Proceedings of the 2nd Annual Nitrogen: Minnesota's' Grand Challenge & Compelling Opportunity Conference

Improved Nitrogen Efficiency Through N Source, Additives, and Time of Application

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Nitrogen Cycle

Loss Pathways

Leaching (NO_3^-)

Denitrification (NO_3^-)

Volatilization (NH_3)

Immobilization (tie-up)

Inputs

Fertilizer

Manure

Mineralization

Atmospheric Fixation

Nitrification

$NH_4^+ \xrightarrow{\text{Nitrosomonas}} NO_2^- \xrightarrow{\text{Nitrobacter}} NO_3^-$

Assimilation

Plant uptake of N

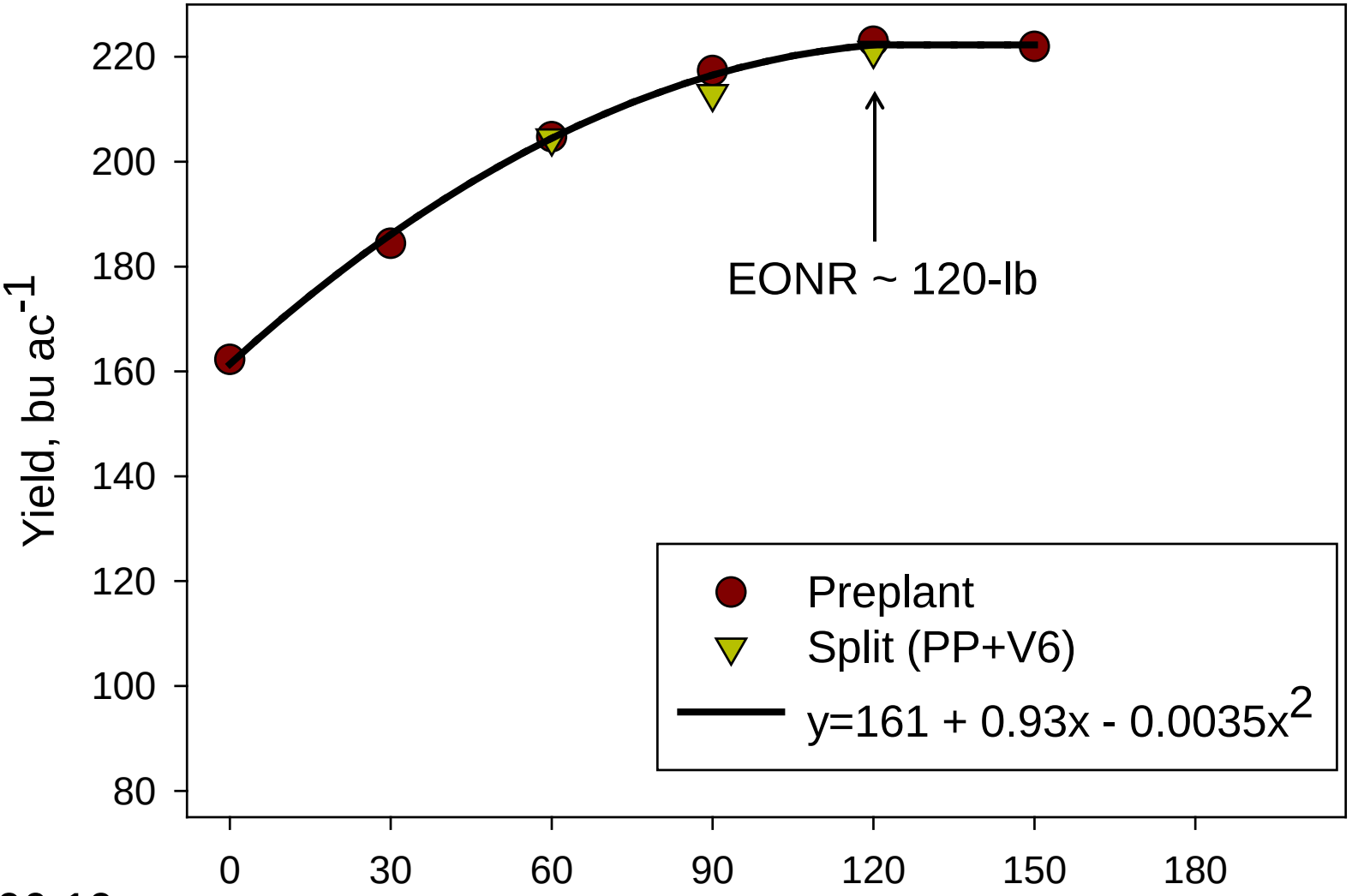

Randall

Management practices that affect nitrogen (N) loss, crop yield and NUE

1. Rate of N application
2. Time of N application
3. Source of N (placement)
4. Nitrification inhibitors and
5. Enhanced efficiency fertilizers, EEF

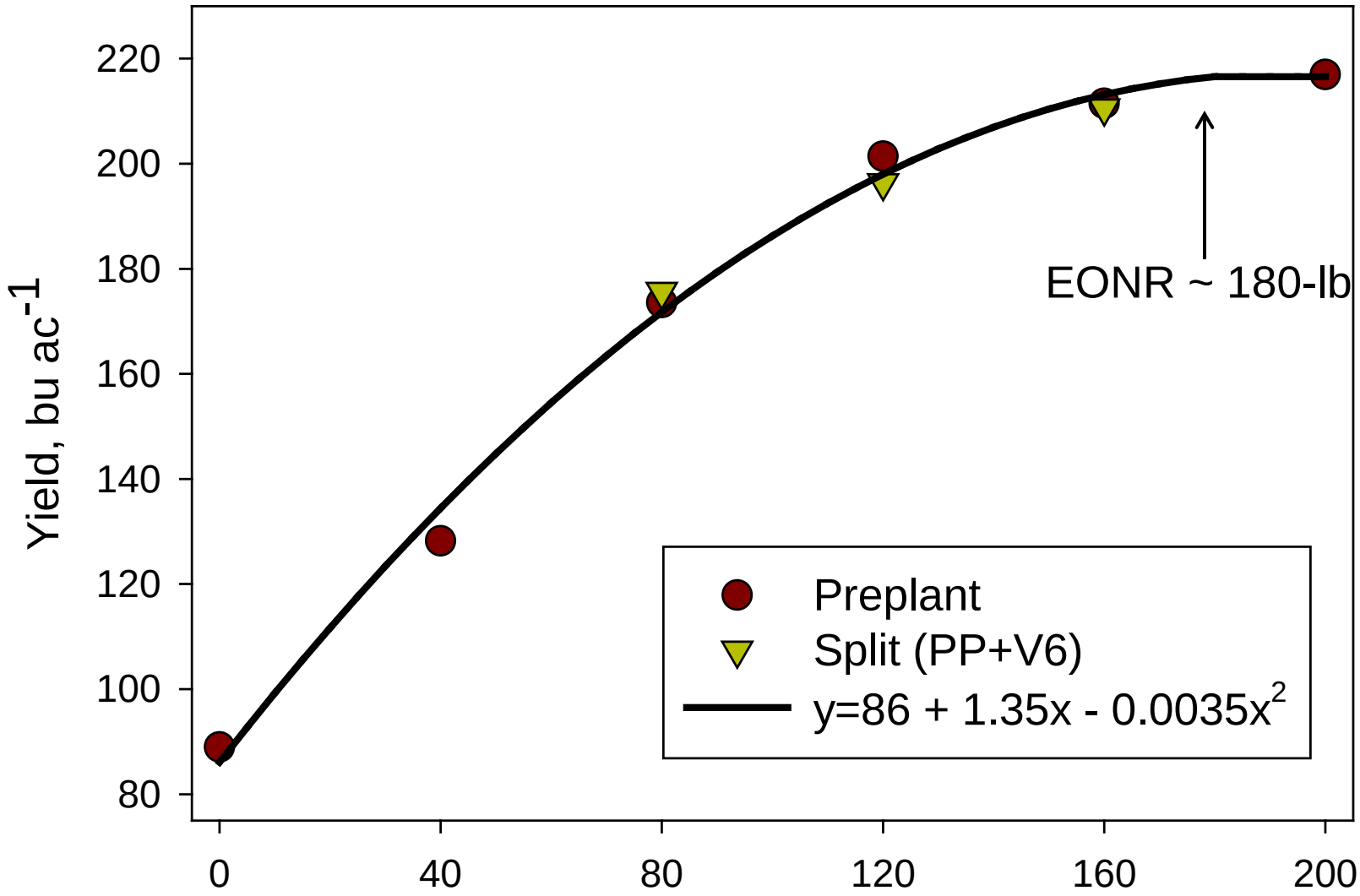
   Generally the 4R's

Corn grain yield following soybean as affected by N rate and application timing (Port Byron sil)



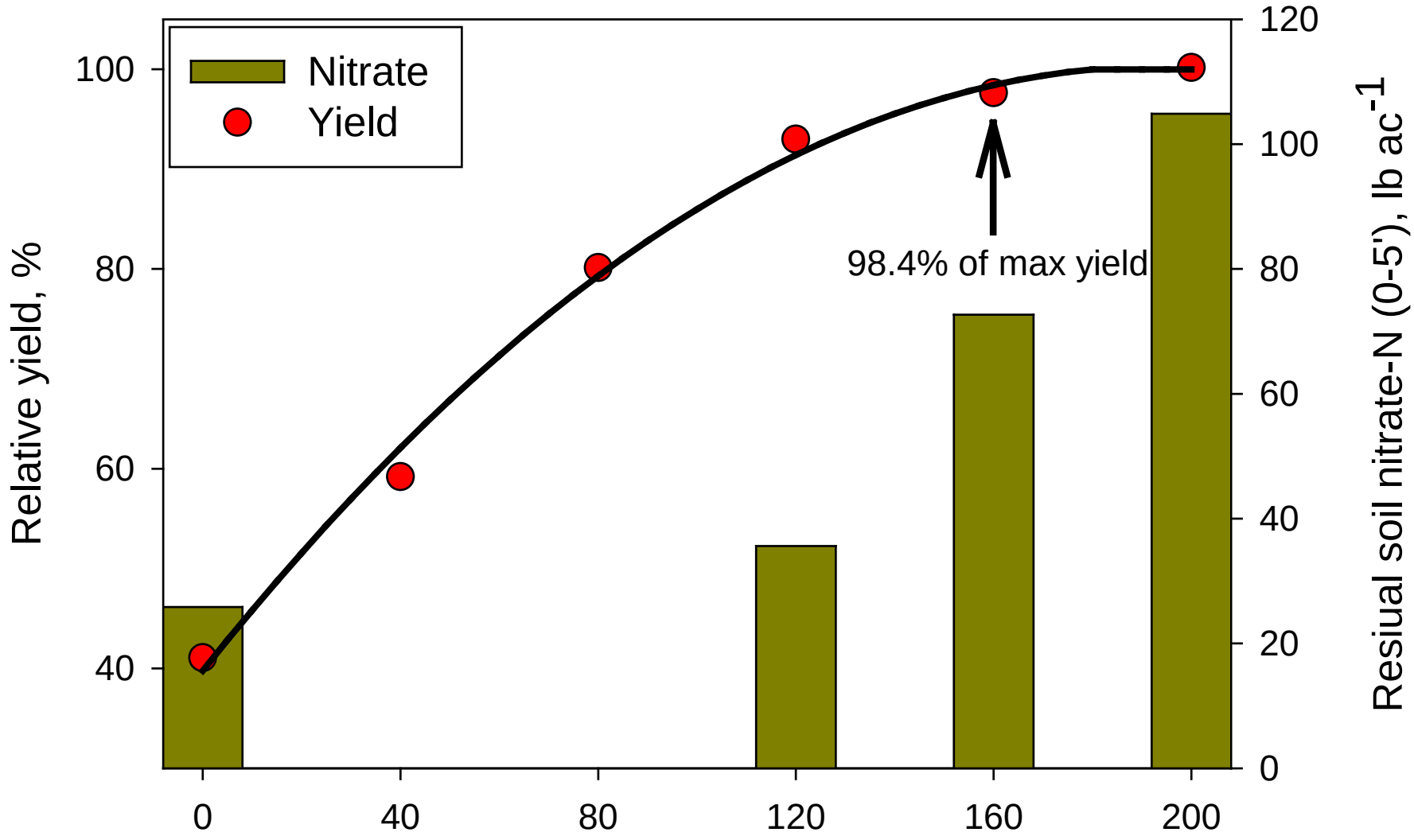
2006-10 average,
Olmsted County

Corn grain yield following corn as affected by N rate and application timing (Port Byron sil)



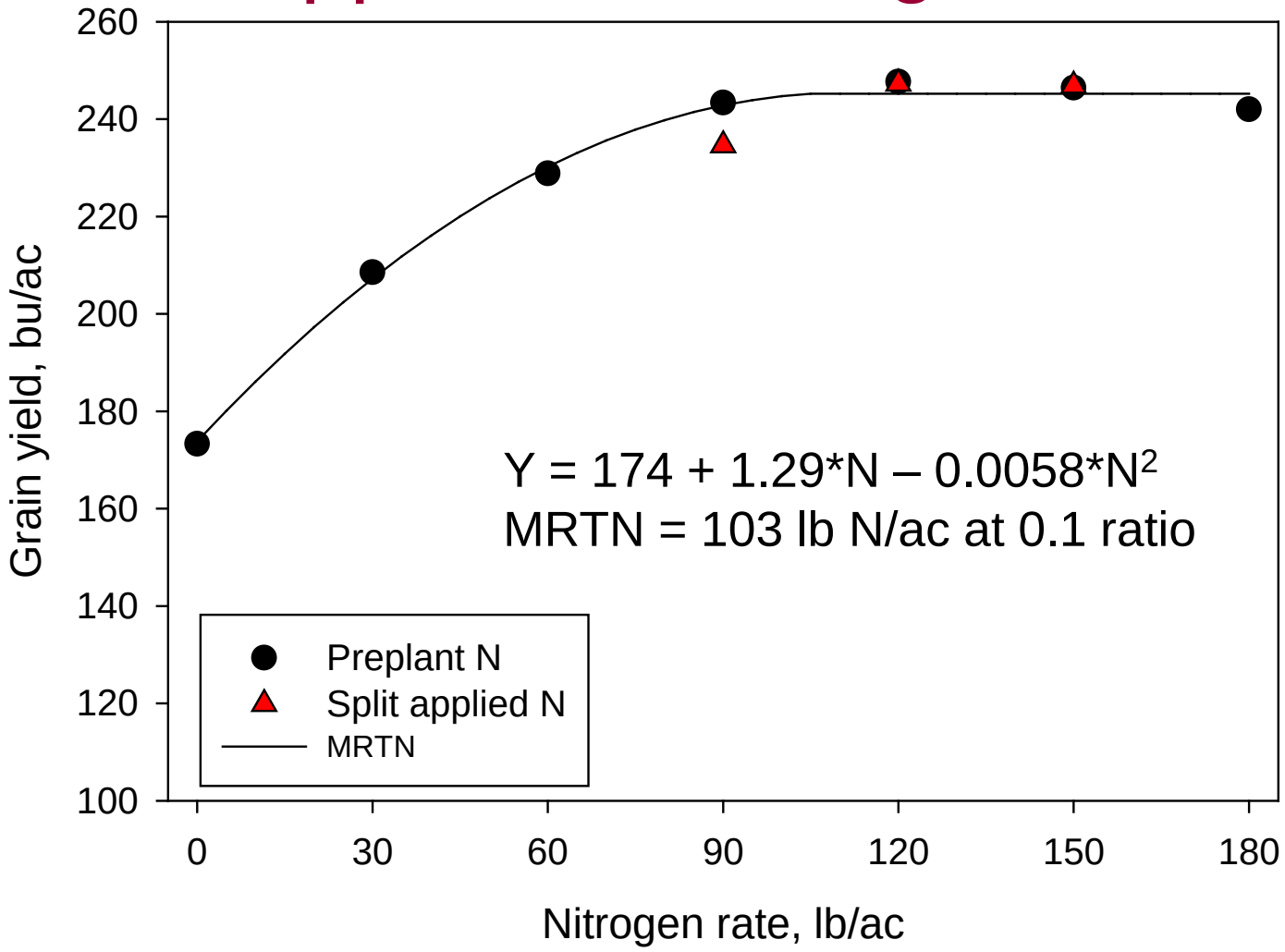
2007-10 average,
Olmsted County

Relative corn yield following corn & residual soil NO_3 (0-5' depth) as affected by N rate (Port Byron sil)



2007-10 average,
Olmsted County

Corn after soybean yields as affected by N rate and application timing in Mower Co.



Background on Instinct

- Instinct™ is an encapsulated formulation of the nitrification inhibitor nitrapyrin (same active ingredient in N-Serve™).
- The encapsulation is designed to:
  - Protect the inhibitor from volatilization loss and fixation on clay particles and organic matter.
  - Allow it to remain on the soil surface for up to 10 days before incorporation (0.5” rain or mechanical).

UAN Instinct™ study at Waseca

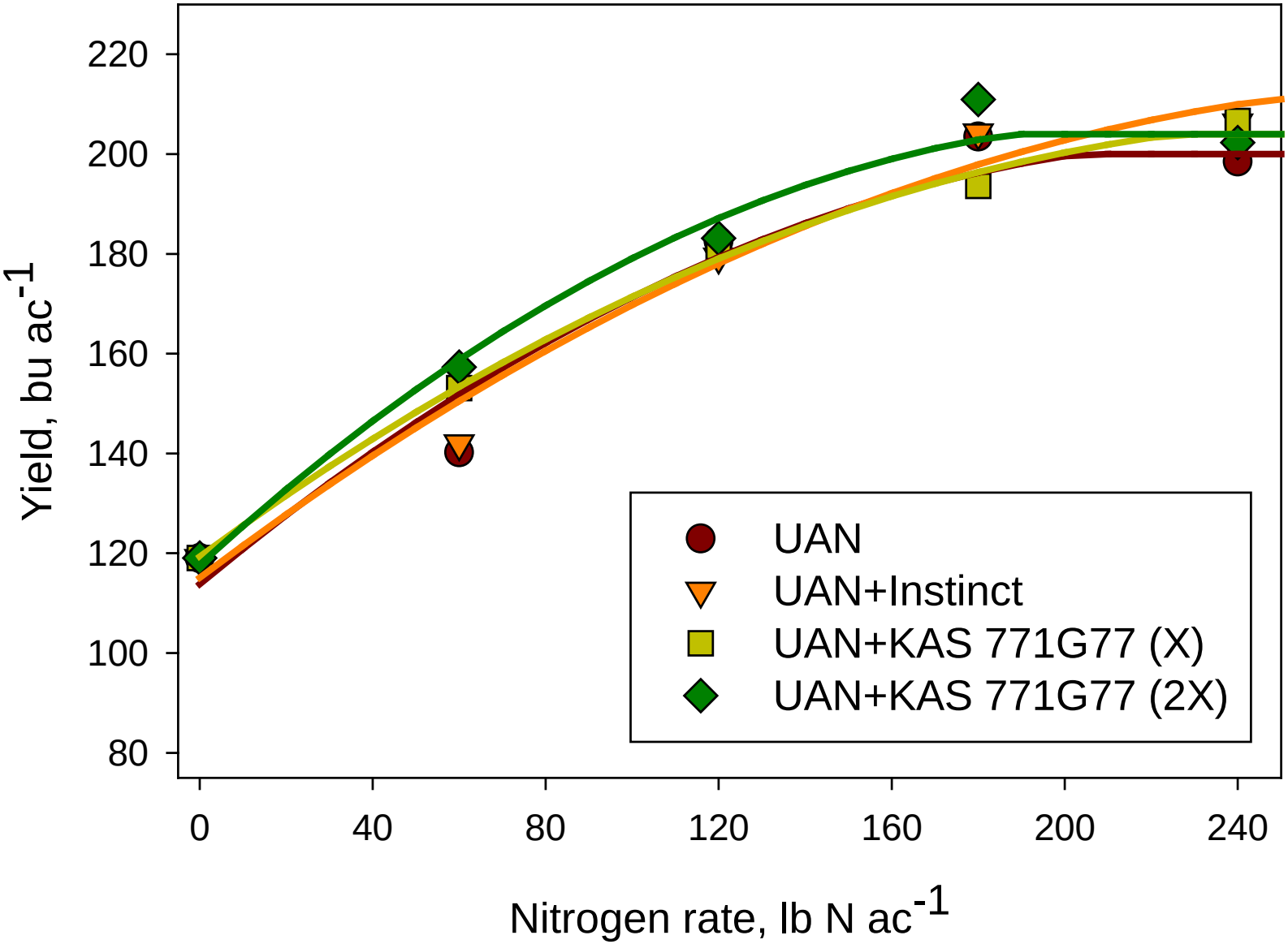
- Treatments (4)
  - Two N rates (80 and 120 lb N/ac) with and without Instinct at 35 oz/ac
  - Corn after corn in 2009, corn after beans in 2008 and 2010
  - Generally, below normal growing season precipitation in 2008 and 2009.
  - Record June + July precipitation in 2010
  - Nicollet/Webster clay loam soils at Waseca

Corn yield and relative leaf chlorophyll content as affected by UAN (PPI) with and without Instinct™.

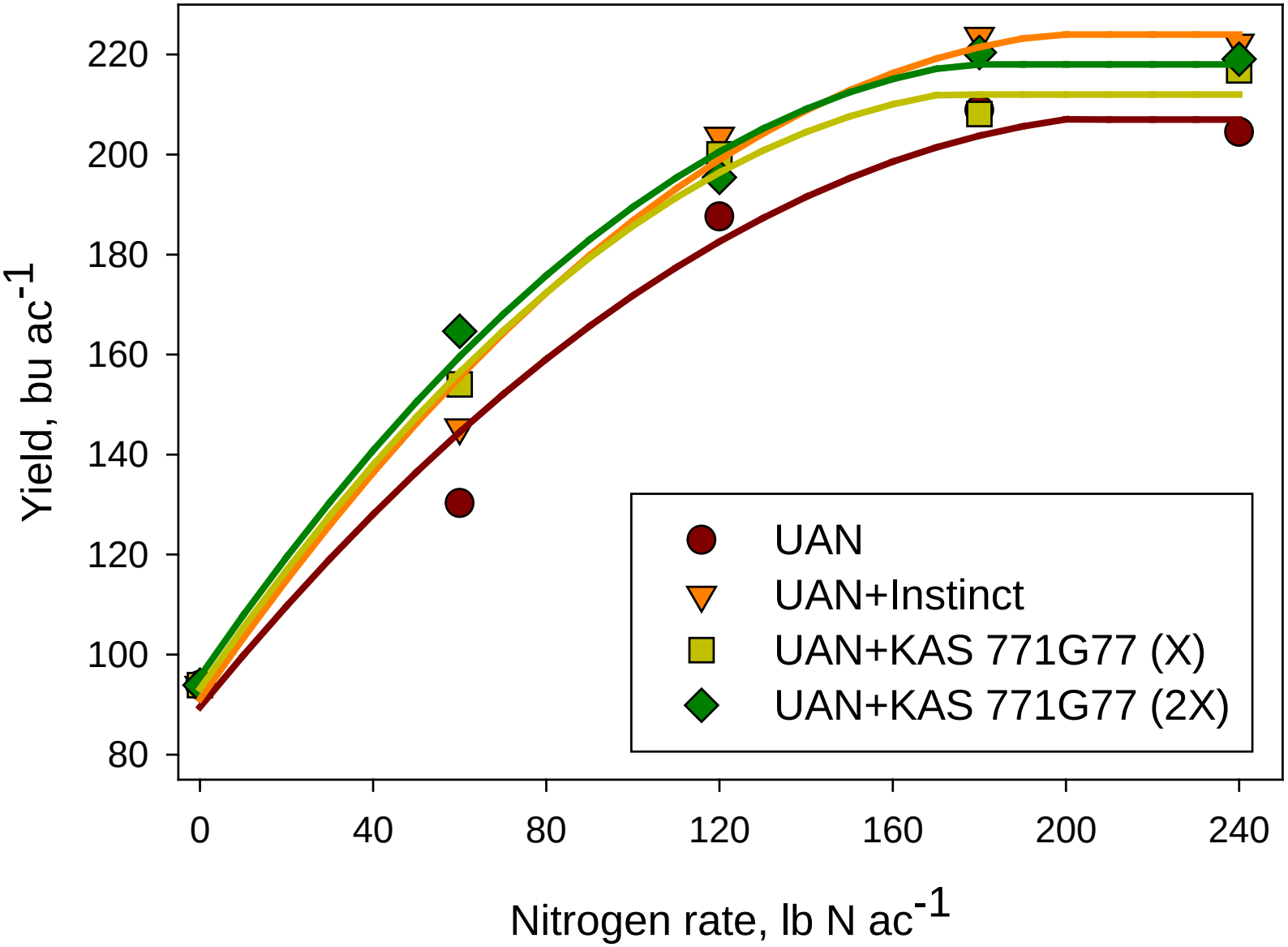
	Corn grain yield				R1 Leaf chlorophyll		
Instinct	2008	2009	2010		2008	2009	2010
fl oz/ac	--------	bu/ac	--------		----------	%	----------
0	148 a	187 a	175 b		95 a	96 a	97 b
35	150 a	188 a	186 a		93 a	96 a	99 a

Data are an average of 80 and 120 lb N/ac rates

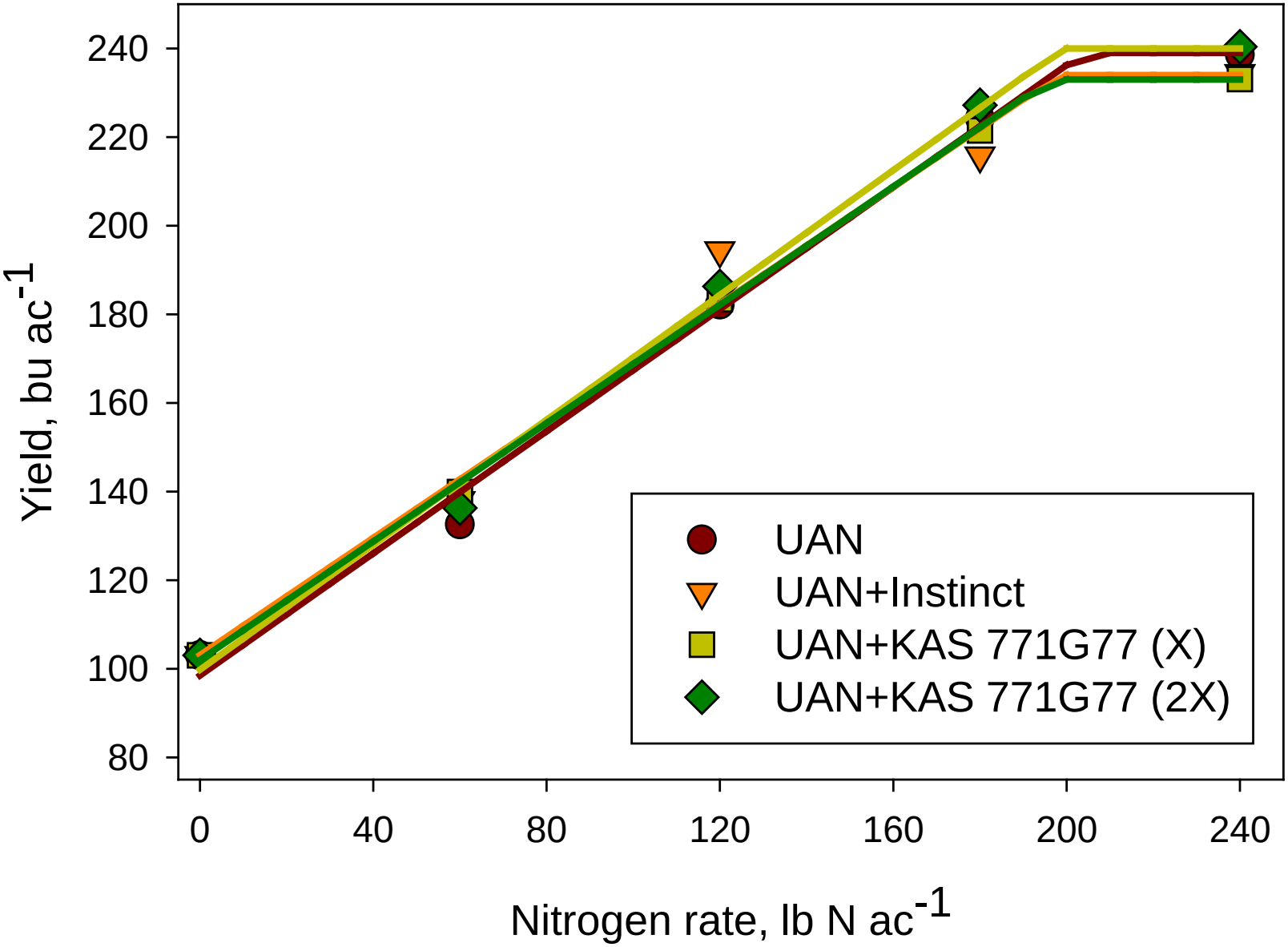
Continuous corn yield as affected by UAN rate and nitrification inhibitors (Webster cl) in 2012.



Continuous corn yield as affected by UAN rate and nitrification inhibitors (Web./Nic. cl) in 2013.



Continuous corn yield as affected by UAN rate and nitrification inhibitors (Web./Nic. cl) in 2015.



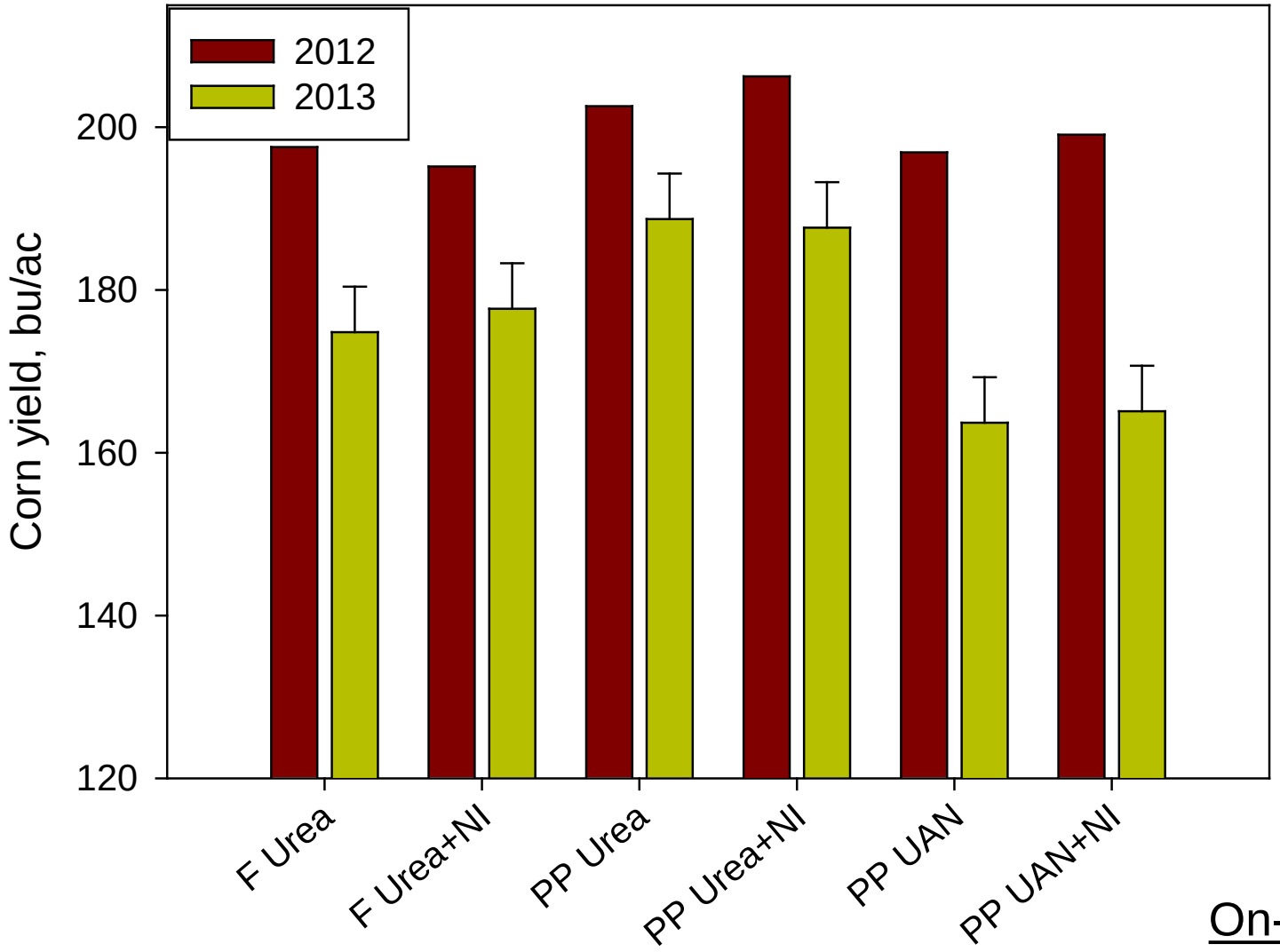
Corn yield as affected by UAN rate and nitrification inhibitors (injected UAN at V2).

- In 2012 and 2015, corn grain yields were not affected by KAS 771G77 and Instinct.
- In the wet spring of 2013, (6” of rain in 19 days after application) corn yields were greater with KAS 771G77 and Instinct.

N Source, Timing and Instinct Study

- Source
  - Urea and UAN
- Time of N application
  - Fall (urea) and preplant (urea and UAN)
- Nitrification inhibitor
  - Instinct™
- Applied at 130 lb N/ac for corn after soybean (on-farmer fields)

Corn yield as affected by N source, time of application and Instinct in south-central, MN.



On-farm N study
6 sites in 2012
5 sites in 2013

Corn yield as affected by N source, timing and Instinct in south-central, MN.

- In a dry spring (2012) corn yields were:
  - spring urea > fall urea at 1 of 6 sites, = at 5 of 6
  - Urea+Instinct > urea at 1 of 6 sites
  - UAN with Instinct = UAN at 6 of 6 sites
  - Spring urea > spring UAN at 2 of 6 sites

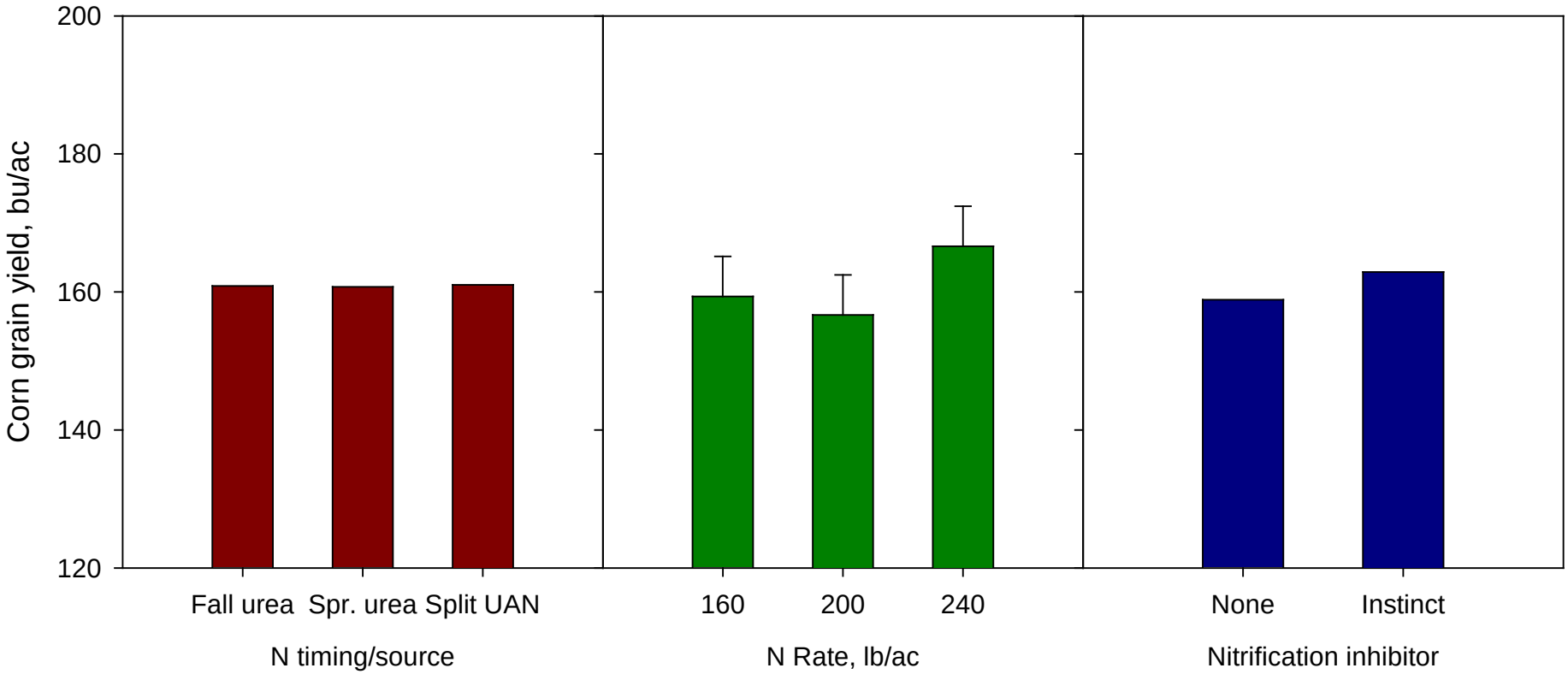
Corn yield as affected by N source, timing and Instinct in south-central, MN.

- In a wet spring (2013) corn yields were:
  - spring urea > fall urea at 2 of 5 sites
  - **at 0.20 level of significance: spring urea > fall urea at 5 of 5 sites**
  - Urea+Instinct = urea at 5 of 5 sites
  - UAN with Instinct > UAN at 1 of 5 sites
  - Spring Urea > spring UAN at 5 of 5 sites

Effects of time of N application and Instinct™ on corn production and nitrate losses from tile drainage.

- Research site: drainage research facility at SROC
- 19 Treatments: three-factor factorial + a control (0-N)
  - (3) N source/timing: urea fall and spring and UAN split
    - urea broadcast and incorporated
    - UAN split (20-30 lb dribble band at planting + stream inject V4)
  - (3) Rates: 160, 200 and 240 lb N/ac
  - (2) Nitrification inhibitor Instinct: 0 and 35 oz/ac
- Tile plot treatments: (3) source/timings × (2) Instinct at 200-lb N + 160-lb N as spring urea with Instinct + control = 8 treatments × 4 reps = 32 tile plots.

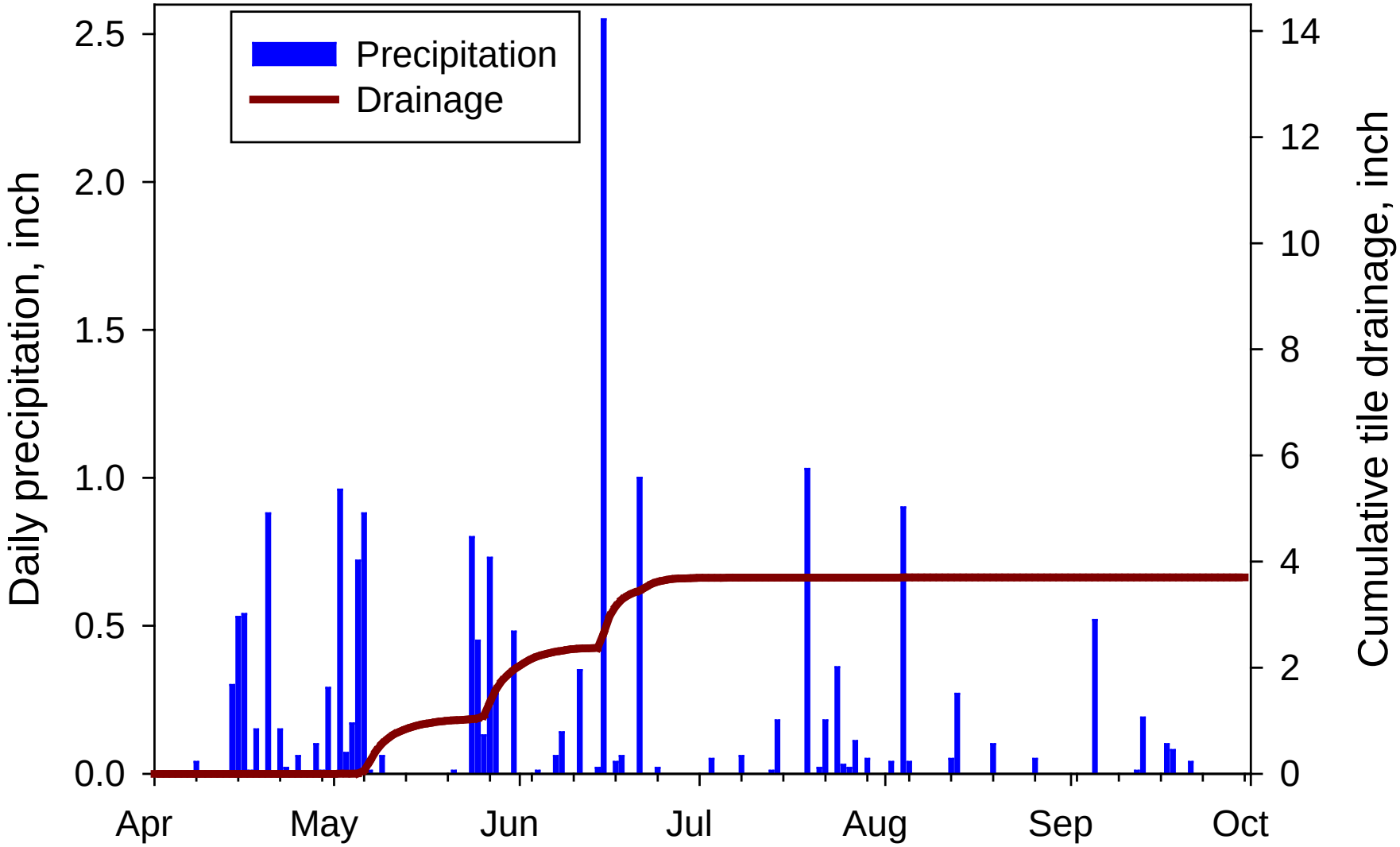
Corn grain yields as affected by treatment main effects (N source/timing, N rate and Instinct) in 2012.



Summary: corn production 2012

- Time of application / N source
  - Did not affect yields
  - Total N uptake & AN recovery were greater with spring urea than with fall urea
  - Grain N uptake & AN removal were greater with split UAN than with fall urea
- N rate
  - 240 lb N/ac had > grain yield, N uptake & RLC than other rates, but lower ANR & NUE
- Instinct
  - No significant differences

Precipitation and cumulative tile drainage volume in 2012



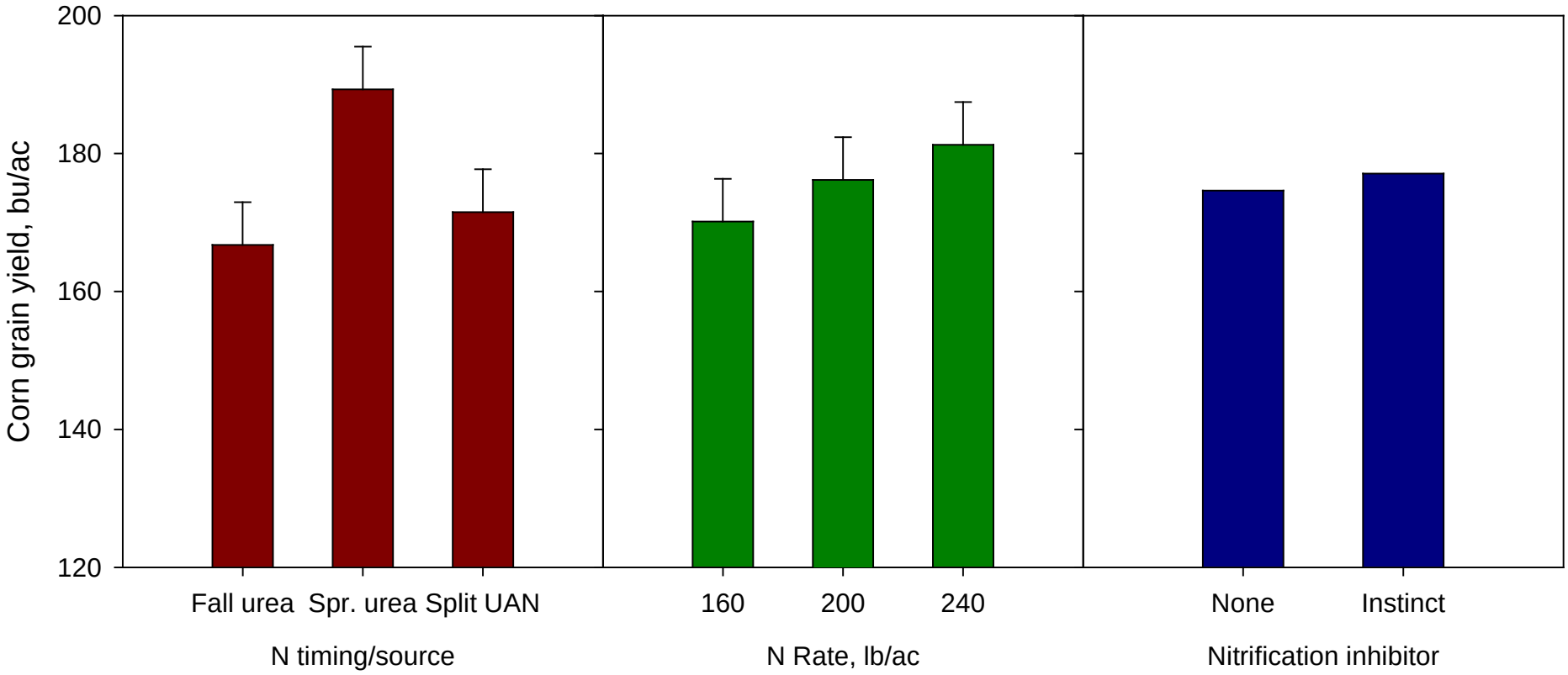
2012 Flow-weighted NO_3-N in tile water

Contrasts	Fl-wt NO_3-N Conc.		
	May	Jun	Avg.
	-------	mg/L	-------
Control	3.2	5.1	4.2
Fertilized	4.1	7.4	5.6
P > F:	**0.06**	**0.09**	**0.08**
Fall urea	4.8	8.9	6.6
Spring urea	3.4	6.4	5.1
P > F:	**0.01**	**0.05**	**0.06**
Fall urea	4.8	8.9	6.6
Split UAN	3.8	7.0	5.3
P > F:	**0.03**	0.12	**0.08**

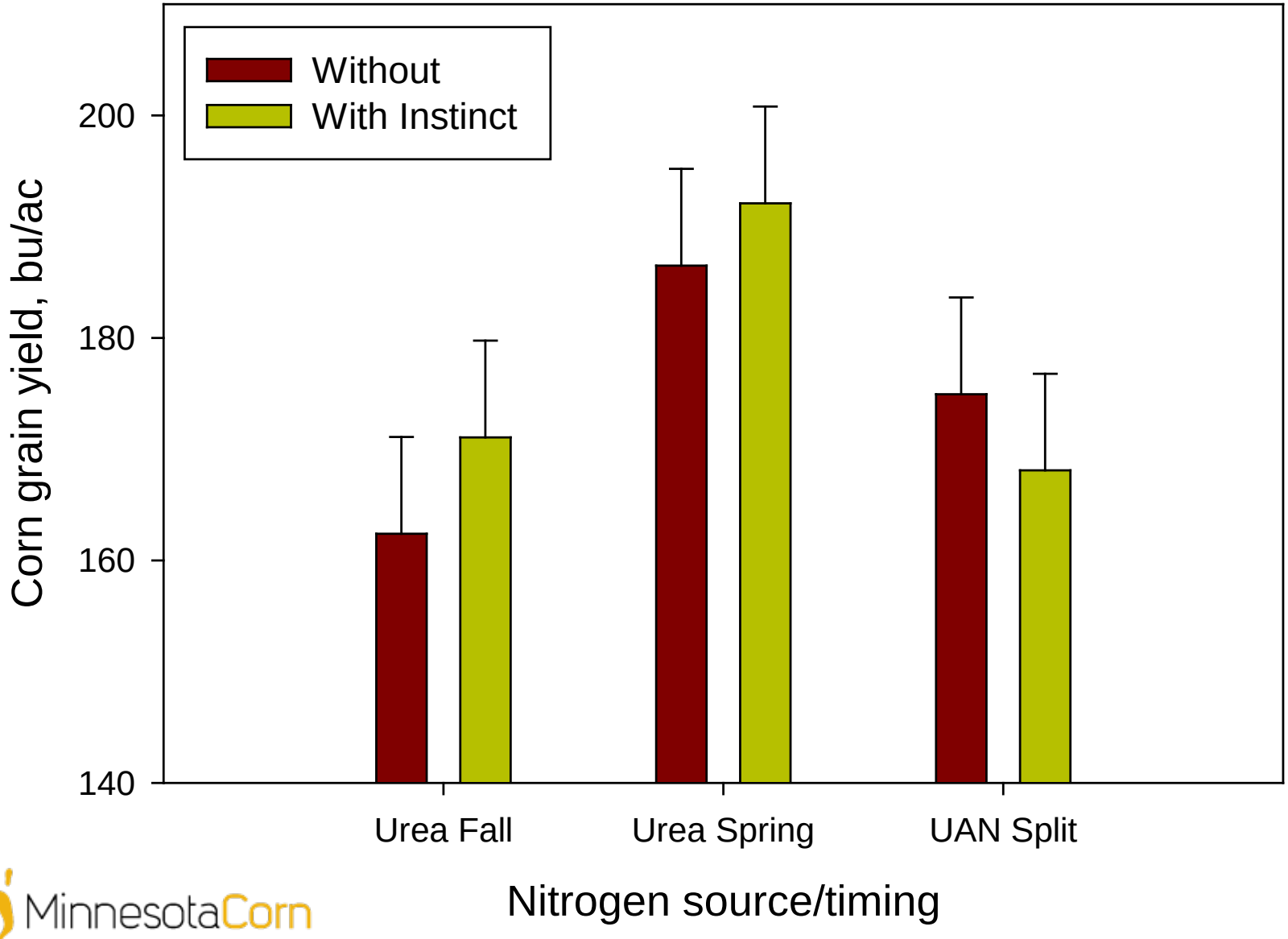
Summary: nitrate in tile water, 2012

- Flow: 2.1” in May & 1.9” in June
- Nitrate-N losses (loads) very low in 2012 about 5 lb NO_3-N/ac, similar to 1987 & 88.
- Flow-weighted NO_3-N concentrations
  - Were less than normal (MRTN rates in 2011, PPNT=21-lb)
  - Were greater with fall urea than with spring urea and split-applied UAN
  - Were NOT affected by Instinct in 2012
  - No difference between 200 lb N/ac and 160 lb N/ac

Corn grain yields as affected by treatment main effects (N source/timing, N rate and Instinct) in 2013.



Corn grain yields as affected by interaction between N source/timing and Instinct in 2013.

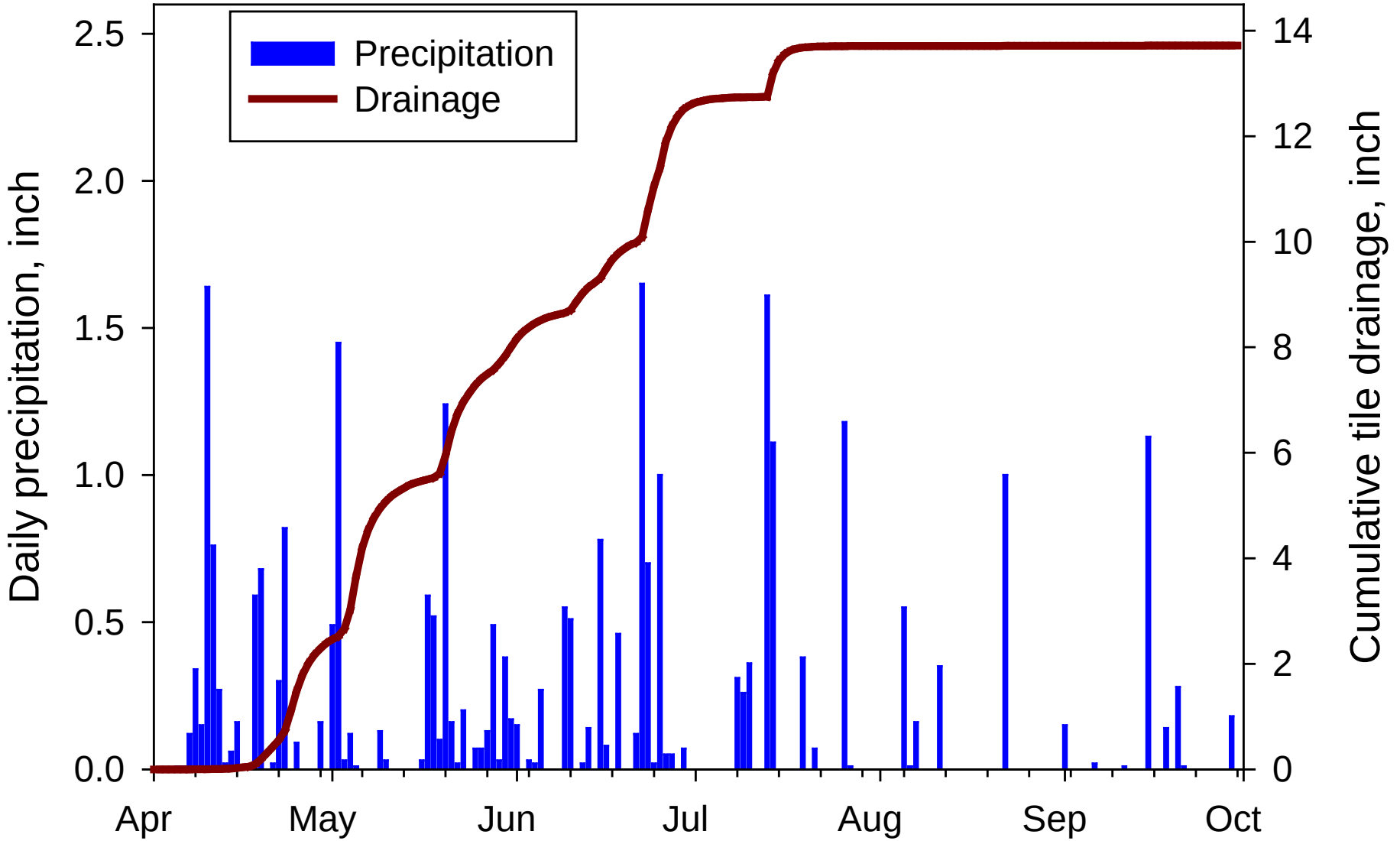


MinnesotaCorn

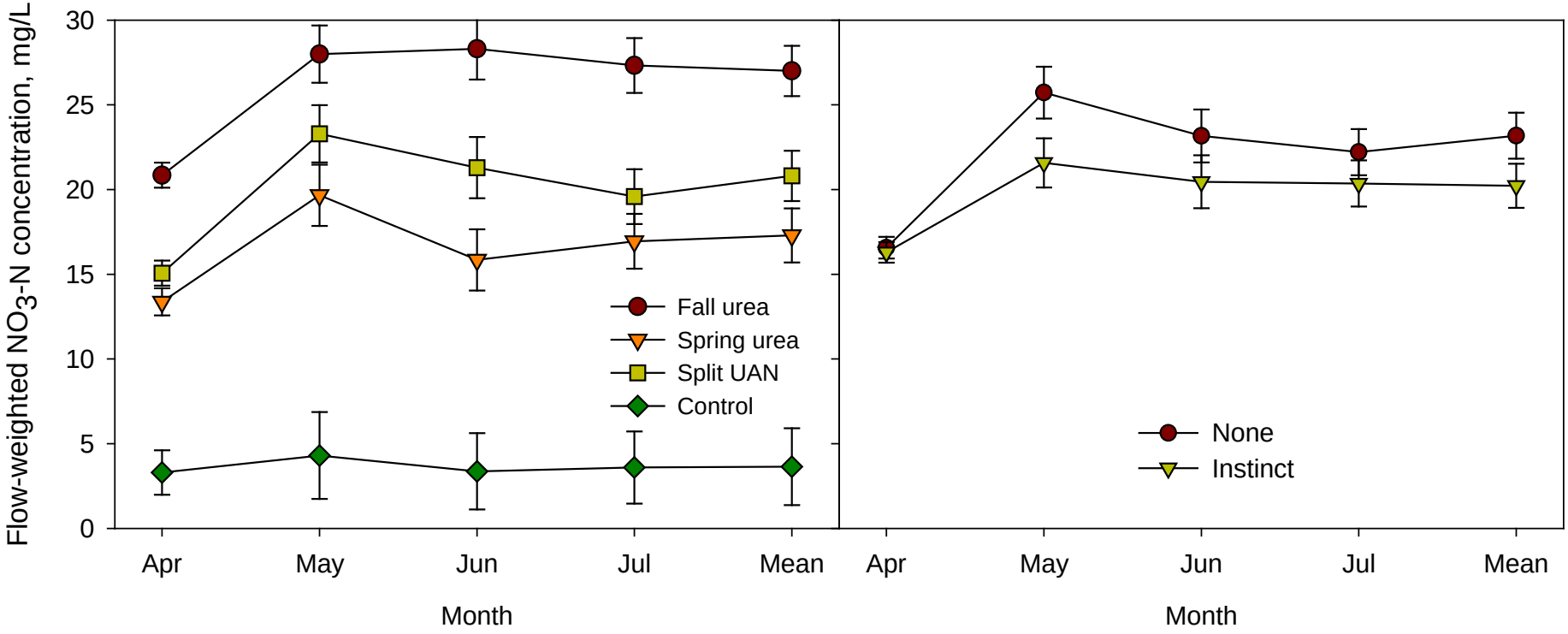
Summary: Corn production in 2013

- Time of application / N source
  - Spring-applied urea had 22 bu/ac greater yield than fall urea and 17 bu/ac more yield than split-applied UAN
  - NUE and ANR were greatest with spring urea
- N rate
  - 240 lb N/ac had greater grain yields than 160-lb, but not greater than 200-lb
- Instinct
  - Increased yields with fall-applied urea

Precipitation and cumulative tile drainage volume in 2013



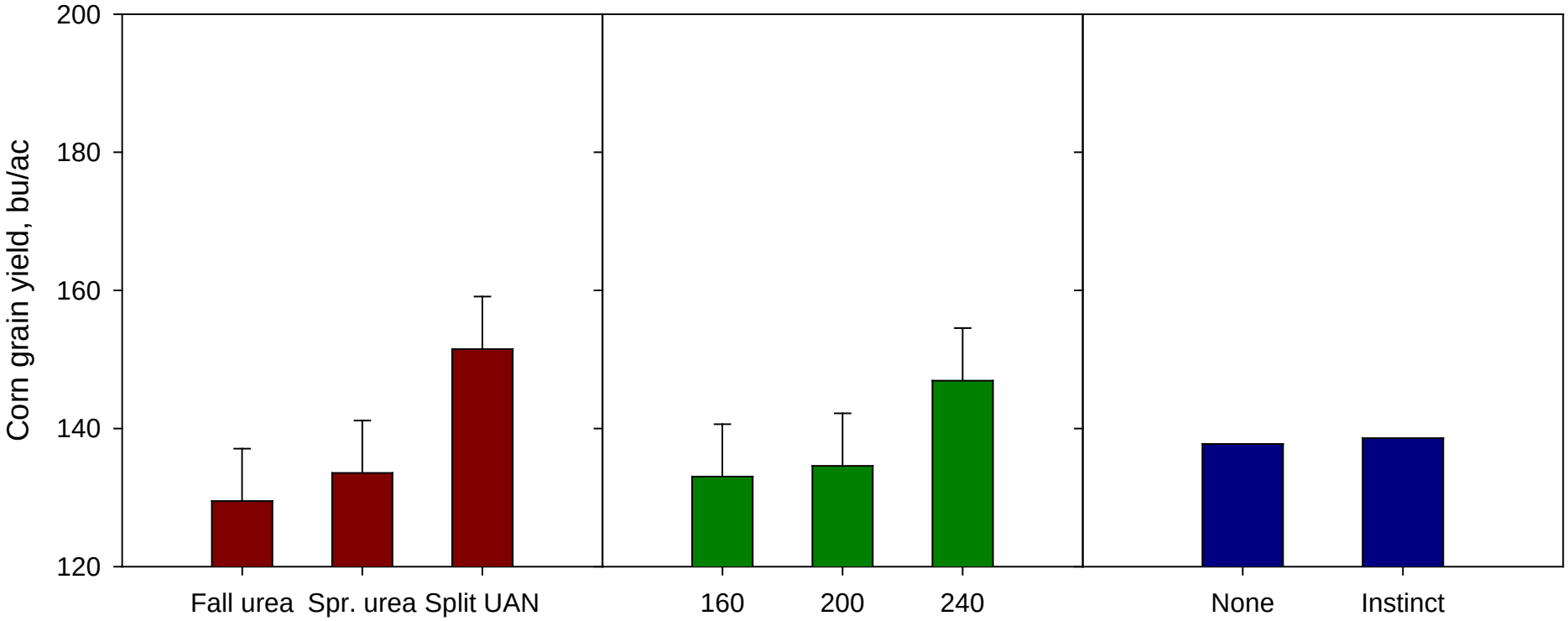
Nitrate-N concentration in tile water (200 lb N/A) as affected by N source/timing and Instinct in 2013



Summary: Nitrate in tile water, 2013

- Tile flow: Nearly 14”, 90% of it in April-June
- Nitrate-N lost (load): ranged from a low of 10 lb/ac in control to 79 lb/ac with fall urea
- Flow adjusted losses were 6.1, 3.9 and 4.6 lb NO_3/inch for fall urea, spring urea and split UAN, respectively.
- Flow-weighted NO_3-N concentrations
  - Were greater than normal, especially with fall urea (drought in 2012)
  - Were reduced with Instinct in 2013
  - No difference between 200 lb N/ac and 160 lb N/ac

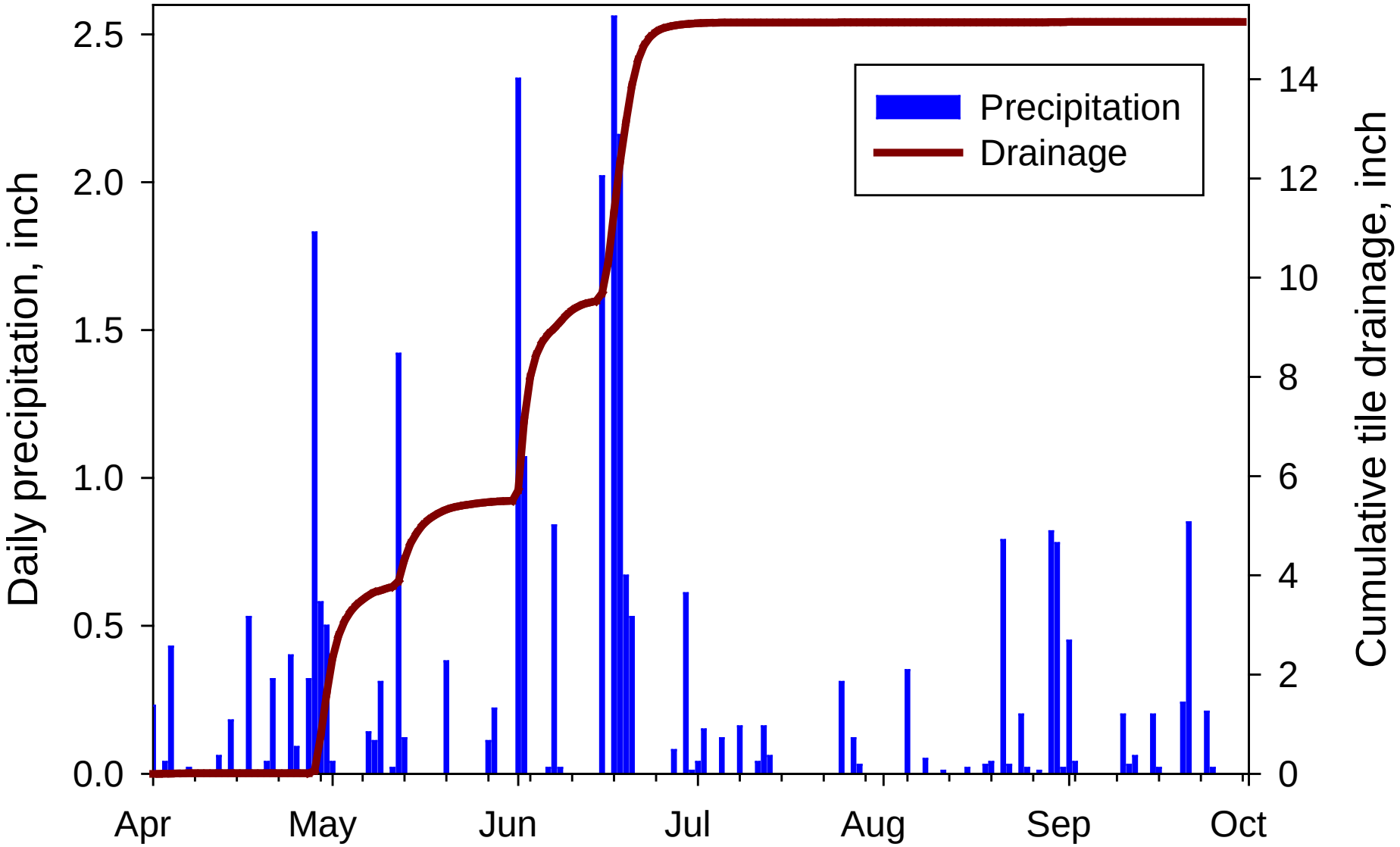
Corn grain yields as affected by treatment main effects (N source/timing, N rate and Instinct) in 2014.



Summary: Corn production in 2014

- Time of application / N source
  - Split-applied UAN had 22 bu/ac greater yields than fall urea and 18 bu/ac more yield than spring urea. NUE and ANR were greatest with split-applied UAN in this record wet spring (June).
- N rate
  - Greatest grain yields were with 240 lb N/ac
- Instinct
  - Had no effect on yields or NUE

Precipitation and cumulative tile drainage volume in 2014



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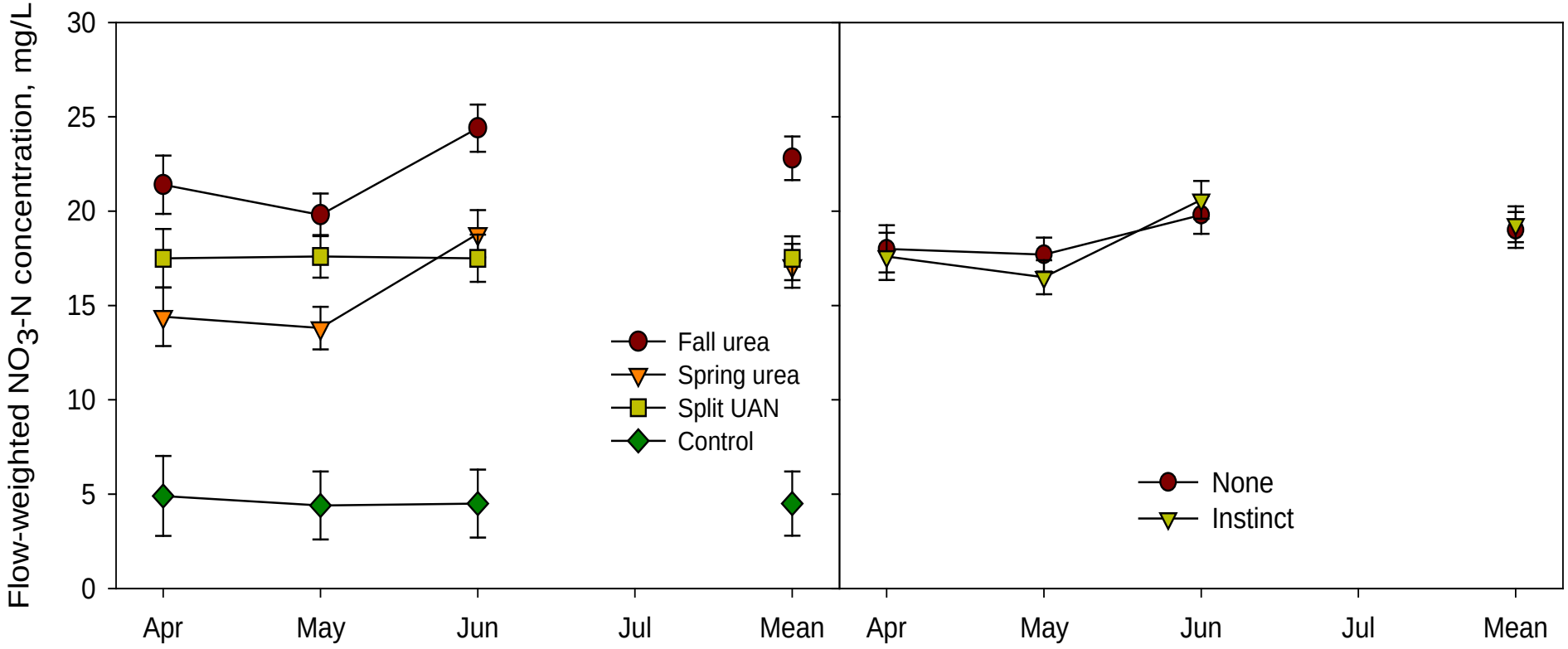
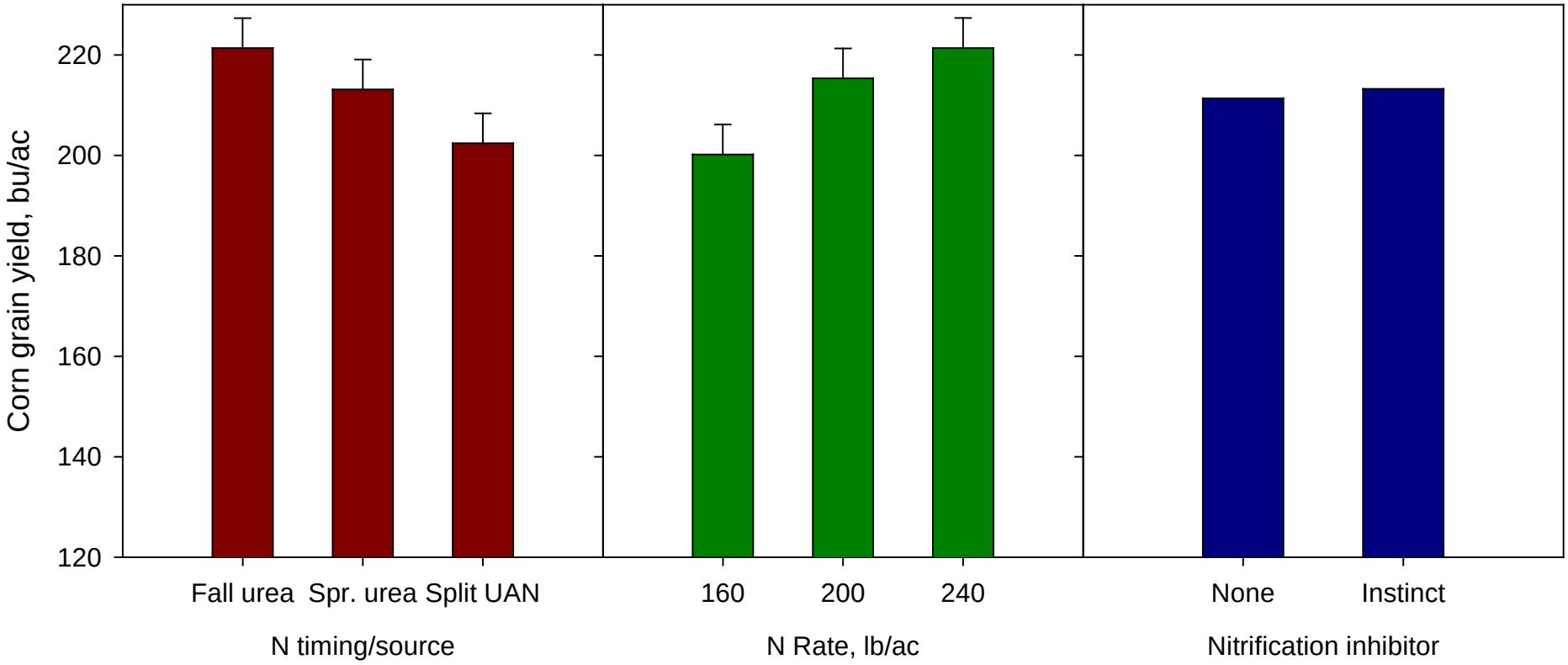


Summary: Nitrate in tile water, 2014

- Tile flow: 15.2”, 99% in April-June, 63% in June
- Nitrate-N loads ranged from 13 lb/ac in control to 89 lb/ac with fall urea+Instinct.
- Flow adjusted losses were greatest with fall urea (5.2 lb NO_3/inch), spring urea and split UAN had 3.9 and 3.9 lb NO_3/inch, respectively.
- Flow-weighted NO_3-N concentrations
  - Were greatest with fall urea
  - Were not affected by Instinct in 2014
  - No difference between 200 lb N/ac and 160 lb N/ac

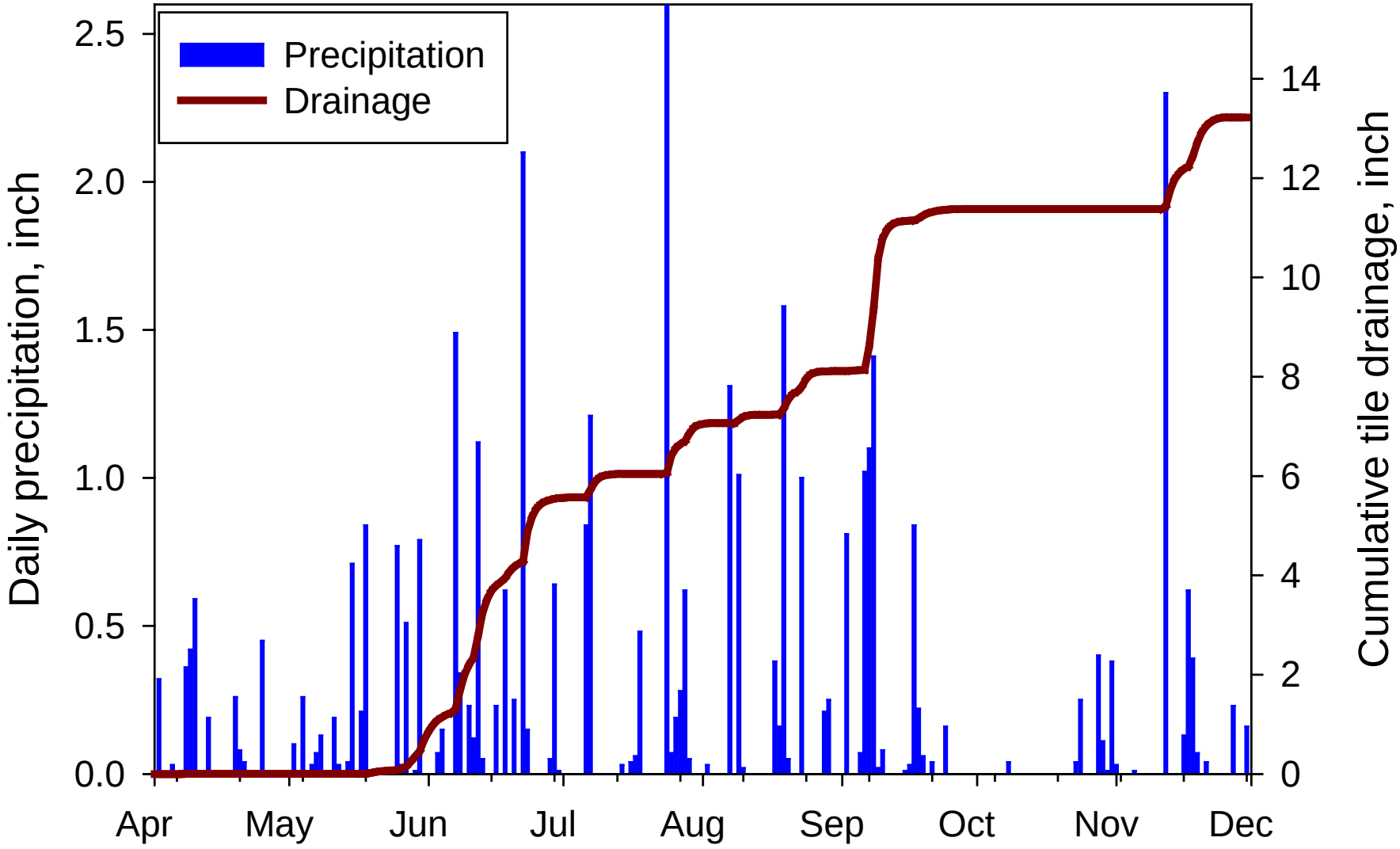
Corn grain yields as affected by treatment main effects (N source/timing, N rate and Instinct) in 2015.



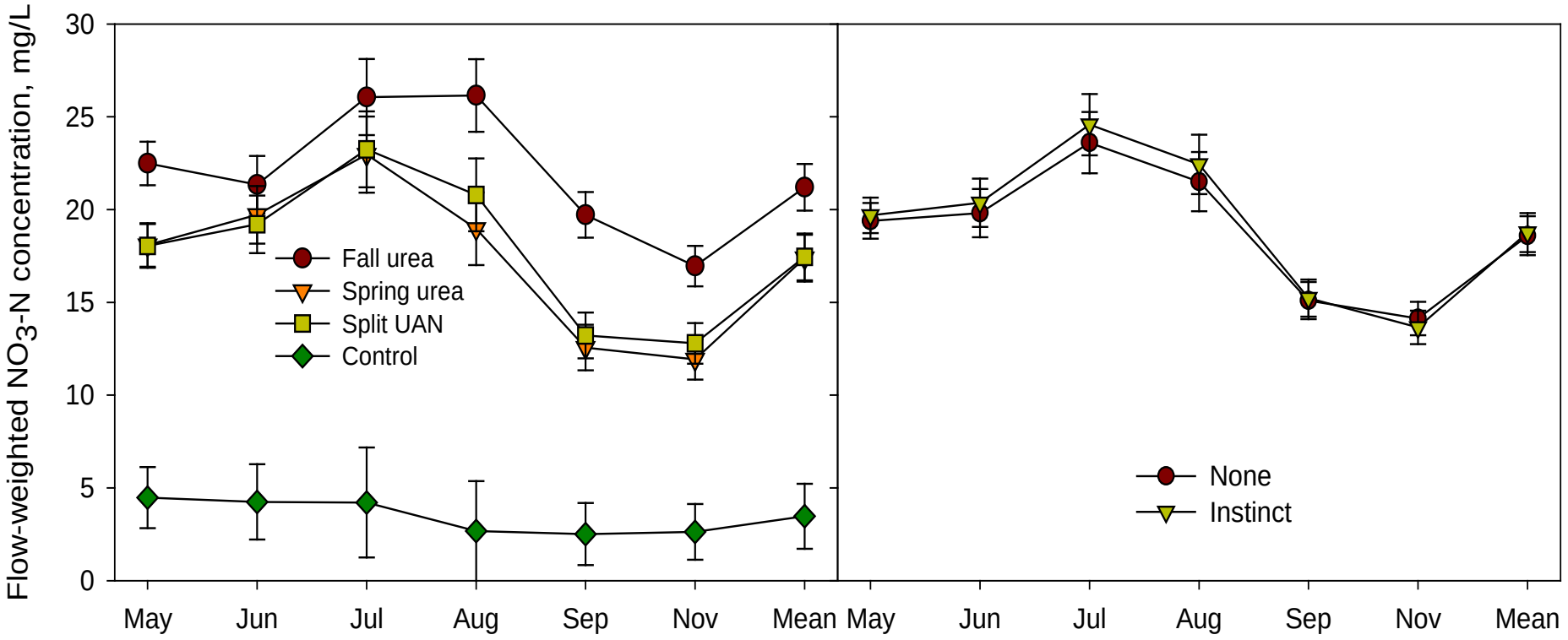
Summary: Corn production in 2015

- Time of application / N source
  - Fall urea had 8 bu/ac greater yields than spring urea and 19 bu/ac more yield than split-applied UAN. NUE and ANR were greatest with fall urea.
- N rate
  - Grain yields ranked: 240-lb > 200-lb > 160-lb; however, economically 240-lb = 200-lb.
- Instinct
  - Had no effect on yields or NUE

Precipitation and cumulative tile drainage volume in 2015



Nitrate-N concentration in tile water (200 lb N/A) as affected by N source/timing and Instinct in 2015



Summary: Nitrate in tile water, 2015

- Tile flow: 13.3”, 42% in April-June < normal
- Nitrate-N loads ranged from 10 lb/ac in control to 70 lb/ac with fall urea+Instinct.
- Flow adjusted losses were greatest with fall urea (4.8 lb NO_3/in.), spring urea and split UAN had 3.9 and 3.9 lb NO_3/inch, respectively.
- Flow-weighted NO_3-N concentrations
  - Were greater with fall urea in 4 of 6 months and average
  - Were not affected by Instinct in 2015
  - No difference between 200 lb N/ac and 160 lb N/ac

Yield and NO_3 loss summary:

- Grain yields with fall application of urea were:
  - much less than spring urea in 1 of 4 yr, similar in 2 of 4 yr (2012 and 2014) and slightly greater in 1 of 4 yr.
- Adding Instinct to fall-applied urea increased yield and reduced NO_3 concentration and loss in tile drainage water only in 2013.
- Based on these data a split application of UAN (30-lb or less as starter and rest at V4) would not be recommended for continuous corn at Waseca.

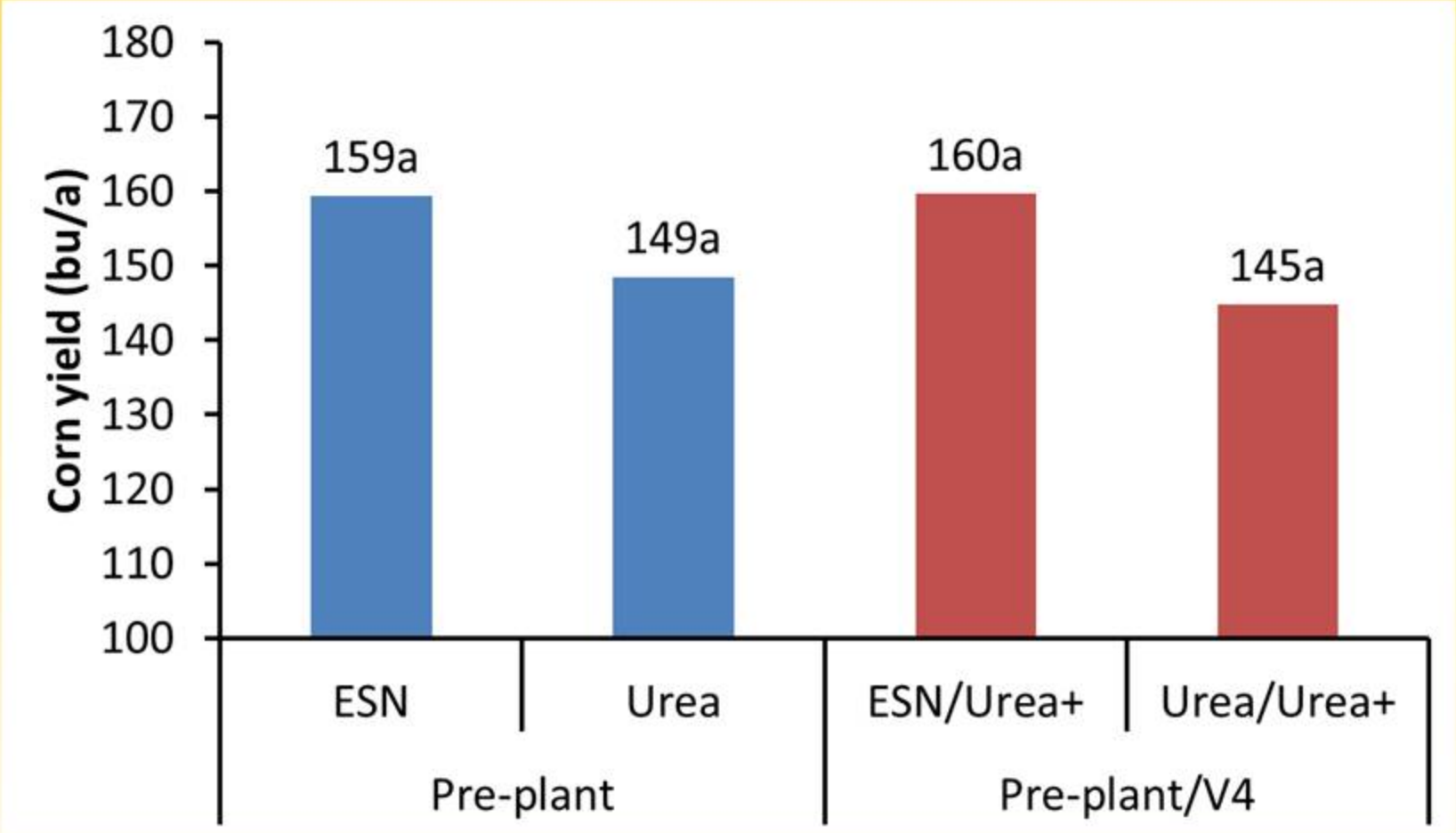
Yield and NO_3 loss summary: cont.

- Fall-applied urea had 38% greater NO_3 loss in tile drainage water than did spring urea, when averaged across 2013 - 2015.
- No difference in NO_3 concentration or load between 160- and 200-lb N/ac rates of spring-applied urea with Instinct.

Acknowledgement

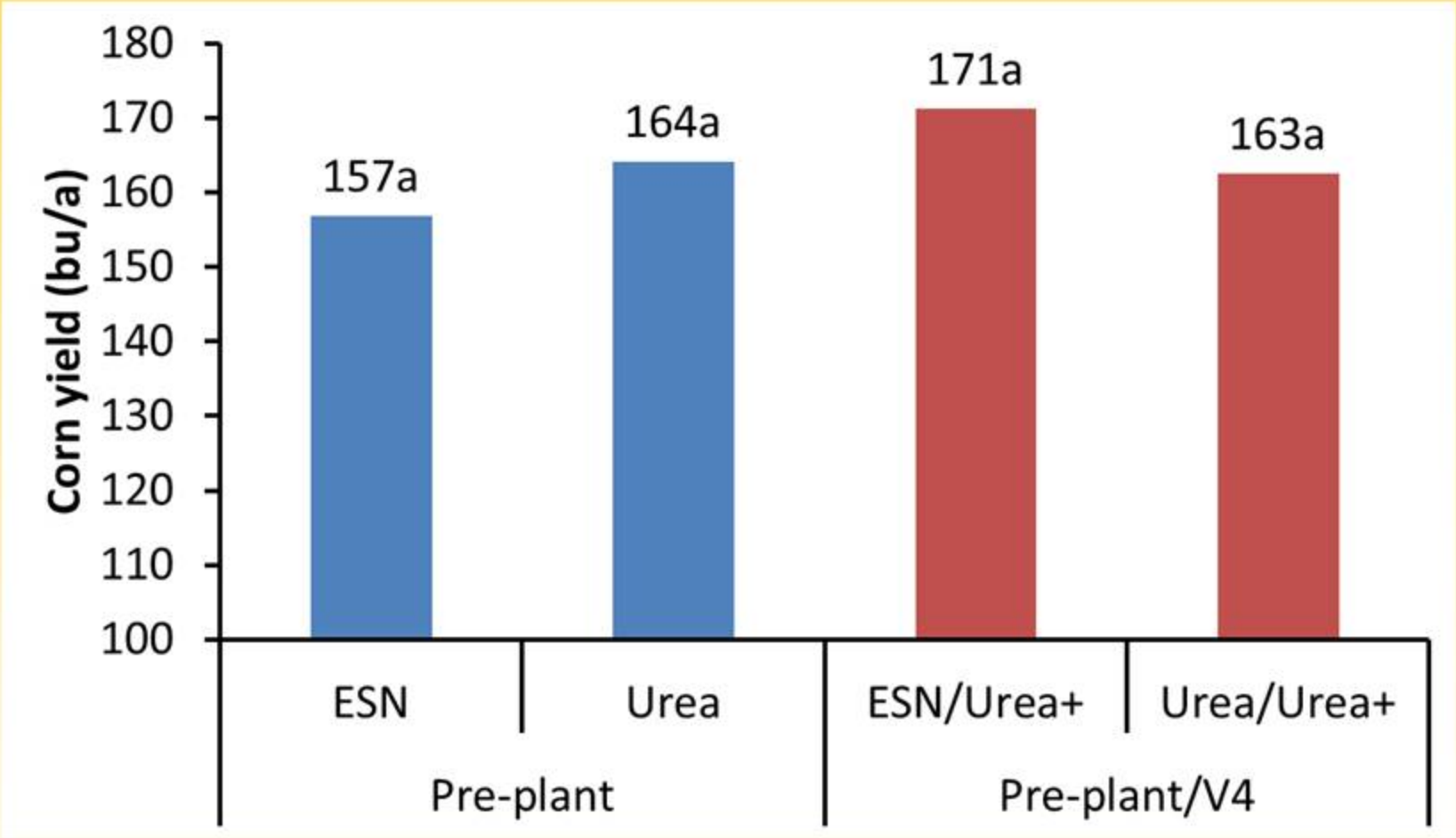
- Funding for Instinct research projects at the Univ. of Minnesota was provided by Dow AgroSciences and is appreciated by the author.
- Funding for KAS 771G77 research at the Univ. of Minnesota was provided by Koch Agronomic Services, LLC and is appreciated by the author.

Corn Yield, 2014



Fernandez et al. unpublished

Corn Yield, 2015



Fernandez et al. unpublished

N rate x timing study, 2014–2015

Davies and Pagliari, unpublished

- **Becker**
  - Irrigated
  - Hubbard-Mosford loamy sand
- **Lamberton**
  - Normania loam
  - Patterned tile drainage
- **Waseca**
  - Nicollet clay loam
  - Patterned tile drainage

AFREC
Agricultural Fertilizer Research & Education Council

N rate x timing study, 2014–2015

- **2014 = followed soybean; 2015 = followed corn**
- **Fertilizer**
  - Fall: SuperU
  - Preplant & in-season: urea
  - All other nutrients supplied at non-limiting levels
- **100% N rate at Becker (irrigated sand)**
  - 150 lb N/ac after soybean
  - 210 lb N/ac after corn
- **100% N rate at Lamberton & Waseca**
  - 120 lb N/ac after soybean
  - 180 lb N/ac after corn

N rate x timing study – Becker (irrigated sand)

Treatment	**2014**	**2015**
	---------- bu/ac ----------	
1) Control (no N applied)	108 ef	78 h
2) Fall (100%)	102 f	108 g
3) Fall (125%)	105 ef	130 f
4) Preplant (100%)	127 de	160 e
5) Preplant (125%)	135 d	187 d
6) Preplant/V6 (75%)	161 c	191 d
7) Preplant/V6 (100%)	178 bc	241 a
8) Preplant/V6/R1 (50%)	175 bc	157 e
9) Preplant/V6/R1 (75%)	190 b	204 c
10) Preplant/V6/R1 (100%)	228 a	231 b

Davies et al. unpublished

N rate x timing study – Waseca (clay loam)

Treatment	**2014**	**2015**
	---------- bu/ac ----------	
1) Control (no N applied)	72 f	113 f
2) Fall (100%)	137 cd	224 cd
3) Fall (125%)	156 bc	233 bc
4) Preplant (100%)	164 ab	229 bcd
5) Preplant (125%)	178 a	237 ab
6) Preplant/V6 (75%)	145 bc	222 d
7) Preplant/V6 (100%)	158 b	244 a
8) Preplant/V6/R1 (50%)	105 e	193 e
9) Preplant/V6/R1 (75%)	126 de	225 c
10) Preplant/V6/R1 (100%)	151 bc	246 a

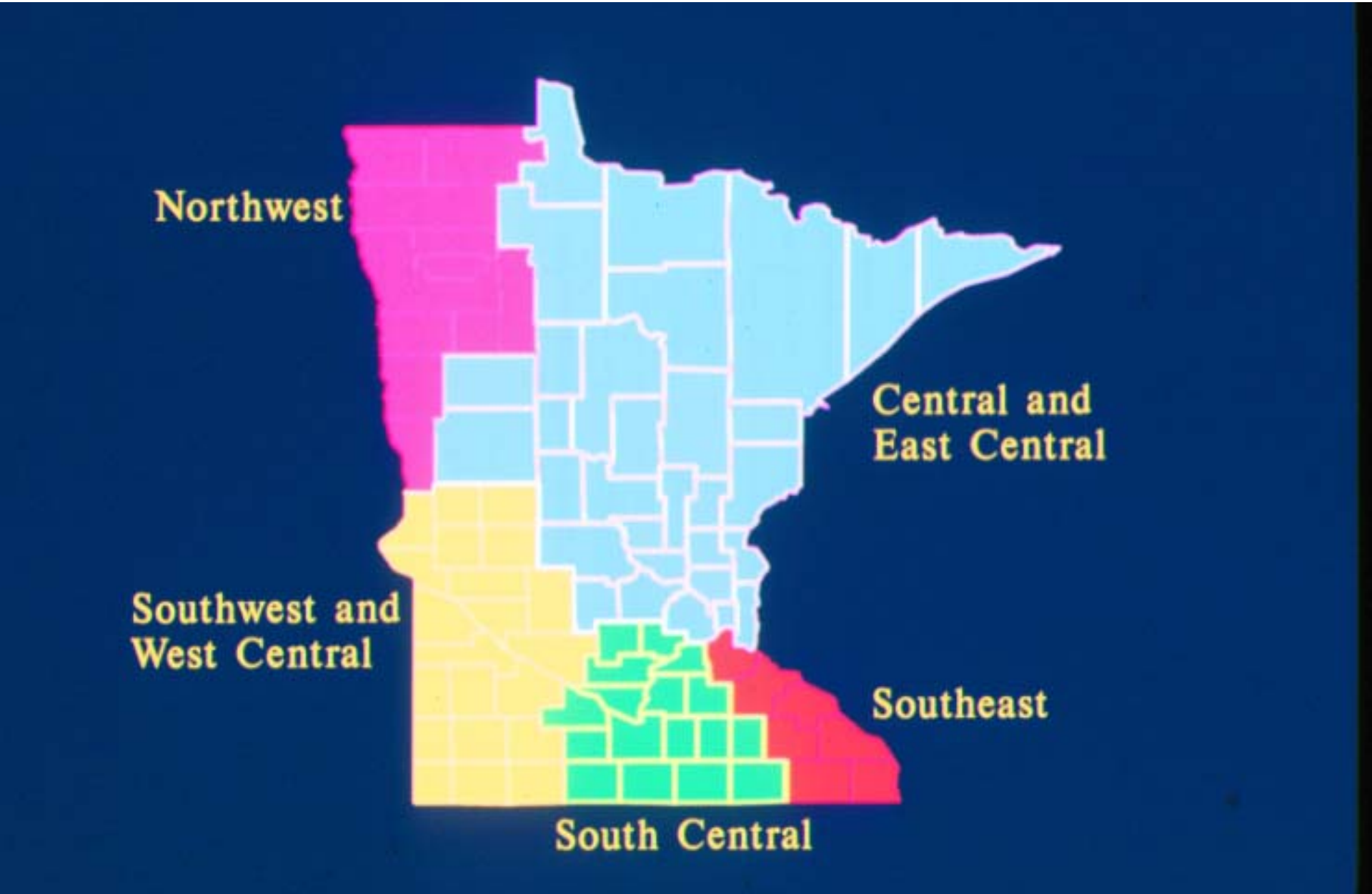
Davies et al. unpublished

N rate x timing study – Lamberton (loam)

Treatment	**2014**	**2015**
	---------- bu/ac ----------	
1) Control (no N applied)	151 f	80 e
2) Fall (100%)	220 c	215 b
3) Fall (125%)	231 a	226 a
4) Preplant (100%)	229 ab	216 ab
5) Preplant (125%)	234 a	226 a
6) Preplant/V6 (75%)	210 d	191 c
7) Preplant/V6 (100%)	221 bc	217 ab
8) Preplant/V6/R1 (50%)	194 e	176 d
9) Preplant/V6/R1 (75%)	202 de	209 b
10) Preplant/V6/R1 (100%)	210 d	211 b

Davies et al. unpublished

Region Specific BMPs for N



The effects of swine manure application timing and Instinct™ on corn yield and N availability.

Jeff Vetsch

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Southern Research and Outreach Center

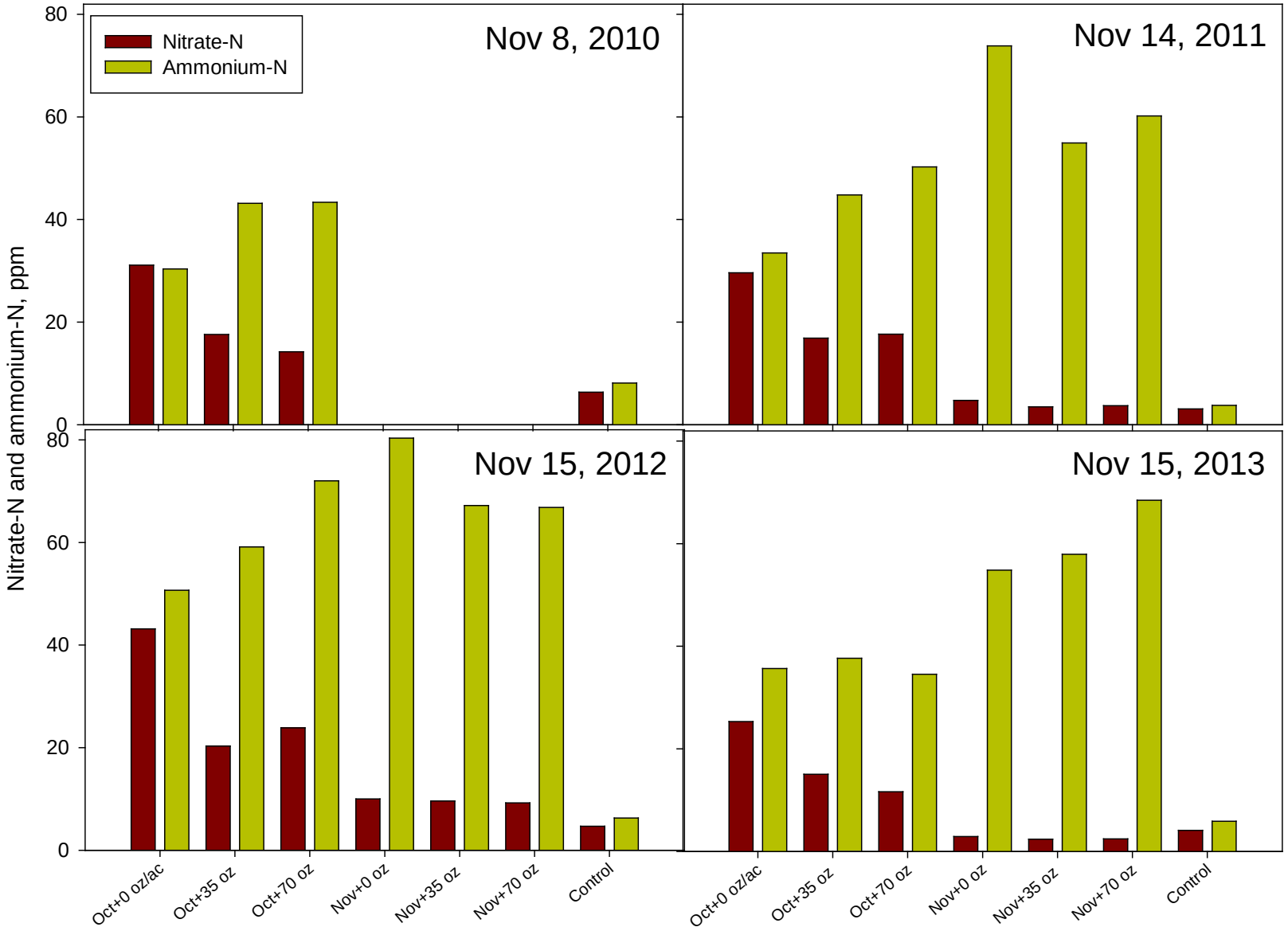
Revised Feb, 2015

Methods for manure study

- Treatments (9)
  - Two manure application timings: Early October (immediately after soybean harvest and early November (soil temps < 50° F).
    - Manure rate based on manure nutrient analysis from each application timing to give 120 lb of available N/ac based on 80% availability if sweep injected.
  - Three rates of Instinct (0, 35, and 70 oz./ac)
  - 120 lb N/ac as AA with and without N-Serve (1qt/ac) on Nov. 1
  - Control (zero N)

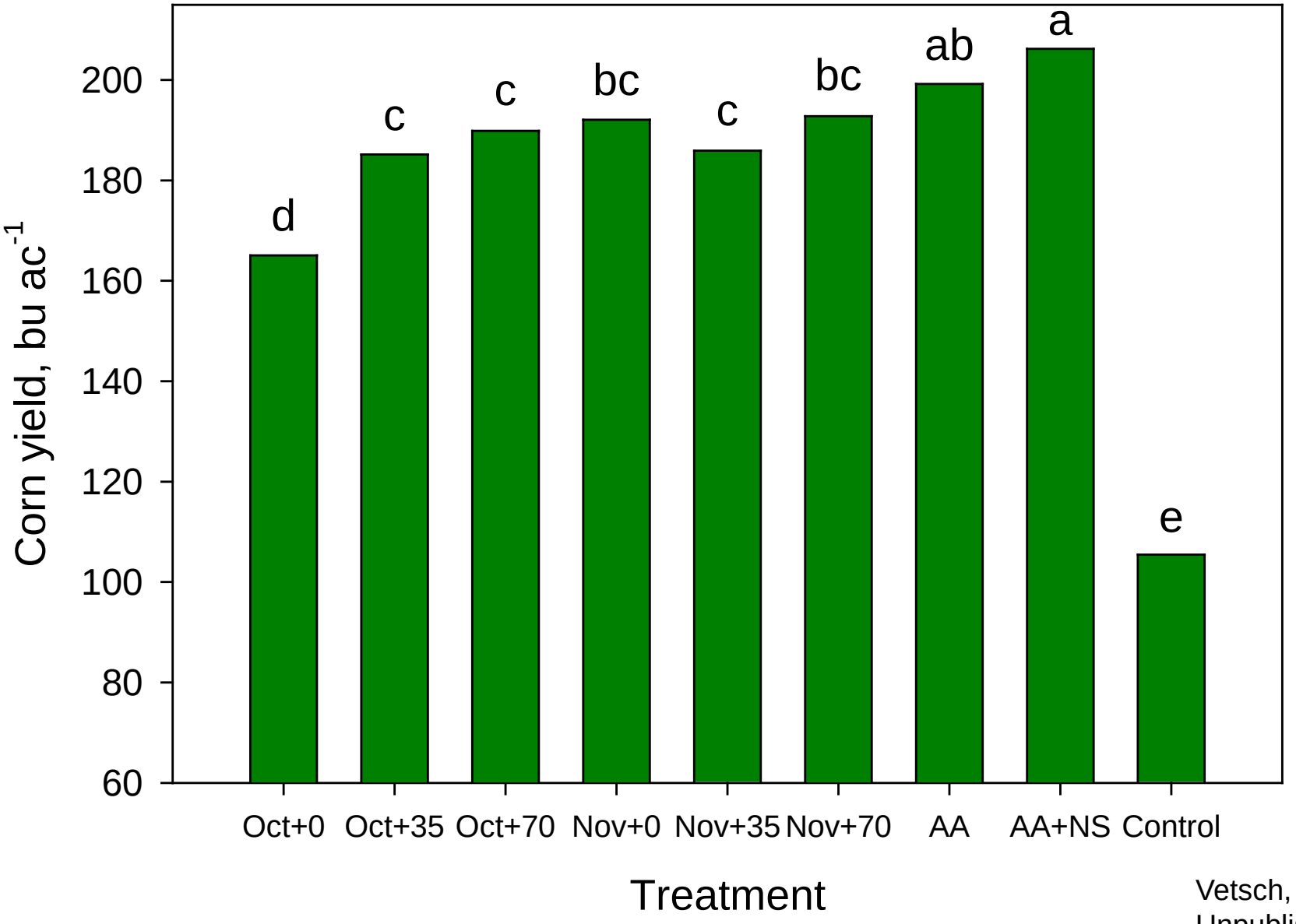
Vetsch, 2015
Unpublished

Soil NO_3-N and NH_4-N (0-1 ft) as affected by swine manure application timing and Instinct™ rate.



Vetsch, 2015. unpublished

Corn grain yield as affected by manure and fertilizer treatments in 2013.



Vetsch, 2015
Unpublished

Corn grain yield as affected by swine manure application timing and Instinct™ rate.

Application Timing	Instinct Rate	Years / Environments				
		2011	2012	2013	2014	4-Yr Avg.
	oz./acre	----------corn grain yields, bu/acre ----------				
October	0	171	175	165b	138	162b
October	35	180	170	185a	161	174a
October	70	185	179	190a	161	179a
November	0	182	188	192a	145	177a
November	35	194	181	186a	158	180a
November	70	194	184	193a	153	181a
Effect of Application Timing						
October		179b	175a	180b	153a	172b
November		190a	184a	190a	152a	179a
Effect of Instinct Rate						
0 oz/ac		177b	182a	178b	142b	170b
35 oz/ac		187a	176a	185ab	159a	177a
70 oz/ac		189a	182a	191a	157a	180a
Interaction Effects						
Timing×Rate		NS	NS	**	NS	*

Vetsch, 2015. unpublished

Summary

- Fall and early spring (April) soil data showed less NO_3-N and greater NH_4-N were found when Instinct was added to swine manure. These data showed Instinct inhibited nitrification of N in fall-applied swine manure.
- Delaying application of manure from early October to early November increased corn grain yields in two of four years and for the four-year average (7 bu ac^{-1}).

Summary cont.

- Adding the nitrification inhibitor Instinct to fall-applied swine manure increased yields in three of four years and the four-year average (7-10 bu ac^{-1}).
- These data show Instinct was an effective nitrification inhibitor for liquid swine manure applied in October in southern Minnesota.

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