Nitrogen Management for Corn Production

John E. Sawyer

Professor

Soil Fertility Extension Specialist

Department of Agronomy

IOWA STATE UNIVERSITY
Extension and Outreach

Four Factors Influencing Optimum Time of Application

- Crop to be grown
  - Timing of N uptake
- Climate: Temperature ⇔ Precipitation
  - Excess water – Nitrate loss
- Soil texture -- drainage
  - Leaching / Saturation / Denitrification
- Nitrogen product - chemical formulation
  - Ammonium vs. Nitrate vs. Urea

Impact of Nitrogen Application Timing on Corn Yield

Year	Fall	4/1	4/15	5/1	5/15	6/1	6/15	7/1	Split E.	Split L.	CK
	- - - - - - - - - -	- - - -	- - - -	- - - -	- - - -	bu/acre	- - - -	- - - -	- - - -	- - - -	- - - -
1989 (Dry)	151	144	149	151	151	138	131	128	143	142	59
1990 (Wet)	114	126	128	128	140	145	143	137	130	136	68

N applied at 112 lb N/acre as liquid fertilizer. Split early wa s at first cultivation, split late was at second cultivation (half – half rate split). Continuous corn. Baker et al., 1995, Ames, IA.

Fall Nitrogen Application for Corn Production

- Relatively good in Corn Belt?
  - Medium - to fine textured soils
  - Soils not conducive to leaching/denitrification
  - On average -- 85 to 90% as effective as Spring applied N
  - Fall and late spring - early summer moisture
- Application after 4 inch soil temperature 50 ºF and cooling (colder the better)
- Only anhydrous ammonia
- Consider nitrification inhibitor

Effect of Time of N Application and N-Serve on Corn Yields after Soybean from 1987–2001 at Waseca, MN

Parameter	Time of N Application		
	Fall	Fall+N-Serve	Spring
15-Yr Avg. Yield (bu/A)	144	153	156
15-Yr Avg. FW NO_3-N Conc. (mg/L)	14.1	12.2	12.0
7-Yr Avg. Yield (bu/A) **	131	146	158

** Seven years when statistically significant differences occurred.

Gyles Randall, Univ. Minnesota

Fall 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.

Corn response to N timing in Iowa, Minnesota, and Wisconsin (1987-1992)

	Location (site-years)		
	Iowa	Minnesota	Wisconsin
Sites	(1987-1991)	(1989-1992)	(1988-1992)
Total	65	32	39
Responsive	25	28	20
PP = SD/Splt.	15	16	17
PP > SD/Splt.	8	4	3
PP < SD/Splt.	2	8	0

Killorn, IA; Randall, MN; Bundy, WI.

L.G. Bundy, Univ. of Wisconsin

Spring Preplant vs. Spring-Sidedress Three Application Split in Iowa

- Across Five Years (1987-1991)
  - Two of three dry springs: preplant > split
  - One dry spring: no difference
  - Two wet springs: split > preplant

From Baker et al., 1995. Iowa State University. Average of liquid N (0 to 180 lb N/acre) point injected with and without N-Serve, Ames IA. Continuous corn.

Preplant or At-Planting and Split/Sidedress

		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**
Chariton (2015)	1	250*	250*	134	129

Based on N response equations and 0.10 N:corn price ratio.

Sawyer, Lundvall, Hall, and Barker, 2014-2016.

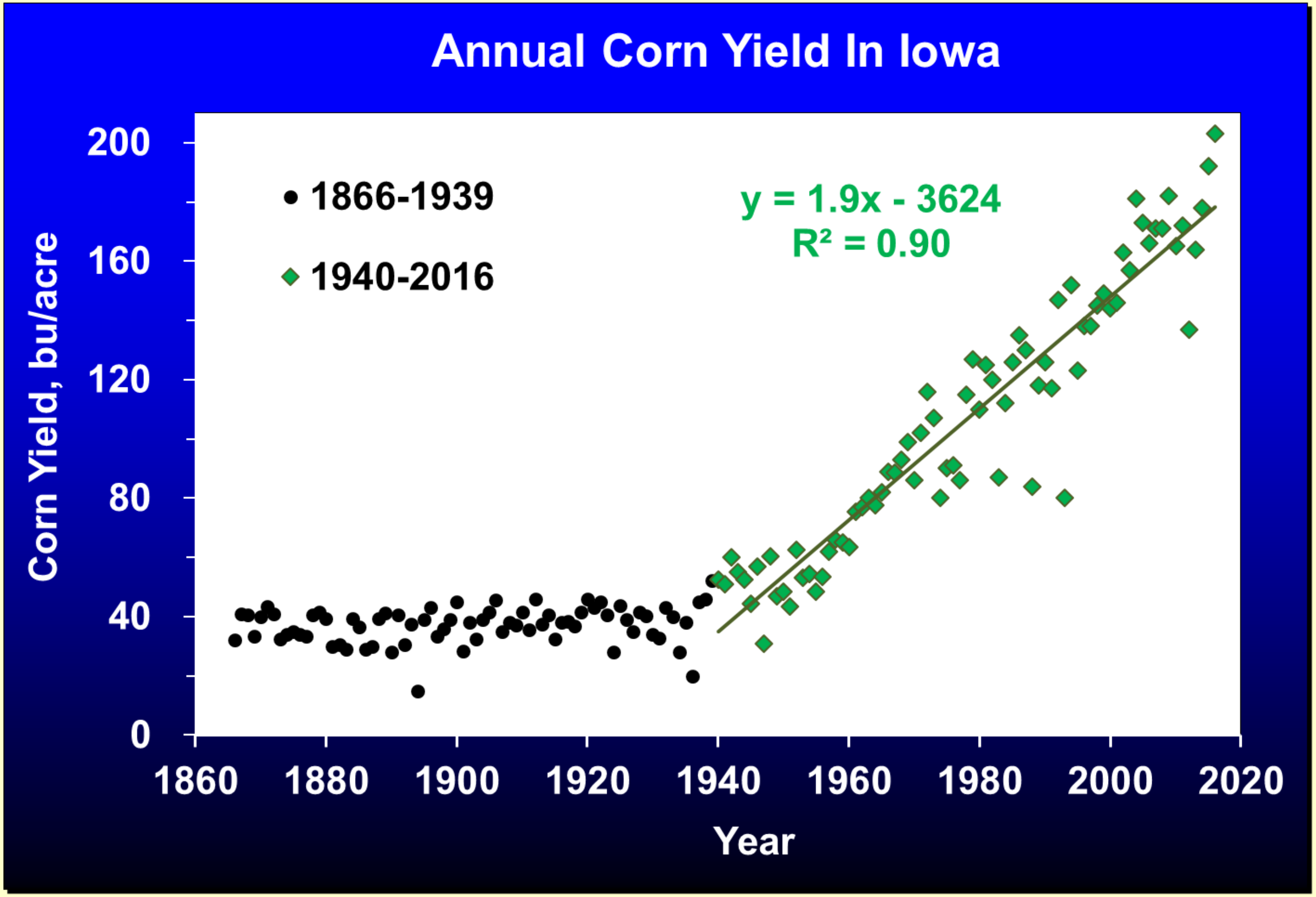
Recommended Timing of Nitrogen Applications for Corn

Soil	Fall	Preplant	Sidedress
Medium/Fine Texture Well-Drained	OK*	Optimum	OK
Medium/Fine Texture Poorly Drained	No	OK	Optimum
Coarse texture	No	No	Optimum

*Includes use of BMPs for fall-applied N.

L.G. Bundy, Univ. of Wisconsin

Has Nitrogen Fertilization Requirement Increased Like Corn Yield?



Data Source: USDA-NASS

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Why Are Nitrogen Rate Guidelines Similar Across Many Years and Corn Yield Gains?

		Suggested N Rate Range
Reference (year)	Rotation	Low – High
		lb N/acre
PM-905 (1979)	Soybean-Corn	100 – 150
	Corn-Corn	150 – 200
CNRC (2018)	Soybean-Corn	126 – 152
	Corn-Corn	175 – 203

PM-905 Crop Rotations, Effect on Yields and Response to Nitrogen, 1979
Corn Nitrogen Rate Calculator (CNRC), 2018

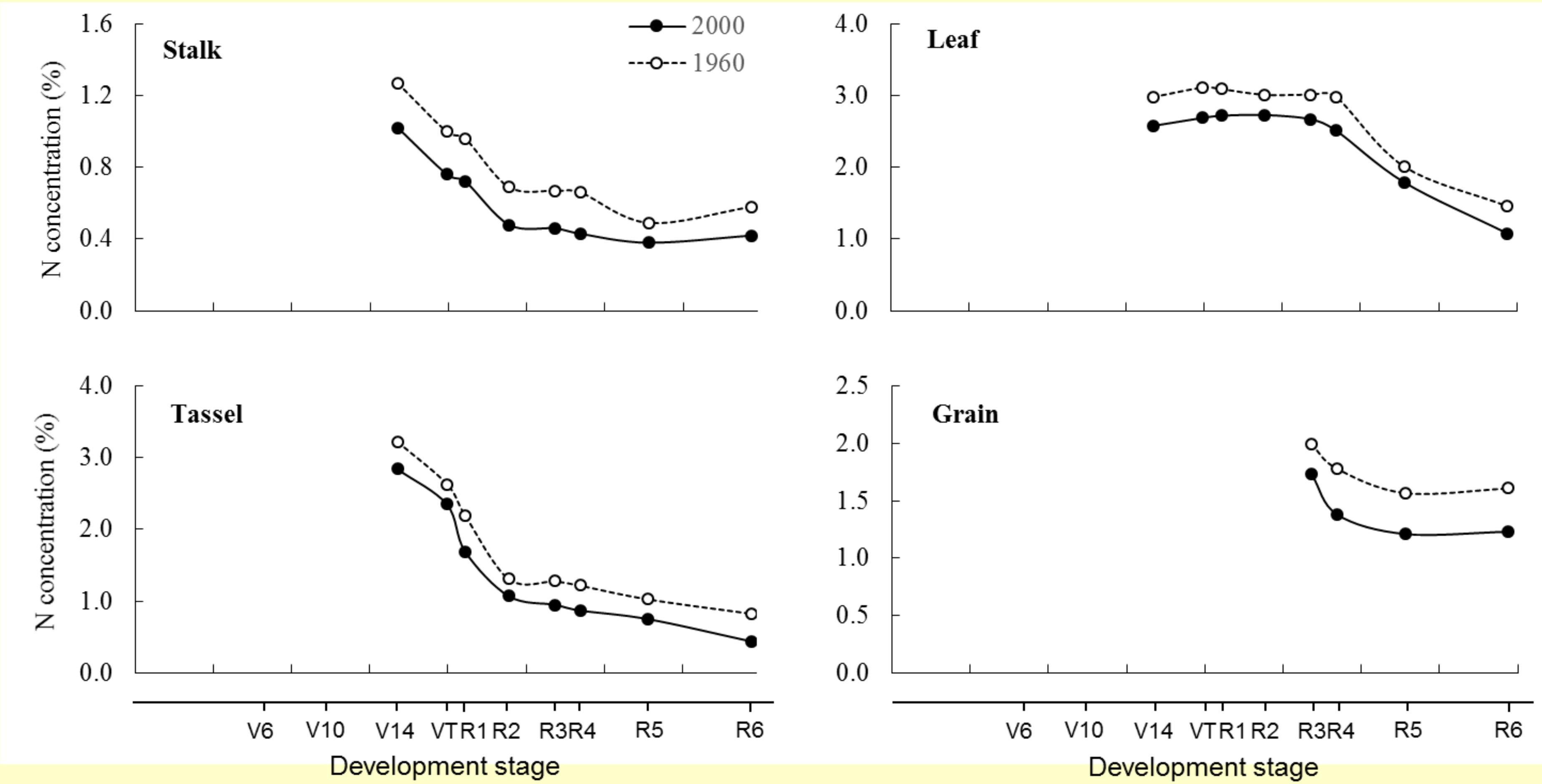
Corn Era Comparison: 1960 vs. 2000
What's Changed?

	Era		For
	1960	2000	2000
Grain Yield (bu/acre)	134b	224a	+67%
Total Plant N (lb/acre)	159b	190a	+19%
Grain N (lb/acre)	113b	138a	+22%
Grain N Harvest Index	0.71a	0.73a	
Harvest Index (%)	49a	53a	
Grain (bu/lb total plant N) *(IE)*	0.84b	1.18a	+40%
Grain N Concentration (%DM)	1.61a	1.23b	-24%
Grain N (lb N/bu) at 15%	0.77a	0.59b	-24%

Inverse of Internal Efficiency (IE) gives the per bushel N factor times yield: 1.2 (1960) and 0.8 (2000).

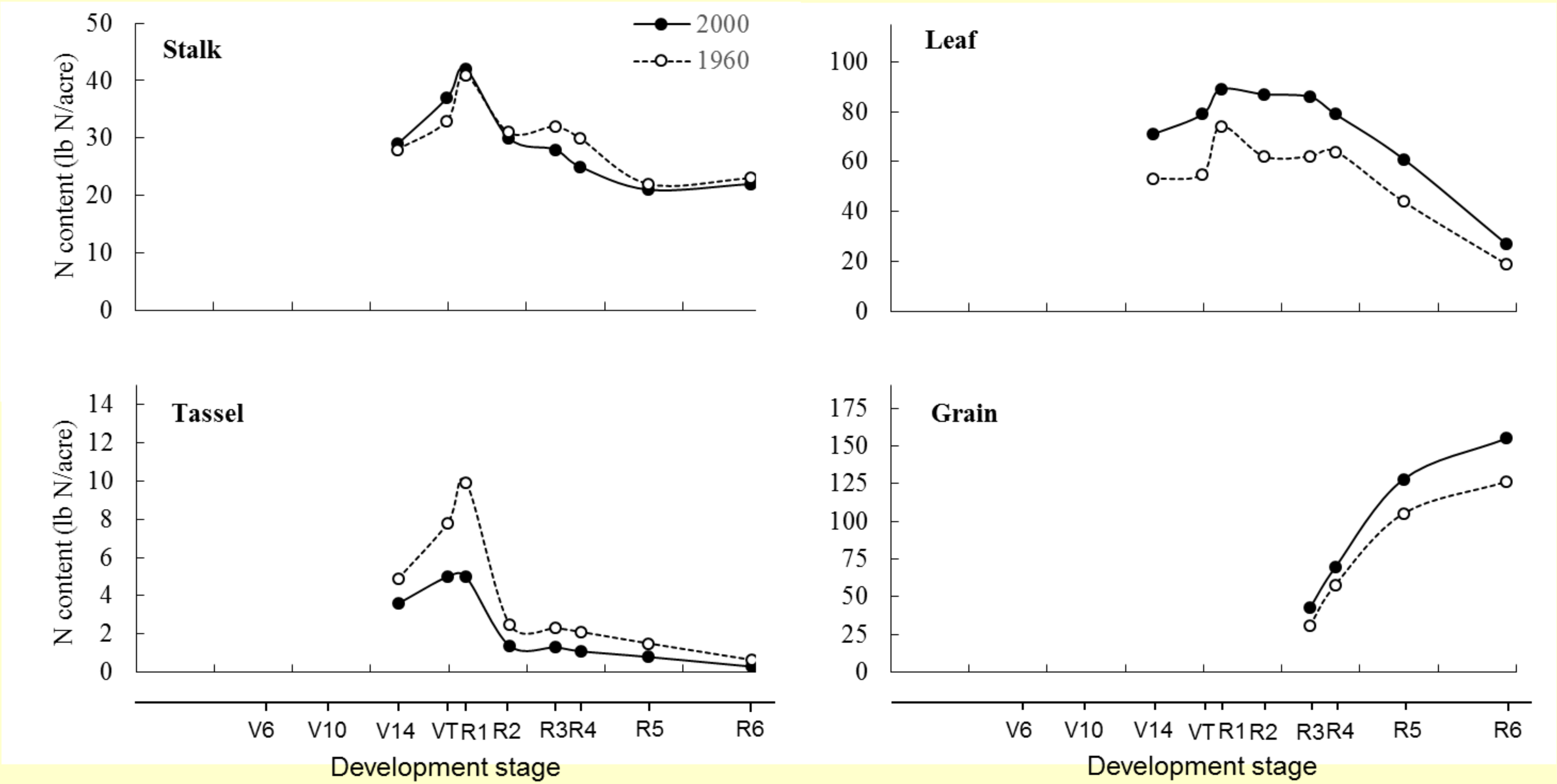
Woli et al.

Corn Era Plant Components
Nitrogen Concentration



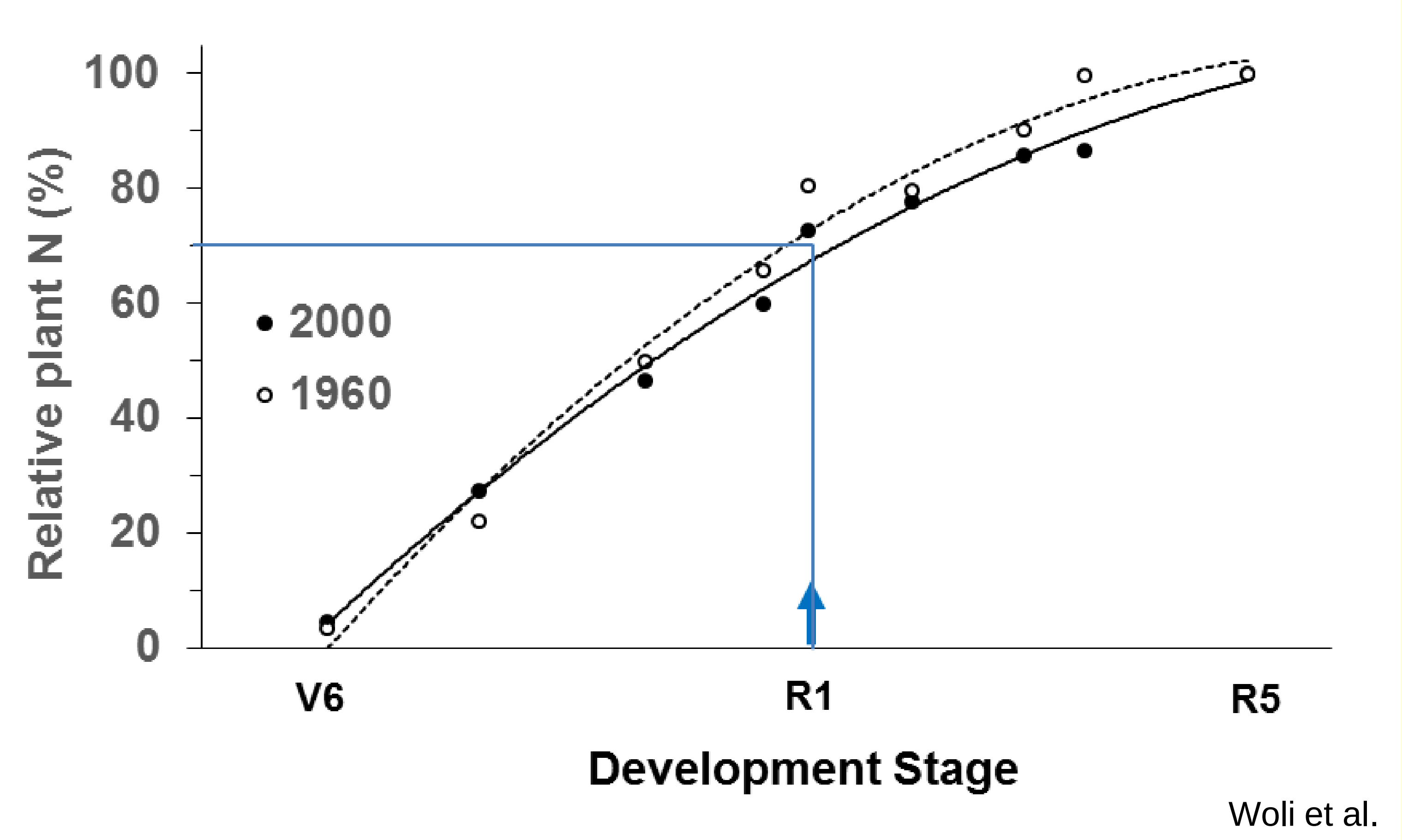
Woli et al.

Corn Era Plant Components
Nitrogen Content

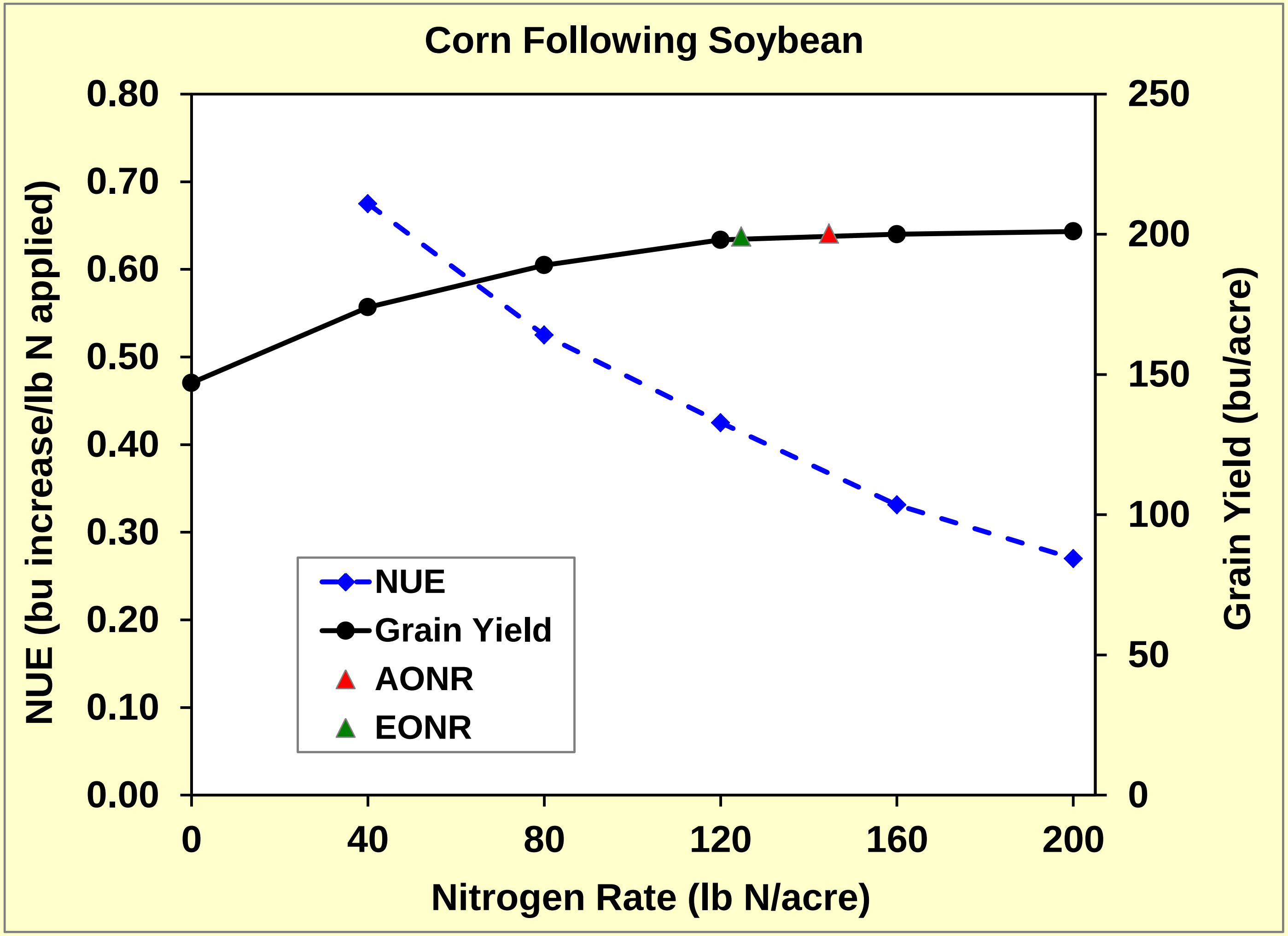


Woli et al.

Corn Era Comparison: 1960 vs. 2000 Nitrogen Uptake Timing has Not Changed



Nitrogen Use Efficiency (NUE) and Yield With Increasing N Rate



2006-2007 - 14 Iowa Sites. Yield/Agronomic Efficiency. Sawyer and Barker, ISU.

Corn Nitrogen

- Corn plant N uptake timing by silking (R1) is still around 70%
- Corn plant total N is around 1 lb N/bu
- Corn grain N concentration is near 0.53 lb N/bu at 15.5% moisture (1.12% N in DM)
  - Example for 240 bu/acre yield
    - 127 lb N/acre in corn grain
- Grain N removal is less than suggested MRTN rates or most profitable N rate ranges

Nitrogen Use and Water Quality
Corn Grain N Removal vs. N Application

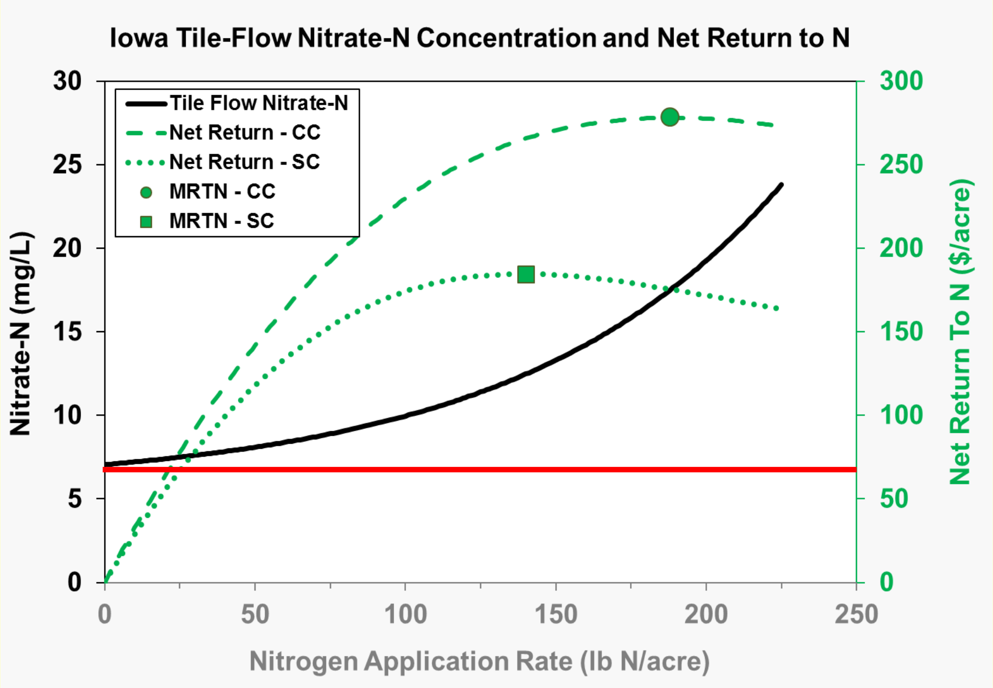
- Example for state of Iowa
  - 1976-1980 vs. *2014-2018*
  - 107 bu/acre vs. *194 bu/acre state corn yield*
  - 87 lb N/acre vs. *103 lb N/acre in grain harvest*
  - 120 lb N/acre vs. *158 lb N/acre fertilizer use*
  - 0.73 ratio vs. *0.65 ratio*
    (grain N removal divided by applied N)
    - 0.82 lb N/bu vs. 0.56 lb N/bu
    - 85% N to planted corn acres per Iowa ground water protection act reporting method
    - USDA-NASS Iowa corn yield

Nitrogen Use and Water Quality

- Increasing N rates in reaction to high corn yields will reduce profitability and worsen environmental issues like nitrous oxide emission and nitrate-N in water systems

❖ A baseline nitrate-N

❖ Reasons why in-field 4R N practices have limits for water quality improvement



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Iowa Nutrient Reduction Practices

	Practice	Comments	% Nitrate-N Reduction+	% Corn Yield Change++
			Average (SD*)	Average (SD*)
Nitrogen Management	Timing	Moving from fall to spring pre-plant application	6 (25)	4 (16)
		Spring pre-plant/sidedress 40-60 split Compared to fall-applied	5 (28)	10 (7)
		Sidedress – Compared to pre-plant application	7 (37)	0 (3)
		Sidedress – Soil test based compared to pre-plant	4 (20)	13 (22)**
	Source	Liquid swine manure compared to spring-applied fertilizer	4 (11)	0 (13)
		Poultry manure compared to spring-applied fertilizer	-3 (20)	-2 (14)
	Nitrogen Application Rate	Nitrogen rate at the MRTN (0.10 N:corn price ratio) compared to current estimated application rate. (ISU Corn Nitrogen Rate Calculator – http://extension.agron.iastate.edu/soilfertility/nrate.aspx can be used to estimate MRTN but this would change Nitrate-N concentration reduction)	10	-1
	Nitrification Inhibitor	Nitrapyrin in fall – Compared to fall-applied without Nitrapyrin	9 (19)	6 (22)
	Cover Crops	Rye	31 (29)	-6 (7)
		Oat	28 (2)	-5 (1)
	Living Mulches	e.g. Kura clover – Nitrate-N reduction from one site	41 (16)	-9 (32)

SP 0435A

Corn Nitrogen Rate Determination

- Setting an N application rate by starting with corn yield goal is a poor system
  - Yield does not equate to N rate need

High Yield Environments in Iowa

Rotation	No.	EONR	Yield
		lb N/acre	bu/acre
SC	40	150	233
CC	13	183	232

EONR at 0.10 N:Corn price ratio.
J. Sawyer and D. Barker. ISU.

Exploring a Regional Approach to Nitrogen Rate Guidelines (MRTN and CNRC)

- Diverse N rate guideline systems across states in the Midwest USA
- Cross-state programs
- Volatile N fertilizer and corn prices
- Lack of optimum N rate relationship with yield
  - Yield-based N rates greater than economic optimum with high yields and too low rates on less productive soils

MRTN Development Timeline

- Discussions in 2004
- Initial N response trial database completion in 2005
- Web based Corn N Rate Calculator (CNRC) in 2005
- Regional extension publication in 2006

Corn Nitrogen Rate Calculator

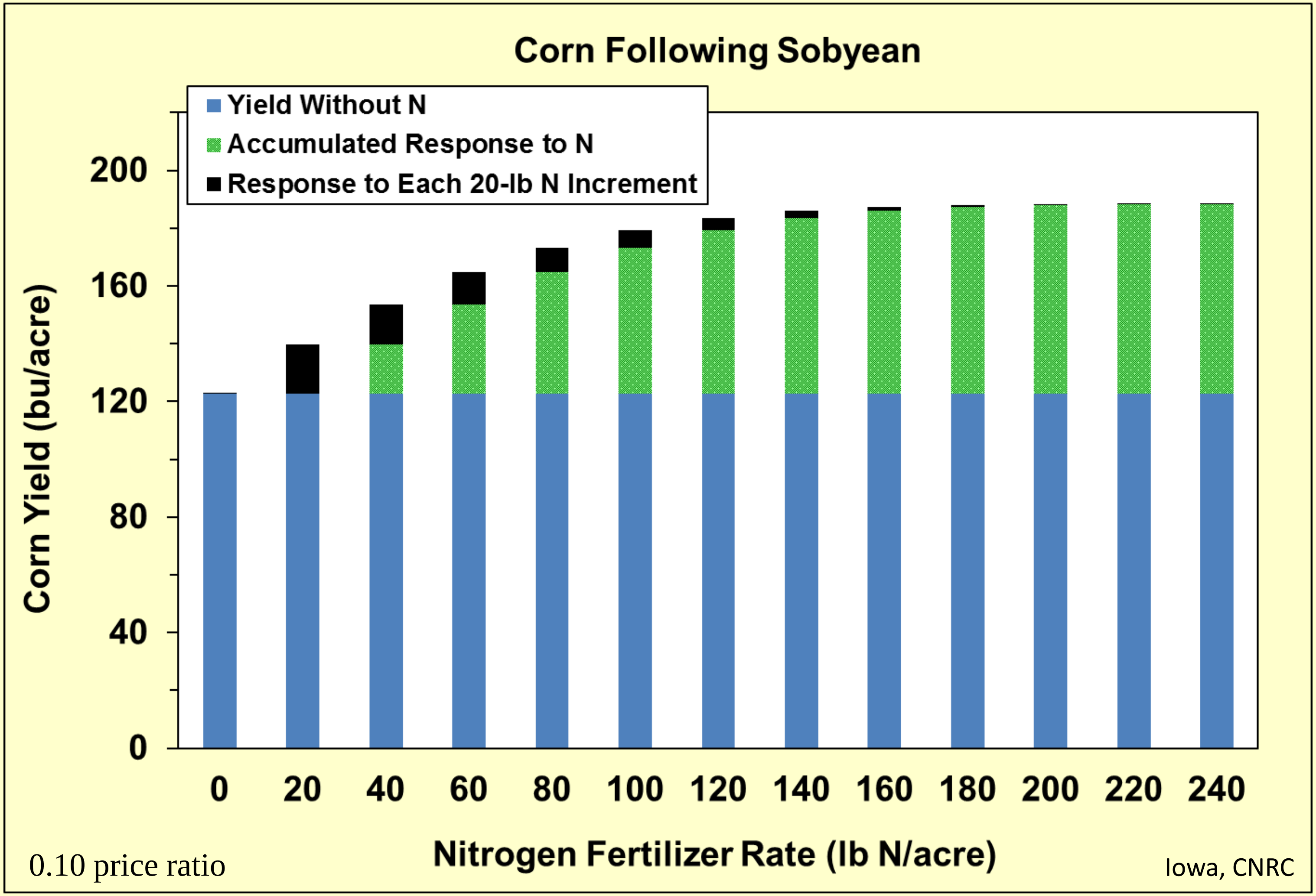
http://cnrc.agron.iastate.edu/

MRTN/CNRC - Database Driven Approach

- Corn response data from many recent research-based N rate trials
  - 2,008 trials
  - > 90% less than 15 years old
  - Iowa: 411 trials
- Analytical/predictive method to determine economic response and most profitable N rates directly from research trials

Current Data → N Rate Guidelines

Diminishing Return to N Application



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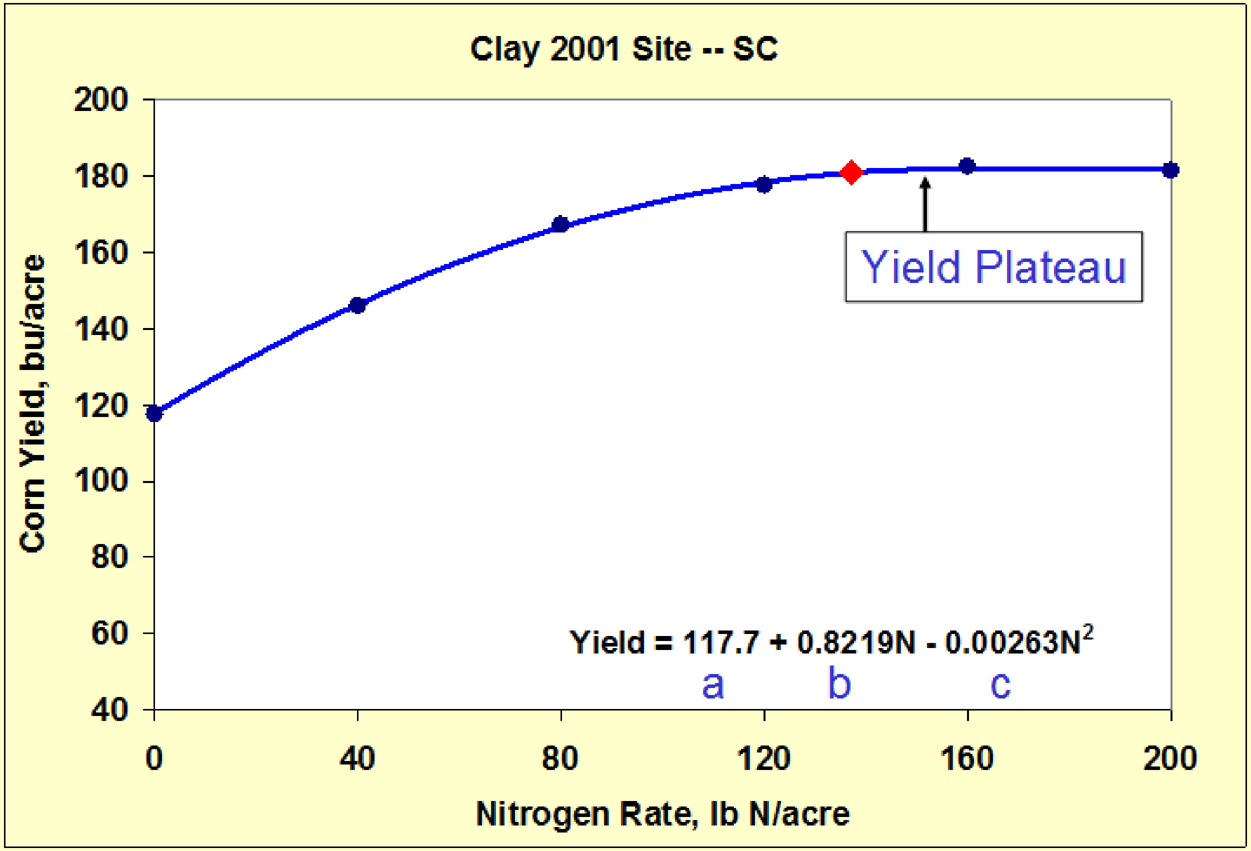
Steps in MRTN Computation

- 1. Collect N response trial site data
- 2. Observe shape of N response data
- 3. Fit regression equation to each trial data
- 4. Compile database of site response equations for CC and SC

Steps in MRTN Computation

- Corn N rate response trial example

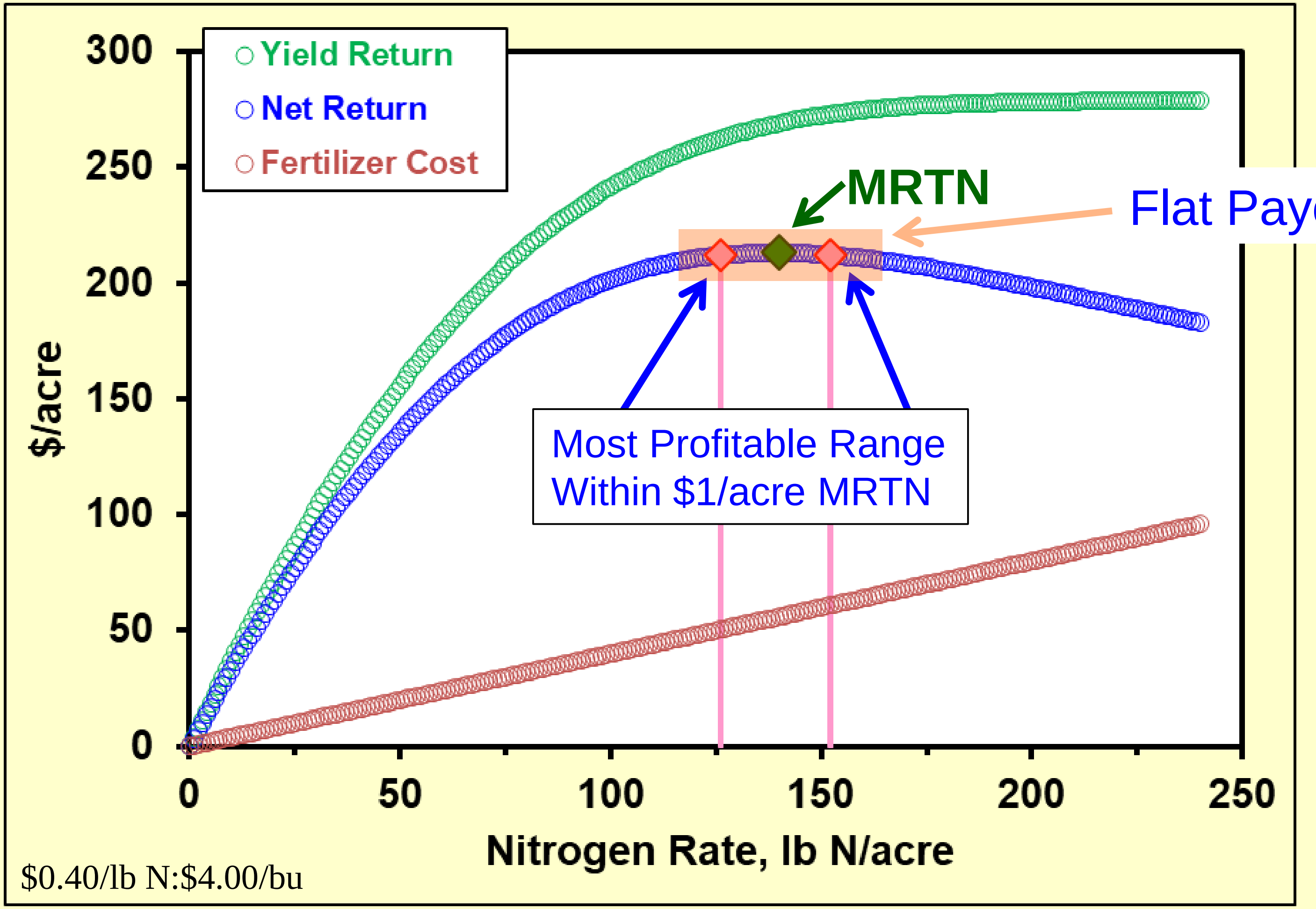


Steps in MRTN/CNRC Computation

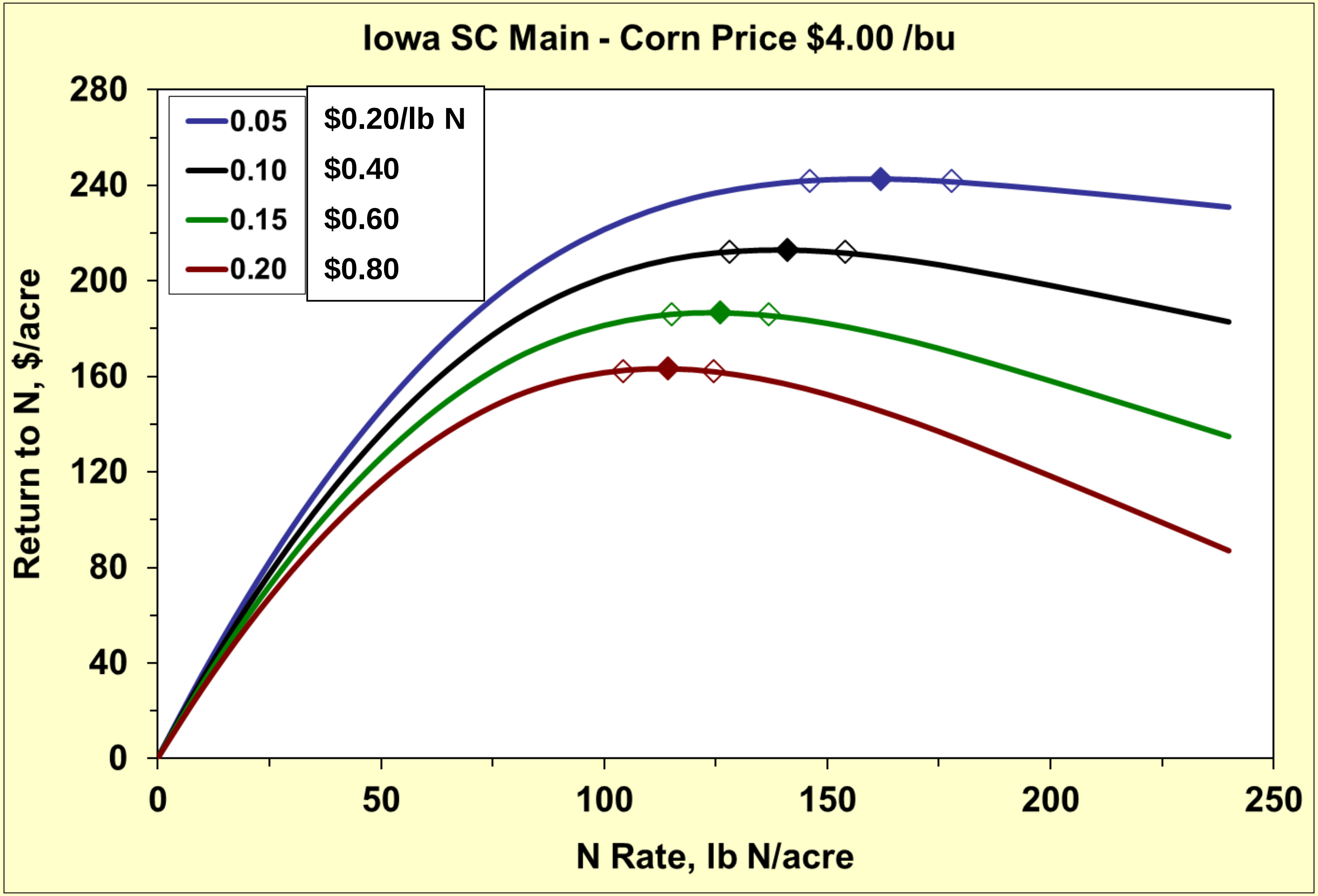
- 5. Calculate by 1-lb N rate increments: gross yield return, fertilizer cost, net return to N (RTN) using the regression equations
- 6. For user specified dataset (C<u>C</u>, S<u>C</u>, state, or substate), N and corn prices -- average across the RTN for selected response trials
- 7. The N rate with largest average RTN is the MRTN rate, with the most profitable range being the N rates within $1.00/acre of the maximum RTN

Ext. Public. PM 2015

Net Return Determines MRTN Rate and Profitable Range



Effect of Prices on MRTN and Most Profitable N Rate Range



Nitrogen Rates for Corn in Iowa

Maximum Return to Nitrogen (MRTN) rate and Most Profitable Rate Range from the Corn Nitrogen Rate Calculator (CNRC).

Price Ratio[1]	Corn Following Soybean		Corn Following Corn	
	Rate	Range	Rate	Range
$/lb N:$/bu	- - - - - - - - - - - - - - - - lb N/acre	- - - - - - - - - - - - - - - -		
MAIN Iowa Region				
0.10	**140**	**126 - 153**	**188**	**174 - 204**
SEIA (Soil Regions 17, 21, 22)				
0.10	**153**	**138 - 168**	**201**	**185 - 220**

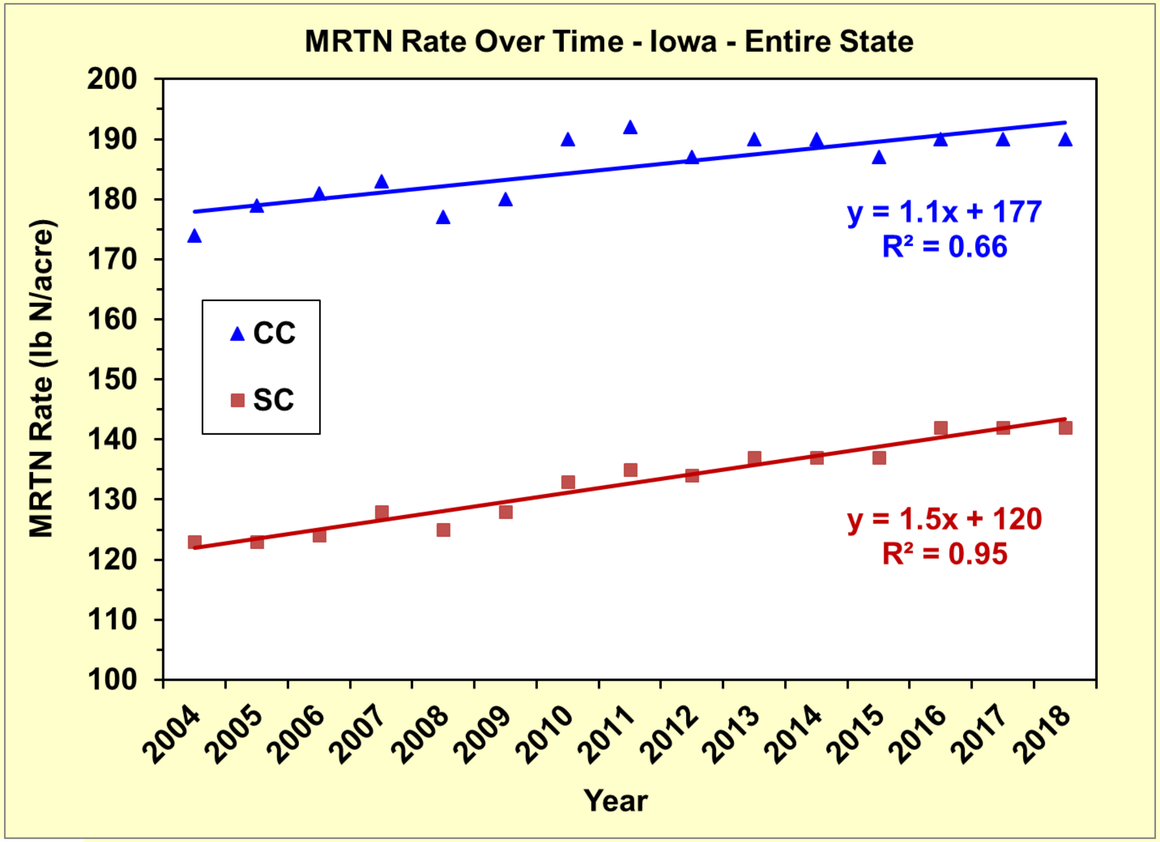
[1] Price per lb N divided by the expected corn price. For example, N at $0.40/lb N and corn at $4.00/bu is a 0.10 price ratio. Corn held at $4.00/bu for all price ratios.

Strengths of MRTN Approach

- Straightforward computation
- Based directly on N rate research
- Can use a variety of N rate trials
- Based on economic profitability
  - Not derived from yield level, but actual yield response which pays for the N applied
- Directly provides CC and SC rate guidelines
  - No reliance on inconsistent “soybean credit”
- Incorporates temporal and spatial variability
- Documents data used for guidelines

Strengths of MRTN Approach

- Easy to add new response trials
  - Keeps rate guidelines current with production practices and climatic conditions



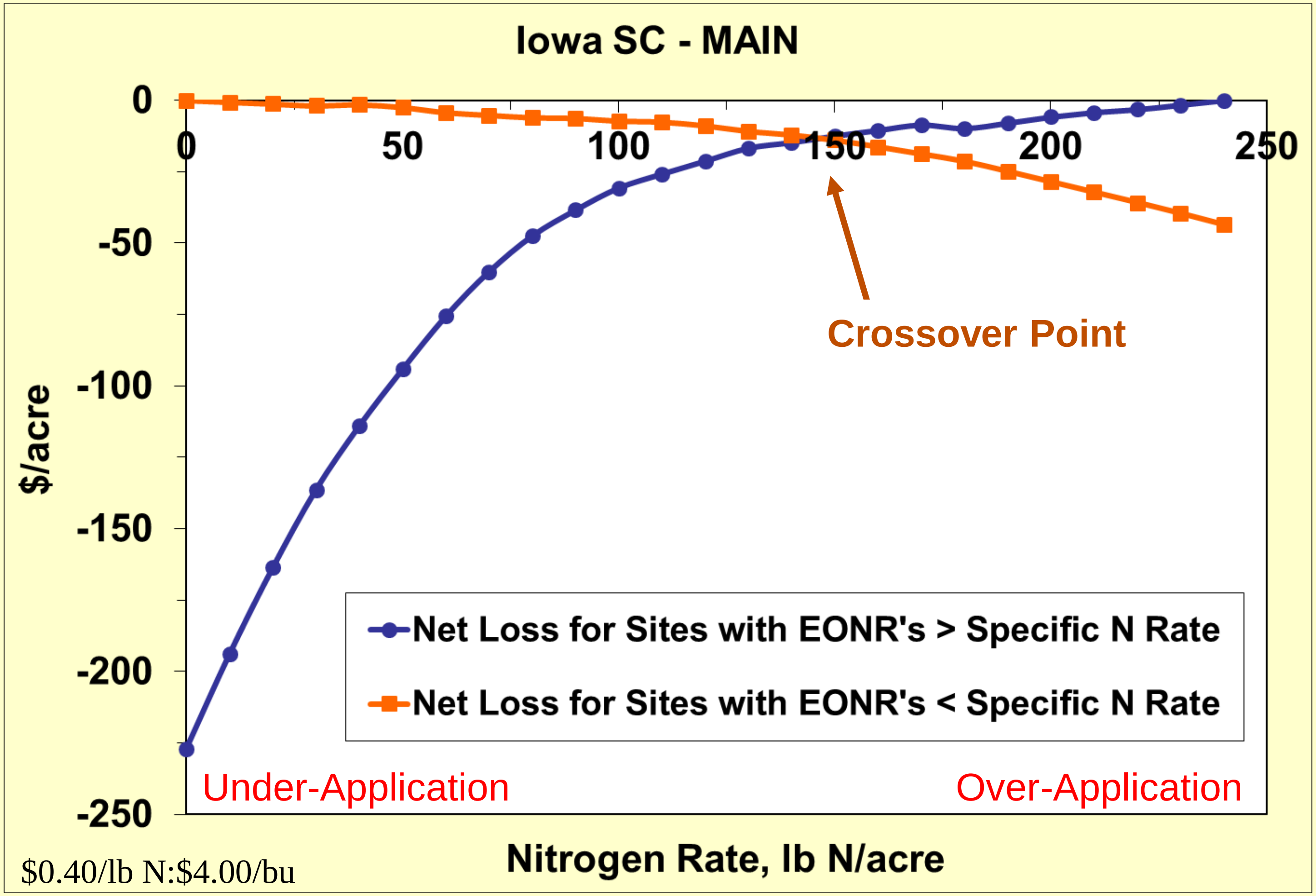
Strengths of MRTN Approach

- Provides opportunity for user input and N rate adjustment
  - Rotation
  - Fertilizer and corn price
  - Profitable N rate range
    - LOW ↔ MRTN ↔ HIGH
      - Farmer experience and attitude toward risk
      - Capitol allocation
      - Water and air quality
      - Local research information
      - Seasonal expectation

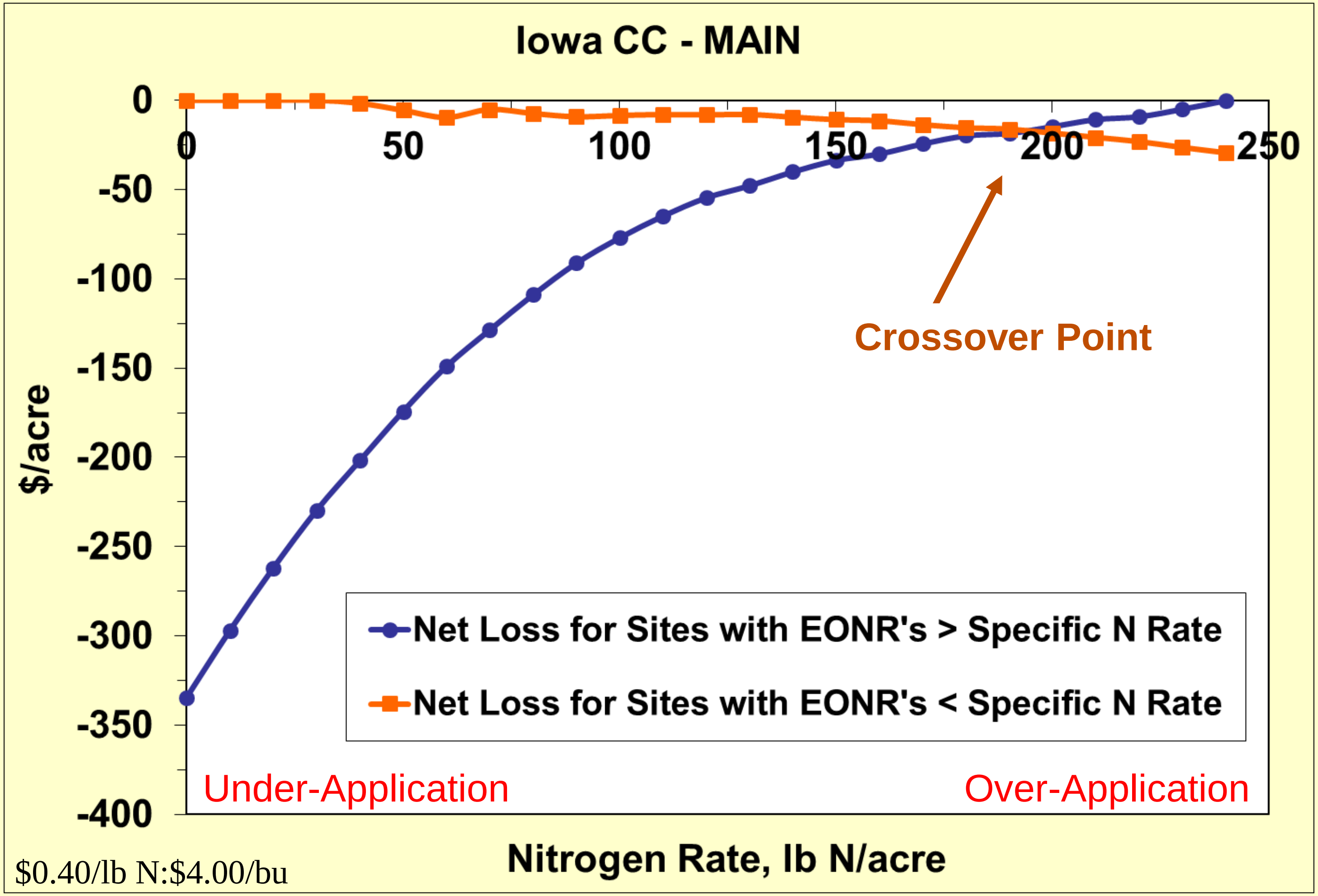
MRTN and N Risk Management

- Although you may want to be 100% certain of N sufficiency, being that certain is not most profitable
  - The risk with lower N rates is decreased profitability due to lost yield
  - The risk with higher N rates is decreased profitability and environmental concerns due to unneeded N
  - Most profitable N rate range helps “protect” these risks

MRTN and N Risk Management



MRTN and N Risk Management



Questions?