Urea and Urea additives

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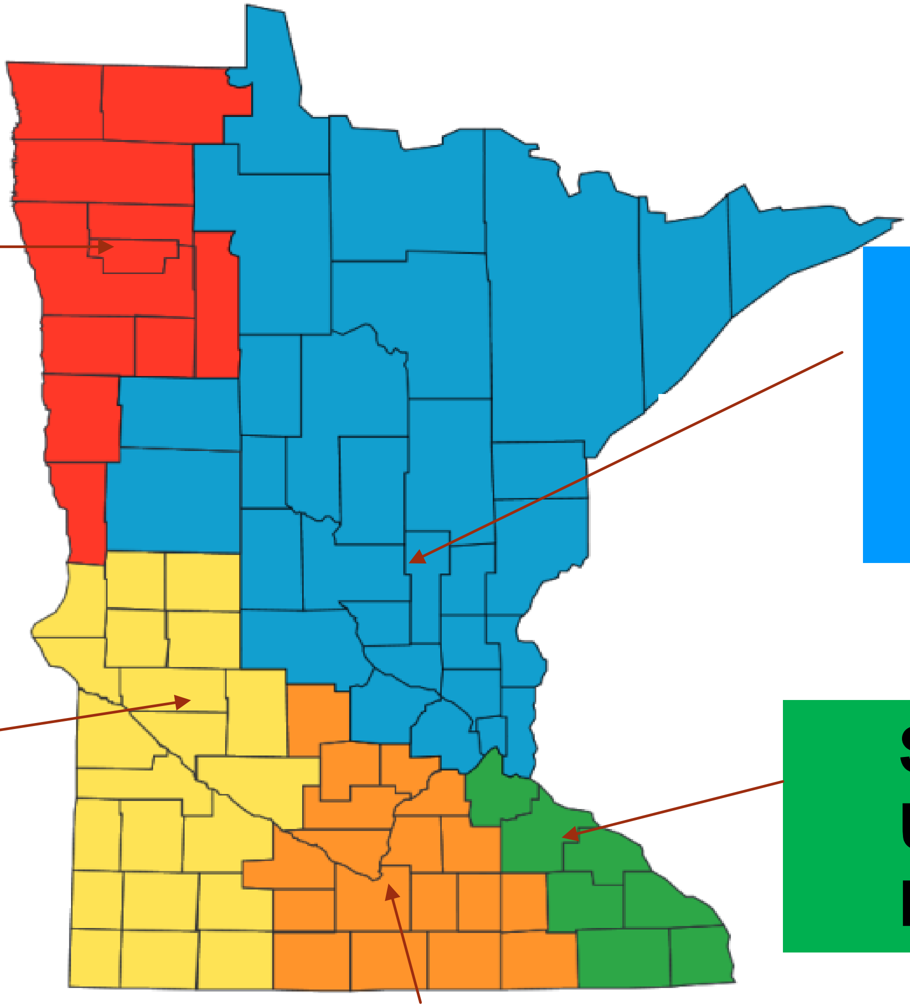
Bierman et al. (2011). Survey of N Fertilizer Use on Corn in Minnesota

N source (statewide): 46% of surveyed farmers use AA , 45% use UREA, and 6.5% Liquid N as the major N source

Northwestern
Urea (79%)
AA (21%)

Southwestern
West Central
AA (48%)
Urea (43%)



Coarse-textured Soils
Urea (67%), AA (20%), Liquid N (5.7%)

Southeastern:
Urea (55%), AA (35%), Liquid N (9%)

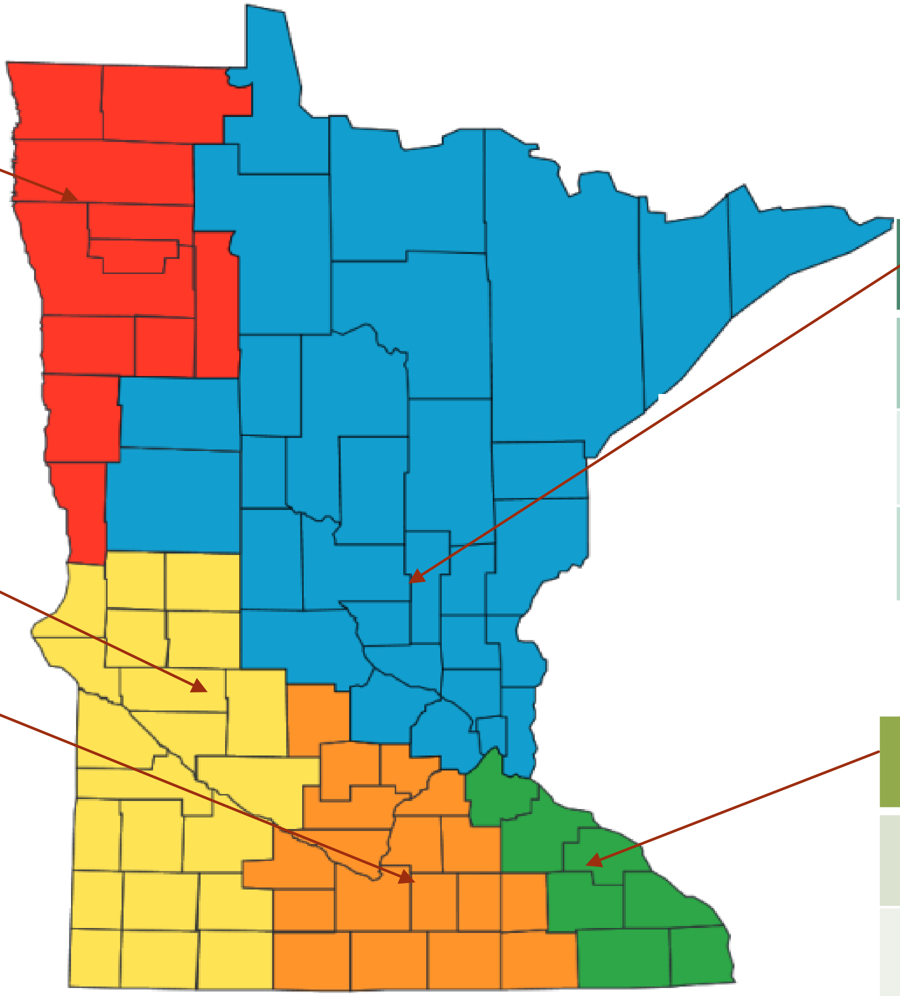
South Central: AA (64%), Urea (29%)

Adapted from Bierman et al. (2011)

Bierman et al. (2011). Survey of N Fertilizer Use on Corn in Minnesota

Application Timing (statewide): 32% of surveyed farmers Fall, 59% Spring, and 9% Sidedress

Northwestern	
Fall	11%
Spring	89%



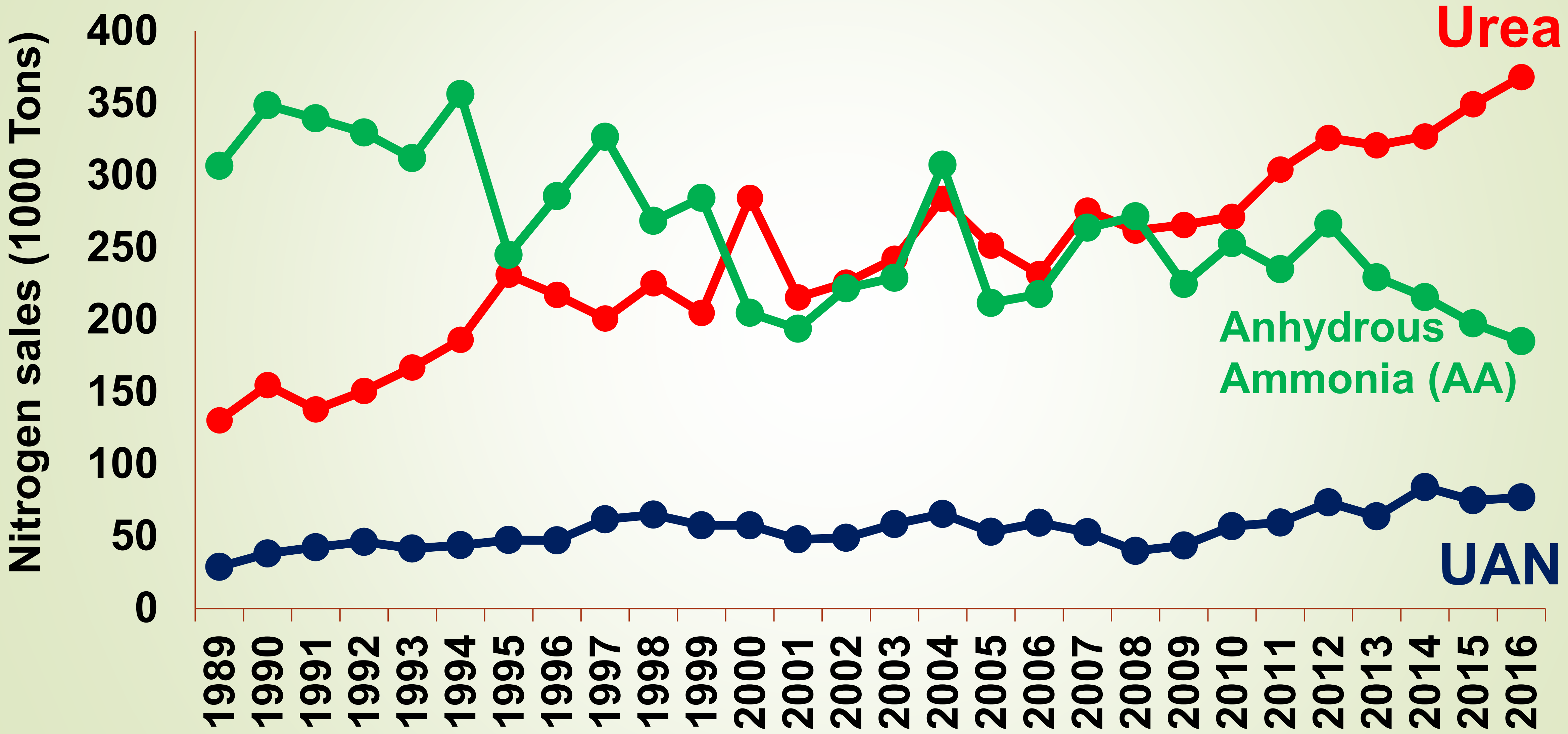
Coarse-textured Soils	
Fall	5%
Spring	70%
Sidedress	25%

Southwestern West Central South Central	
Fall	45%
Spring	50%
Sidedress	5%

Southeastern	
Fall	7%
Spring	88%
Sidedress	5%

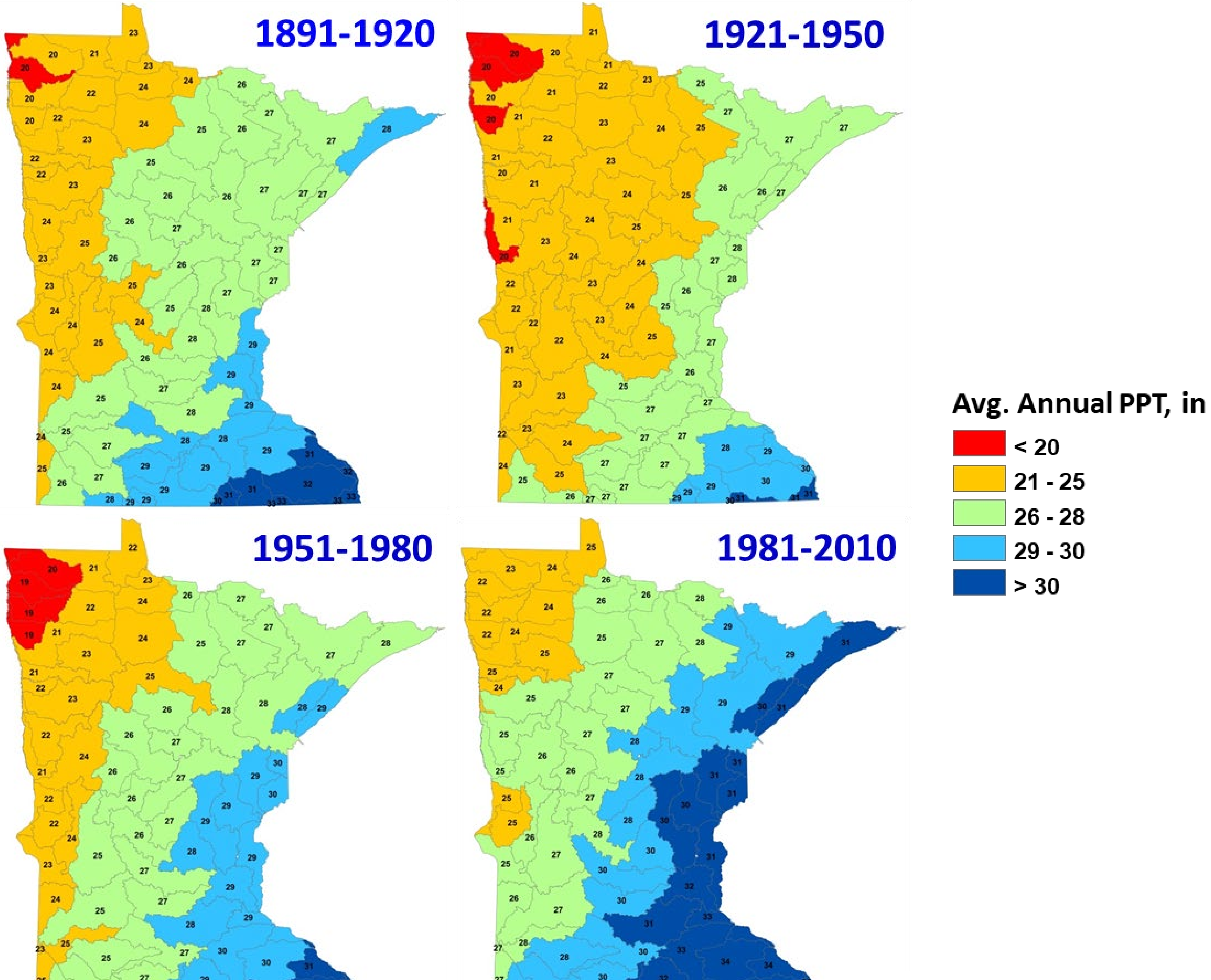
Adapted from Bierman et al. (2011)

Minnesota Nitrogen Sales



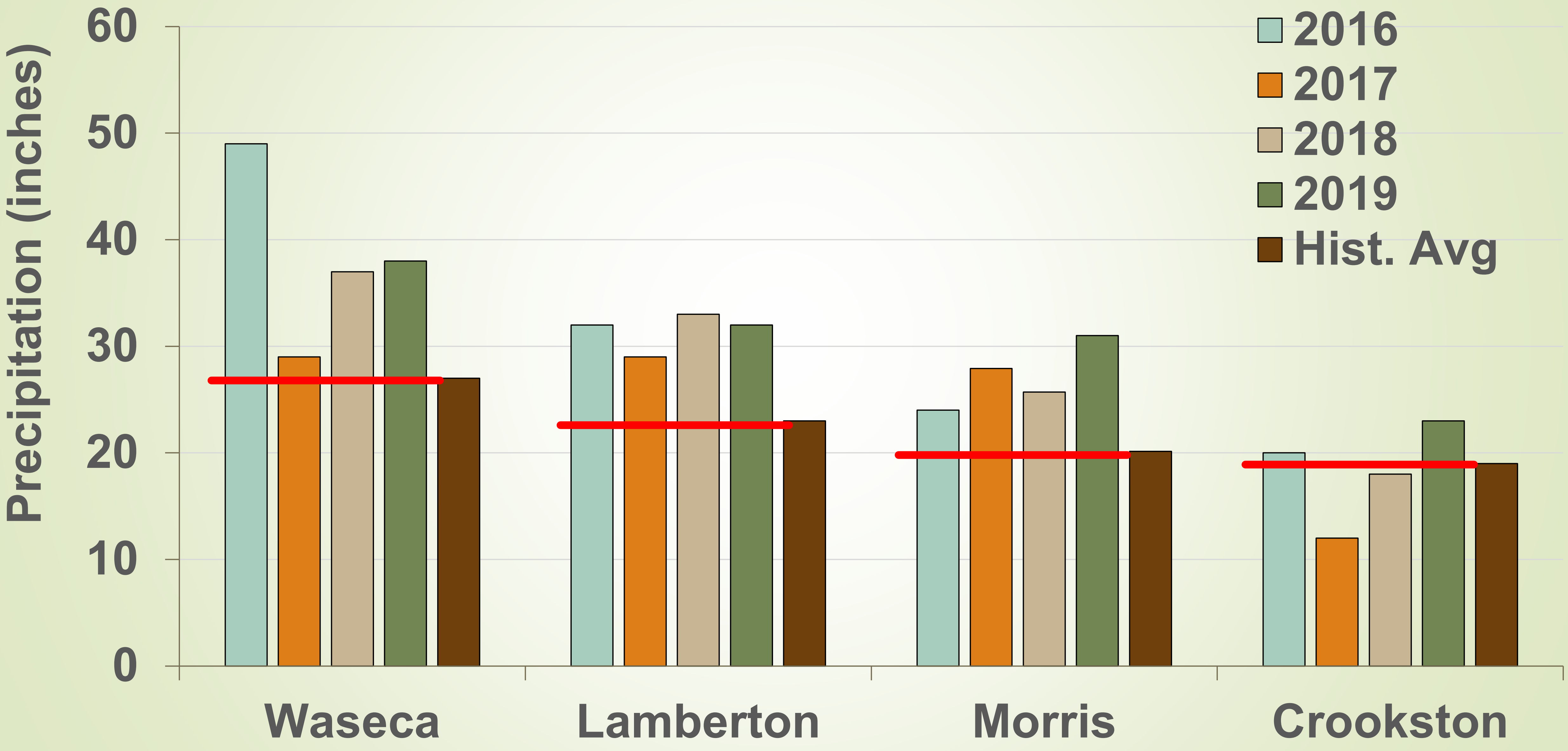
Source: Minnesota Department of Agriculture, 2019

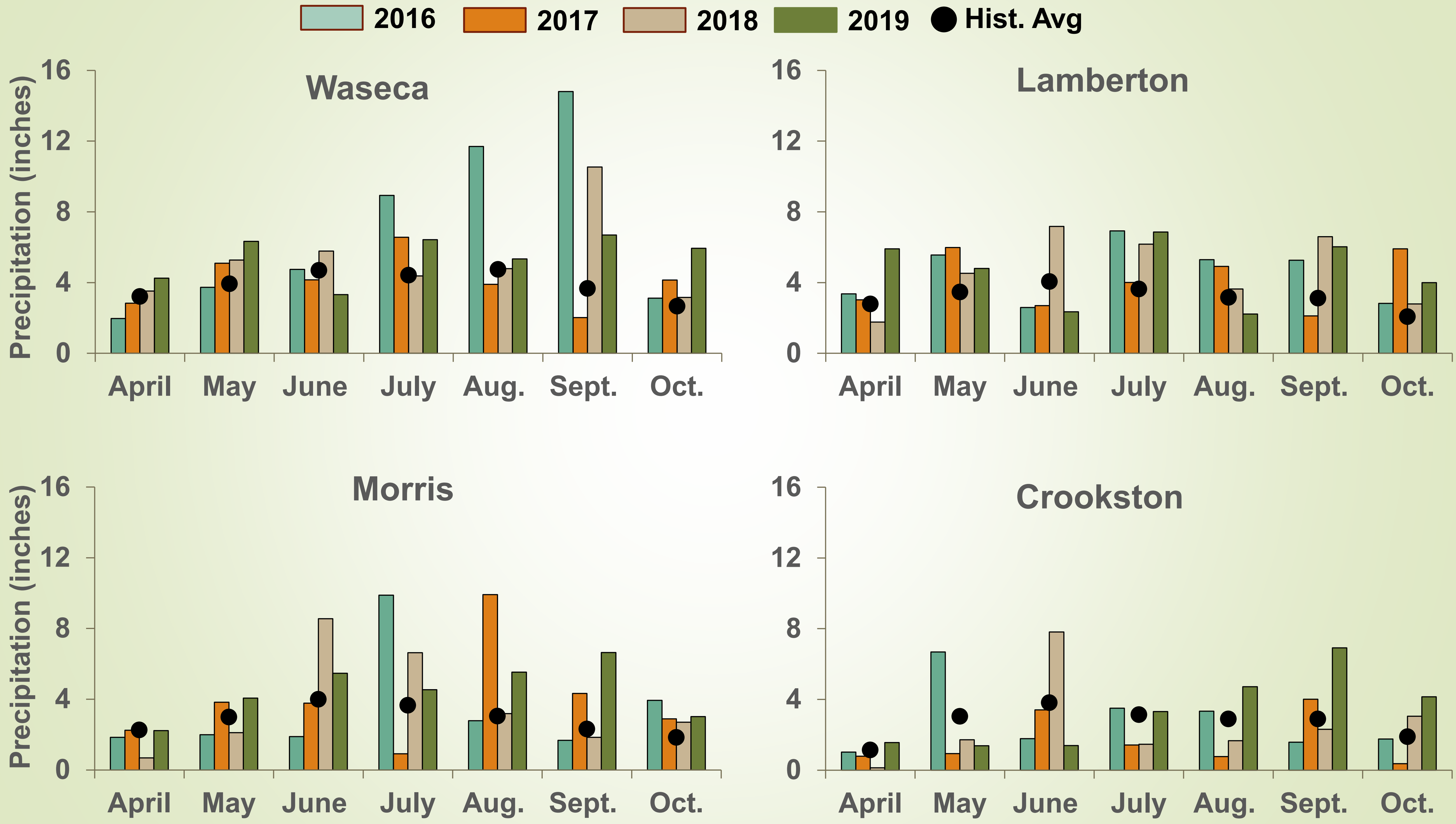
Minnesota Avg. Annual Precipitation



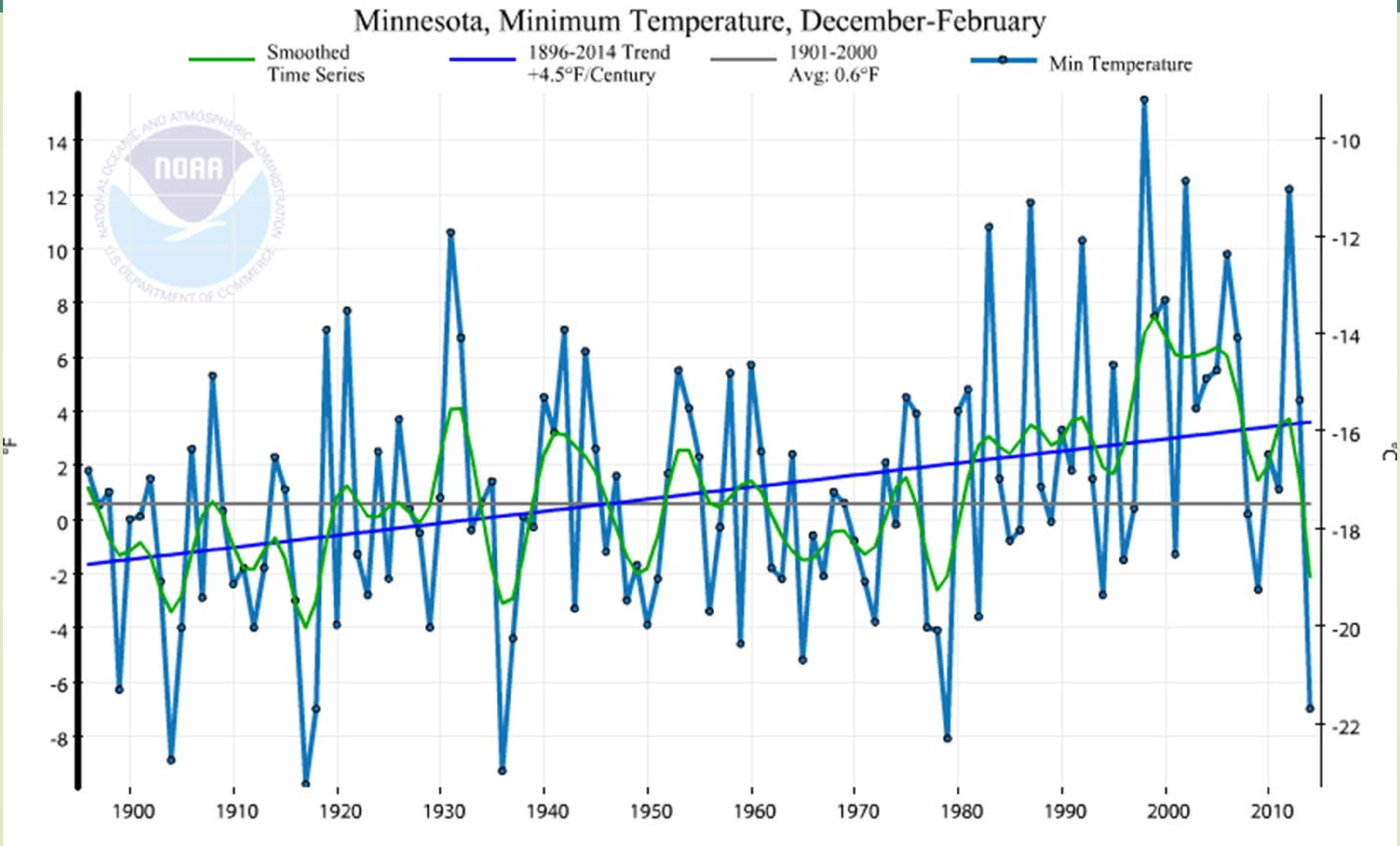
Source: Gupta et al., 2014

Growing Season Precipitation (Apr-Oct)

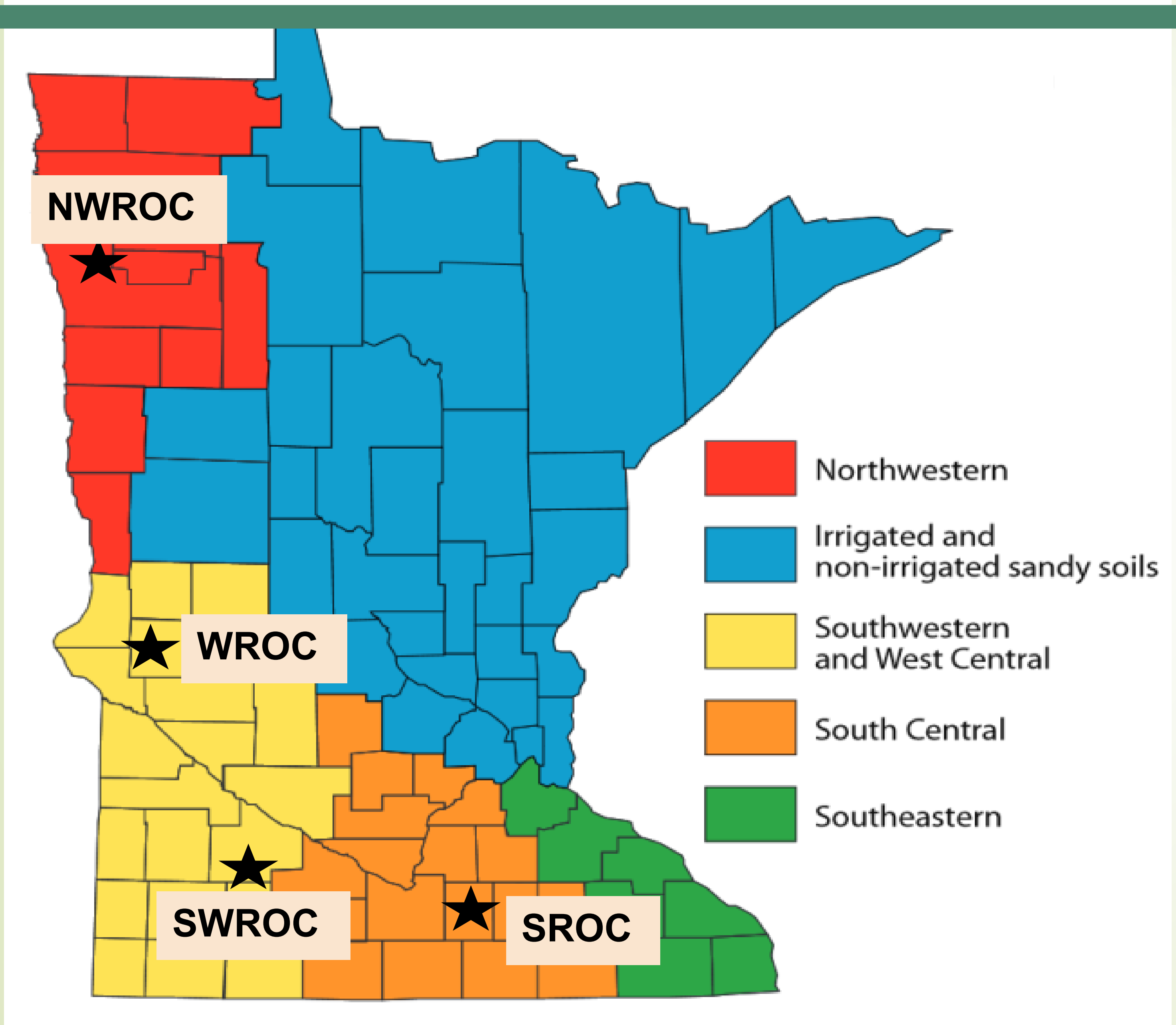



2016
2017
2018
2019
Hist. Avg
Waseca
Lamberton
Morris
Crookston
Precipitation (inches)
16
12
8
4
0
April
May
June
July
Aug.
Sept.
Oct.

Minnesota – Minimum Air Temperature



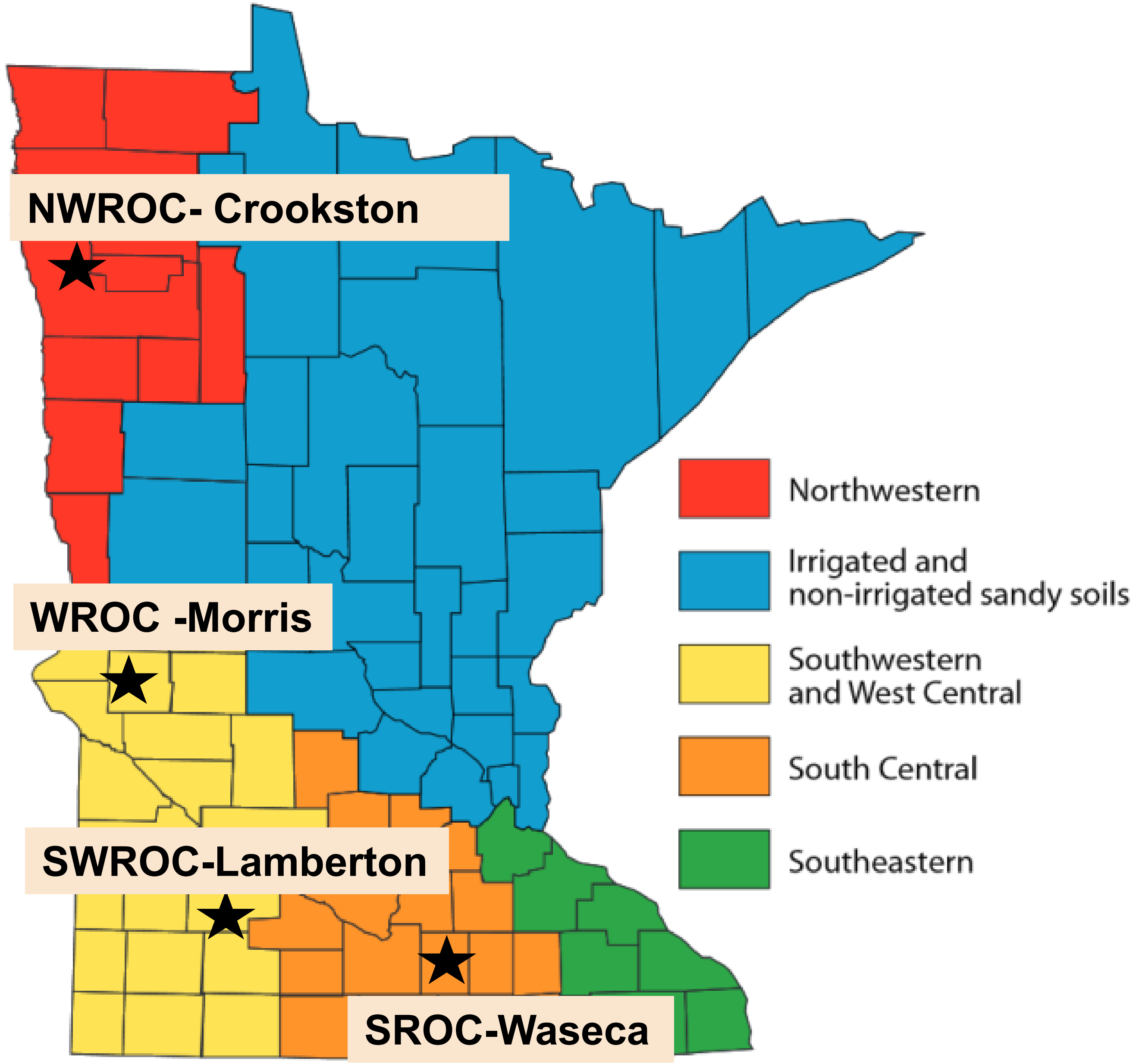
Re-evaluate Minnesota Nitrogen BMPs



Research Questions

- **N Timing:** What are the differences between Fall and Spring Urea application on corn grain yield?
- **N Placement:** Can we improve nitrogen management by subsurface banding instead of broadcasting and incorporating urea?
- **N sources:** Are there benefits using a nitrification inhibitor or other N sources?

Materials and Methods



4 corn growing season (2016 to 2019):

Crop rotation:

- **Continuous Corn = CC**
- **Corn-Soybean = CSb**

Corn-Wheat = CWh only Crookston 2017 and 2018

Materials and Methods

➢ Effect of N rate and Time of application on corn yield

N source	N time	CC lb N ac^{-1}	CSb-CWh lb N ac^{-1}
Control		0	0
Urea/BI‡	Fall vs Spring	40	40
		80	80
		120	120
		160	160
		200	200
		240	-

‡ Broadcasted and incorporated (BI)

Materials and Methods

- Effect of N sources and Time of application on corn yield

N source	N time	CC lb N ac^{-1}	CSb or CWh lb N ac^{-1}
Anhydrous Ammonia (AA)‡	Fall vs Spring	120	120
Urea (U)†		120	80/120
Urea + Instinct II (U+I)†		120	80
Environmental Smart N (ESN)±		120	80

‡ Injected (Inj)/ N-serve applied in the Fall
† Broadcasted and incorporated (BI) or subsurface banded (SSB)
± Broadcasted and incorporated (BI)

Materials and Methods

- Evaluate the use of Inhibitor and Placement method on corn yield

	N time	CC lb N ac^{-1}	CSb or CWh lb N ac^{-1}
Urea (U)	Fall vs Spring	120	80
Urea + Instinct II (U+I)		120	80
Broadcasted and incorporated (BI)	Fall vs Spring	120	80
Subsurface banded (SSB)		120	80

Measurements

- Corn grain yield
- Corn N uptake
- Soil inorganic N (NH_4^+ and NO_3^-) at 0-12, 12-24 and 24-36 inches
- Canopy sensing for the V6 and V12 development stages


RESULTS
N - RATE

Waseca	Rotation	Time	Response to N	EONR (lb N ac^{-1})	EONR Yield (bu ac^{-1})
2016	CC	Fall	Linear	240	217
	CC	Spring	Quadratic plateau	202	234
	CSb	Fall	Quadratic plateau	188	241
	CSb	Spring	Quadratic plateau	184	251
2017	CC	Fall	Linear	240	222
	CC	Spring	Quadratic plateau	206	224
	CSb	Fall	Quadratic plateau	156	226
	CSb	Spring	Quadratic plateau	132	233
2018	CC	Fall	Linear	240	191
	CC	Spring	Quadratic plateau	178	208
	CSb	Fall	Linear	200	224
	CSb	Spring	Quadratic plateau	164	235
2019	CSb	Fall	Linear	200	189
	CSb	Spring	Quadratic plateau	161	203
Difference	CC			-45	12
	CSb			-26	11

Lamberton	Rotation	Time	Response to N	EONR (lb N ac^{-1})	EONR Yield (bu ac^{-1})
2016	CC	Fall	Linear	240	150
	CC	Spring	Linear	240	197
	CSb	Fall	Linear	200	214
	CSb	Spring	Quadratic plateau	154	199
2017	CC	Fall	Linear	240	201
	CC	Spring	Linear	240	202
	CSb	Fall	Quadratic plateau	170	183
	CSb	Spring	Quadratic plateau*	200	207
2018	CC	Fall	Linear	240	122
	CC	Spring	Linear	240	183
	CSb	Fall	Linear	200	187
	CSb	Spring	Linear	200	207
2019	CC	Fall	Quadratic plateau	195	159
	CC	Spring	Quadratic plateau	190	140
	CSb	Fall	Quadratic	131	186
	CSb	Spring	Linear plateau	99	178
Difference	CC			-1	23
	CSb			-12	5

Morris	Rotation	Time	Response to N	EONR (lb N ac^{-1})	EONR Yield (bu ac^{-1})
2016	CSb	Fall	Quadratic plateau	193	204
	CSb	Spring	Quadratic plateau	168	206
2017	CC	Fall	Linear	240	140
	CC	Spring	Linear	240	182
2018	CC	Fall	Linear	240	157
	CC	Spring	Quadratic plateau	192	164
	CSb	Fall	No N response	0/200	196/163
	CSb	Spring	No N response	0/200	161/193
2019	CC	Fall	Linear	240	190
	CC	Spring	Quadratic plateau	176	175
	CSb	Fall	Quadratic plateau	165	170
	CSb	Spring	Linear	200	166
Difference	CC			-37	12
	CSb (2yr)			5	-1

Crookston	Rotation	Time	Response to N	EONR (lb N ac^{-1})	EONR Yield (bu ac^{-1})
2017	CWh	Fall	Quadratic plateau	182	157
	CWh	Spring	Quadratic plateau	111	155
	CSb	Fall	No N response	0/200	149/148
	CSb	Spring	No N response	0/200	176/170
2018	CWh	Fall	No N response	0/200	119/135
	CWh	Spring	Quadratic	86	133
	CSb	Fall	No N response	0/200	149/149
	CSb	Spring	No N response	0/200	138/161
2019	CC	Fall	No N response	0/200	101/118
	CC	Spring	No N response	0/200	106/112
	CSb	Fall	Linear	200	182
	CSb	Spring	Quadratic plateau	189	198
Difference	CWh (1yr)			-71	-2
	CSb (1yr)			-11	16

Site	Rotation	Time	MRTN lb ac^{-1}	MRTN Yield bu ac^{-1}
Waseca	CC	Fall	240	210
		Spring	195	222
	CSb	Fall	186	220
		Spring	160	231
Lamberton	CC	Fall	229	158
		Spring	228	181
	CSb	Fall	175	193
		Spring	163	198
Morris	CC	Fall	240	162
		Spring	203	174
	CSb	Fall (2-yr)	179	187
		Spring (2-yr)	184	186
Crookston	CWh	Fall (1-yr)	182	157
		Spring (1-yr)	111	155
	CSb	Fall (1-yr)	200	182
		Spring (1-yr)	189	198

Fall	208	184
Spring	179	193
Diff	-29	9

Waseca: -36 lb N ac^{-1}, 12 bu ac^{-1}

Lamberton: -7 lb N ac^{-1}, 14 bu ac^{-1}

Morris: -16 lb N ac^{-1}, 5.5 bu ac^{-1}

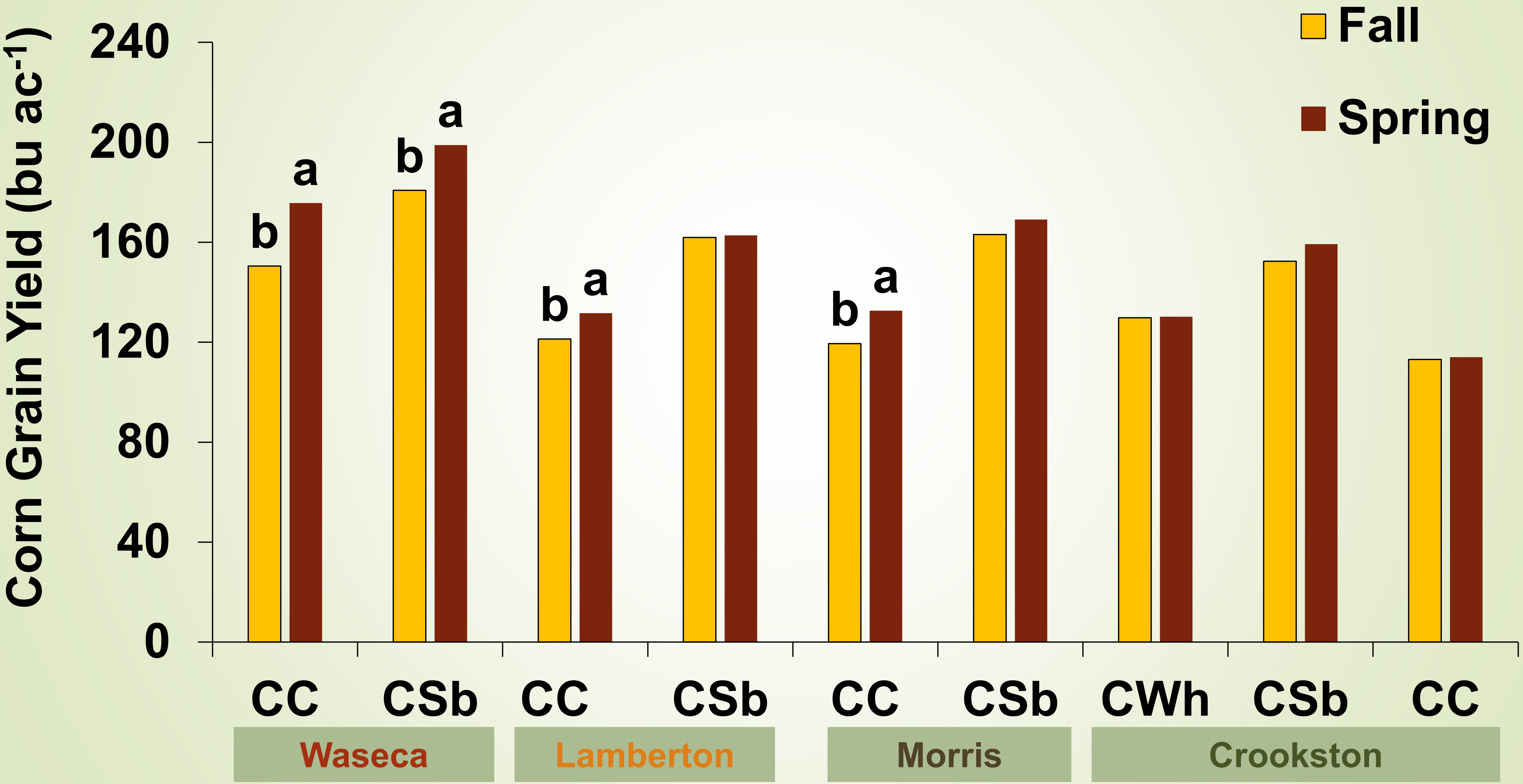
Crookston: -41 lb N ac^{-1}, 7 bu ac^{-1}


RESULTS
N - TIME

Urea - Fall vs Spring Applications

		Corn Yield (bu ac^{-1})								
		Waseca		Lamberton		Morris		Crookston		
		CC	CSb	CC	CSb	CC	CSb	CWh	CSb	CC
2016	Fall	156 b	207 b	116 b	165	-	178	-	-	-
	Spring	183 a	218 a	136 a	170	-	180	-	-	-
2017	Fall	151 b	199 b	154	159 b	98 b	-	133 b	161	-
	Spring	173 a	210 a	151	168 a	123 a	-	141 a	171	-
2018	Fall	144 b	168 b	90 b	141	121	162 b	127	150	-
	Spring	171 a	198 a	120 a	156	132	177 a	120	144	-
2019	Fall	-	149 b	124	167	138	151	-	147	113
	Spring	-	170 a	115	162	143	152	-	163	115

Urea - Fall vs Spring Applications




RESULTS
N - SOURCE

		N rate	Corn Yield (bu ac^{-1})		
2019		lb N ac^{-1}	Lamberton - CC	Morris - CC	Crookston - CC
Fall	AA+Nserve/I	120	145	165	-
	ESN/BI	120	135	183	117
	U/BI	120	134	124	117
	U/SSB	120	149	158	-
	U + I/BI	120	128	104	117
	U + I/SSB	120	135	149	-
Spring	AA/I	120	155 a	199	-
	ESN/BI	120	147 ab	178	111
	U/BI	120	129 bc	166	114
	U/SSB	120	138 abc	159	-
	U + I/BI	120	138 abc	153	115
	U + I/SSB	120	125 c	164	-

			Corn Yield (bu ac^{-1})			
2019	Source	N rate lb N ac^{-1}	Waseca CSb	Lamberton CSb	Morris CSb	Crookston CSb
Fall	ESN/BI	80	163 a	166	159	133
	U/BI	80	146 b	165	152	132
	U/SSB	80	177 a	181	146	-
	U + I/BI	80	143 b	148	145	133
	U + I/SSB	80	175 a	162	145	-
Spring	ESN/BI	80	154	169	162	172 a
	U/BI	80	177	170	151	159 b
	U/SSB	80	163	167	155	-
	U + I/BI	80	165	173	184	150 b
	U + I/SSB	80	156	160	160	-

		Corn Yield (bu ac^{-1})			
2019	Source	N rate lb N ac^{-1}	Waseca CSb	Lamberton CSb	Morris CSb
Fall	AA+Nserve/I	120	-	179	190 a
	U/BI	120	-	190	157 b
Spring	AA/I	120	196	179	161
	U/BI	120	189	179	174

N Sources: 2016-2019

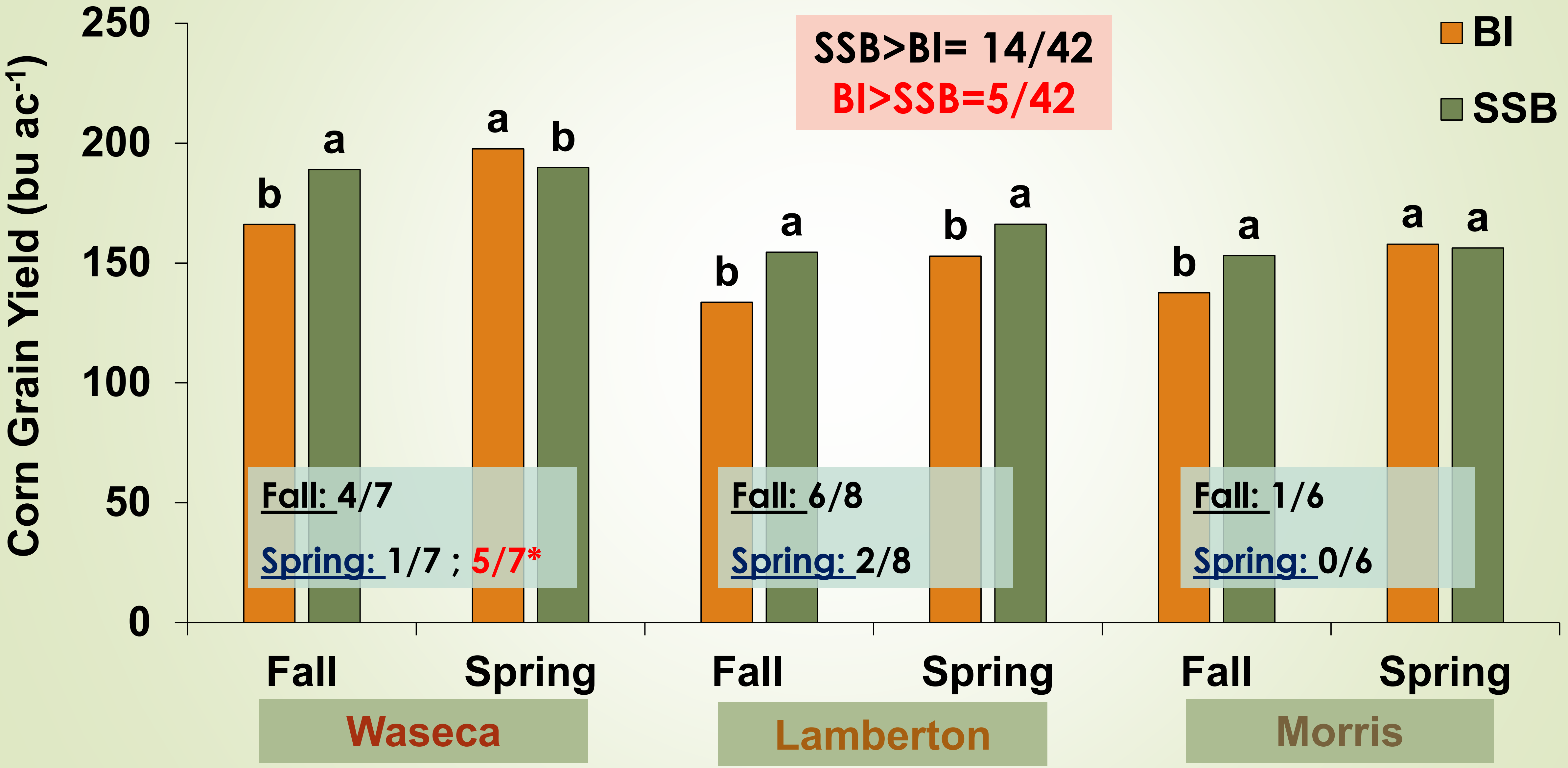
Comparison	Time	Occurrence	Percent %	Yield Diff bu ac^{-1}
AA > Urea BI	Fall	18/30	60	49
(combined across w & w/o inhibitor)	Spring	10/31; 1/31*	32; 3	45; -29
AA > Urea SSB	Fall	6/20	30	58
(combined across w & w/o inhibitor)	Spring	6/20; 2/20*	30; 10	32; -49
ESN > Urea BI	Fall	5/22	23	37
	Spring	6/22	27	30
ESN > AA	Fall	0/8; 2/8*	0; 25	; -39
	Spring	2/8	25	29

*Reverse response. All other comparisons were non-significant


RESULTS
N - PLACE

Corn Yield (bu ac^{-1})			Waseca		Lamberton		Morris	
Year	Time	Placement	CC	CSb	CC	CSb	CC	CSb
2016	Fall	BI	167 b**	208	115 b*	157 b*	-	183
		SSB	196 a	214	139 a	182 a	-	177
	Spring	BI	210 a*	224 a*	147	178	-	184
		SSB	197 b	215 b	172	184	-	183
2017	Fall	BI	163	197	165 b**	155 b*	94 b*	-
		SSB	166	198	182 a	182 a	139 a	-
	Spring	BI	193 b*	222	161	172	126	-
		SSB	233 a	223	168	182	126	-
2018	Fall	BI	143 b*	146 b*	75 b*	119 b*	125	161
		SSB	160 a	190 a	100 a	143 a	129	172
	Spring	BI	190 a*	198 a*	108 b*	150 b**	143	170
		SSB	162 b	171 b	160 a	169 a	139	174
2019	Fall	BI	-	144 b*	131.5	155.1	114.1	149.8
		SSB	-	176 a	141.9	171.1	153.6	145.3
	Spring	BI	-	171 a*	133.3	171.4	159.5	167.1
		SSB	-	159 b	131.8	163.8	161.1	157.4

Urea – SSB > BI

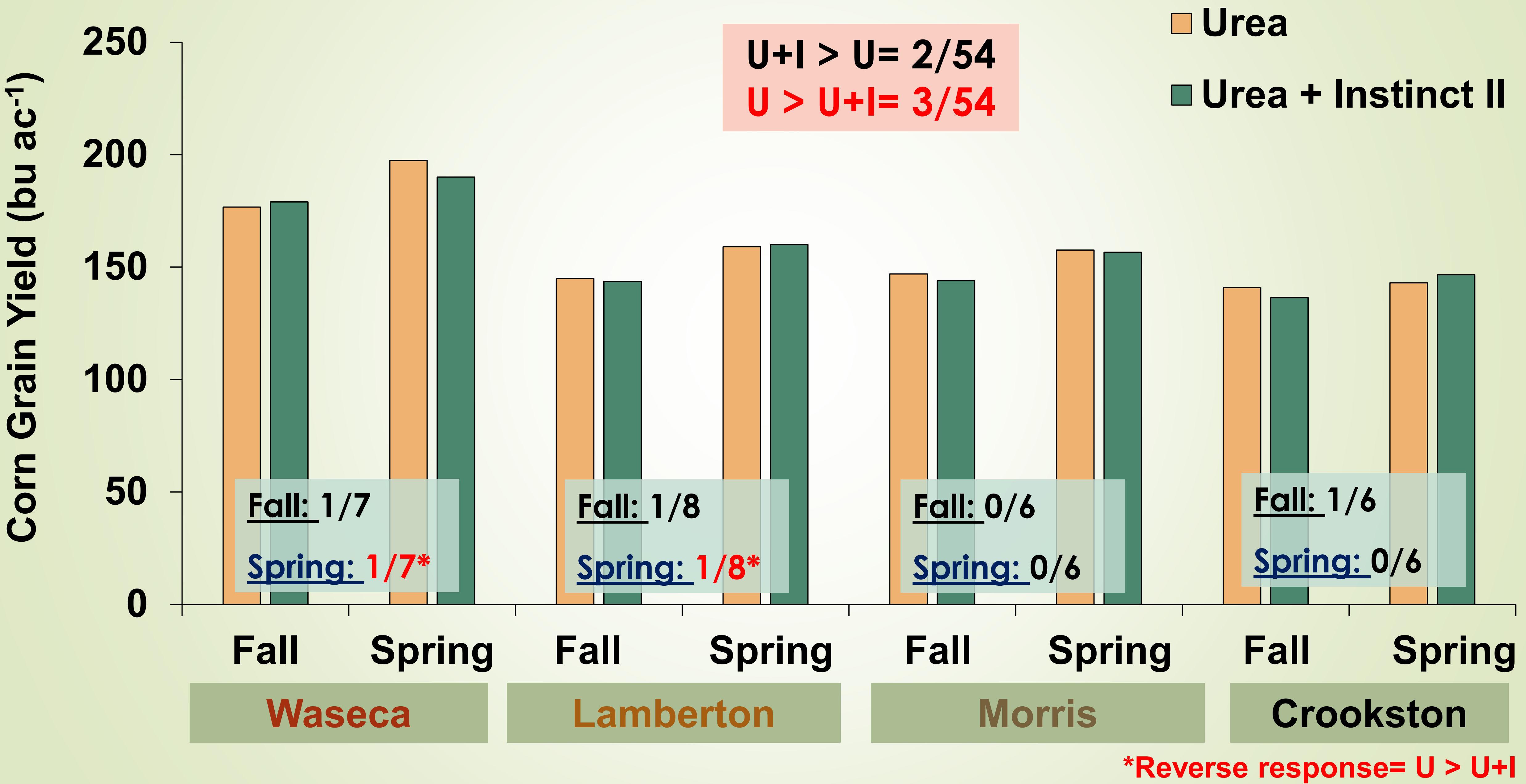


*Reverse response= BI > SSB


RESULTS
N - INHIBITORS

Corn Yield (bu ac^{-1})			Waseca		Lamberton		Morris		Crookston	
Year	Time	Inhibitor	CC	CSb	CC	CSb	CC	CSb	CWh	CSb
2016	Fall	U	177	209	125	162		177		
		U+I	185	213	129	177		182		
	Spring	U	205	221	153	179		184		
		U+I	202	218	165	184		183		
2017	Fall	U	153 b	199	176	173	114		132	148
		U+I	176 a	197	171	163	118		134	168
	Spring	U	217	221	172 a	180	132		150	158
		U+I	209	224	157 b	173	120		148	169
2018	Fall	U	174	172	89	133	131	167	134	155 b
		U+I	161	167	85	128	123	166	132	162 a
	Spring	U	187 a	182	131	162	144	172	128	144
		U+I	164 b	180	137	157	137	172	138	167
2019	Fall	U		161.3	141.6	174 a	141.4	149.1	123.4	133.8
		U+I		158.7	131.8	155 b	126.3	146.0	111.3	131.1
	Spring	U		169.8	133.8	168.6	162.5	153.0	113.6	155.1
		U+I		160.7	131.3	166.7	158.1	171.5	115.4	151.1

Urea - U + I > U



Corn Grain Yield (bu ac-1)
250
200
150
100
50
0
U+I > U= 2/54
U > U+I= 3/54
Urea
Urea + Instinct II
Fall: 1/7
Spring: 1/7*
Fall: 1/8
Spring: 1/8*
Fall: 0/6
Spring: 0/6
Fall: 1/6
Spring: 0/6
Fall
Spring
Fall
Spring
Fall
Spring
Fall
Spring
Waseca
Lamberton
Morris
Crookston
*Reverse response= U > U+I

Summary

- Fall urea is problematic due to wet springs and warmer falls/winters
- All variables equal, spring applications produced more grain than fall applications
- Anhydrous ammonia is superior to Urea, especially in the Fall
- Banding Urea (SSB) or using ESN in the Fall had limited advantage
- Overall, the use of N inhibitor did not increase yield

Acknowledgement

- Field Crew - Soil Water and Climate Department
- Research and Outreach Centers' personnel

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QUESTIONS?