The Role of Soil Testing in Precision Agriculture

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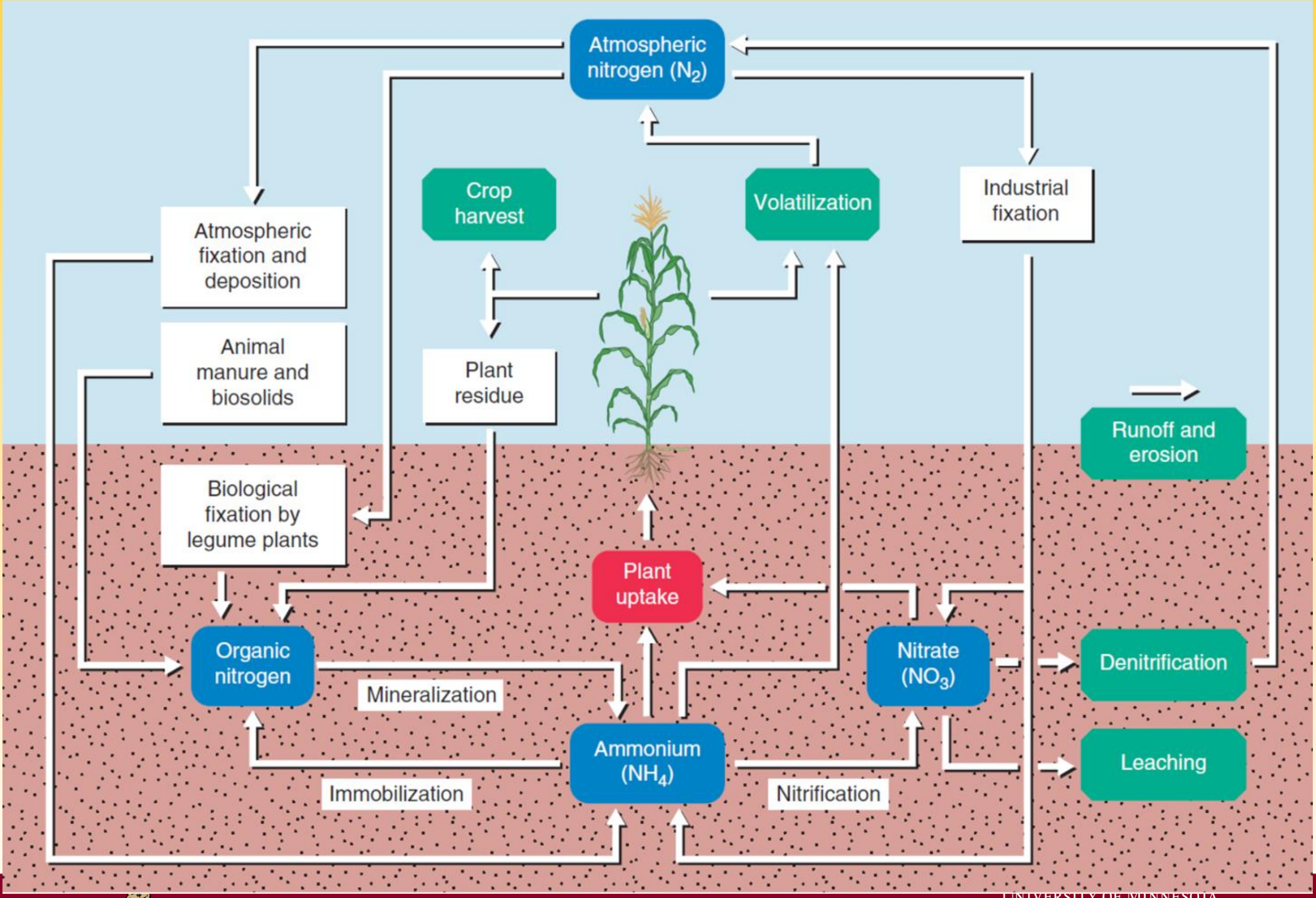
Soil Testing

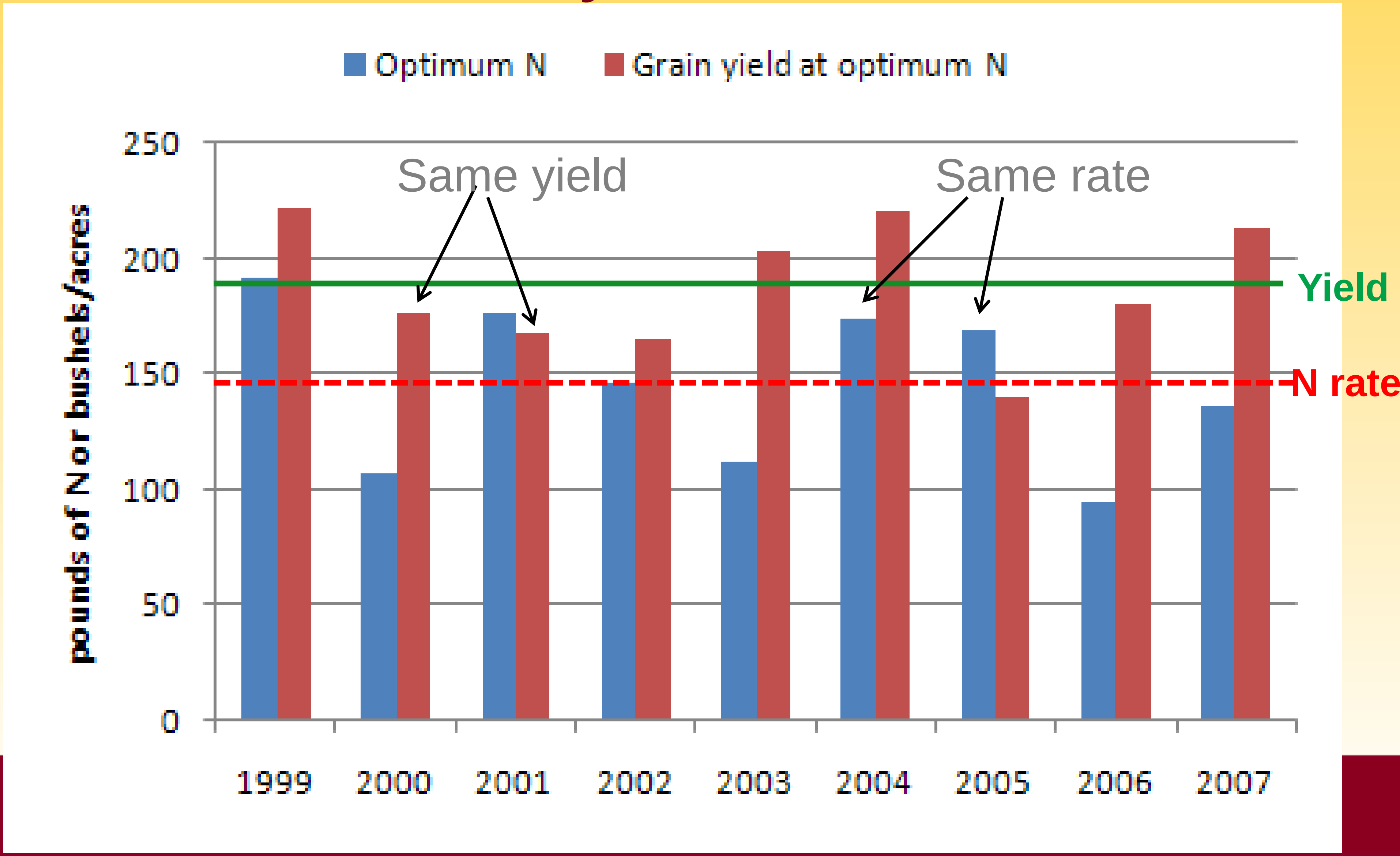
- Soil testing **IS** a useful tool
- Soil testing is **NOT** perfect
  - Don't overvalue its worth
  - Natural processes and management practices can make it difficult to translate test results into fertilizer recommendations/guidelines

Field Soil Test Calibration

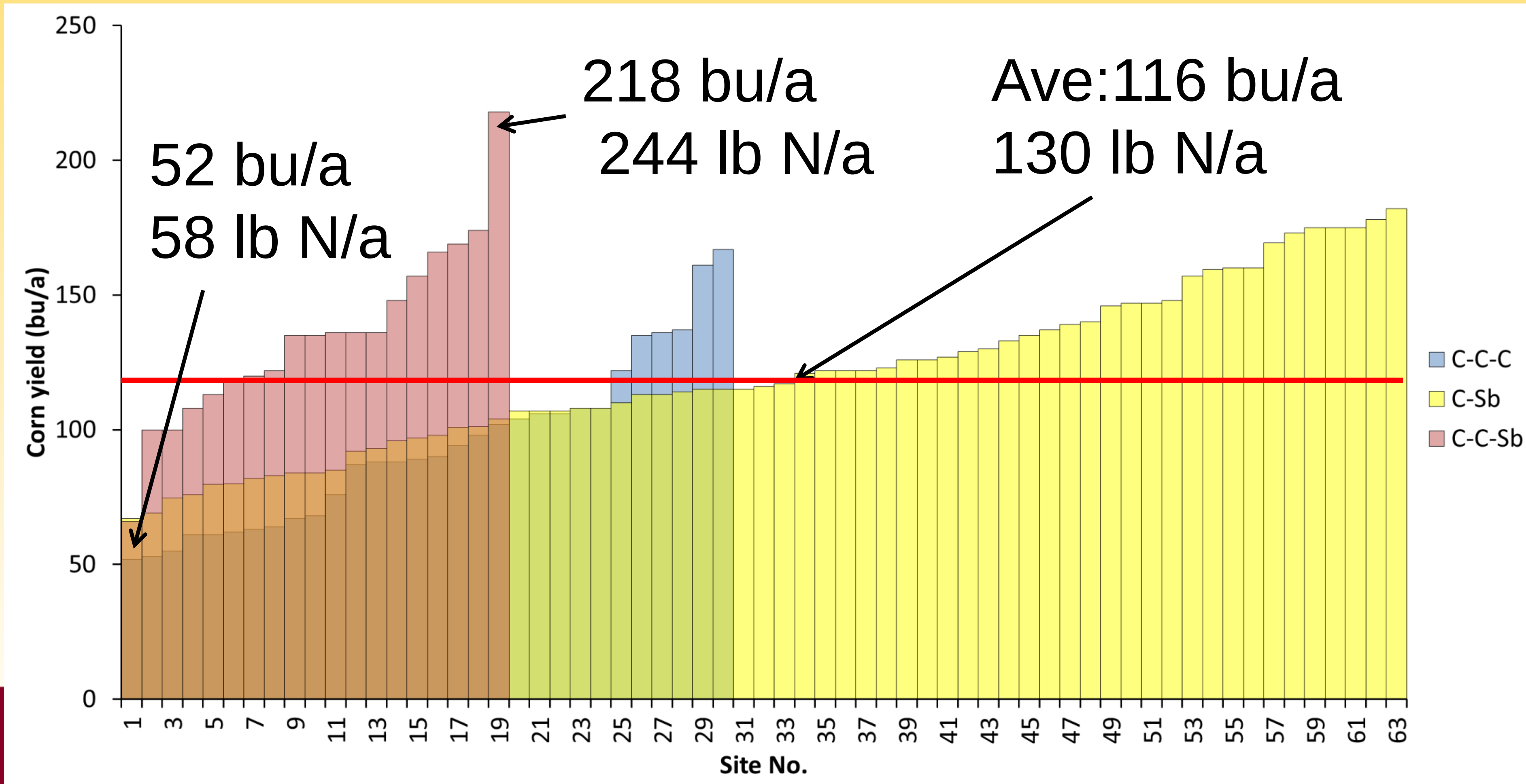
- Soil test values **only** indicate the **available** nutrient in the soil, **not** the **fertilizer required** to grow a crop
- Field soil test calibration **gives meaning** to a soil-test value in terms of nutrient sufficiency and fertilizer need
  - Units of measurement for test results are **meaningless** without proper field calibration with yield response
- Follow your state recommendations/guidelines


Atmospheric nitrogen (N_2)
Crop harvest
Volatilization
Industrial fixation
Atmospheric fixation and deposition
Animal manure and biosolids
Plant residue
Runoff and erosion
Biological fixation by legume plants
Plant uptake
Organic nitrogen
Nitrate (NO_3)
Denitrification
Mineralization
Ammonium (NH_4)
Leaching
Immobilization
Nitrification

Dark Colored "Prairie Soils"
Corn-Soybean Rotation



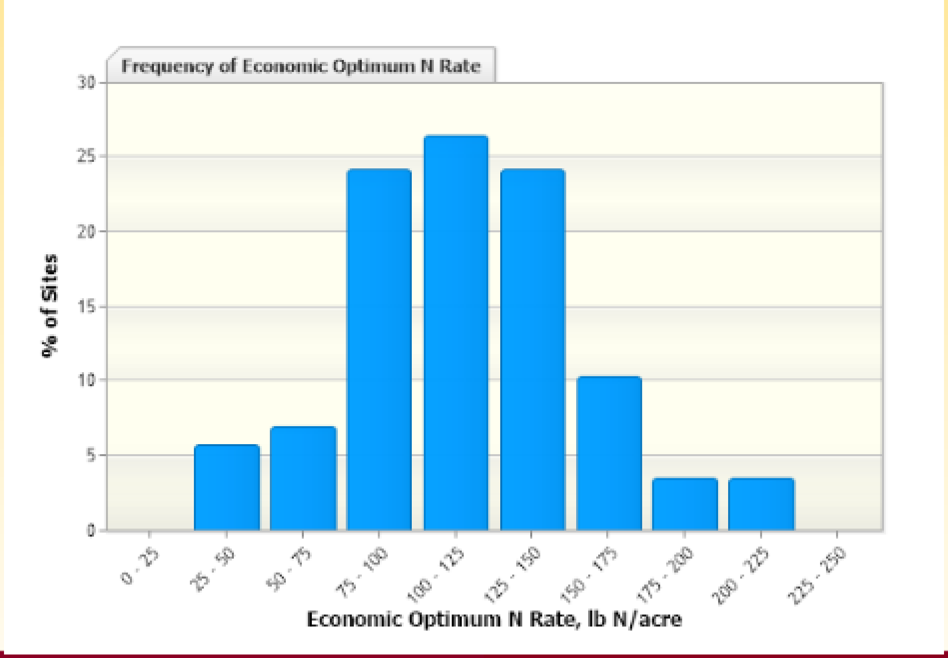
How Much Yield Can We Get Through Mineralization in MN?
Percent of Corn Yield at EONR Obtained from the 0-N Check 53% C-C, 71% C-S



- Nitrogen management is risk management
  - So many unpredictable variables can make it a “game of chance”
- Need to manage based on probability

MRTN Rate

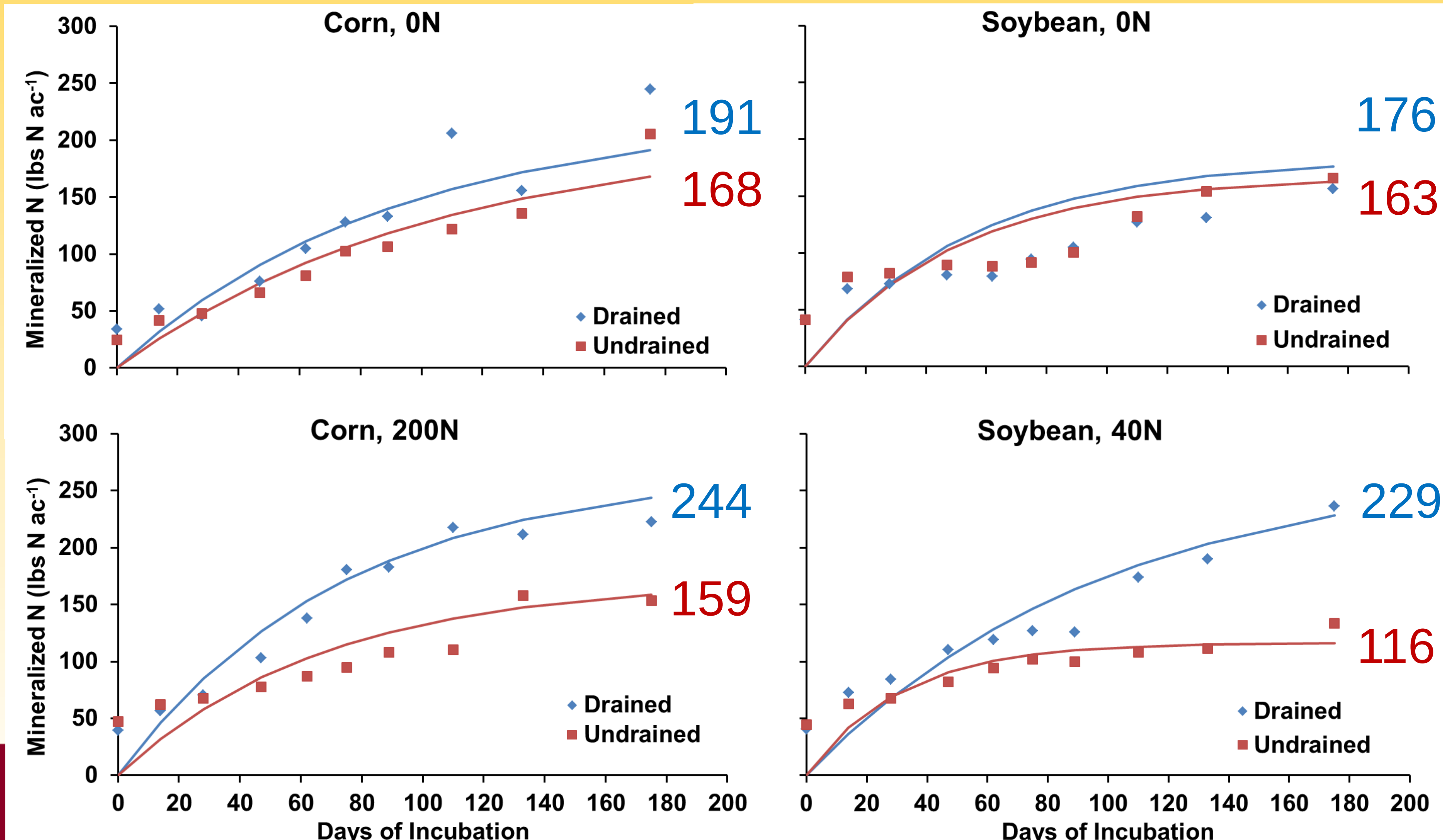
108 (120) 133



Marna silty clay loam and Nicollet silty clay loam; 5.3% OM

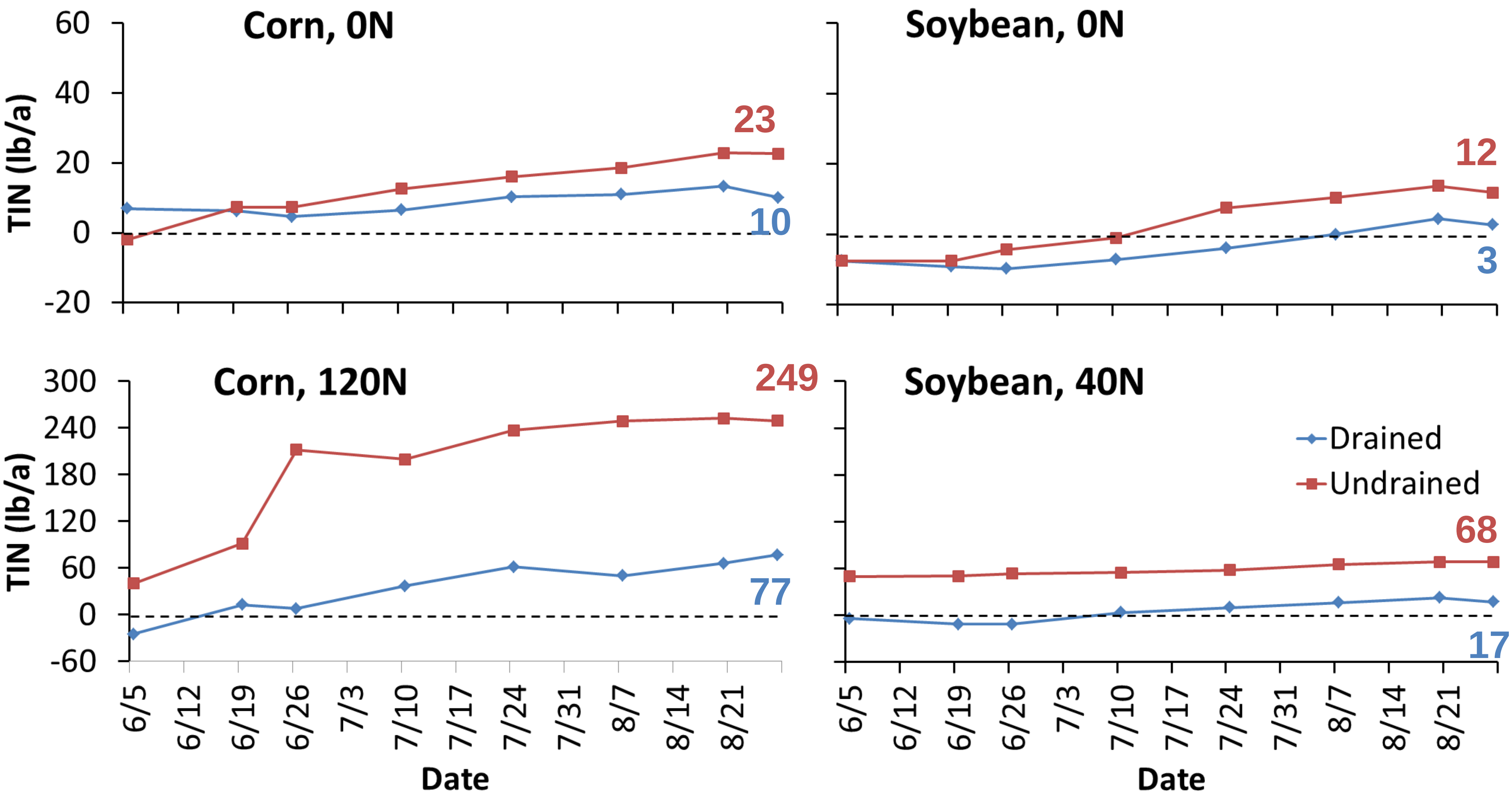
21% greater TOC and 12% greater TN in the undrained soil

Adding N in D increase Nmin	**Yes**
Adding N in UD decrease Nmin	**Yes**
Soybean less Nmin than corn	**Yes**
D greater Nmin than UD	**Yes**



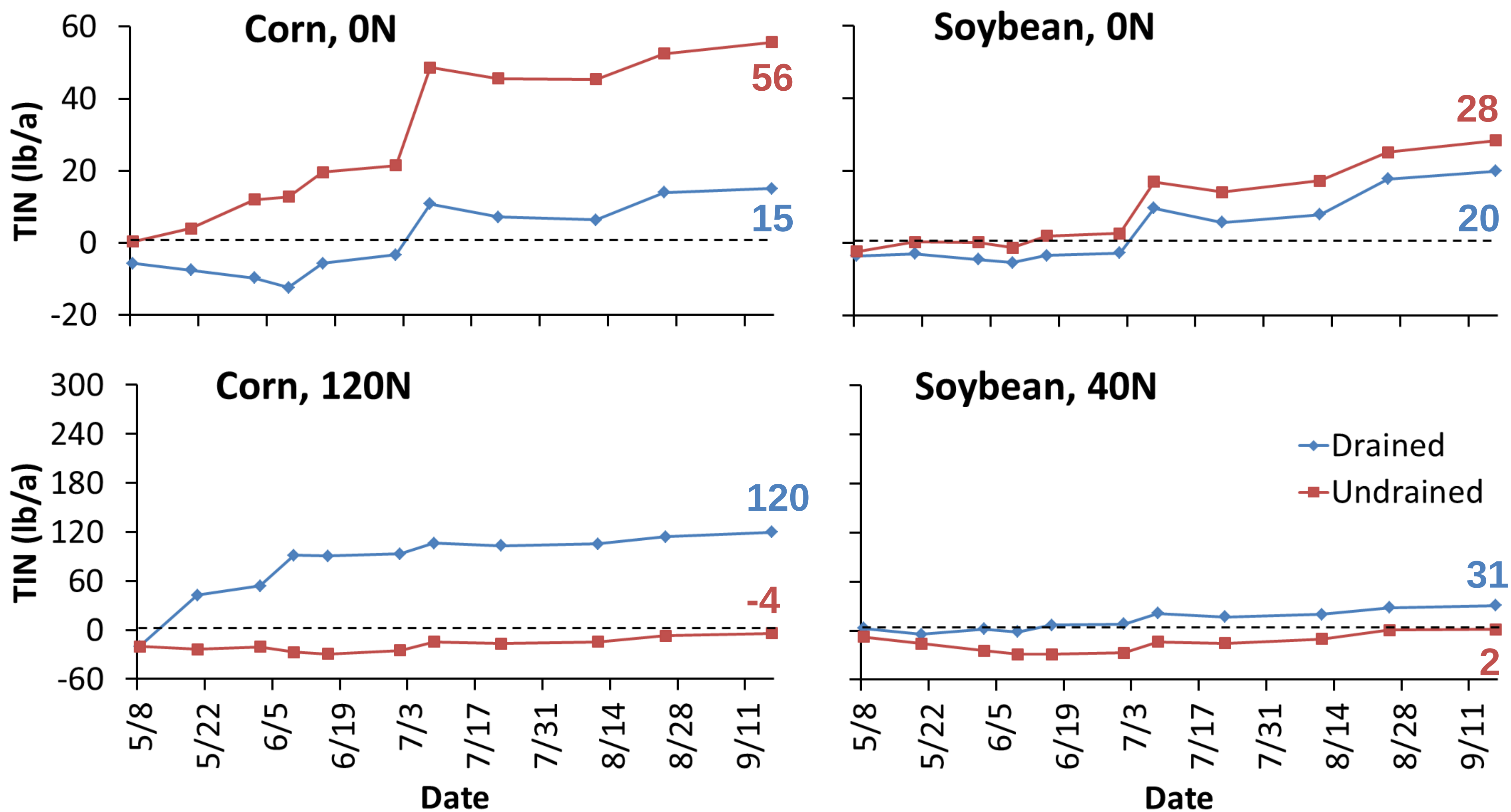
2014

Adding N in D increase Nmin	Yes
Adding N in UD decrease Nmin	No
Soybean less Nmin than corn	Yes
D greater Nmin than UD	No



2015

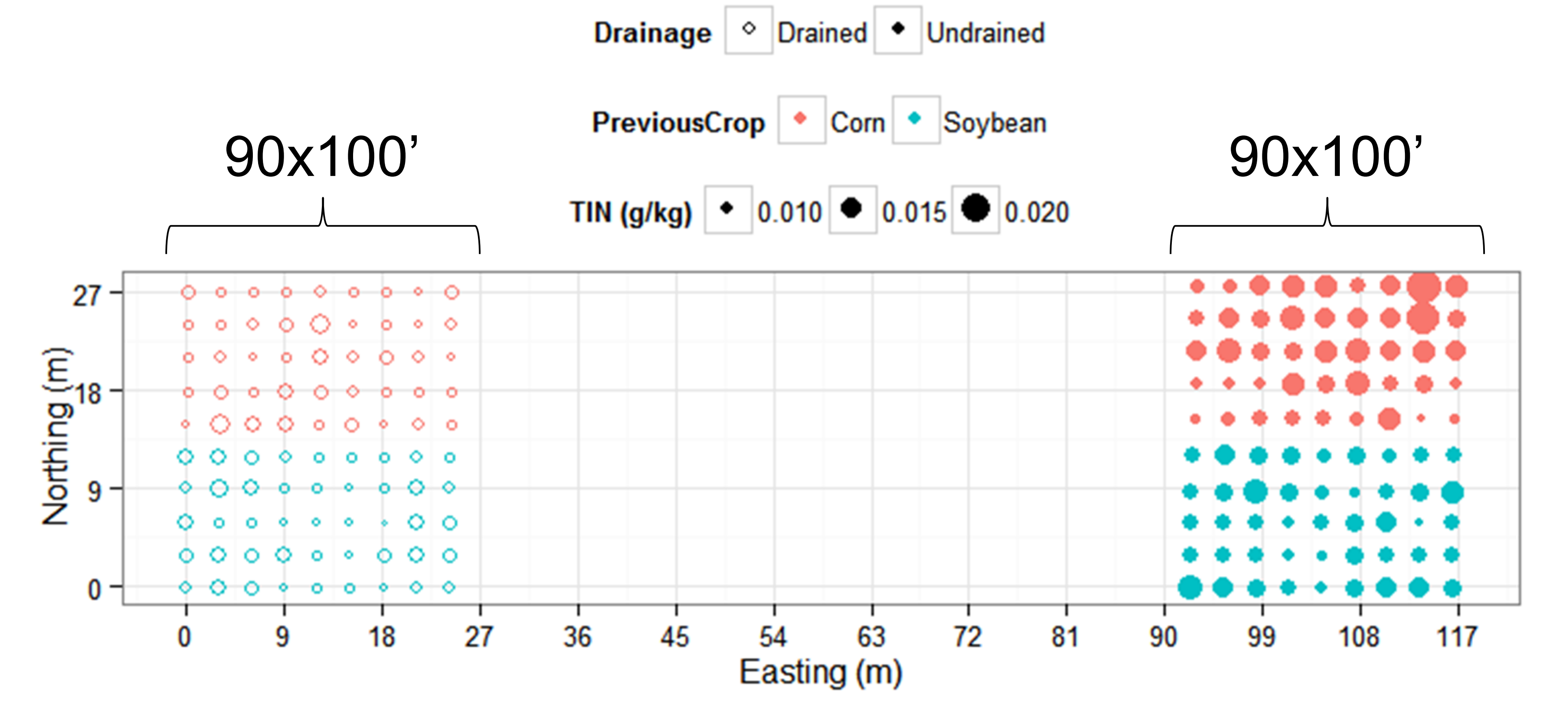
Adding N in D increase Nmin	Yes
Adding N in UD decrease Nmin	Yes
Soybean less Nmin than corn	Yes
D greater Nmin than UD	Yes for fert. trt only

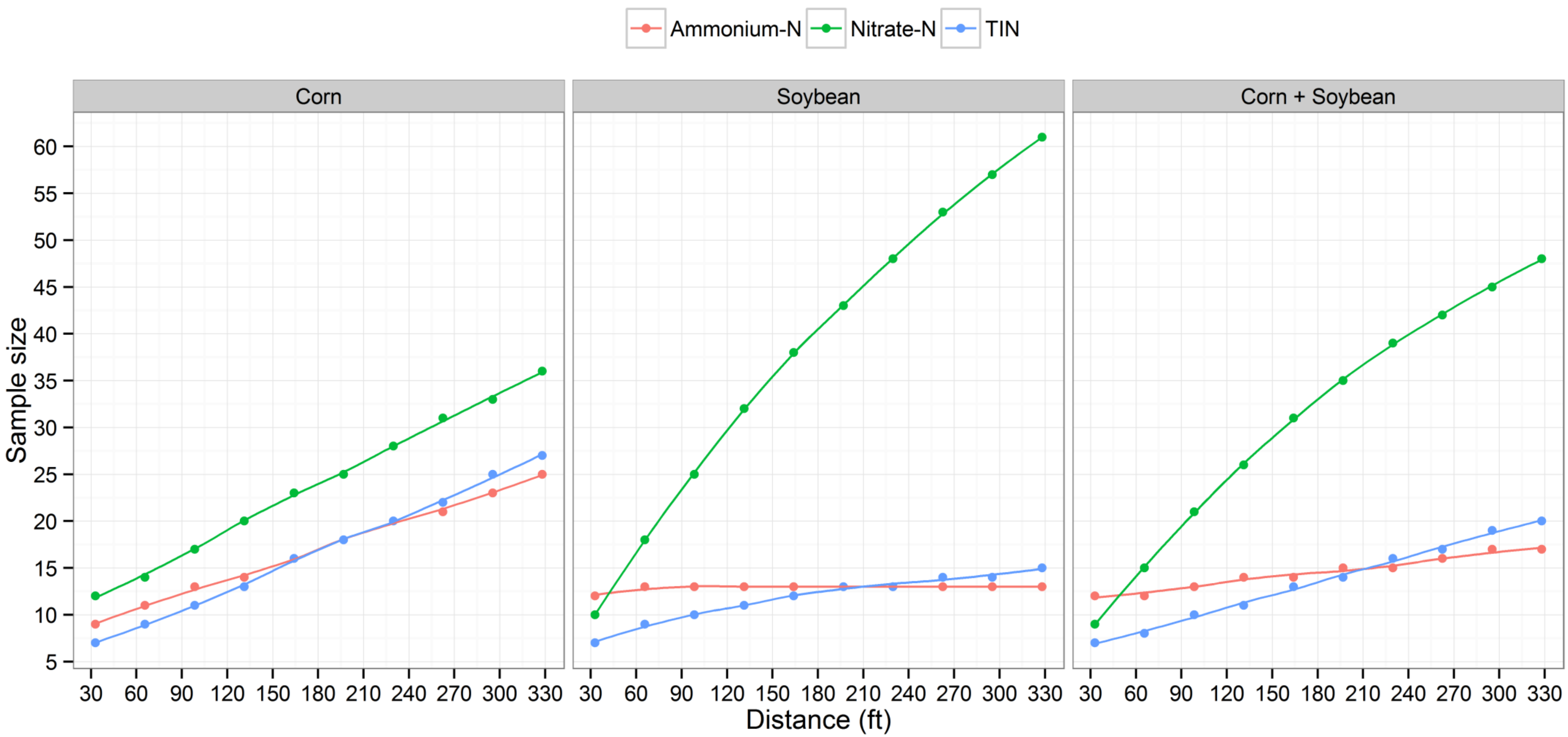


400 samples
0-12” deep
Every 6” distance
½ acre linear transect

TIN Spatial Variability

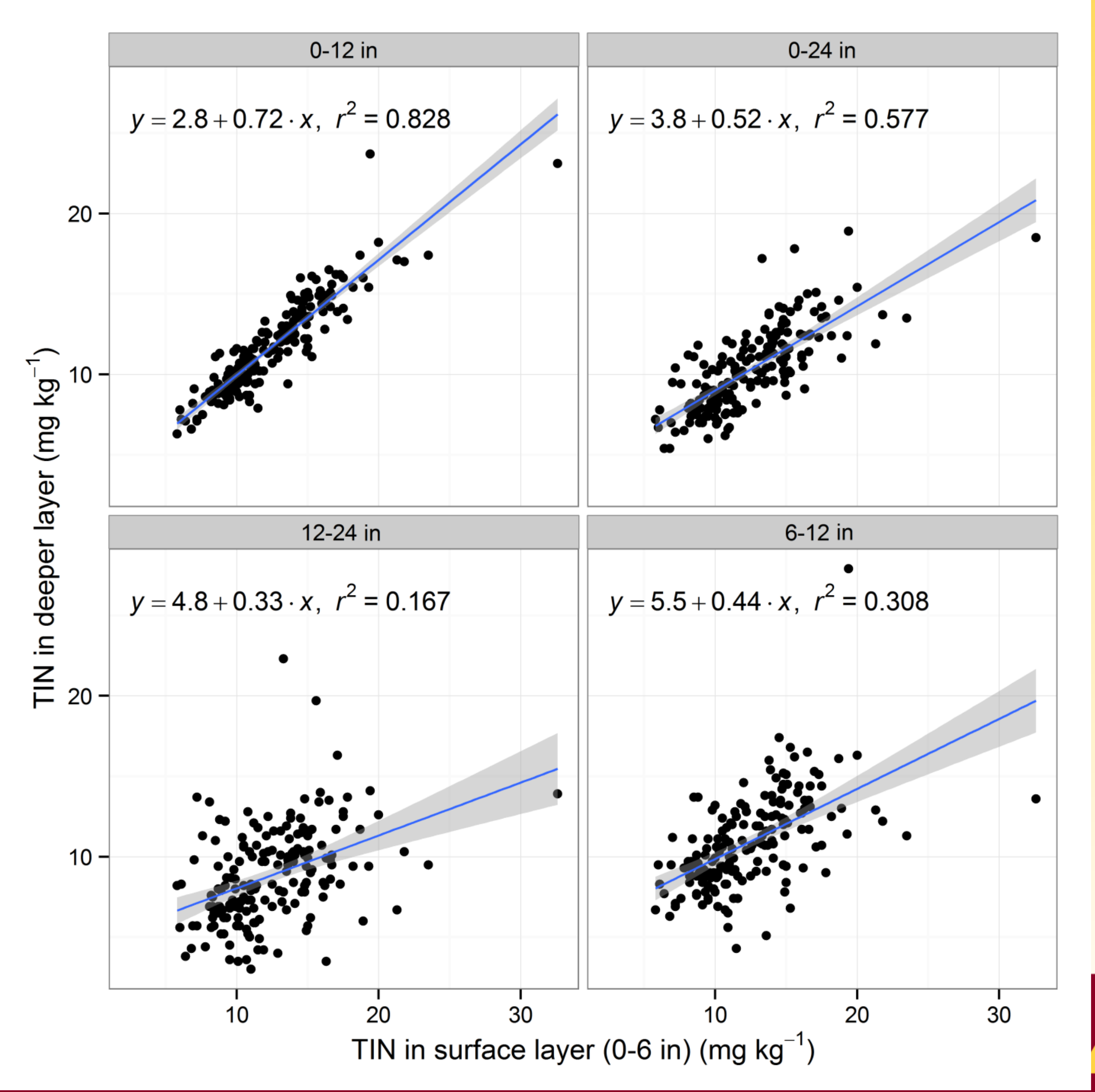
180 samples (0-6”, 6-12”, 12-24”)
10-core composite
Each dot is a 10x10’ area





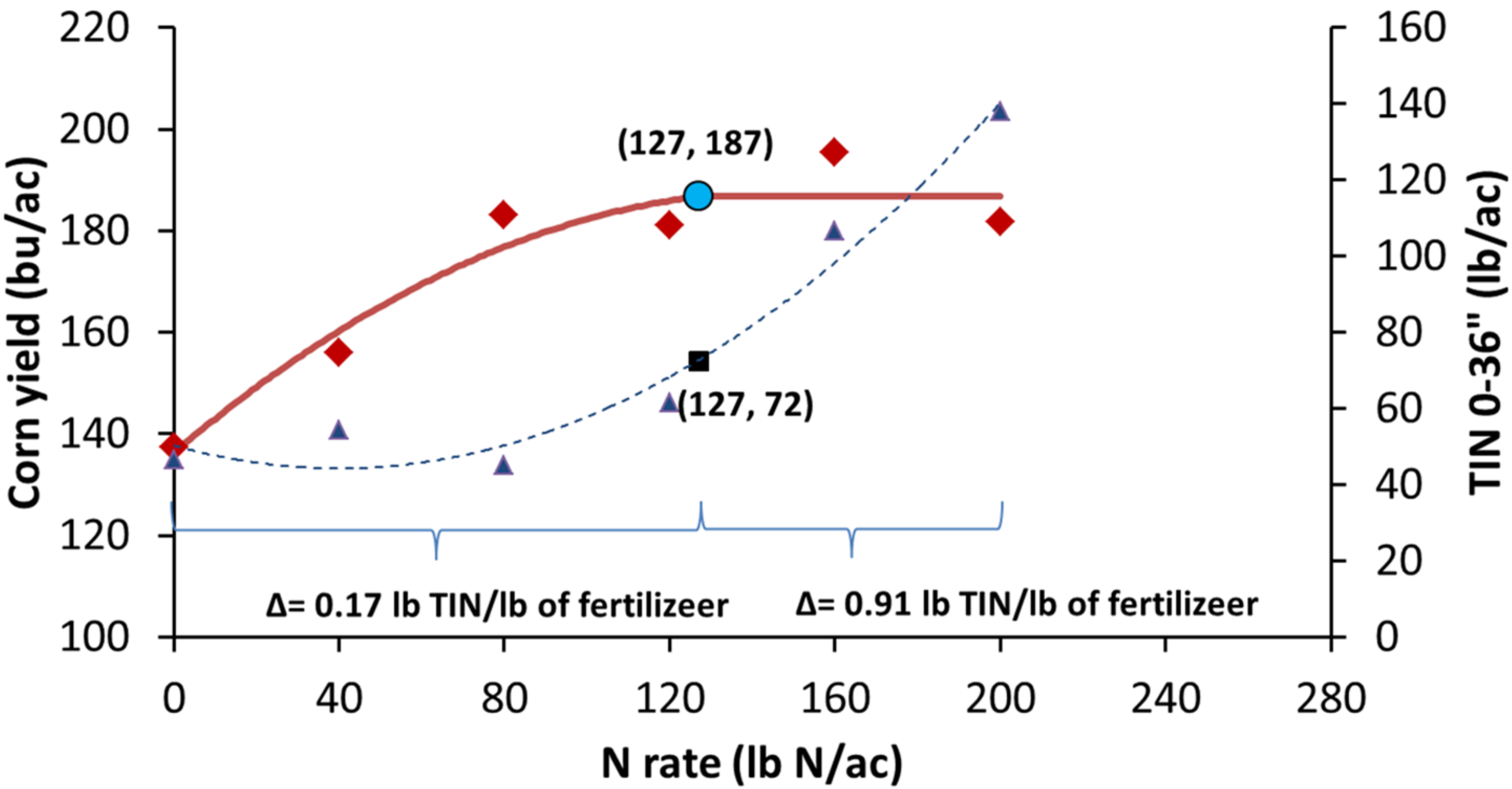
Overall, 20 samples per 2.5 acres are needed to achieve a TIN estimate with 10% error margin at 0.05 significance level

Can a shallow sample estimate a deeper sample?

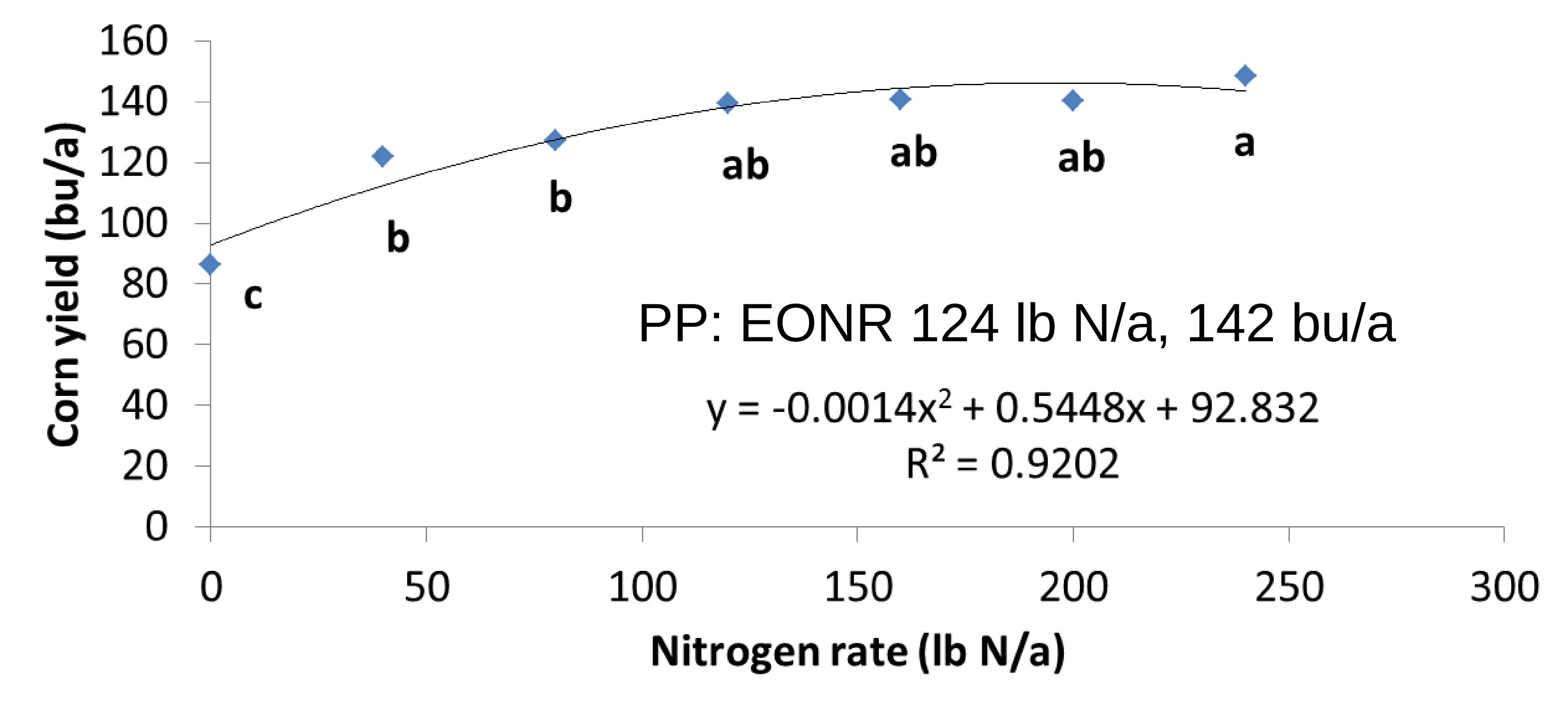


0-6” soil samples can be good predictors of 0-12” soils, but the predicting power for 6-12”, 12-24”, and 0-24” soils is limited

End of Season Soil N

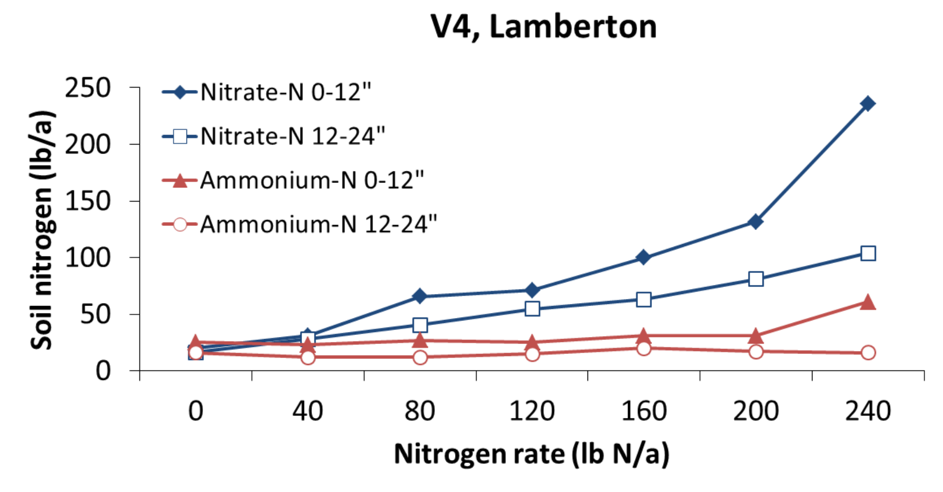


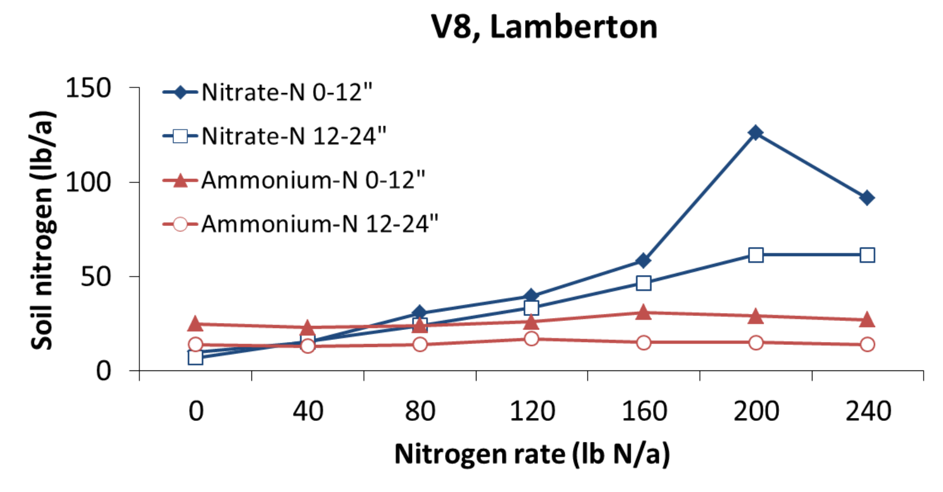
Lamberton, Yield



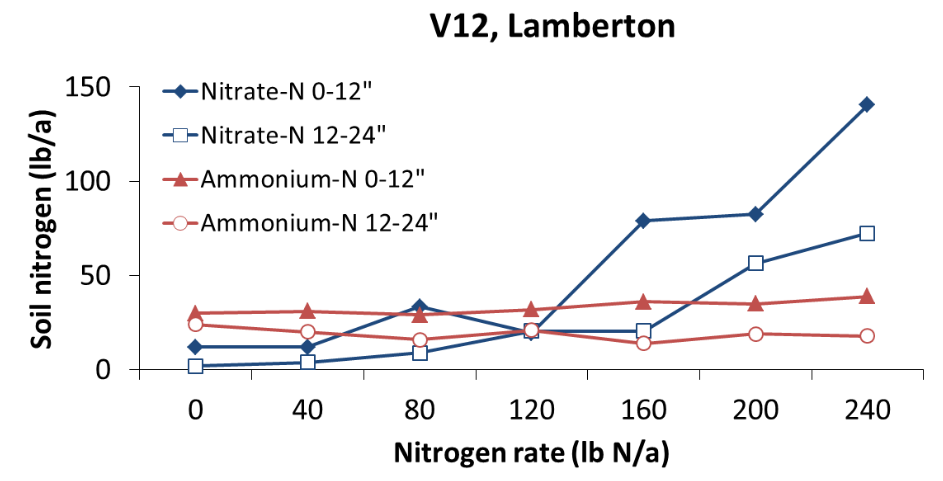
Ves loam soil

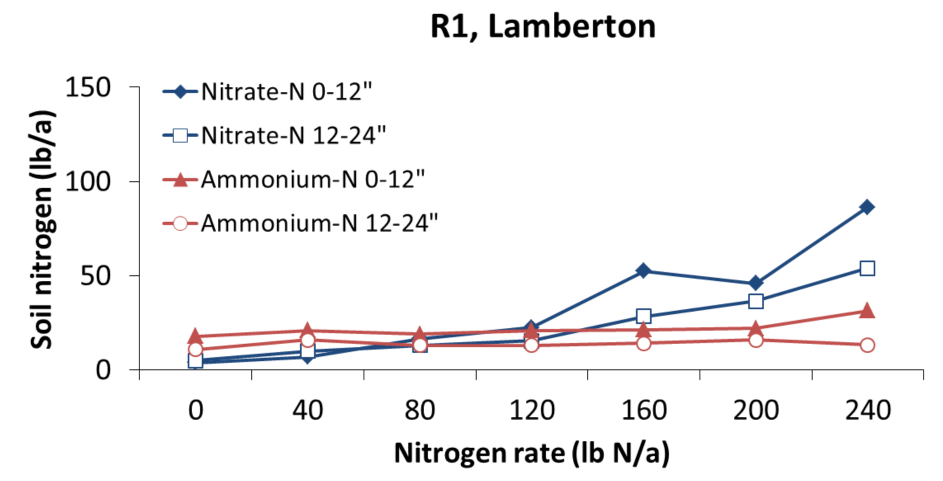
Soil N with Pre-plant Applications





Soil with 4% OM, CEC 24 meq/100g





Ves loam soil

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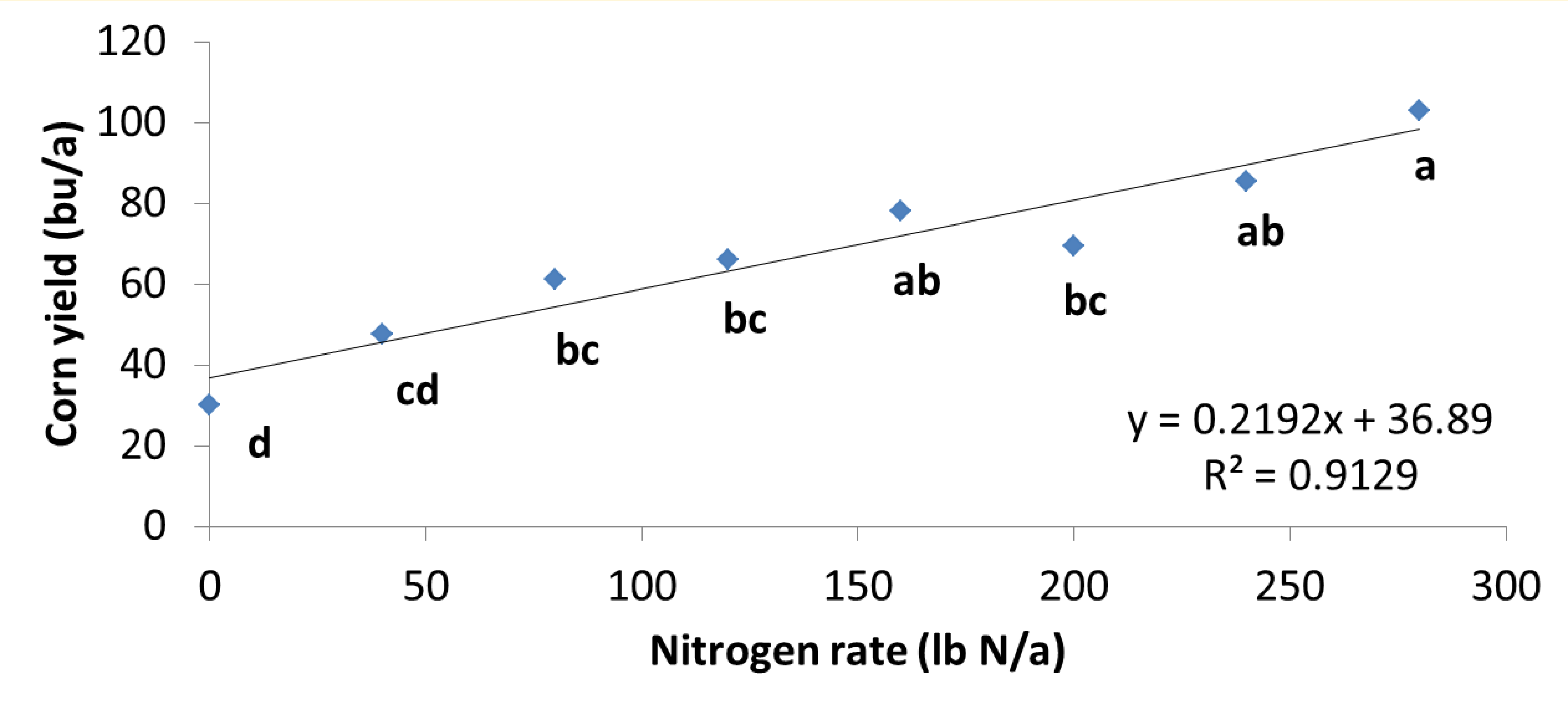
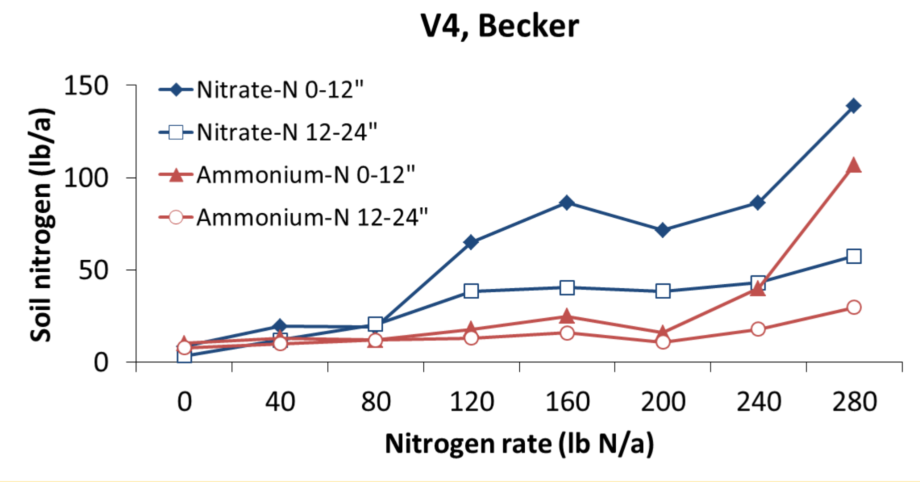
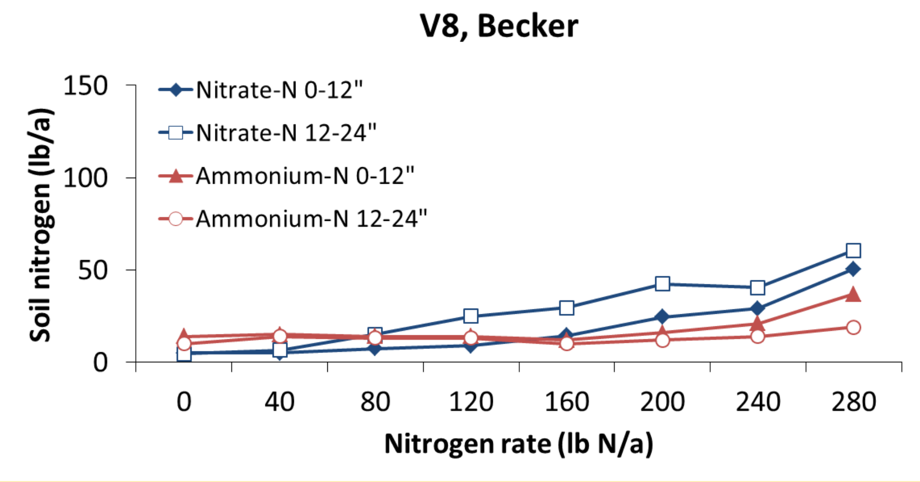
Becker, Yield



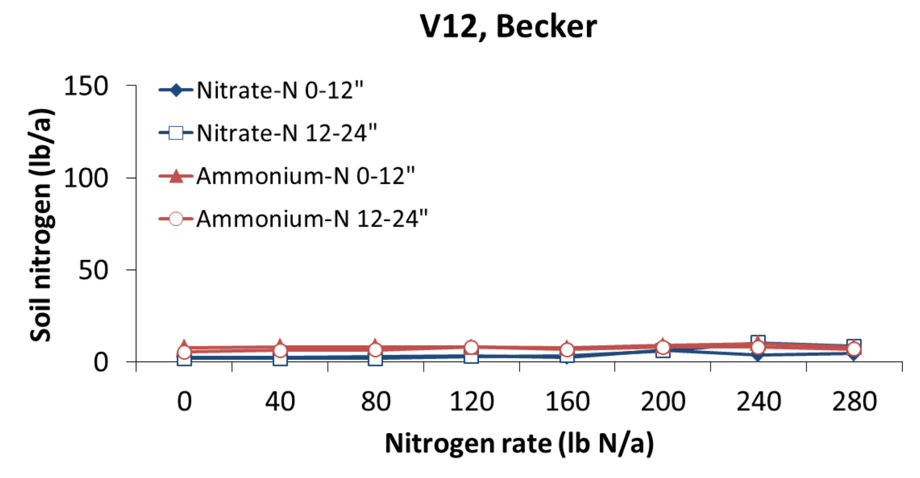
Hubbard loamy sand

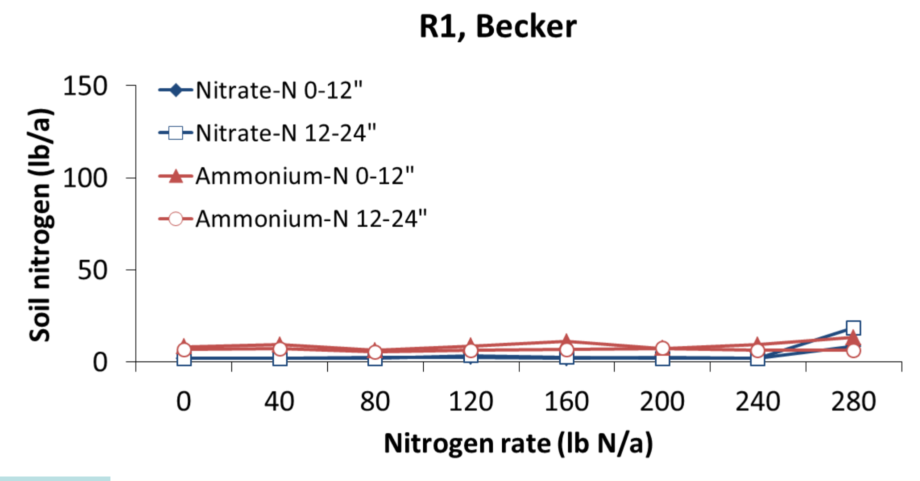
Soil N with Pre-plant Applications





Soil with 1.6% OM, CEC 8 meq/100g





Hubbard loamy sand

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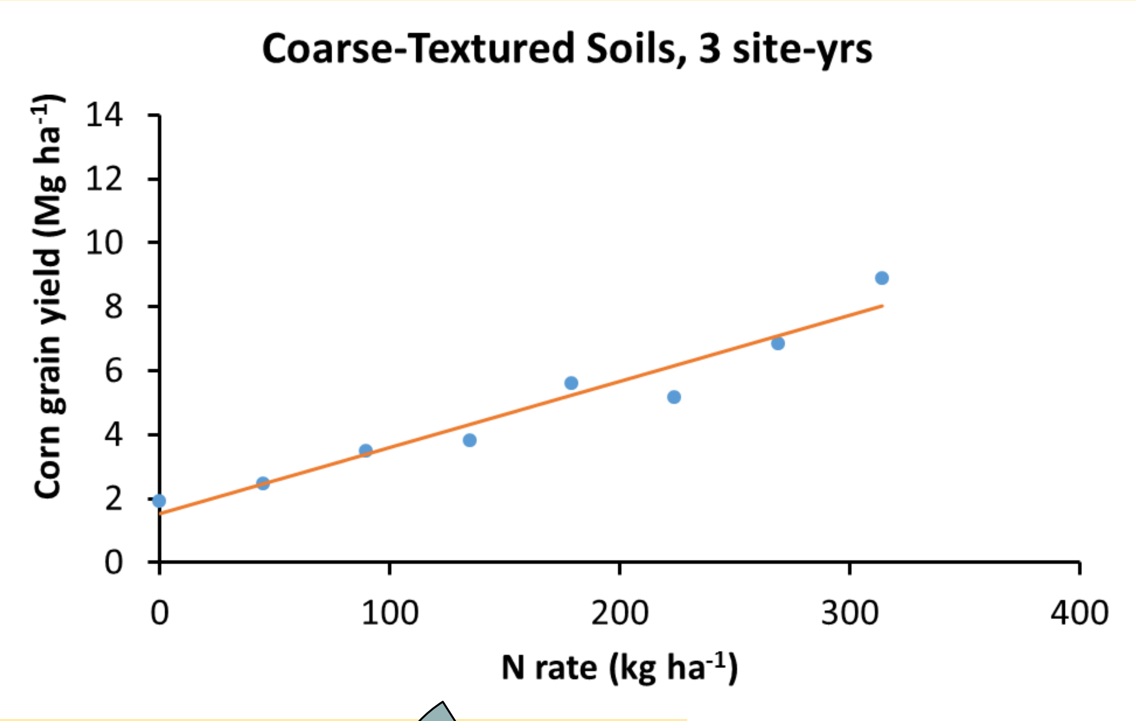
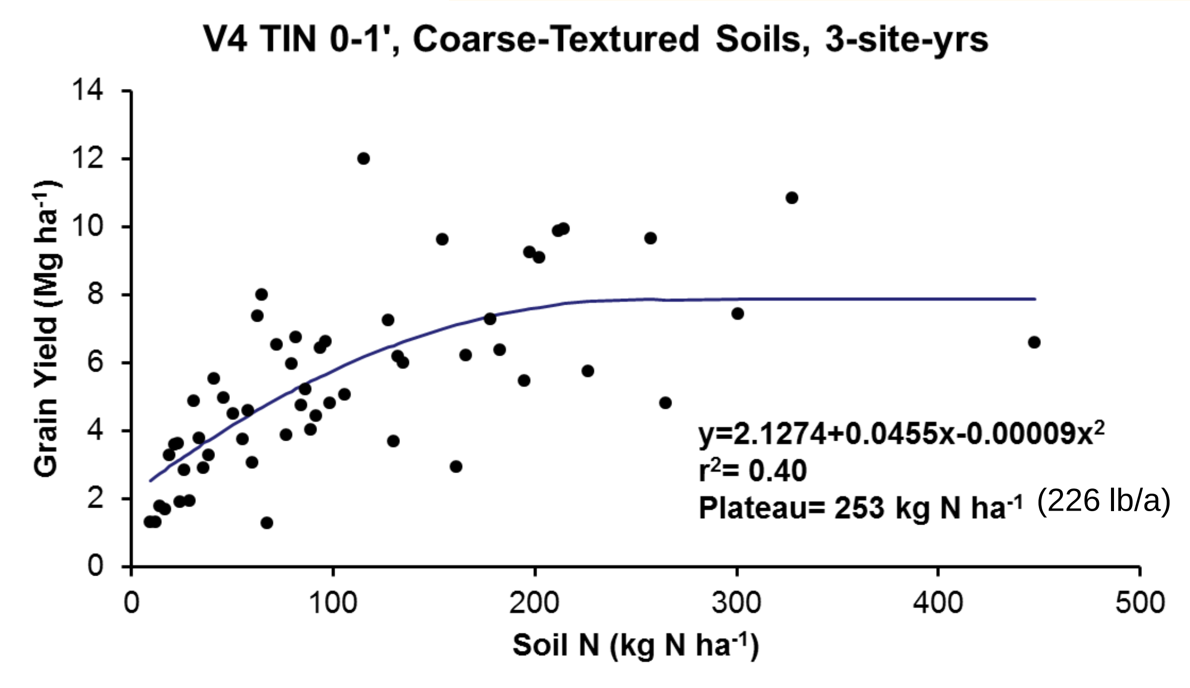
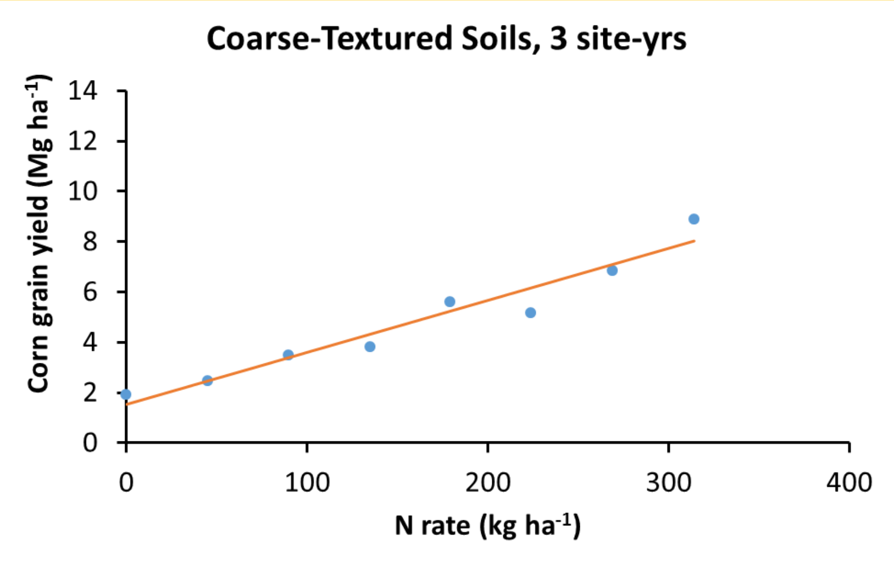


Coarse-Textured Soils, 3 site-yrs
Corn grain yield (Mg ha-1)
N rate (kg ha-1)
0
2
4
6
8
10
12
14
0
100
200
300
400

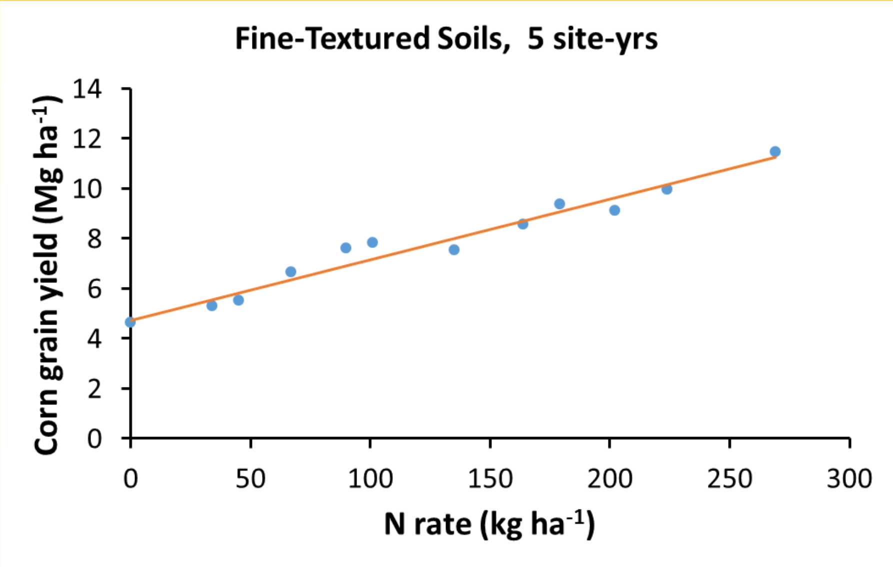


V4 TIN 0-1', Coarse-Textured Soils, 3-site-yrs
Grain Yield (Mg ha-1)
Soil N (kg N ha-1)
y=2.1274+0.0455x-0.00009x2
r2= 0.40
Plateau= 253 kg N ha-1 (226 lb/a)
0
2
4
6
8
10
12
14
0
100
200
300
400
500

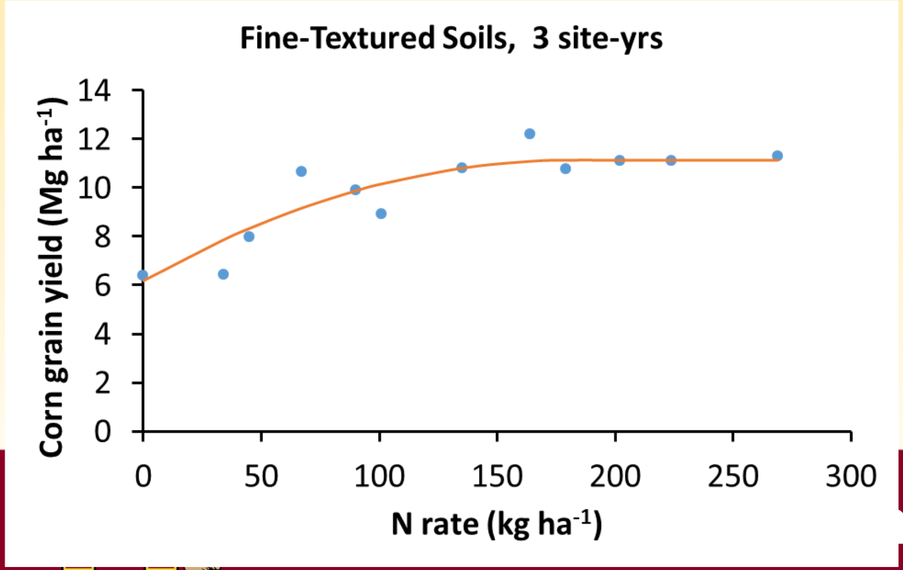
Becker 2014; 2015a,b



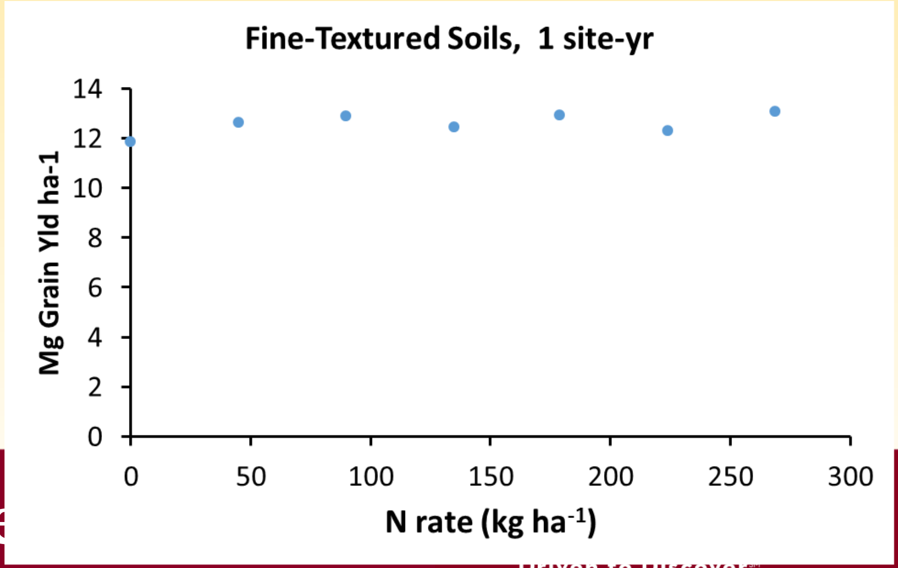
Clara City 2014; Waseca 2014 a,b; Waseca 2015 a,b



Clara City 2015; Lamberton 2014; Theilman 2014



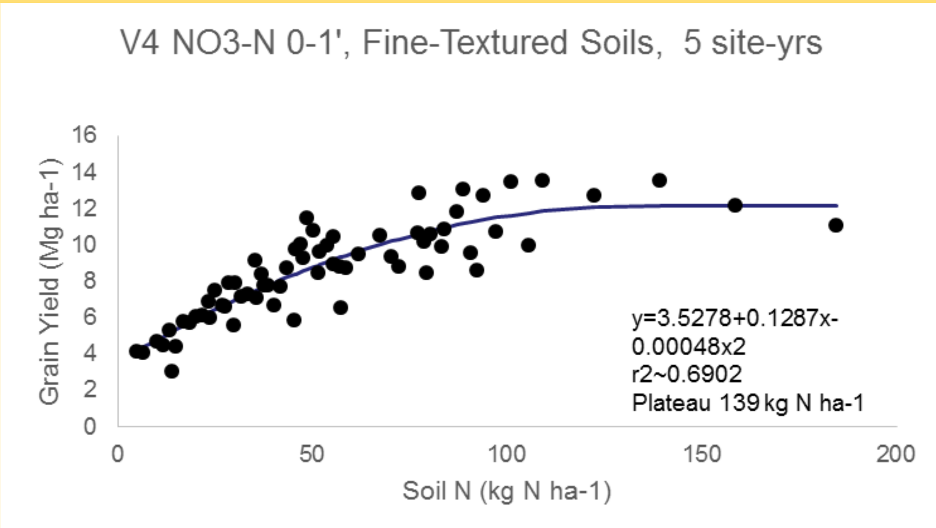
Lamberton 2014

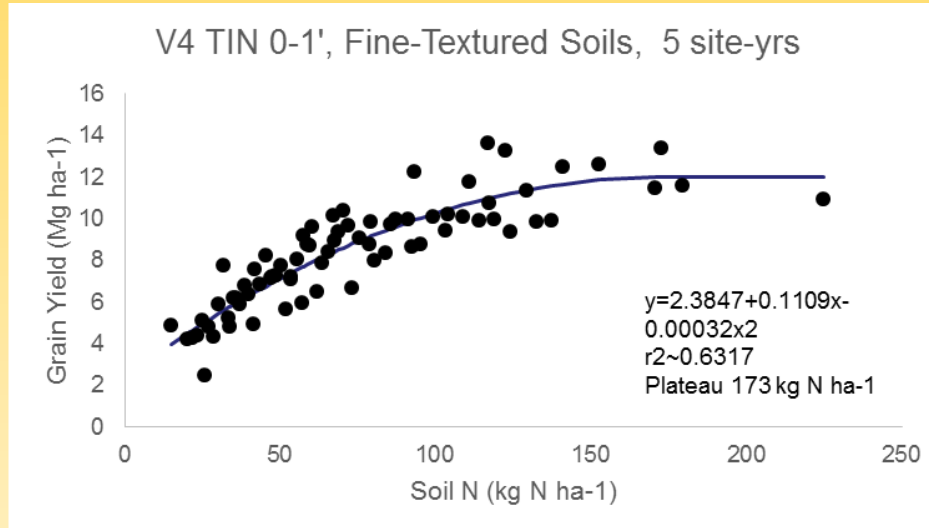


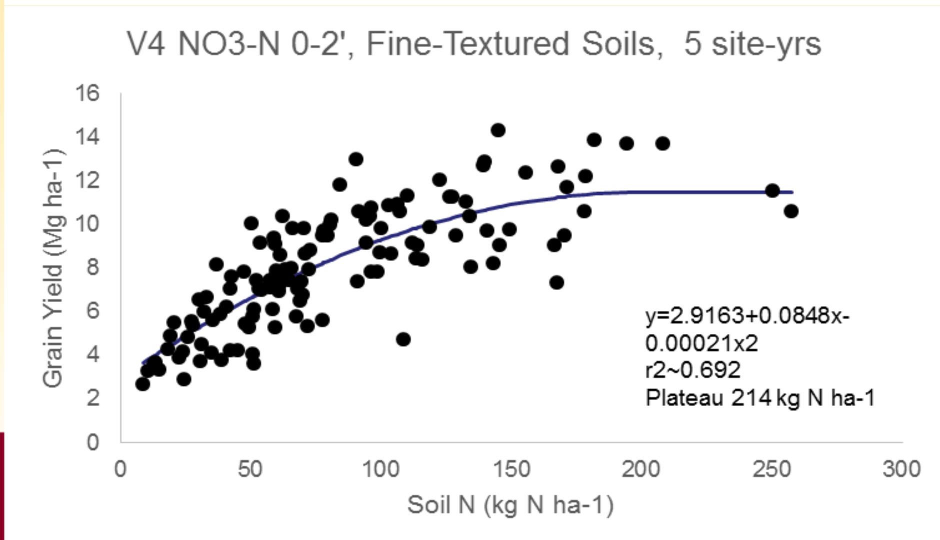
V4

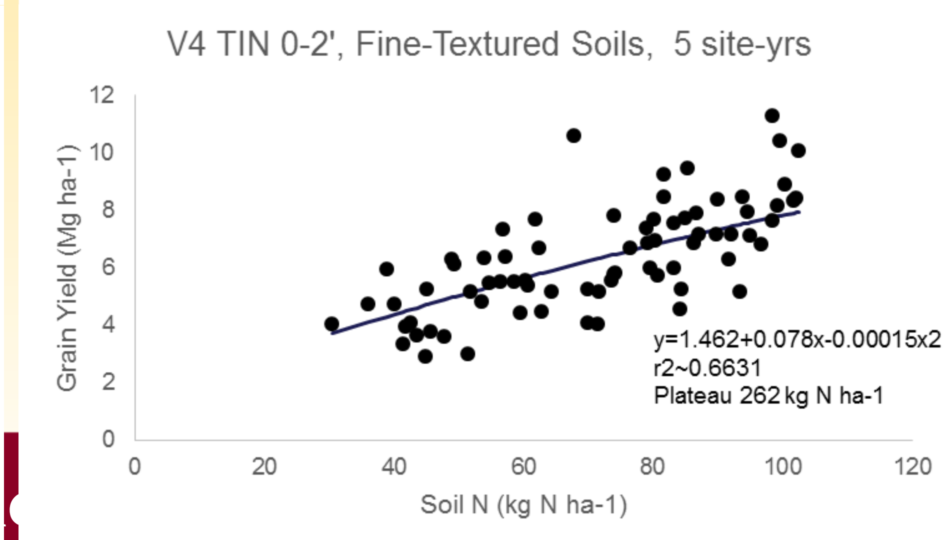
Nitrate

TIN





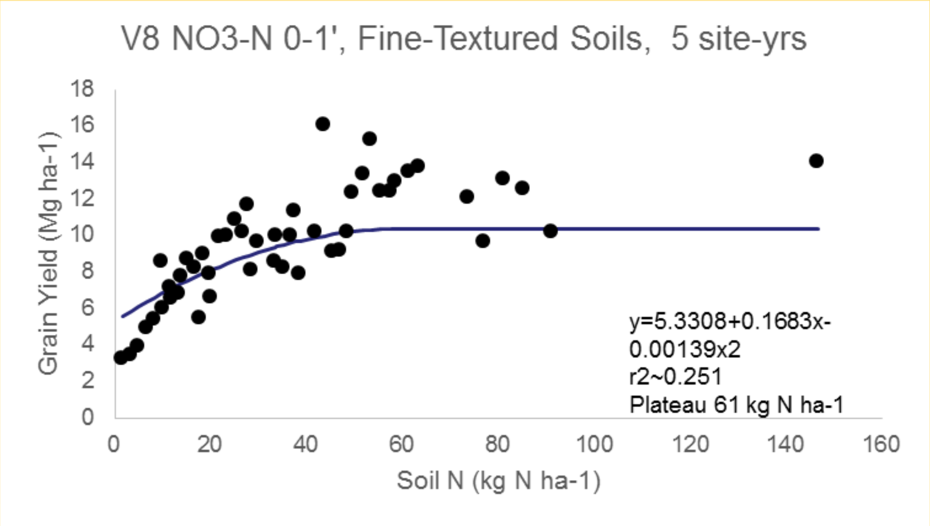


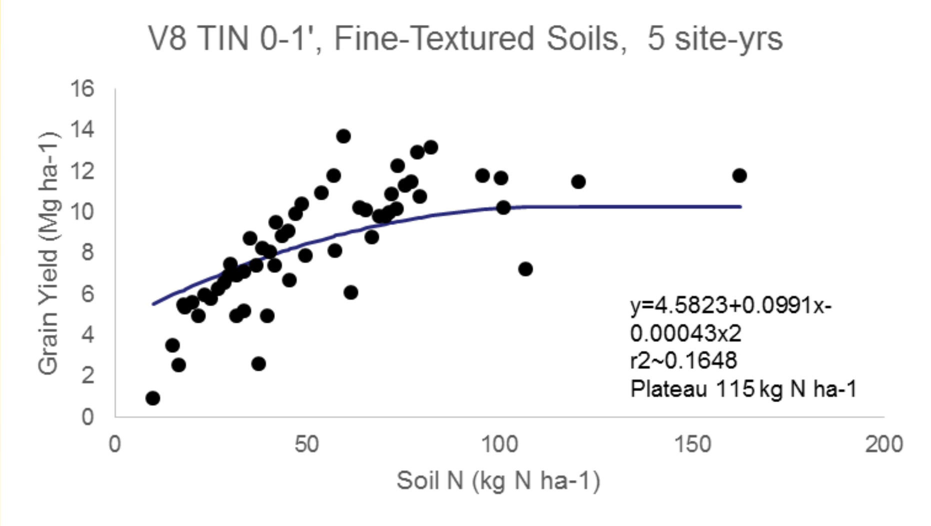


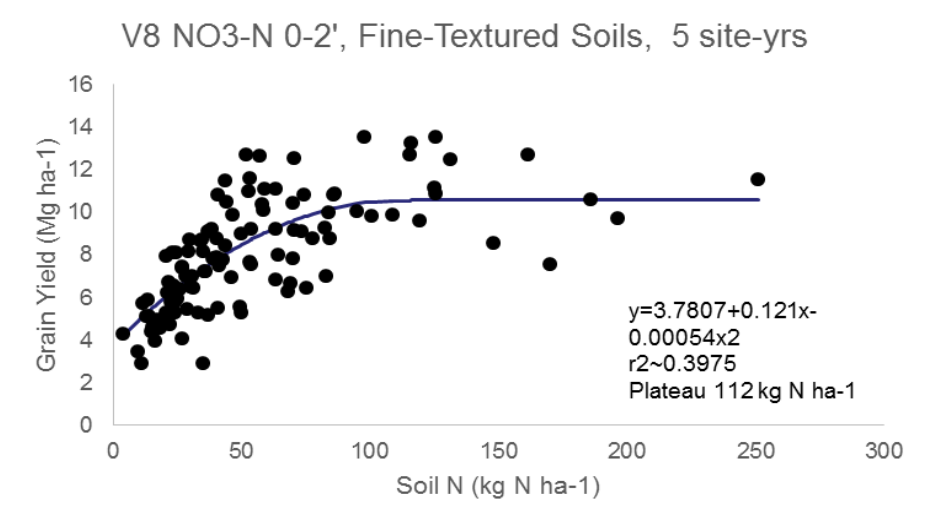
V8

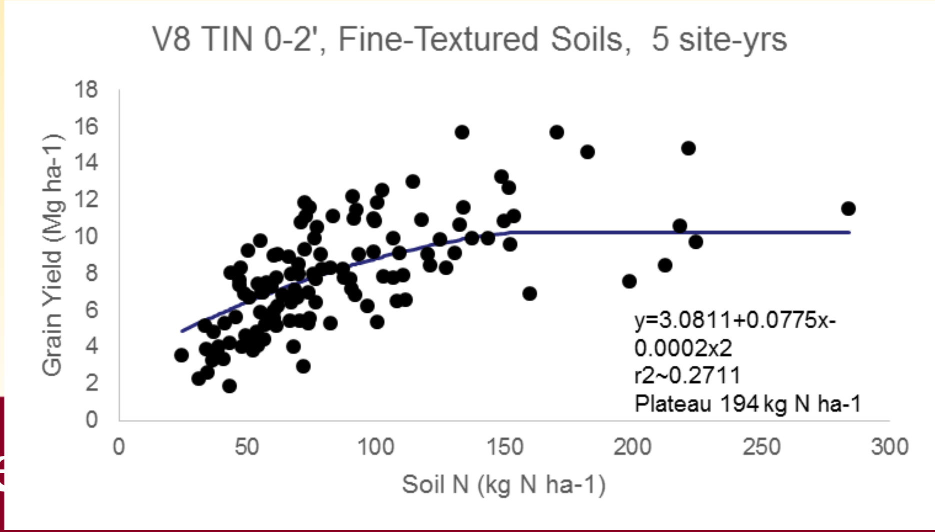
Nitrate

TIN







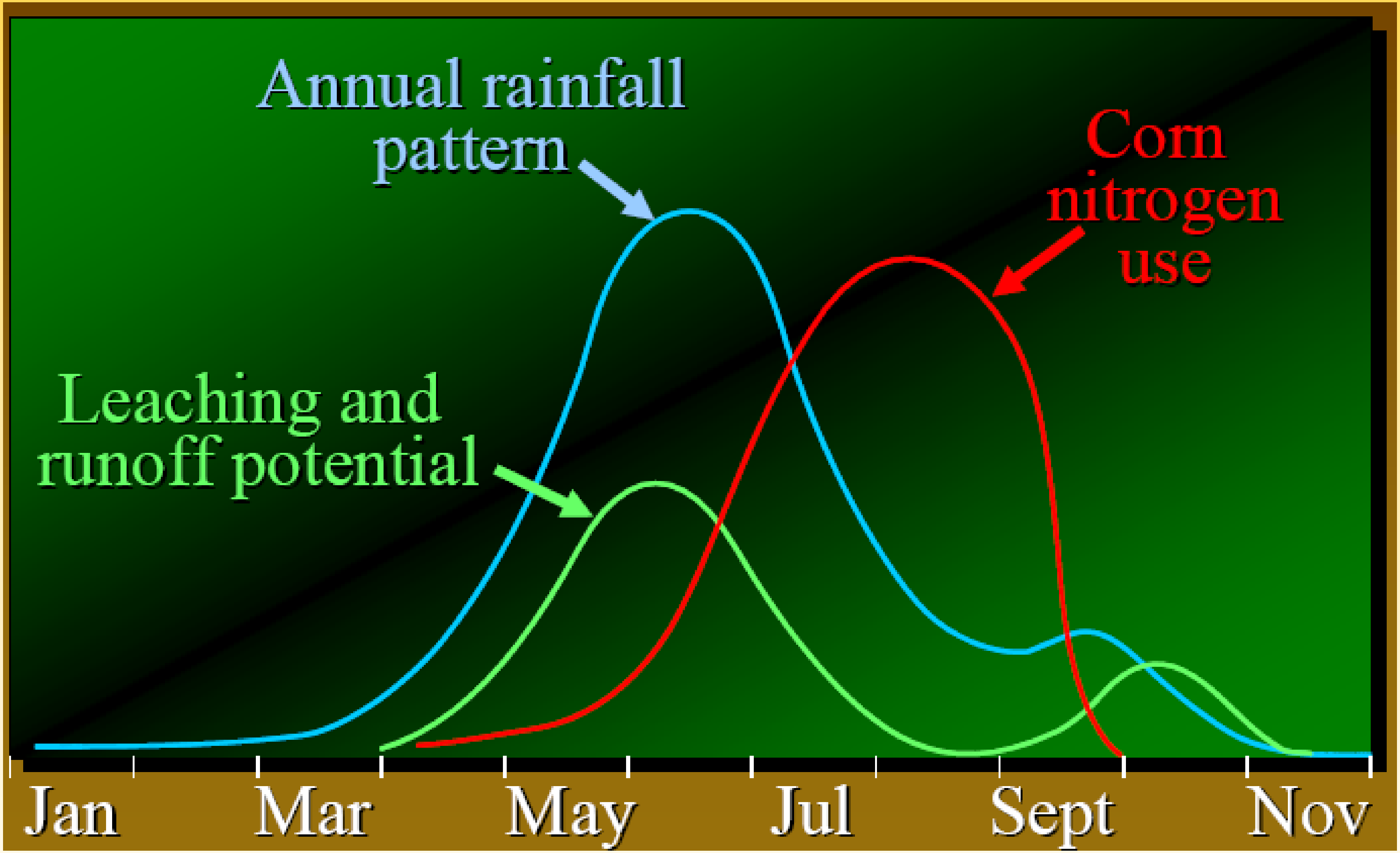


V4 soil N (lb ac^{-1}) corn yield prediction

Soil	Grouping	NO_3				TIN			
		0-1'		0-2'		0-1'		0-2'	
		R^2	Plateau	R^2	Plateau	R^2	Plateau	R^2	Plateau
Coarse-Textured	3 Site-yrs	0.31	113	0.38	269	0.40	226	0.36	---
Fine-Textured	5 Site-yrs	0.69	124	0.69	191	0.63	154	0.66	---
	3 Site-yrs	0.27	109	0.33	121	0.20	145	0.26	168
	1 Site-yrs	0.06	74	0.15	120	0.12	85	0.13	142

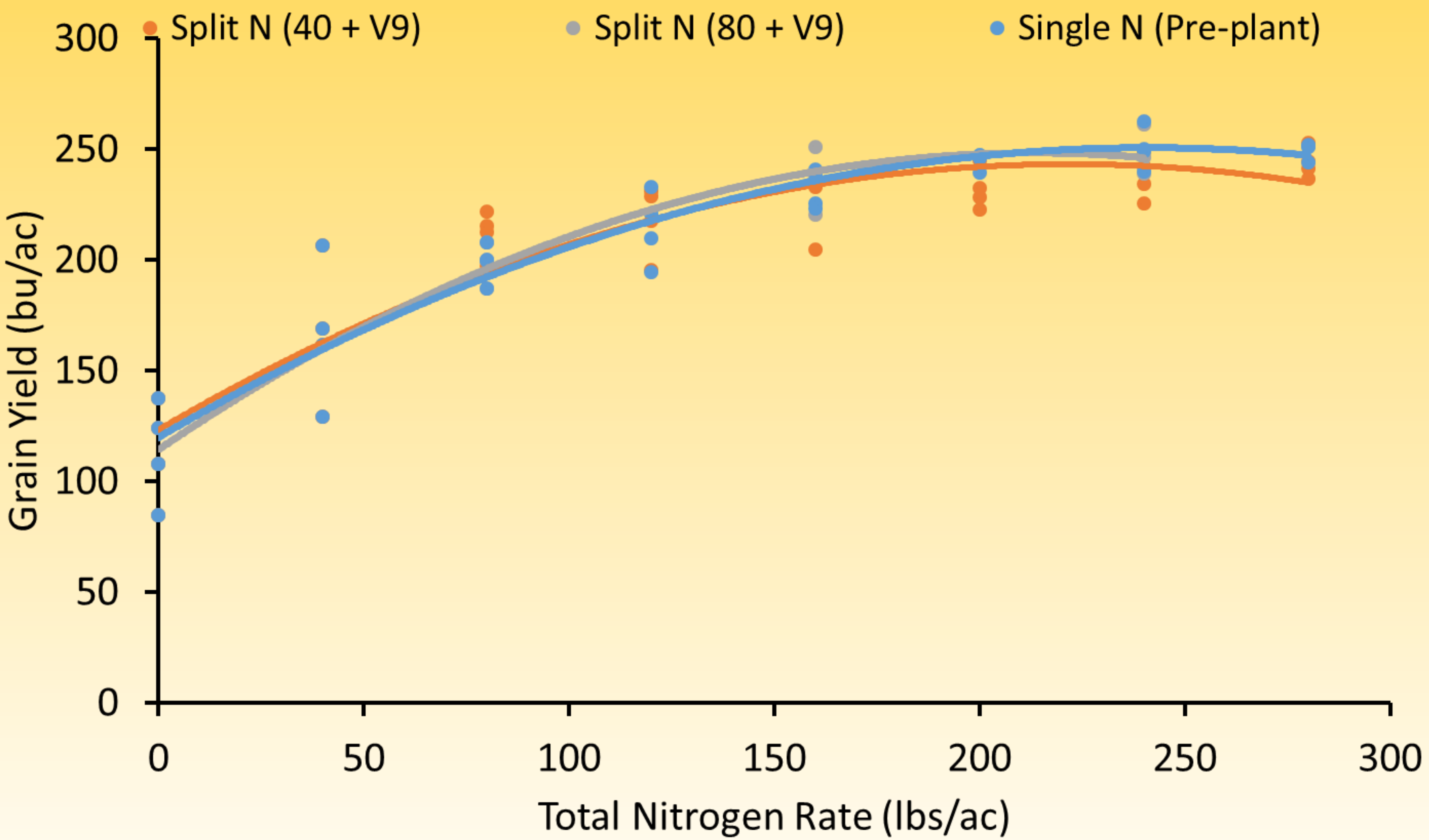
V8 soil N (lb ac^{-1}) corn yield prediction

Soil	Grouping	NO_3				TIN			
		0-1'		0-2'		0-1'		0-2'	
		R^2	Plateau	R^2	Plateau	R^2	Plateau	R^2	Plateau
Coarse-Textured	3 Site-yrs	0.32	58	0.42	---	0.30	119	0.40	---
Fine-Textured	5 Site-yrs	0.25	54	0.40	100	0.16	103	0.27	173
	3 Site-yrs	0.20	62	0.25	84	0.14	92	0.19	121
	1 Site-yrs	0.12	---	0.13	---	0.26	---	0.38	---

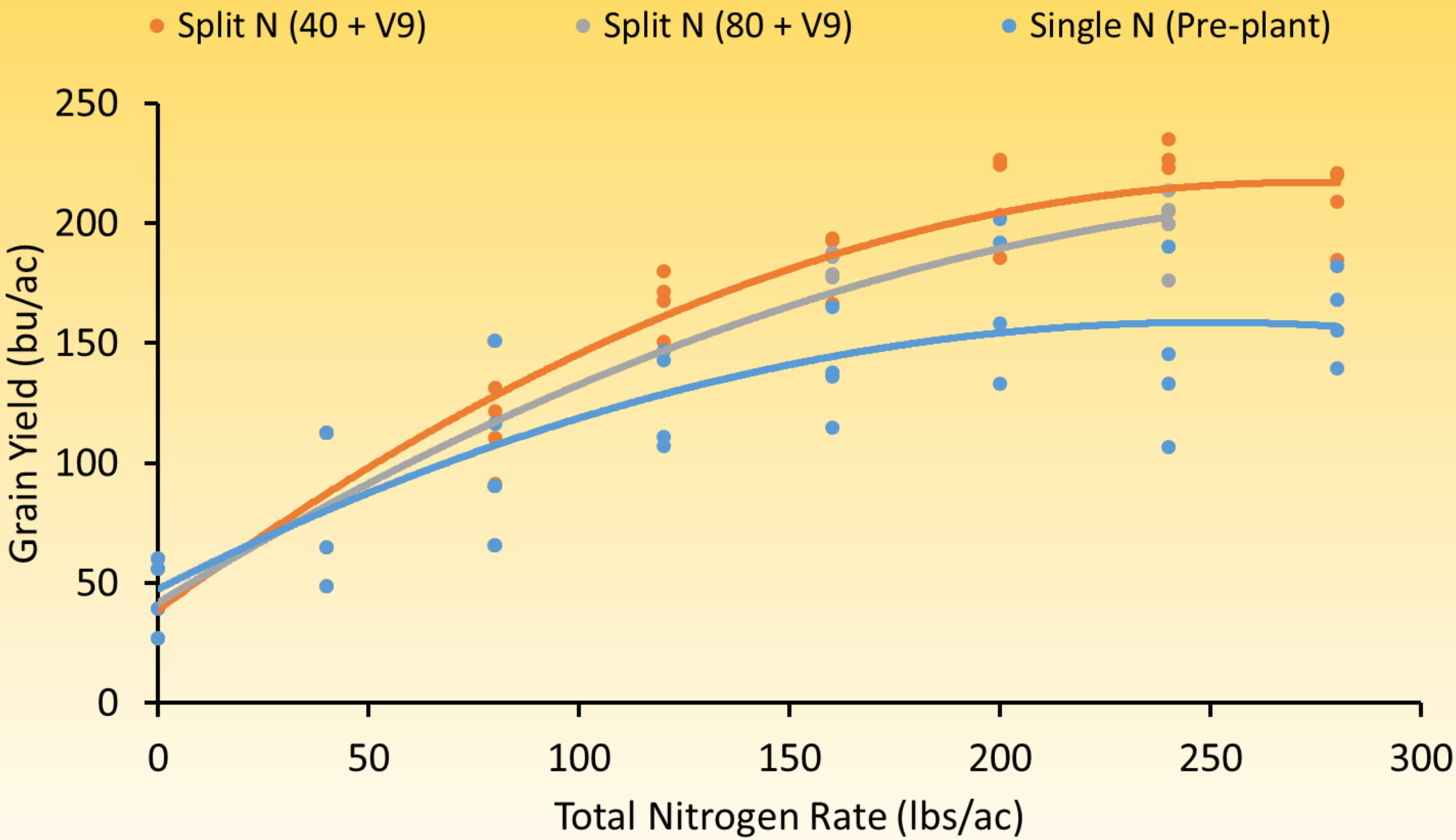


Annual rainfall pattern
Corn nitrogen use
Leaching and runoff potential
Jan
Mar
May
Jul
Sept
Nov

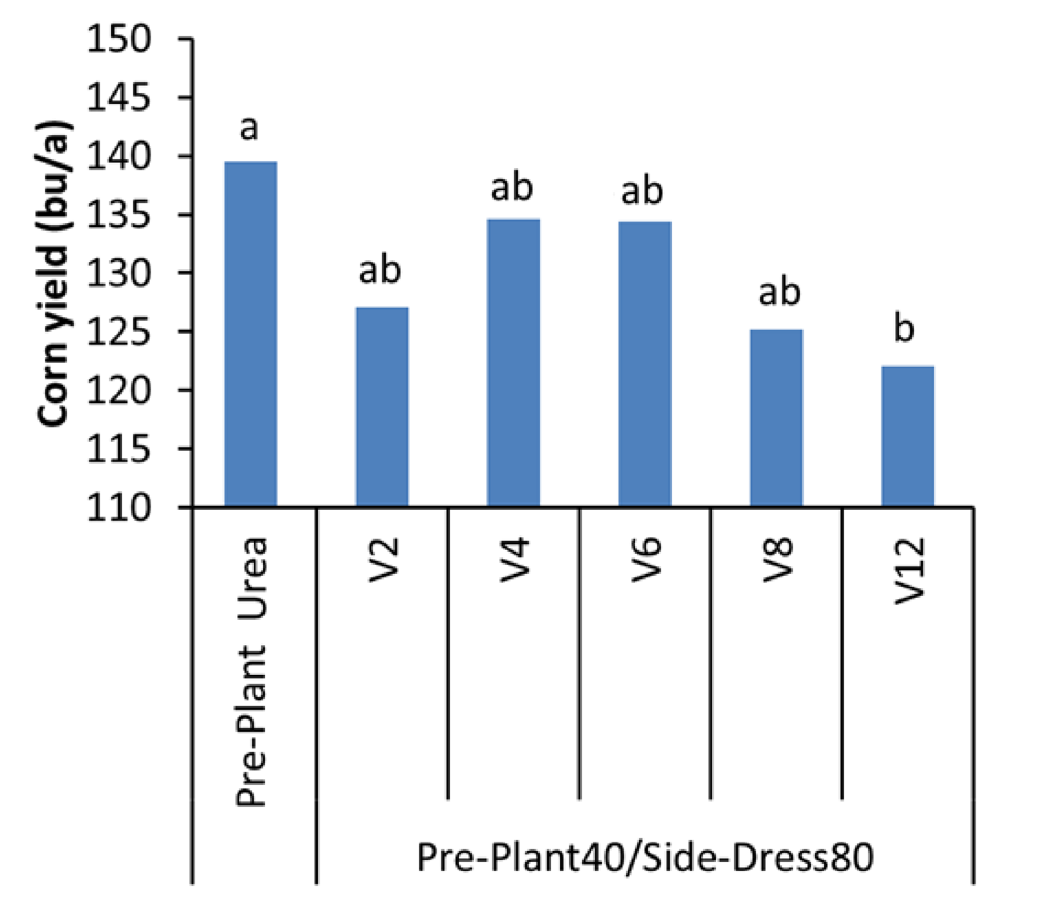
Waseca, MN; clay loam soil

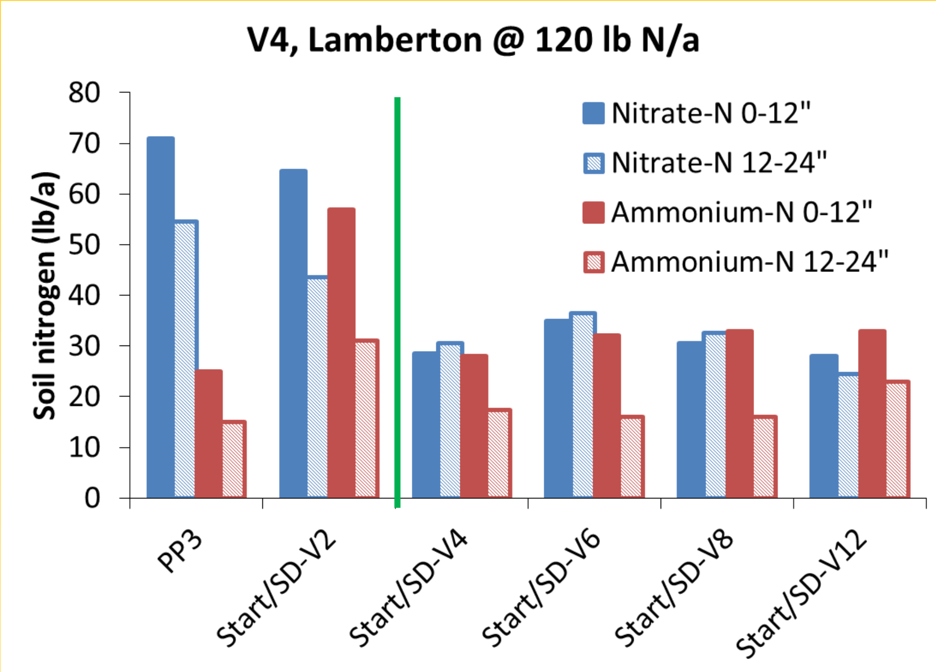


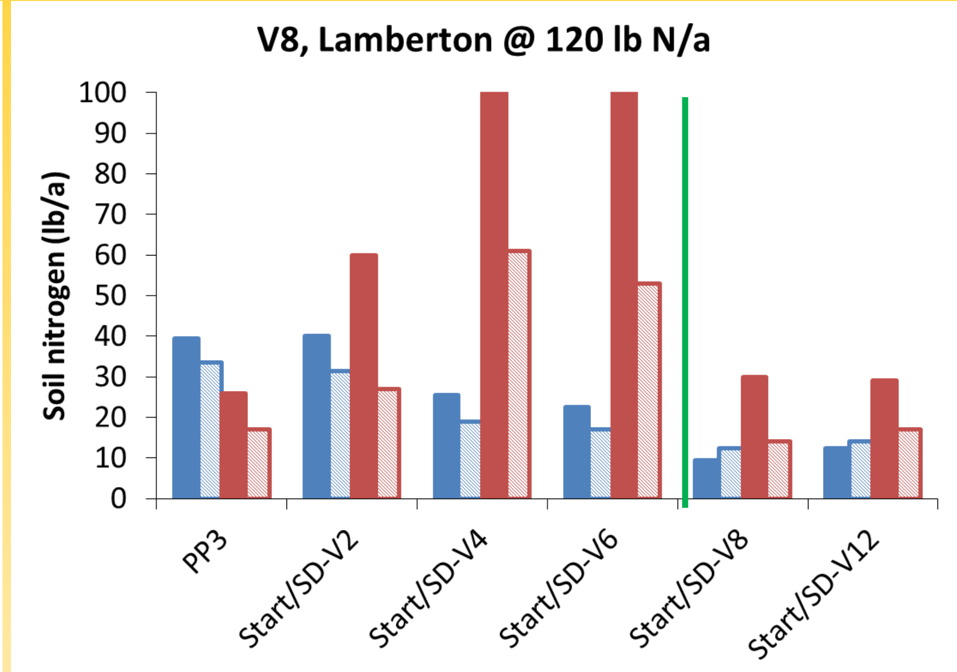
Becker, MN; sandy soil

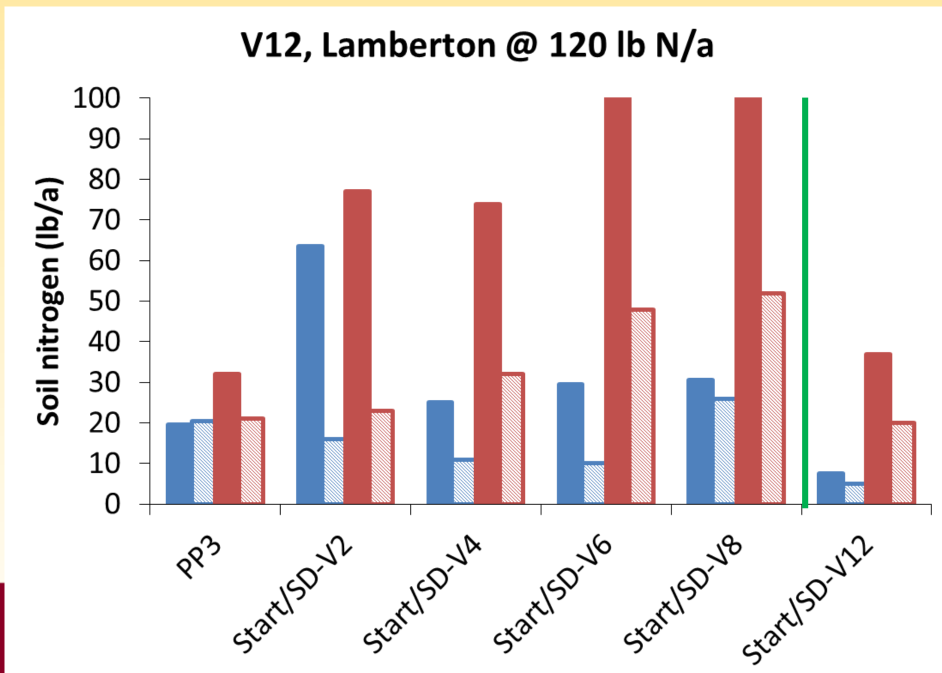


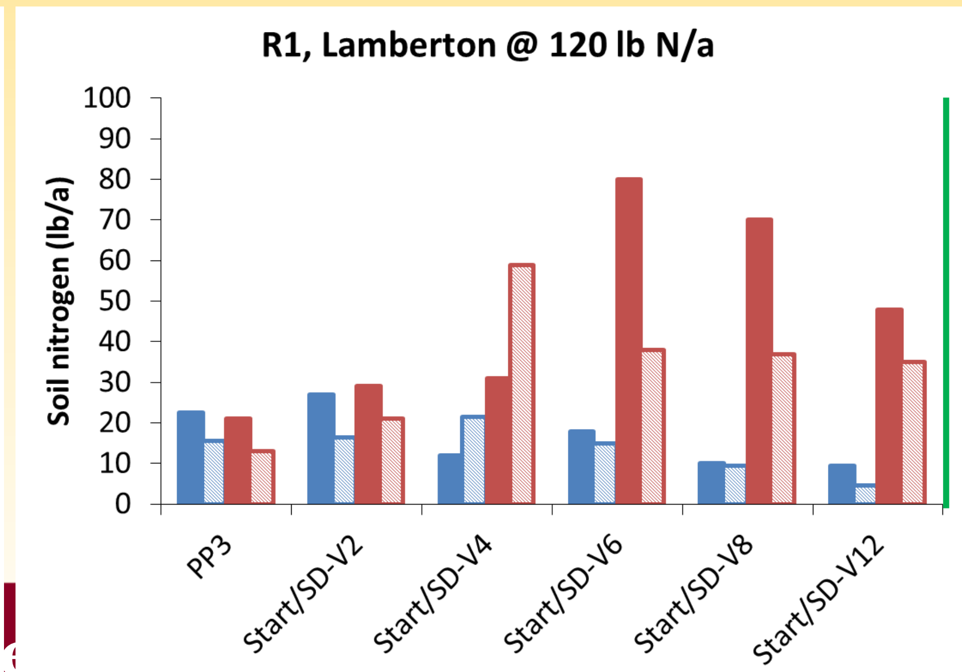
Lamberton, C-C at 120 lb N/a



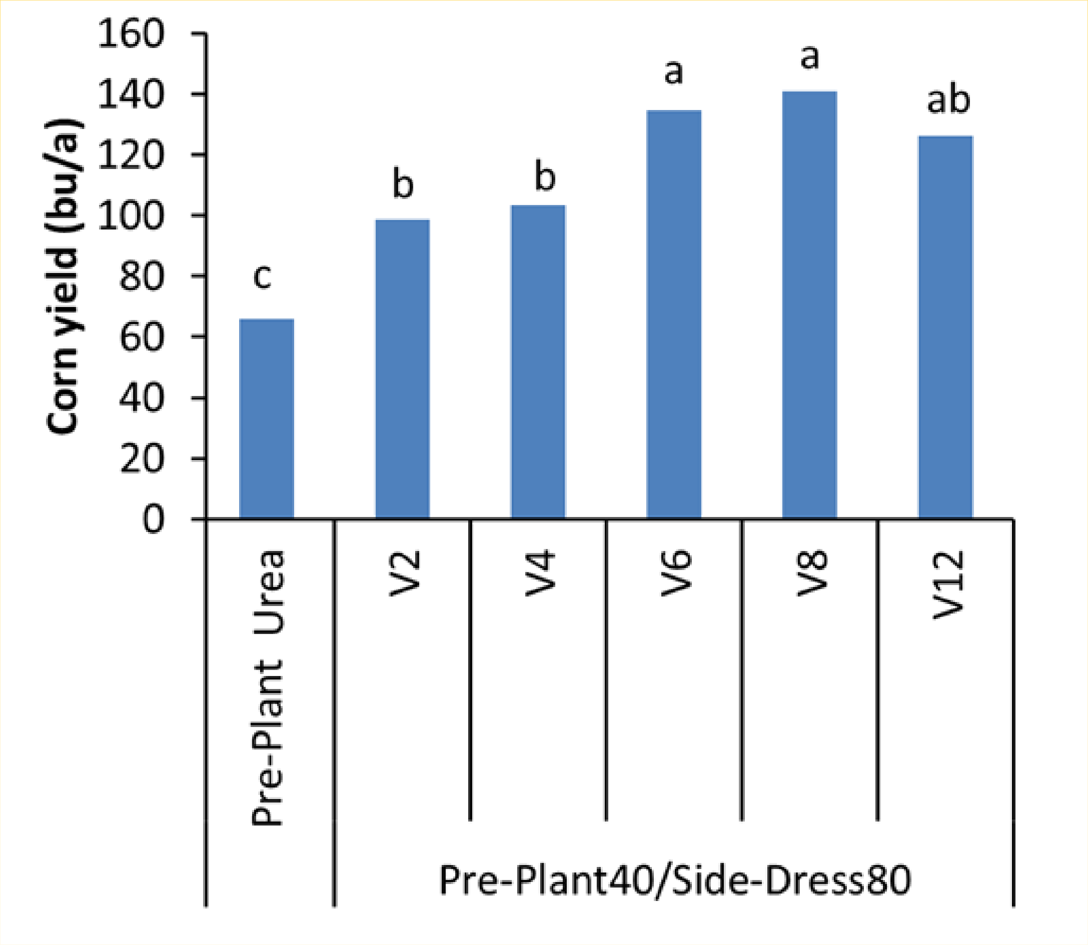

V4, Lamberton @ 120 lb N/a
Soil nitrogen (lb/a)
0
10
20
30
40
50
60
70
80
Nitrate-N 0-12"
Nitrate-N 12-24"
Ammonium-N 0-12"
Ammonium-N 12-24"
PP3
Start/SD-V2
Start/SD-V4
Start/SD-V6
Start/SD-V8
Start/SD-V12


V8, Lamberton @ 120 lb N/a
Soil nitrogen (lb/a)
0
10
20
30
40
50
60
70
80
90
100
PP3
Start/SD-V2
Start/SD-V4
Start/SD-V6
Start/SD-V8
Start/SD-V12


V12, Lamberton @ 120 lb N/a
Soil nitrogen (lb/a)
0
10
20
30
40
50
60
70
80
90
100
PP3
Start/SD-V2
Start/SD-V4
Start/SD-V6
Start/SD-V8
Start/SD-V12


R1, Lamberton @ 120 lb N/a
Soil nitrogen (lb/a)
0
10
20
30
40
50
60
70
80
90
100
PP3
Start/SD-V2
Start/SD-V4
Start/SD-V6
Start/SD-V8
Start/SD-V12

Becker, C-C at 120 lb N/a



Hubbard loamy sand

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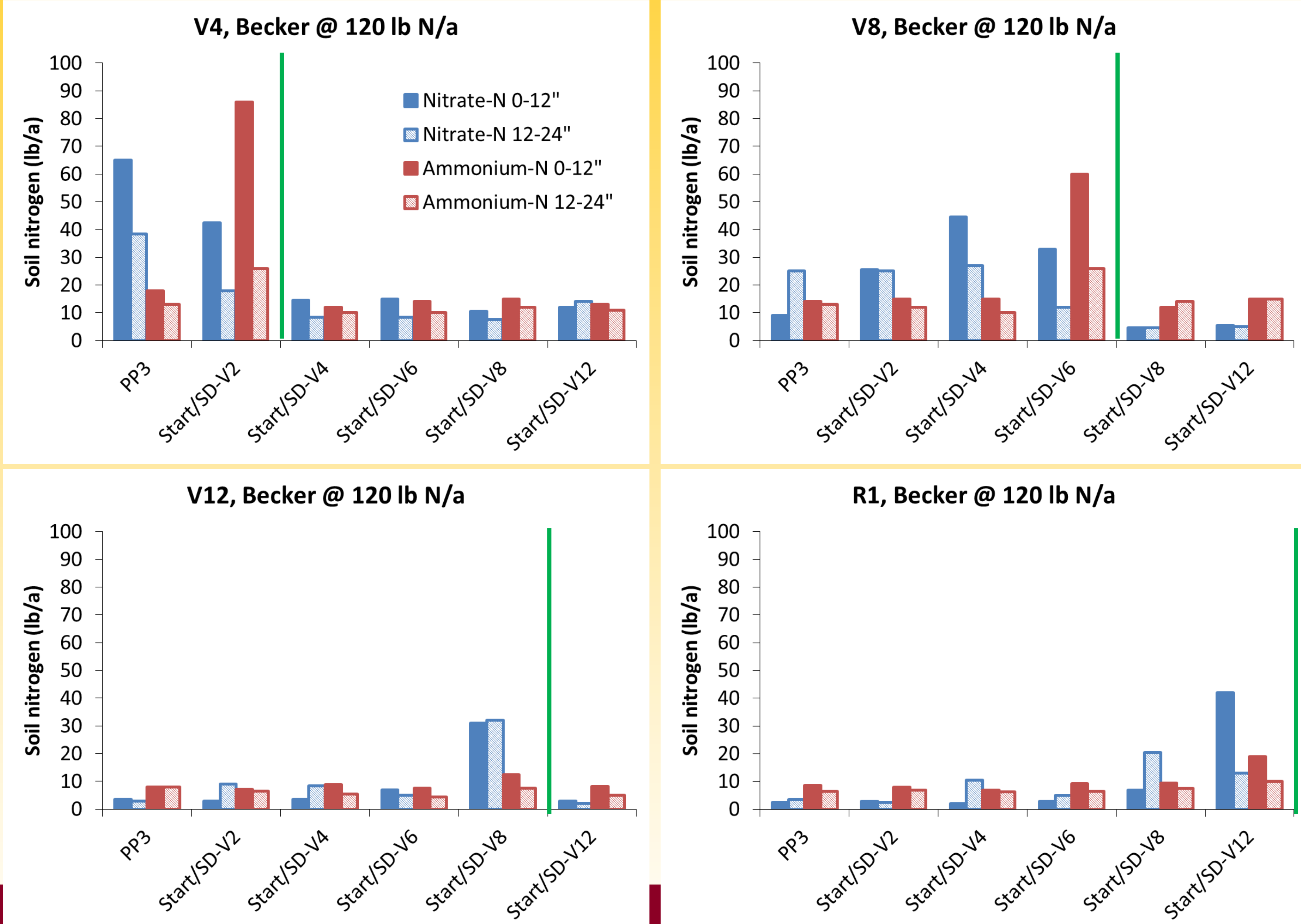
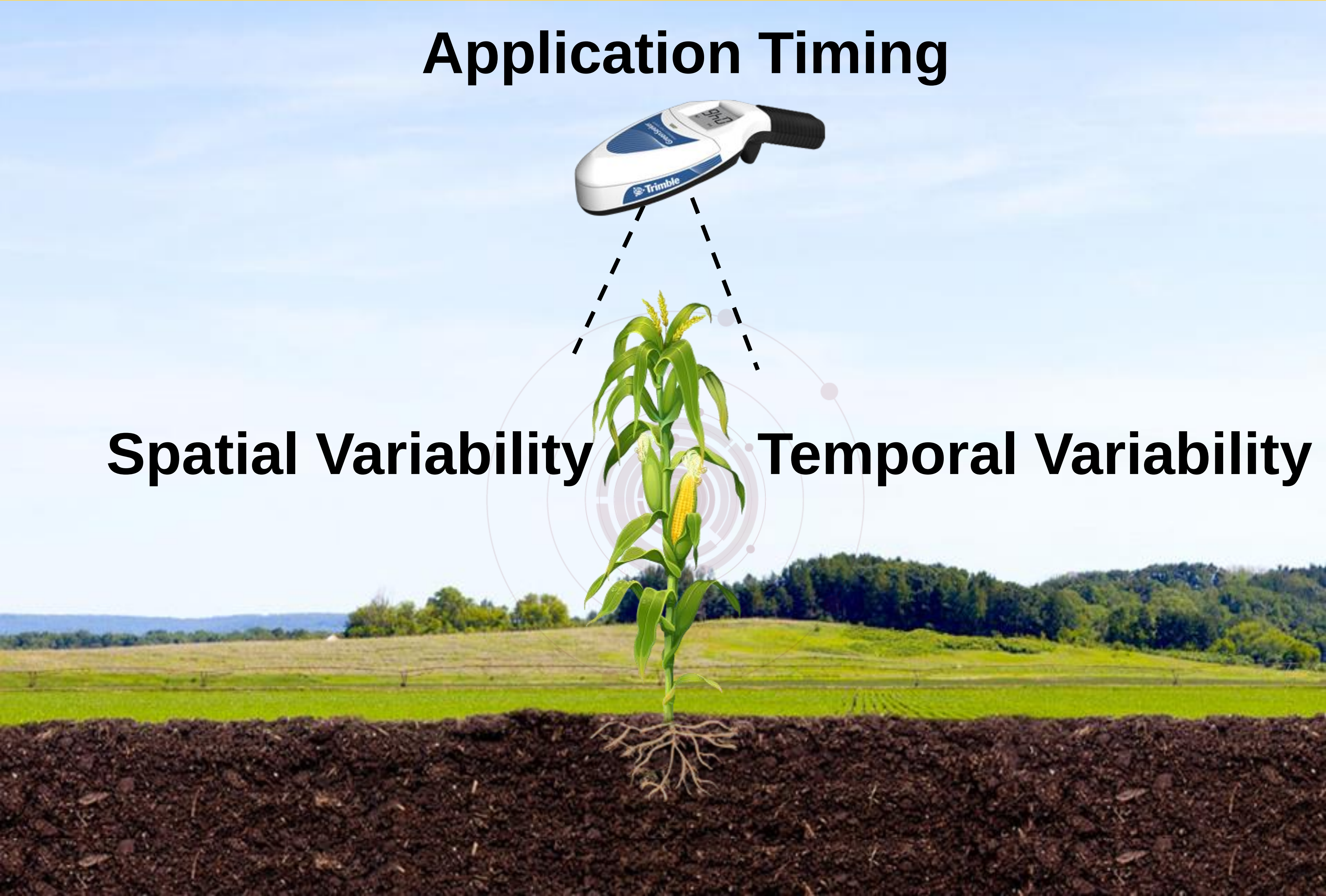
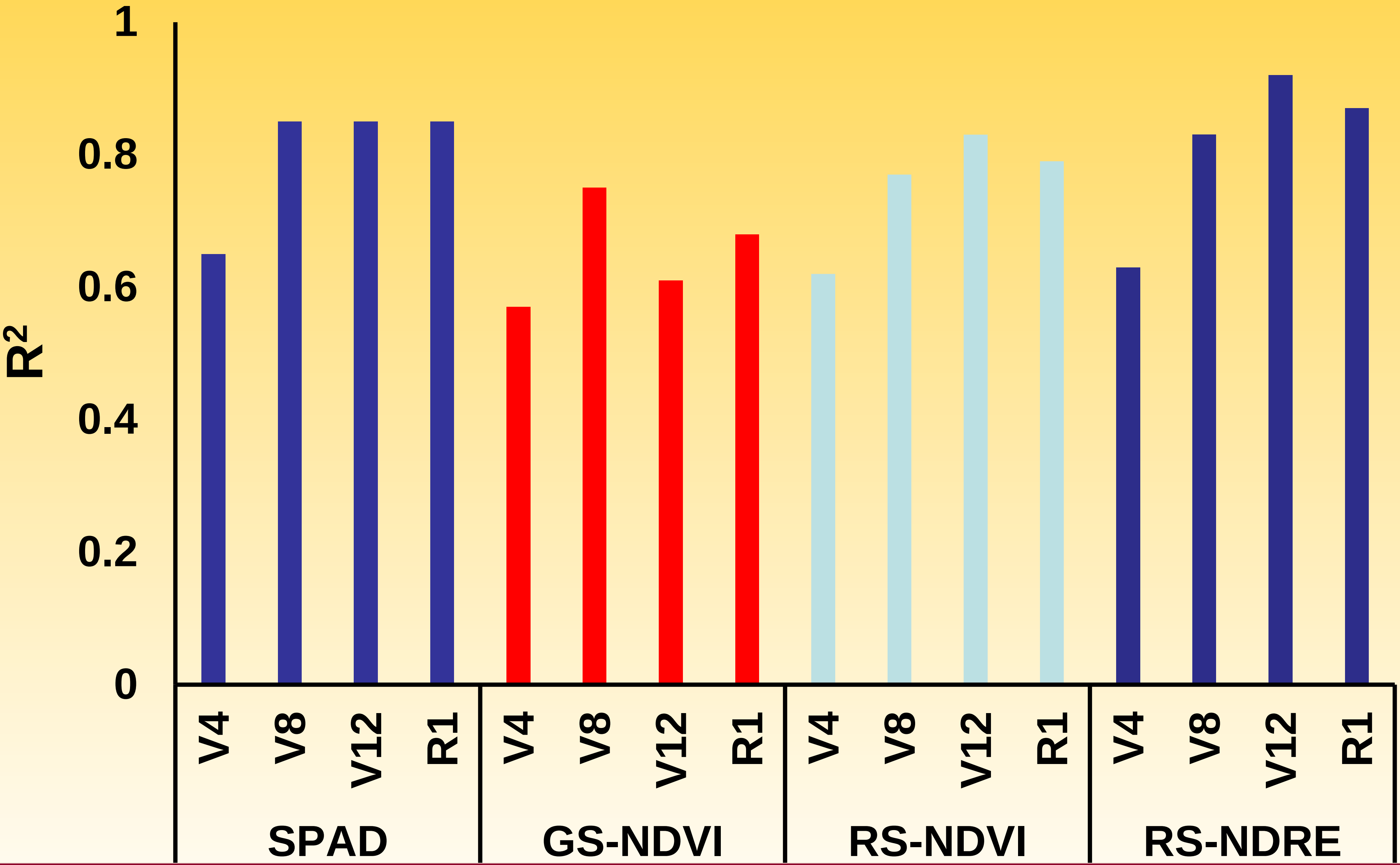


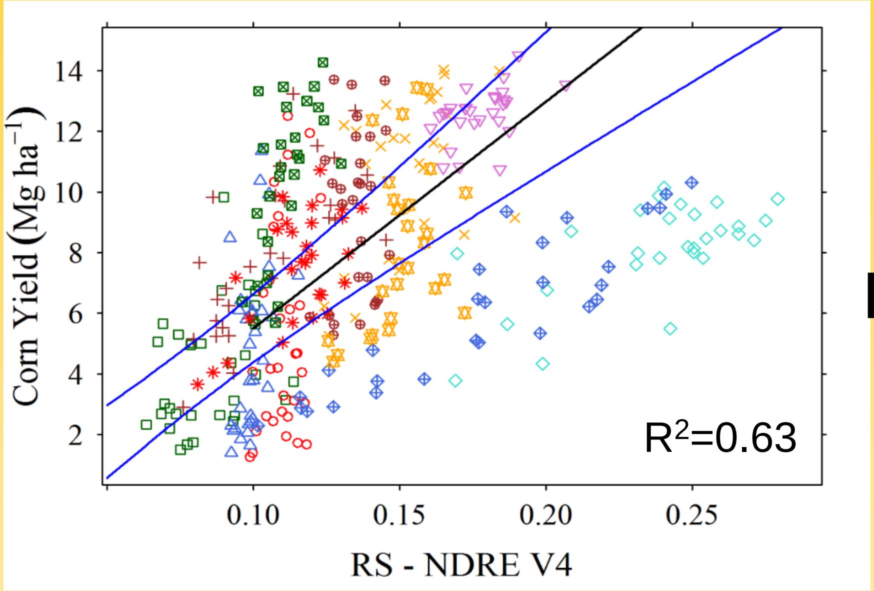
V4, Becker @ 120 lb N/a
V8, Becker @ 120 lb N/a
V12, Becker @ 120 lb N/a
R1, Becker @ 120 lb N/a
Soil nitrogen (lb/a)
Nitrate-N 0-12"
Nitrate-N 12-24"
Ammonium-N 0-12"
Ammonium-N 12-24"
PP3
Start/SD-V2
Start/SD-V4
Start/SD-V6
Start/SD-V8
Start/SD-V12

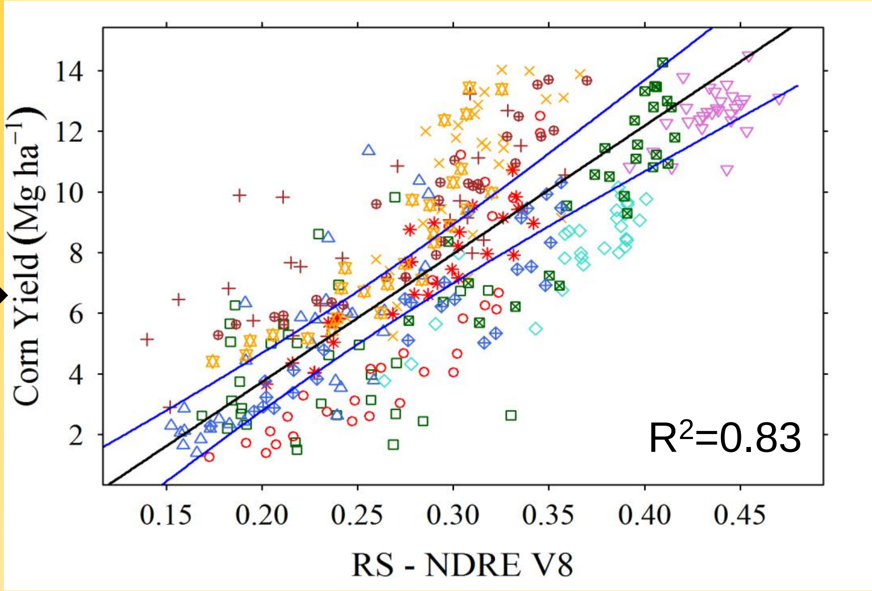
Can We Use Crop Sensors To Improve N Management?

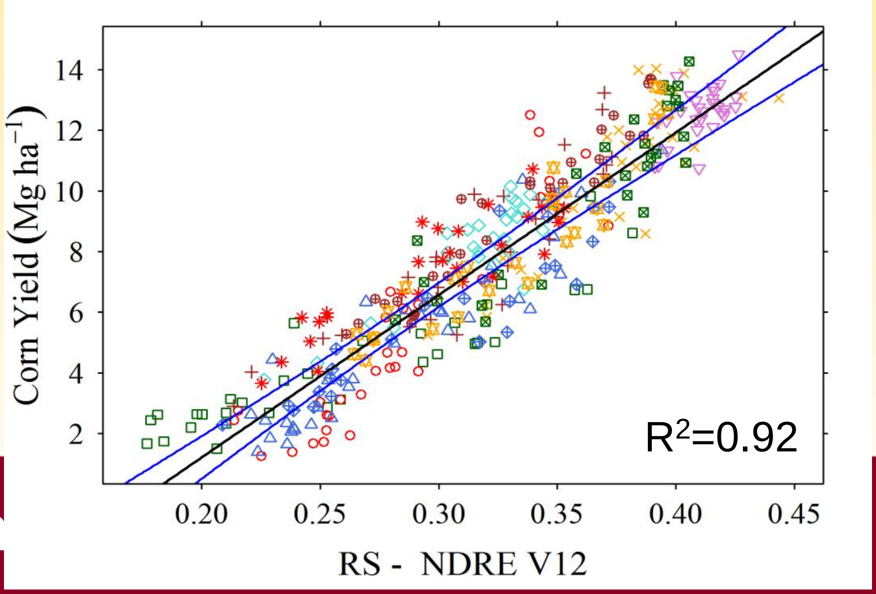


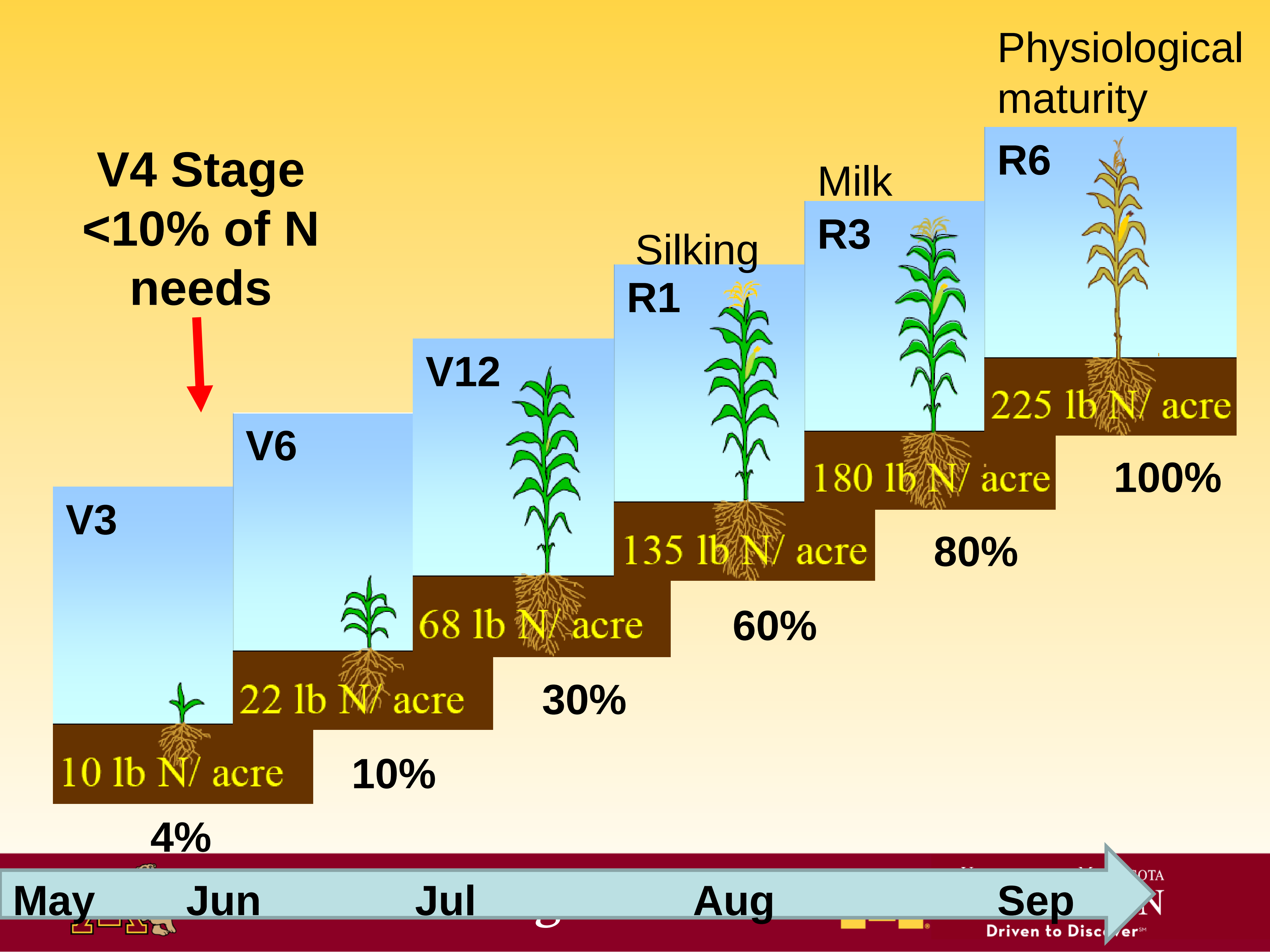
Grain Yield Prediction – Sensor only




Corn Yield (Mg ha^{-1})
RS - NDRE V4
R^2=0.63


Corn Yield (Mg ha^{-1})
RS - NDRE V8
R^2=0.83


Corn Yield (Mg ha^{-1})
RS - NDRE V12
R^2=0.92



Physiological maturity
V4 Stage
<10% of N needs
Milk
Silking
R6
R3
R1
V12
V6
V3
225 lb N/ acre
180 lb N/ acre
135 lb N/ acre
68 lb N/ acre
22 lb N/ acre
10 lb N/ acre
100%
80%
60%
30%
10%
4%
May
Jun
Jul
Aug
Sep
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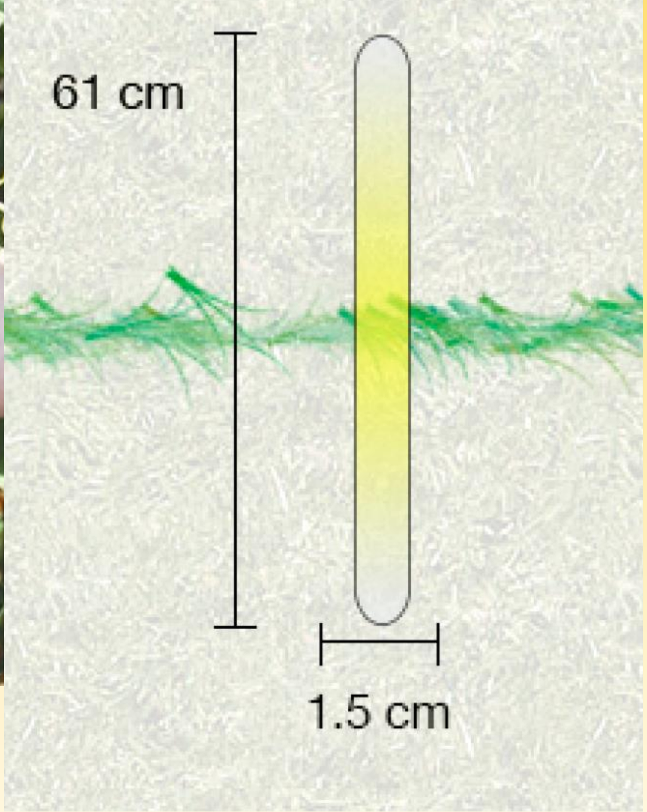
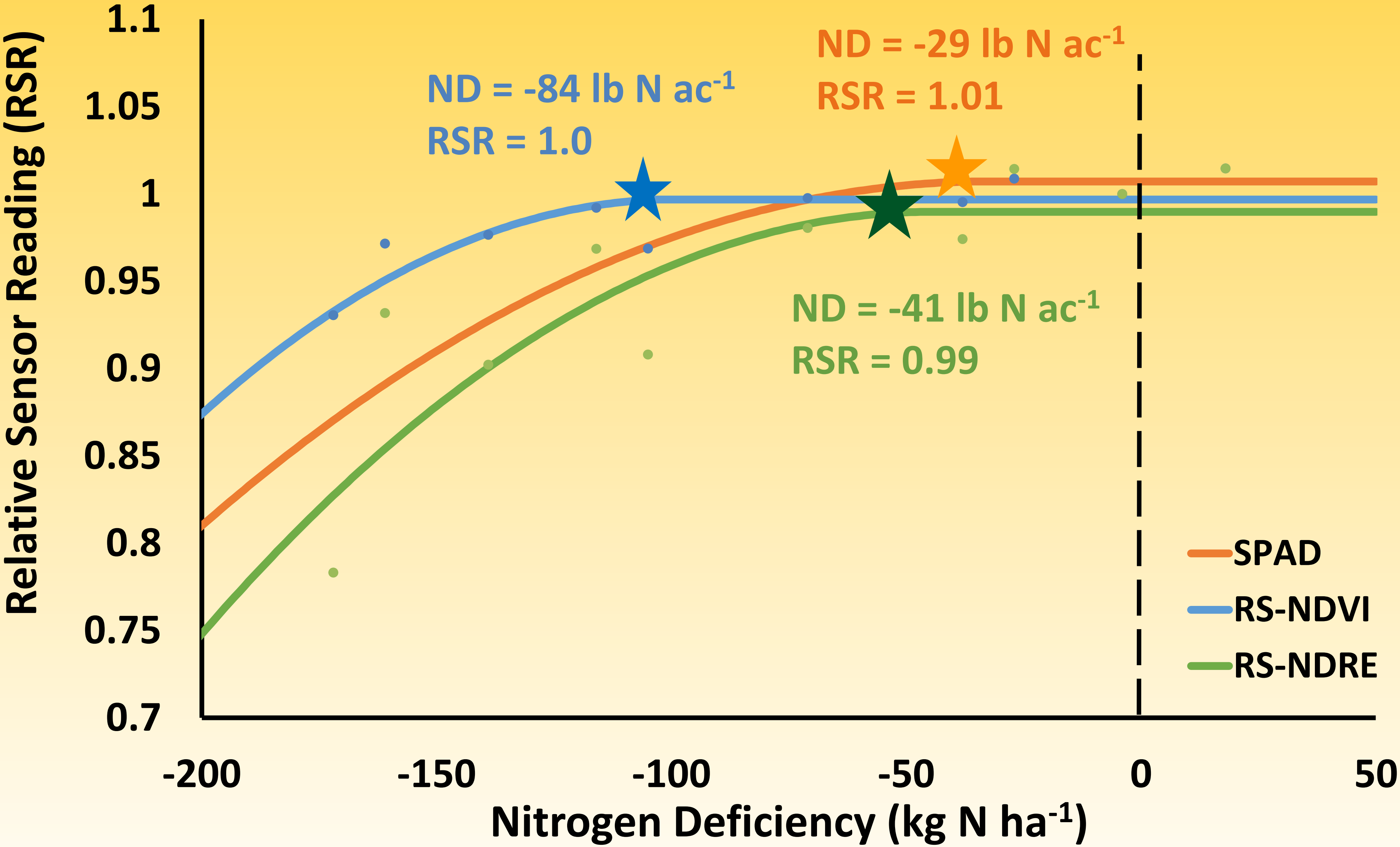
Grain Yield Prediction – Sensor only – V4

GreenSeeker Field of View

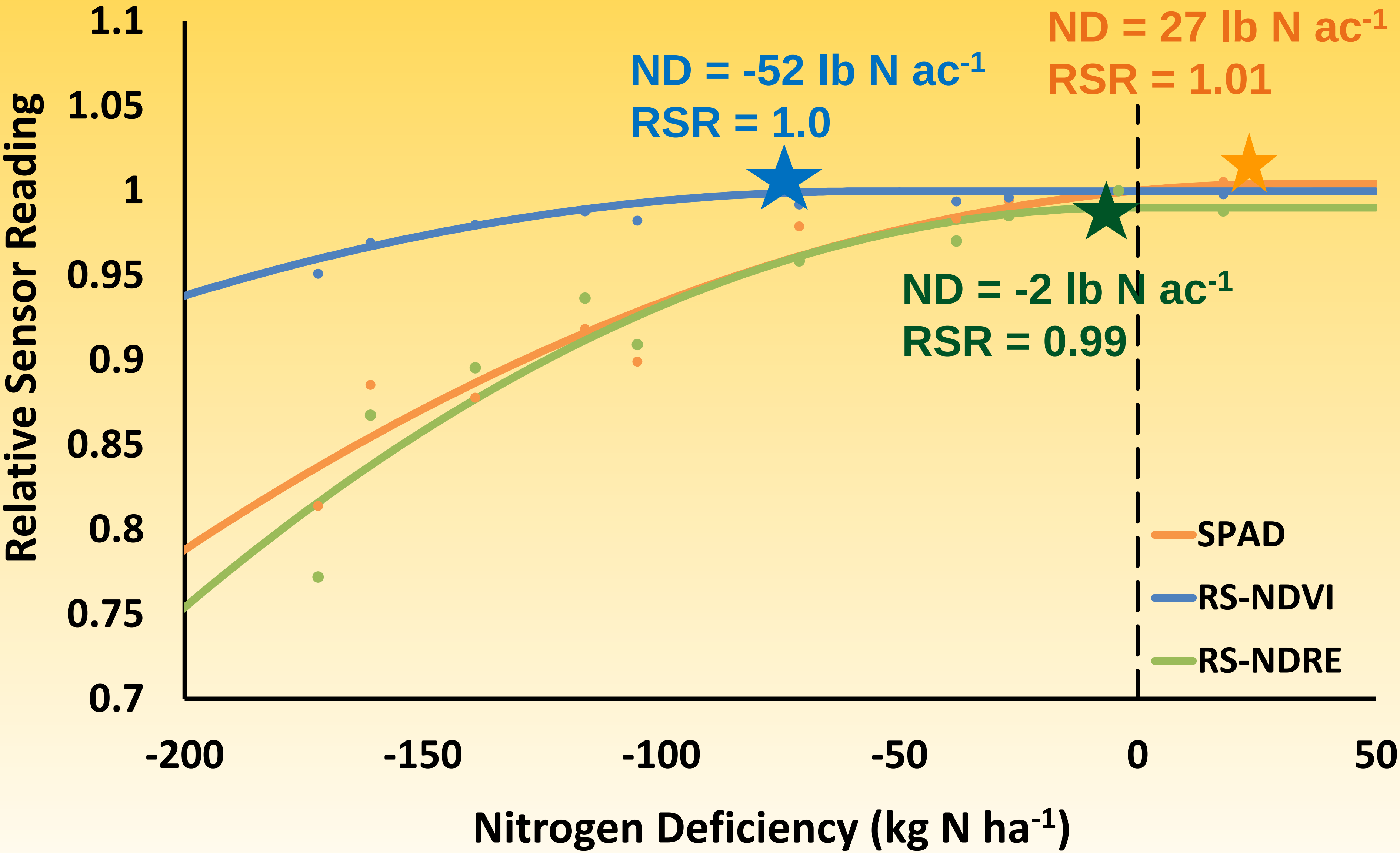


Adapted from Barmeier and Schmidhalter, (2016)

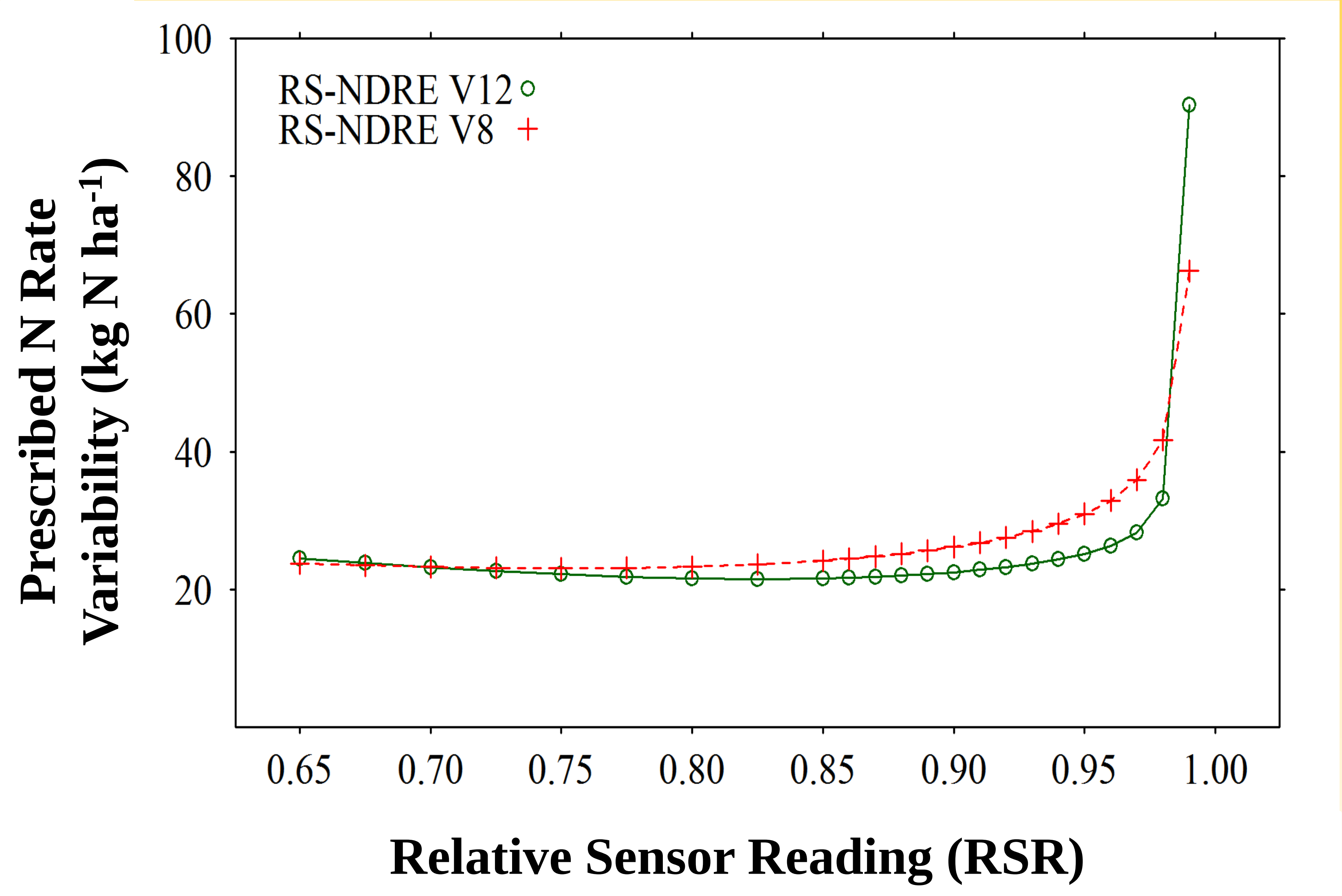
N Deficiency Determination – Sensor only –QPLoc – V8



N Deficiency Determination – Sensor only – QPLoc – V12



N Deficiency Determination – Sensor only – QPLoc



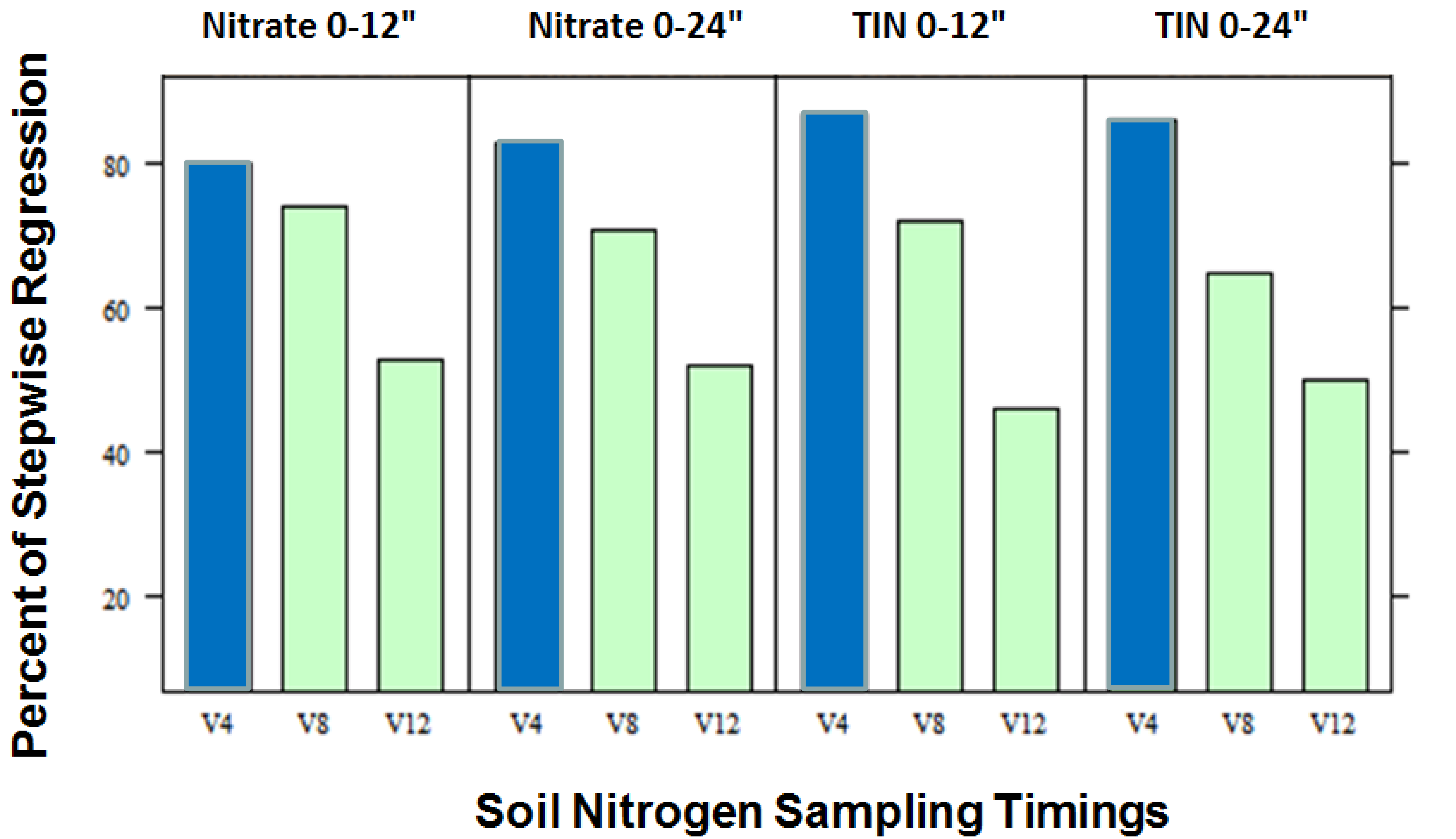
N Deficiency Determination – Sensor only – LINLoc

Stage	SPAD	GS-NDVI	RS-NDVI	RS-NDRE
V4	Linear	Q-P	Linear	Linear
V8	Q-P	Q-P	Linear	Linear
V12	Linear	ns	Linear	Linear
R1	Linear	ns	Linear	Linear

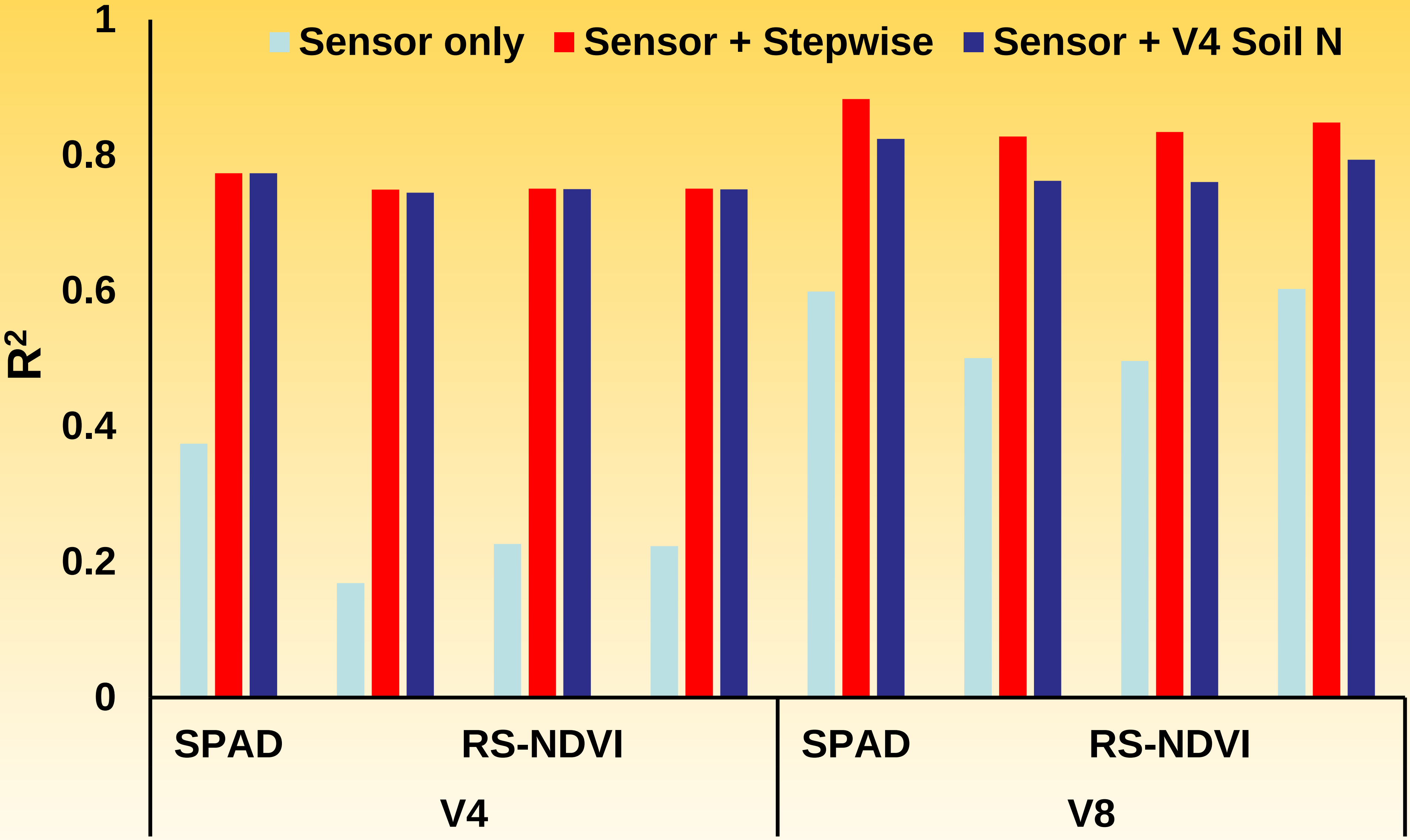
$R^2 = 0.65$

$R^2 = 0.64$

Soil N sampling timing to improve sensor predictions of N deficiency



Improving Sensor Measurements



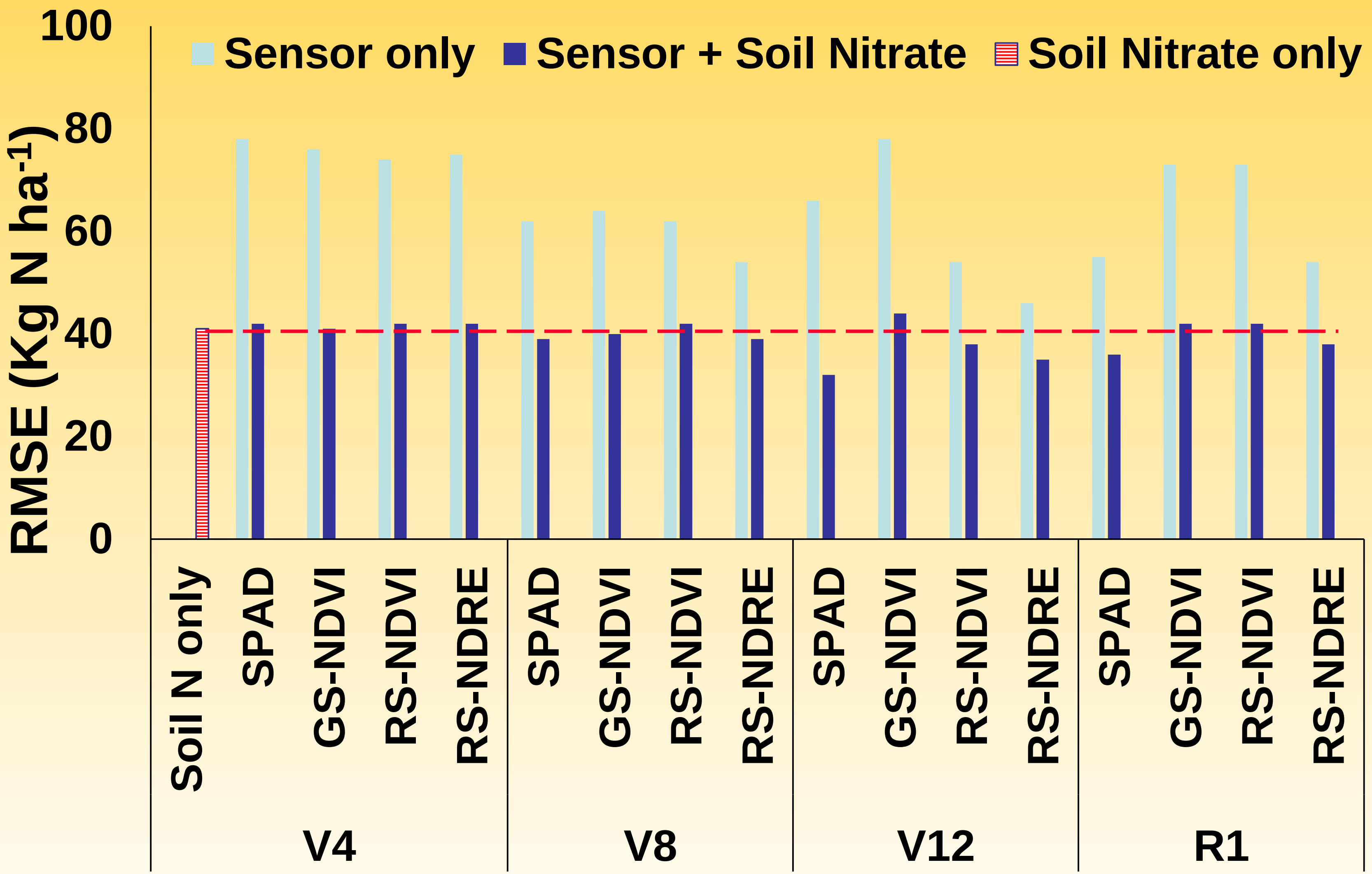
Sampling Depth and Nitrogen Measurement

Predicitve Tool	AIC*	R^2
Sensor only	784	0.34
Sensor + 0-24” TIN	**729**	**0.78**
Sensor + 0-12” TIN	735	0.74
Sensor + 0-24” NO_3^-	731	0.79
Sensor + 0-12” NO_3^-	**741**	**0.76**

* Lower AIC means better fit

V4 Soil NO_3^- @ 0-12” is the best approach to improve predictive power

Utility of Soil Nitrogen to Improve Predictive Power of N Deficiency



Take Home Messages

- Soil N is variable but it is an important tool
- Canopy sensors can help us manage N:
  - The earlier the sensing the greater the flexibility to apply nitrogen, BUT
  - The earlier the sensing the lesser the predictive power
  - The later the sensing the greater the predictive power, BUT
  - The later the sensing the lesser the flexibility to apply nitrogen and greater potential for yield loss
- Canopy sensor adjustments with soil N show promise
- In-season N application is A tool

http://mawrc.org/events

Management

Questions?

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