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Proceedings of the

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Minnesota Crop Production Retailers Association Trade Show

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High-Yield Corn Systems

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Questions

- **What yield levels are possible?**
- **How far is current production from these levels?**

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NCGA yield contest winners in MN, 2010–2014

Year	County	Yield	RM	Final pop.
'14	Fillmore	271	105	35
'14	Carver	264	105	34
'14	Wabasha	259	104	34
'13	Faribault	281	107	39
'13	Winona	277	112	34
'13	Wabasha	273	103	35
'12	Winona	288	110	36
'12	Carver	277	105	37
'12	Olmsted	274	108	34

Year	County	Yield	RM	Final pop.
'11	Winona	246	111	36
'11	Wabasha	241	108	34
'11	Fillmore	241	103	34
'10	Faribault	264	105	35
'10	Martin	261	103	34
'10	Winona	258	107	34

AA non-irrigated class

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NCGA yield contest winners in MN, 2010–2014

- **Location in MN**
  - Southeast (10/15 cases)
  - South-central (3/15 cases)
- **Hybrid RM**
  - 103 to 105 (8/15 cases)
  - 107 to 112 (7/15 cases)
- **Harvest population**
  - 34K to 35K (11/15 cases)
  - 36K to 39K (4/15 cases)

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Factors affecting corn yield

- Weather
- Soil productivity, quality, drainage
- Pest management & nutrition
- Hybrid selection
- Tillage
- Crop rotation
- Planting date & rate

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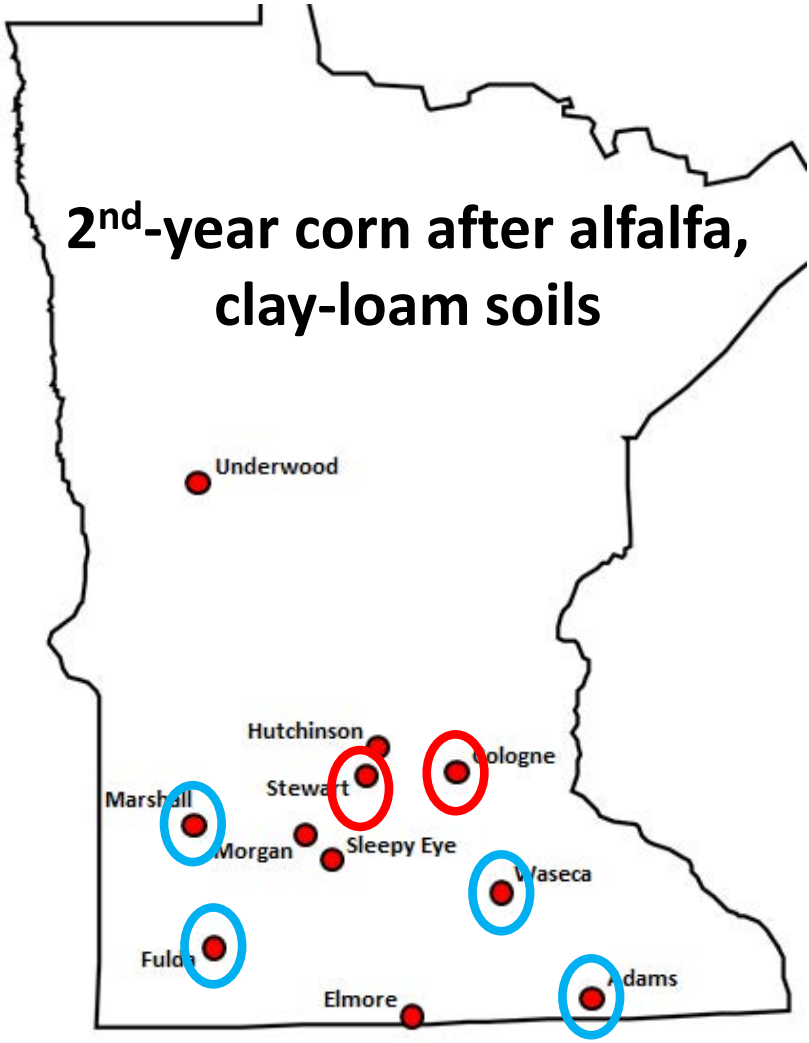
Maximum yields in 2015 on-farm trials

Location	Yield (bu/ac)	Hybrid RM	Planting rate
Adams	235	99	34
Cologne	254	102	30
Elmore	219	107	34
Fulda	230	105	33
Hutchinson	220	104	34
Marshall	235	100	35
Morgan	200	103	34
Sleepy Eye	209	103	34
Stewart	248	101	35
Underwood	211	96	34
Waseca	230	103	35



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Crop rotation increases yield

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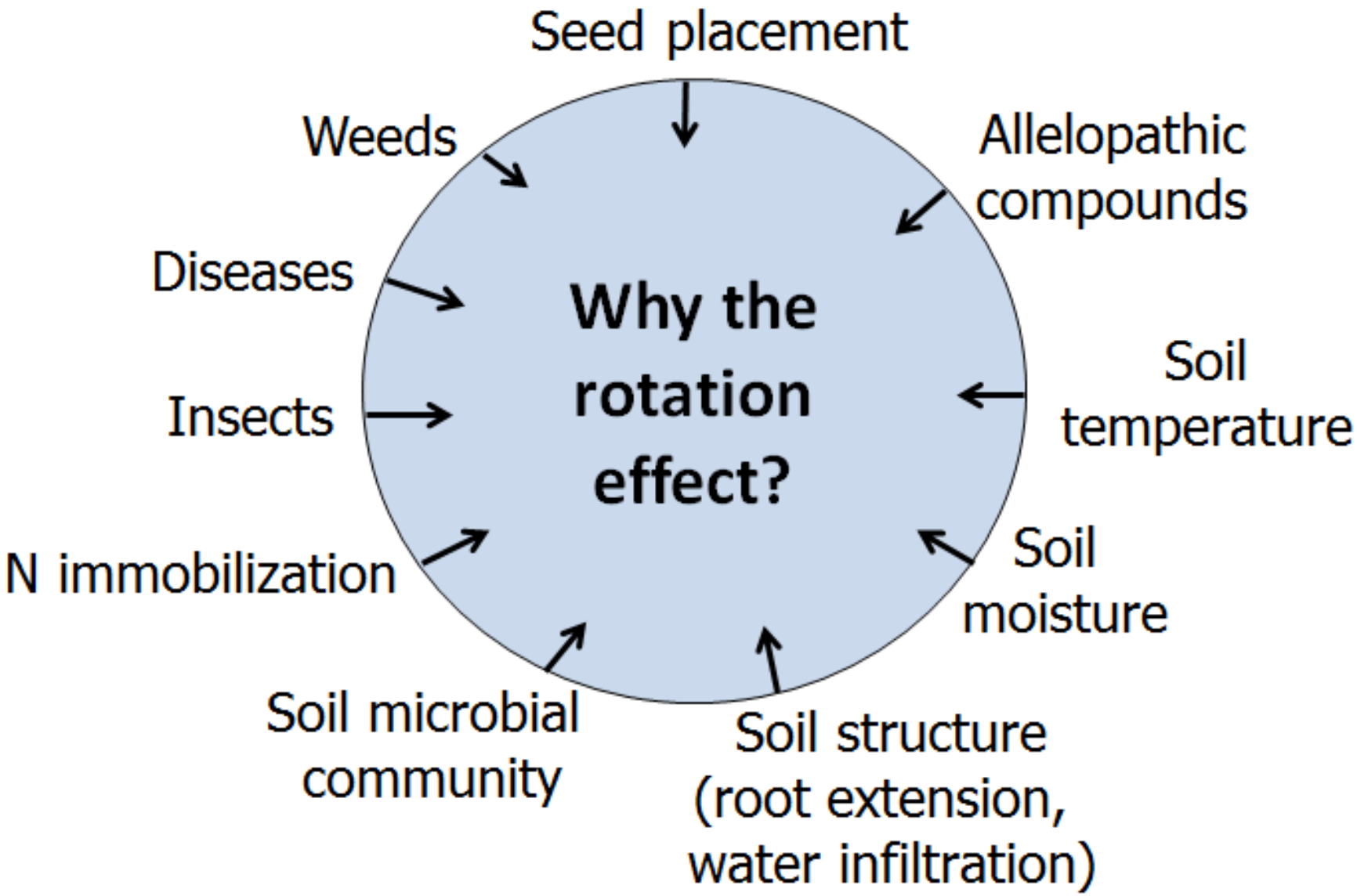

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Priorities

- **Profitability**
  - Yield
  - Efficiency of inputs
  - Costs
  - Grain price
- **Environmental stewardship**
  - Nutrient losses
  - Water quality

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Opportunities

- **Integrate agronomic & nutrient management to simultaneously…**
  - Close yield gaps
  - Reduce nutrient losses
  - Reduce risk
  - Enhance profitability

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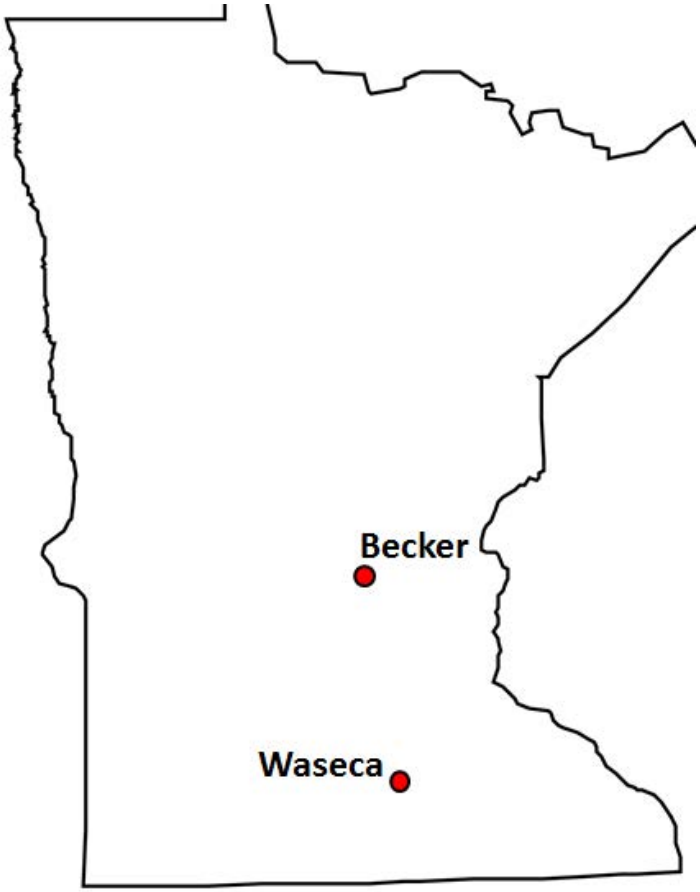
Continuous corn intensification study

- **In collaboration with:**
  - Jeff Vetsch (Univ. of MN)
  - Scott Murrell (IPNI)
  - Paul Fixen (IPNI)



IPNI International Plant Nutrition Institute

AFREC Agricultural Fertilizer Research & Education Council

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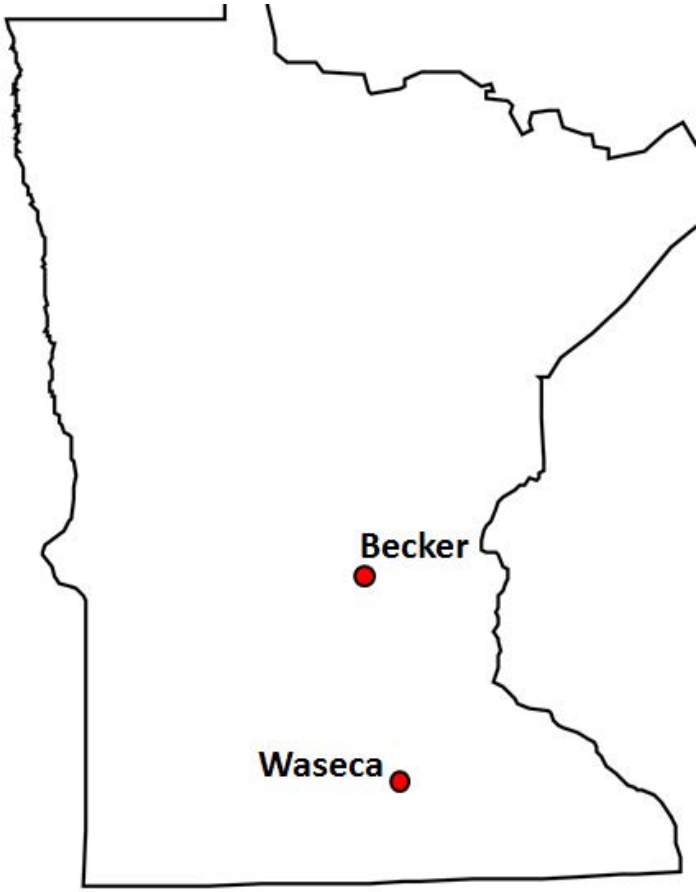
Continuous corn intensification study

- **Waseca** (2013 – present)
  - Nicollet clay loam
  - Very High P, High K
  - Patterned tile drainage
- **Becker** (2014 – present)
  - Irrigated
  - Hubbard-Mosford loamy sand
  - Very High P, Low K



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Continuous corn intensification study

- **Treatments:**
  - Normal agronomics + standard nutrient mgt.
  - Normal agronomics + ***advanced nutrient mgt.***
  - ***Intensive agronomics*** + standard nutrient mgt.
  - ***Intensive* agronomics** + ***advanced nutrient mgt.***

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Factors evaluated

- **Agronomic mgt.**
  - Removal of corn stover
  - Longer-season hybrid
  - Higher planting rate
- **Nutrient mgt.**
  - P + K based on grain removal
  - Surface-dribbled starter (28-0-0 and 12-0-0-26)
  - N timing & rate

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Surface dribble evaluated in previous research:

No.†	APP, 10-34-0 Rate	APP, 10-34-0 Placement	UAN, 28-0-0 Rate	UAN, 28-0-0 Placement	ATS, 12-0-0-26 Rate	ATS, 12-0-0-26 Placement	N+P+S Application rate
	gal./A		gal./A		gal./A		lb $N+P_2O_5+S$
1	0	---	0	---	0	---	0+0+0
2	0	---	0	---	2	Surface dribble	3+0+5.8
3	0	---	0	---	4	Surface dribble	5+0+11.5
4	0	---	8	Surface dribble	0	---	24+0+0
5	0	---	8	Surface dribble	2	Surface dribble	27+0+5.8
6	0	---	8	Surface dribble	4	Surface dribble	29+0+11.5
7	4	In furrow	0	---	0	---	5+16+0
8	4	In furrow	0	---	2	Surface dribble	7+16+5.8
9	4	In furrow	0	---	4	Surface dribble	10+16+11.5
10	4	In furrow	8	Surface dribble	0	---	29+16+0
11	4	In furrow	8	Surface dribble	2	Surface dribble	31+16+5.8
12	4	In furrow	8	Surface dribble	4	Surface dribble	34+16+11.5
13	4	In furrow	0	---	1	In furrow	6+16+2.9
14	4	In furrow	8	Surface dribble	1	In furrow	30+16+2.9

Slide from Jeff Vetsch

Research by Vetsch, Kaiser, & Randall (2010-2012)

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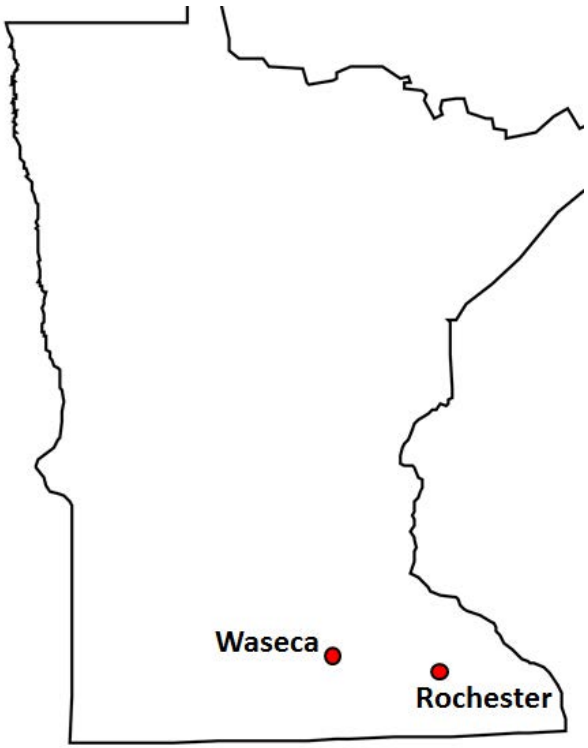
Previous starter research (2010–2012)

- **Continuous corn, disk-rip system**
- **Waseca, MN**
  - Webster or Canisteo clay loam
  - Bray P = Very High (23–47)
  - pH = 5.5–7.0
- **Rochester, MN**
  - Mt. Carrol silt loam
  - Bray P = Med. to Very High (13–22)
  - pH = 6.3–7.5
- **Starter treatments at planting**
- **UAN at V2 to give all plots same N rate (180–200 lb N/ac)**



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Source: Jeff Vetsch

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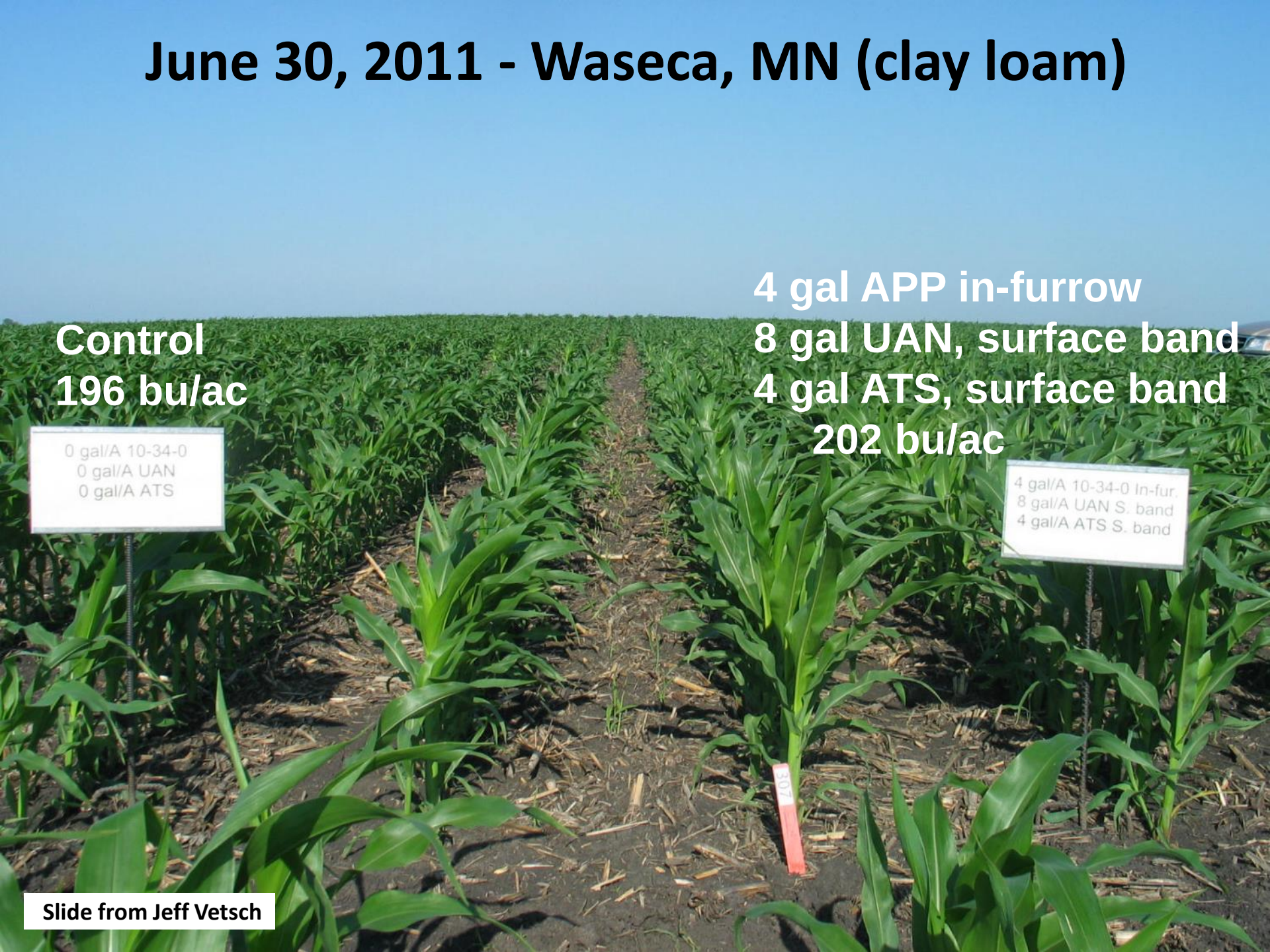
June 21, 2010 - Waseca, MN (clay loam)

Slide from Jeff Vetsch

June 21, 2010
Waseca, MN (clay loam)
193 bu/ac, 21%
209 bu/ac, 16%
0 gal/A 10-34-0
0 gal/A UAN
0 gal/A ATS
4 gal/A 10-34-0 In-
8 gal/A UAN S. ba
4 gal/A ATS S. ba
Slide from Jeff Vetsch

June 30, 2011 - Waseca, MN (clay loam)



Slide from Jeff Vetsch

June 30, 2011 - Waseca, MN (clay loam)

Slide from Jeff Vetsch

June 30, 2011 - Waseca, MN (clay loam)
4 gal APP in-furrow
8 gal UAN, surface band
4 gal ATS, surface band
4 gal/A ATS S. band
Slide from Jeff Vetsch

June 13, 2012 - Waseca, MN (clay loam)

Slide from Jeff Vetsch

June 13, 2012 - Waseca, MN (clay loam)

Slide from Jeff Vetsch

2010-2012 summary – Waseca, MN (clay loam)

- **Applying 4 gal/ac of APP in-furrow**
  - did not affect grain yield (Very High soil-test P sites, neutral pH)
  - reduced grain moisture in 2 of 3 years
  - increased plant height &/or DM yield in 3 of 3 years
- **Applying 8 gal/ac of UAN as a surface dribble band**
  - Did not affect grain yield
  - reduced grain moisture in 2 of 3 years
  - increased plant height & DM yield in 3 of 3 years
- **Applying ATS in a surface dribble band**
  - increased grain yield in 1 of 3 years (4 bu/ac)
  - reduced grain moisture in 1 of 3 years
  - increased plant height &/or DM yield in 3 of 3 years

Slide from Jeff Vetsch

2010-2012 summary – Rochester, MN (silt loam)

- **Applying 4 gal/ac of APP in-furrow**
  - increased grain yield in 1 of 3 yr & decreased it in 1 of 3 yr
  - reduced grain moisture in 2 of 3 years
  - increased plant height &/or DM yield in 3 of 3 years
- **Applying 8 gal/ac of UAN as a surface dribble band**
  - did not affect grain yield
  - reduced grain moisture in 1 of 3 years
  - increased plant height in 2 of 3 years
- **Applying ATS in a surface dribble band**
  - increased grain yield in 1 of 3 years

Slide from Jeff Vetsch

Conclusions

- Generally, starter fertilizers containing N, P, & S increased early growth and reduced plant variability of continuous corn with reduced tillage
- Starter fertilizers containing N, P, & S reduced grain moisture at harvest
- Yield responses to N, P, & S starters were inconsistent during this study period
- Yield responses are more likely on poorly-drained glacial-till soils

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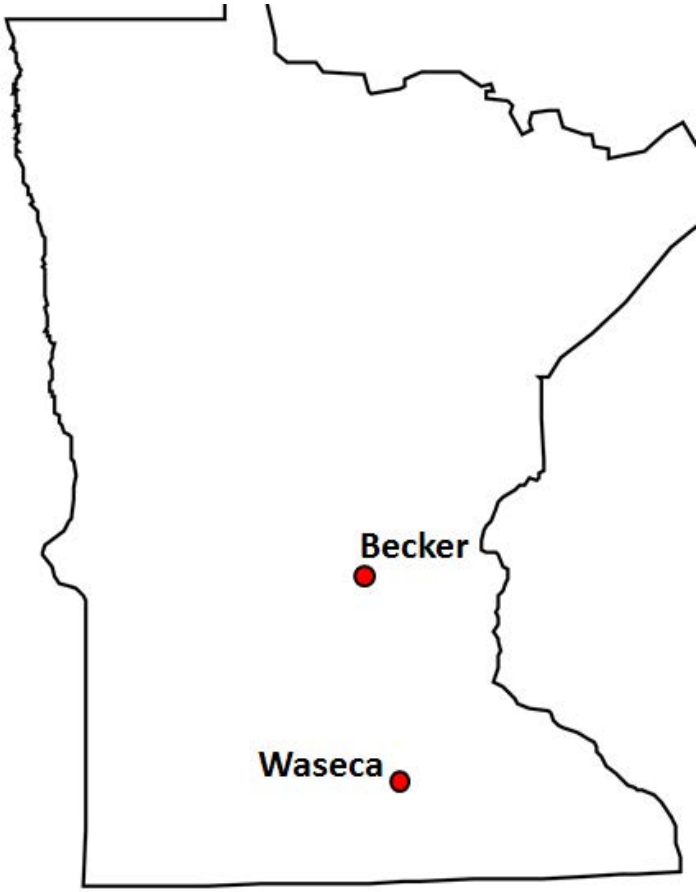
Continuous corn intensification study

- **Waseca** (2013 – present)
  - Nicollet clay loam
  - Very High P, High K
  - Patterned tile drainage
- **Becker** (2014 – present)
  - Irrigated
  - Hubbard-Mosford loamy sand
  - Very High P, Low K



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Agronomic mgt. – Waseca (clay loam)

Agronomic mgt.	**Normal**	**Intensive**
Corn stover removed	---	40%
Tillage system	disk-rip	disk-rip
Hybrid maturity	99-day	104-day
Planting rate	36,000/ac	41,000/ac

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Nutrient mgt. – Waseca (clay loam)

Nutrient mgt.	**Standard**	**Advanced**
Broadcast $P_2O_5 + K_2O$ (lb/ac)	U of M guidelines (0 + 30)	Grain removal (90 + 70)
Foundational S	15 lb S/ac	15 lb S/ac
10-34-0 in furrow	4 gal/ac	4 gal/ac
Surface-dribbled starter (2" x 0")	---	7 gal/ac 28-0-0 + 2 gal/ac 12-0-0-26
Urea (pre-plant)	160 lb N/ac	136 lb N/ac
28-0-0 (sidedressed)	---	40 lb N/ac
Total N applied	165 lb N/ac	205 lb N/ac

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Results – Waseca (clay loam)

	Normal agronomics + standard nutrient mgt.	Normal agronomics + advanced nutrient mgt.	Intensive agronomics + standard nutrient mgt.	Intensive agronomics + advanced nutrient mgt.
Increase in input costs ($/ac)	---	90	18	108
2013				
Yield (bu/ac)	193 c	215 b	210 b	233 a
Efficiency of applied N (lb N/bu)	0.85	0.95	0.79	0.88
Change in net return with drying ($/ac)	---	-13	38	25
2014				
Yield (bu/ac)	92 c	121 b	124 b	156 a
Efficiency of applied N (lb N/bu)	1.79	1.69	1.33	1.31
Change in net return with drying ($/ac)	---	11	90	109
2015				
Yield (bu/ac)	203 c	220 b	234 a	242 a
Efficiency of applied N (lb N/bu)	0.81	0.93	0.71	0.85
Change in net return with drying ($/ac)	---	-36	43	-19

LSD (0.10)

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Agronomic mgt. – Becker (irrigated sand)

Agronomic mgt.	**Normal**	**Intensive**
Corn stover removed	---	40%
Tillage system	disk-rip	disk-rip
Hybrid maturity	97-day	103-day
Planting rate	36,000/ac	41,000/ac

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Nutrient mgt. – Becker (irrigated sand)

Nutrient mgt.	**Standard**	**Advanced**
Broadcast $P_2O_5 + K_2O$ (lb/ac)	U of M guidelines (0 + 100)	Grain removal (90 + 100)
Foundational S	20 lb S/ac	20 lb S/ac
10-34-0 in furrow	4 gal/ac	4 gal/ac
Surface-dribbled starter (2" x 0")	---	7 gal/ac 28-0-0 + 2 gal/ac 12-0-0-26
V2 sidedress (urea)	40 lb N/ac	---
V6 sidedress (urea)	165 lb N/ac	70 lb N/ac
V12 sidedress (urea)	---	76 lb N/ac
VT sidedress (urea)	---	35 lb N/ac
Total N applied	210 lb N/ac	210 lb N/ac

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Results – Becker, MN (irrigated sand)

	Normal agronomics + standard nutrient mgt.	Normal agronomics + advanced nutrient mgt.	Intensive agronomics + standard nutrient mgt.	Intensive agronomics + advanced nutrient mgt.
Increase in input costs ($/ac)	---	71	18	89
2014				
Yield (bu/ac)	159 c	192 ab	180 b	205 a
Efficiency of applied N (lb N/bu)	1.32	1.09	1.17	1.02
Change in net return with drying ($/ac)	---	44	53	65
2015				
Yield (bu/ac)	163 d	183 c	197 b	222 a
Efficiency of applied N (lb N/bu)	1.29	1.15	1.07	0.96
Change in net return with drying ($/ac)	---	-4	84	81

LSD (0.10)

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N rate x timing study

- **In collaboration with:**
  - Paulo Pagliari (Univ. of MN)
  - Benjamin Davies (Univ. of MN)
  - Jeff Vetsch (Univ. of MN)

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Photo: B. Davies

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N rate x timing study

- **Objectives**
  - Determine whether corn yield & NUE are influenced by splitting N into 2 or 3 applications
  - Determine whether split applications can allow less N to be used without reducing corn yield

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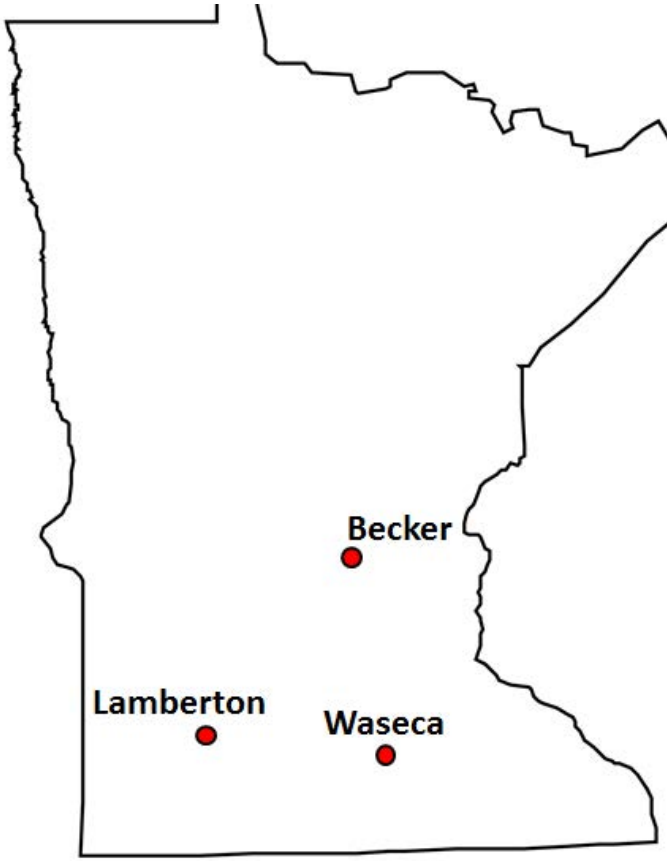
N rate x timing study, 2014–2015

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



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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

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N rate x timing study

- **Treatments**

1) Control (no N applied)
2) Fall (100%)
3) Fall (125%)
4) Preplant (100%)
5) Preplant (125%)
6) Preplant/V6 (75%)
7) Preplant/V6 (100%)
8) Preplant/V6/R1 (50%)
9) Preplant/V6/R1 (75%)
10) Preplant/V6/R1 (100%)

Photo: T. Varga

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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

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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

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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

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N rate x timing study – greatest yields with:

- **Becker (irrigated sand)**
  - 100% split 3 times (2014)
  - 100% split 2 times (2015)
- **Lamberton (loam)**
  - 125% in fall (both years)
  - 100% or 125% preplant (both years)
  - 100% split 2 times (2015)
- **Waseca (clay loam)**
  - 100% or 125% preplant (2014)
  - 125% preplant (2015)
  - 100% split 2 or 3 times (2015)

Photo: B. Davies

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Planting rate x N rate study

- Questions addressed:
  - What are the optimum planting rates in high-yield environments?
  - Do greater planting rates require more N?
  - What are the maximum corn yields that are possible?
  - How do these vary among growing environments?

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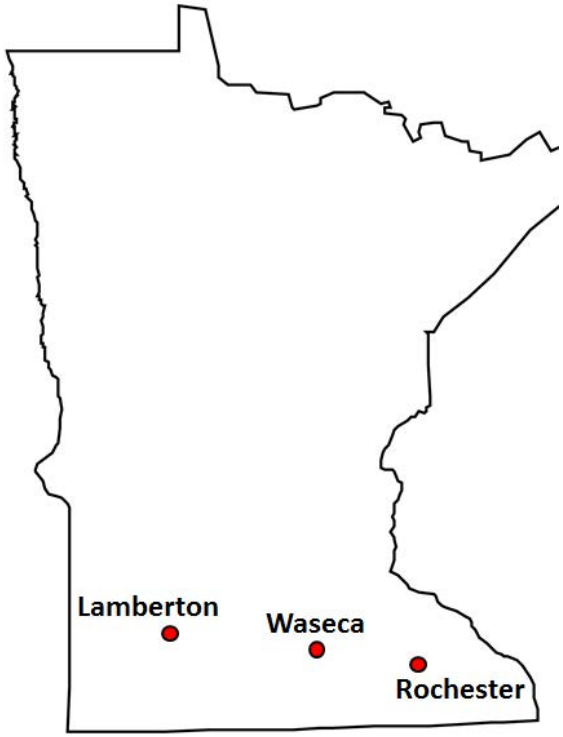
Planting rate x N rate study

Location	Soil series
Lamberton	Normania loam
Waseca	Nicollet clay loam
Rochester	Port Byron silt loam



In collaboration with Tom Hoverstad (U of M)

- **<u>Managed for maximum yield</u>:**
  - Corn followed soybean
  - All nutrients (excluding N) supplied at non-limiting levels
  - 10-34-0 in-furrow
  - 103-day hybrid (DKC53-78RIB BLEND)

MinnesotaCorn GROWERS ASSOCIATION

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Planting rate x N rate study

- 3 planting rates (30,000, 36,000, 42,000 seeds/ac)
- 4 N rates (65, 110, 155, 200 lb N/ac)

N fertilizer applied (lb N/ac)				
Total	**Preplant MAP**	**Preplant urea**	**Starter (10-34-0)**	**Sideress at V6 (28-0-0)**
65	10	10	5	40
110	10	55	5	40
155	10	100	5	40
200	10	145	5	40

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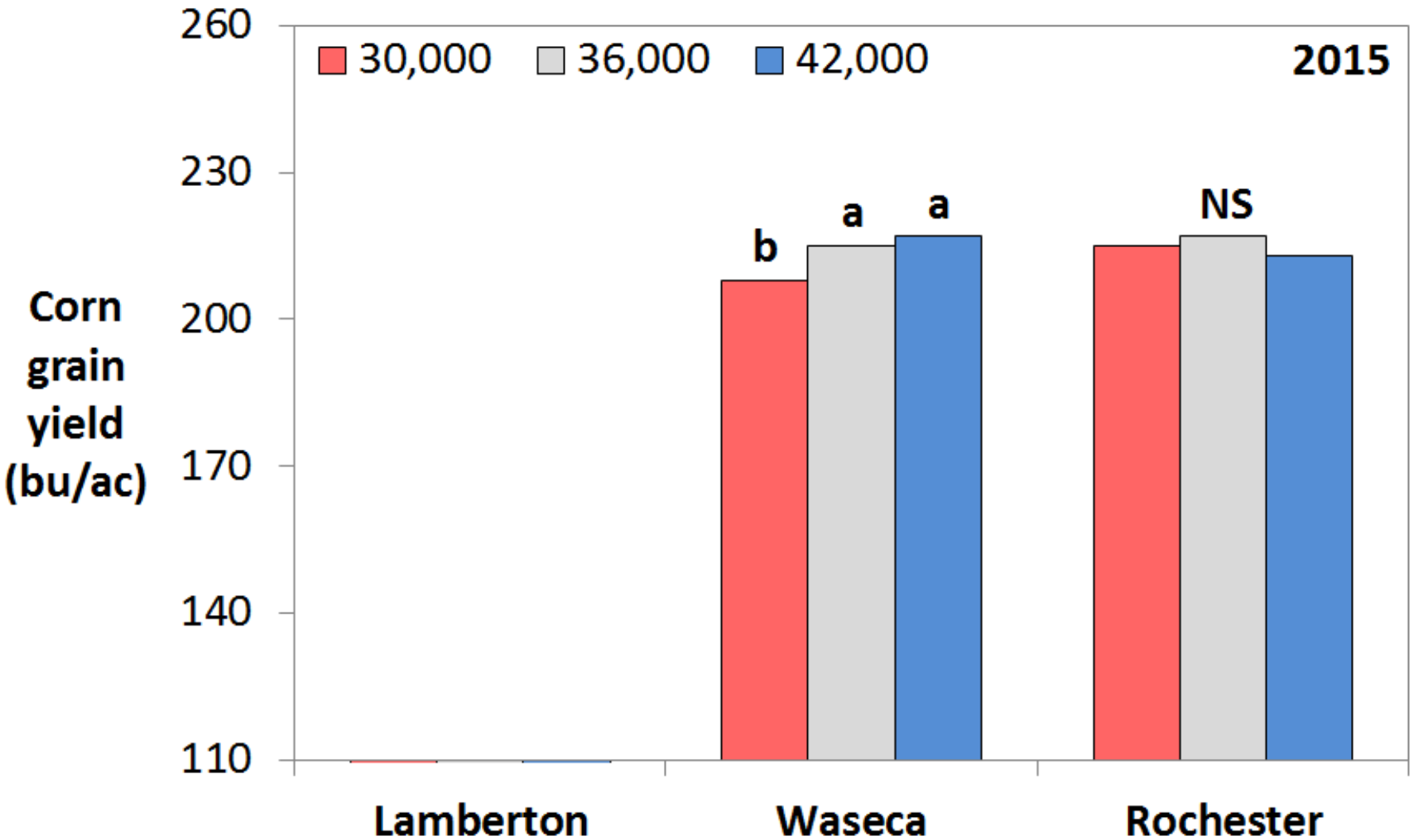
Averaged across N rates



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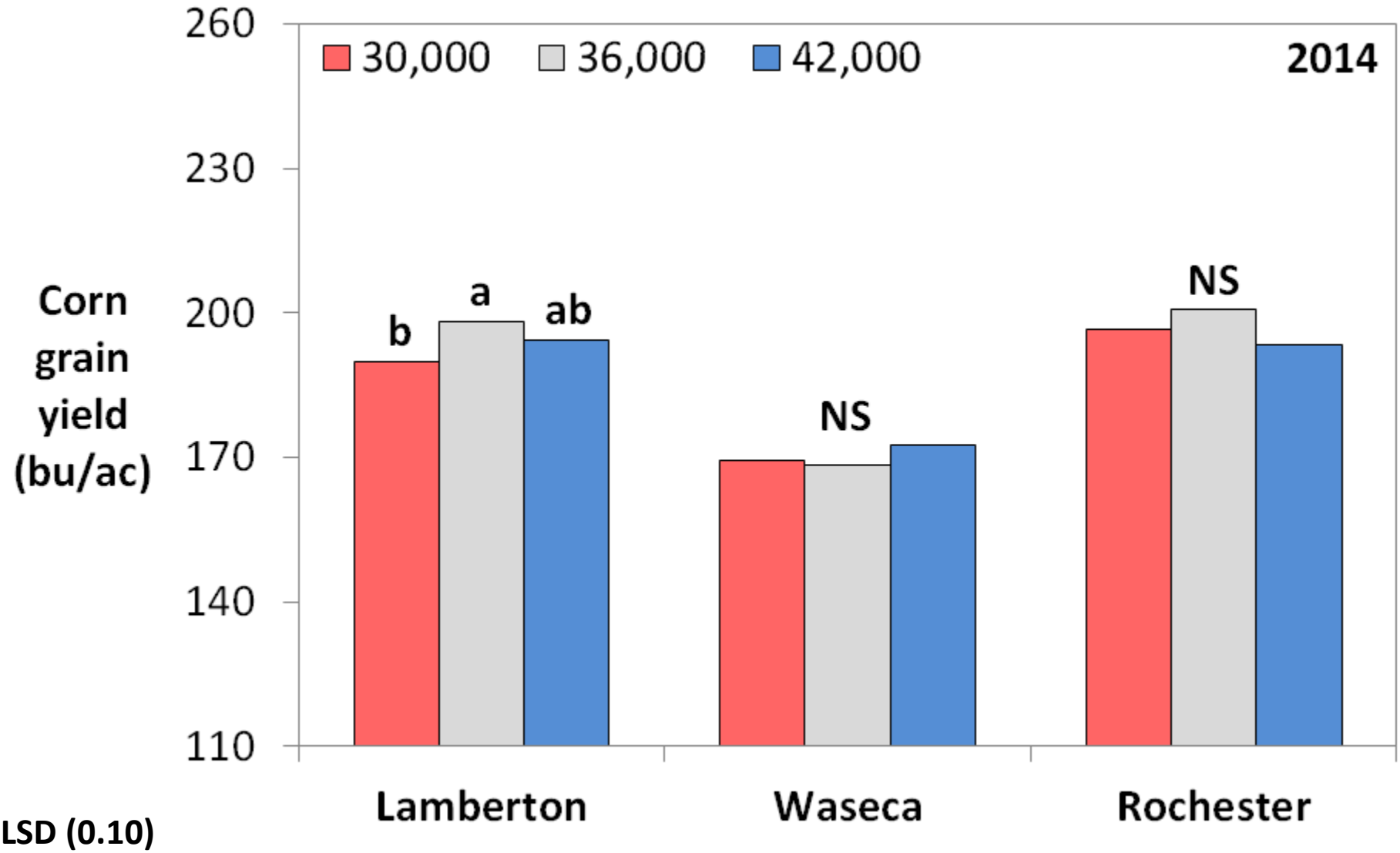
Averaged across N rates



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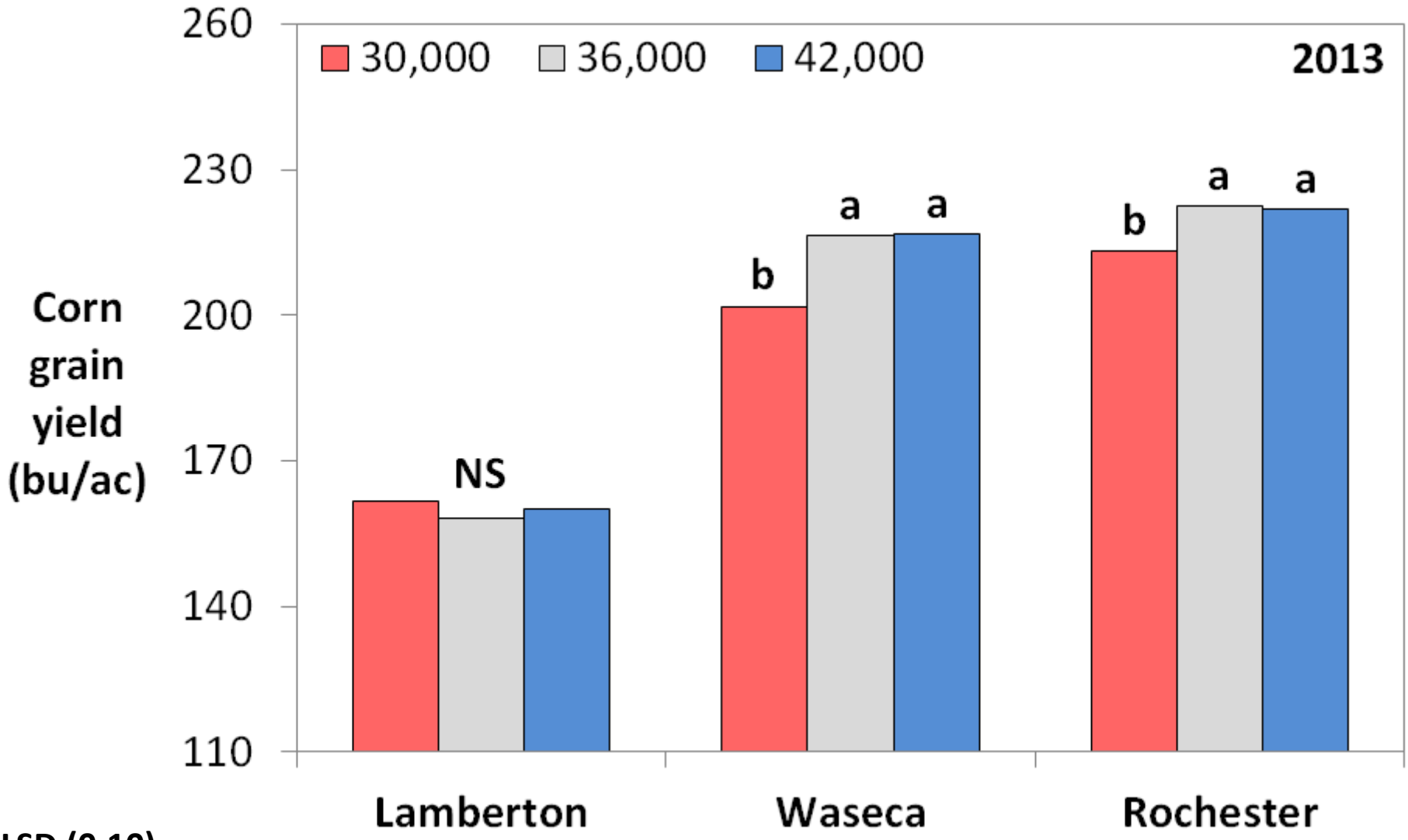
Averaged across N rates



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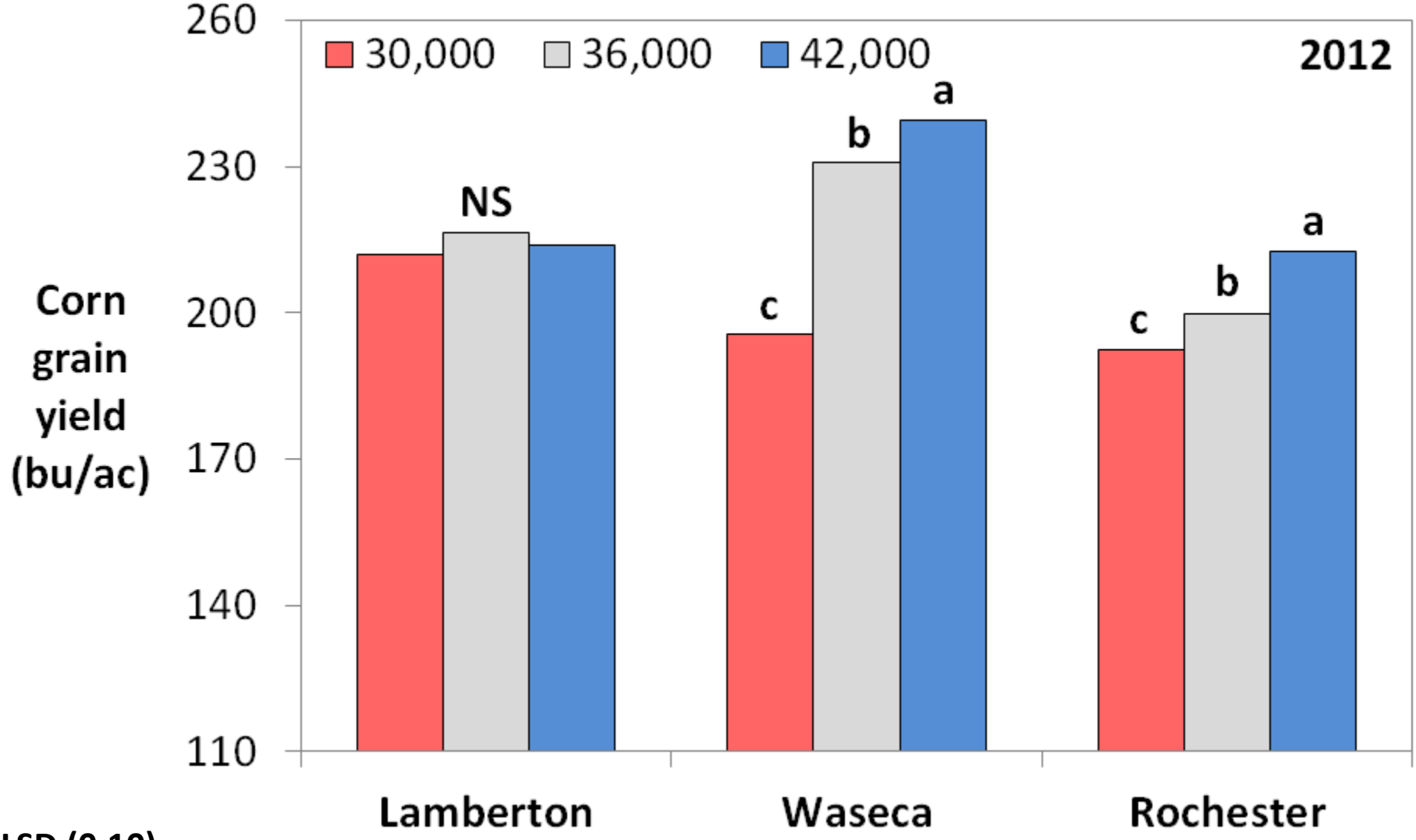
Averaged across N rates



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Lamberton (loam)

			Difference compared to 36,000 seeds/ac + 155 lb N/ac			
Year	Planting rate	N rate	Yield	Revenue at $3.50/bu	Input costs	Net return
	(seeds/ac)	(lb N/ac)	(bu/ac)	---------- $/ac ----------		
2012	42,000	155	**-17**	**-60**	**21**	**-81**
	42,000	200	**-22**	**-77**	**40**	**-117**
2013	42,000	155	**-14**	**-49**	**21**	**-71**
	42,000	200	**-4**	**-14**	**40**	**-54**
2014	42,000	155	**3**	**11**	**21**	**-10**
	42,000	200	**3**	**11**	**40**	**-29**

$280/80,000 seeds **$0.43/lb N**

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Waseca (clay loam)

Year	Planting rate	N rate	Yield	Revenue at $3.50/bu	Input costs	Net return
			Difference compared to 36,000 seeds/ac + 155 lb N/ac			
	(seeds/ac)	(lb N/ac)	(bu/ac)	---------- $/ac ----------		
2012	42,000	155	**10**	**35**	**21**	**14**
	42,000	200	**11**	**39**	**40**	**-1**
2013	42,000	155	**13**	**46**	**21**	**25**
	42,000	200	**2**	**7**	**40**	**-33**
2014	42,000	155	**6**	**21**	**21**	**0**
	42,000	200	**16**	**56**	**40**	**16**
2015	42,000	155	**10**	**35**	**21**	**14**
	42,000	200	**6**	**21**	**40**	**-19**

$280/80,000 seeds **$0.43/lb N**

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Rochester (silt loam)

			Difference compared to 36,000 seeds/ac + 155 lb N/ac			
Year	Planting rate	N rate	Yield	Revenue at $3.50/bu	Input costs	Net return
	(seeds/ac)	(lb N/ac)	(bu/ac)	---------- $/ac ----------		
2012	42,000	155	**6**	**21**	**21**	**0**
	42,000	200	**7**	**25**	**40**	**-13**
2013	42,000	155	**-2**	**-7**	**21**	**-28**
	42,000	200	**-6**	**-21**	**40**	**-61**
2014	42,000	155	**-24**	**-84**	**21**	**-105**
	42,000	200	**-3**	**-11**	**40**	**-51**
2015	42,000	155	**-7**	**-25**	**21**	**-46**
	42,000	200	**-12**	**-42**	**40**	**-82**

$280/80,000 seeds **$0.43/lb N**

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Summary – planting rate x N rate study

- Greater planting rates never required more N
- Response to planting rate varied
  - No yield increase with more than 30,000 seeds/ac in 5 of 11 environments
  - Yield with 36,000 seeds/ac among the greatest in 9 of 11 environments
  - Yield with 42,000 seeds/ac among the greatest 11 of 11 environments

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Take home points

- Increases in corn yield & net return are limited in frequency & magnitude with above-normal planting rates & uses of other inputs

- Weather can have a much larger impact on yield than agronomic inputs & it greatly influences optimum N management

- Have a 'Plan B' & 'Plan C' in case the weather causes challenges

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Be an economist, pay attention to details

- Control costs without impacting yield
- Conduct simple on-farm tests to evaluate inputs
- Be timely
- Don't overlook the basics
  - Crop rotation
  - Hybrid selection
  - Stand establishment
  - Weed control

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Thank you!

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