In-Field Nitrogen Management, Nitrogen Loss, and Crop Production

Nitrogen and Water Week

Prepared by
John E. Sawyer
Professor
Department of Agronomy
Iowa State University

Current Situation

- Concern for nitrate-N concentrations in local and regional water systems
- Hypoxia Action Plan in 2008 called for development and implementation of comprehensive N and P reduction strategies for states in the Mississippi/Atchafalaya River Basin

Nitrogen Reduction Goals

- Many states have implemented Nutrient Reduction Strategies with suggested practices
- To reach goal of 45% total N load reduction
  - Non-point in Iowa 41%
  - All practices are needed
    - In-field agronomic N management
    - Cropping practices and land use
    - Edge-of-field practices

Nitrate-N Reduction Practices

	Practice	% Nitrate-N Reduction [Avg. (Std. Dev.)]	% Corn Yield Change [Avg. (Std. Dev.)]
N-Mgt.	Timing (Fall to spring)	6 (25)	4 (16)
	Timing (Preplant to sidedress)	7 (37)	0 (3)
	Nitrogen Application Rate (to MRTN rate from CNRC, effect depends on starting N rate)	10	-1
	Fall with nitrapyrin (with AA) compared to without	9 (19)	6 (22)
	Rye Cover Crop	31 (29)	-6 (7)

SP 435 A

Nitrate-N Reduction Practices

	Practice	% Nitrate-N Reduction [Avg. (Std. Dev.)]	% Corn Yield Change [Avg. (Std. Dev.)]
Land Use	Perennial – Pasture/Land retirement	85 (9)	---
	Perennial – Energy Crops	72 (23)	---
	Extended Rotations (at least 2 years alfalfa in a 4 or 5 year rotation	42 (12)	7(7)

SP 435 A

Nitrate-N Reduction Practices

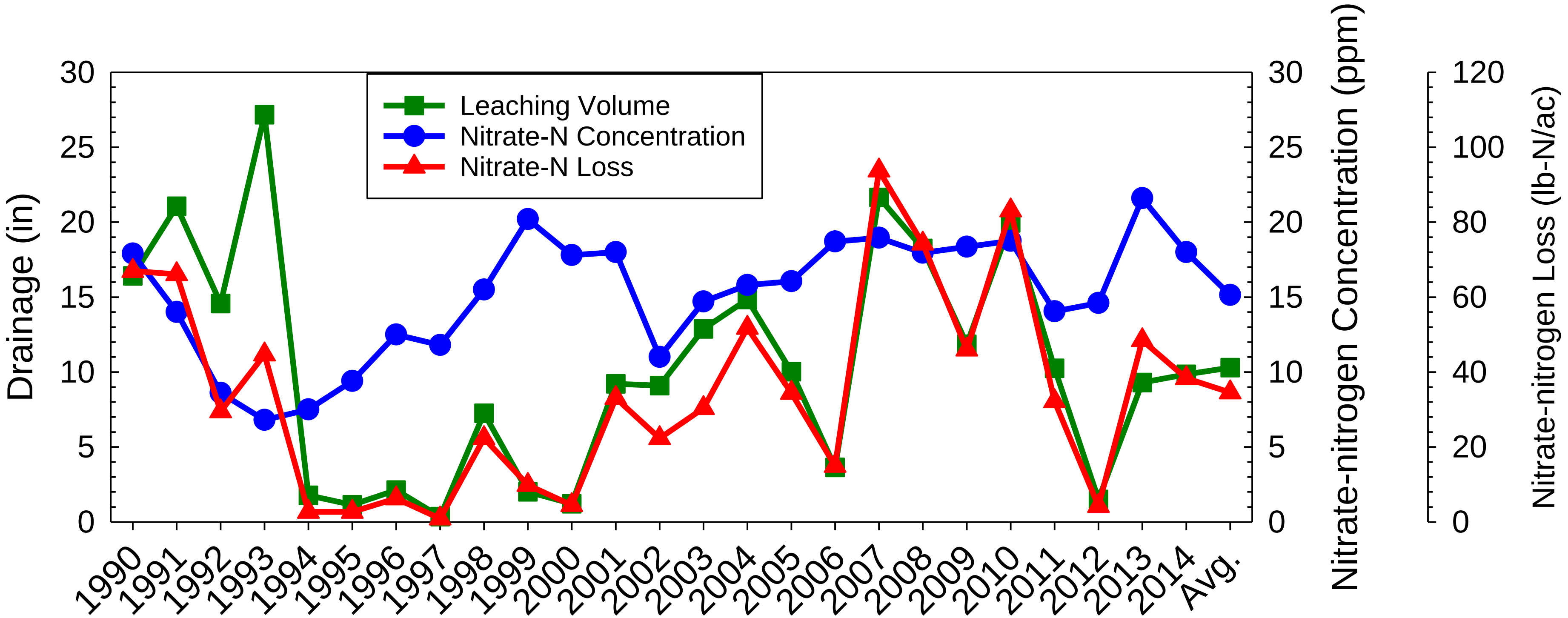
	Practice	% Nitrate-N Reduction [Avg. (Std. Dev.)]	% Corn Yield Change [Avg. (Std. Dev.)]
Edge-of-Field	Controlled Drainage	33 (32)*	---
	Shallow Drainage	32 (15)*	---
	Wetlands	52	---
	Bioreactors	43 (21)	---
	Buffers	91 (20)**	---
	Saturated Buffers	50 (13)	---

SP 435 A

* Load reduction not concentration reduction.

**Concentration reduction of that water interacts with active zone below the buffer.

Tile-Flow and Nitrate-N loss Across Time
(Gilmore City Ag Drainage Site)

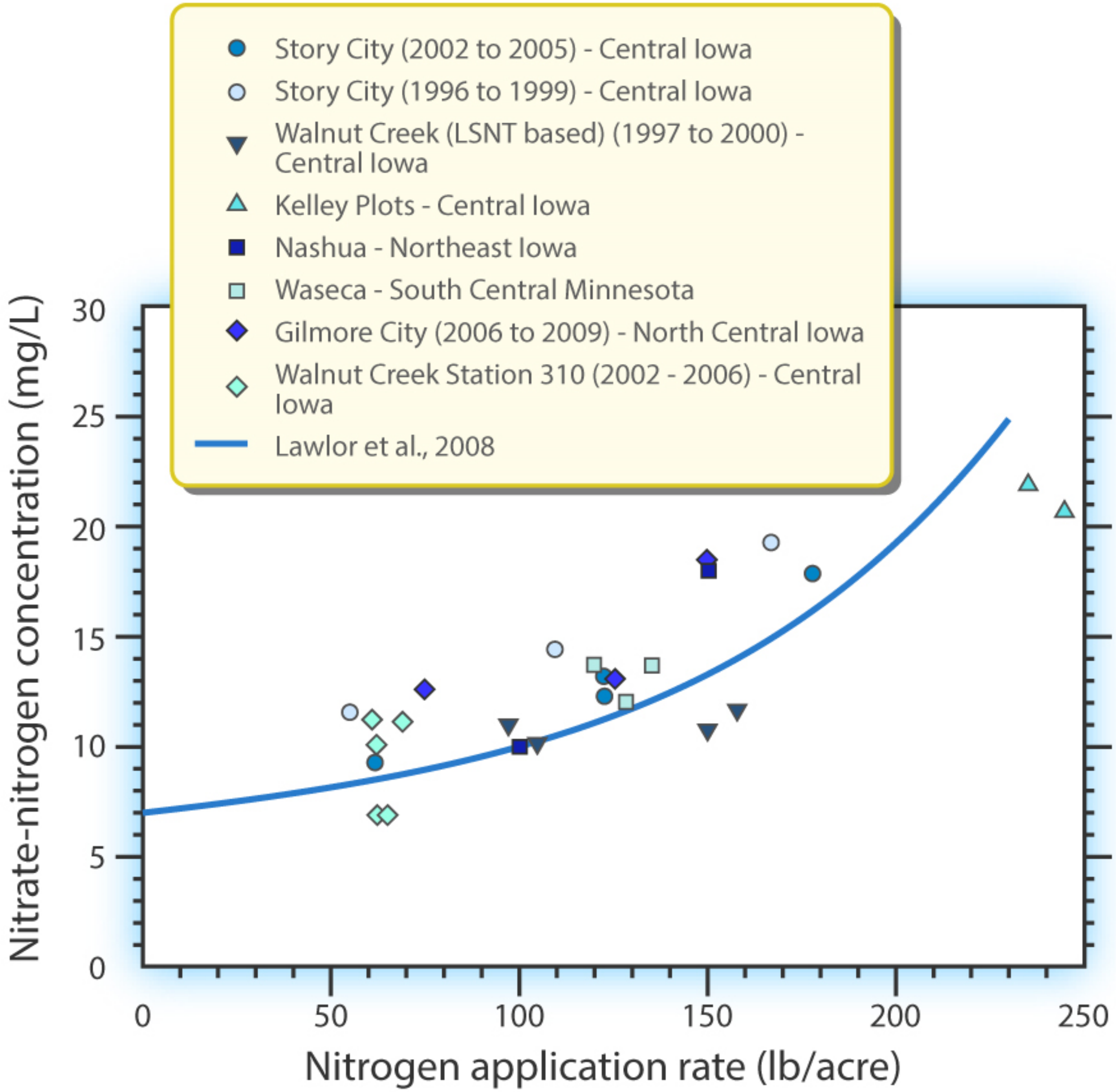


Combined Corn-Soybean System – Same N management
– Early Spring Sidedress at 150-160 lb-N/acre

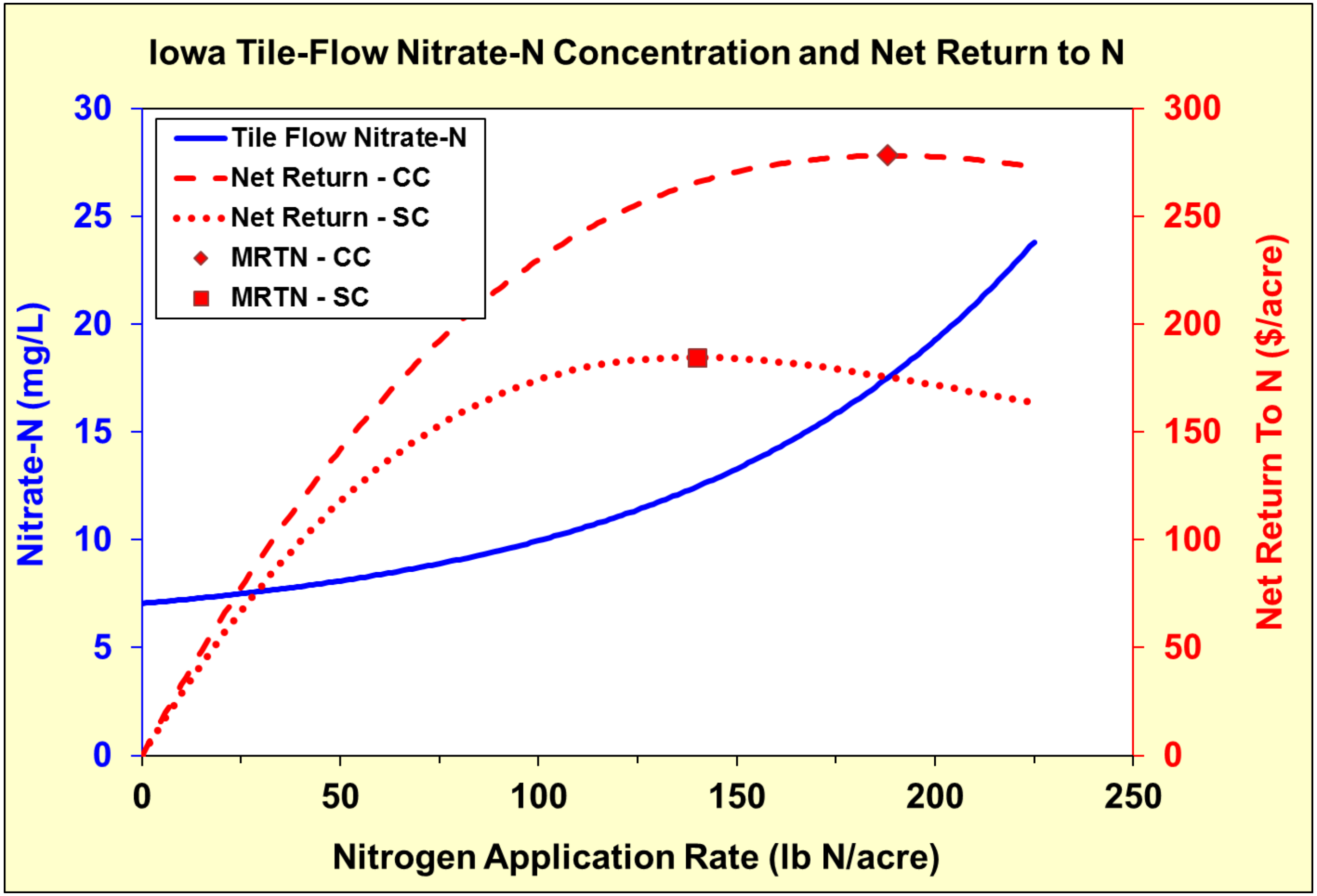
Nitrogen Rate

- The impact of N rate on nitrate-N in tile drainage or groundwater recharge depends on the initial N rate compared to a recommended rate (MRTN rate)
- The reduction strategy indicates 10% reduction, but it can be more or less than that depending on actual N rate being used

Nitrate-N Concentration in Tile Drainage



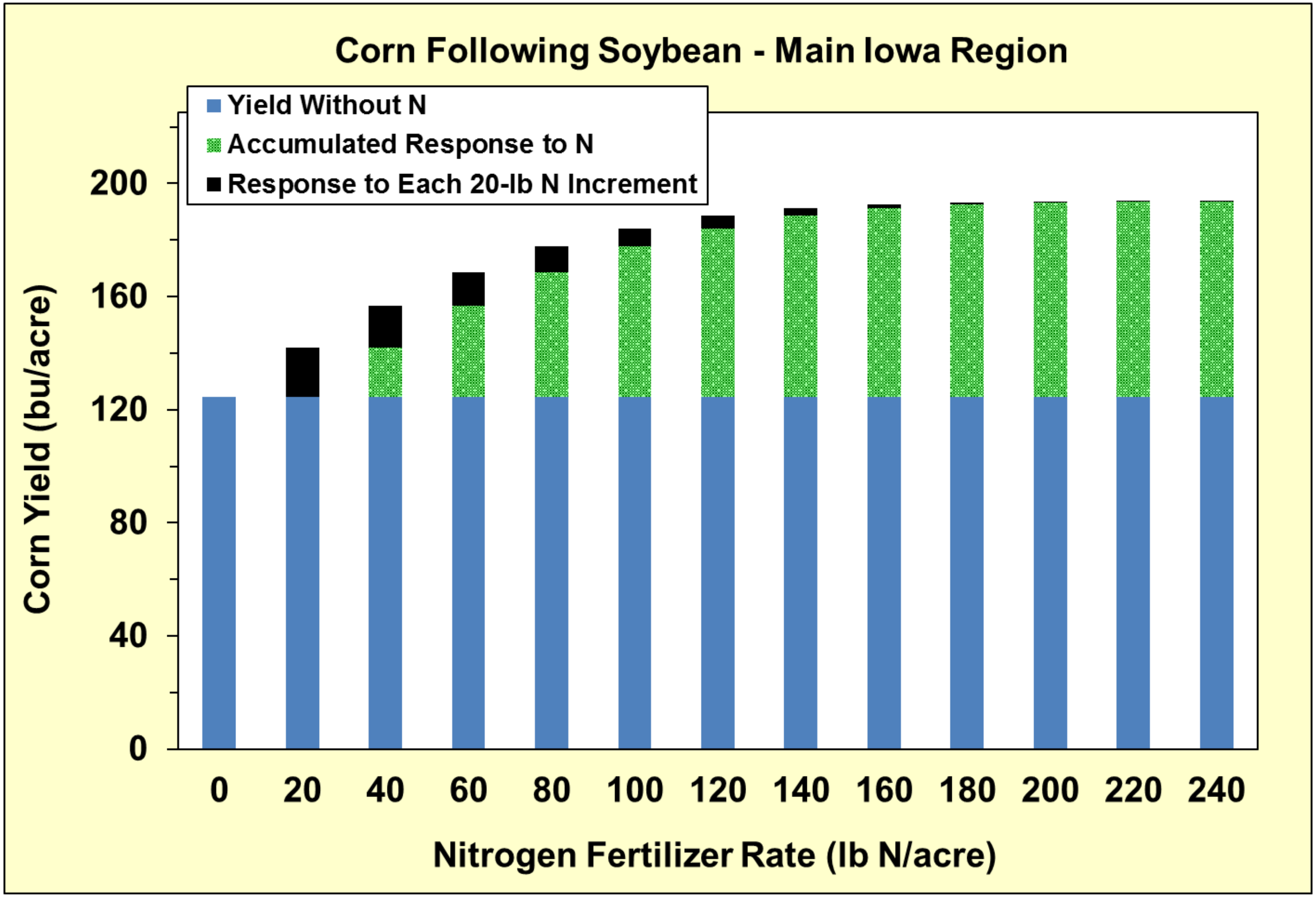
Net Return to Nitrogen Application and Nitrate-N Concentration in Tile Drainage



Nitrogen at $0.35/lb N and corn at $3.50/bu

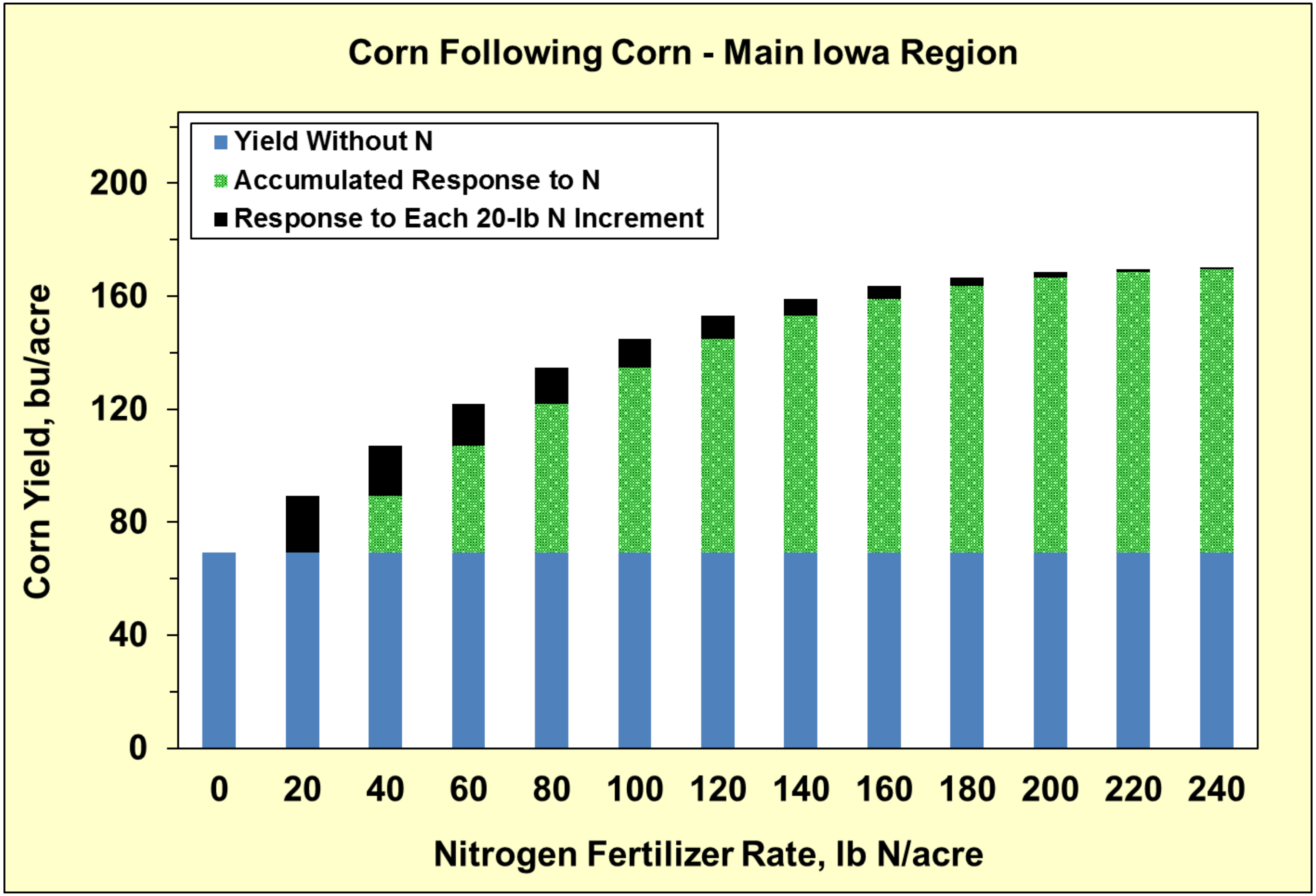
CNRC – Iowa Main region and Lawlor et al., 2008.

Nitrogen Needed for Corn – But There Is A Diminishing Return to Increasing Nitrogen Rate



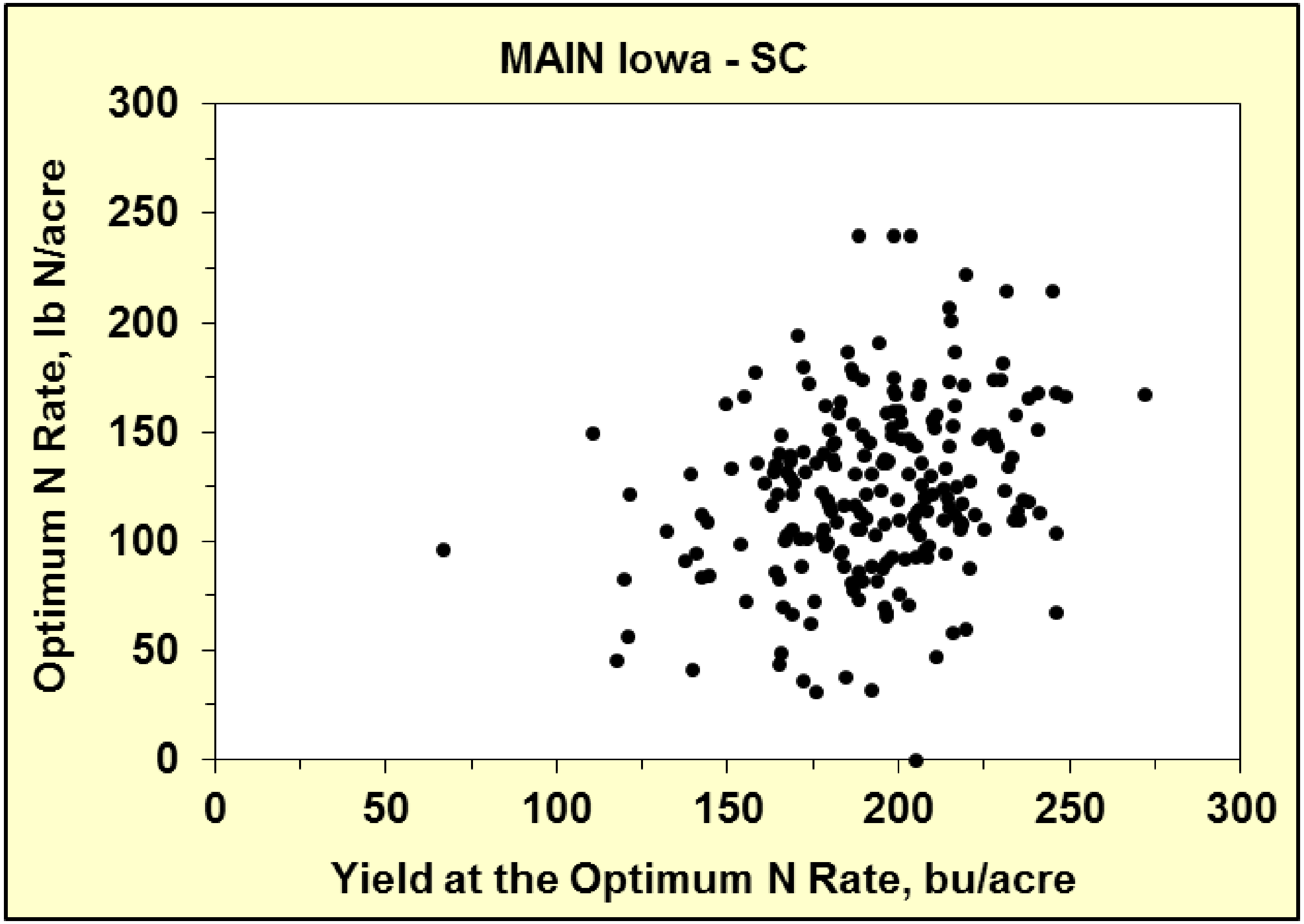
CNRC – Iowa Main region, 0.10 price ratio.

Nitrogen Needed for Corn – But There Is A Diminishing Return to Increasing Nitrogen Rate



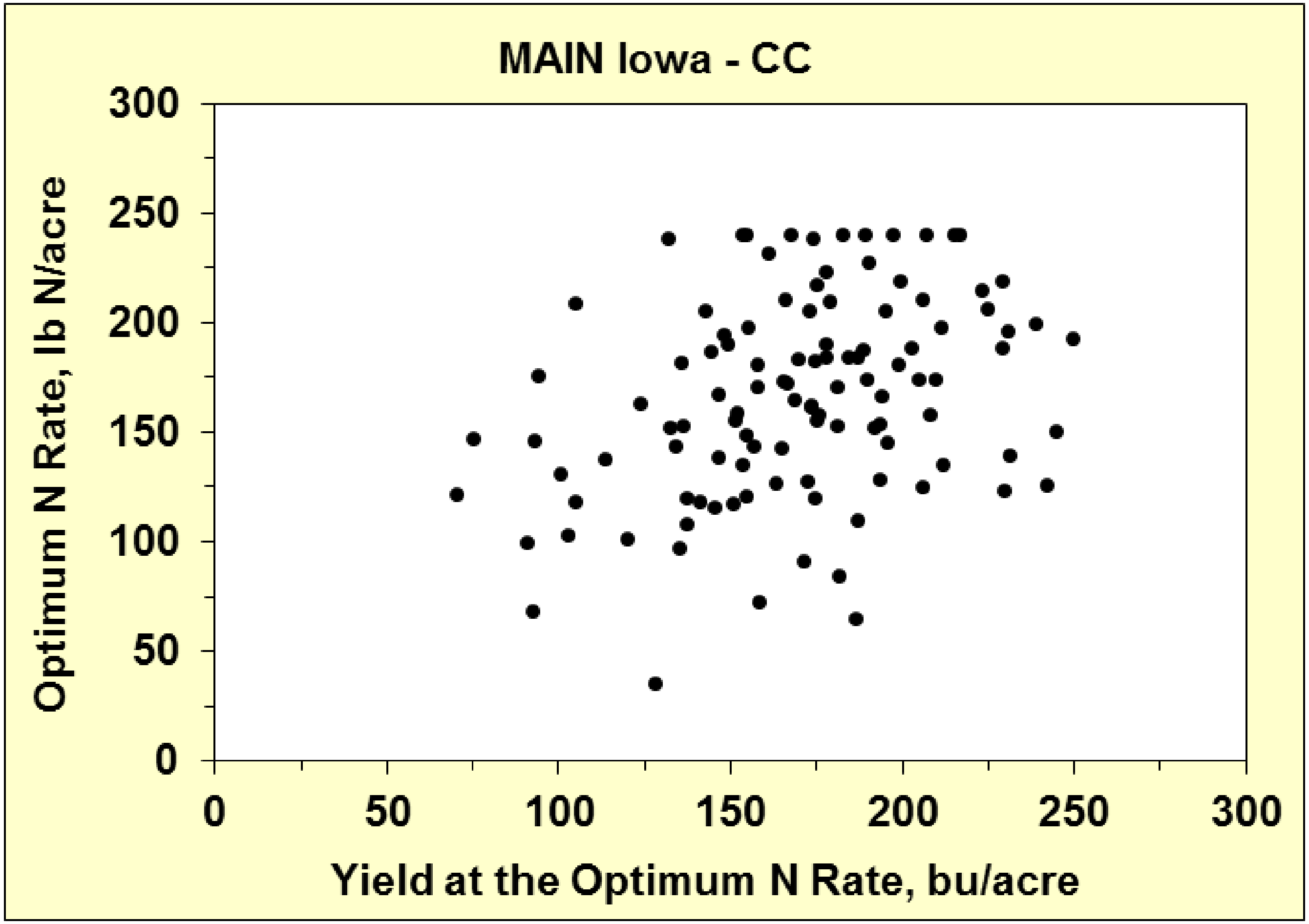
CNRC – Iowa Main region, 0.10 price ratio.

Does Corn Yield Predict Optimal Nitrogen Application Rate -- An Old System That is No Longer Used



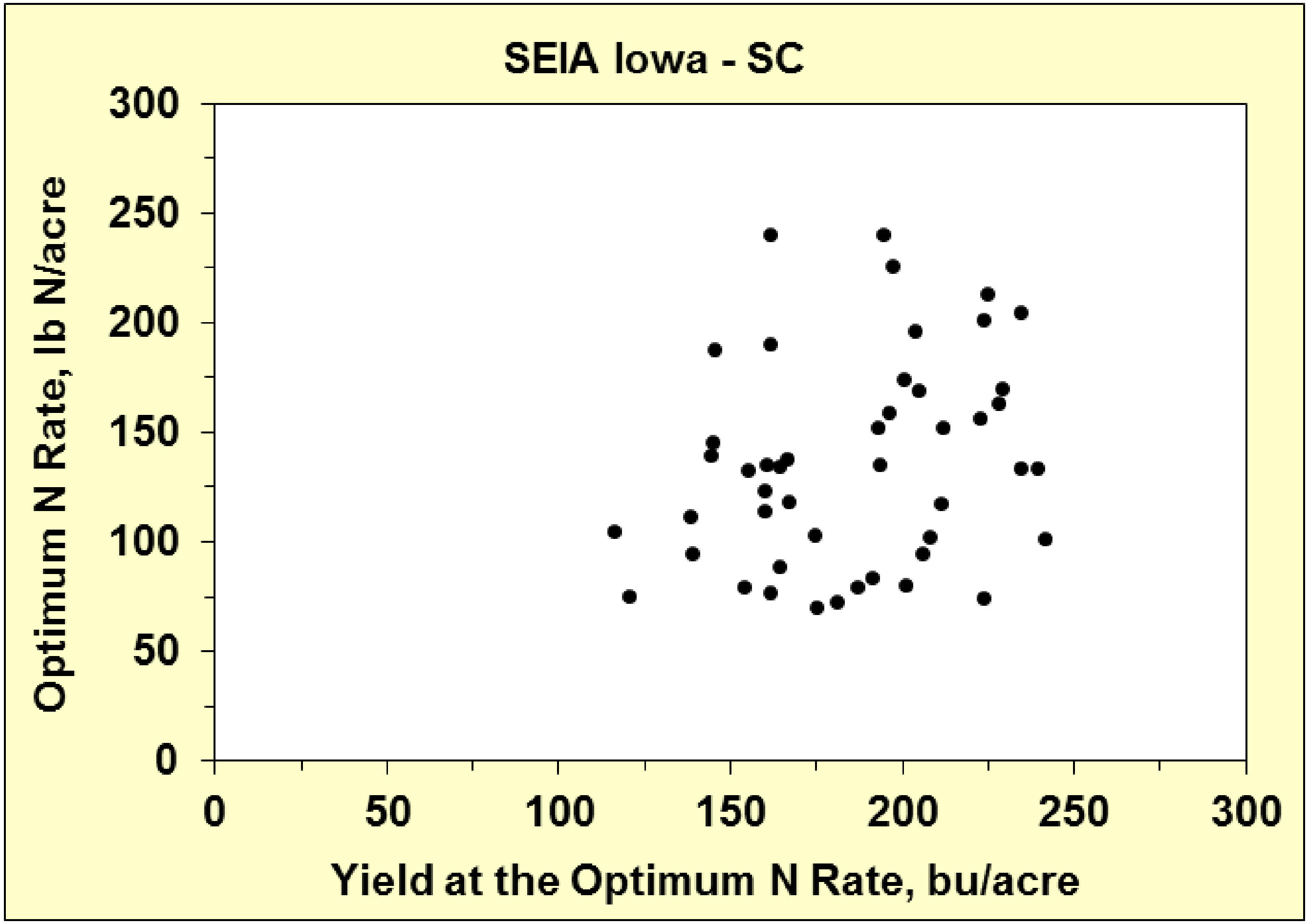
CNRC – Iowa Main region, 0.10 price ratio.

Does Corn Yield Predict Optimal Nitrogen Application Rate -- An Old System That is No Longer Used



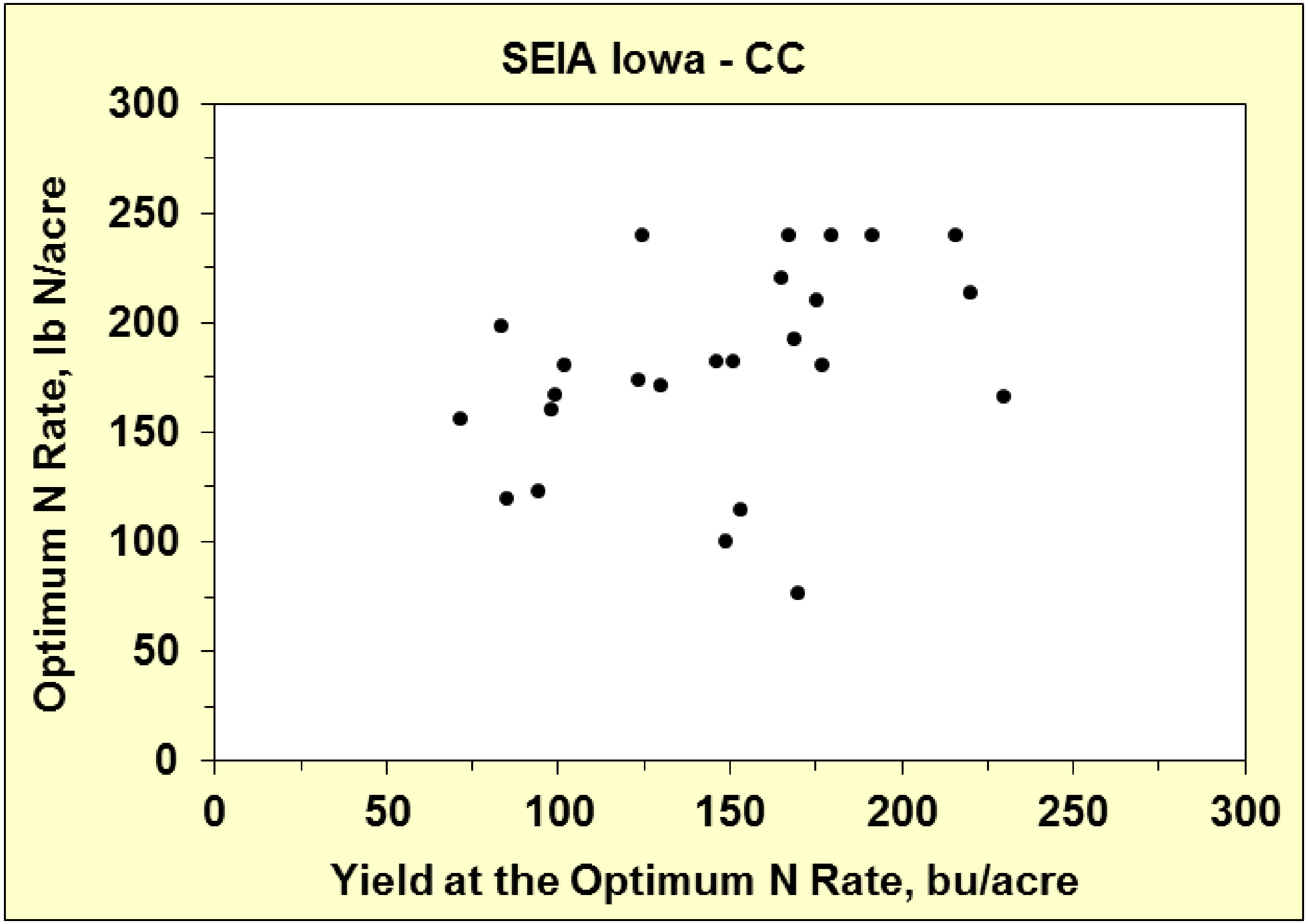
CNRC – Iowa Main region, 0.10 price ratio.

Does Corn Yield Predict Optimal Nitrogen Application Rate -- An Old System That is No Longer Used

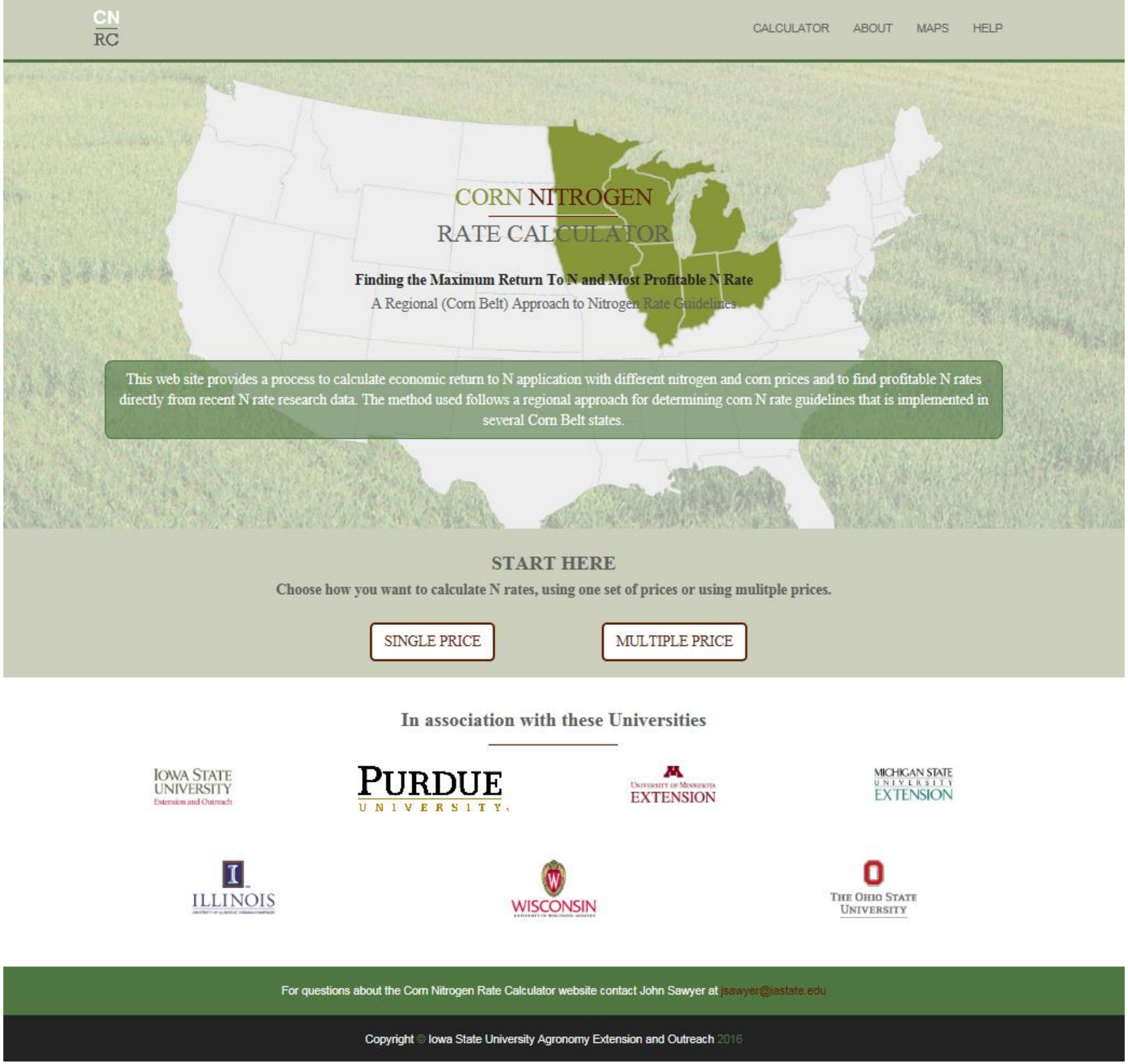


CNRC – Iowa SEIA region, 0.10 price ratio.

Does Corn Yield Predict Optimal Nitrogen Application Rate -- An Old System That is No Longer Used



CNRC – Iowa SEIA region, 0.10 price ratio.



http://cnrc.agron.iastate.edu/

Nitrogen Rates for Corn
MRTN and Profitable Range

Nitrogen rate guidelines for Iowa continuous corn and corn following soybean based on output of the Corn Nitrogen Rate Calculator (CNRC).

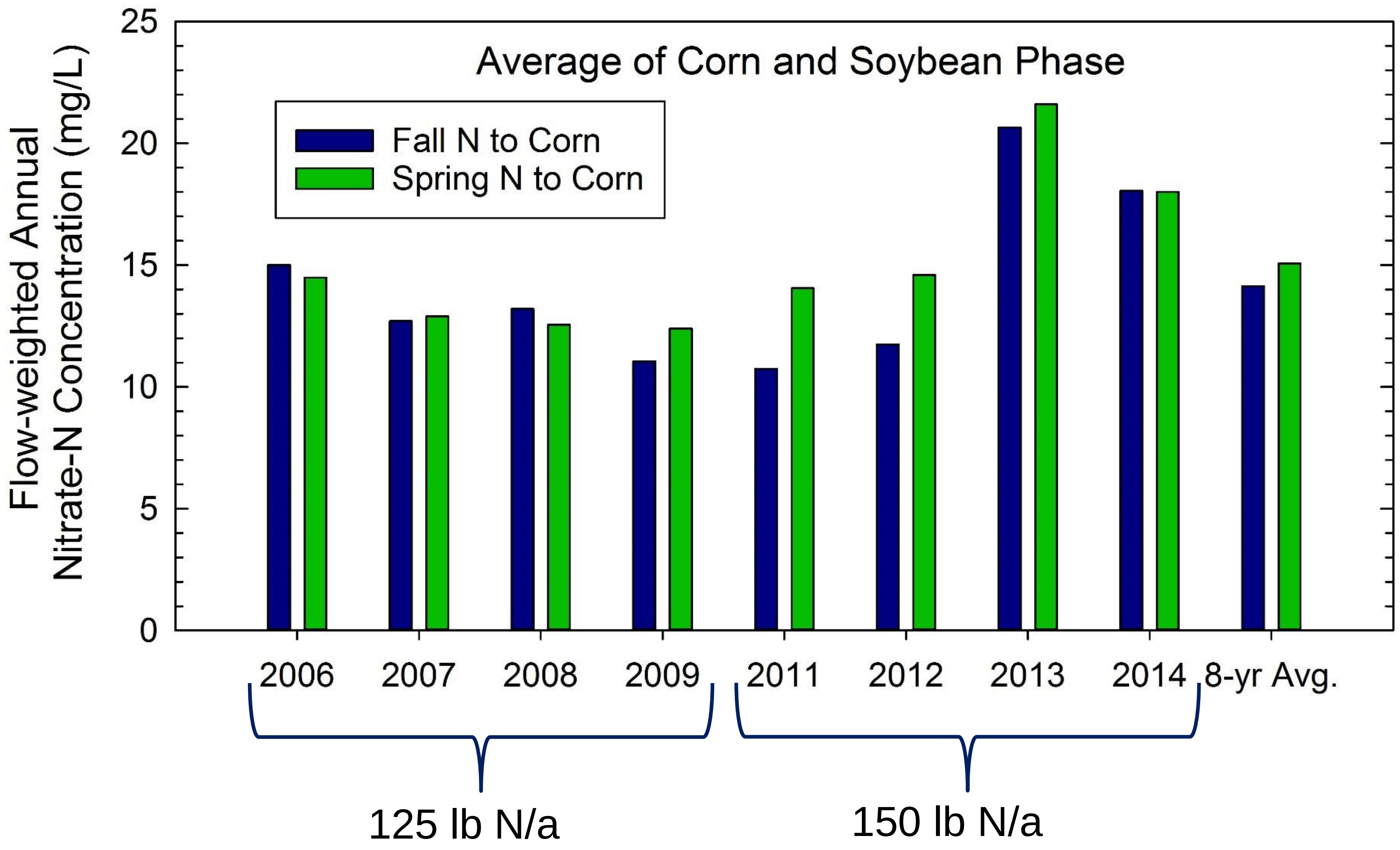
Price	Corn Following Soybean		Corn Following Corn	
Ratio	Rate	Range	Rate	Range
$/lb N:$/bu	- - - - - - - - - - - - - - - - -	lb N/acre	- - - - - - - - - - - - - - - - -	
Main Iowa Region				
0.05	160	143 - 177	210	195 - 228
0.10	140	126 - 152	188	175 - 203
0.15	124	113 - 136	171	157 - 185
0.20	113	103 - 123	154	143 - 166
Southeast Iowa (Soil Regions 17, 21, 22)				
0.05	180	162 - 201	239	220 - 240
0.10	154	140 - 169	204	187 - 221
0.15	136	127 - 149	183	176 - 195
0.20	128	117 - 137	180	166 - 186

Price per lb N divided by the expected corn price. Corn held at $3.50/bu for all price ratios. CNRC as of April, 2017 (http://cnrc.agron.iastate.edu/).

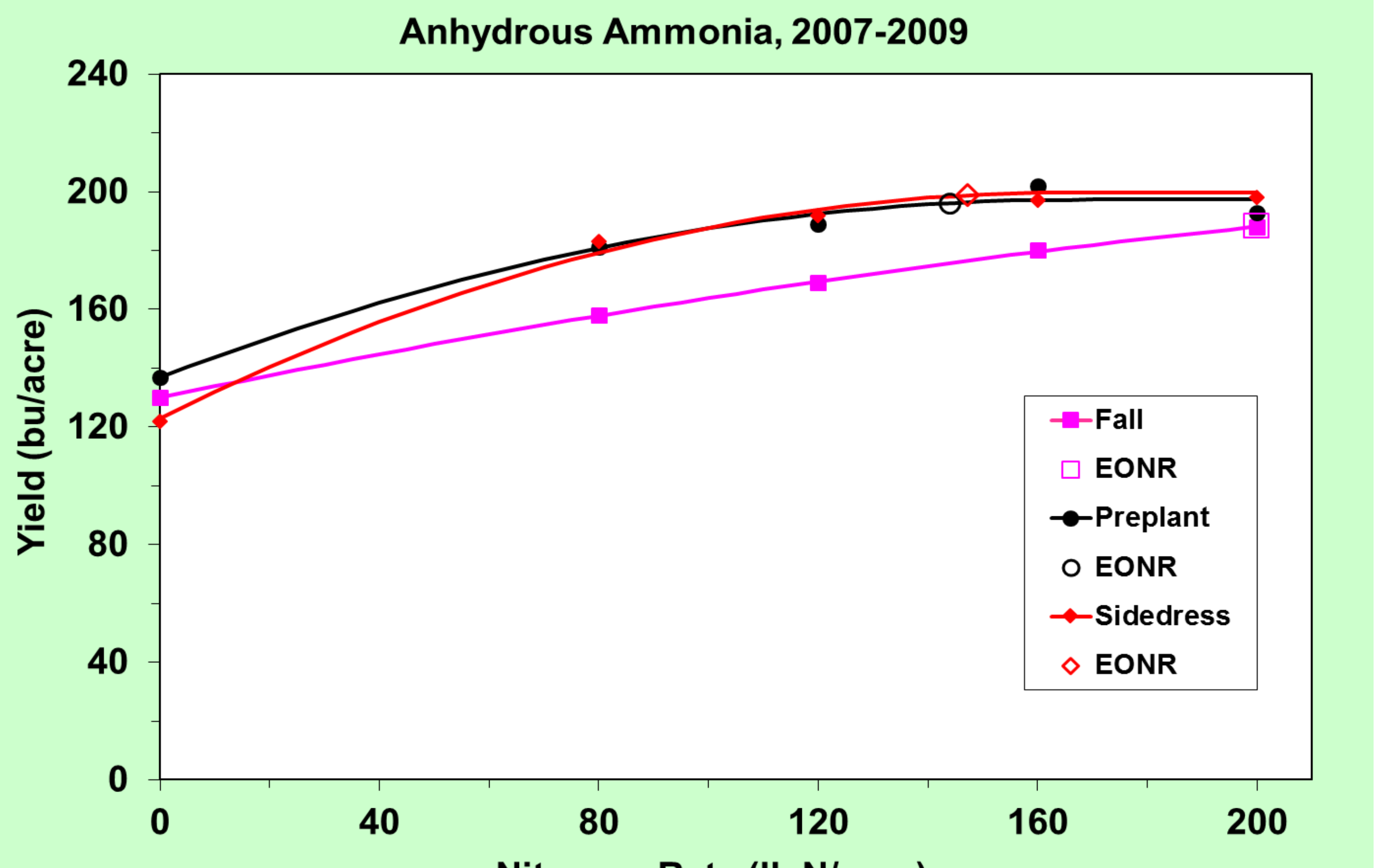
Application Timing

- Nitrogen application timing has less impact on nitrate-N loss to water systems and corn yield than other in-field N management practices
- Nitrate-N loss is similar within the corn year and soybean year

Impact of N Application Timing (2006-2014)
(Gilmore City Ag Drainage Site)



Fall, Preplant, and Split/Sidedress Anhydrous Ammonia



Sawyer, Barker, Hanna, 2009

Fall vs. Spring Urea Application

Northern Research Farm, 2007-2010				
	N rate applied to corn, lb N/acre			
Crop	0	80	160	240
	- - - - - - - - bu/acre - - - - - - - -			
Corn, sp urea	59	126	158	186
Corn, fall urea	62	99	151	165

Continuous corn.

Mallarino and Rueber, 2010.

Preplant (At-Planting) vs. Split/Sidedress
UAN, Urea, Ammonium Nitrate

		Mean EONR		Mean YEONR	
Category	Sites	Pre	Split	Pre	Split
		- - lb N/acre - -		- - bu/acre - -	
Split EONR at least 10 lb N/acre lower than Preplant	4	167	138	202	201
Preplant EONR at least 10 lb N/acre lower than Split	3	108	126	203	206
Preplant and Split EONR within 10 lb N/acre	7	151	147	221	221
Overall Mean	**14**	**146**	**140**	**212**	**212**

Based on N response equations and 0.10 N:corn price ratio.
Sawyer, Lundvall, Hall, and Barker, 2014-2016.

Nitrogen Applied Pre and Pre+Post-Sensing

N Application Treatment[1]	Mean Total N Applied[2]	Sites with Post-Sensing N Applied	Mean Yield[3]
	lb N/acre	n	bu/acre
0	0	--	141d
60	60	--	177c
60+	115	28	185b
120	120	--	192a
120+	131	9	193a
240	240	--	197a

[1] Pre-N rates applied preplant or early sidedress; N post-sensing "+" applied from V15 to R1 stages (SPAD meter, UAN high-clearance).
[2] Sum of pre-N and post-sensing N rate.
[3] Yields statistically different when followed by different letter ($P \leq 0.10$).
Thirty producer sites (field-length strips) with corn following soybean.
Hawkins, Lundvall, Sawyer (2006).

EONR(0.10) for Pre-N rates = 132 lb N/acre.

Nitrogen Product and Timing

Treatment: all 150 lb N/acre	Rank 1 to 15	Avgerage bu/acre
All N applied at planting:		
UAN injected mid-row	4	220 abc
UAN dribbled mid-row	13	215 def
Urea/Agrotain broadcast	1	223 a
SuperU broadcast	2	223 ab
ESN broadcast	8	219 abcde
UAN/Agrotain broadcast	15	213 f
NH_3 injected mid-row	12	216 cdef
NH_3/N-Serve injected mid-row	11	216 cdef
Split N application (1st at planting):		
UAN 50 broadcast+UAN 100 injected V5	9	218 bcde
UAN 100 inj+UAN 50 injected V5	5	220 abc
UAN 100 inj+Urea/AT 50 broadcast V5	7	219 abcd
UAN 100 inj+UAN 50 dribbled in-row V9	3	221 abc
UAN 100 inj+Urea/AT 50 broadcast V9	10	218 cde
All N sidedressed:		
UAN injected mid-row at V5	6	220 abc
UAN dribbled mid-row at V9	14	214 ef

Dr. Emerson Nafziger, Univ. of Illinois, 2014-2016, 10 site-years

Nitrogen Product and Timing

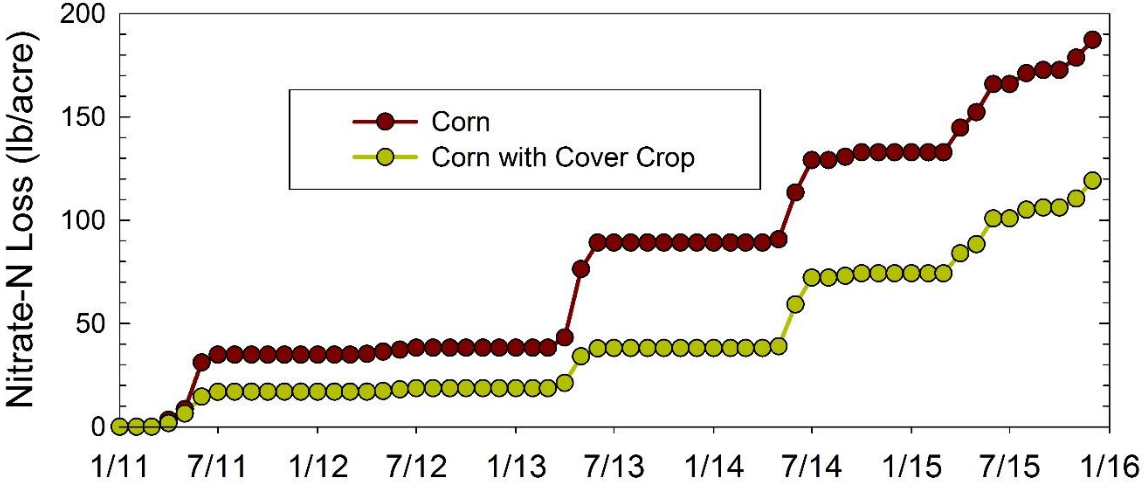
Data from 2015 (3 sites) and 2016(4)	Rank (1 to 19)			Yield	p=0.1
All N applied at planting:	2015	2016	2-yr	bu/acre	
UAN injected mid-row	7	7	7	221	ab
UAN dribbled mid-row	19	13	17	214	ef
Urea/Agrotain broadcast	9	1	2	223	ab
SuperU broadcast	1	2	1	225	a
ESN broadcast	12	3	5	222	ab
UAN/Agrotain broadcast	17	18	19	213	f
NH_3 injected mid-row	18	11	15	215	cdef
NH_3/N-Serve injected mid-row	16	15	16	215	def
UAN/Instinct II injected mid-row	13	16	14	217	bcdef
Split N application (1st at planting):					
UAN 50 broadcast+UAN 100 inj V5	15	9	13	218	bcdef
UAN 100 inj+UAN 50 injected V5	4	14	10	220	abcde
UAN 100 inj+Urea/AT 50 broadcast V5	5	10	8	221	abc
UAN 100 inj+UAN 50 dribbled in-row V9	8	5	4	222	ab
UAN 100 inj+Urea/AT 50 broadcast V9	11	8	11	220	abcde
UAN 100 inj+UAN 50 dribble in-row V5	2	6	3	223	ab
UAN 100 inj+UAN 50 dribble mid-row VT	14	4	9	221	abcd
UAN 100 inj+UAN 50 dribble in-row VT	3	12	6	222	ab
All N sidedressed:					
UAN injected mid-row V5	6	17	12	218	bcdef
UAN dribbled mid-row V9	10	19	18	213	f

Dr. Emerson Nafziger, Univ. of Illinois, 2014-2016

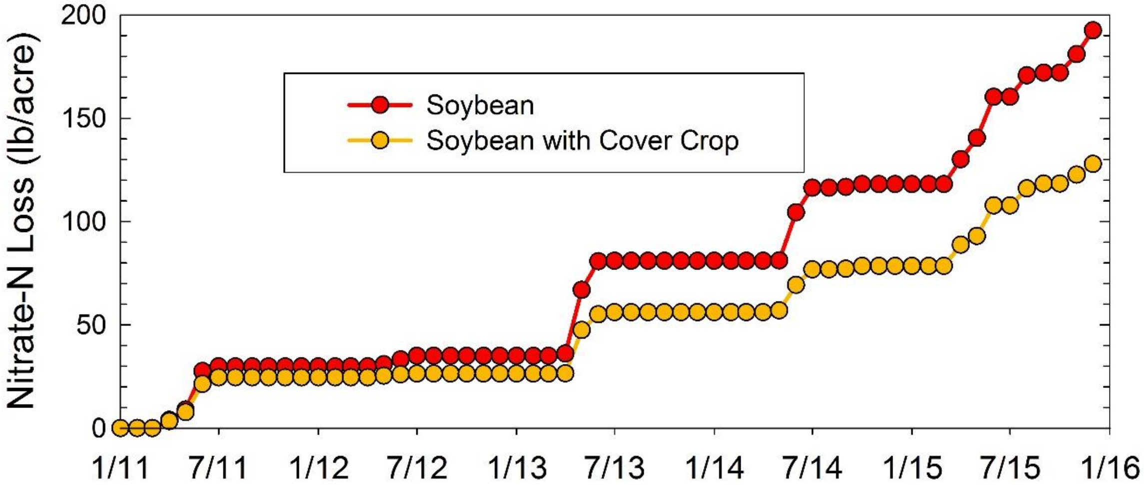
Cereal Rye Cover Crop

- Rye as a cover crop and in-field management practice has the largest impact on reducing nitrate-N loss
- However, rye cover crops have a neutral to negative effect on corn yield whereas other in-field practices have a positive effect on corn yield
- Rye does not affect soybean yield
- Rye does not affect needed N rate

Impact of Rye Cover Crop on Nitrate-N Load in Tile Drainage (Gilmore City Ag Drainage Site)



36% Reduction



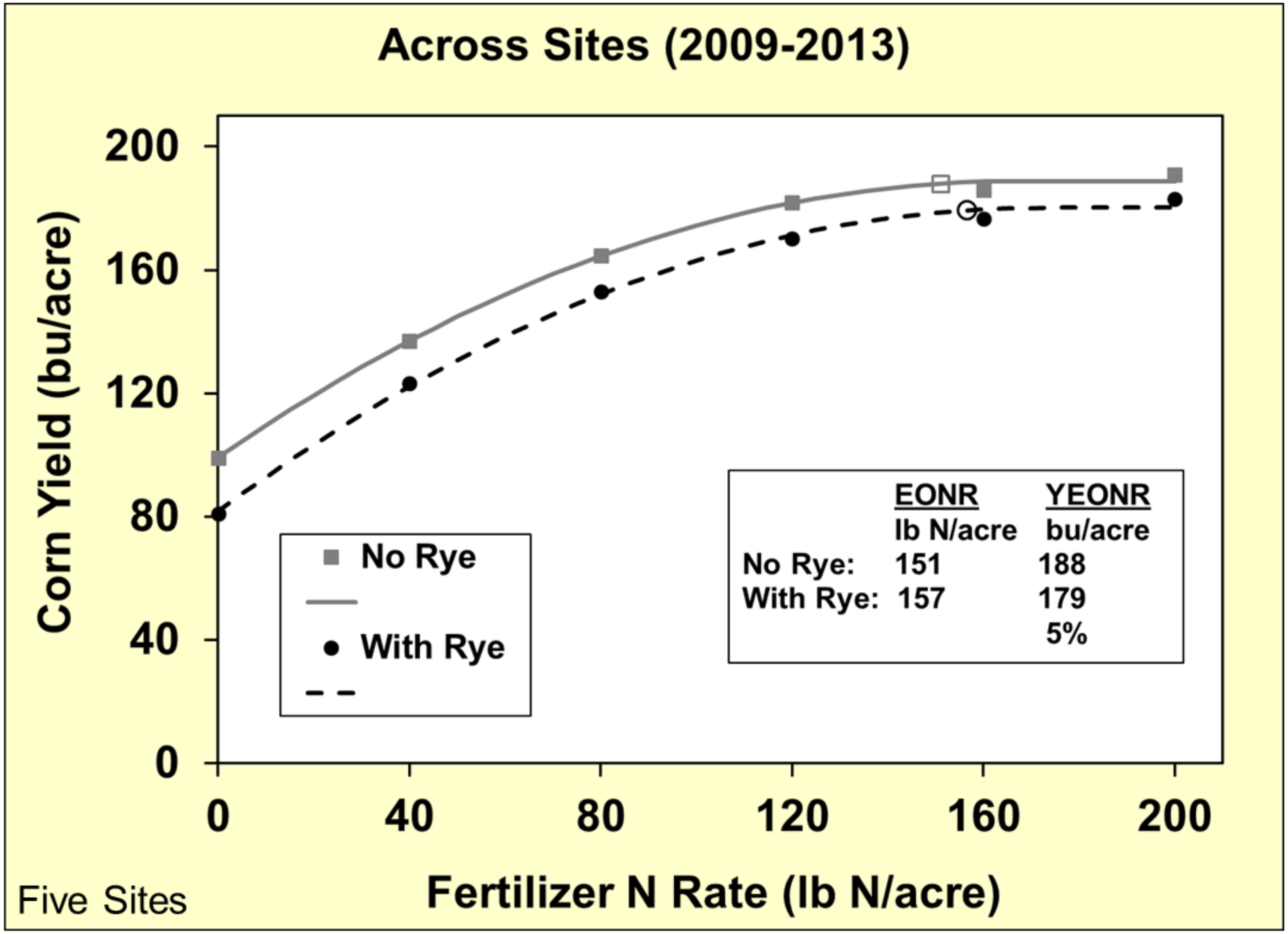
34% Reduction

IOWA DEPARTMENT OF AGRICULTURE AND LAND STEWARDSHIP

SUSTAINABLE CORN.ORG
CROPS, CLIMATE, CULTURE AND CHANGE

USDA
United States Department of Agriculture
National Institute of Food and Agriculture

Nitrogen Rate with Rye Cover Crop

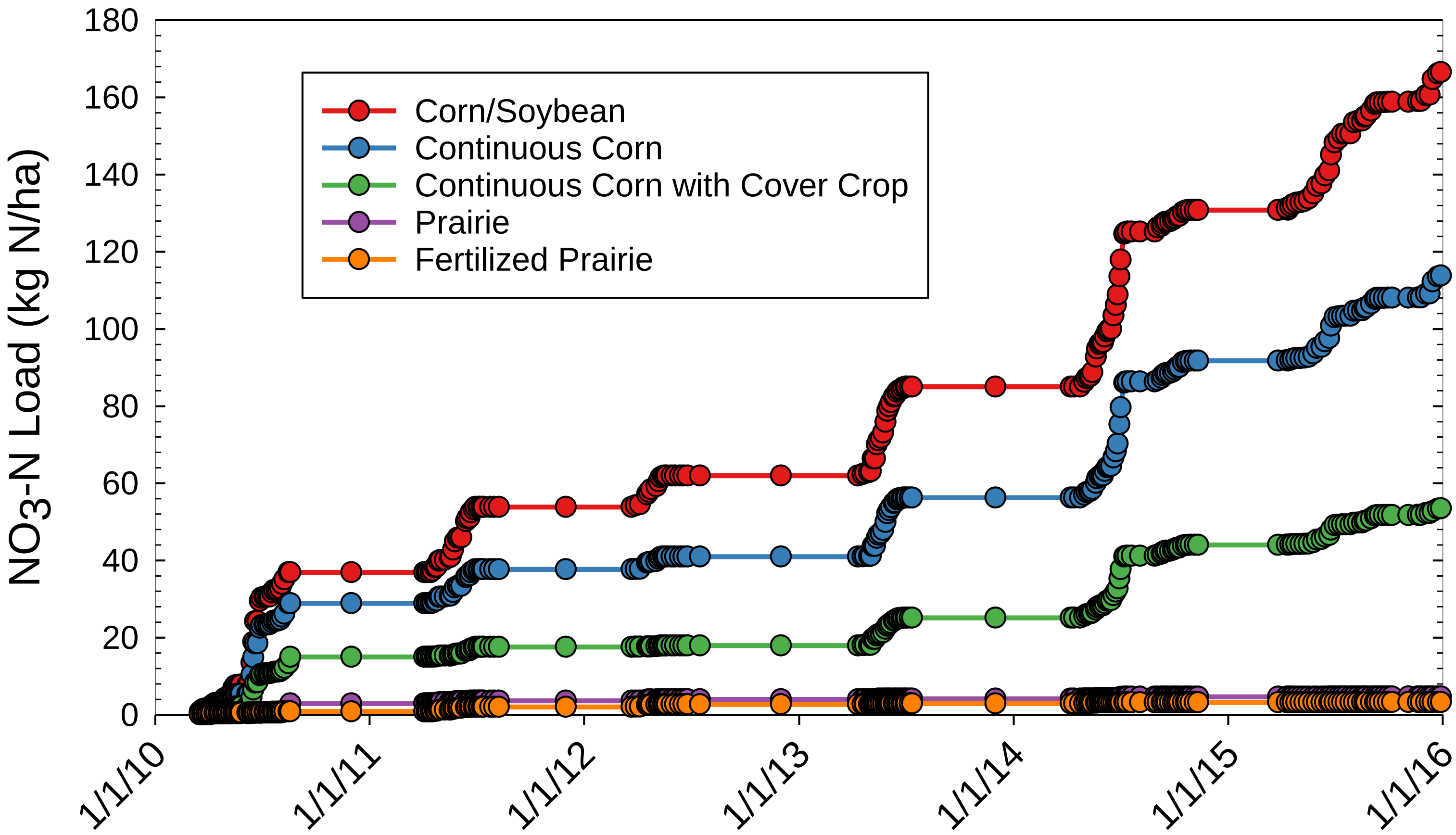


Pantoja et al., Iowa State Univ.

Land Use

- Land use changes have great potential for reducing nitrate-N loss to water systems and by themselves can meet the reduction goal
- However, land use decisions are complex and can dramatically change cropping systems as they involve use of perennial crop systems; and they need to be profitable

Impact of Land Use Change on Nitrate-N Load in Tile Drainage (Gilmore City Ag Drainage Site)



Example of What It Might Take to Reach the Nitrogen Reduction Goal

Example: Combination Scenarios that Achieves N Goal From Non-Point Sources for Iowa Nutrient Reduction Strategy – *for illustration only*.

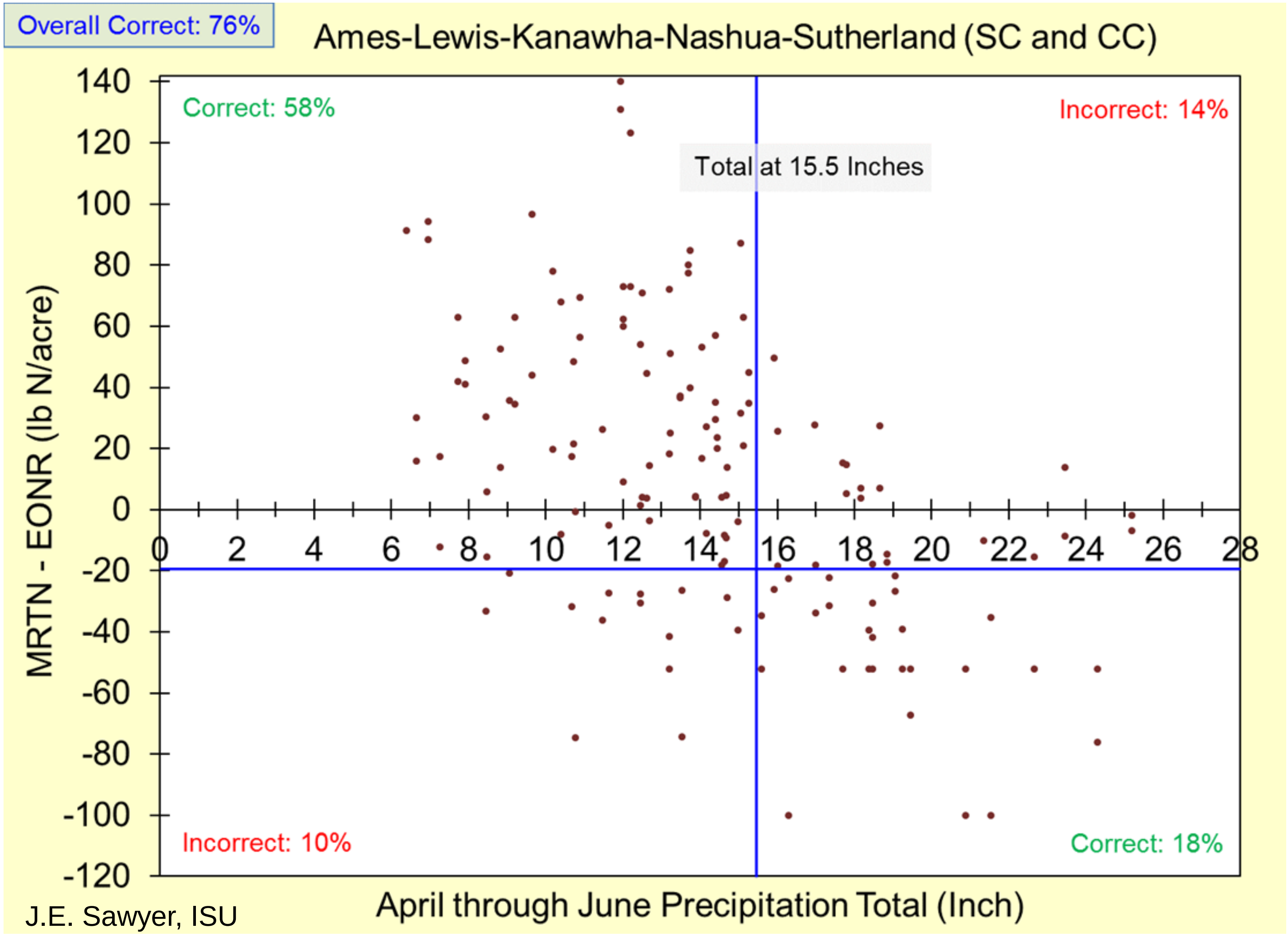
Practice/Scenario	Nitrate-N Reduction	Total Equal Annualized Cost
	% (from baseline)	Million $/yr
N management - Maximum Return to Nitrogen Application Rate and 60% of all Corn-Bean and Continuous Corn Acres with Cover Crop **Edge-of-Field** - 27% of all ag land treated with wetland and 60% of all subsurface drained land with bioreactor	42	756

In Iowa: ~7,600 wetlands and ~120,000 bioreactors

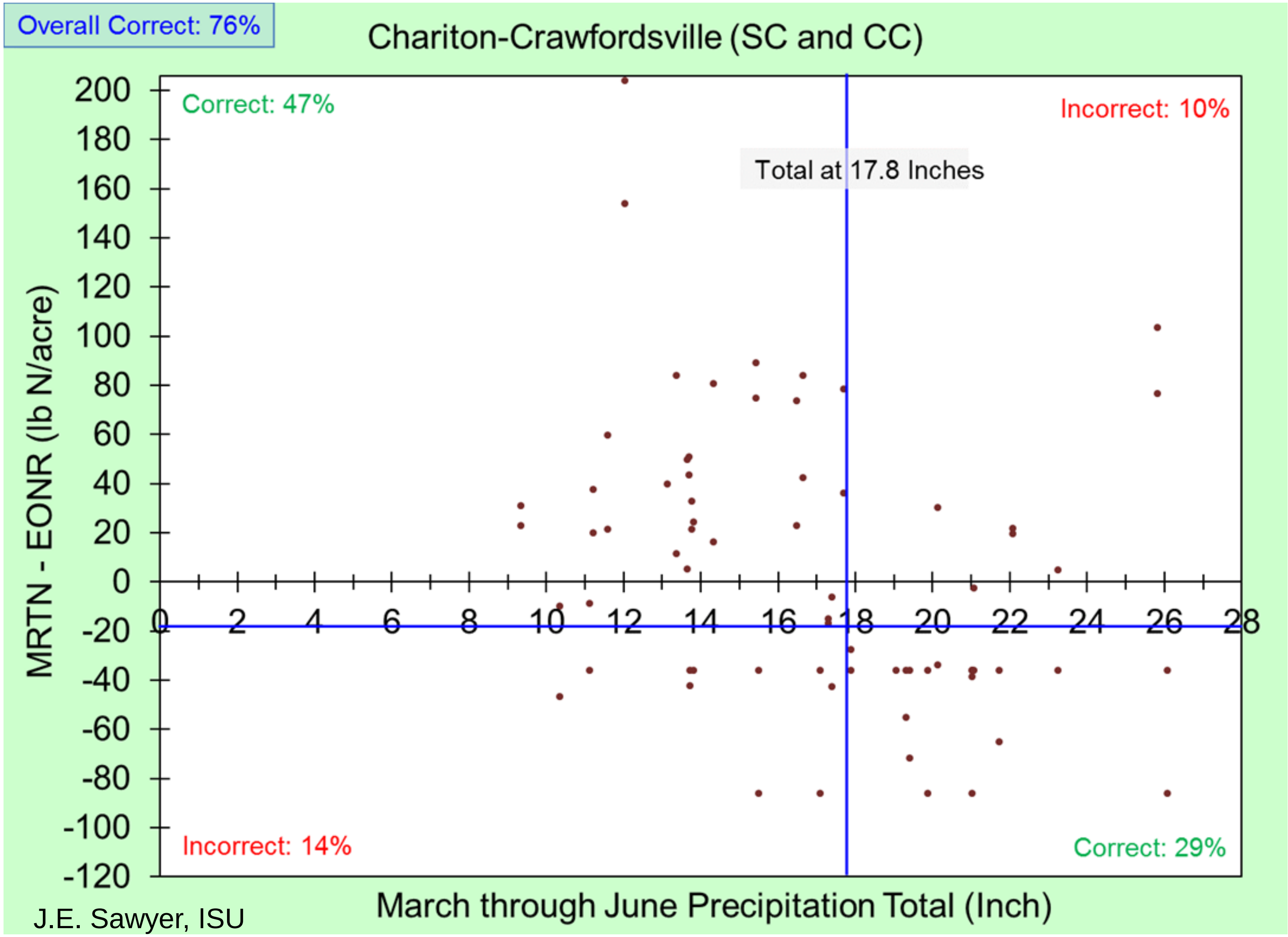
Springtime Nitrogen Loss?

- How is the weather impacting N loss potential this year?

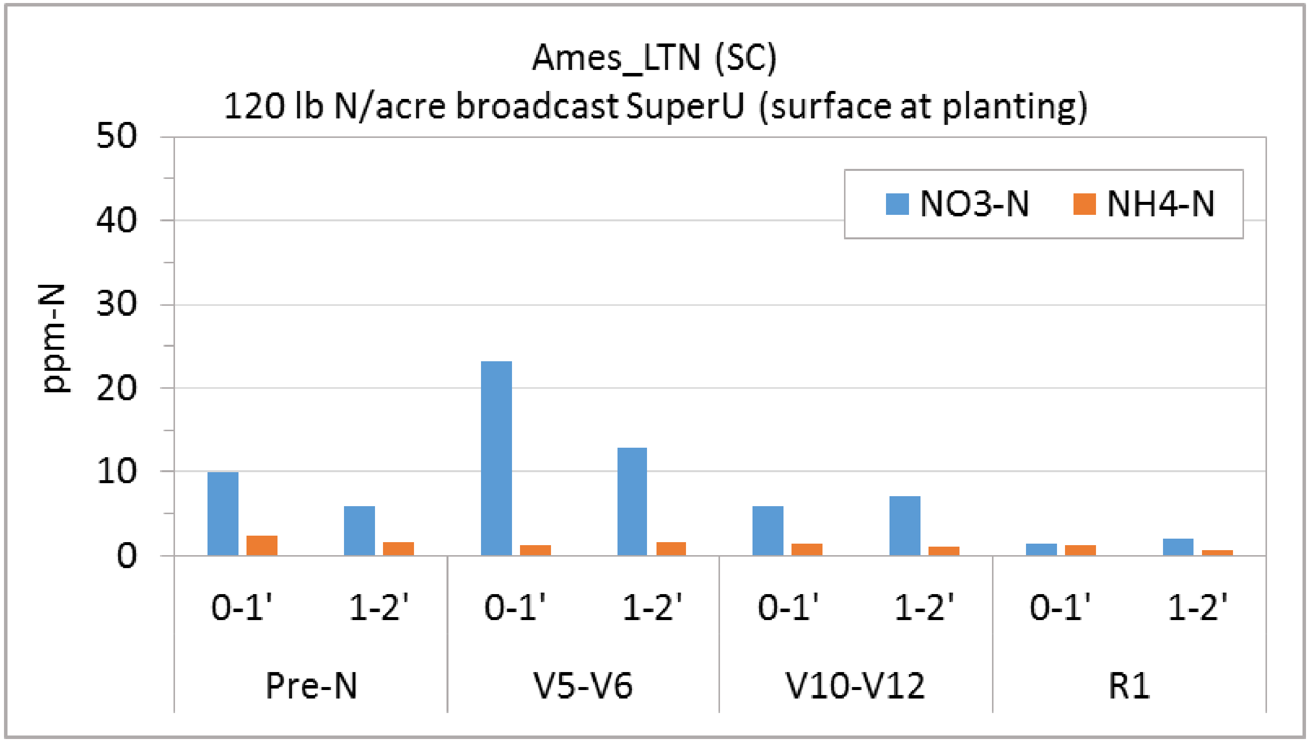
Wet Spring – Need More Nitrogen? Main Iowa Region



Wet Spring – Need More Nitrogen? SE Iowa Region



Is Normal for Soil Nitrate to Decrease Over Time with Corn N Uptake



Sawyer and Barker, 2015

Soybean-Corn
EONR: 112 lb N/acre
Pre-N sample: 5/13
N app: 5/18
V5-V6: 6/18
V10-V12: 7/1
R1: 7/23

Questions?