Proceedings of the 5th Annual Nitrogen: Minnesota's Grand Challenge & Compelling Opportunity Conference

UNIVERSITY OF MINNESOTA EXTENSION

MAKING A DIFFERENCE IN MINNESOTA: ENVIRONMENT + FOOD & AGRICULTURE + COMMUNITIES + FAMILIES + YOUTH

Managing Corn for High Yield & Environmental Stewardship While Controlling Costs

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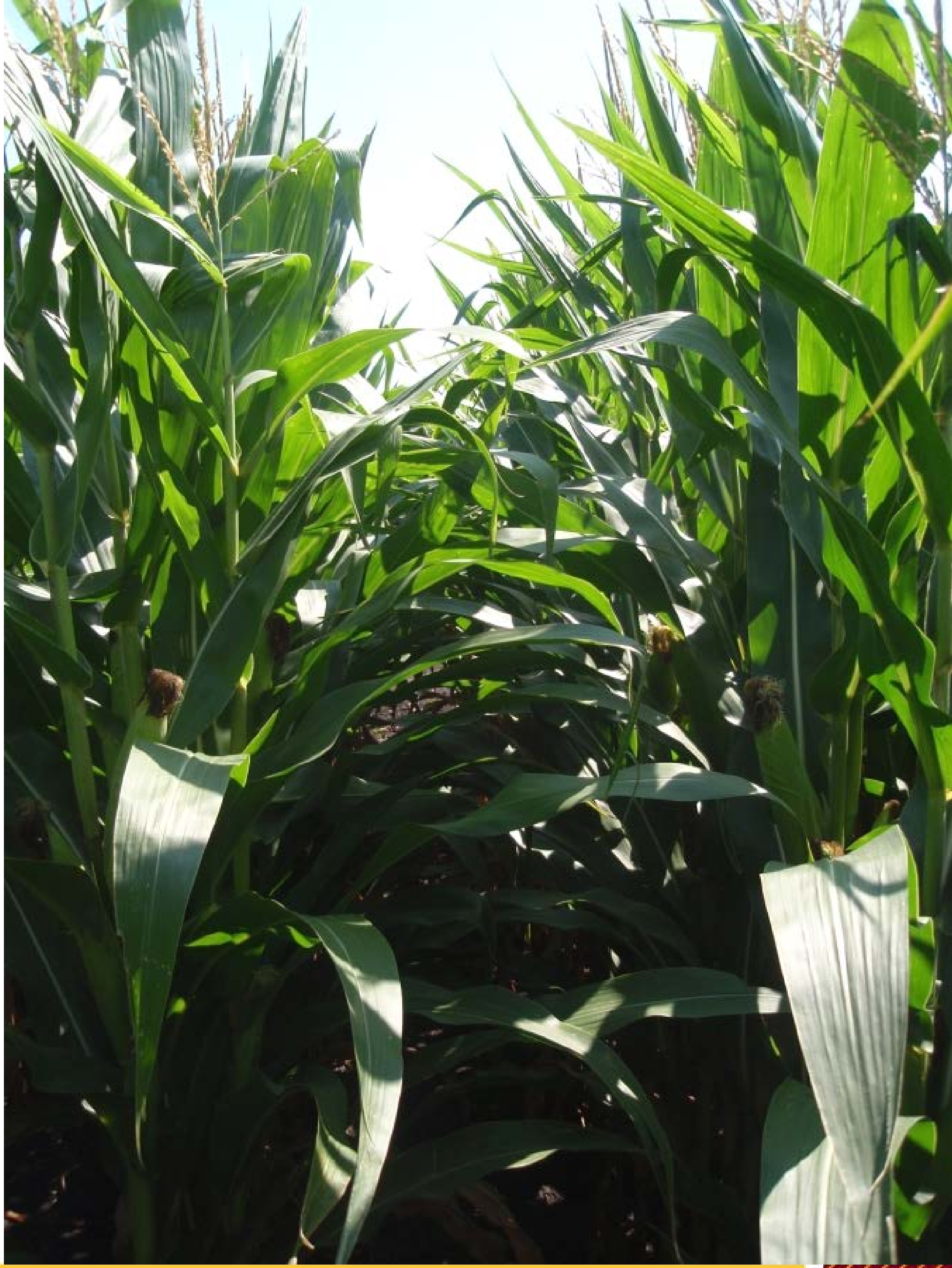
Overview

- Row width
- Planting rate
- N management
- New innovations



Growers are adopting greater planting rates

- Optimum planting rates tend to be greater in high-yield environments

- Often no yield penalty for too high of planting rate

Narrow rows can reduce competition among plants when high planting rates

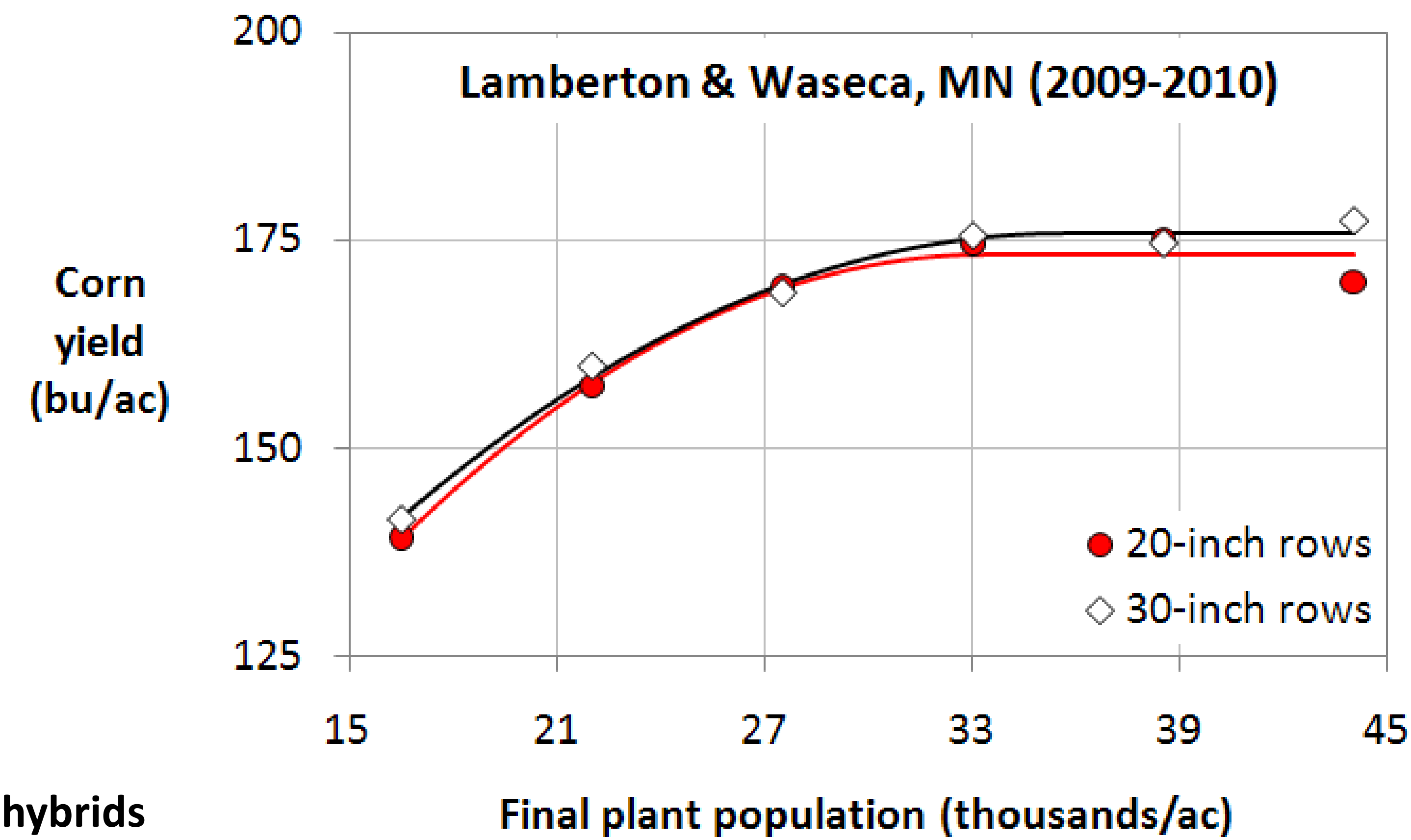
30-inch rows
47,000 seeds/acre

22-inch rows
47,000 seeds/acre

1) Similar yield for both row widths

2) Similar response to plant population for both row widths

3) Yield was maximized at 34,300 plants/ac or greater



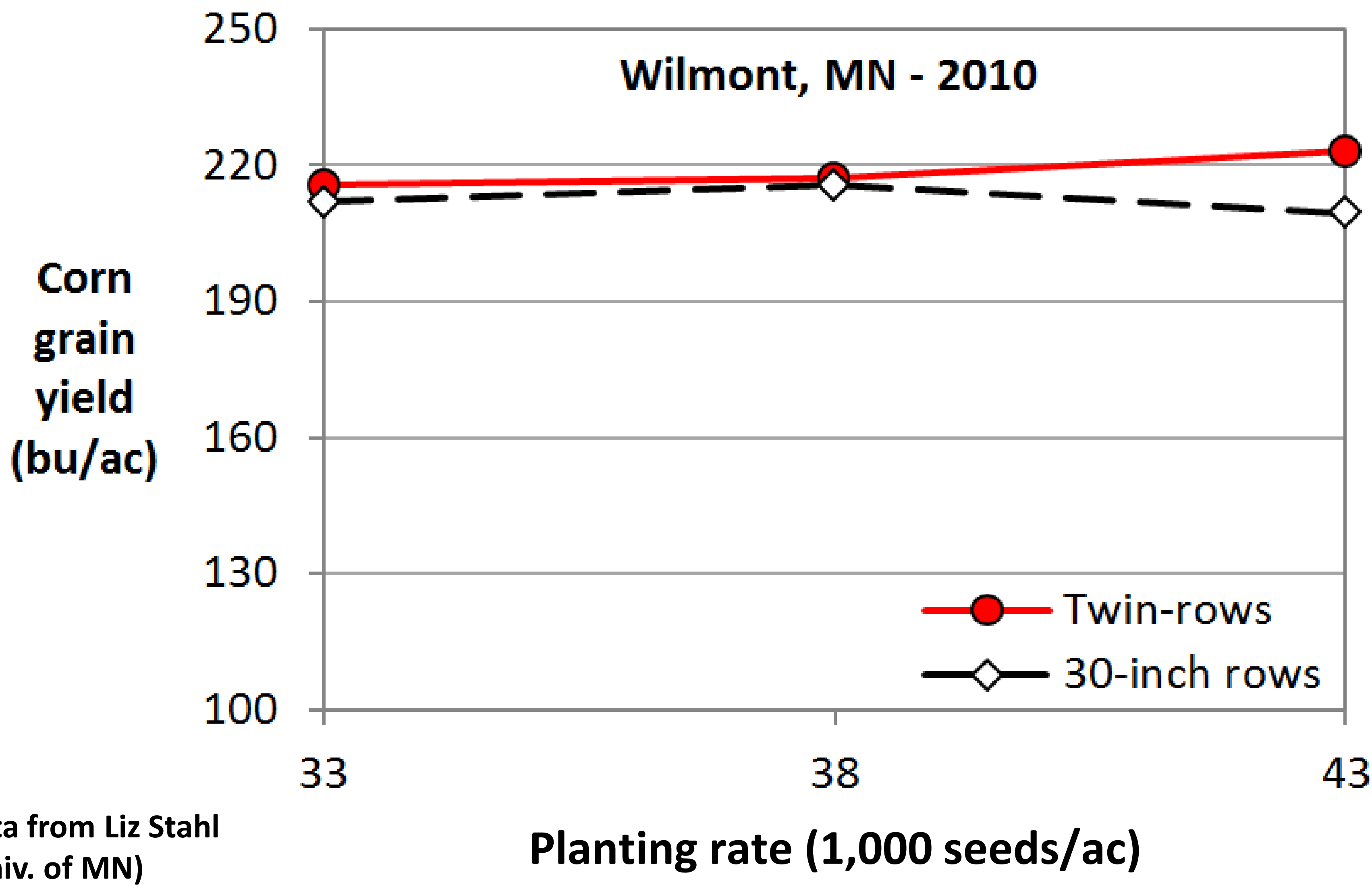
Avg. of 3 hybrids

30-inch rows

22-/8-inch twin rows

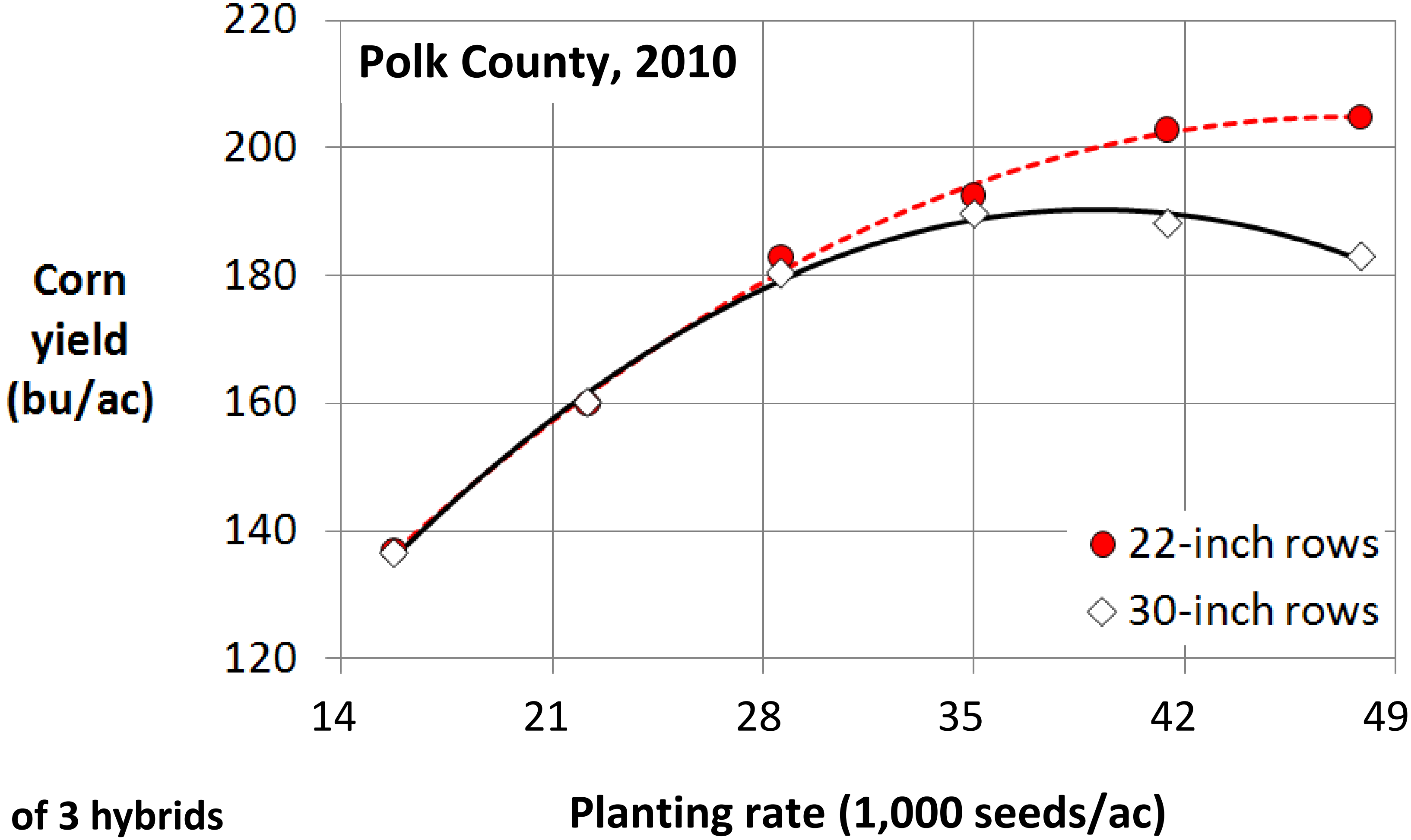
Photos: Liz Stahl (Univ. of MN)

Yield differences in 1 of 5 trials in southern MN



Data from Liz Stahl (Univ. of MN)

Yield & optimum planting rate were greater with 22-inch rows in 1 of 4 trials in northwestern MN



Avg. of 3 hybrids

Nitrogen

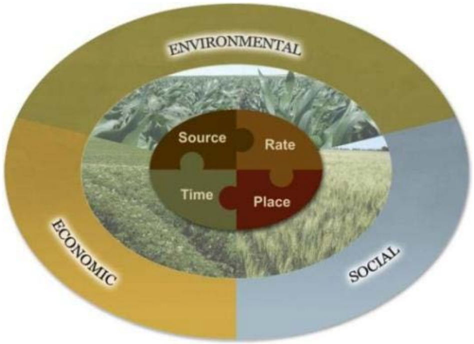
- Often the most limiting nutrient for corn
- Application in excess of corn requirements reduces risk of yield loss, but with economic & environmental consequences

N use efficiency (NUE)

- NUE can be increased by:
  - Greater corn uptake of applied N
  - Reduced N losses

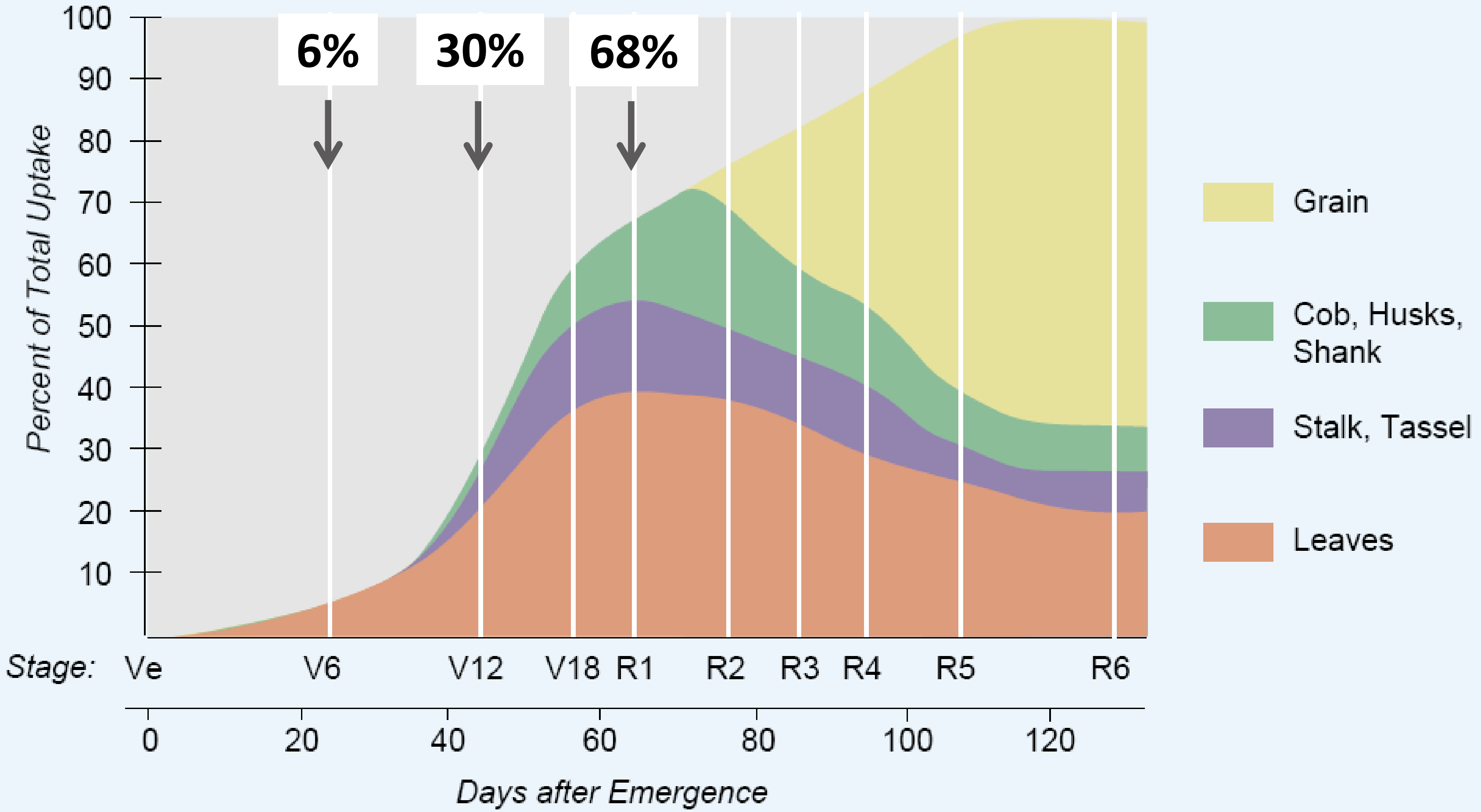
- Synchrony between N supply & corn N uptake is key to optimizing yield, profit, & environmental protection

Cassman et al. (2002)



Source: IPNI

Nitrogen Uptake by Corn



(Adapted from *How a Corn Plant Develops*, Special Report 48. Iowa State University)

Hoeft et al. (2000)

N supply

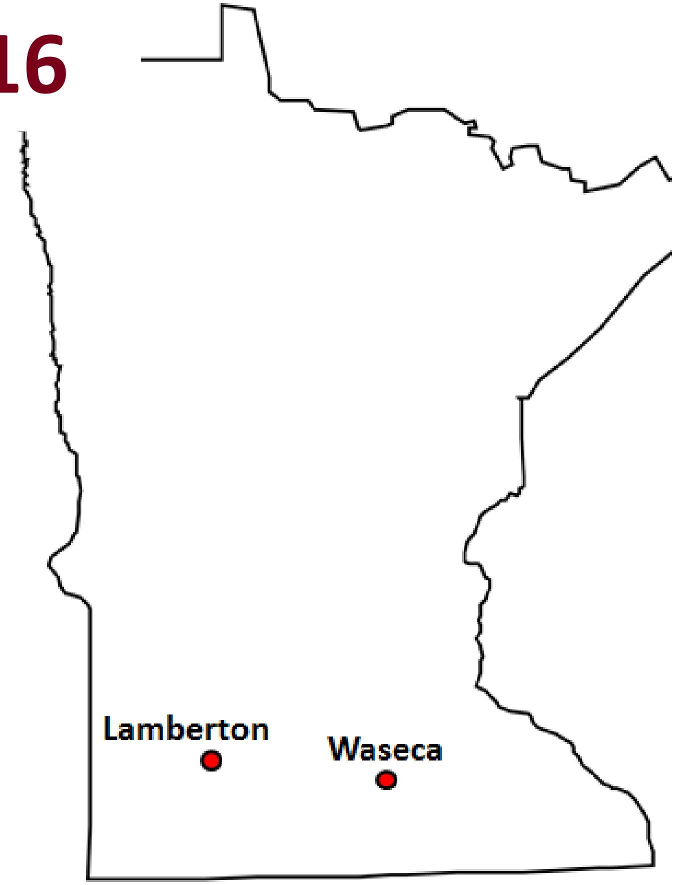
- Applied N
- Soil N (variable & difficult to predict)
  - Nitrate & ammonium
  - Mineralization from soil organic matter & crop residues

N rate x timing study

- **Objectives**
  - Determine whether yield & NUE can be increased with split applications of N
  - Determine whether split applications can allow less N to be used without reducing yield

N rate x timing study, 2014–2016

- Lamberton (loam soil)
- Waseca (clay loam soil)
- Continuous corn
- Fertilizer
  - Fall N = SuperU
  - Preplant & in-season N = urea
  - All other nutrients supplied at non-limiting levels



With Paulo Pagliari, Ben Davies, & Jeff Vetsch (Univ. of MN)

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Agricultural Fertilizer Research & Education Council

- Greatest yield at both locations with 225 lb N/ac preplant
- Greatest yield also with 225 lb N/ac in fall at Lamberton or 180 lb N/ac in 2 or 3 splits at Waseca

3-year average

N application time	N rate	Lamberton	Waseca
	lb N/ac	------------- bu/ac	-------------
Fall	180	219 ab	186 b
Fall	225	234 a	191 ab
Preplant	180	225 ab	197 ab
Preplant	225	232 a	206 a
Preplant + V6	135	208 b	191 ab
Preplant + V6	180	225 ab	203 a
Preplant + V6 + tasseling	135	208 b	184 b
Preplant + V6 + tasseling	180	218 ab	203 a

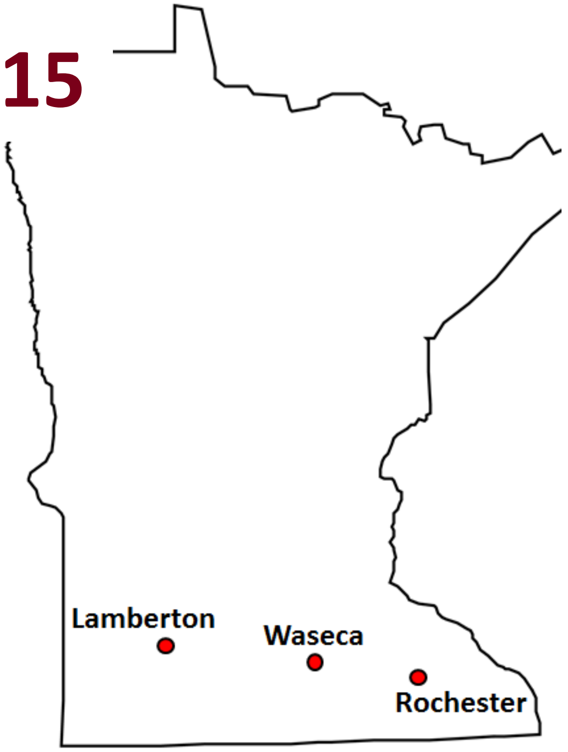
LSD (0.05)

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?

Planting rate x N rate study, 2012–2015

- Lamberton (loam soil)
- Waseca (clay loam soil)
- Rochester (silt loam soil)
- Managed for maximum yield:
  - Corn followed soybean
  - All nutrients other than N supplied at non-limiting levels
  - 10-34-0 in-furrow
  - 103 RM hybrid



With Tom Hoverstad (Univ. of MN)

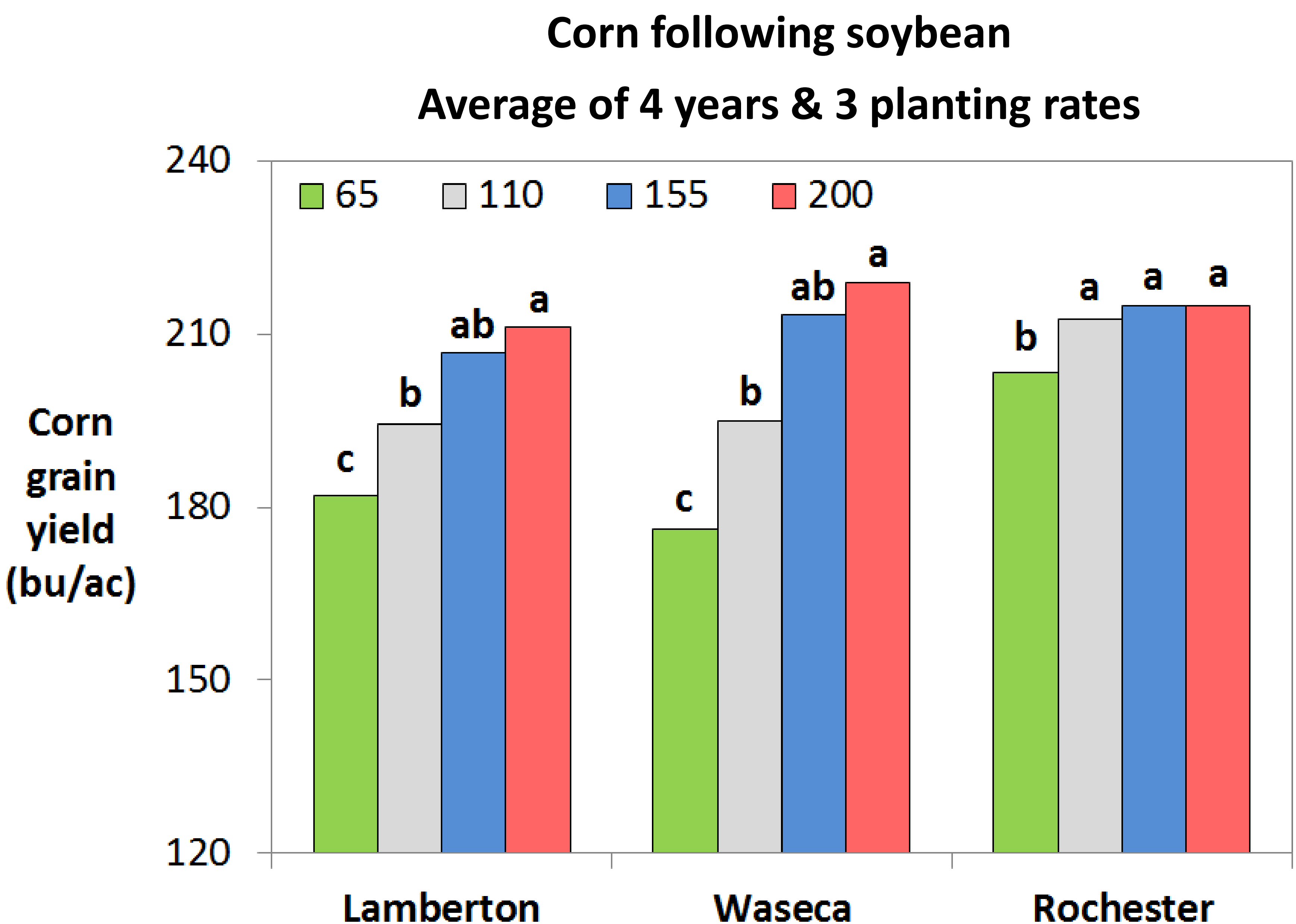
Minnesota Corn Growers Association

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


Average of 4 years & 4 N rates
240
210
180
150
120
30,000
36,000
42,000
Corn grain yield (bu/ac)
b
a
a
b
ab
a
b
a
a
Lamberton
Waseca
Rochester


Corn following soybean
Average of 4 years & 3 planting rates
Corn grain yield (bu/ac)
240
210
180
150
120
65
110
155
200
c
b
ab
a
c
b
ab
a
b
a
a
a
Lamberton
Waseca
Rochester

Summary – planting rate x N rate study

- Greater planting rates never required more N
- On average, greatest yield with:
  - 155 lb N/ac or more at Lamberton & Waseca
  - 110 lb N/ac or more at Rochester (silt loam soil)
  - 36,000 seeds/ac or more at all locations

Summary – planting rate x N rate study

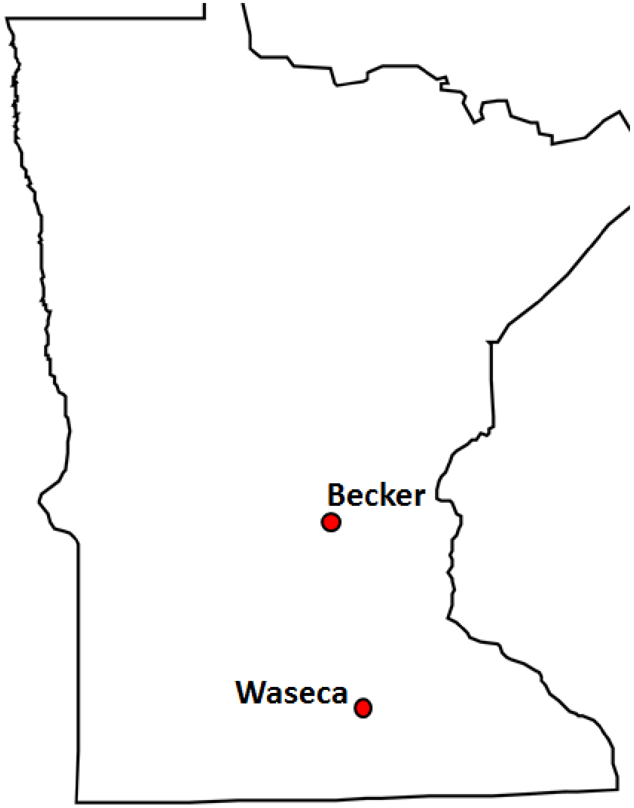
- Compared to 155 lb N/ac + 36,000 seeds/ac:
  - Increasing only the planting rate to 42,000 seeds/ac increased net return in 3 of 12 trials
  - Increasing only the N rate to 200 lb N/ac increased net return in 2 of 12 trials

Continuous corn intensification study

- Questions addressed:
  - What yield levels are possible?
  - How far are current yields from these levels?
  - Is standard fertilizer management capable of attaining yields at levels close to yield potential?

Continuous corn intensification study

- **Waseca** (2013 – present)
  - Nicollet clay loam
  - Patterned tile drainage
  - Continuous corn
- **Becker** (2014 – present)
  - Irrigated
  - Hubbard-Mosford loamy sand
  - Continuous corn

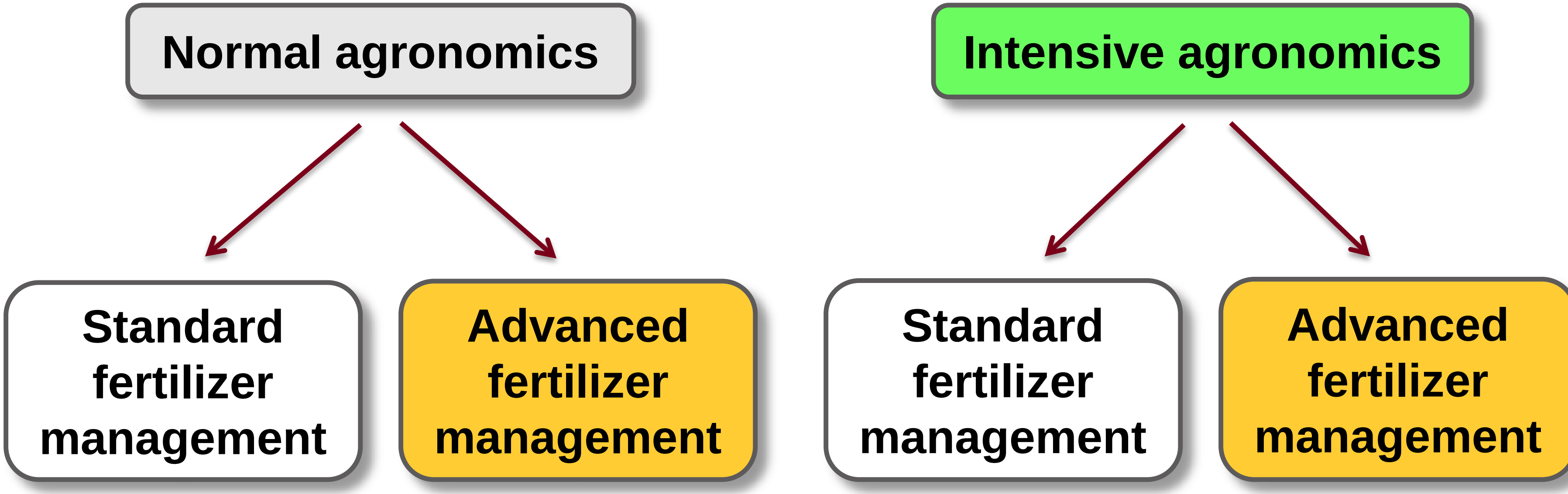


With Jeff Vetsch (Univ. of MN) & Scott Murrell (IPNI)

IPNI International Plant Nutrition Institute

AFREC Agricultural Fertilizer Research & Education Council

- **Continuous corn**
  - Requires top management for high yields
  - Greater risk of nutrient losses
- **Irrigated sands**
  - High yield potential
  - Greater risk of crop nutrient deficiency
  - Greater risk of nutrient losses



- **'Systems' treatments developed & updated over time:**
  - Crop advisors, industry agronomists, farmers

Agronomic treatments – Waseca

	Normal	Intensive
Corn stover harvested (%)	0	40
Hybrid maturity (CRM)	101	105
Planting rate (seeds/acre)	36,000	41,000
Fungicide at tasseling	No	Yes

Fertilizer treatments – Waseca

	Standard	Advanced
S	20 lb SO_4/ac	20 lb SO_4/ac
P	U of M guidelines	50% grain removal
K	U of M guidelines	100% grain removal
10-34-0 in furrow	4 gal/ac	4 gal/ac
Surface-banded starter (2" x 0")	---	7 gal/ac 28-0-0 + 2 gal/ac 12-0-0-26
Pre-plant N (urea)	175 lb N/ac	111 lb N/ac
V6 N (28-0-0, injected)	---	40 lb N/ac
V14 N (28-0-0, Y-DROPs)	---	40 lb N/ac
Total N	180 lb N/ac	220 lb N/ac

- **Yield gap = 16 to 64 bu/ac (average = 35 bu/ac)**
- **Greatest yield = advanced fertilizer mgt. + intensive agronomics**
- **Moderate yield = advanced fertilizer mgt. or intensive agronomics**

Waseca

Agronomic management	Normal	Normal	Intensive	Intensive
Fertilizer management	Standard	Advanced	Standard	Advanced
------------ year ------------	-------------------- grain yield (bu/ac) --------------------			
2013	193 c	215 b	210 b	233 a
2014	92 c	121 b	124 b	156 a
2015	203 c	220 b	234 a	242 a
2016	214 c	220 b	233 a	239 a
2017	209 c	230 b	228 b	238 a
2018	213 b	224 a	218 b	229 a
6-year average	187 c	205 b	208 b	223 a

- Net return increased with intensive agronomics in 2 of 6 years

Waseca

Agronomic management	Normal	Normal	Intensive	Intensive
Fertilizer management	**Standard**	**Advanced**	**Standard**	**Advanced**
Added inputs ($/ac)	**---**	**77 & 54**	**18 & 33**	**95 & 87**
------------ year ------------	-- change in net return after drying + inputs ($/ac) --			
2013	---	-8	-3	-8
2014	---	6	64	80
2015	---	-22	45	-4
2016	---	-56	6	-49
2017	---	-14	-6	-43
2018	---	-27	-54	-68
6-year average	---	-19	10	-13

Agronomic treatments – Becker (irrigated)

	Normal	Intensive
Hybrid maturity (CRM)	96	103
Planting rate (seeds/acre)	36,000	41,000

Fertilizer treatments – Becker (irrigated)

	Standard	Advanced
S	25 lb SO_4/ac	25 lb SO_4/ac
P	U of M guidelines	50% grain removal
K	U of M guidelines	100% grain removal
10-34-0 in furrow	4 gal/ac	4 gal/ac
V2 N (urea)	40 lb N/ac	40 lb N/ac
V6 N (urea)	185 lb N/ac	70 lb N/ac
V12 N (urea)	---	70 lb N/ac
VT N (urea)	---	45 lb N/ac
Total N	230 lb N/ac	230 lb N/ac

- **Yield gap = 38 to 59 bu/ac (average = 46 bu/ac)**
- **Greatest yield = advanced fertilizer mgt. + intensive agronomics**
- **Moderate yield = advanced fertilizer mgt. or intensive agronomics**

Becker (irrigated)

Agronomic management	Normal	Normal	Intensive	Intensive
Fertilizer management	**Standard**	**Advanced**	**Standard**	**Advanced**
------------ year ------------	------------------- grain yield (bu/ac) -------------------			
2014	159 c	192 ab	180 b	205 a
2015	163 d	183 c	197 b	222 a
2016	190 c	189 c	209 b	229 a
2017	169 c	192 b	171 c	224 a
2018	169 c	207 a	190 b	190 b
5-year average	178 c	200 b	201 b	217 a

- Greatest net return with advanced fertilizer mgt. in 3 of 5 years & advanced fertilizer mgt. + intensive agronomics in 2 of 5 years
- Net return increased with advanced fertilizer mgt. or intensive agronomics in 4 of 5 years

Becker (irrigated)

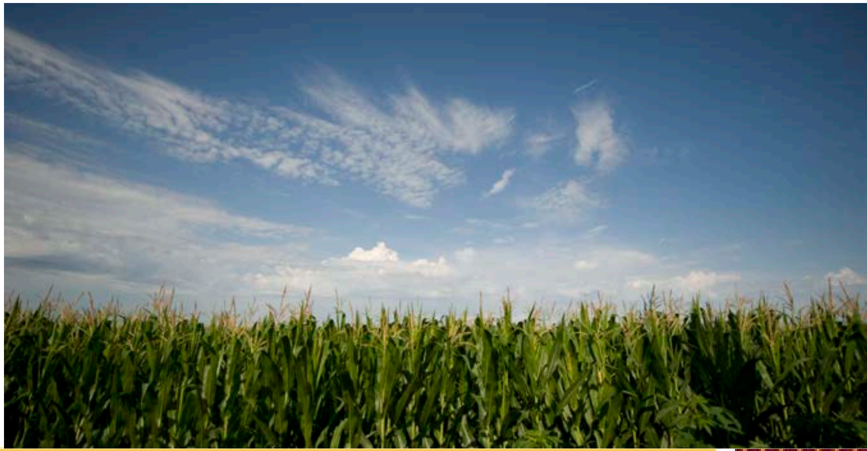
Agronomic management	Normal	Normal	Intensive	Intensive
Added inputs ($/ac)	---	52 & 38	18	70 & 56
Fertilizer management	Standard	Advanced	Standard	Advanced
------------ year ------------	-- change in net return after drying + inputs ($/ac) --			
2014	---	44	28	36
2015	---	16	84	101
2016	---	-54	31	42
2017	---	12	-6	-17
2018	---	73	19	-17
5-year average	---	19	31	29

Conclusions

- Increases in profitability are limited in frequency & magnitude with above-normal rates of seed & other inputs

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

- Have back-up plans for when weather causes challenges



Be an economist, pay attention to details

- Control costs without impacting yield
- Conduct simple on-farm tests
- Be timely & site specific
- Don't overlook the basics:
  - Crop rotation
  - Hybrid selection
  - Stand establishment
  - Weed control

New Innovations in Corn Cropping Systems

With John Baker, Rod Venterea, & Jon Alexander

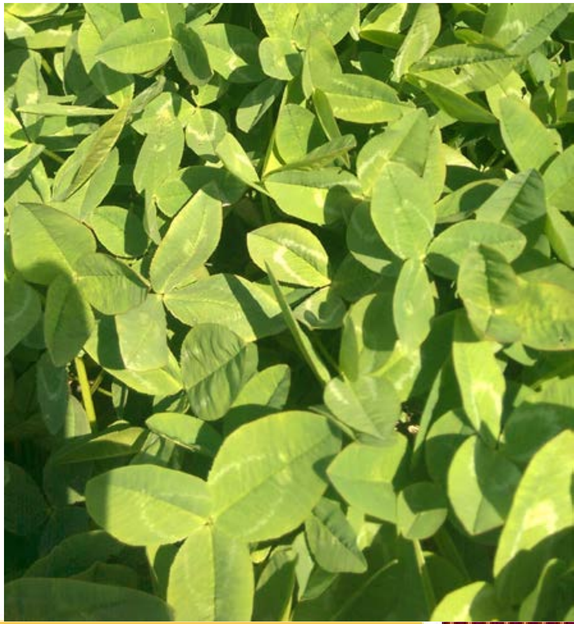
(USDA-ARS & Univ. of MN)

Corn production in kura clover living mulch

To improve water & soil quality without reducing profitability

Kura clover

- Perennial
- Spreads by rhizomes
- Deep rooted – can scavenge soil N
- Legume – can fix N
- Cold hardy
- Persistent



Photos: John Baker, USDA-ARS

Kura clover living mulch-corn systems demonstrate potential in northern Corn Belt

- Compared with standard corn systems:
  - Reduces runoff by 50% & erosion by 77% on 8-15% slope
  - Enhances soil organic carbon
  - 74% reduction in soil nitrate-N in non-fertilized corn
  - Kura clover competes with corn if not properly suppressed
  - Even with proper suppression, corn grain yield can be reduced by 5 to 21%, depending on precipitation

New research is developing ways to gain these benefits & mitigate the drawbacks

Corn production in kura clover living mulch

Step 1: Establish kura clover (photo: April 24, 2017)

Photo: John Baker, USDA-ARS

Corn production in kura clover living mulch

Step 2: Mow kura clover in spring

Corn production in kura clover living mulch

Step 3: Rotary zone tillage with some N application (photo: May 11, 2017)

Corn production in kura clover living mulch

Step 4: Plant glyphosate-tolerant corn on strips

(photo: May 12, 2017)

Corn production in kura clover living mulch

Vigorous re-growth 2 weeks after planting (May 25, 2017)

Corn production in kura clover living mulch

Step 5: Apply glyphosate to suppress kura clover (photo following glyphosate application)

Corn production in kura clover living mulch

Step 6: Sidedress additional N

(photo on June 21, 2017)

July 6: Healthy stand of clover fills in understory by mid-season

Aug 24: Canopy closes over clover by late season

Photos: Jon Alexander, Univ. of MN

Corn production in kura clover living mulch

Step 7: Harvest corn grain & stover

Step 8: Repeat on strips in spring

- **Research from 2017 & 2018 for 1st- & 2nd-year corn in kura clover living mulch indicates:**
  - Yield similar to corn following soybean & corn
  - Reduced N fertilizer requirement
    (similar to 1st - & 2nd-year corn following alfalfa)
- **Limitations:**
  - Kura clover seed availability & establishment
  - Economic viability uncertain

Thank you!

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