Lessons on Nitrogen Management During a Tough Growing Season

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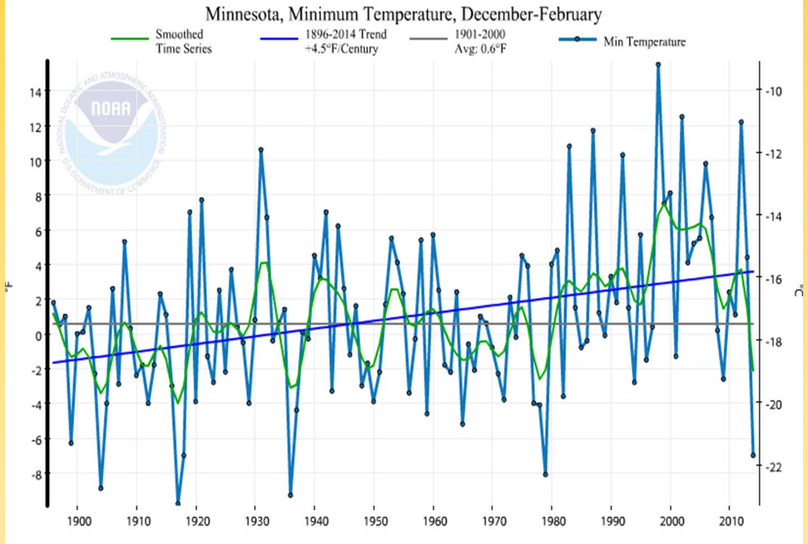
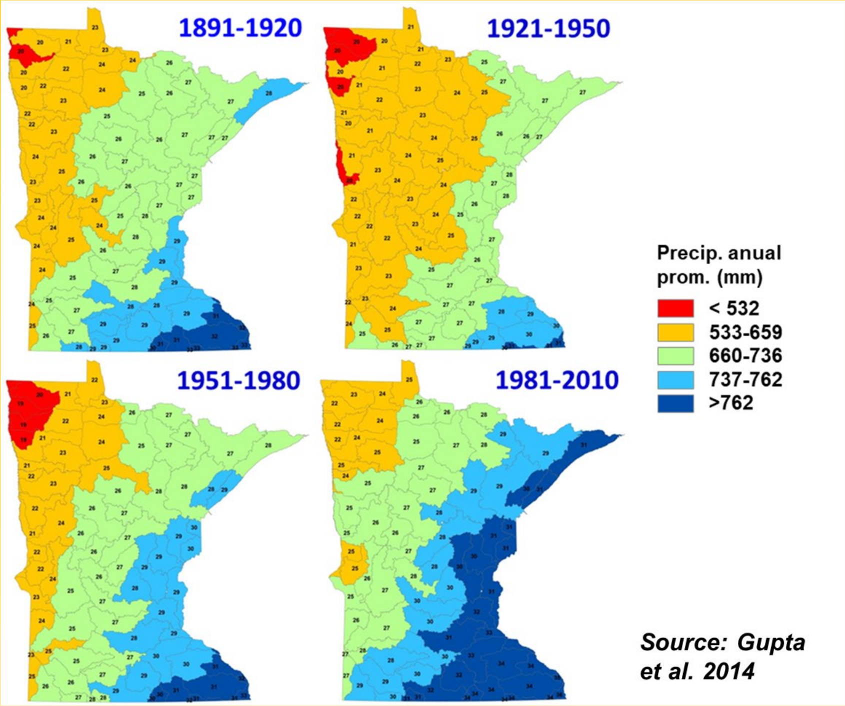
Northwood, IA

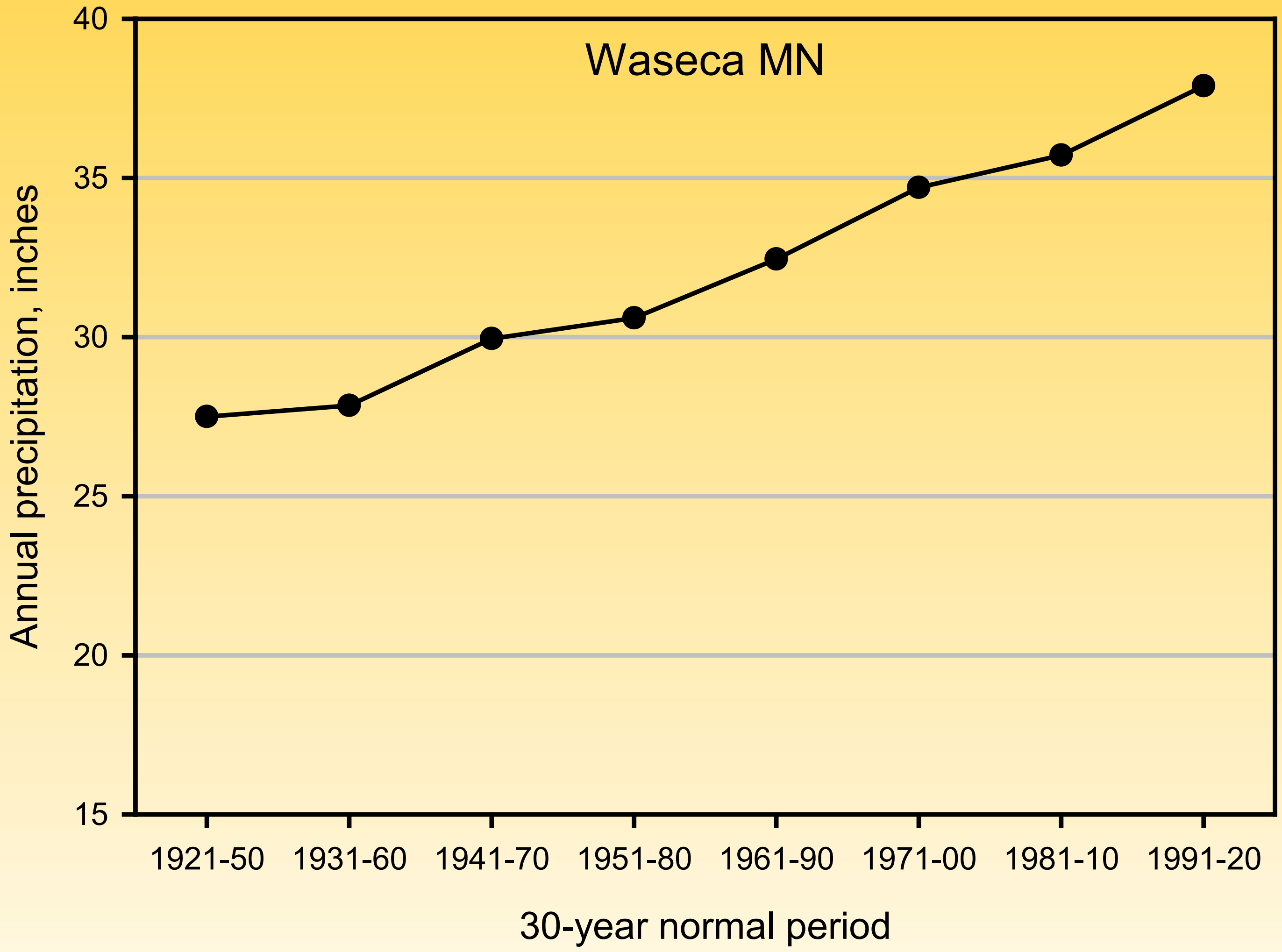
University of Minnesota
Driven to Discover℠





"Increased heavy rainfall events primarily in the early warm season (April–July)"
(Harding and Snyder, 2014)

Warmer winters + **Wetter conditions** = **Nitrogen challenges**

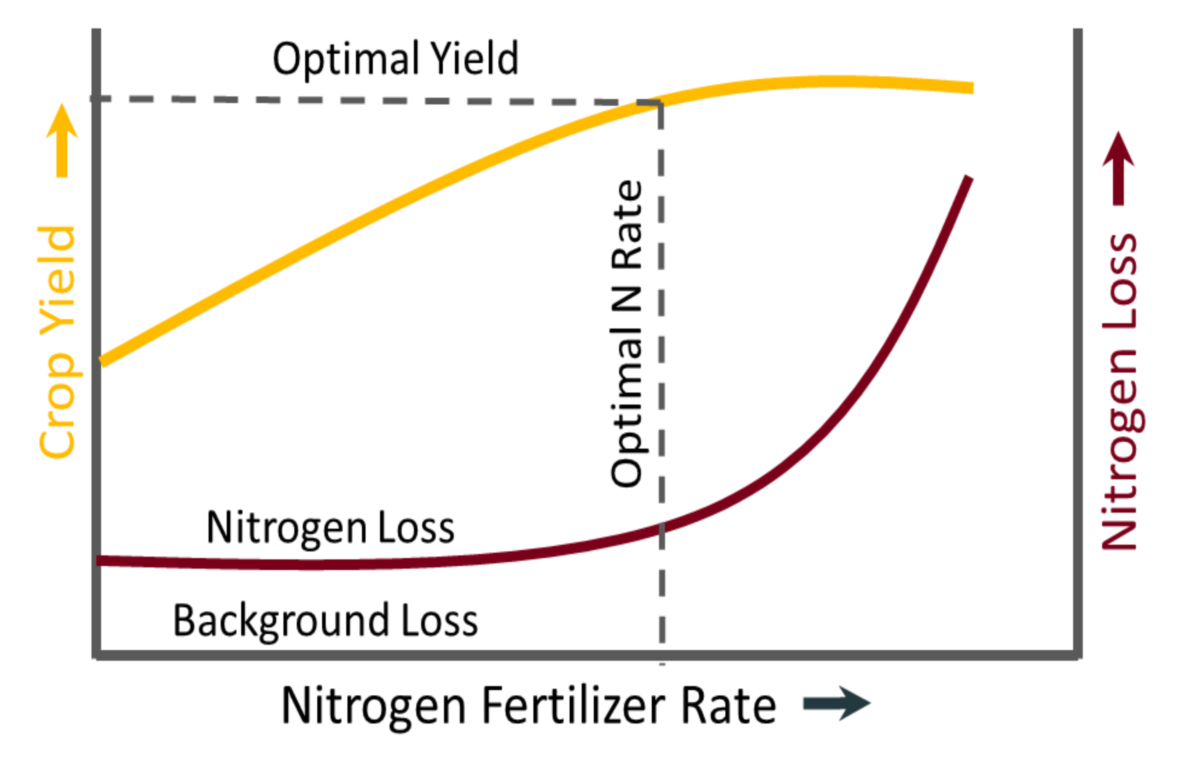


- 30-year normal annual precipitation at SROC has increased from about 30 inches from 1941-1970 to nearly 38 inches from 1991-2020.
- All months have increased some in 40 years.
- June is currently the wettest month
  - May-Sep all > 4”
- Growing season is significantly wetter.

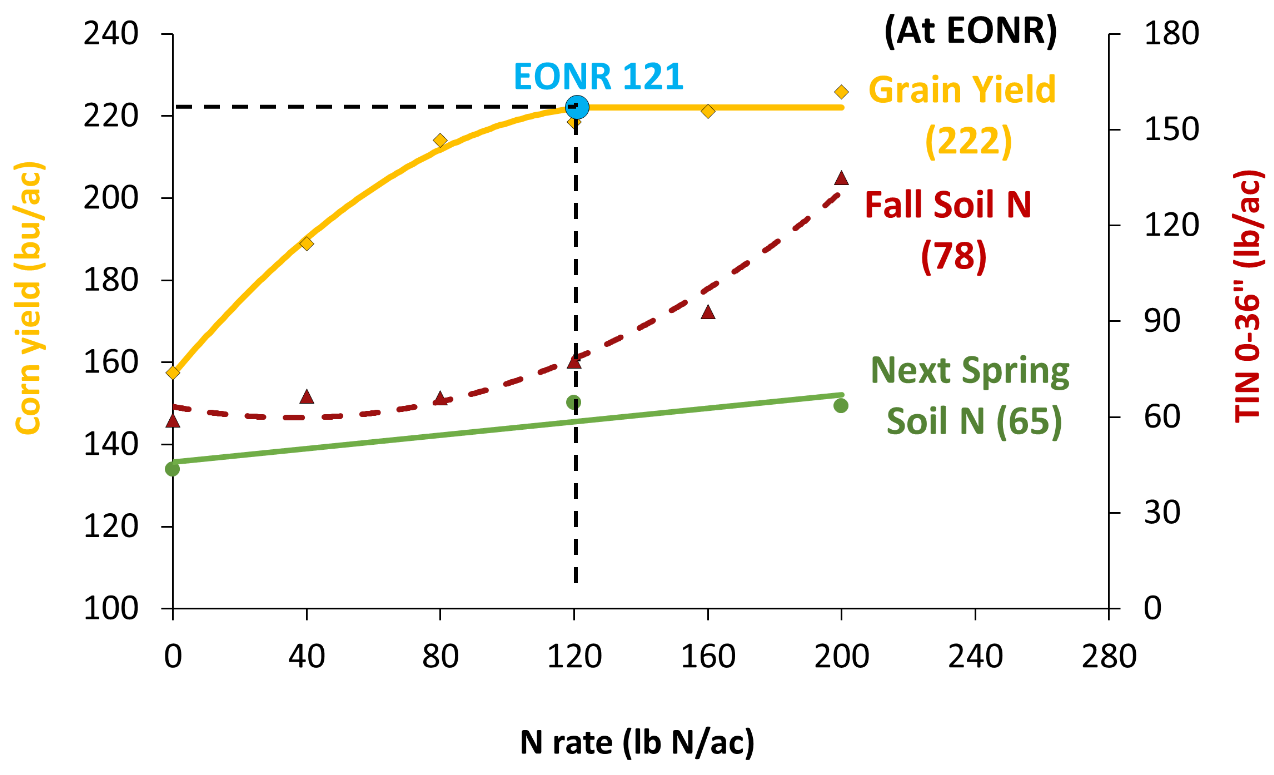
Jeffrey Vetsch

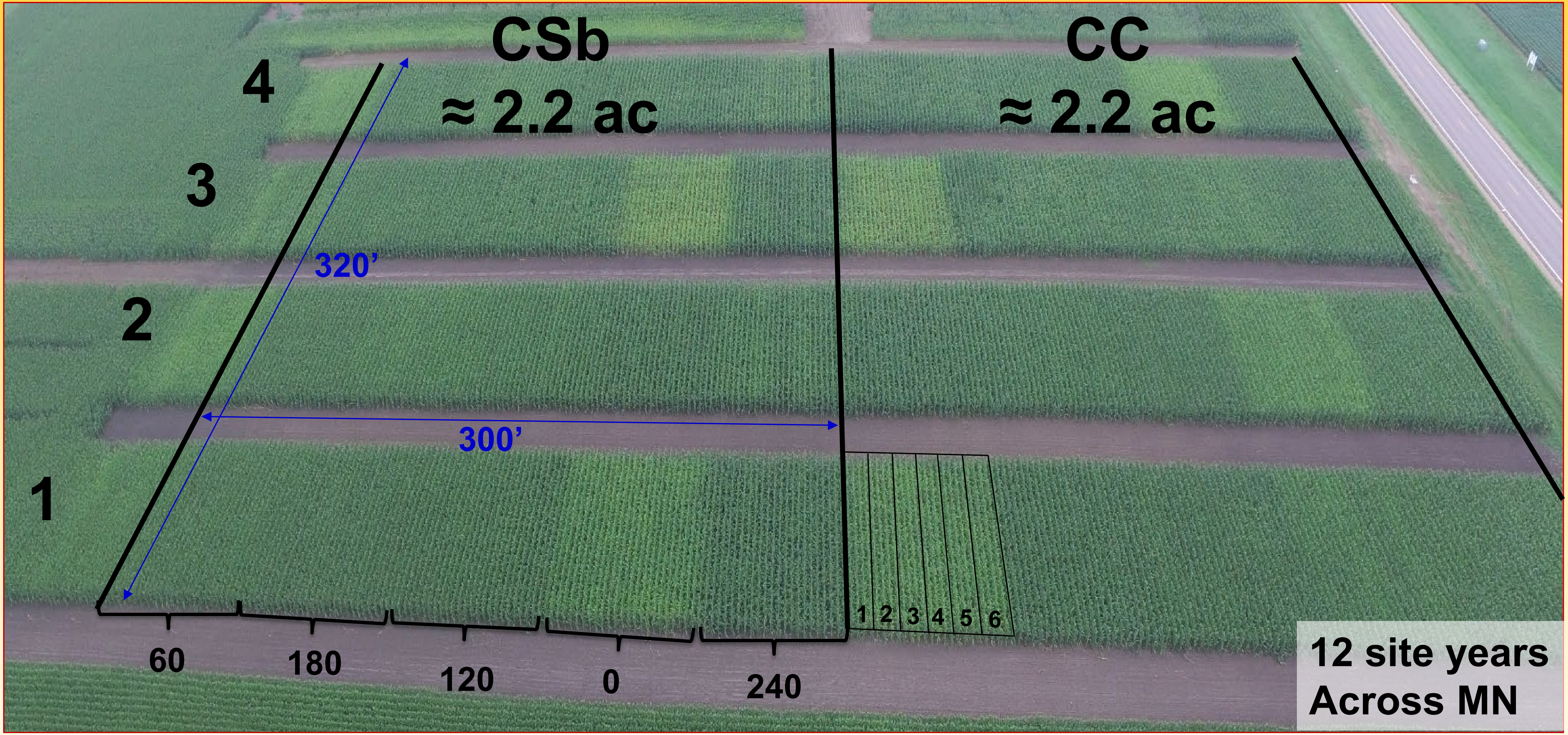
Rate

Theory



Reality (7 site-year study)

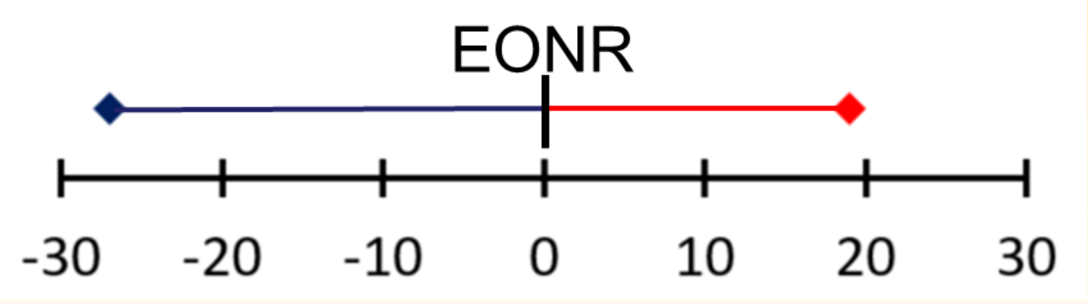



CSb
≈ 2.2 ac
CC
≈ 2.2 ac
4
3
2
1
320’
300’
1 2 3 4 5 6
60
180
120
0
240
12 site years
Across MN

12 site-yrs of Data:

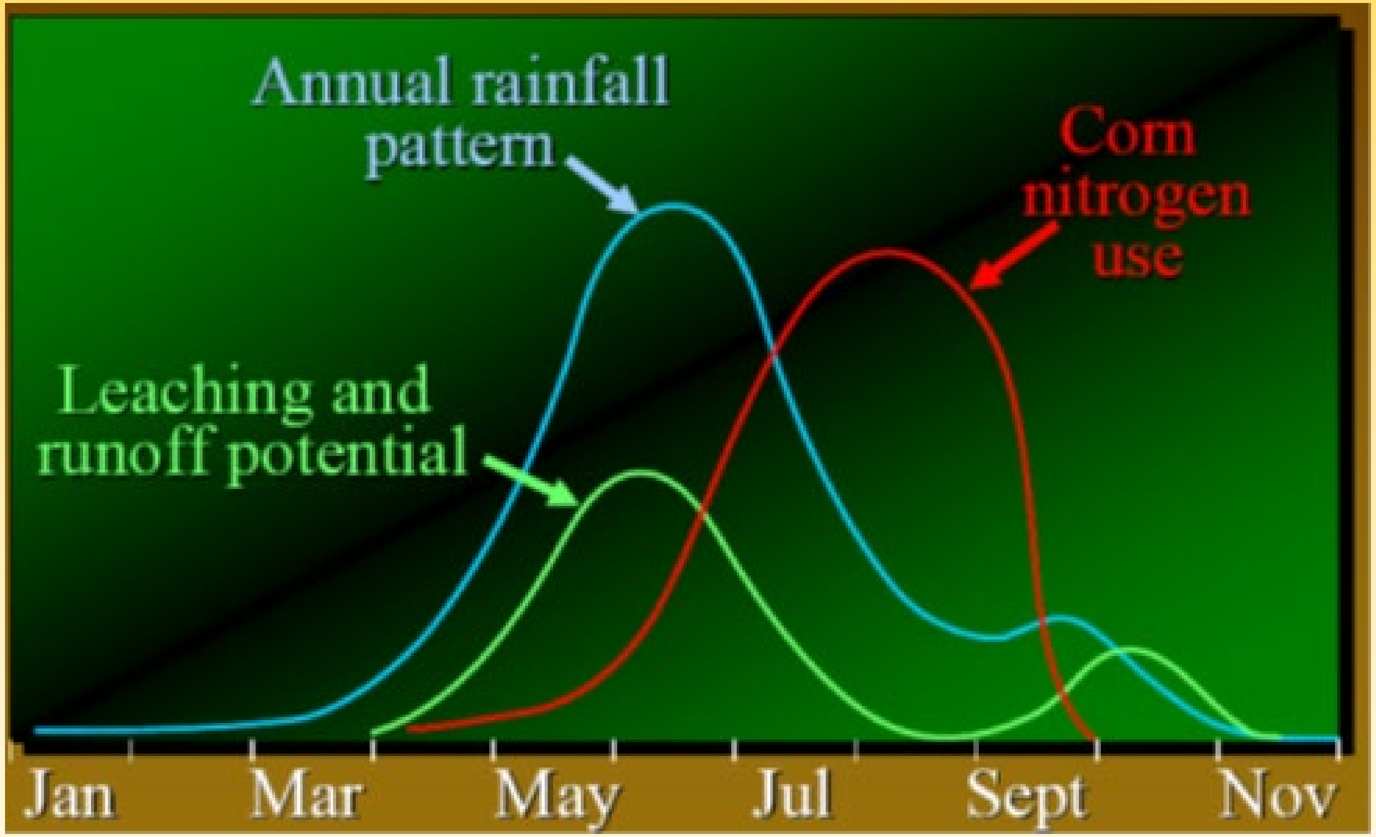
On 2.2 acres one should expect:

- The EONR to vary by 47 lbs N/acre and the yield at the EONR by 12 bu/ac
- We are doing Very Well if we are within ≈ 30 lbs N/ac of the EONR
  - Difference below ≈ -27 lb N/ac
  - Difference above ≈ +19 lb N/ac)

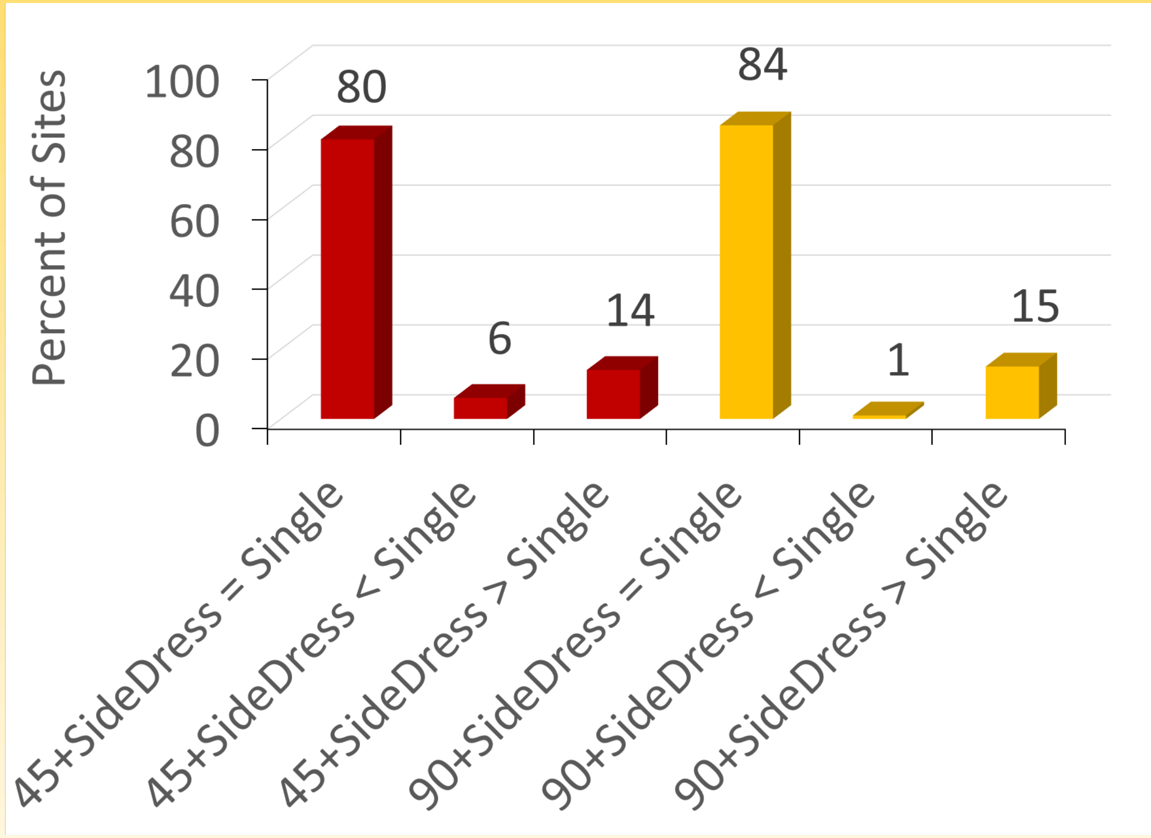


Time

Theory



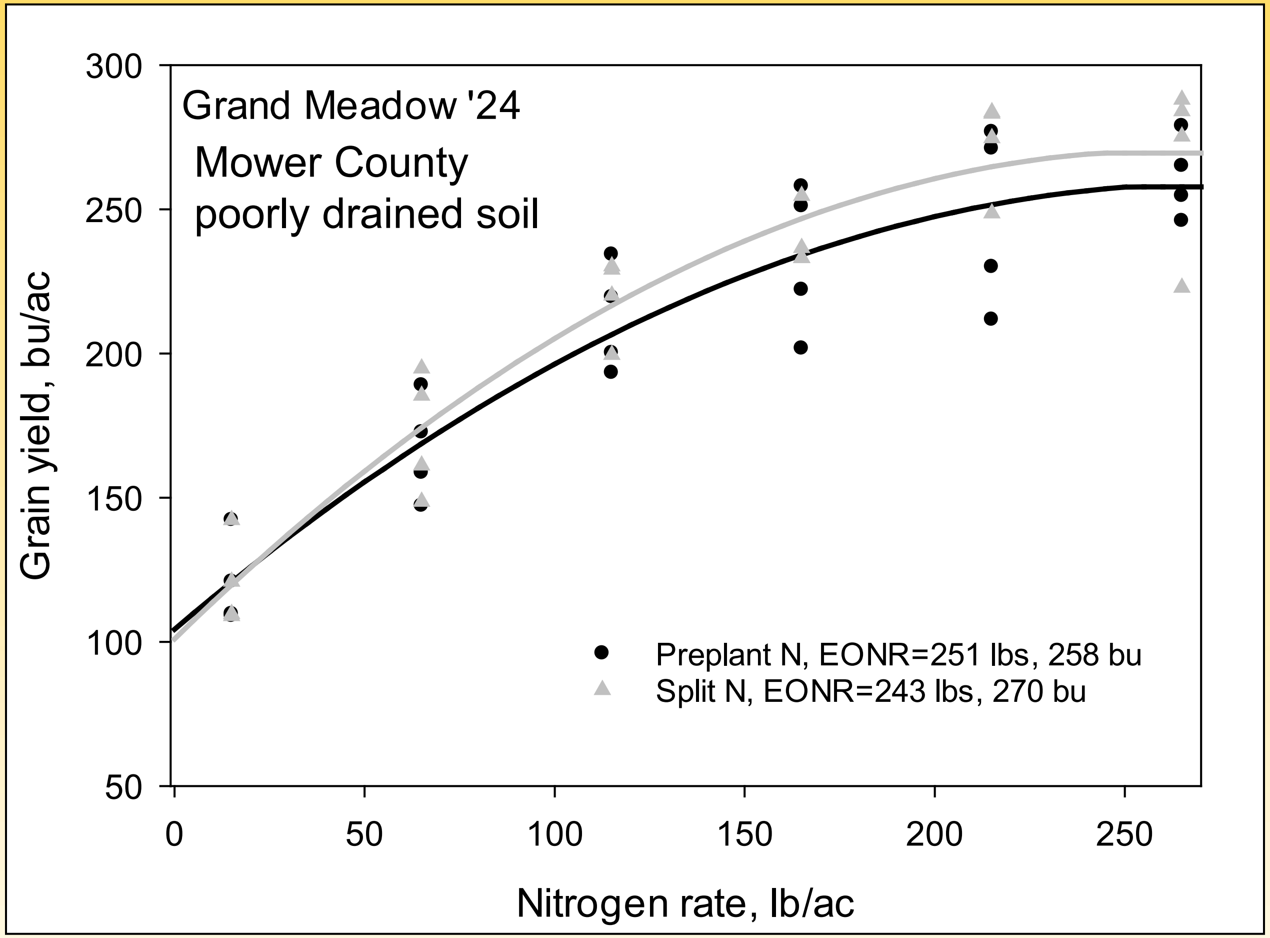
Reality (49 site-years)

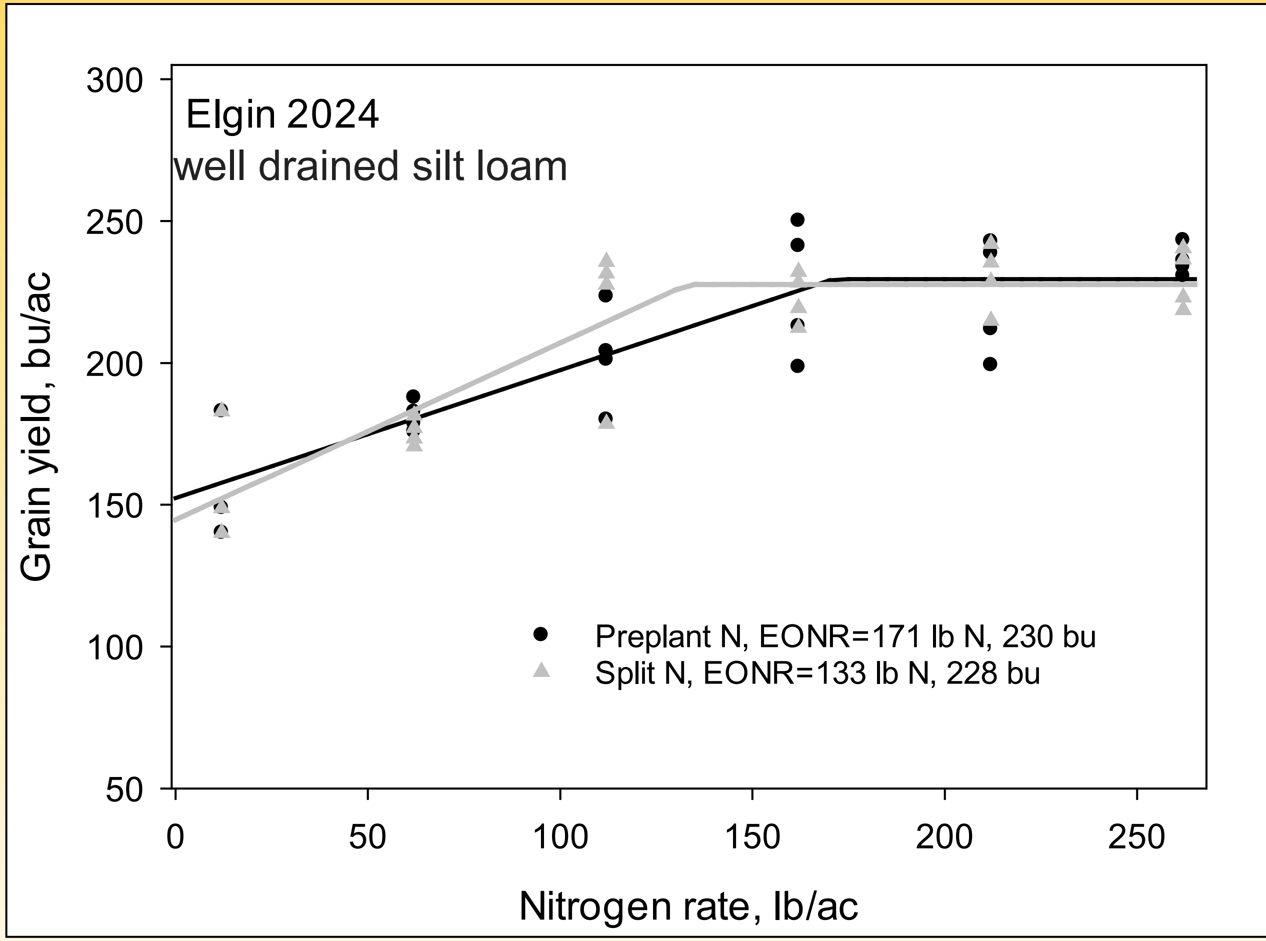


SE MN

Rate & Time

Corn after soybean (split-app got 50 lb N/ac at V5)





10.9” of rain in June + 3.3” from July 1–5, preplant vs split (*P* > F=0.01)

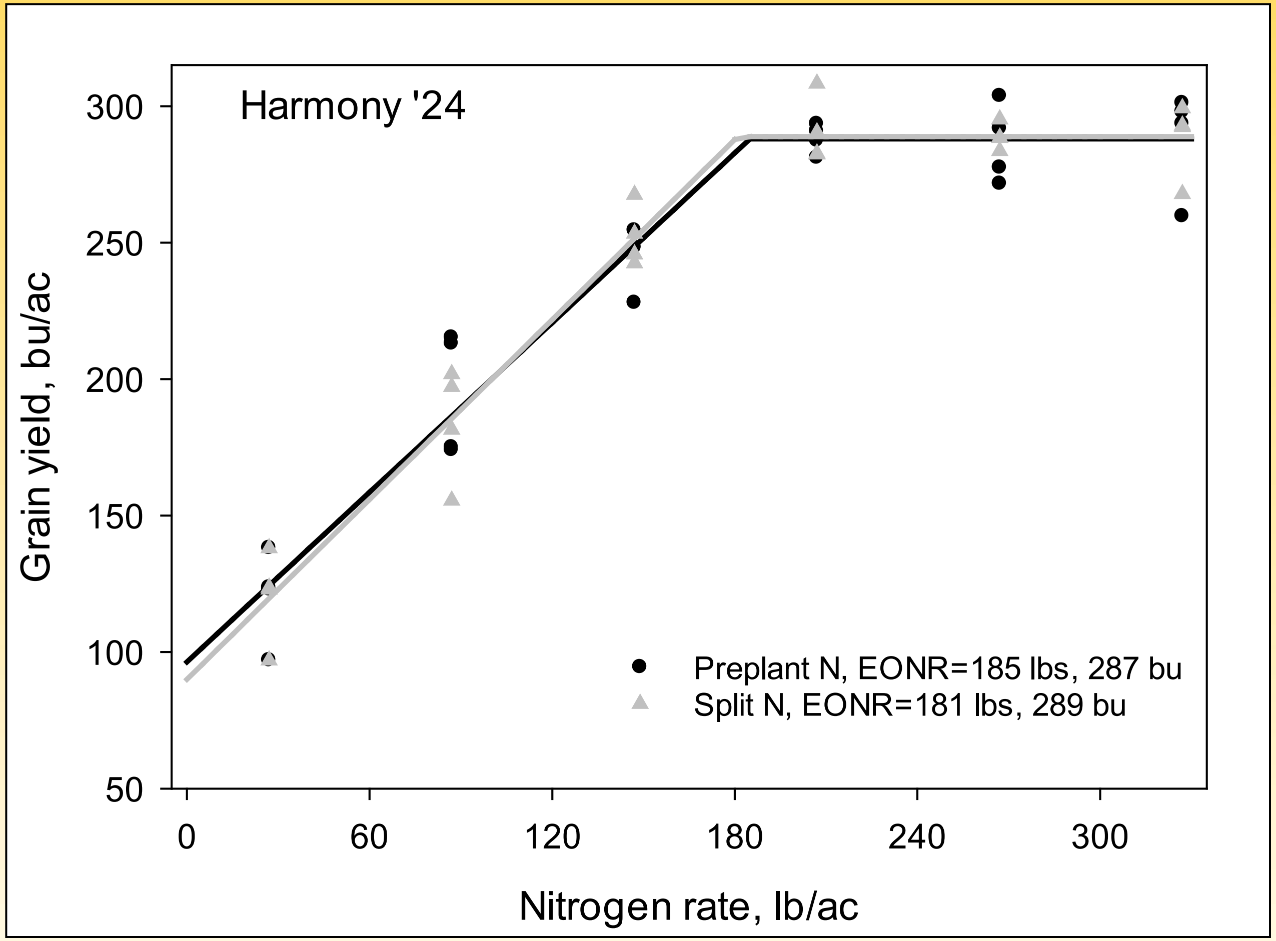
10.7” of rain in June, only 26,500 plants/ac,

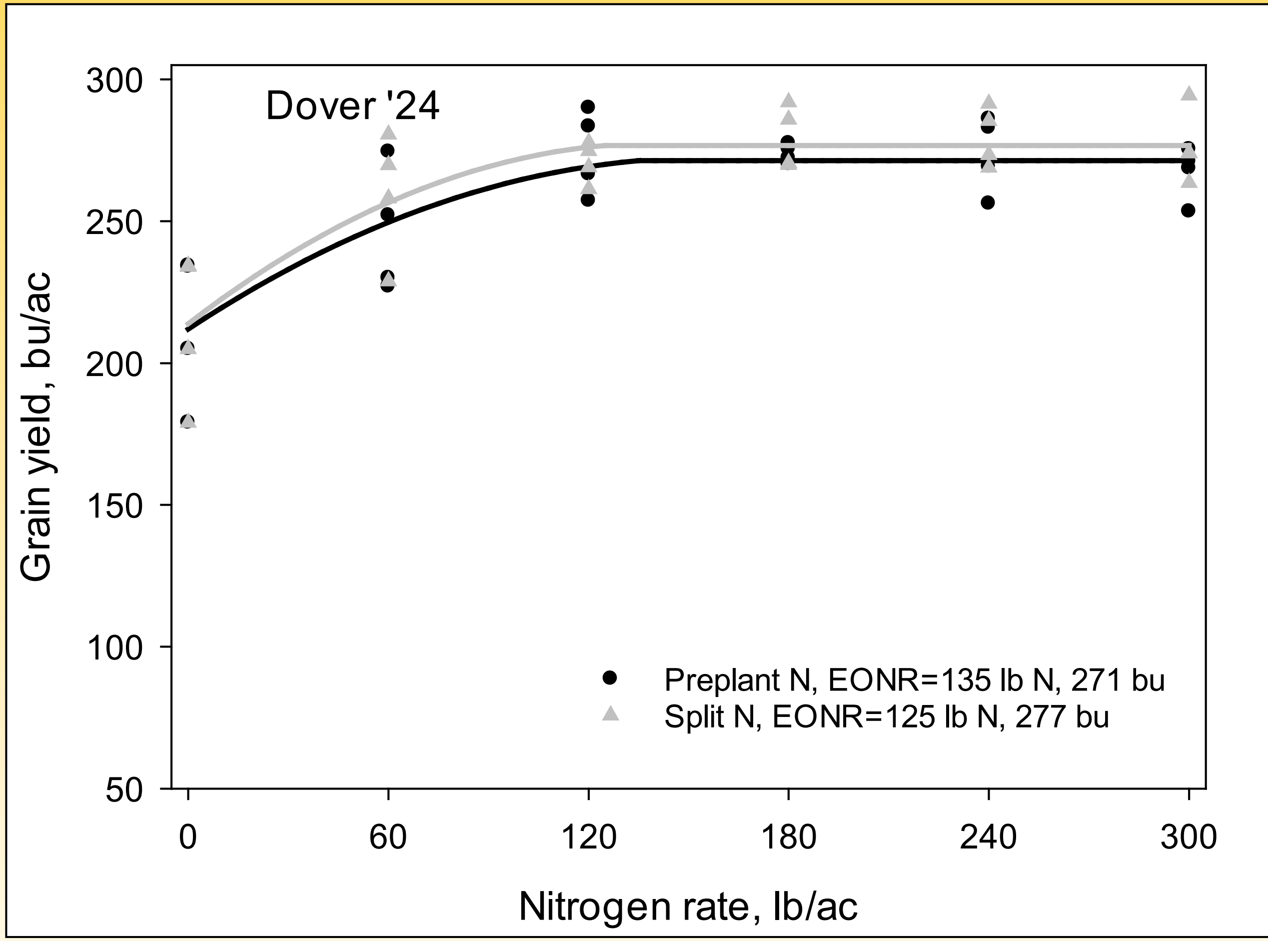
Jeff Vetsch

SE MN, well-drained silt loam soils

Corn after corn (split-app got 60 lb N/ac at V4-5)

Rate & Time

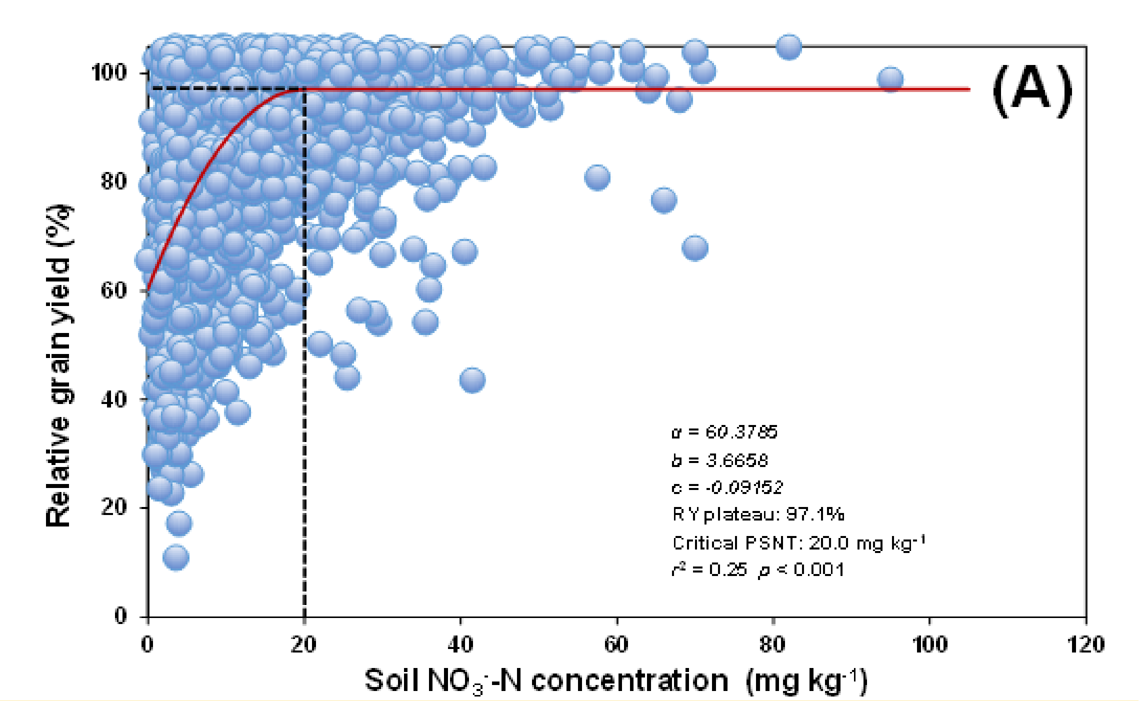


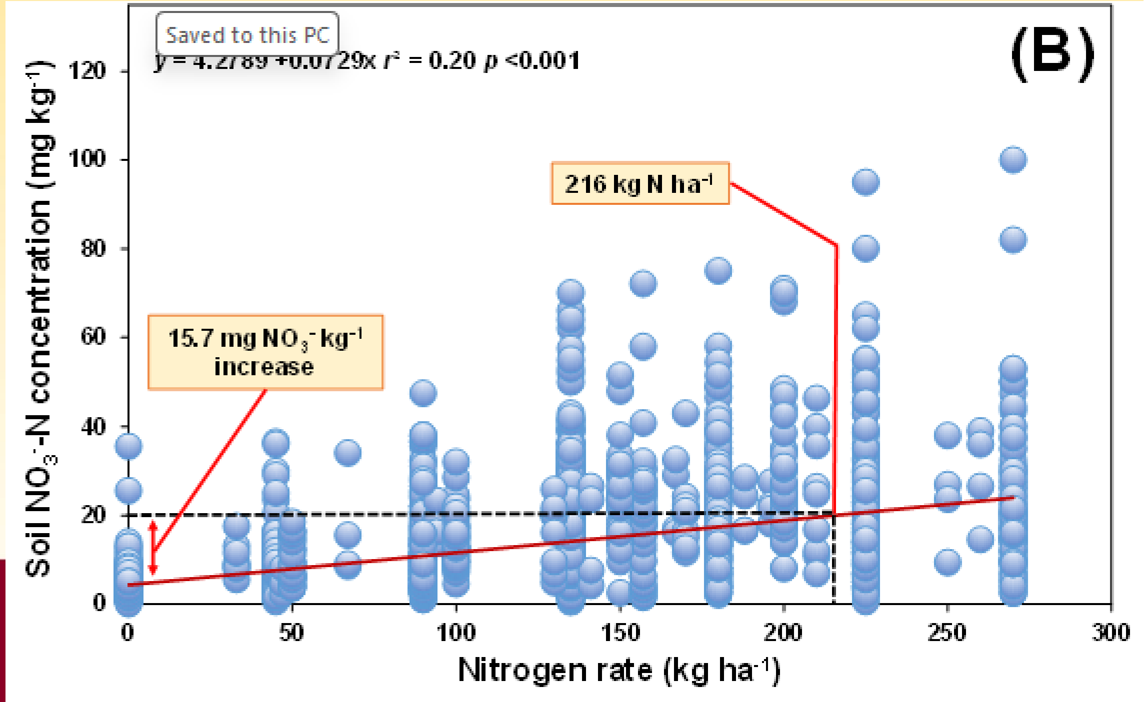


7.0” of rain in June + 3.4” from July 1–5.

10.1” of rain in June, corn after sweet corn with a cover crop
Timing (P > F=0.15)

Jeff Vetsch





- Assessment across 34 field experiments
- The PSNT is a viable tool to guide in-season N fertilization applications.
- At V4-V6 corn development stages, the critical PSNT is 20 ± 2.5 mg kg^{-1}.
- On average the top foot of the soils had 20 lb N ha^{-1} (5 mg kg^{-1}) available prior to planting and required 173 lb N ac^{-1} to reach 20 mg kg^{-1} at V4-V6
- Overall, when soil test values are below the critical PSNT, a 12.3±2.1 lb N ac^{-1} rate would be needed to increase soil NO_3^--N concentrations by 1 mg kg^{-1}.

EXTENSION
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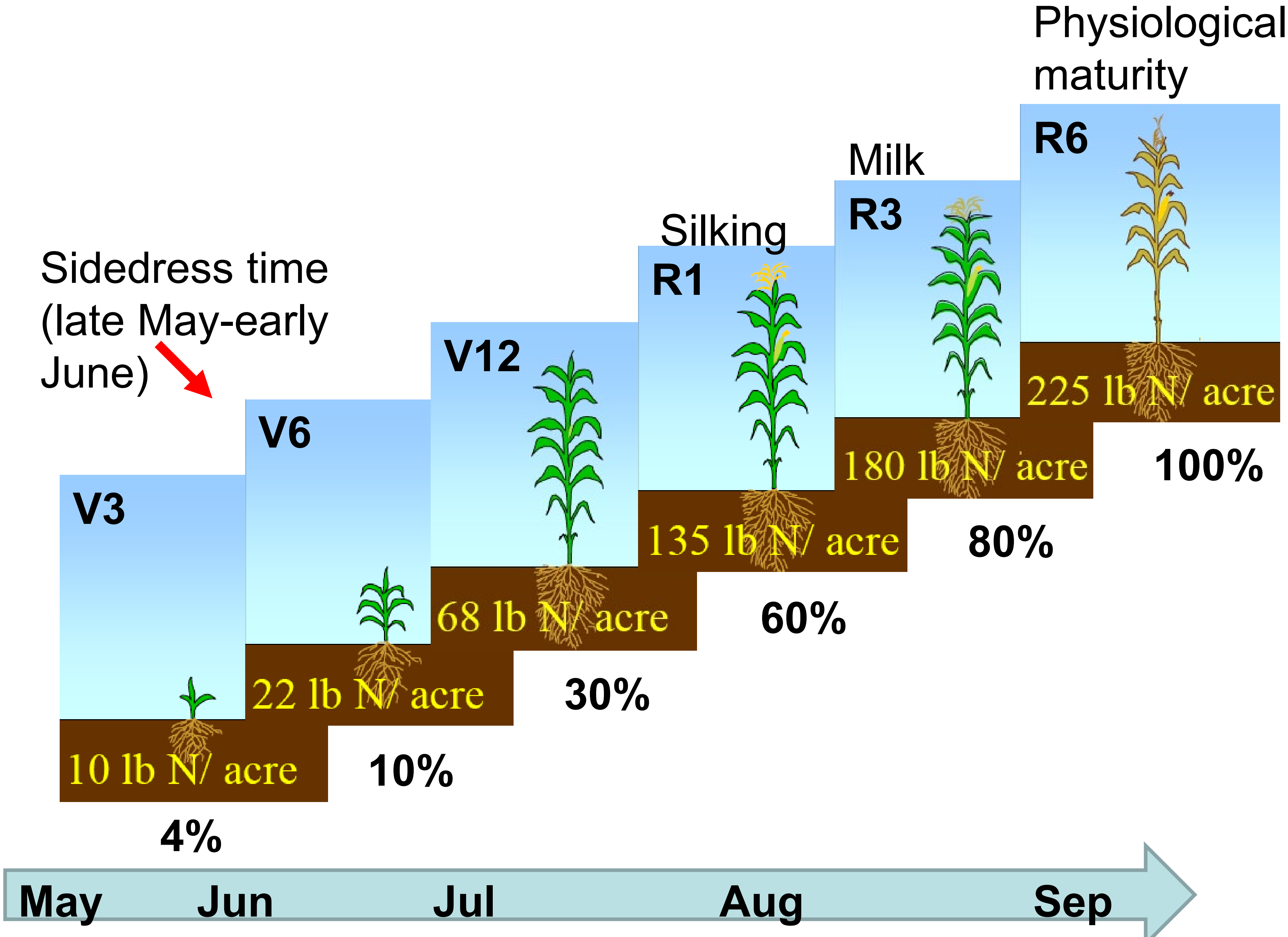
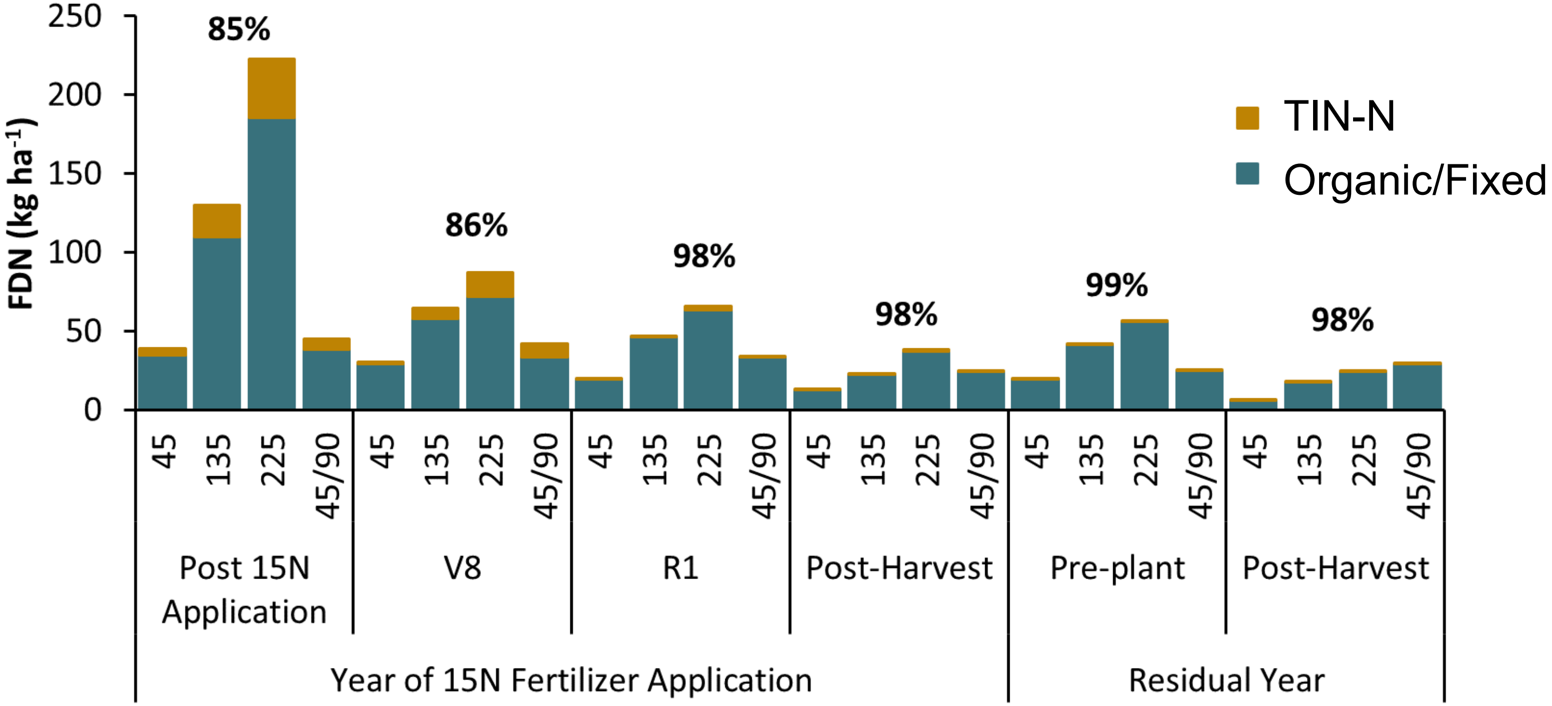
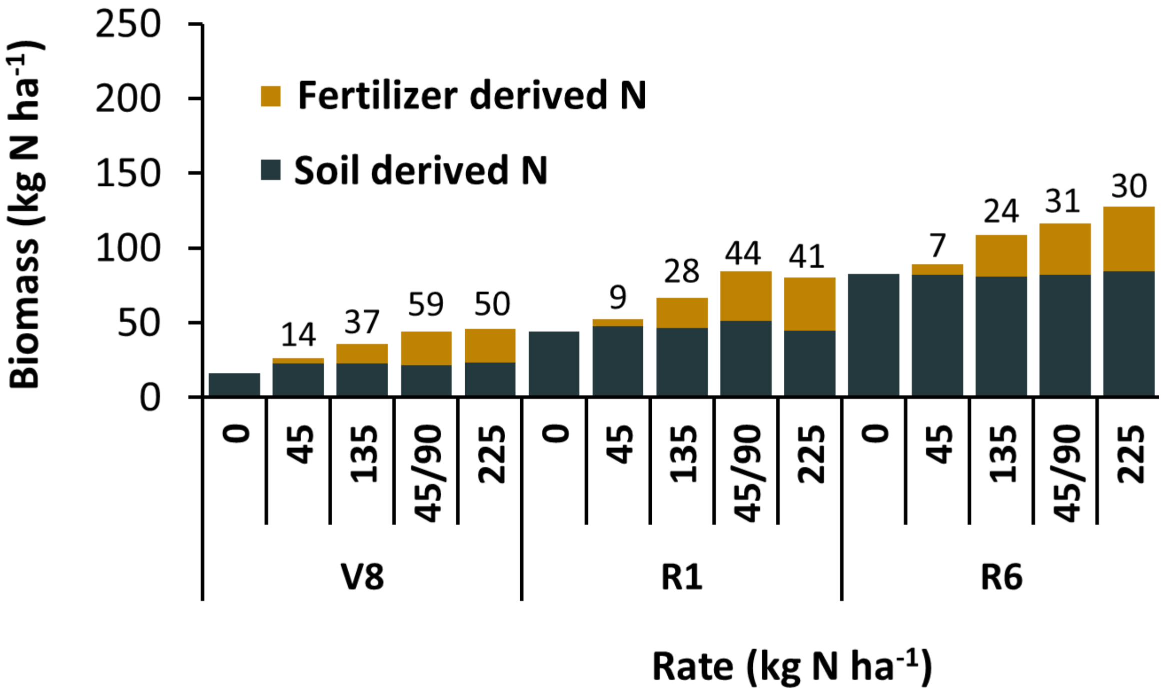

Physiological maturity
R6
Milk
R3
Silking
R1
Sidedress time (late May-early June)
V12
V6
V3
225 lb N/ acre
100%
180 lb N/ acre
80%
135 lb N/ acre
60%
68 lb N/ acre
30%
22 lb N/ acre
10%
10 lb N/ acre
4%
May
Jun
Jul
Aug
Sep



Most of the fertilizer is rapidly immobilized or fixed



Progressively the soil provides most of the N

Site	Rotation	Time	MRTN lb ac^{-1}	MRTN Yield bu ac^{-1}
Waseca	CC	Fall (3-yr)	240	210
		Spring (3-yr)	195	222
	CSb	Fall (4-yr)	186	220
		Spring (4-yr)	160	231
Lamberton	CC	Fall (5-yr)	227	158
		Spring (5-yr)	214	175
	CSb	Fall (5-yr)	168	195
		Spring (5-yr)	158	203
Morris	CC	Fall (3-yr)	240	162
		Spring (3-yr)	203	174
	CSb	Fall (2-yr)	179	187
		Spring (2-yr)	184	186
Crookston	CWh/CC	Fall (2-yr)	191	164
		Spring (2-yr)	108	161
	CSb	Fall (1-yr)	200	182
		Spring (1-yr)	189	198

Rate & Time

-35 lb N ac^{-1}
11 bu ac^{-1}

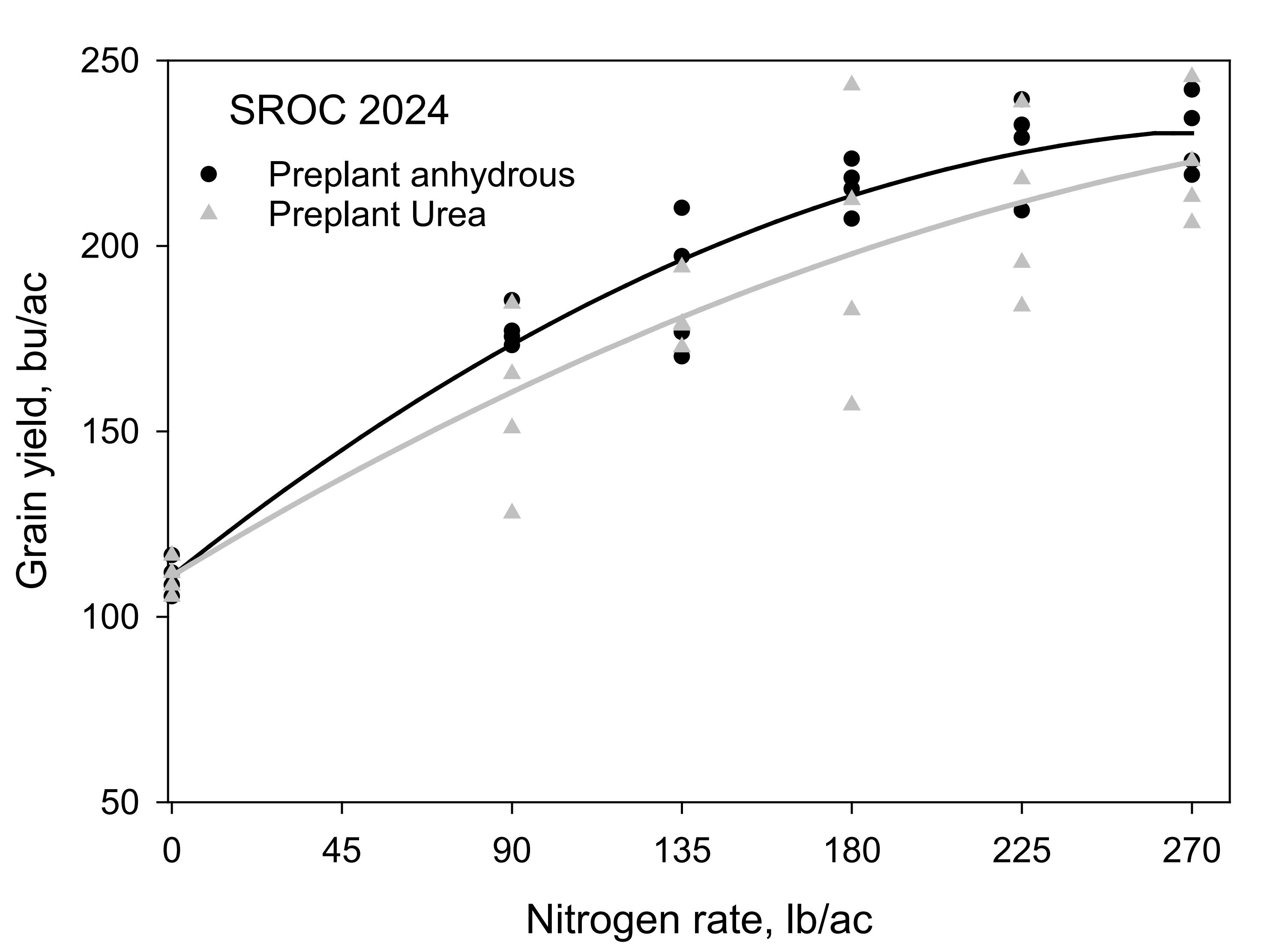
-12 lb N ac^{-1}
13 bu ac^{-1}

-16 lb N ac^{-1}
5 bu ac^{-1}

-47 lb N ac^{-1}
7 bu ac^{-1}

Fall	204	185
Spring	176	194
Diff	-28	9

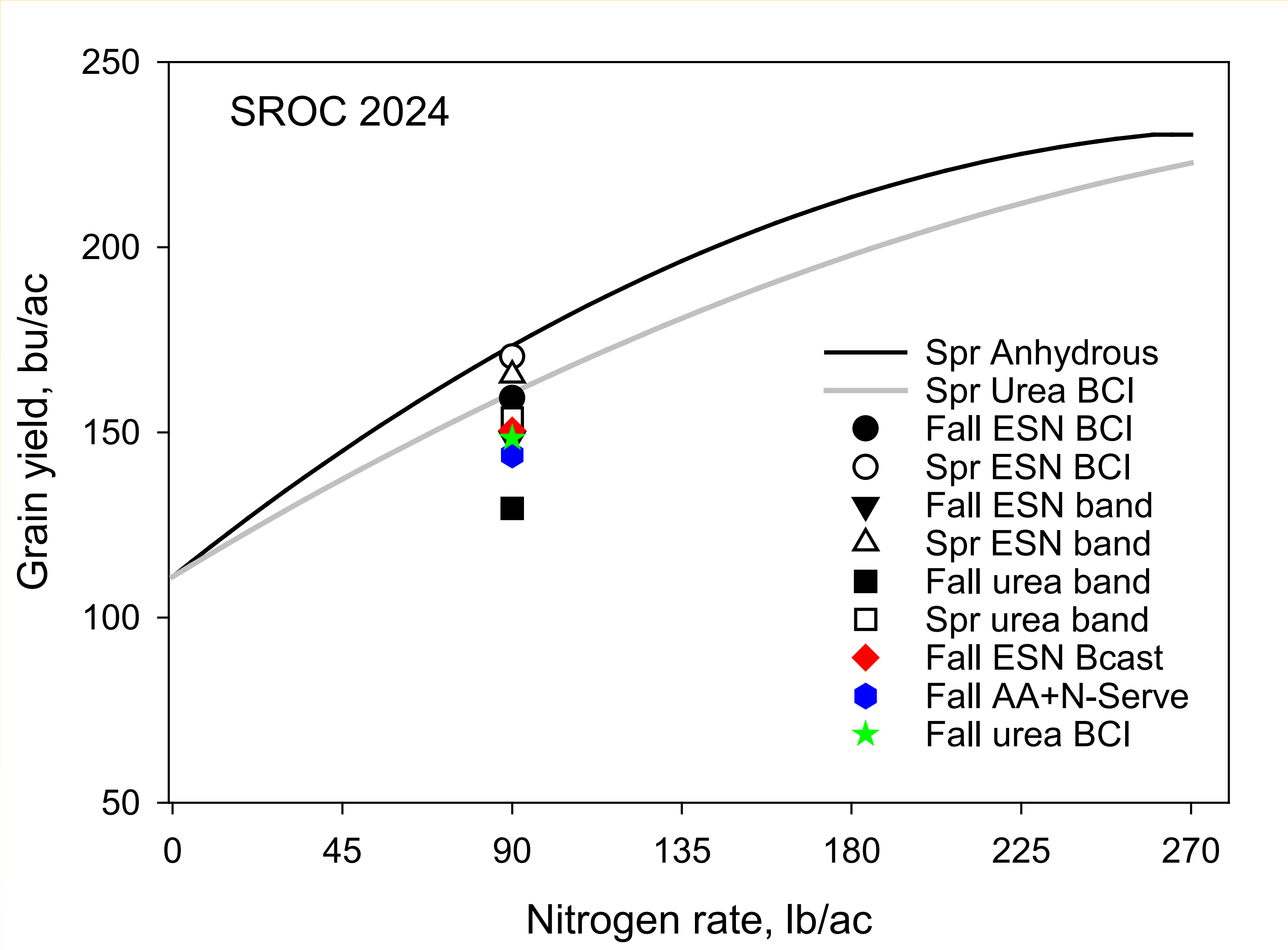
Rate & Source



- **Corn after soybean**
- Economic optimum N rate at $0.50/lb N and $5.00/bu corn.
- Preplant Anhydrous
  - **EONR: 260 lb/ac**
  - **Yield: 230 bu/ac**
- Preplant urea
  - **EONR: 270 lb/ac**
  - **Yield: 222 bu/ac**

Greater yield variability with urea than anhydrous

Time, Source & Placement



ESN broadcast incorp.
Fall and spring

ESN deep band
Fall and spring

ESN broadcast
Fall no incorporation

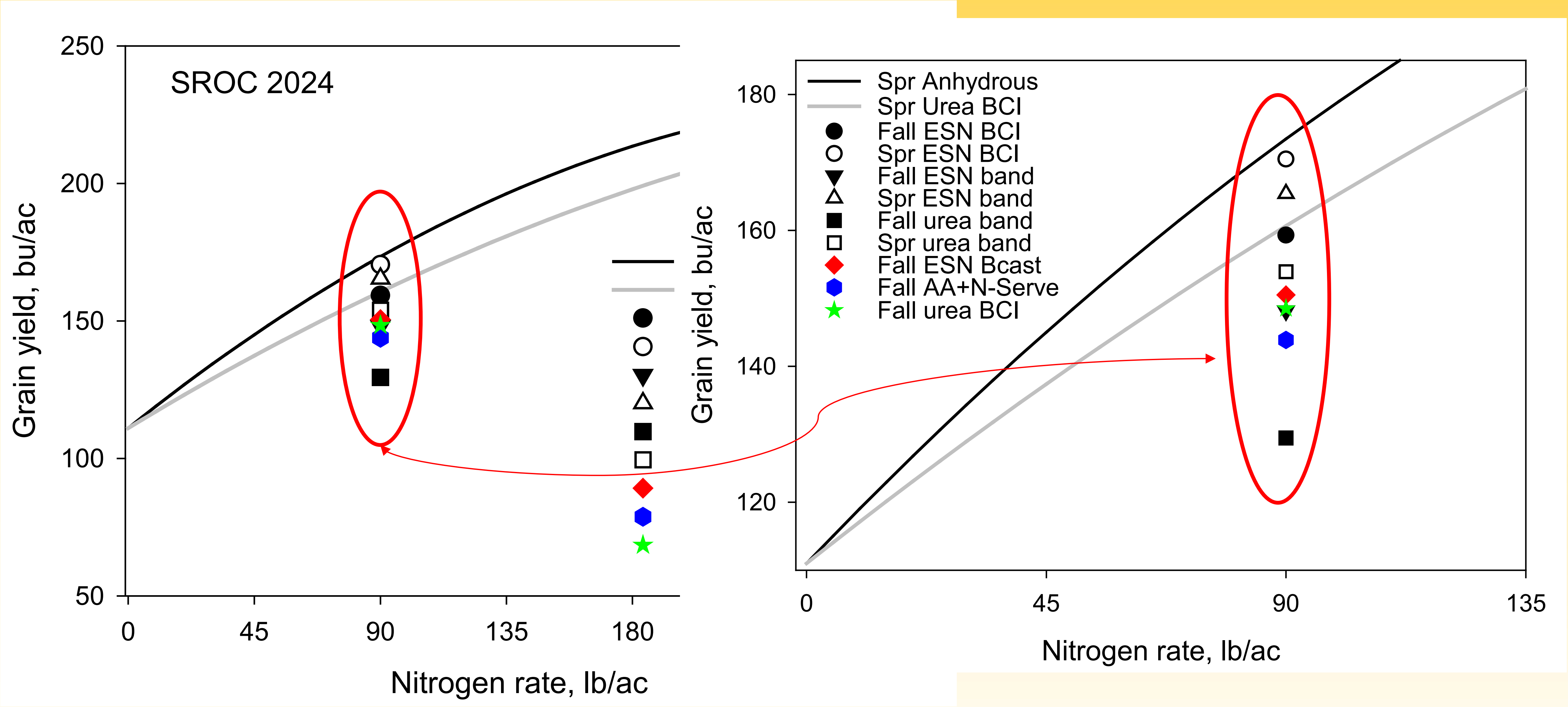
Urea broadcast incorp.
Fall and spring

Urea deep band
Fall and spring

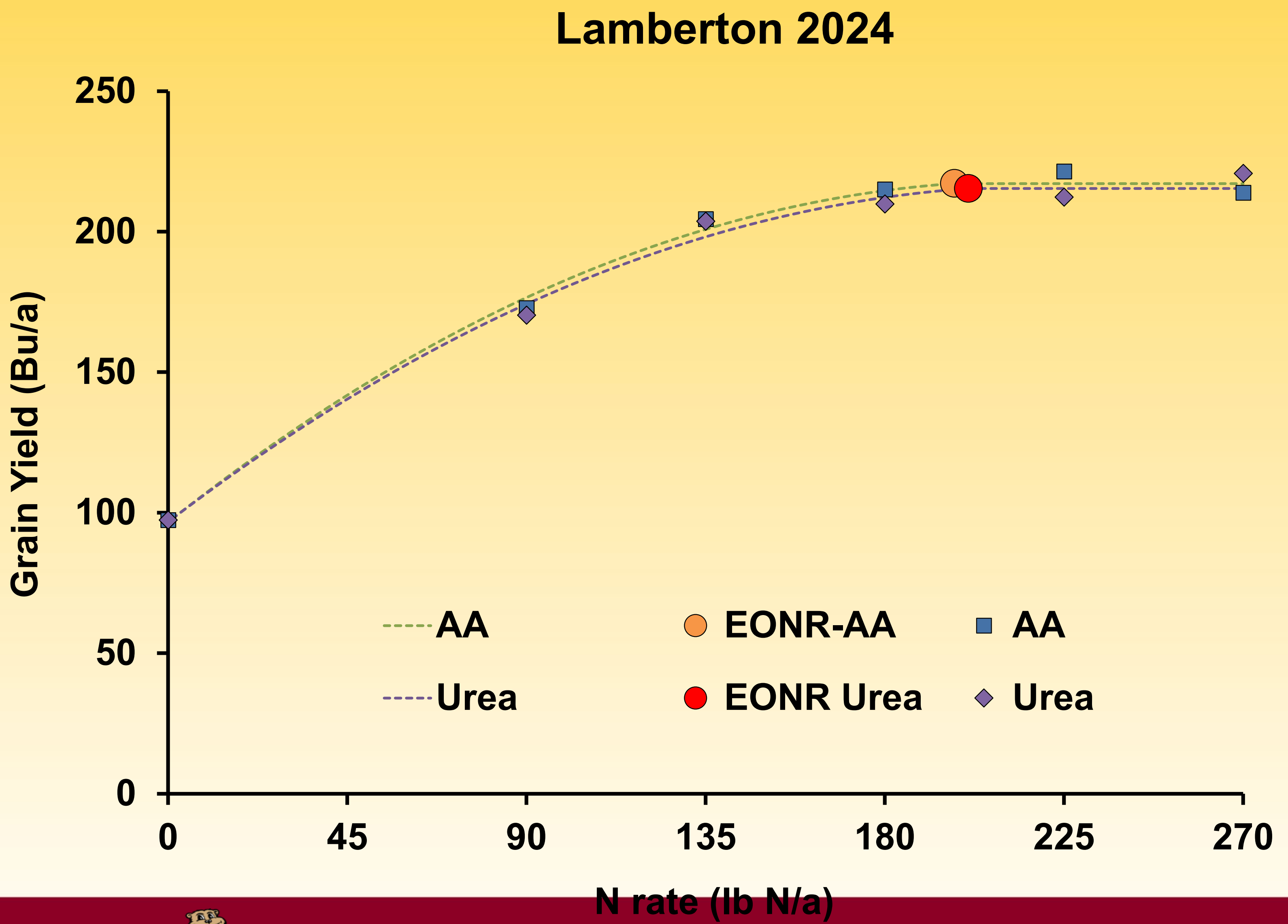
Anhydrous
spring

Anhydrous + N-Serve
Fall

Time, Source & Placement



Rate & Source



- **Corn after soybean**
- Economic optimum N rate at $0.50/lb N and $5.00/bu corn.
- Preplant Anhydrous
  - EONR: 197 lb/ac
  - Yield: 217 bu/ac
- Preplant urea
  - EONR: 201 lb/ac
  - Yield: 215 bu/ac

NO significant differences at 90 lb N/ac

Jeffrey Vetsch, 2018-2025

2016-2020

Time, Source & Placement

Comparison	Time	Occurrence	Percent %	Yield Diff bu ac^{-1}
AA > Urea BI	Fall	18/30	60	49
(combined across w & w/o inhibitor)	Spring	10/31; 1/31*	32; 3	45; -29
AA > Urea SSB	Fall	6/20	30	58
(combined across w & w/o inhibitor)	Spring	6/20; 2/20*	30; 10	32; -49
ESN > Urea BI	Fall	5/27	19	37
	Spring	7/27; 1/27*	26; 4	33; -26
ESN > AA	Fall	0/8; 2/8*	0; 25	; -39
	Spring	2/8	25	29

*Reverse response. All other comparisons were non-significant

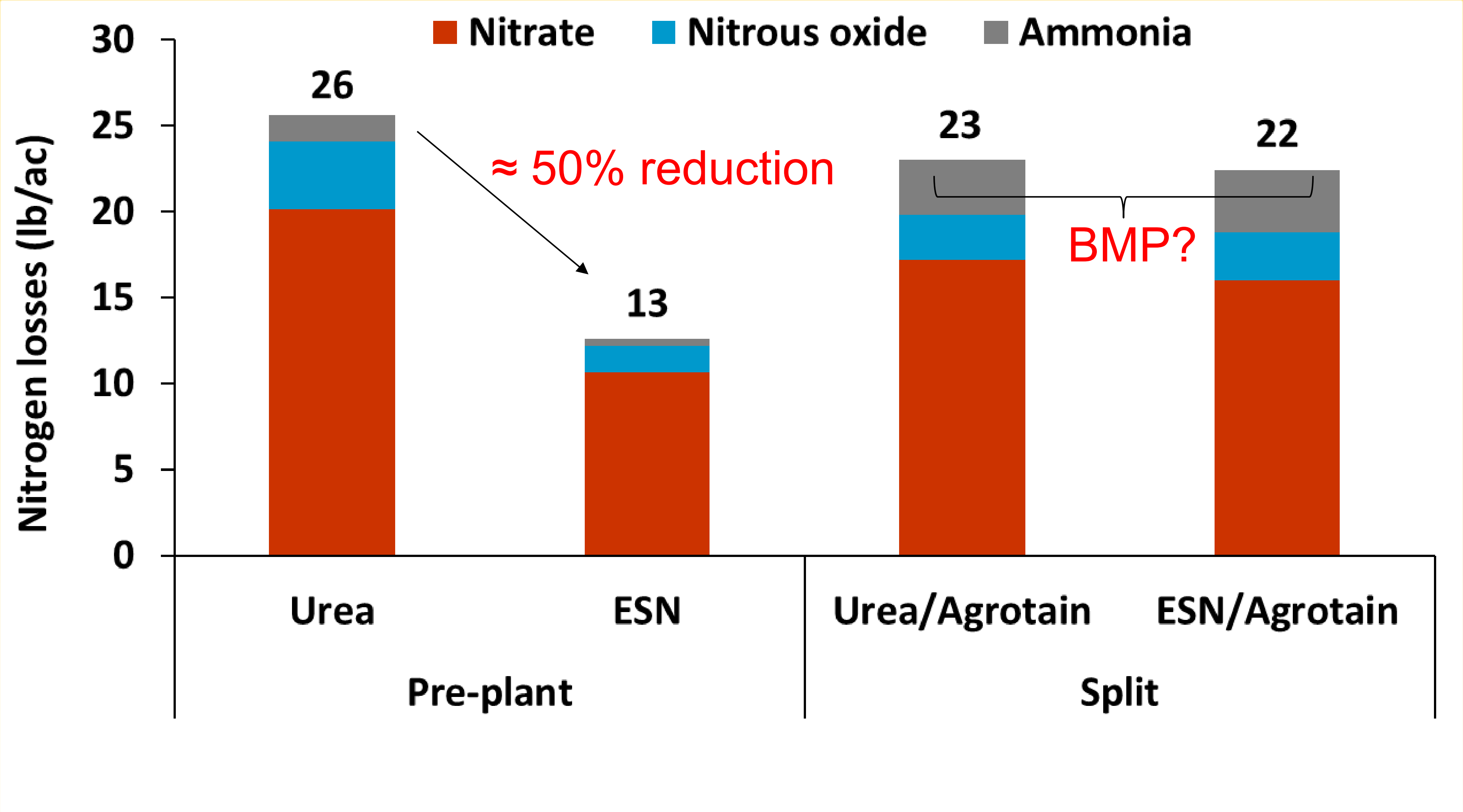
Time & Source

Webster clay loam
7 yr study (2014-2020)

Source	lb N. ac^{-1}	Application timing
Urea	180	Pre-plant
ESN	180	Pre-plant
Urea/Urea+Agrotain	60/120	Pre-plant / Split at V4/V6
ESN/Urea+Agrotain	60/120	Pre-plant / Split at V4/V6

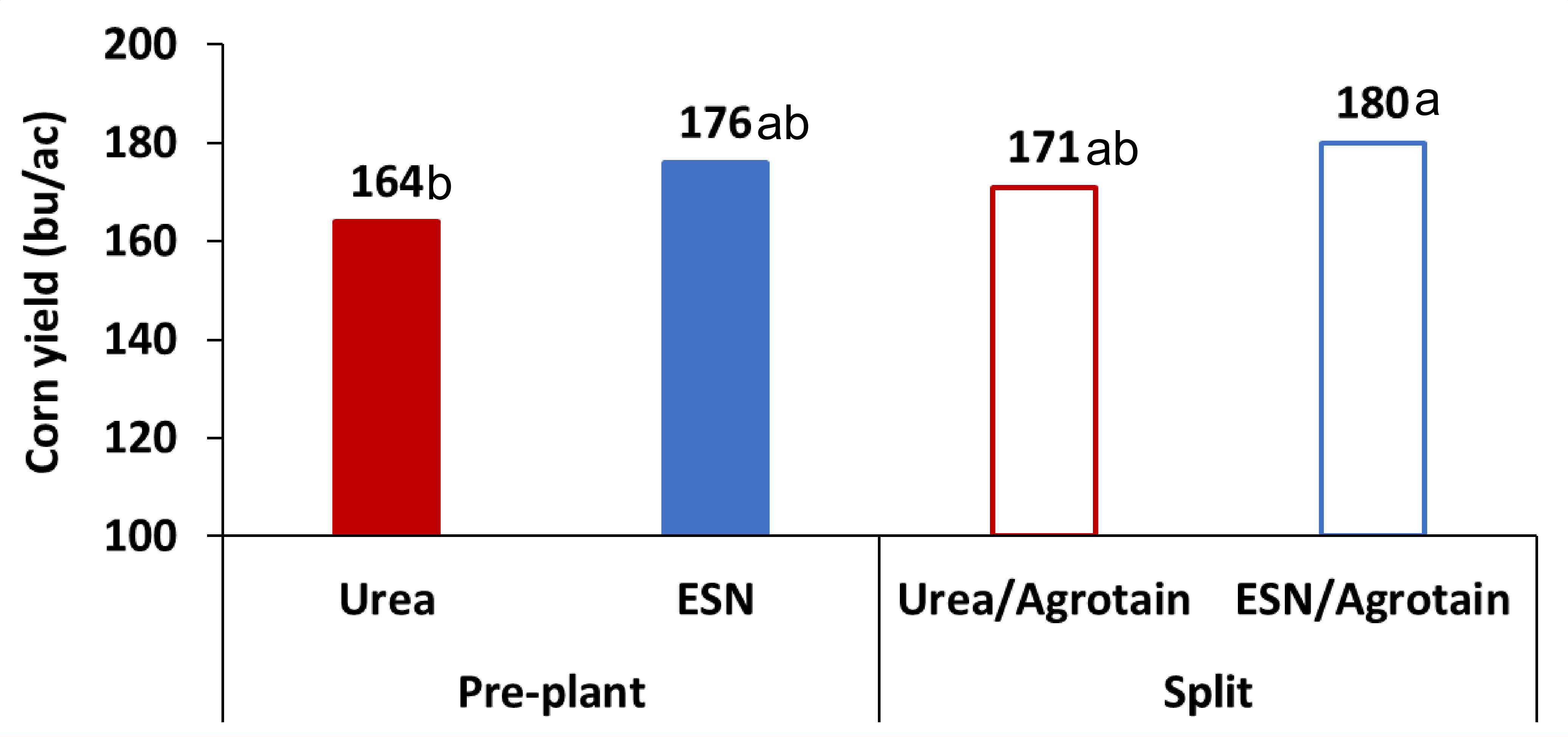
Cumulative Nitrogen losses

Time & Source



Time & Source

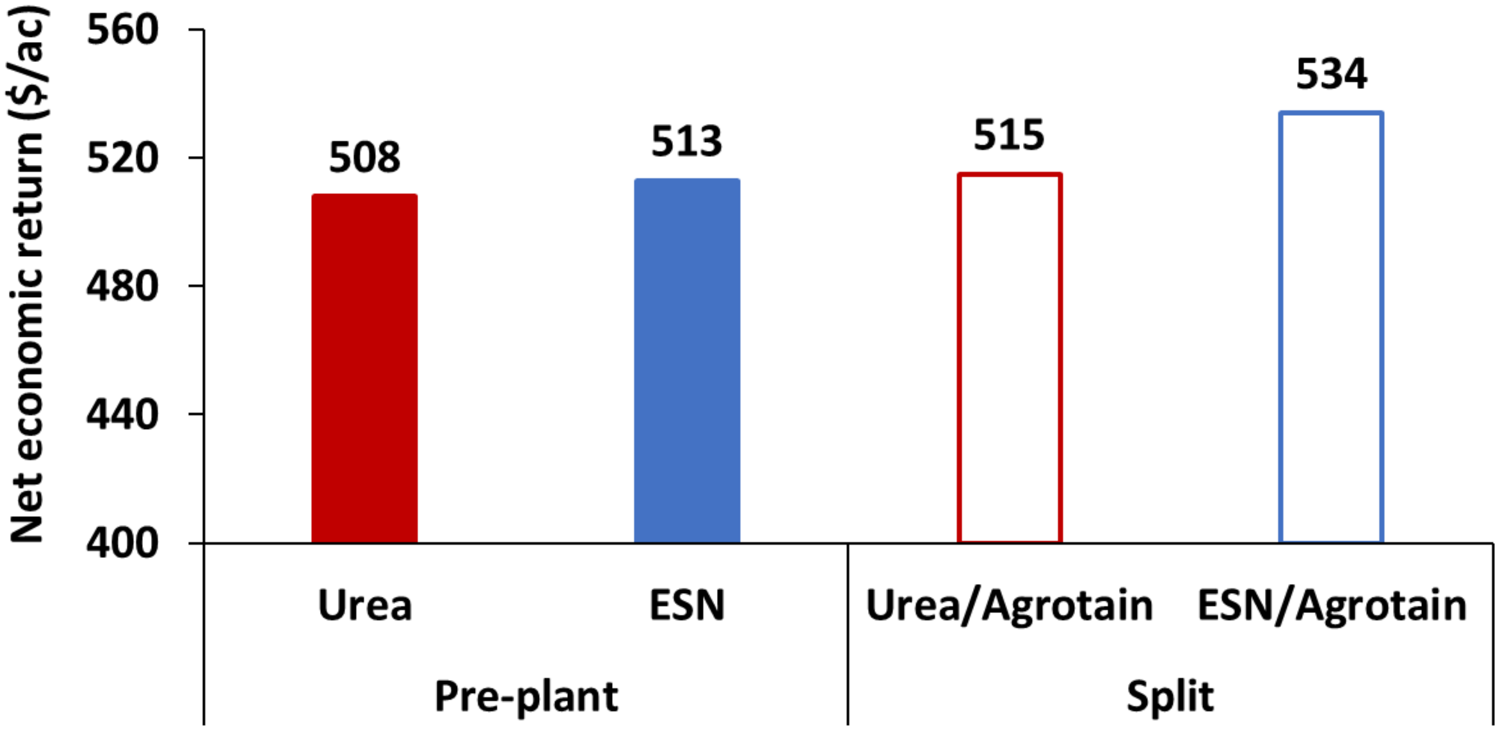
Corn grain yield



Time & Source

Net Economic Return

Cost	$66	$102	$82	$94 /ac
Net return vs urea		+$5	+$7	+$26 /ac



Corn price $3.50 bu^{-1}

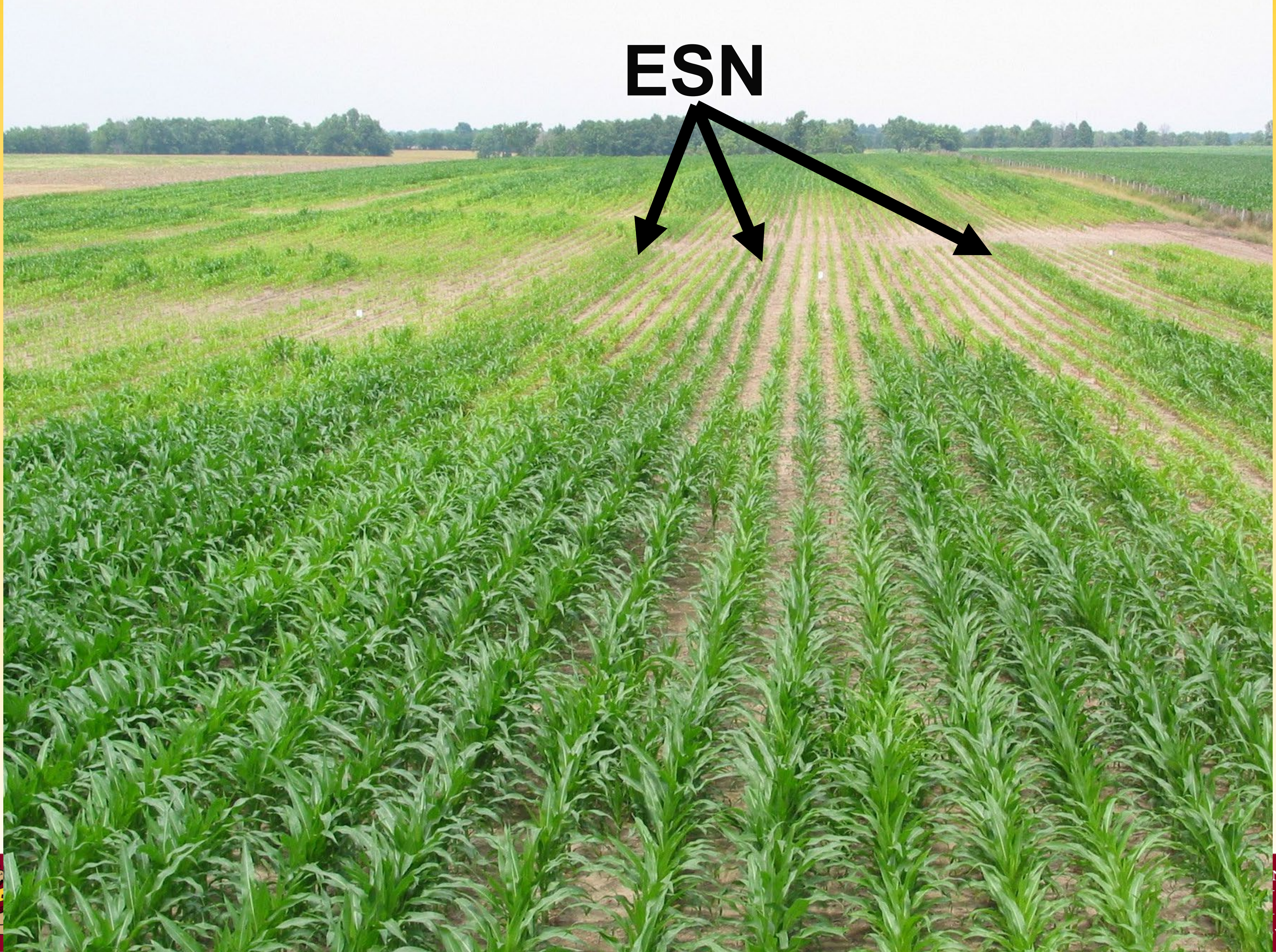
Urea $0.35 $lb\text{-}N^{-1}$

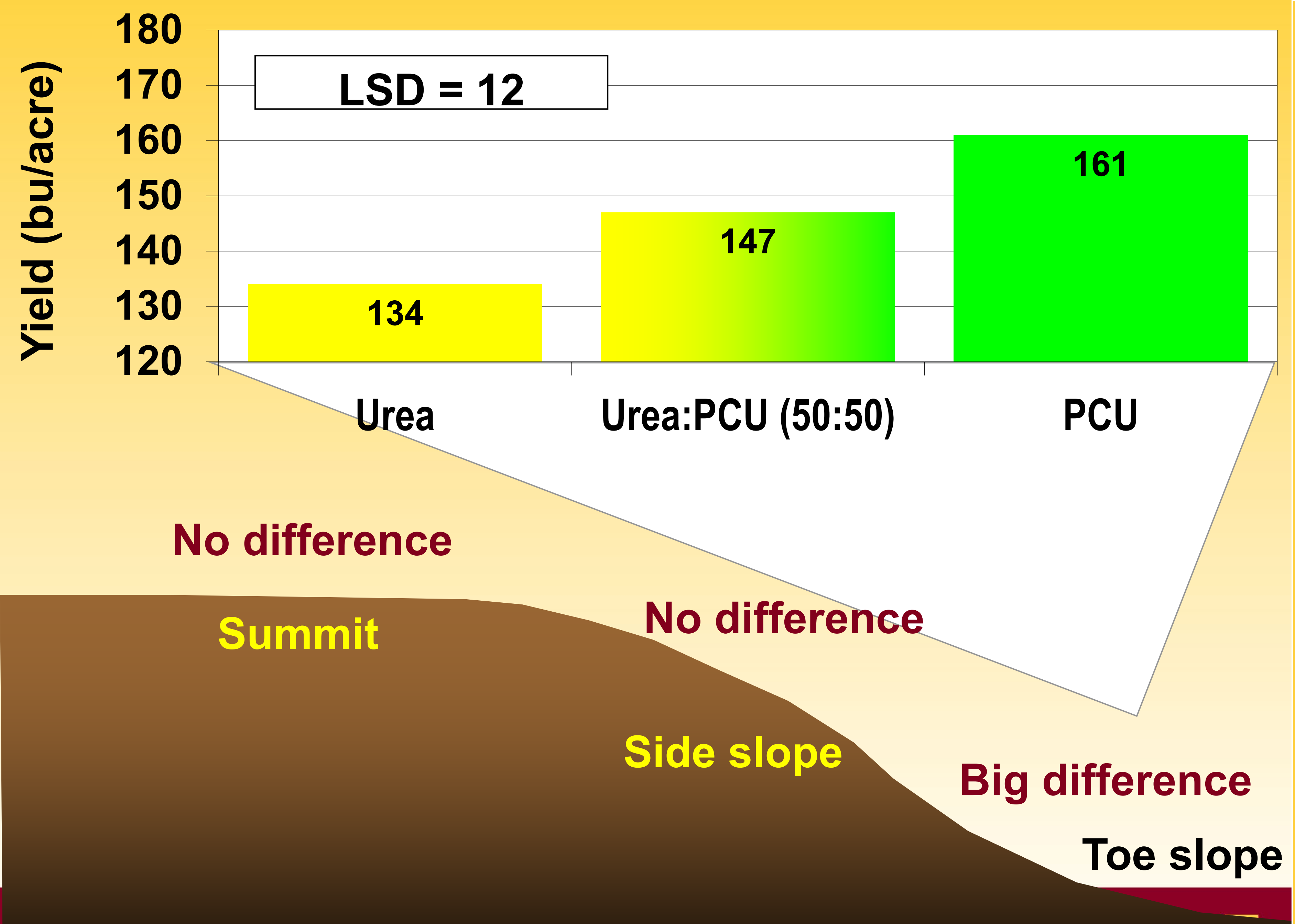
ESN $0.55 $lb\text{-}N^{-1}$

Urea+ $0.39 $lb\text{-}N^{-1}$

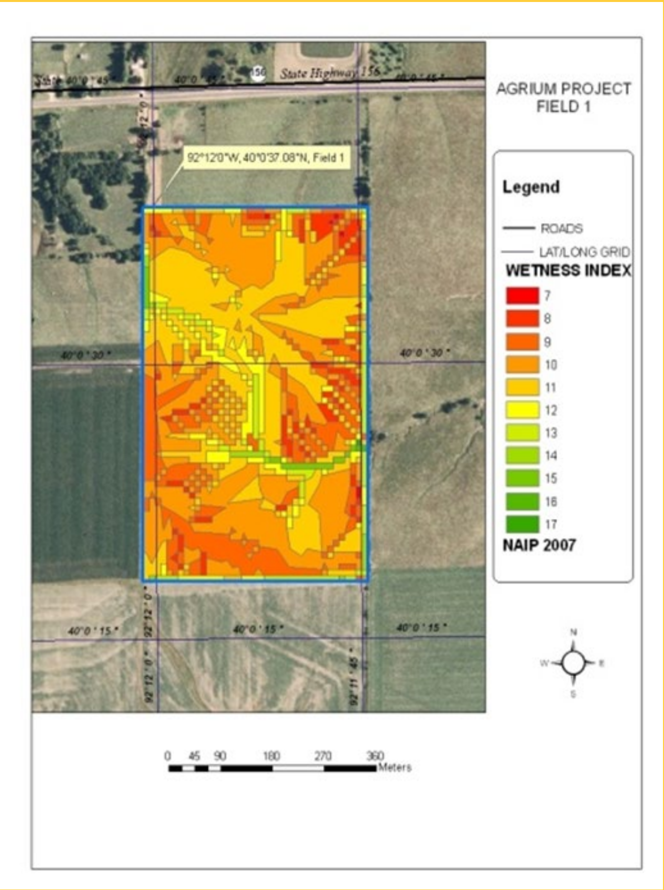
Pre-plant applic. $4.5 ac^{-1}

Split applic.$11.00 ac^{-1}


ESN



Noellsch et al. 2009. *Agron. J.* Conventional tillage. 2005 & 2006



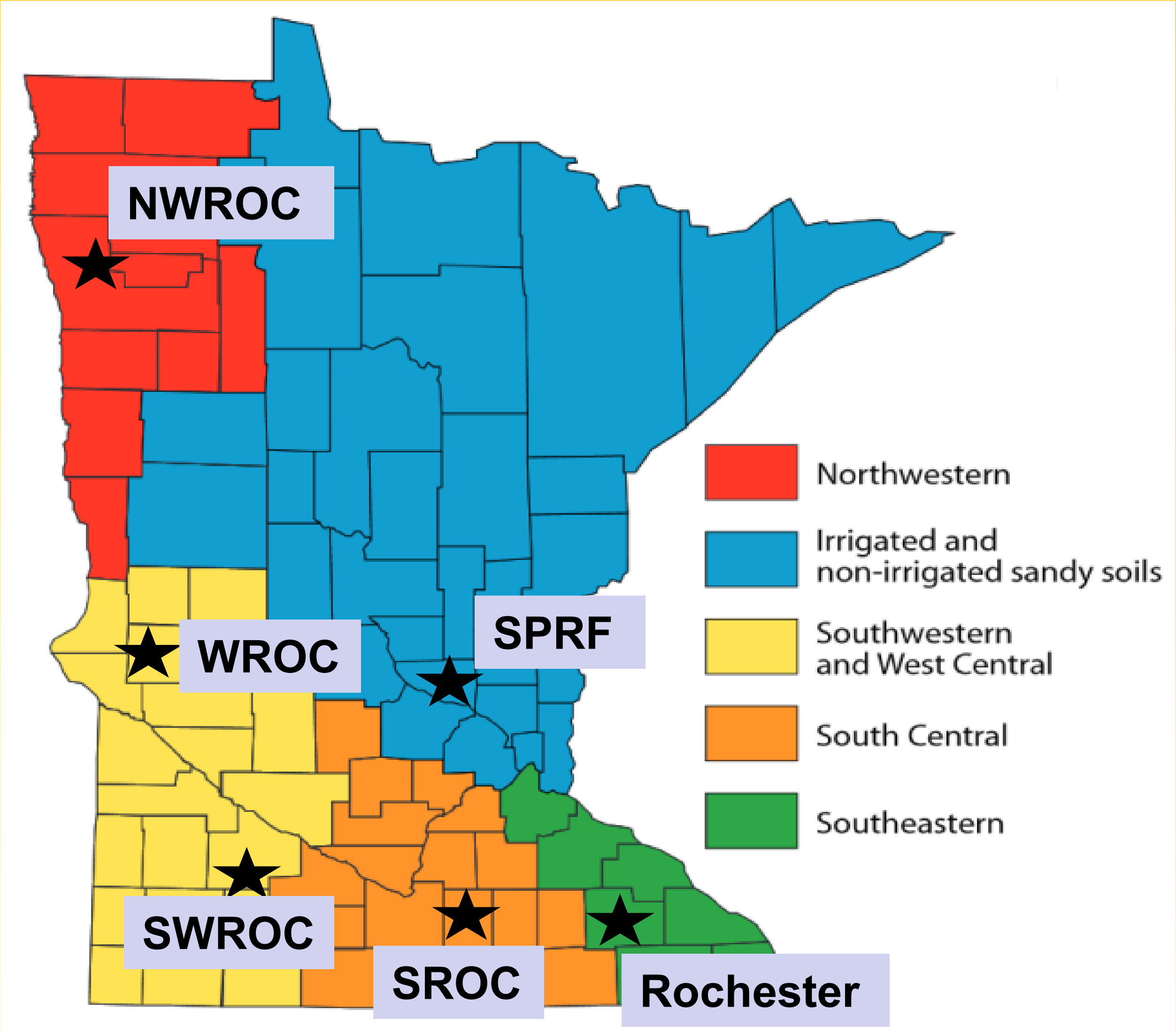
Variable Product Agrochemical Application based on wetness index

Dryland fine-textured sites
(All other sites)
(pre-plant)

- Urea
- 1/3 ESN, 2/3 Urea
- 2/3 ESN, 1/3 Urea

Coarse-textured irrigated site
(Becker)

V2	V6	V10
Urea	Urea	Urea
ESN	Urea	Urea
2/3 ESN	1/3 Urea	xxx



4-yr Mean (2021-2024)

		C-C		C-Sb	
Location	Source	EONR	$Yield_{EONR}$	EONR	$Yield_{EONR}$
		lb N/ac	bu/ac	lb N/ac	bu/ac
Fine	**Urea**	**186**	**156**	**139**	**186**
	Urea+ESN (2:1)	186	157	142	186
	Urea+ESN (1:2)	192	156	145	188

Relative to Urea

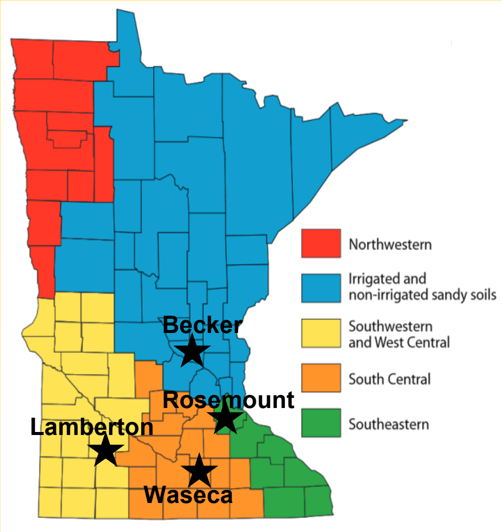
		C-C		C-Sb	
Location	Source	Freq. (%)	N Reduct. (lb /ac)	Freq. (%)	N Reduct. (lb/ac)
Fine	Urea+ESN (2:1)	5/12 (42)	21	6/8 (75)	20
	Urea+ESN (1:2)	3/12 (25)	27	5/8 (63)	24

Nrate (lb N/ac)
0
60
120
180
240

Dryland fine-textured sites

N Source -Preplant
Urea
1/3 ESN + 2/3 Urea
2/3 ESN + 1/3 Urea
ESN

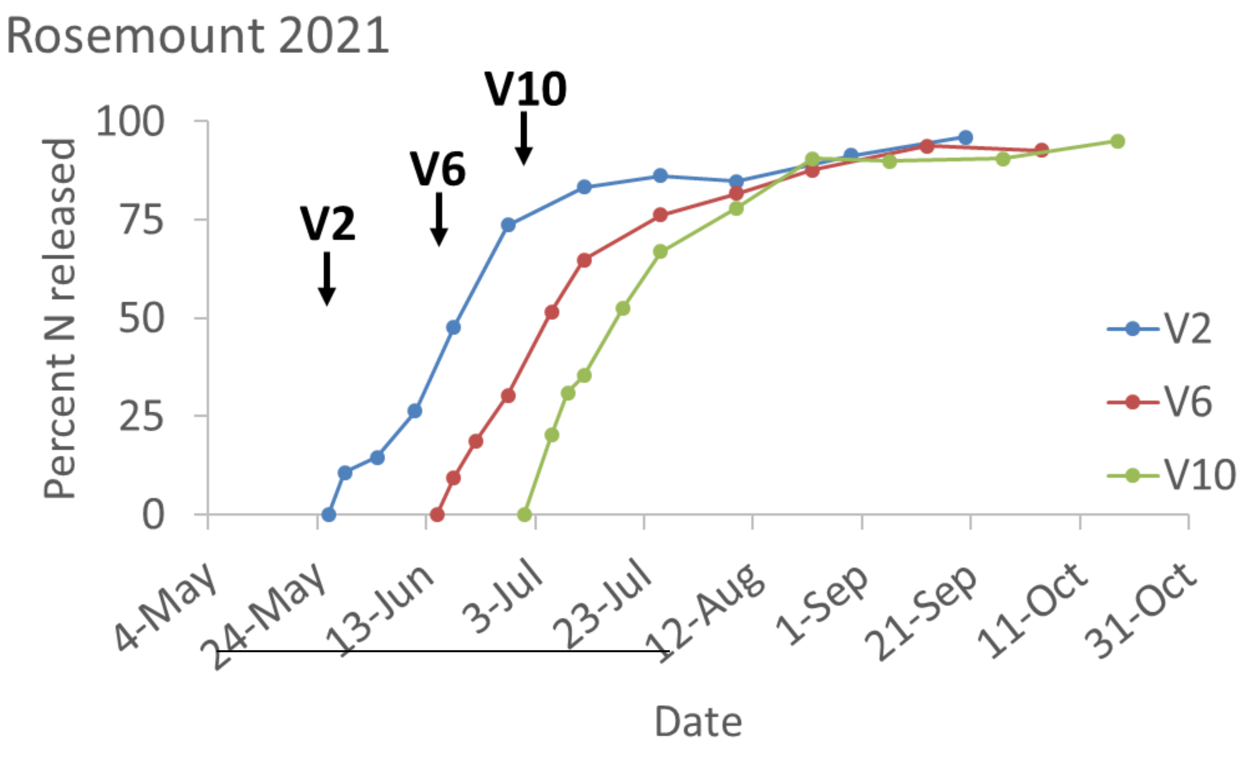
4-yr study (2021-2024)
C-Sb

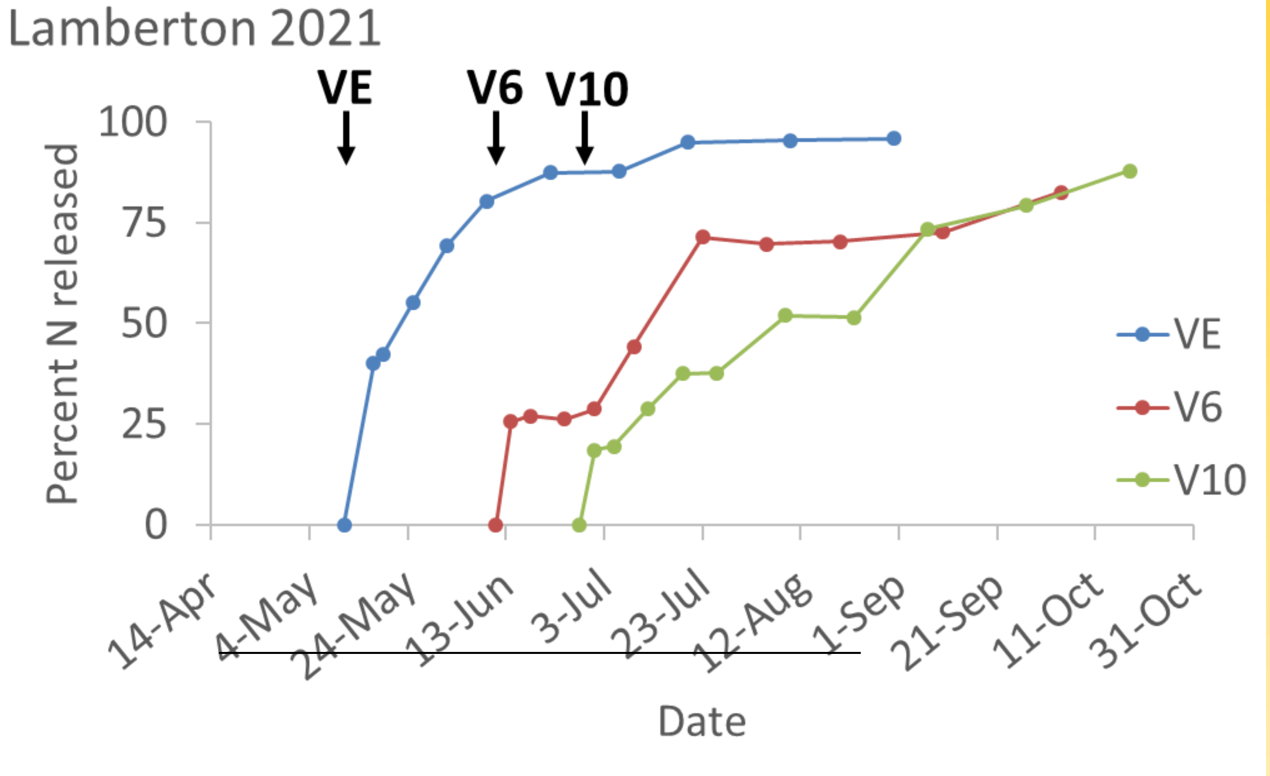


N rate (lb N/ac)
0
80
160
240
320

Irrigated coarse-textured sites

N source		
V2	V6	V10
1/3Urea	1/3Urea	1/3Urea
1/3ESN	1/3Urea	1/3Urea
1/3ESN	1/3ESN	1/3Urea
1/3-(1Urea:2ESN)	1/3-(2Urea:1ESN)	1/3-(Urea)


Rosemount 2021
V2
V6
V10
Percent N released
100
75
50
25
0
4-May
24-May
13-Jun
3-Jul
23-Jul
12-Aug
1-Sep
21-Sep
11-Oct
31-Oct
Date
V2
V6
V10


Lamberton 2021
VE
V6
V10
Percent N released
100
75
50
25
0
14-Apr
4-May
24-May
13-Jun
3-Jul
23-Jul
12-Aug
1-Sep
21-Sep
11-Oct
31-Oct
Date
VE
V6
V10

Fine-textured soils- across years (2021-2024)

------Nitrogen Blend-----	Waseca			Lamberton		
	EONR	Yield	Net return	EONR	Yield	Net return
Preplant	lb N/ac	bu/ac	$/ac	lb N/ac	bu/ac	$/ac
Urea	181	194	792	211	196	763
1/3 ESN - 2/3 Urea	168	193	790	128	179	740
2/3 ESN - 1/3 Urea	165	192	795	146	182	729
ESN	185	193	784	200	193	729

Prices: **Urea** 0.54, 1.03, 0.85 $/lbN; **ESN** 0.76, 1.25, 1.07 $/lbN; **Corn** $5.22, 6.64, 4.9$/bu for 2021,2022, and 2023 respectively

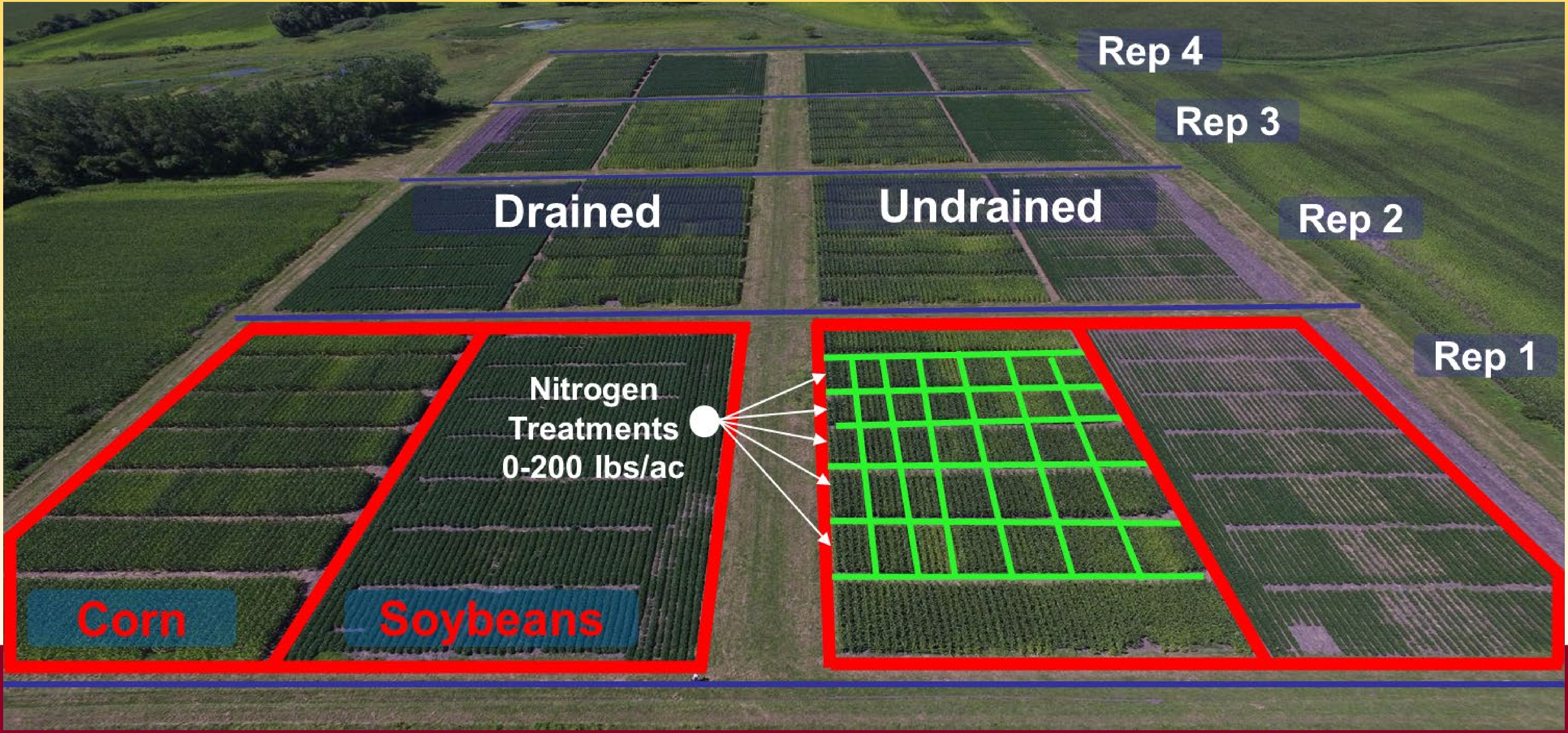
Fine-Textured Soils Treatments Compared at 120 lbs N/ac

------Nitrogen Blend------		Waseca					Lamberton				
		2021	2022	2023	2024	Net return	2021	2022	2023	2024	Net return
Preplant	**V6**	Bu/ac				$	Bu/ac				$
Urea		161	212 bc	170	153 b	**811**	124 abc	182	162	213 c	**784**
1/3 ESN - 2/3 Urea		157	206 c	157	148 b	**765**	128 ab	178	162	229 bc	**714**
2/3 ESN - 1/3 Urea		158	225 a	161	166 ab	**813**	131 a	183	162	236 abc	**766**
ESN		161	219 ab	154	169 ab	**792**	127 ab	186	161	211c	**765**
1/3 ESN	2/3 Urea	162	222 a	156	185 a	**818**	112 d	172	163	266 a	**772**
2/3 ESN	1/3 Urea	158	216 ab	162	178 a	**800**	116 bcd	181	141	227 bc	**753**
1/3 - Urea + ESN (1:1)	2/3 - Urea + ESN (0.25:0.75)	164	224 a	157	175 a	**814**	115 cd	178	155	253 ab	**747**
Mean		160	218	160	168	**802**	115	178	155	224	**757**
* P< 0.10											

Prices: Urea 0.54, 1.03, 0.85, 0.64 $/lbN; **ESN** 0.76, 1.25, 1.07, 0.86 $/lbN; **Corn** $5.22, 6.64, 4.90, 4.05 $/bu for 2021,2022, 2023 and 2024 respectively

Soil Drainage

720 10x30’ plots
Farmer field near Wells, MN



Year	Timing	EONR (lbs N/ac)		Yield @ EONR (bu/ac)	
		Drained	Undrained	Drained	Undrained
2014	PL	149	128	188	186
2015	PL	108	200	214	212
2016	PL	92	121	217	223
2017	PL	155	200	217	214
2018	PL	200	200	237	204
2019	PL	120	200	177	196
Mean	PL	138	175	209	206
2014	SP	--	--	--	--
2015	SP	140	160	217	209
2016	SP	78	160	215	226
2017	SP	200	200	225	206
2018	SP	173	167	228	210
2019	SP	157	157	204	186
Mean	SP	150	169	218	207

- **In favorable conditions Undrained soils can be as productive and profitable as drained**
- **Split applications are as effective as single pre-plant applications**

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- **In wet years drained soils are more productive and profitable**
- **Split applications result in less N needed**

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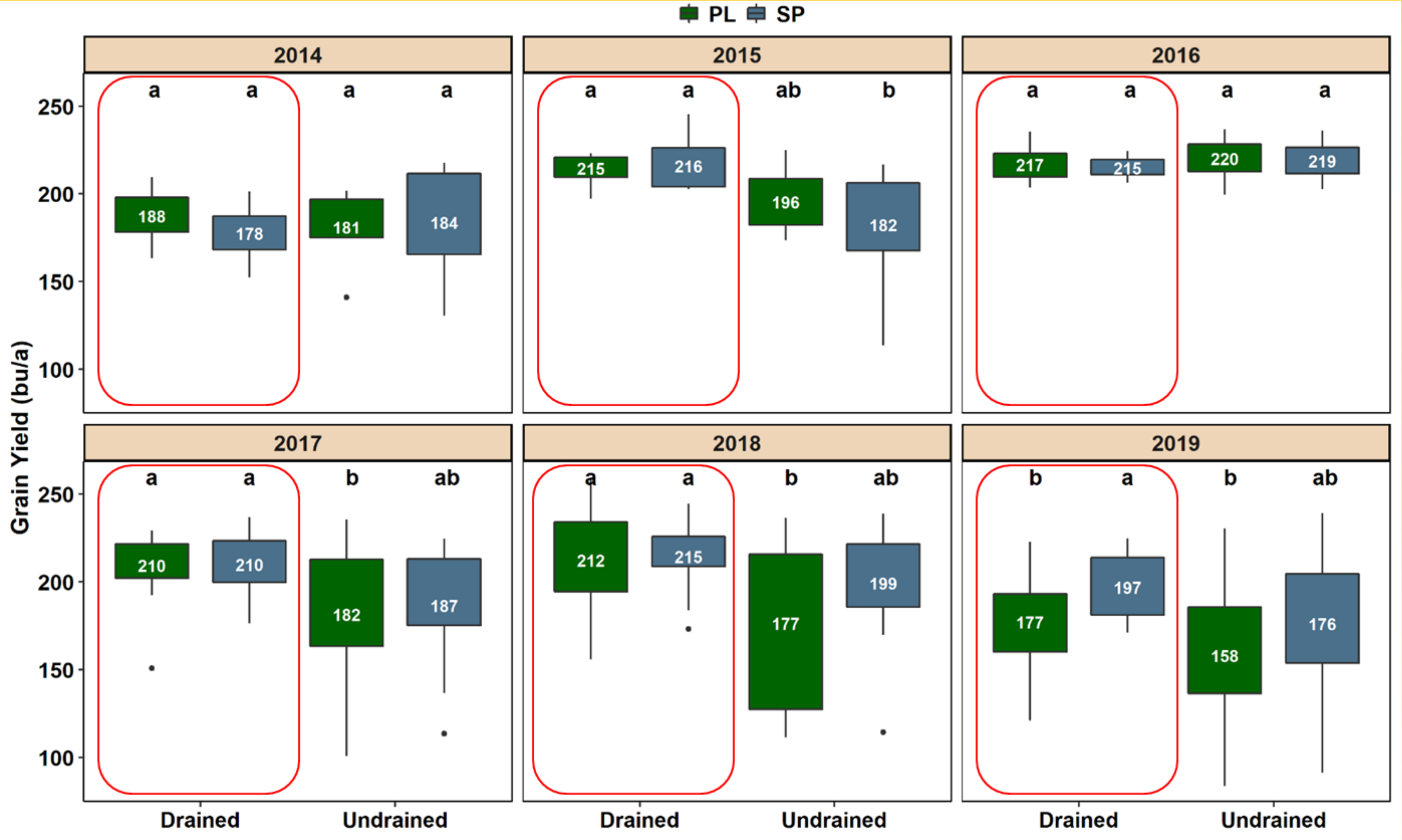
- Split applications result in less N needed

- **Regardless of timing, undrained soils need 28 lb/ac more N and have lower NUE**
- **Drainage reduces N needed by 11% and increases corn yield by 5% relative to undrained soils**
- **Pre-plant applications are adequate for drained soils (14 lb N/ac more with split)**
- **Split applications can be better for undrained soils (14 lb N/ac more with preplant)**

Corn Yield More Variable in Undrained Soil



Nutrient Management

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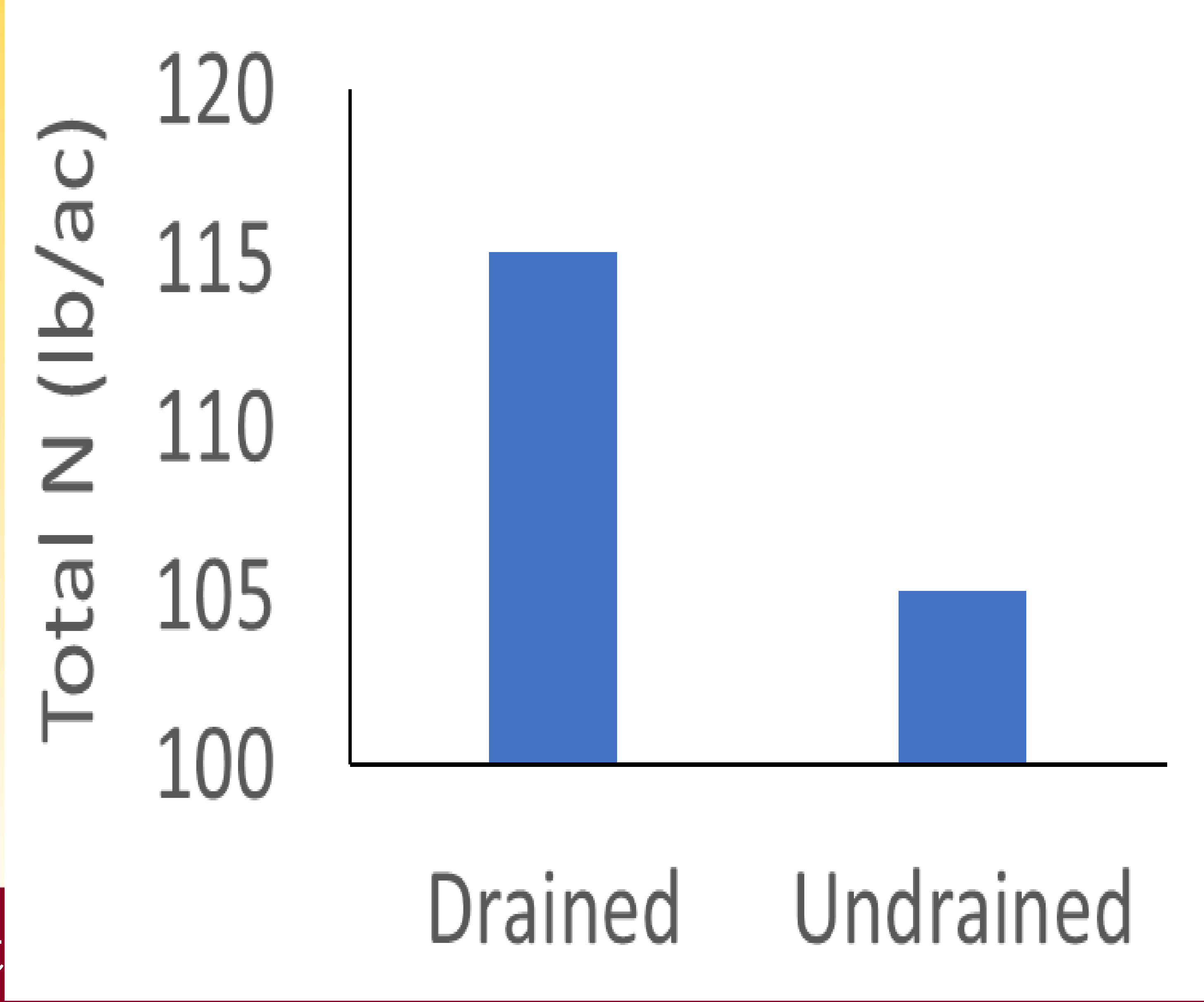
Relatively Greater N Loss in Undrained Soil



Profitability of Growing Corn in Drained vs. Undrained Conditions

Measurement	Unit	Drained		Undrained		D-Un Difference	
		PreP	Split	PreP	Split	PreP	Split
EONR	lb N/ac	135	150	184	169	-49	-19
Yield at EONR	bu/ac	212	218	210	208	2	10
Margin at EONR	$/ac	$792	$798	$763	$750	29	48
MRTN	lb N/ac	130	130	130	130	0	0
Yield at MRTN	bu/ac	204	206	182	192	22	14
Margin at MRTN	$/ac	$763	$759	$675	$705	88	54

Assuming price of $6.80 bu/ac for corn and $0.90/lb N.
Assuming cost of sidedress application of $12/ac

Thank You

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“Probing Our Country’s Soil Health”

- **What you would need to do:**
- During a 45 to 60 minute Zoom interview, share general information for how 2 or 3 fields from your operation have been managed.
- Grant access to fields for hand-probe soil sampling, typically 2 or 3 sampling sites from each field.
- Sampling will typically occur within 3-6 months of the survey, and you will be notified prior to when that will happen

- **Participants will receive:**
- A personalized soil health report of their field(s).
- A copy of a book called “Probing Our Country's Soil Health”. This will be a hard-copy photo book illustrating soil health across the country and the outcomes to this project.
- An appreciation gift card

Main product: a tool to better manage soils called Soil Health Assessment Protocol and Evaluation (SHAPE)

Coordinated Educational Program for Nutrient Management in Minnesota

University of Minnesota
EXTENSION

MAWRC
MINNESOTA AGRICULTURAL WATER RESOURCE CENTER

Nitrogen Conference

Tuesday, February 4, 2025 in Mankato
More info: **z.umn.edu/Ncon**

Nutrient Management Conference

Tuesday, February 18, 2025 in Saint Cloud
More info: **z.umn.edu/NMcon**