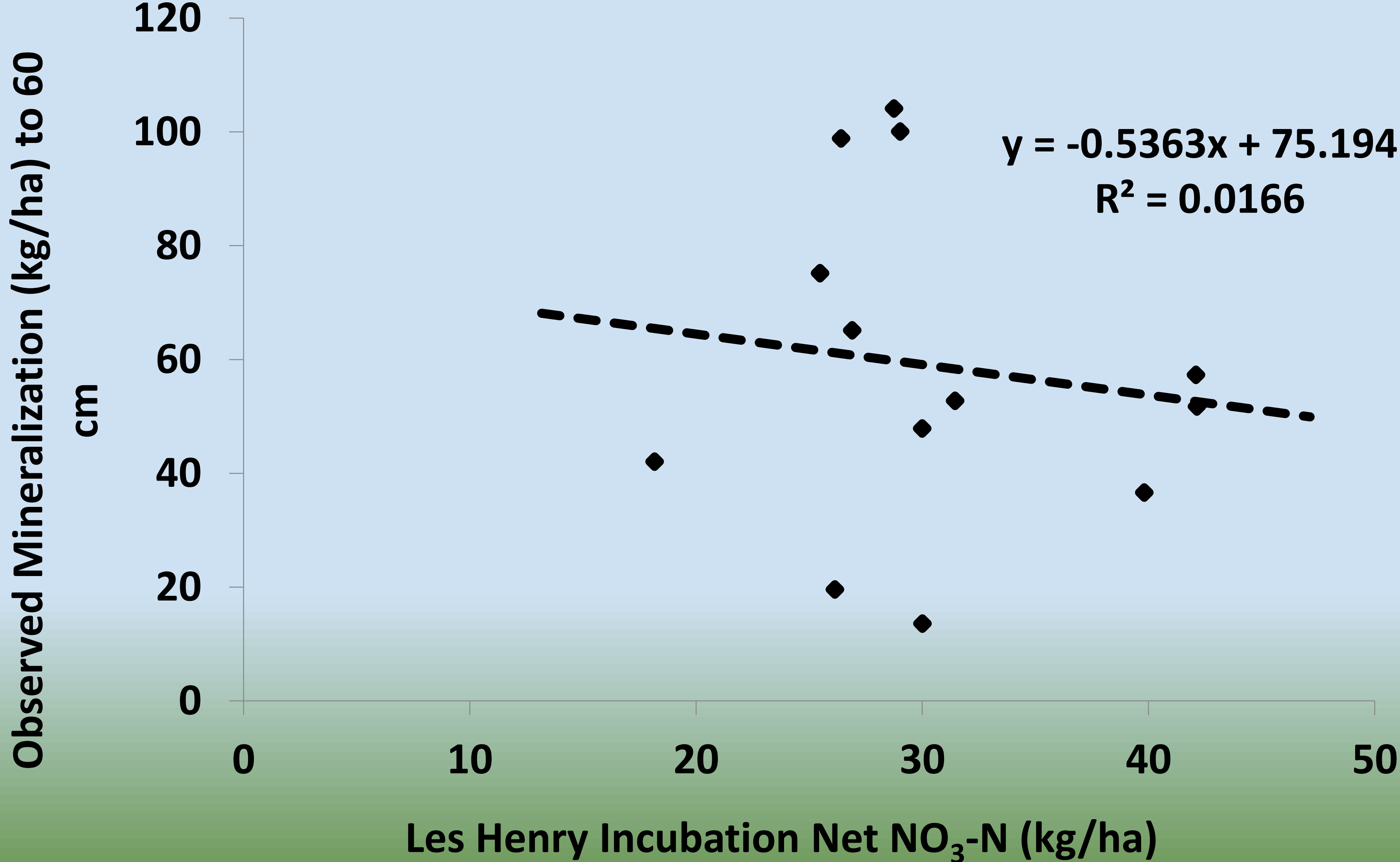
Wanted to evaluate some of the methods that have previously been used and could be useful at predicting the soil mineralization potential:

- **Organic Matter content**
- **Pre-season nitrate**
- **Les Henry Net mineralization**
- **$NaHCO_3$ absorbance**
- **Pre-side dress nitrate soil test (PSNT)**

Soil Organic Matter Content vs. Observed Mineralization



Les Henry Mineralization Test (Net) vs. Observed Mineralization



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