Proceedings of the 10th Annual Nutrient Management Conference

Thank you to all of our Supporters!

In-Season Nitrogen Application: Yes, No, or Maybe (and if so, how?)

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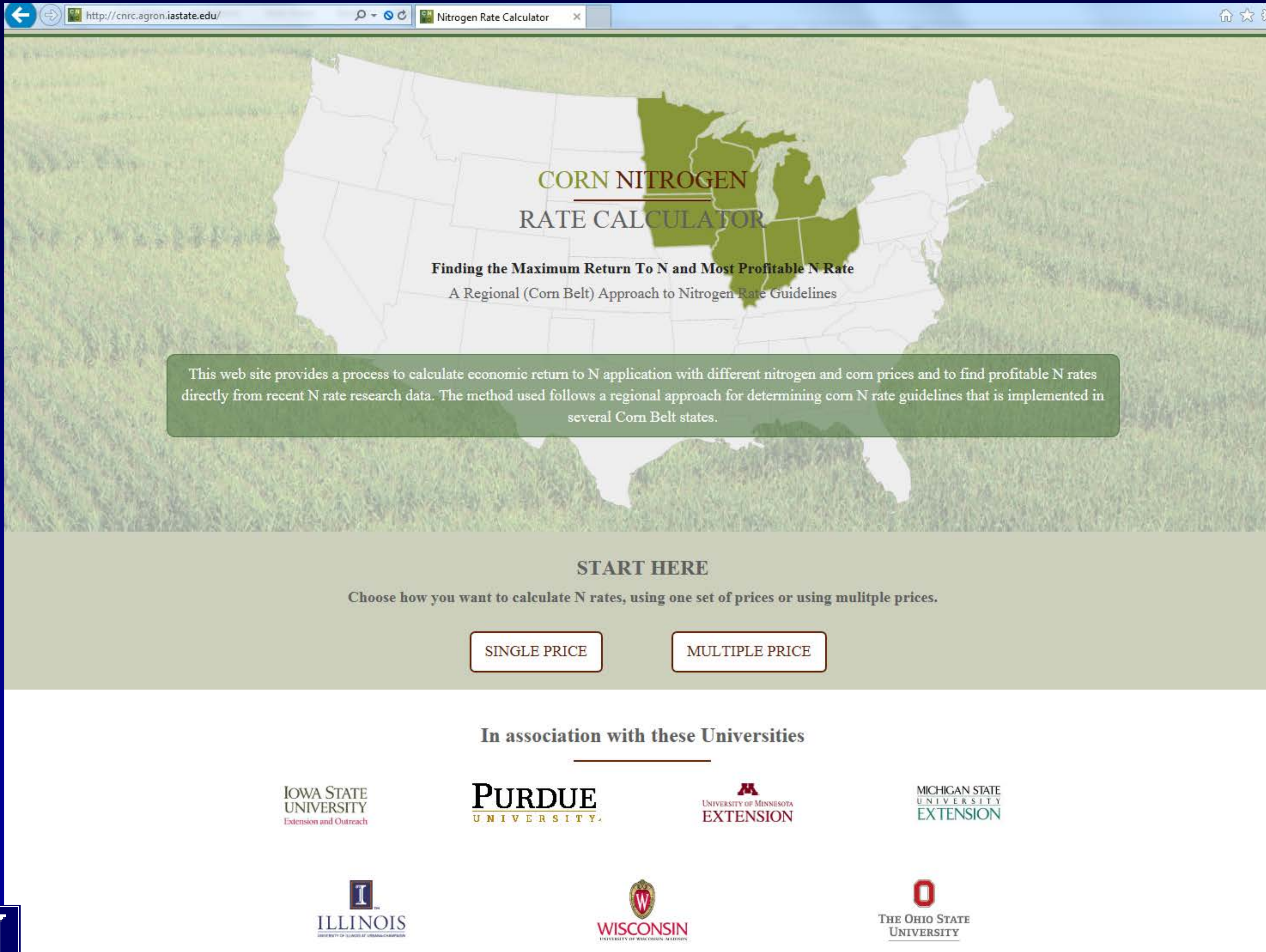
Questions for today:

- Getting the N rate right
  - Do high yields require a lot of N?
  - Is getting a high NUE (low lb N/unit of yield) a worthy goal (and accomplishment?)
- In-season N: forms, application timing, and additives
  - Does splitting N into multiple applications increase profits?
  - Do some forms of N fertilizer work better than others?
  - Do N additives/stabilizers increase profits?
  - Can soil N level accurately tell us when to add more N?
- Variable-rate with canopy sensing?

N response database – the first step

- The N Rate Calculator aggregates N response data (for a state or region, and by previous crop – soy or corn) and uses the aggregate to predict Maximum Return To N rate (MRTN) N rates for the that region
- It includes user-input prices for corn and N in order to adjust N rate based on the price ratio
- The database should be large enough so that output changes relatively slowly as new data are added

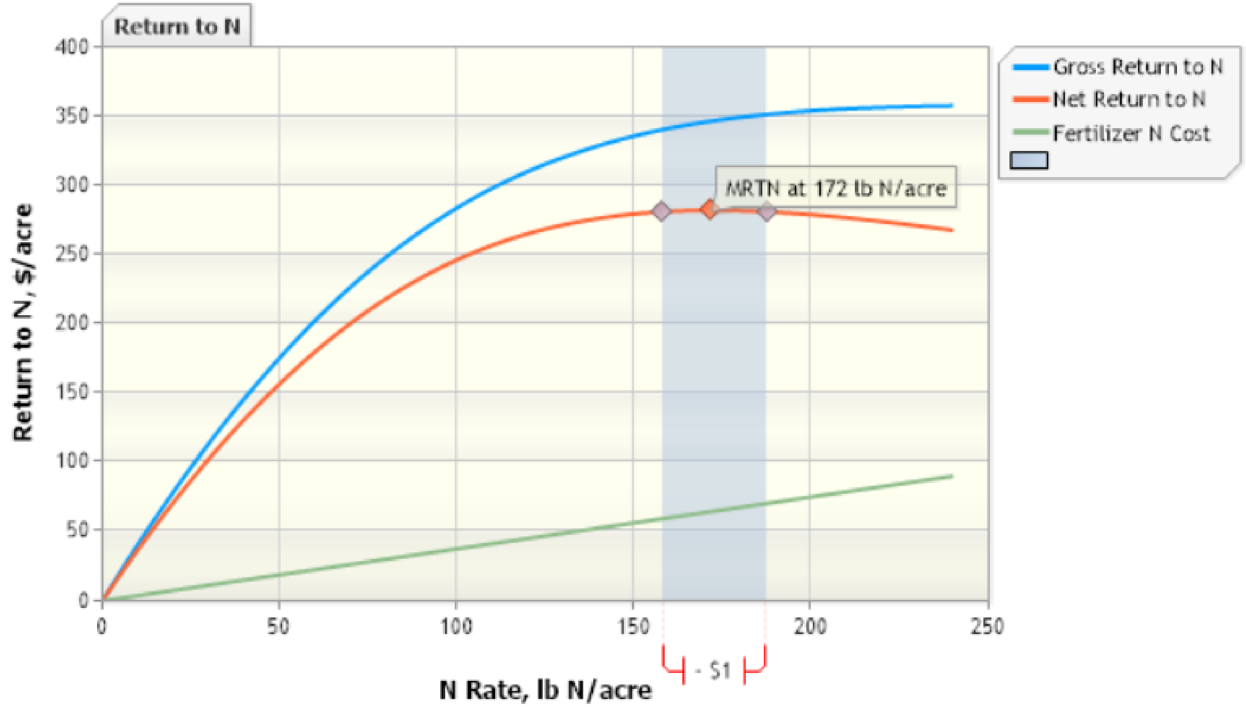

http://cnrc.agron.iastate.edu/
Nitrogen Rate Calculator
CORN NITROGEN
RATE CALCULATOR
Finding the Maximum Return To N and Most Profitable N Rate
A Regional (Corn Belt) Approach to Nitrogen Rate Guidelines
This web site provides a process to calculate economic return to N application with different nitrogen and corn prices and to find profitable N rates directly from recent N rate research data. The method used follows a regional approach for determining corn N rate guidelines that is implemented in several Corn Belt states.
START HERE
Choose how you want to calculate N rates, using one set of prices or using mulitple prices.
SINGLE PRICE
MULTIPLE PRICE
In association with these Universities
IOWA STATE UNIVERSITY
Extension and Outreach
PURDUE UNIVERSITY
University of Minnesota
EXTENSION
MICHIGAN STATE UNIVERSITY
EXTENSION
ILLINOIS
WISCONSIN
THE OHIO STATE UNIVERSITY

Central Illinois

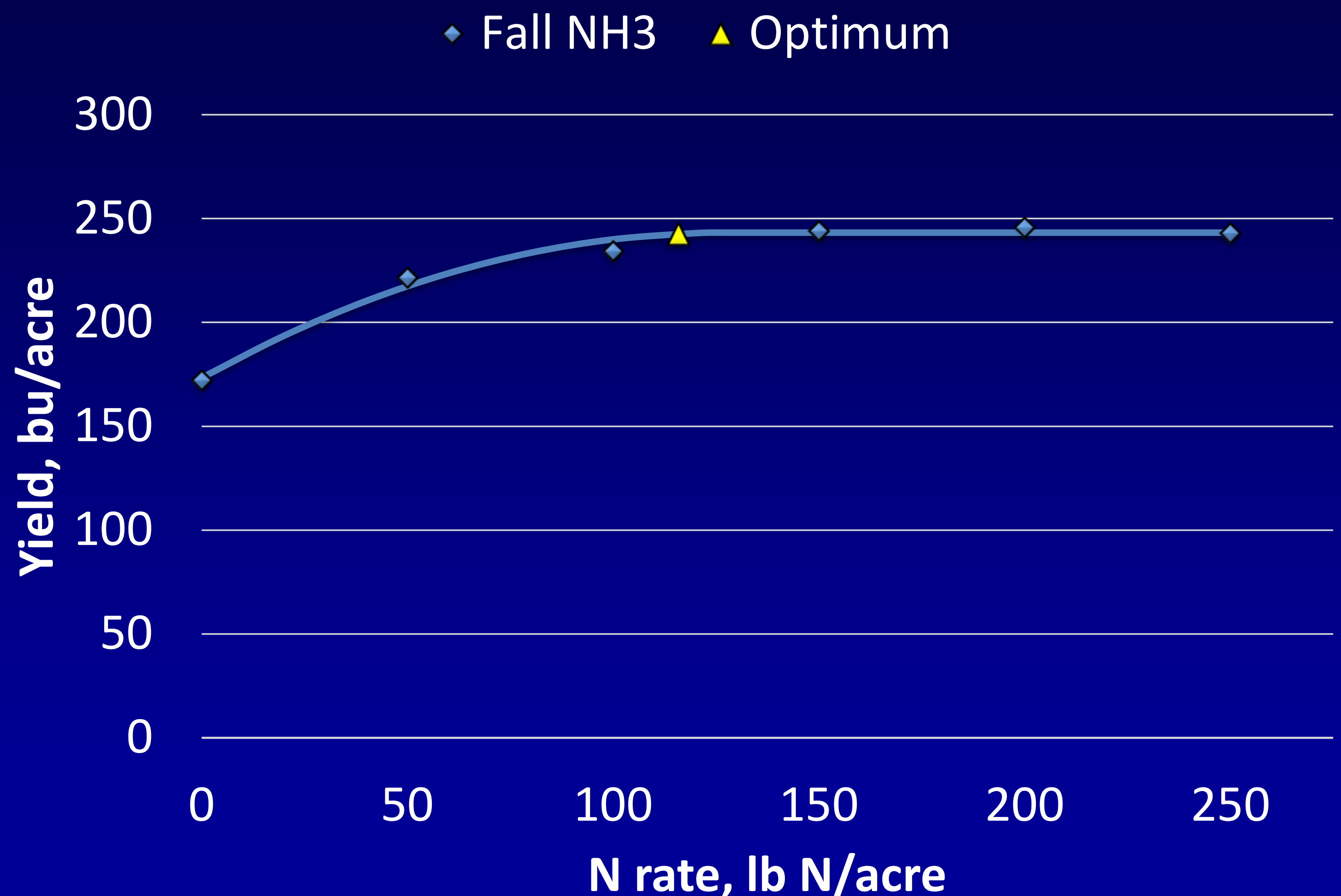
Corn following soybean 245 sites

State: Illinois
Region: Central
Number of sites: 245
Rotation: Corn Following Soybean

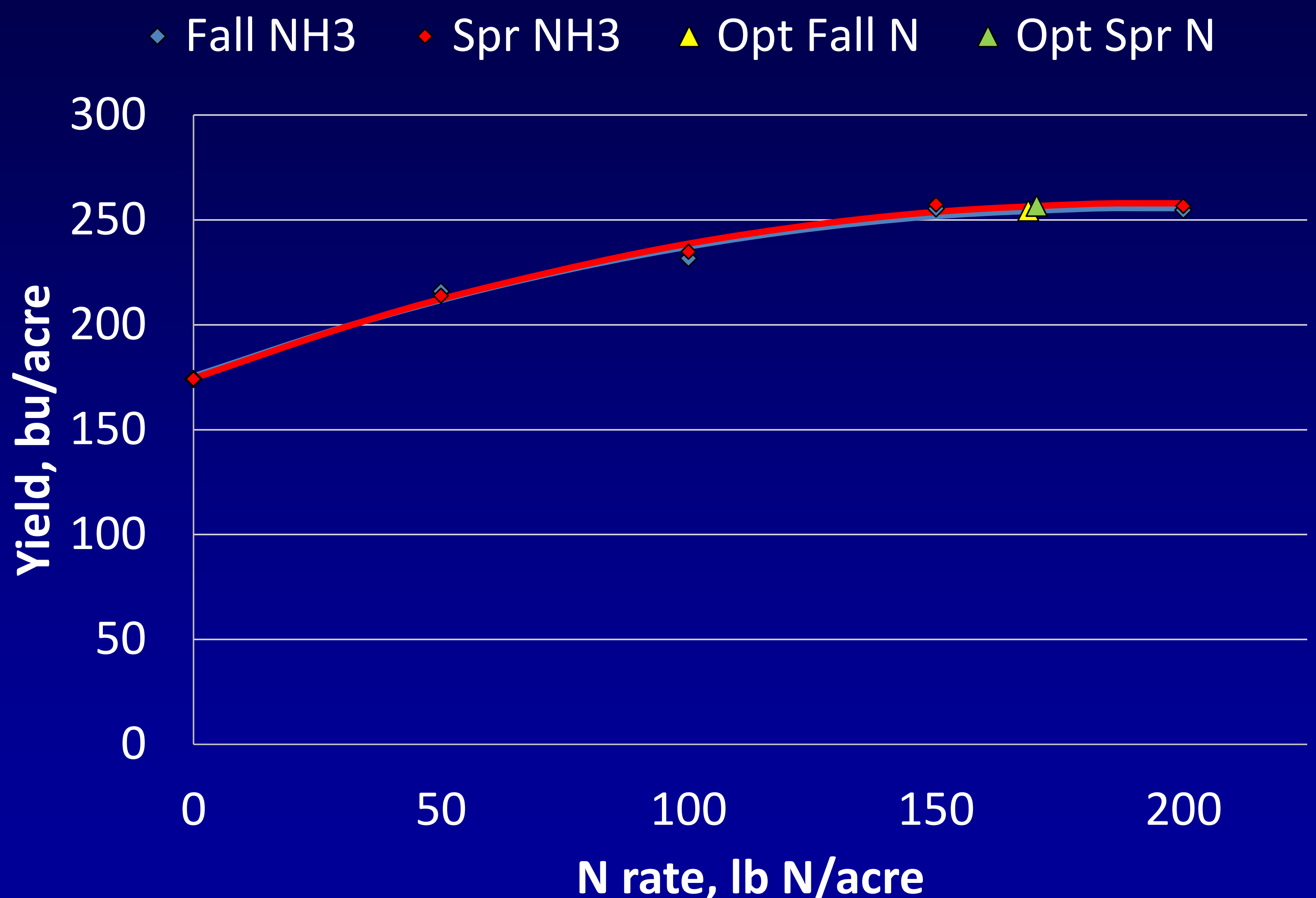
Nitrogen Price ($/lb):	0.38
Corn Price ($/bu):	3.75
Price Ratio:	0.10
MRTN Rate (lb N/acre):	172
Profitable N Rate Range (lb N/acre):	157 - 187
Net Return to N at MRTN Rate ($/acre):	$282.00
Percent of Maximum Yield at MRTN Rate:	98%
Anhydrous Ammonia (82% N) at MRTN Rate (lb product/acre):	209
Anhydrous Ammonia (82% N) Cost at MRTN Rate ($/acre):	$64.50



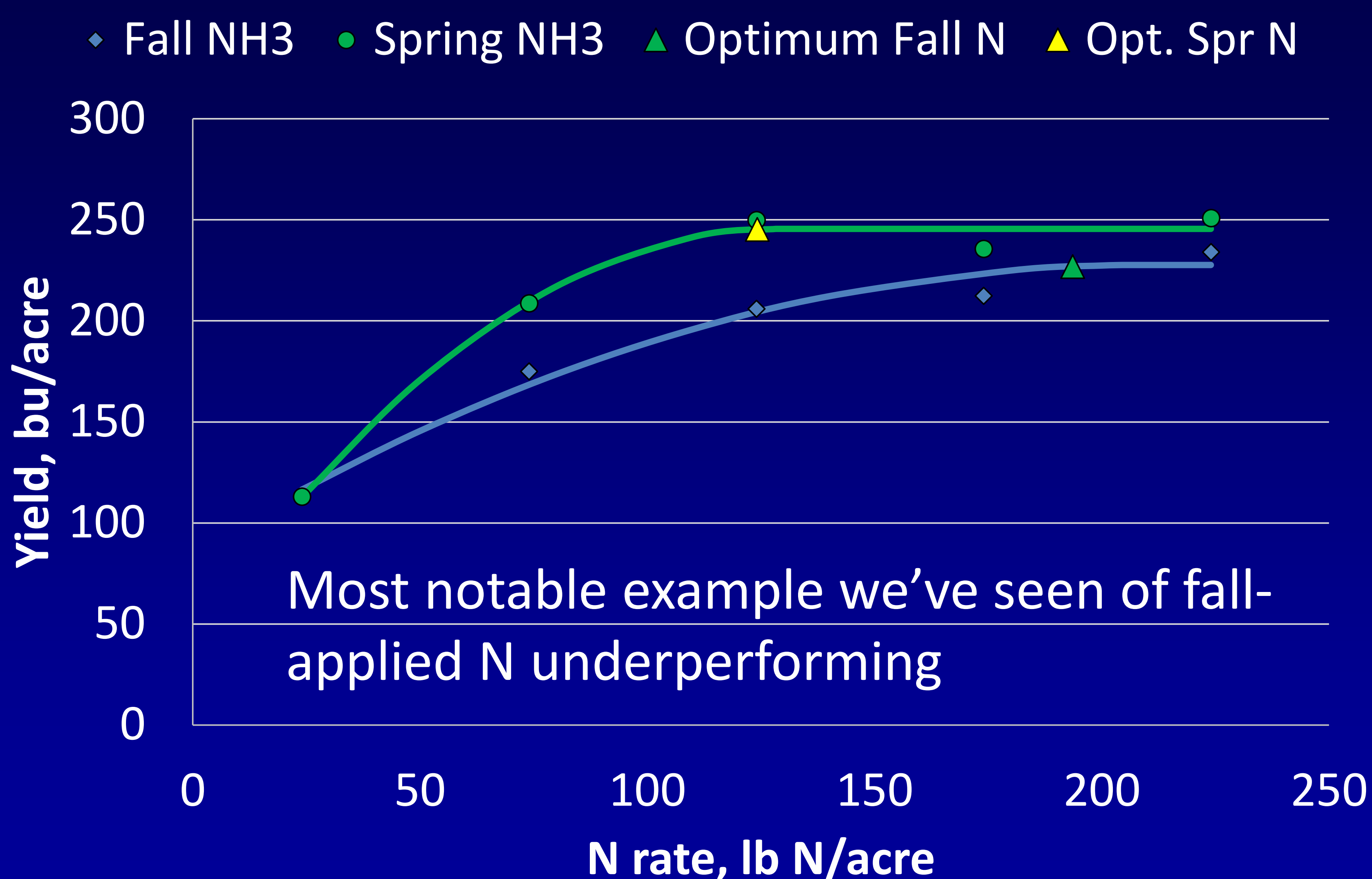
Christian County Soy-Corn 2017



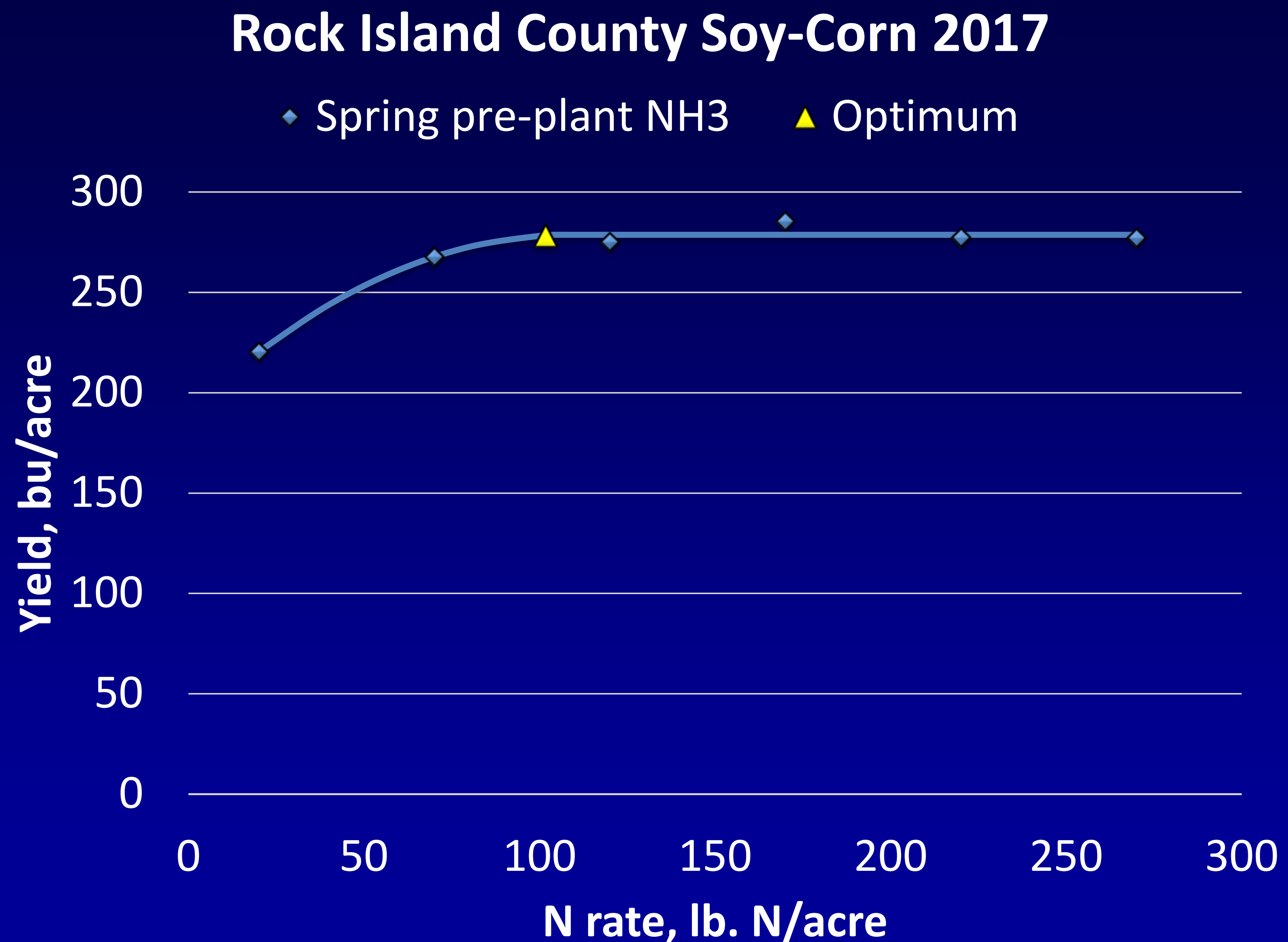
Sangamon Co. Soy-Corn 2017



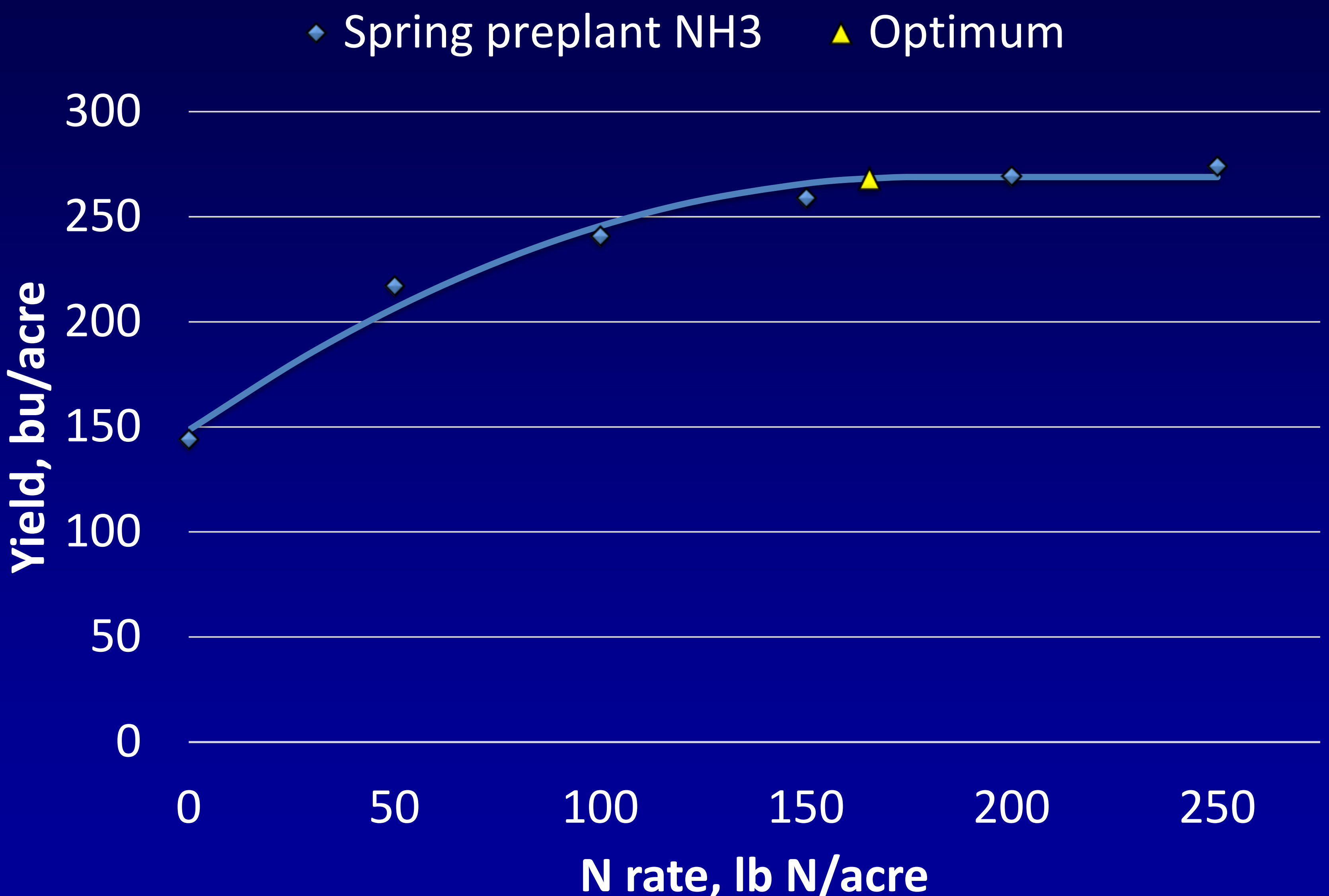
Pike County Soy-Corn 2017



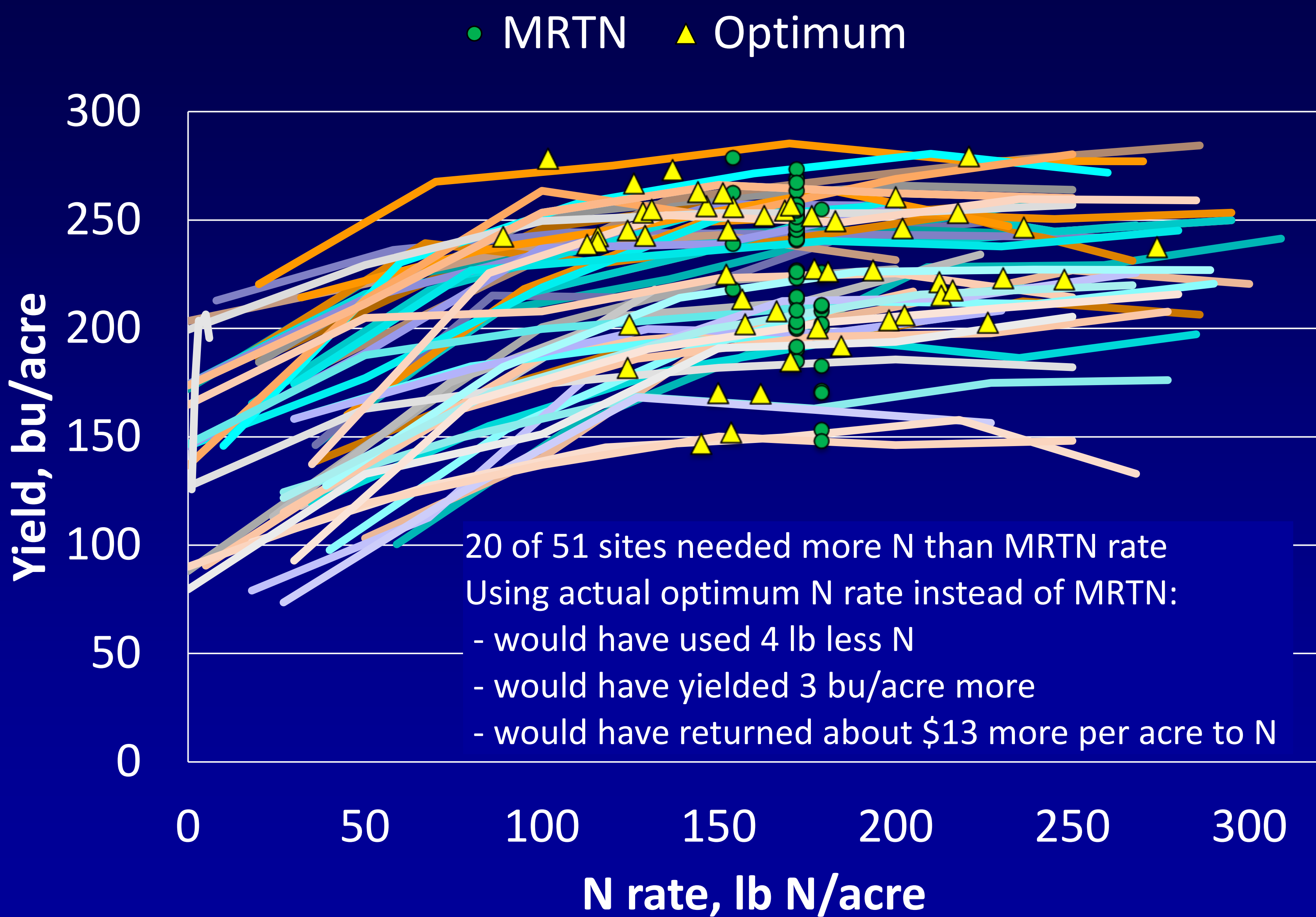
Most notable example we've seen of fall-applied N underperforming


Rock Island County Soy-Corn 2017
Spring pre-plant NH3
Optimum
Yield, bu/acre
300
250
200
150
100
50
0
0
50
100
150
200
250
300
N rate, lb. N/acre

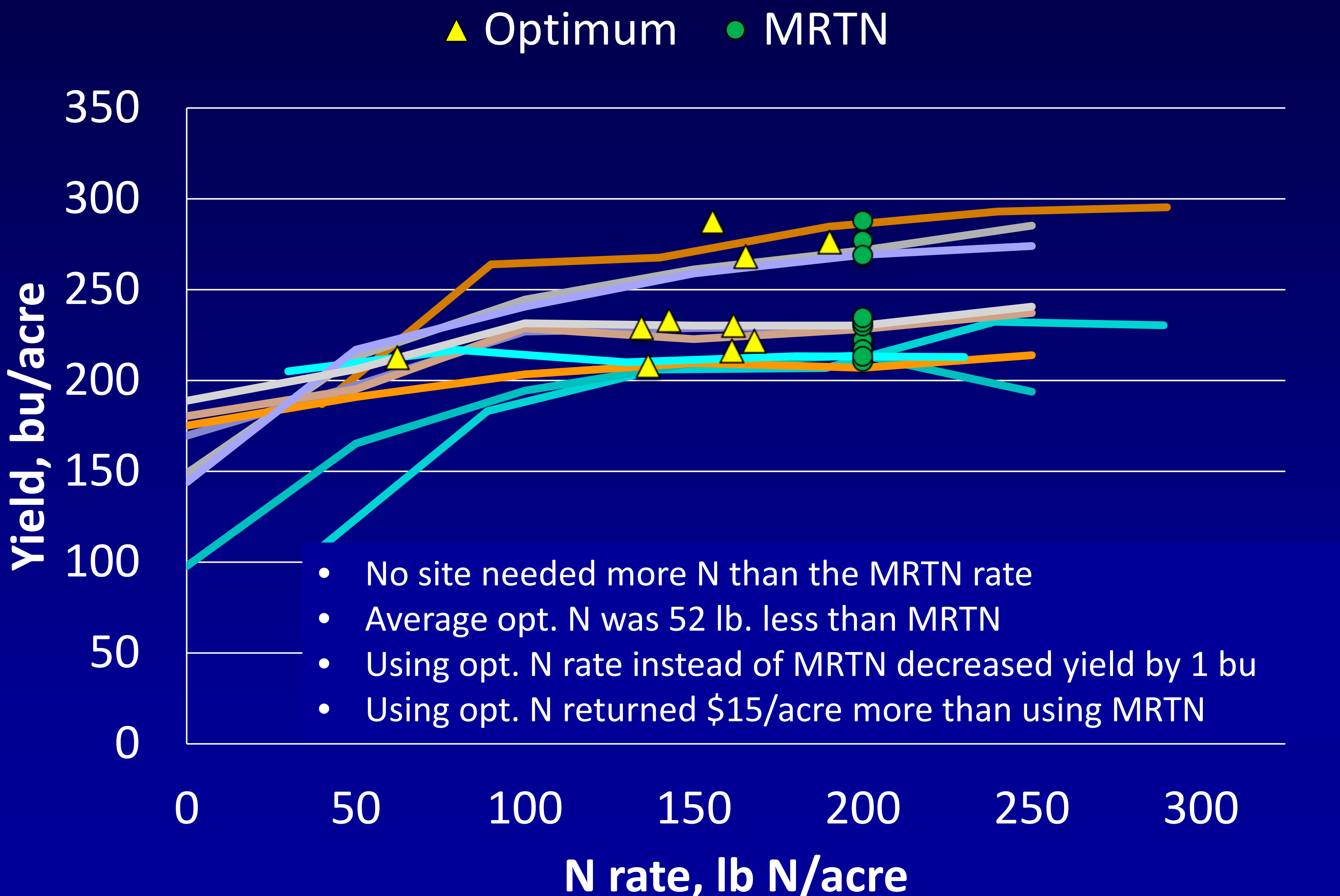
Stephenson County Corn-Corn 2017



51 on-farm N trials, soy-corn, 2017



10 on-farm N trials, corn-corn, 2017



- No site needed more N than the MRTN rate
- Average opt. N was 52 lb. less than MRTN
- Using opt. N rate instead of MRTN decreased yield by 1 bu
- Using opt. N returned $15/acre more than using MRTN

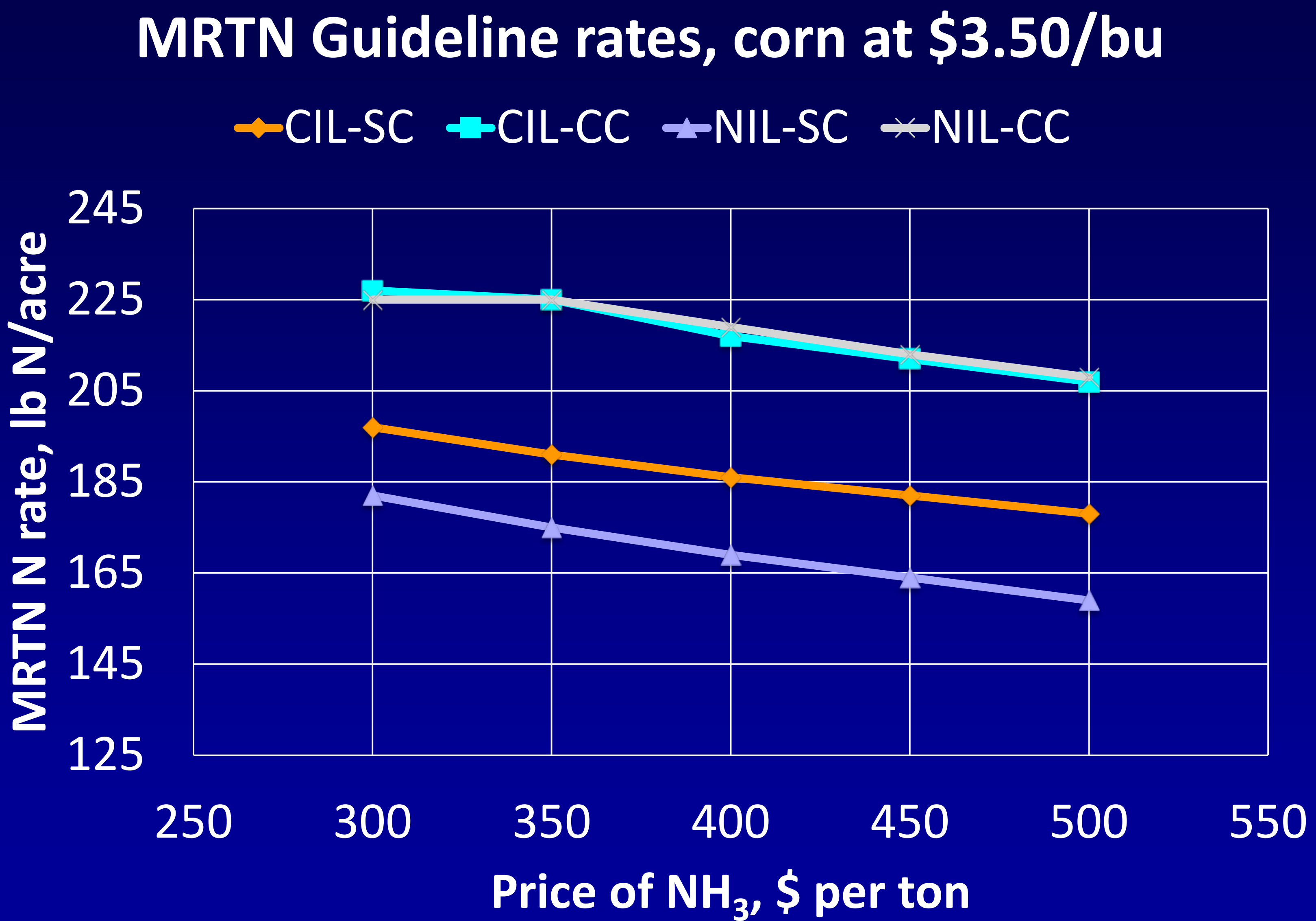
Current MRTN N rate guidelines from the N rate calculator

- Based on N price = $0.35/lb and corn price = $3.50/bu

IL region	Soy-corn	Corn-corn
North	154 (81)	200 (83)
Central	172 (245)	200 (152)
LSW	166 (22)	202 (10)
South	179 (116)	189 (48)

Data used to generate these rates will be updated by March 2018
Because N responses were not very unusual, changes won't be large

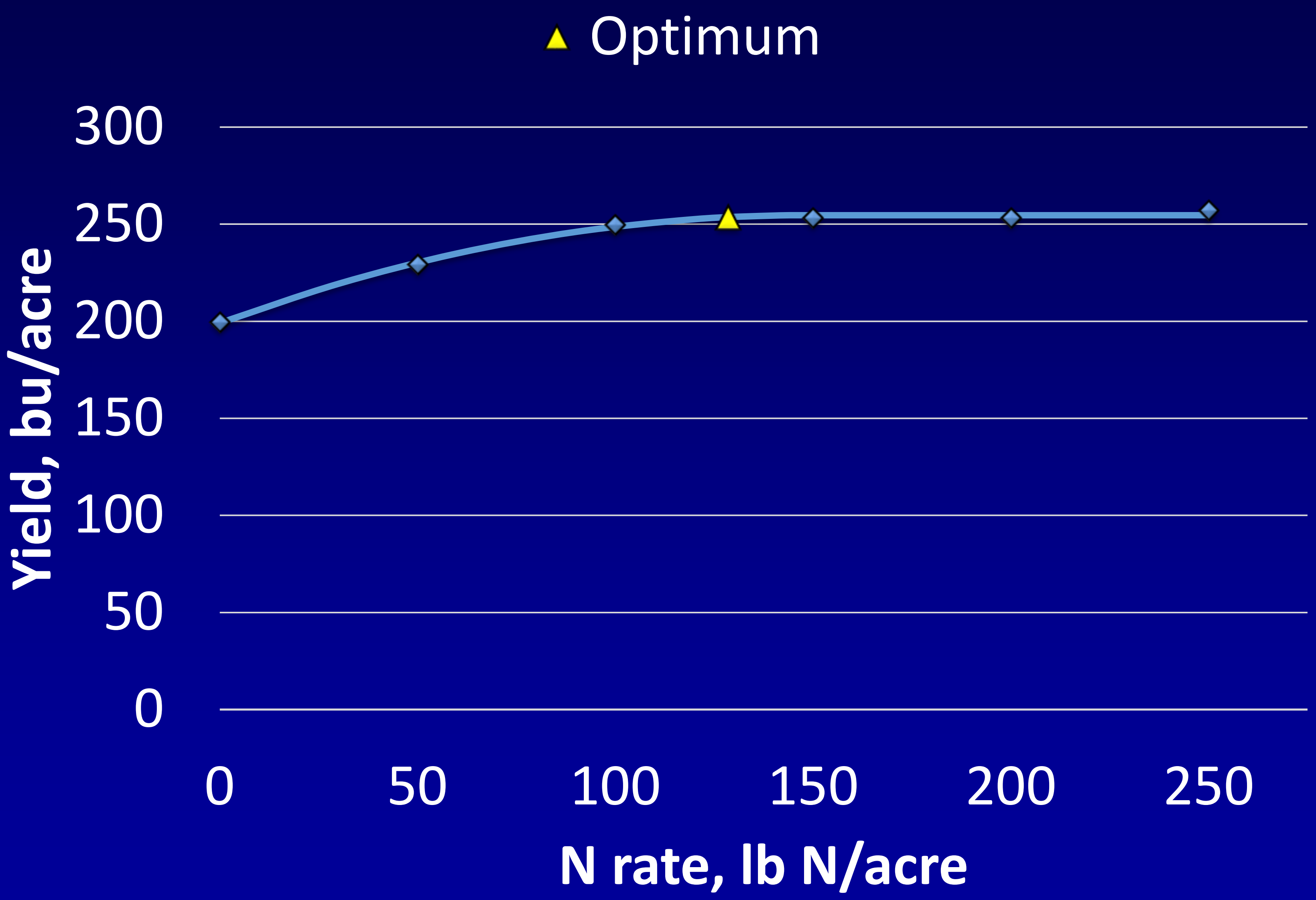
Changing N prices



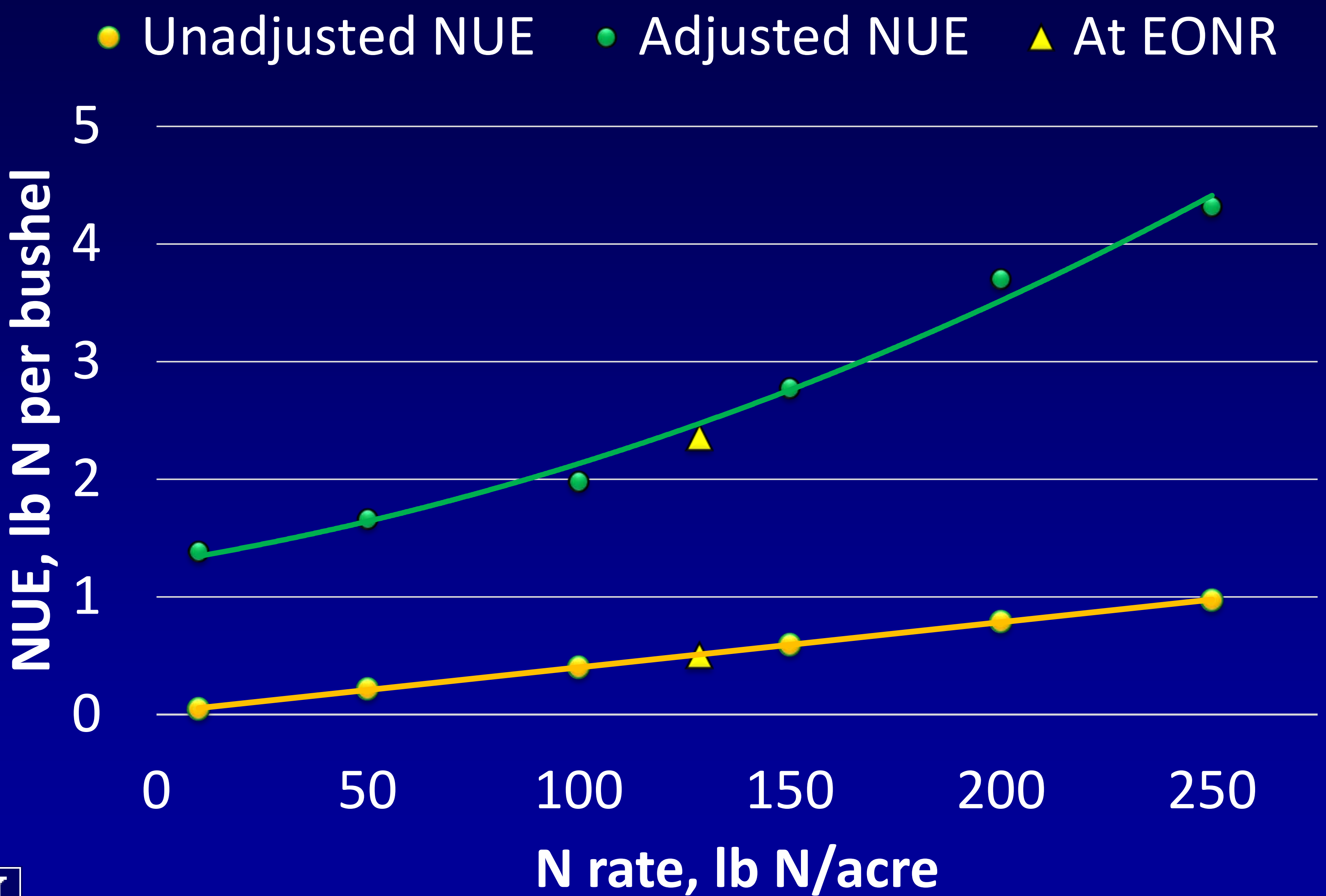
Thinking about NUE

- A "quick and easy" (and popular) way to calculate NUE is to divide fertilizer N rate by yield to come up with lb. N "needed" per bushel of yield – we'll call that "unadjusted" NUE: having this be less than 1 is an informal goal
- A useful modification is to divide the EONR by the yield *increase* from using N (ΔY, or yield at EONR minus yield without N) – we'll call this the "adjusted" NUE, which includes only the response to fertilizer N (and requires a trial, or at least a zero-N yield
- By this definition of NUE, **lower values (lb N per bushel) mean higher efficiency**

Sample N response curve, soy-corn



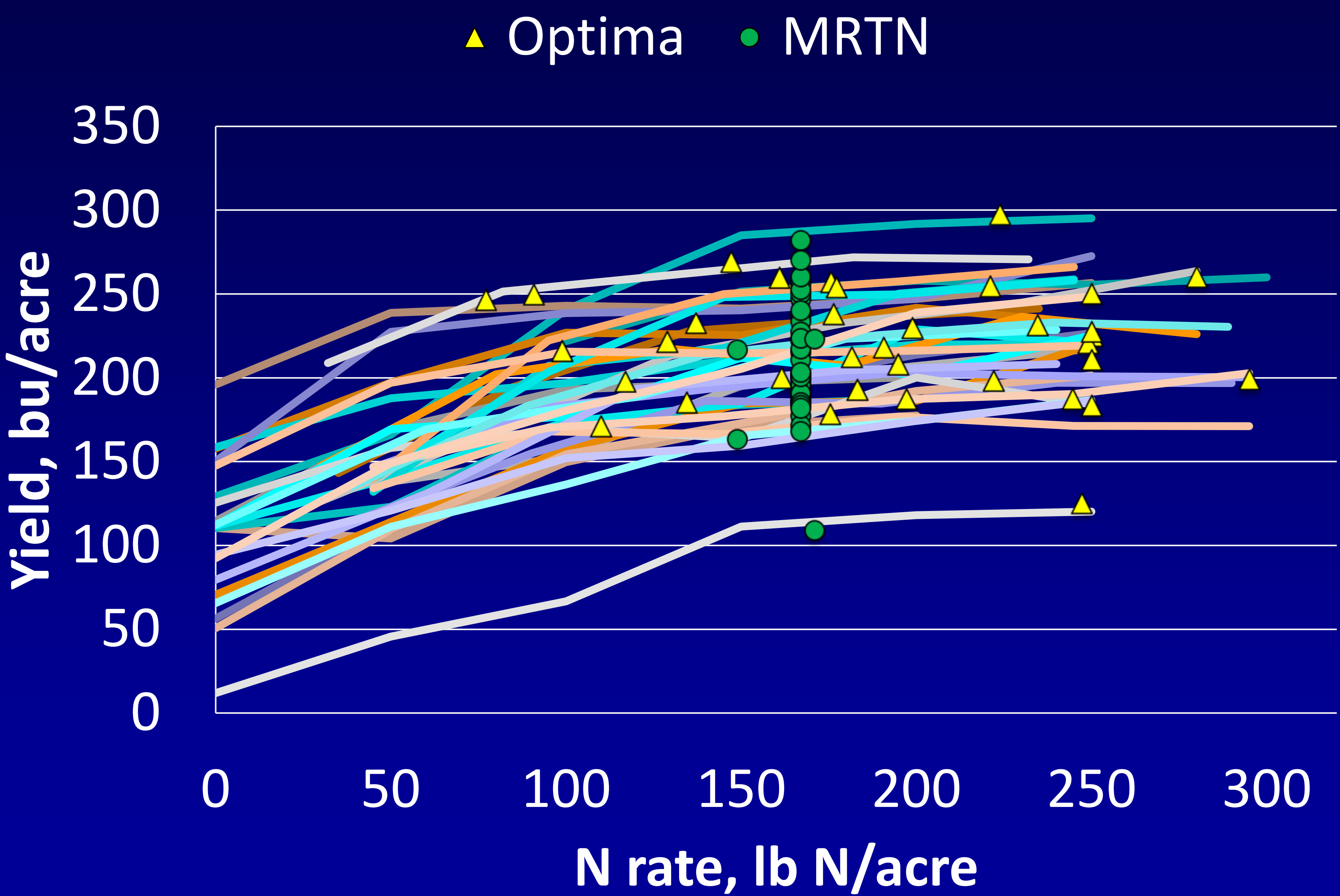
NUE from sample response



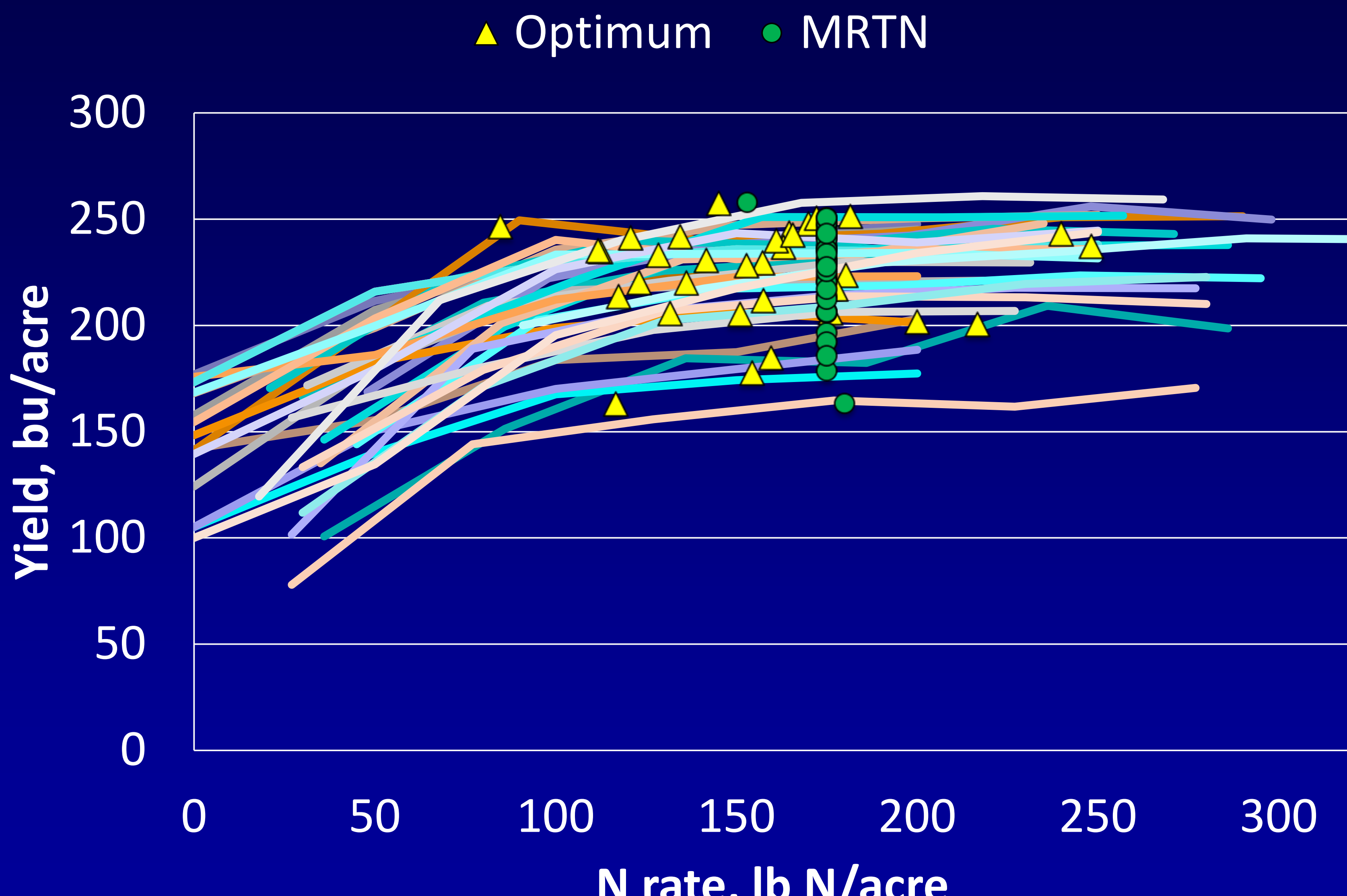
"Improved" N efficiency?

- Efficiency as measured by how many lb. N is required per bushel of yield does **not** identify what the "best" N rate is:
  - The lower the N rate, the higher the efficiency
  - Efficiency is **not** maximized at the "optimum" N rate, which is the N rate that gives the maximum $ return to N
  - For an N rate used in a given field, high yields make for high efficiency, but we can't know the "best" efficiency unless we know how much fertilizer N was needed; only a trial can tell us that

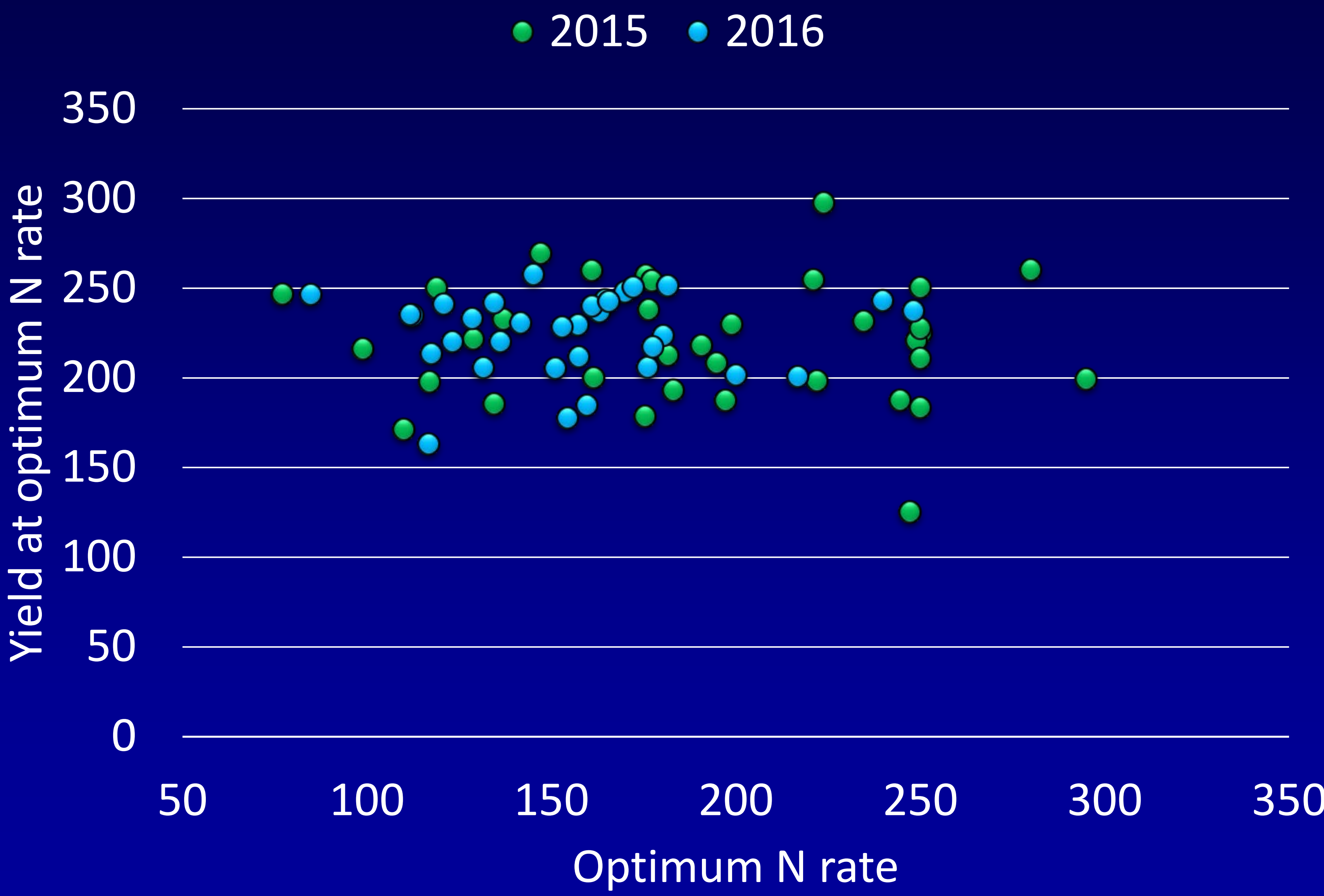
35 on-farm trials Soy-Corn 2015



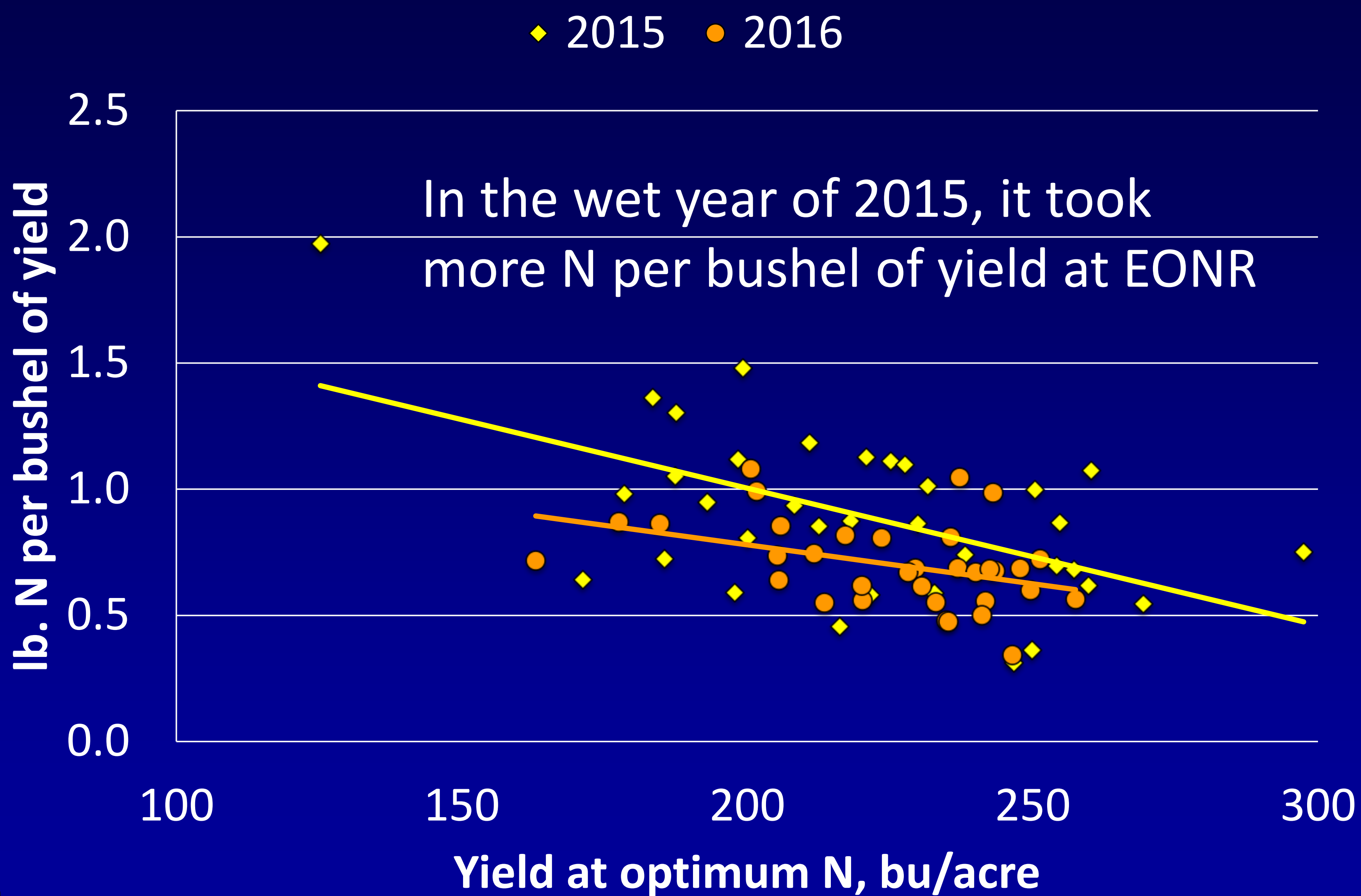
33 on-farm N trials Soy-Corn 2016



On-farm trials, soy-corn, 2015-2016

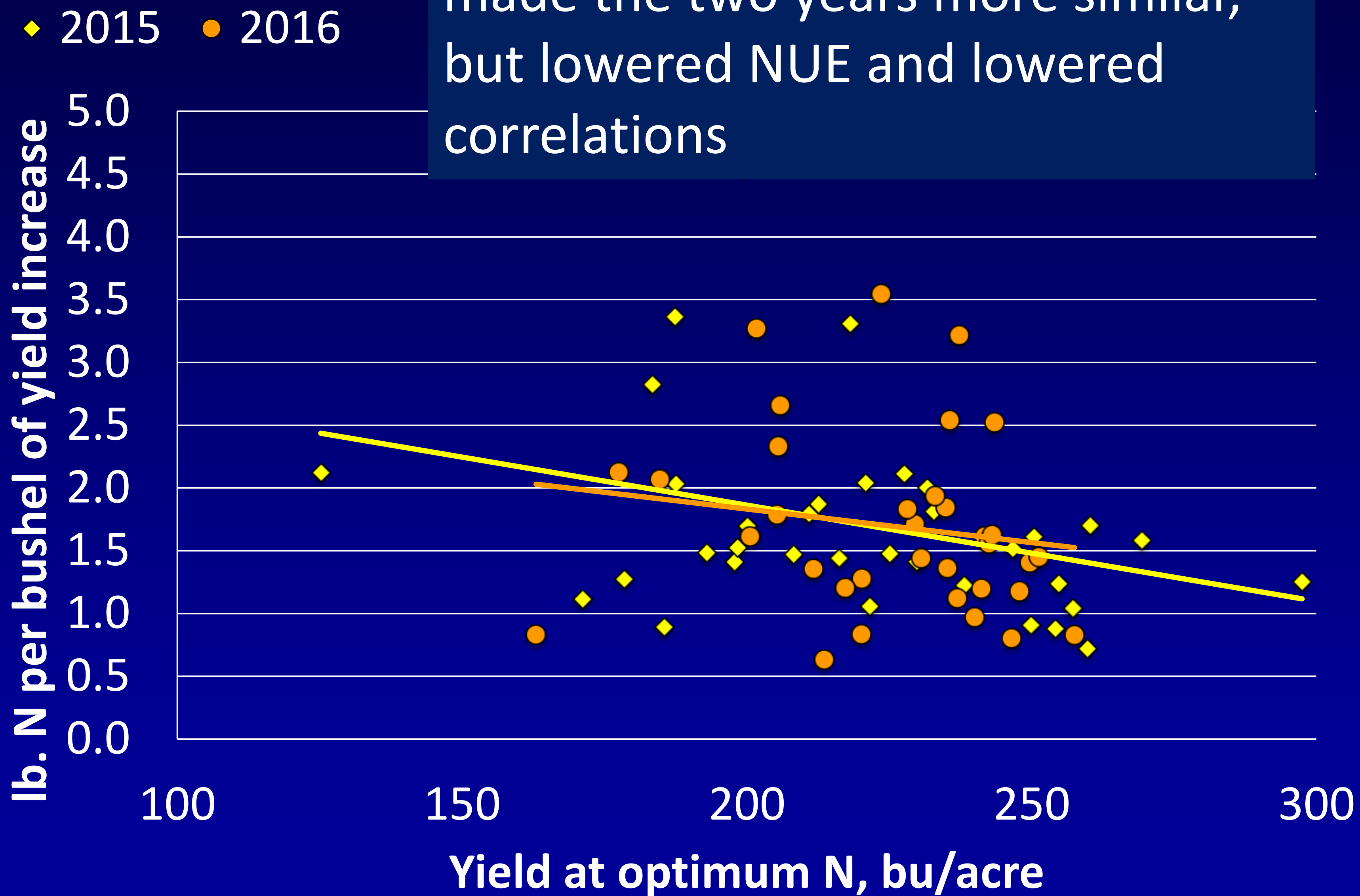


Unadjusted NUE

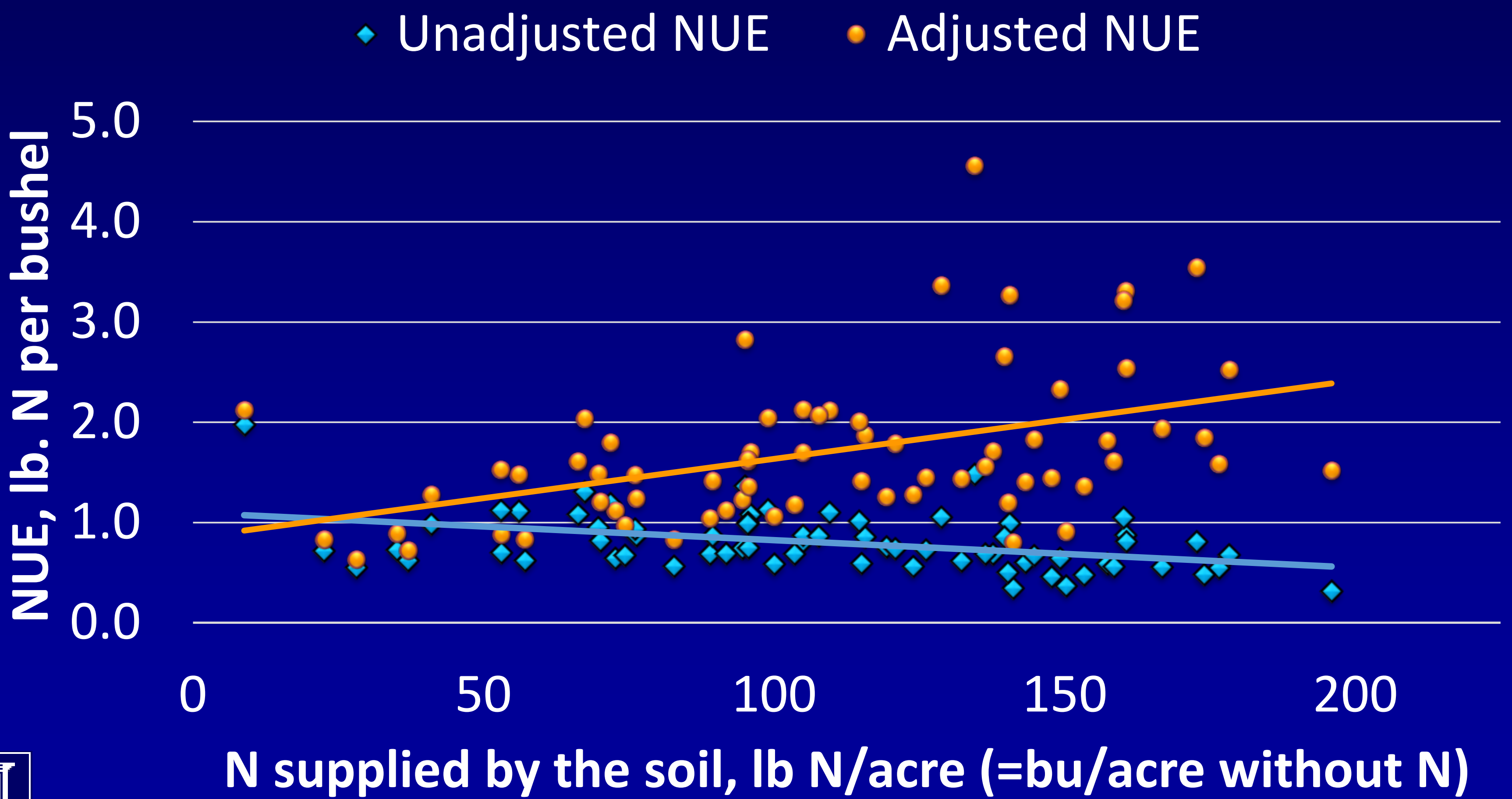


Adjusted NUE

Adjusting (for yield without N) made the two years more similar, but lowered NUE and lowered correlations



More soil-supplied N increases unadjusted NUE because fertilizer and soil N are combined; more N from soil lowers adjusted NUE lower by separating the two sources of N (fertilizer and soil)



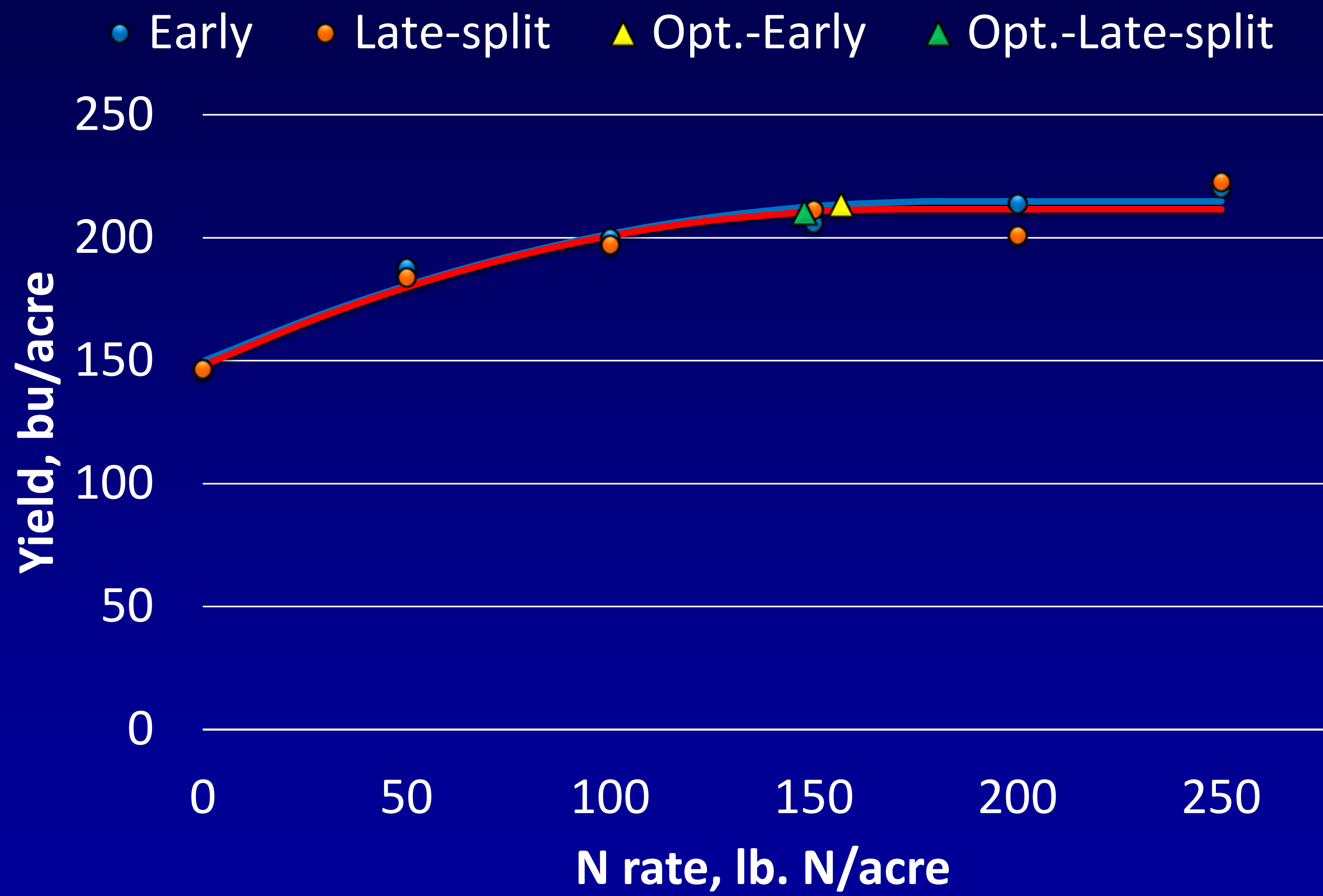
Soil N

- The amount of N mineralized from soil organic matter is highly variable, but can easily make up half the N taken up by the corn crop
- Potential soil N supply is generally considered to be about 2% of SON per cropping season
- Soil N has a large effect on (unadjusted) NUE – the plant doesn't distinguish between fertilizer and soil-supplied N
- Soil-supplied N varies widely among fields and years, but attempts to predict amounts of N from SOM (in order to adjust fertilizer rates) have not been very successful

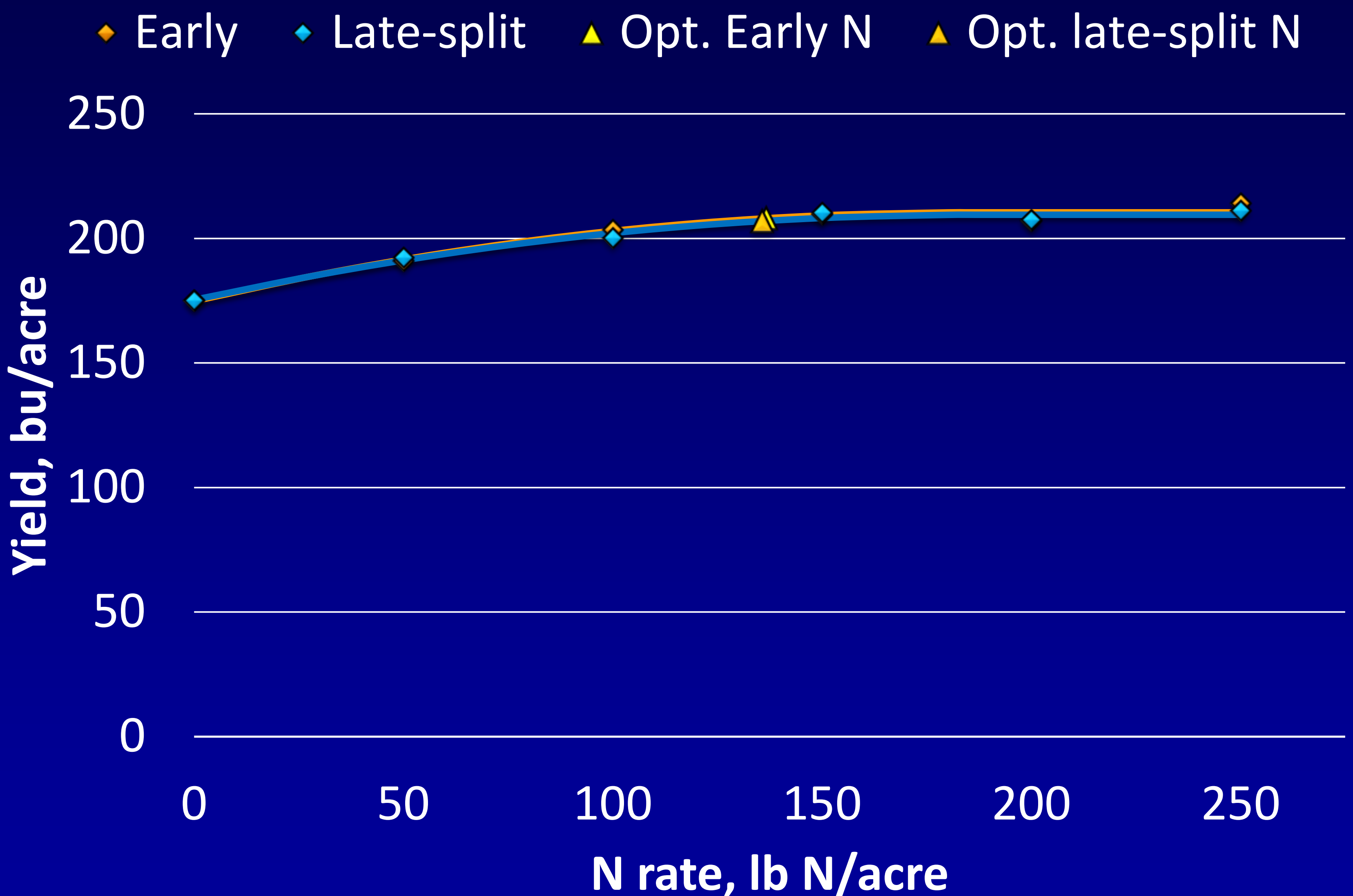
Y-Drop Tubes

-the means to apply N anytime during vegetative growth

Urbana Soy-Corn 2017



Urbana Corn-Corn, 2017



Soy-corn

Site	Optimum N rate Early	Optimum N rate Late-split	Yield at opt. N Early	Yield at opt. N Late-split	RTN advantage to late-split N
	lb/ac		bu/acre		$/acre
DK 16	191	163	236	231	-$6.85
MN 16	112	131	235	238	$5.68
UR 16	129	124	233	234	$6.24
OR 16	112	138	235	238	-$0.04
DK 17	151	208	262	265	-$11.93
MN 17	128	153	254	253	-$9.75
UR 17	157	148	214	210	-$7.71
OR 17	152	139	225	222	-$6.10
NEO 17	145	165	147	151	$9.13
Avg.	142	152	227	227	-$2.37

Corn-Corn

Site	Optimum N rate		Yield at opt. N		RTN advantage
	Early	Late-split	Early	Late-split	to late-split N
	lb/ac		bu/acre		$/acre
MN 16	151	128	231	233	$15.13
UR 16	166	175	235	235	-$2.91
OR 16	139	152	228	227	-$7.20
MN 17	162	147	230	223	-$21.22
UR 17	137	136	208	207	-$3.71
OR 17	161	159	216	215	-$3.98
Avg.	153	149	225	223	-$3.98

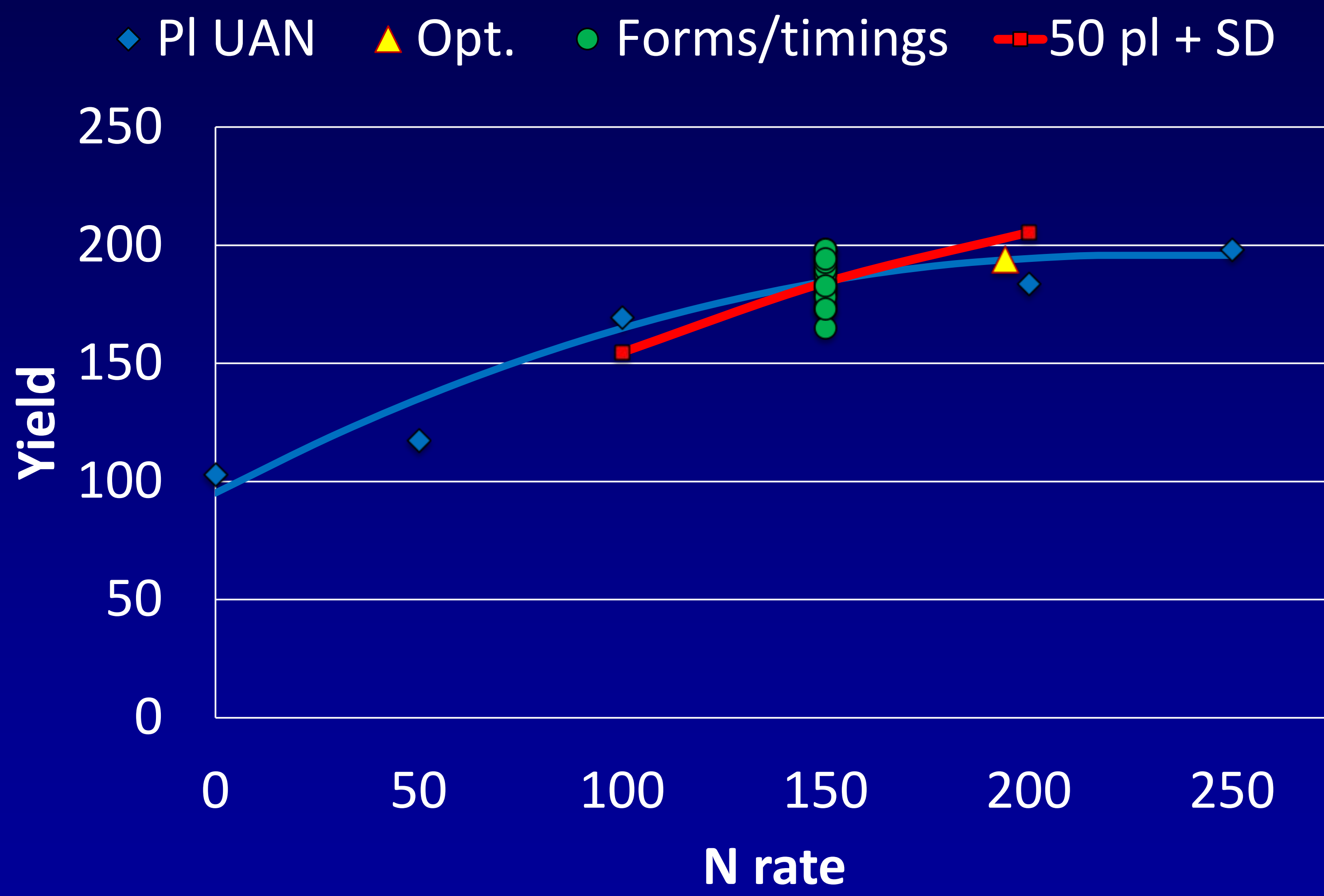
Does late-split N make sense?

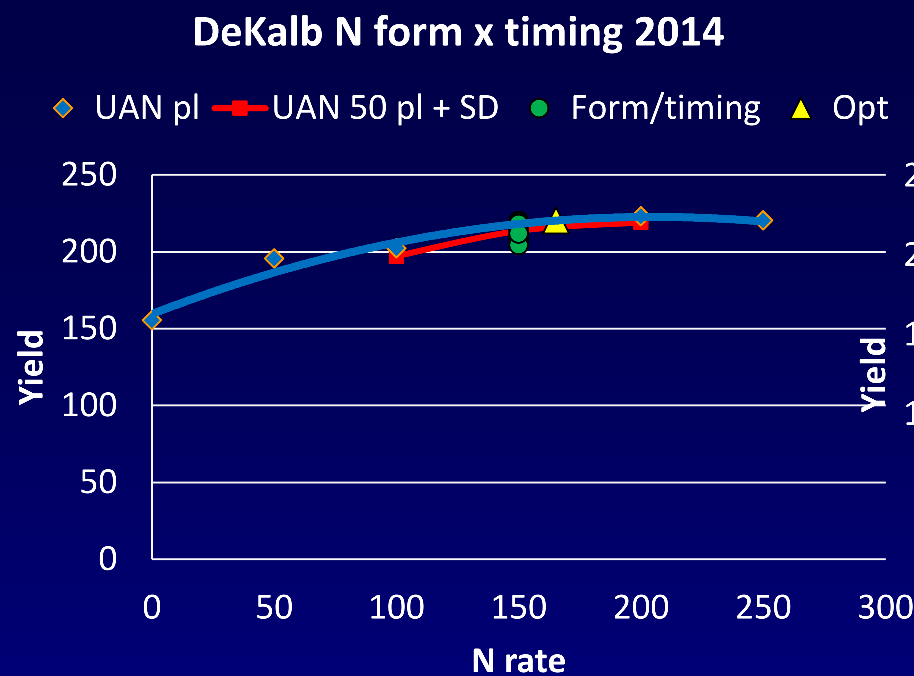
- When planting-time N rates are low, applying 50 lb N at tassel boosts yield, BUT: to no higher than if the (same rate of) N is applied early
- $ return to N is not increased by a late-split approach, and added cost means a loss
- Actual optimum N rates were almost always lower than MRTN rates – at the MRTN rate, yield differences between early and late-split would have disappeared entirely
- With such consistent results so far, we will replace the late-split with a normal sidedress-time split in 2018

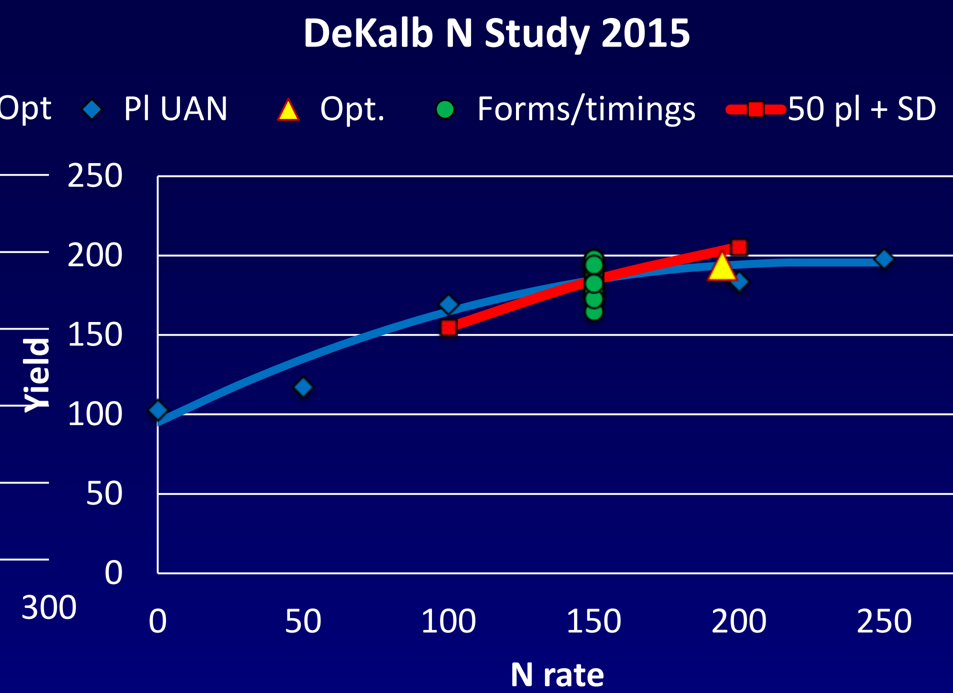
Form and timing: small-plot trials

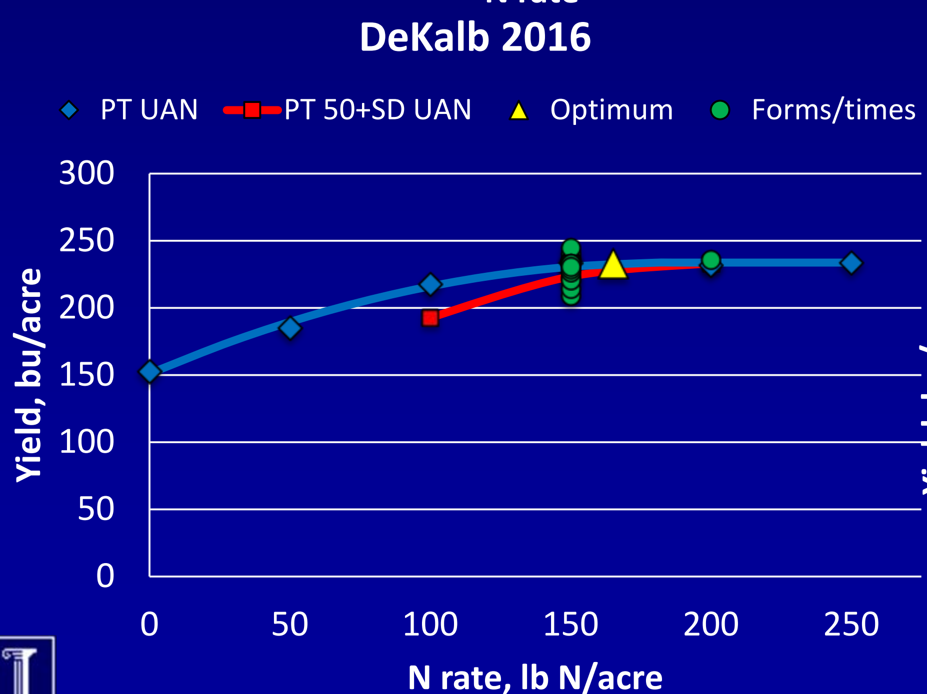
- At 5 research sites, corn following soybean
- Base rates of injected UAN: 0, 50, 100, 150, 200, 250
- Set of rates with 50 lb N as broadcast UAN at planting and 50, 100, 150 lb N as injected UAN at sidedress
- And ~20 different ways to apply 150 lb N

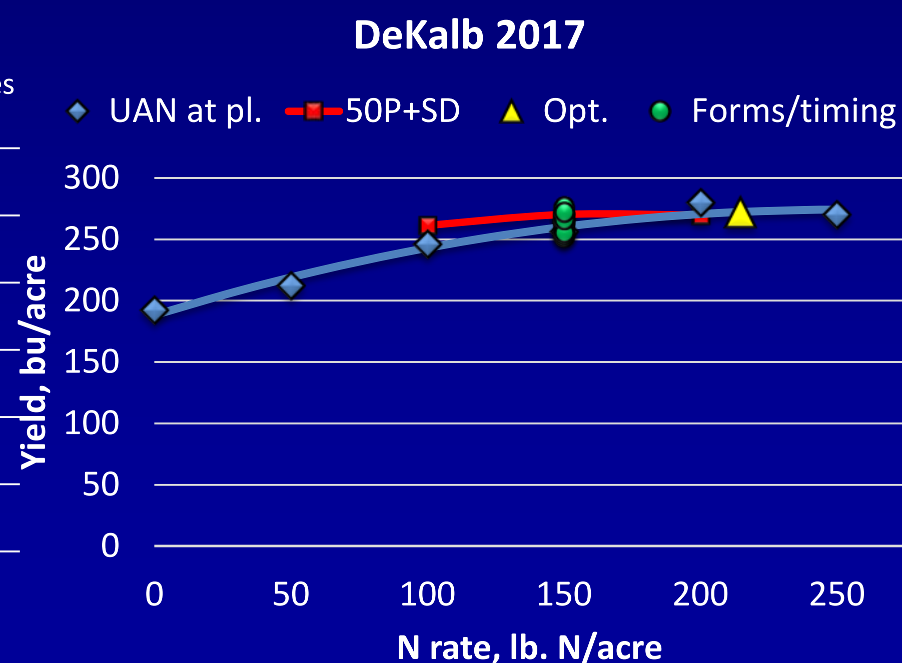
DeKalb N Study 2015

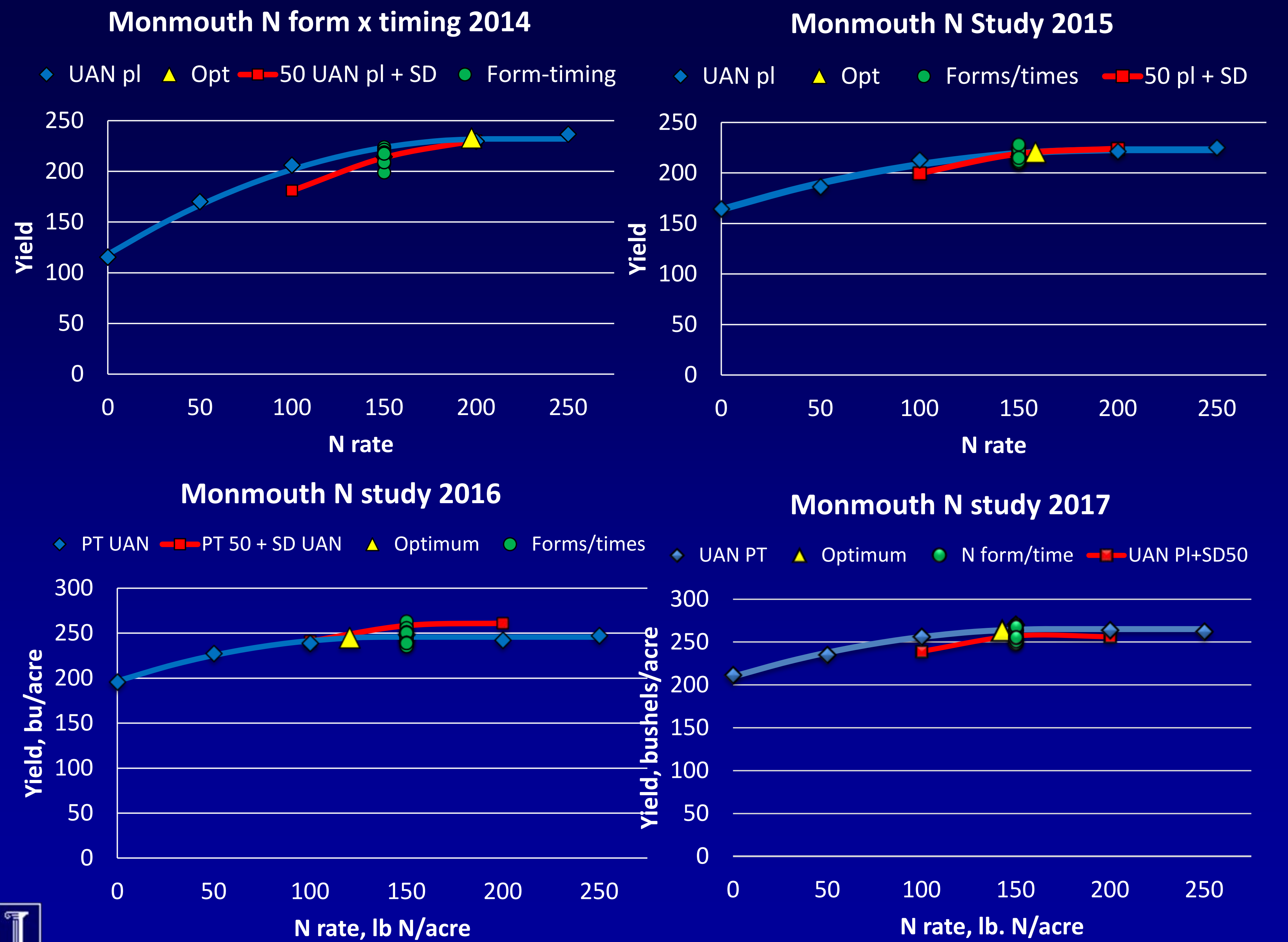



DeKalb N form x timing 2014
UAN pl
UAN 50 pl + SD
Form/timing
Opt
Yield
N rate
0
50
100
150
200
250
300


DeKalb N Study 2015
Pl UAN
Opt.
Forms/timings
50 pl + SD
Yield
N rate
0
50
100
150
200
250

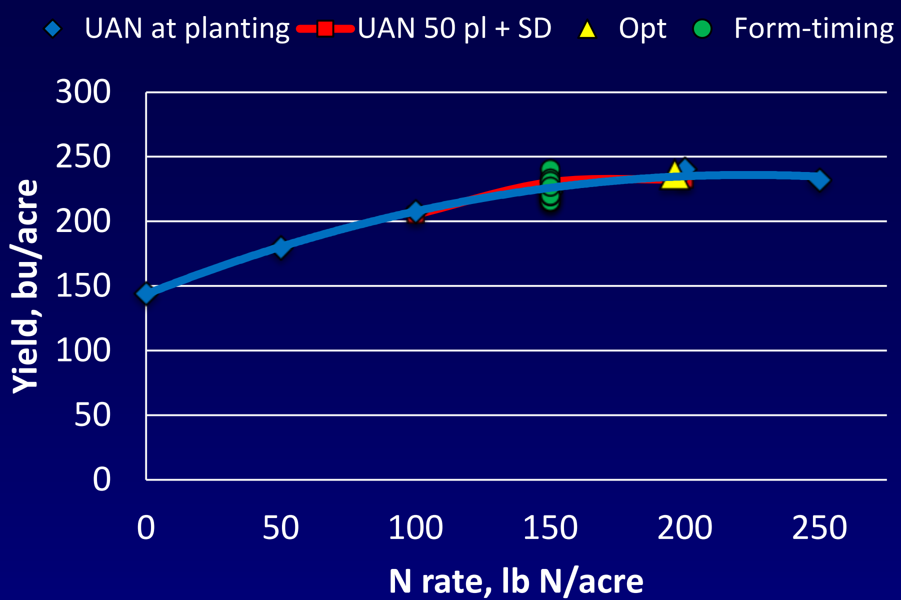

DeKalb 2016
PT UAN
PT 50+SD UAN
Optimum
Forms/times
Yield, bu/acre
N rate, lb N/acre
0
50
100
150
200
250
300


DeKalb 2017
UAN at pl.
50P+SD
Opt.
Forms/timing
Yield, bu/acre
N rate, lb. N/acre
0
50
100
150
200
250
300

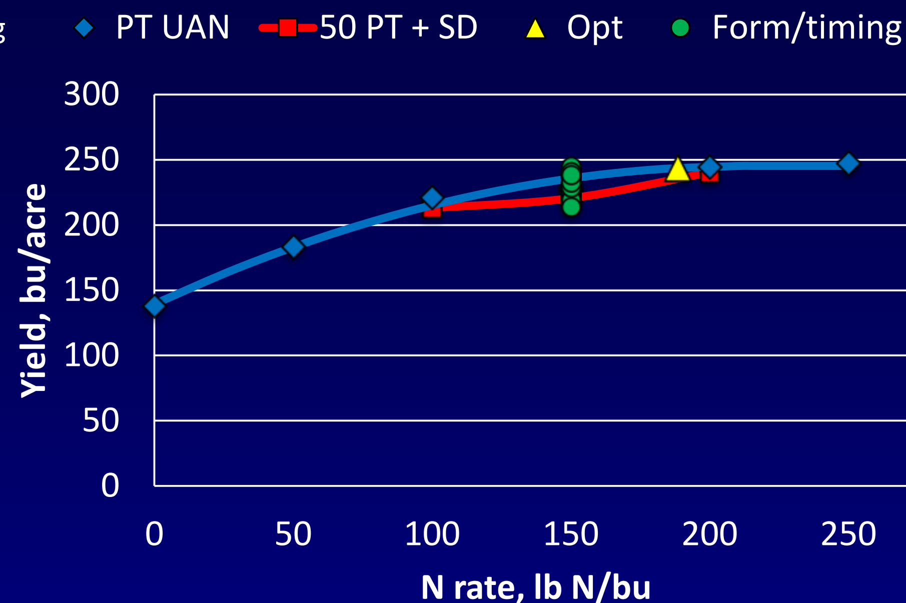


Monmouth N form x timing 2014
UAN pl
Opt
50 UAN pl + SD
Form-timing
Yield
N rate
Monmouth N Study 2015
UAN pl
Opt
Forms/times
50 pl + SD
Yield
N rate
Monmouth N study 2016
PT UAN
PT 50 + SD UAN
Optimum
Forms/times
Yield, bu/acre
N rate, lb N/acre
Monmouth N study 2017
UAN PT
Optimum
N form/time
UAN Pl+SD50
Yield, bushels/acre
N rate, lb. N/acre

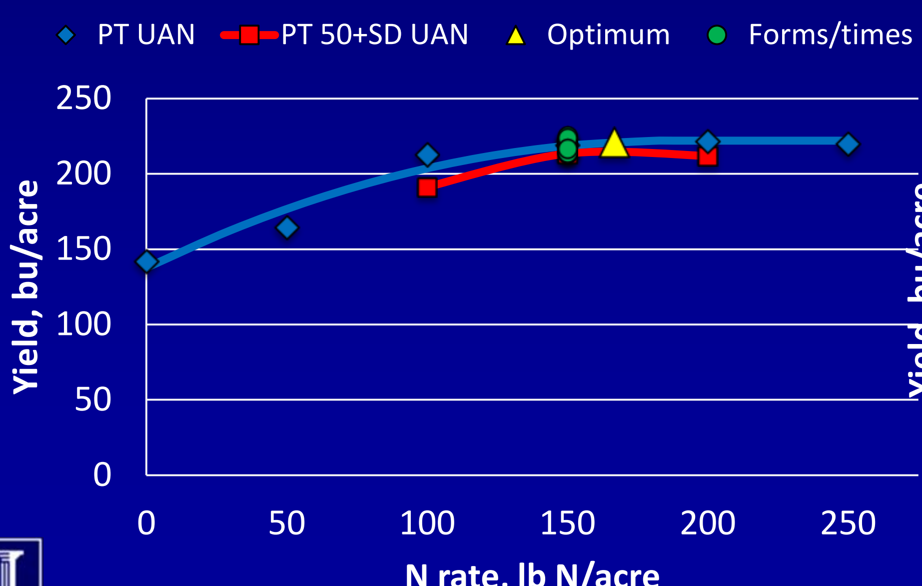
Urbana Form x timimg 2014 Soy-Corn



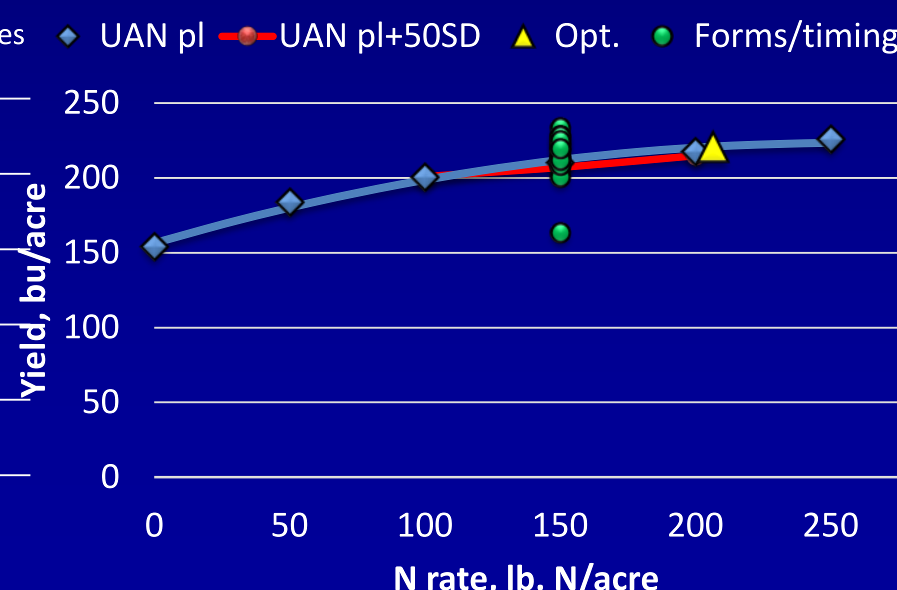
Urbana N Study 2015

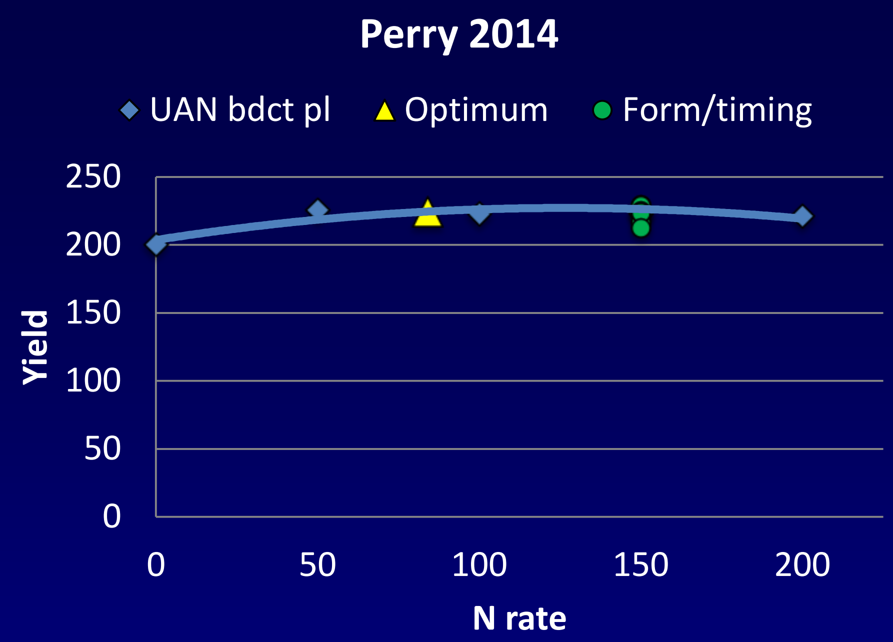


Urbana N study 2016

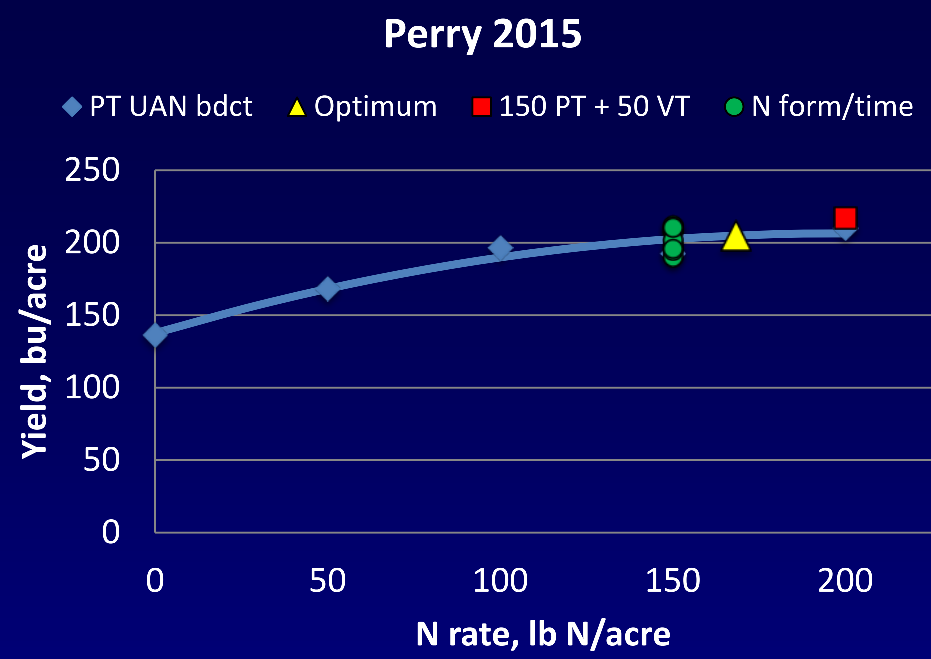


Urbana N Study 2017

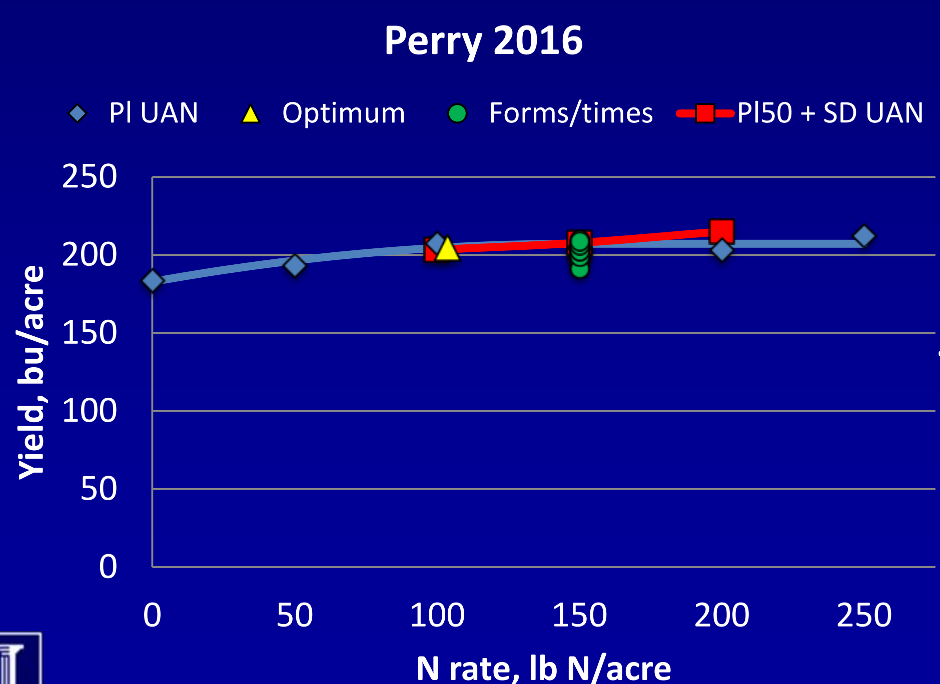




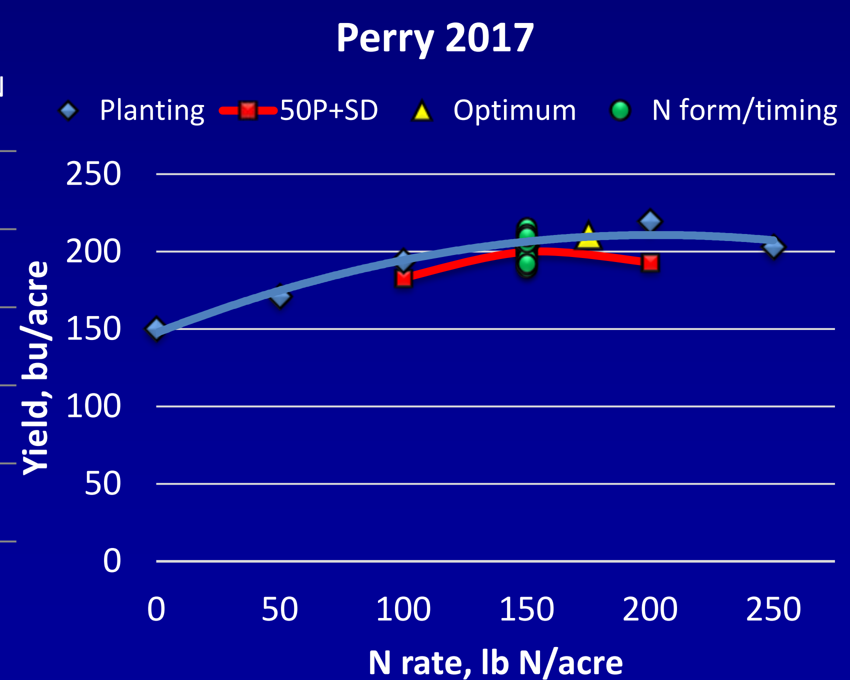
Perry 2014
UAN bdct pl
Optimum
Form/timing
Yield
250
200
150
100
50
0
0
50
100
150
200
N rate



Perry 2015
PT UAN bdct
Optimum
150 PT + 50 VT
N form/time
Yield, bu/acre
250
200
150
100
50
0
0
50
100
150
200
N rate, lb N/acre

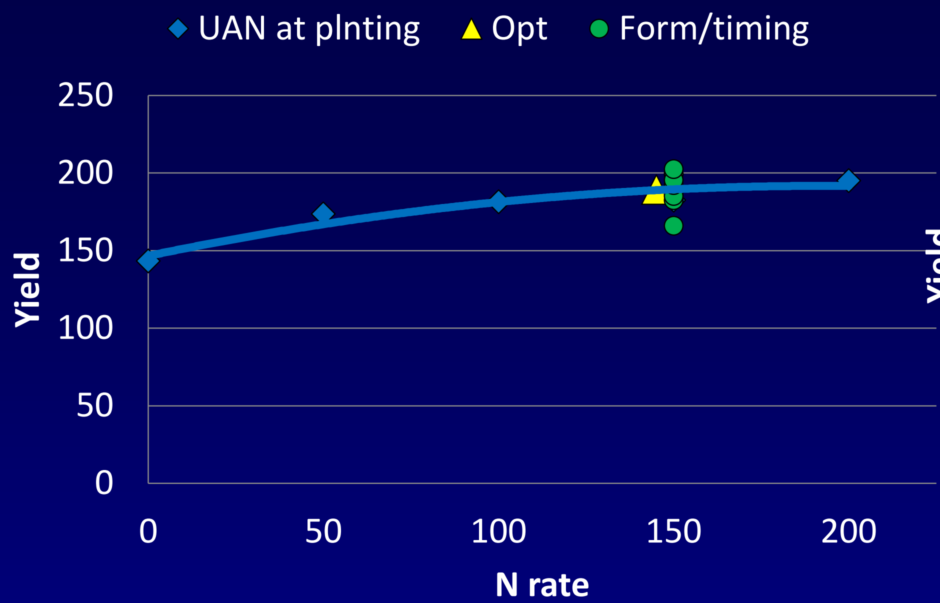


Perry 2016
Pl UAN
Optimum
Forms/times
Pl50 + SD UAN
Yield, bu/acre
250
200
150
100
50
0
0
50
100
150
200
250
N rate, lb N/acre

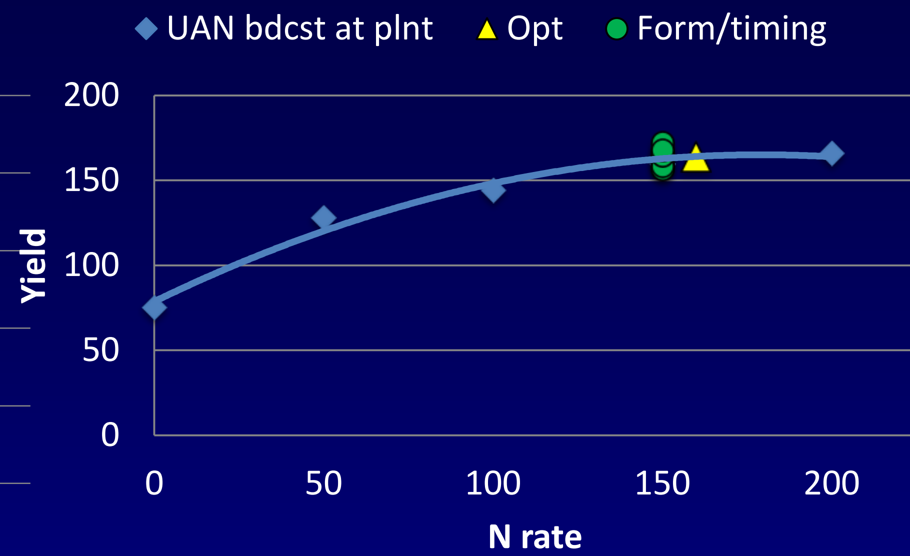


Perry 2017
Planting
50P+SD
Optimum
N form/timing
Yield, bu/acre
250
200
150
100
50
0
0
50
100
150
200
250
N rate, lb N/acre

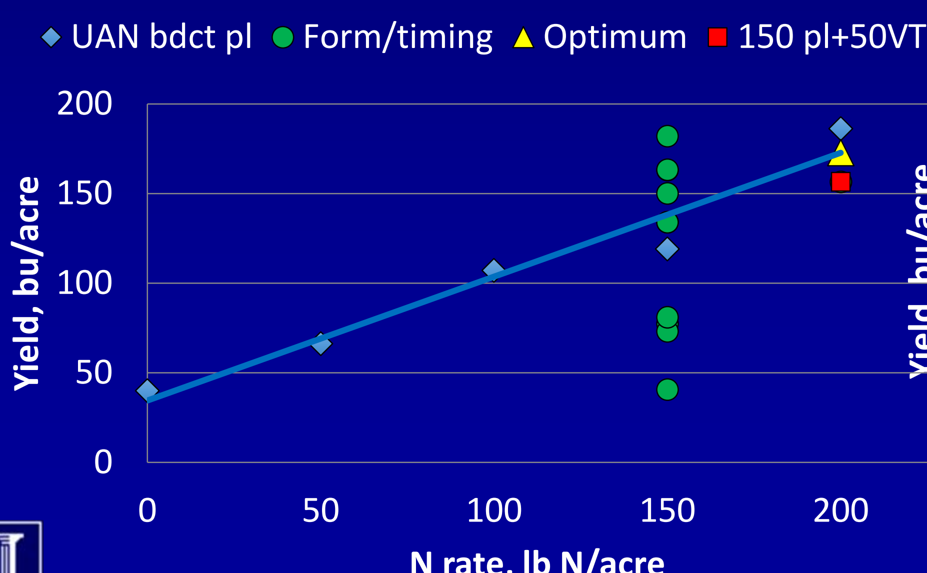
Brownstown Soy-Corn 2014



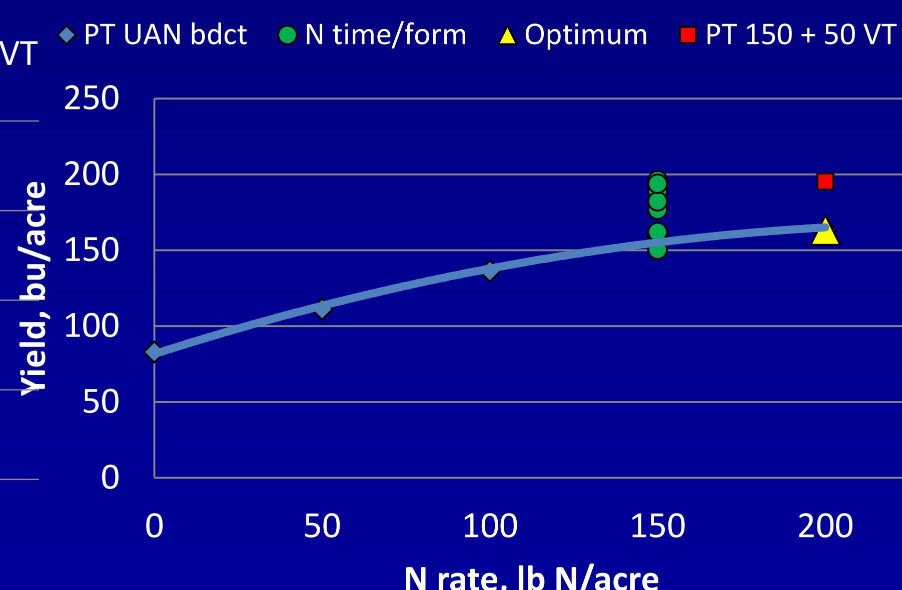
Dixon Springs Soy-Corn 2014



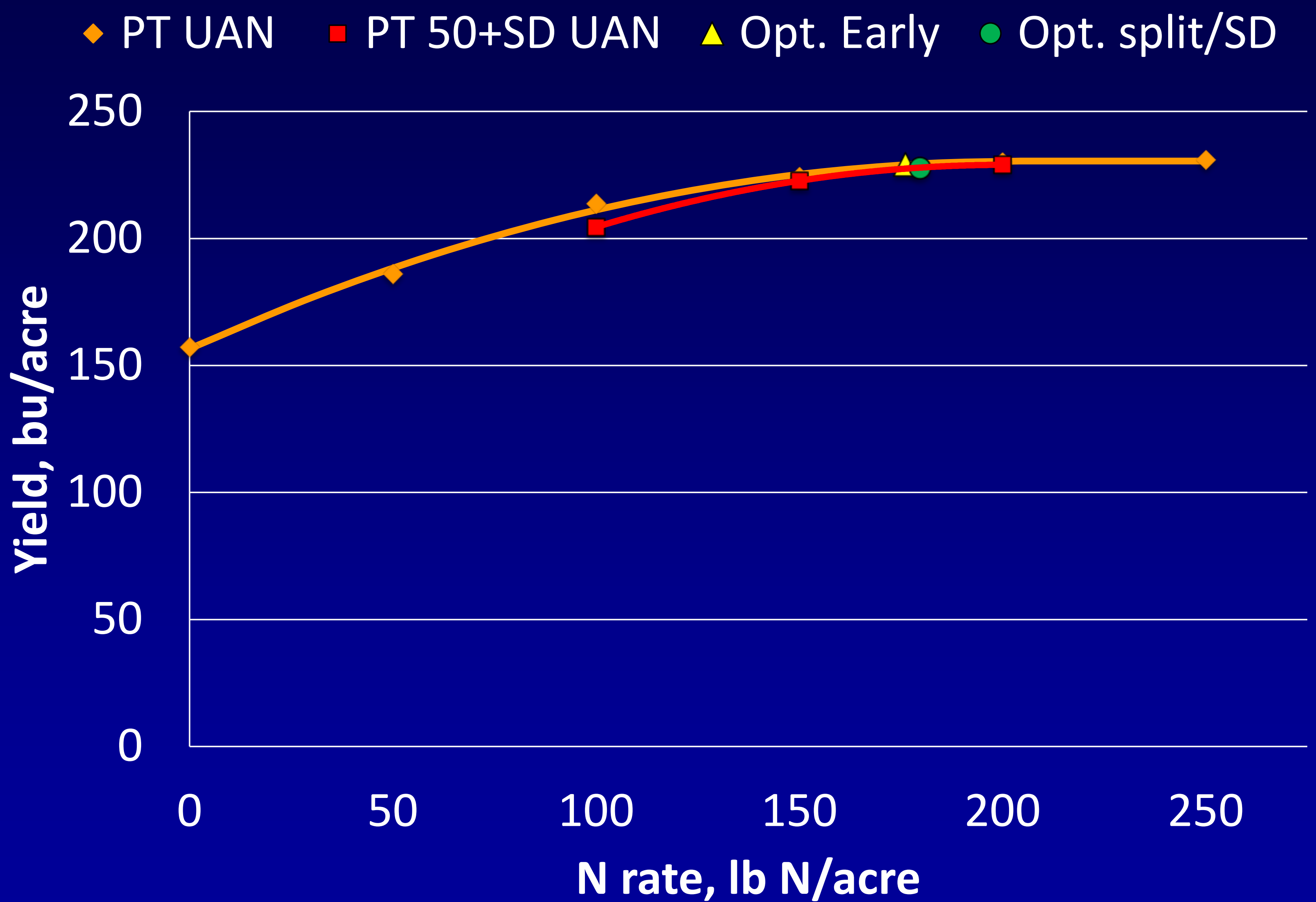
Brownstown, 2015



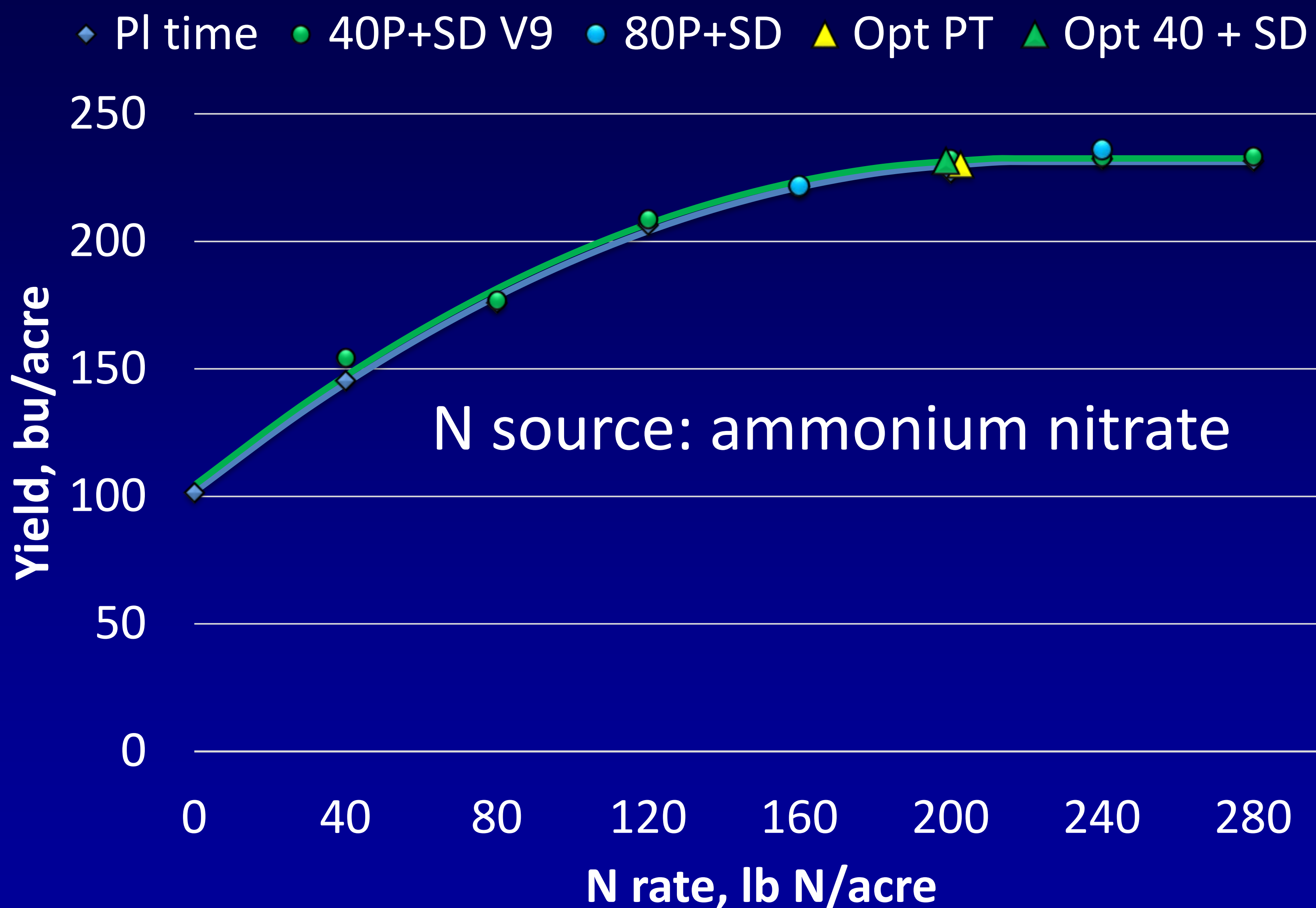
Dixon Springs N form x timing 2015



Planting-time vs. split/SD N, avg. 14 sites



Urbana Soy-Corn, 3-yr avg 2014-16



Sidedress N – better or not?

- Across site-years, split-N treatments (at 150 lb N total) have not yielded consistently more than the same rate of N as UAN injected at planting time
- Not having all of the N available early may **sometimes** mean lower yields, even when sidedress N is added later to provide plenty of N
- It's also likely that we **<u>lose less N</u>** from medium- to heavy-textured soils than we think

Treatment	Rank (1 to 19)				Yield	p=0.1
	2015	2016	2017	3-yr	bu/acre	
All N applied at planting:						
UAN injected mid-row	7	7	11	5	226	abcd
UAN dribbled mid-row	19	13	4	16	223	cdef
Urea/Agrotain broadcast	9	1	18	10	226	abcde
SuperU broadcast	1	2	7	1	229	a
ESN broadcast	12	3	19	12	225	abcdef
UAN/Agrotain broadcast	17	18	1	14	223	bcdef
NH3 injected mid-row	18	11	6	15	223	cdef
NH3/N-Serve injected mid-row	16	15	15	18	221	ef
UAN/Instinct II injected	13	16	17	17	222	def
Split N application (1st at planting):						
UAN 50 broadcast+UAN 100 injected V5	15	9	13	13	224	bcdef
UAN 100 inj+UAN 50 injected V5	4	14	10	9	226	abcde
UAN 100 inj+Urea/AT 50 broadcast V5	5	10	3	3	228	abc
UAN 100 inj+UAN 50 dribbled in-row V9	8	5	2	2	228	ab
UAN 100 inj+Urea/AT 50 broadcast V9	11	8	5	7	226	abcde
UAN 100 inj+UAN 50 dribble in-row V5	2	6	14	8	226	abcde
UAN 100 inj+UAN 50 dribble mid-row VT	14	4	9	6	226	abcd
UAN 100 inj+UAN 50 dribble in-row VT	3	12	12	4	226	abcd
All N sidedressed:						
UAN injected mid-row V5	6	17	8	11	225	abcde
UAN dribbled mid-row V9	10	19	16	19	219	f

N timing & form: summary

- Treatments consistently good:
  - UAN 150 injected at planting (“check”)
  - SuperU 150 broadcast at planting
  - UAN 100 injected at planting + urea/Agrotain 50 broadcast at V5
  - UAN 100 injected at planting + UAN 50 dribbled in-row at V9
- Treatments giving variable results, but good overall:
  - UAN 100 injected at planting + UAN 50 dribbled in-row at VT
  - UAN 100 injected at planting + UAN 50 dribbled mid-row at VT

N timing & form

- Treatments giving variable results, with average overall response:
  - ESN 150 broadcast at planting (affected by rain)
  - Urea 150/Agrotain broadcast at planting
  - UAN 100 injected at planting + UAN 50 injected at V5
  - UAN 100 injected at planting + urea/Agrotain 50 broadcast at V9
  - UAN 100 injected at planting + UAN 50 dribbled in-row at V5
  - UAN 150 injected mid-row at V5

N timing & form

- Treatments that seldom or never excelled:
  - NH_3 with or without N-Serve injected at or before planting
  - UAN dribbled mid-row at planting
  - UAN with Instinct II injected at planting
  - UAN 50 broadcast at planting + 100 UAN injected at V5
  - UAN 150 dribbled mid-row at V9
  - UAN/Agrotain 150 broadcast at planting (but good at 2 sites in 2017)

N timing & form - conclusions

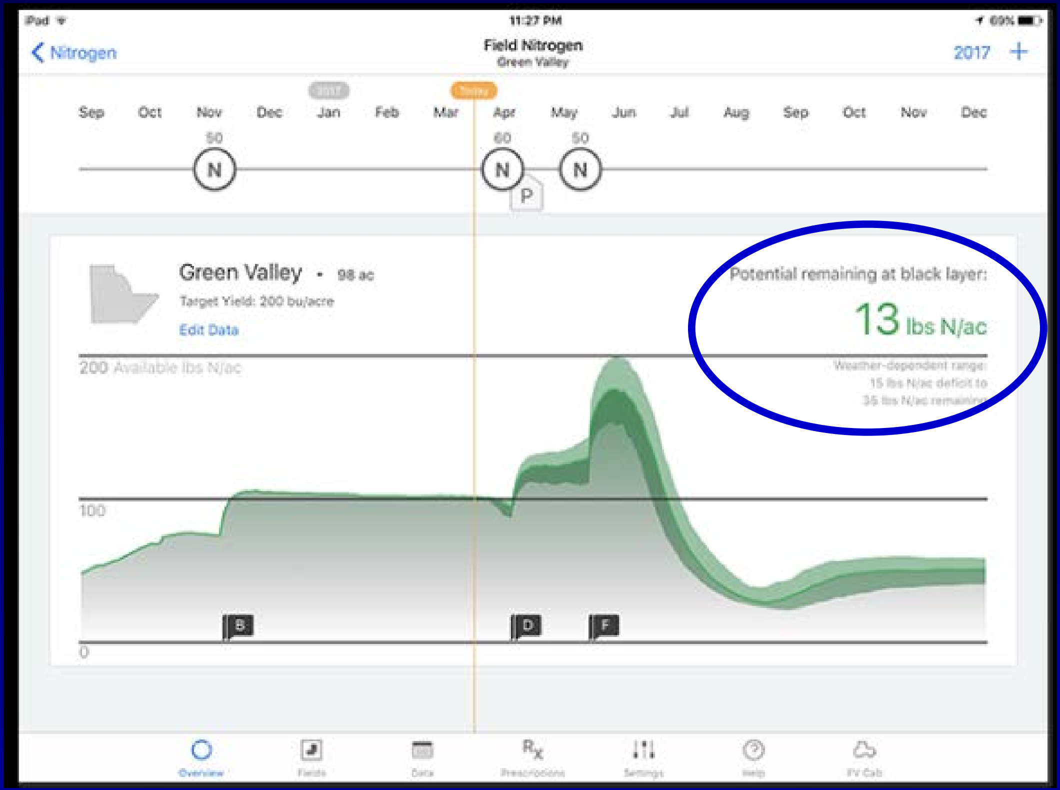
- Over a diverse set of sites (mostly weather) a large set of treatments did not separate very well into “good-better-best” ways to manage N, including in-season N
- Results are generally consistent with the hypothesis that having most or all of the N present at planting may perform more consistently than splitting N with most applied in-season
- N stabilizers have likely improved performance of some forms of N, especially dry urea (with both urease and nitrification inhibitor) but not all comparisons were included
- Adding inhibitors to UAN or NH_3 has not generally improved performance

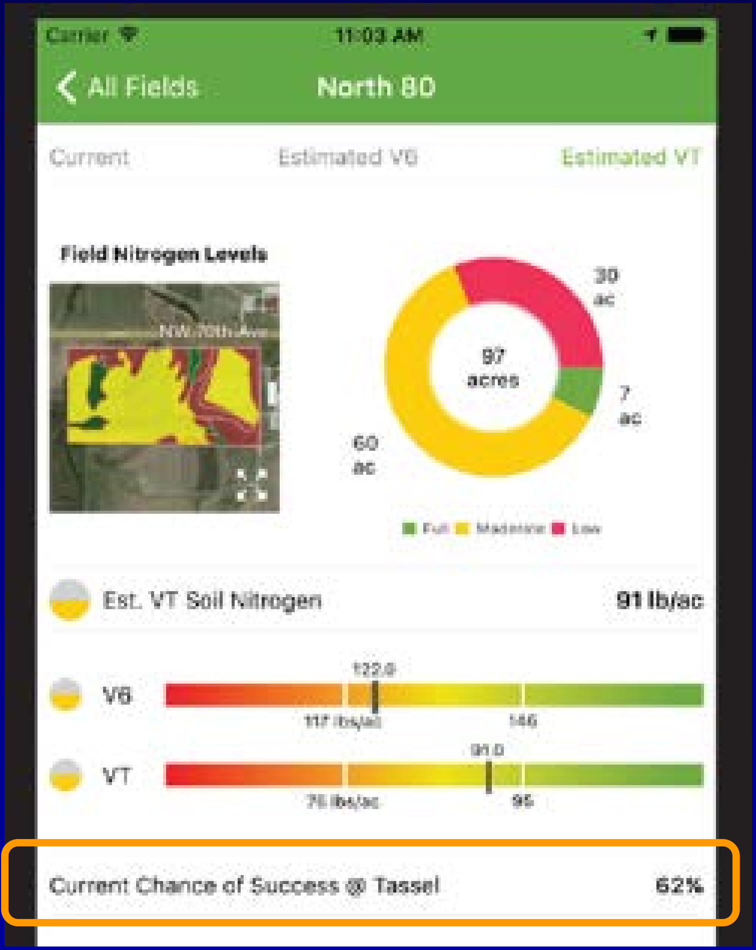
Can soil N guide N management?

- There are large efforts underway to measure or model soil N during vegetative development to determine if (and how much) more N is needed
- We’ve run a series of experiments to measure the effect of different forms and timings of 200 lb N on soil N

Climate FieldView™

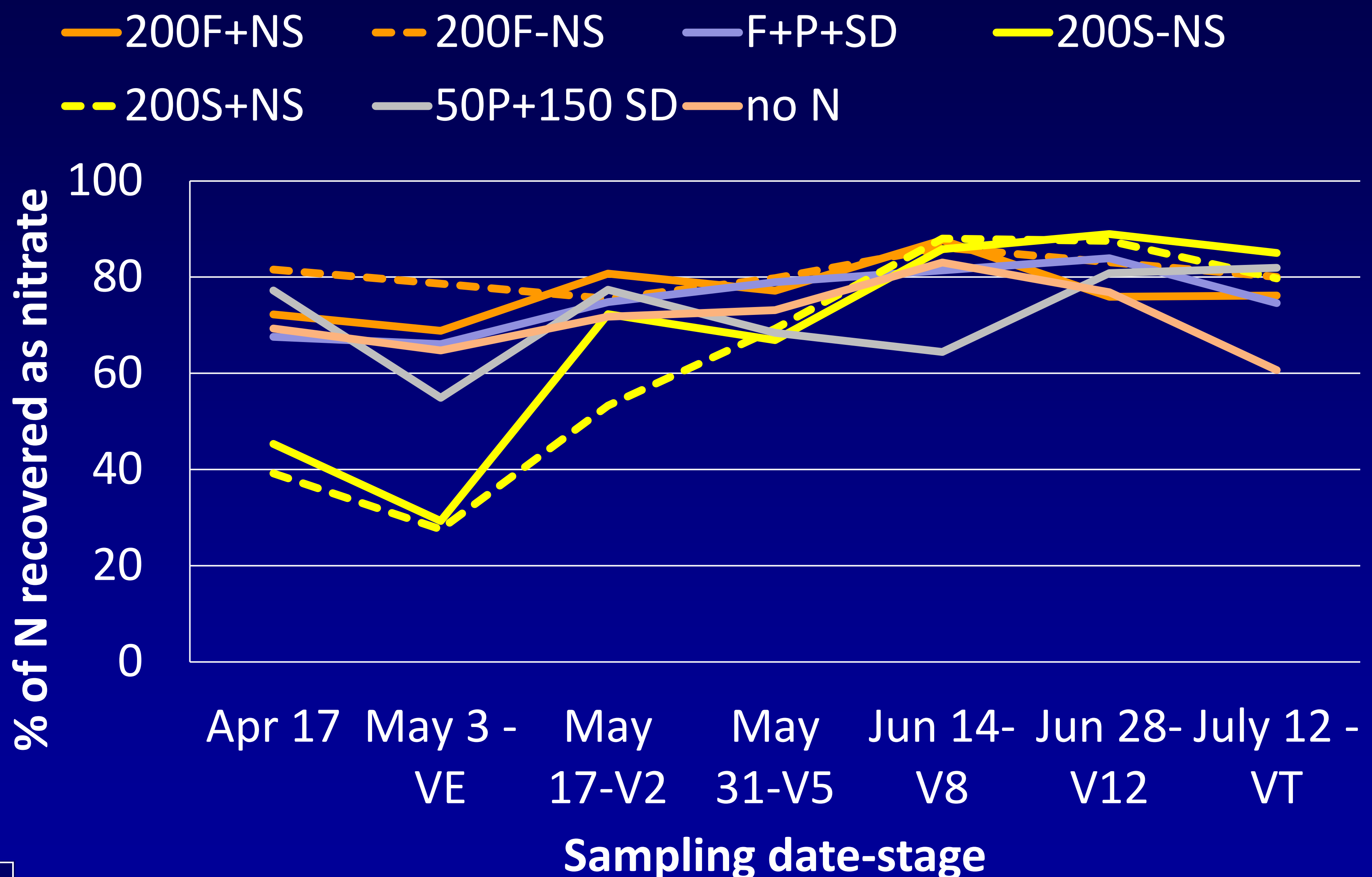
Encirca®

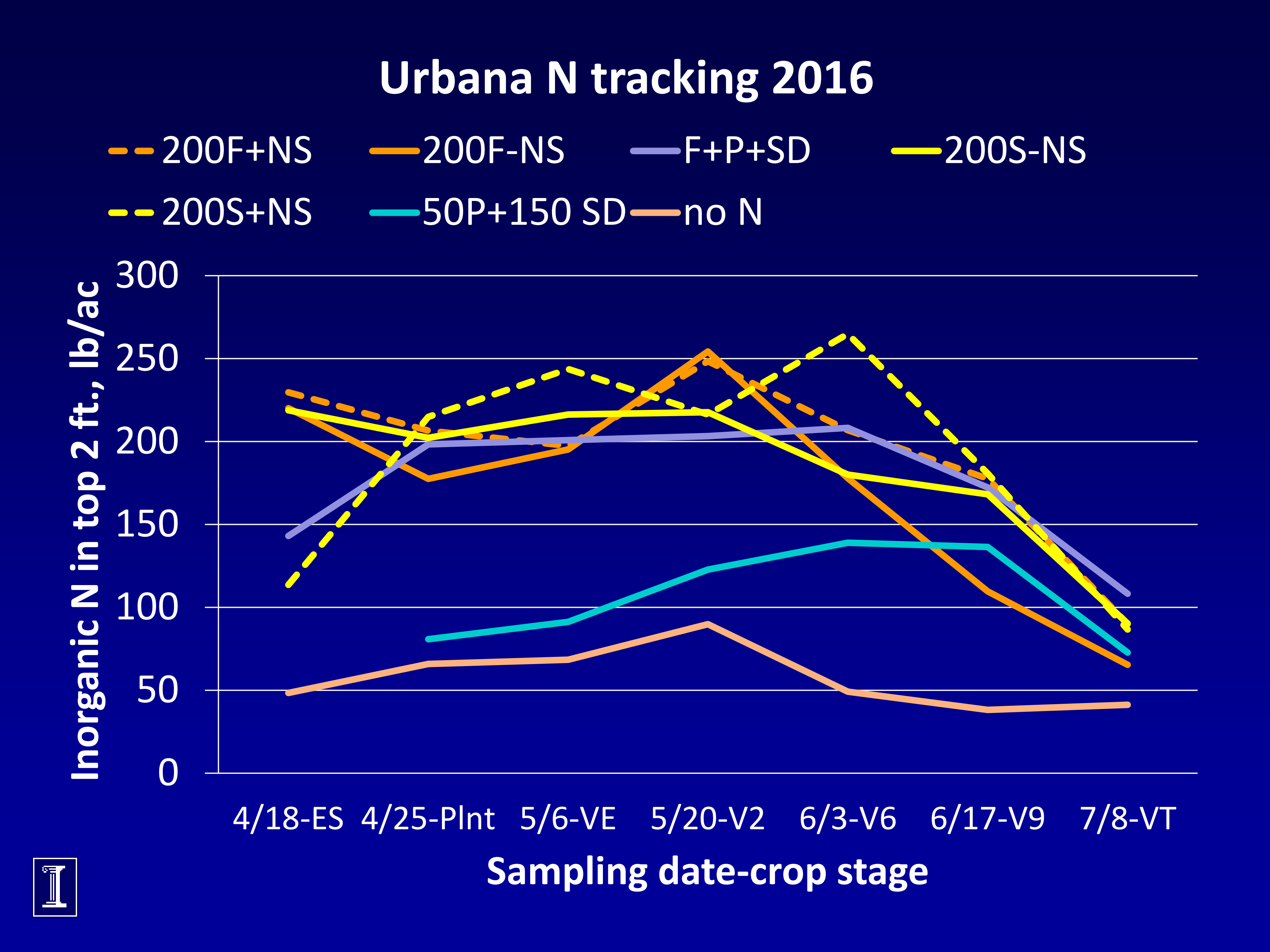




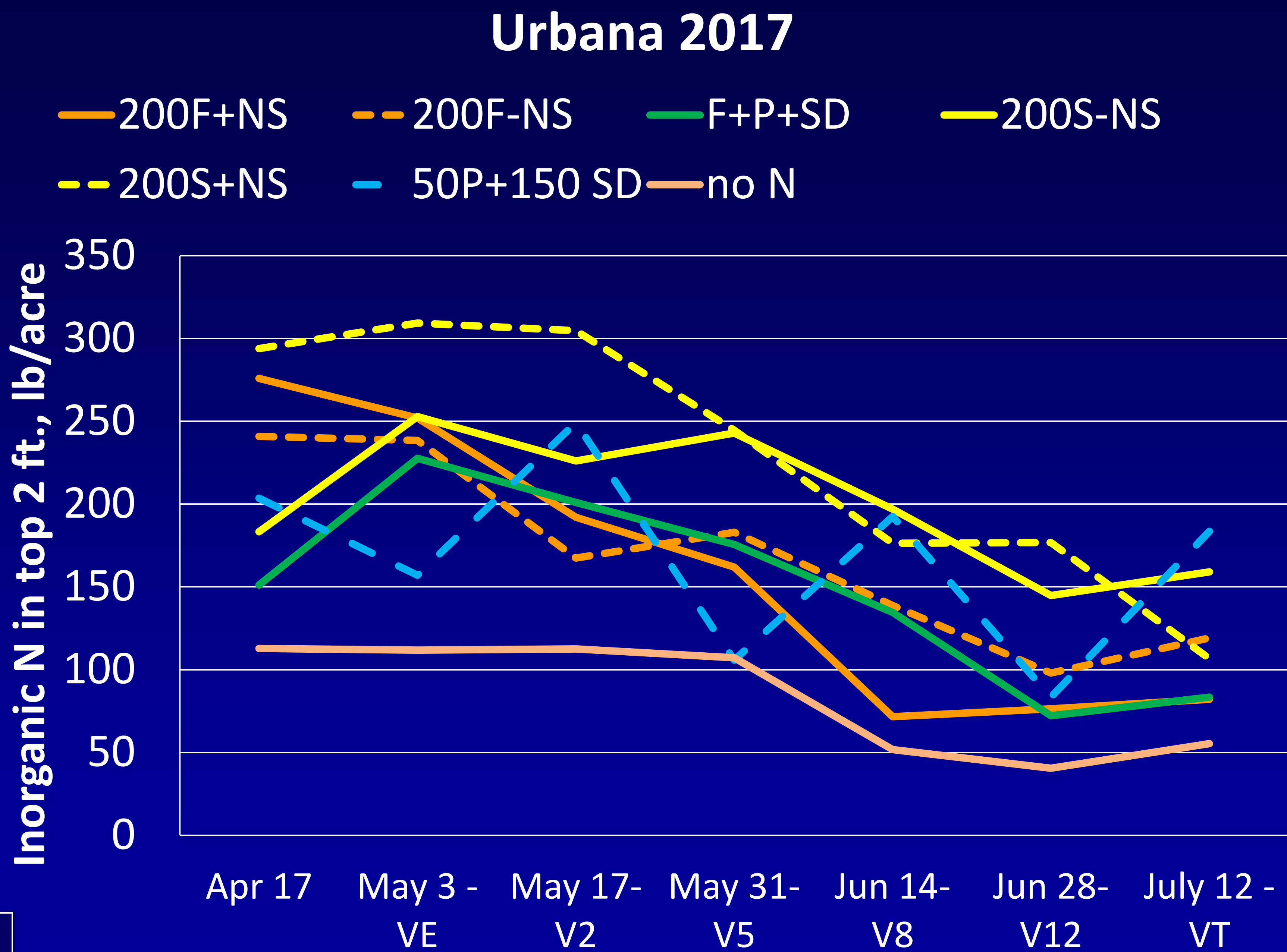
The Soil Scan 360® - analyzes a soil slurry for nitrate and uses yield goal and growth stage to turn this into an N recommendation

Soil N, % nitrate, Urbana 2017

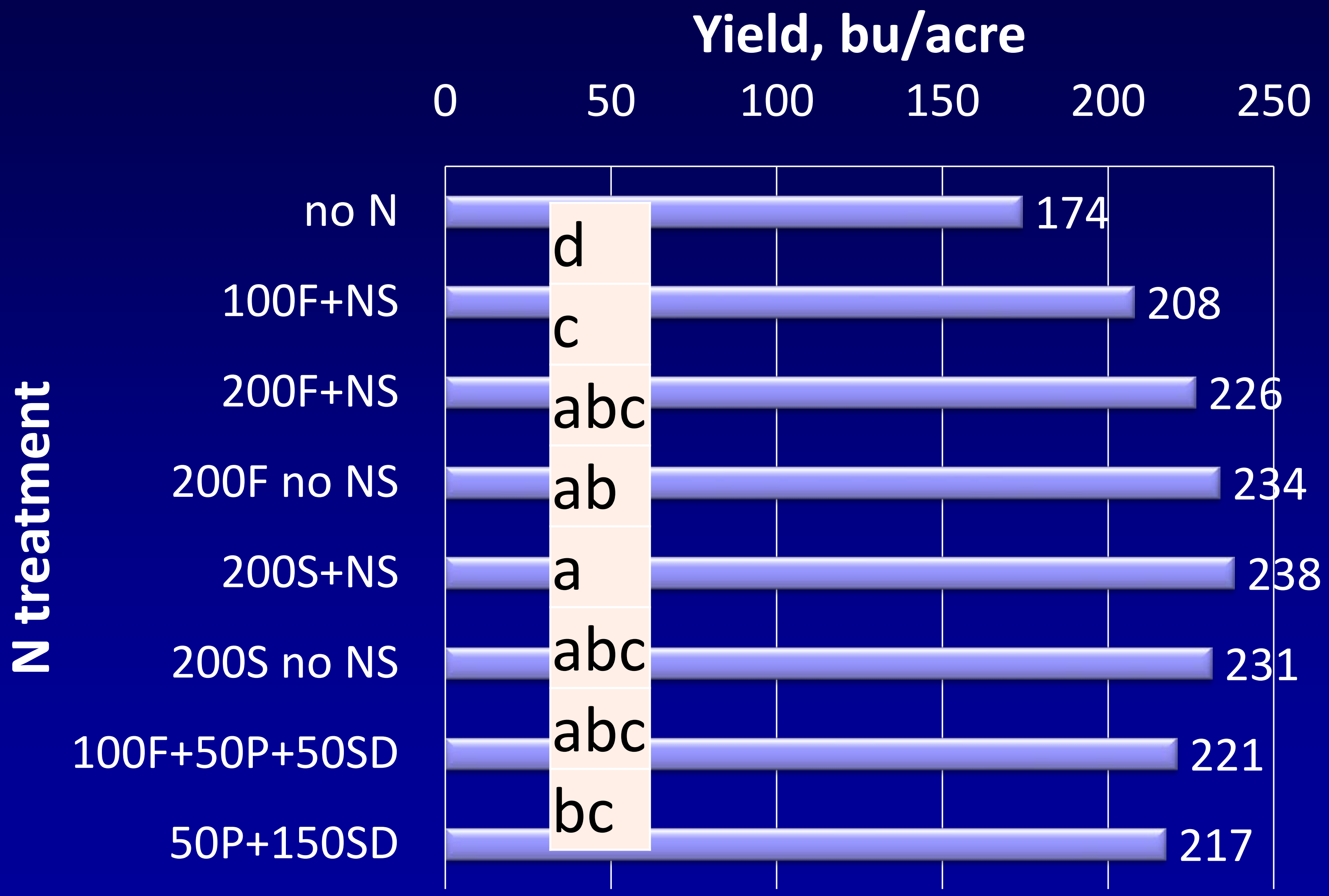




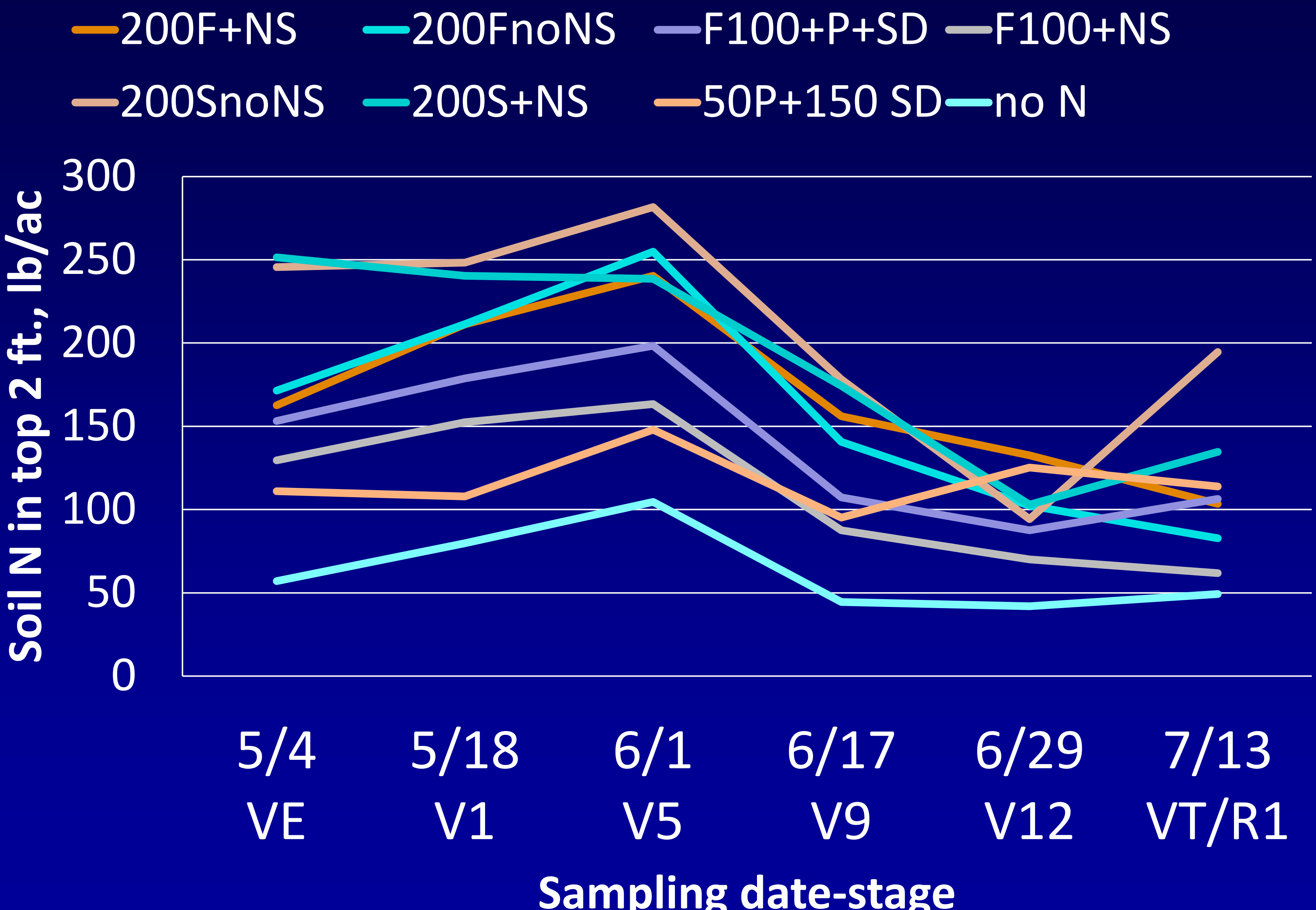
Urbana N tracking 2016
200F+NS
200F-NS
F+P+SD
200S-NS
200S+NS
50P+150 SD
no N
300
250
200
150
100
50
0
Inorganic N in top 2 ft., lb/ac
4/18-ES
4/25-Plnt
5/6-VE
5/20-V2
6/3-V6
6/17-V9
7/8-VT
Sampling date-crop stage


Urbana 2017
200F+NS
200F-NS
F+P+SD
200S-NS
200S+NS
50P+150 SD
no N
Inorganic N in top 2 ft., lb/acre
350
300
250
200
150
100
50
0
Apr 17
May 3 - VE
May 17- V2
May 31- V5
Jun 14- V8
Jun 28- V12
July 12 - VT

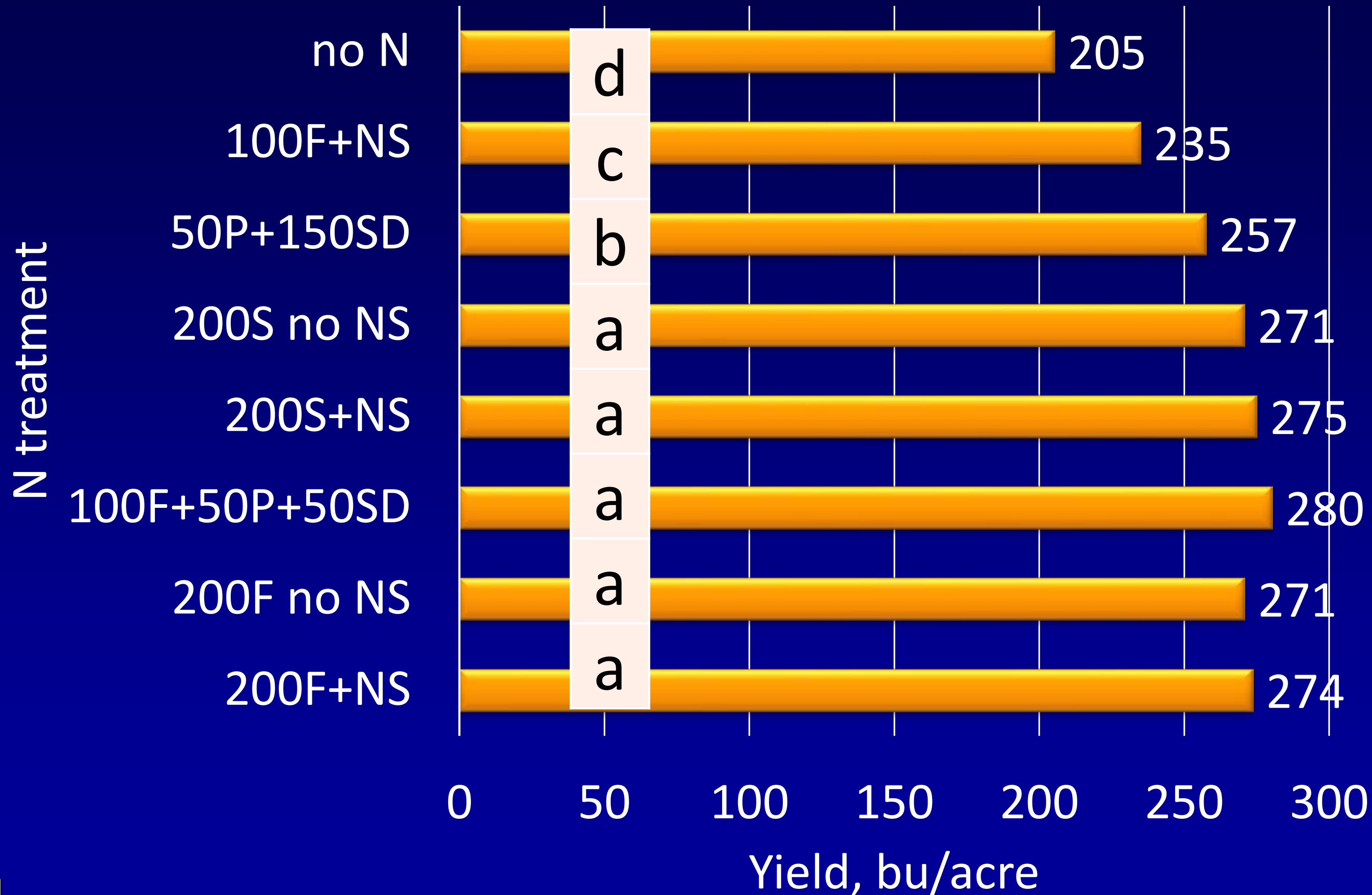
Urbana N-tracking yields 2017



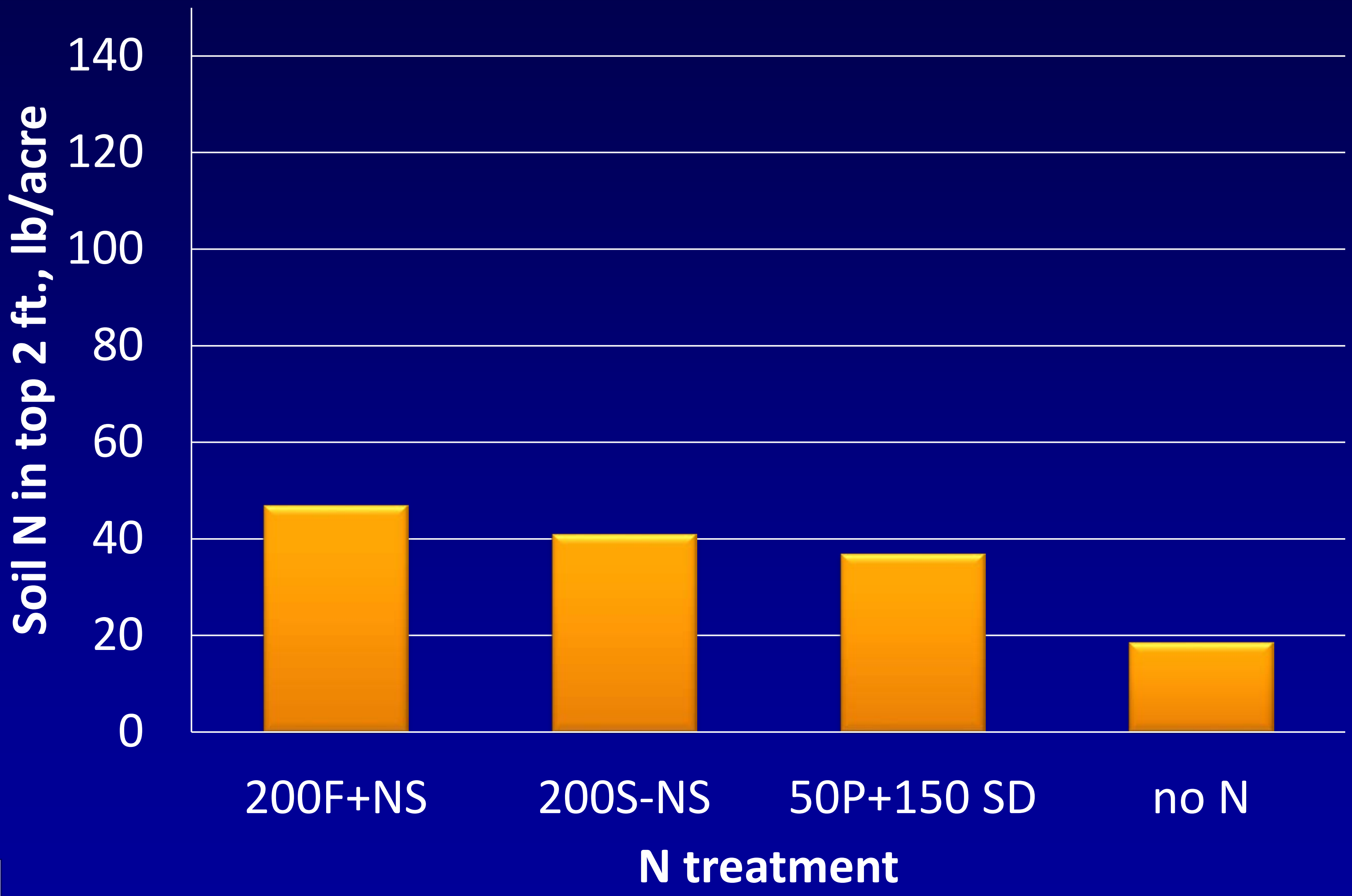
Monmouth 2017

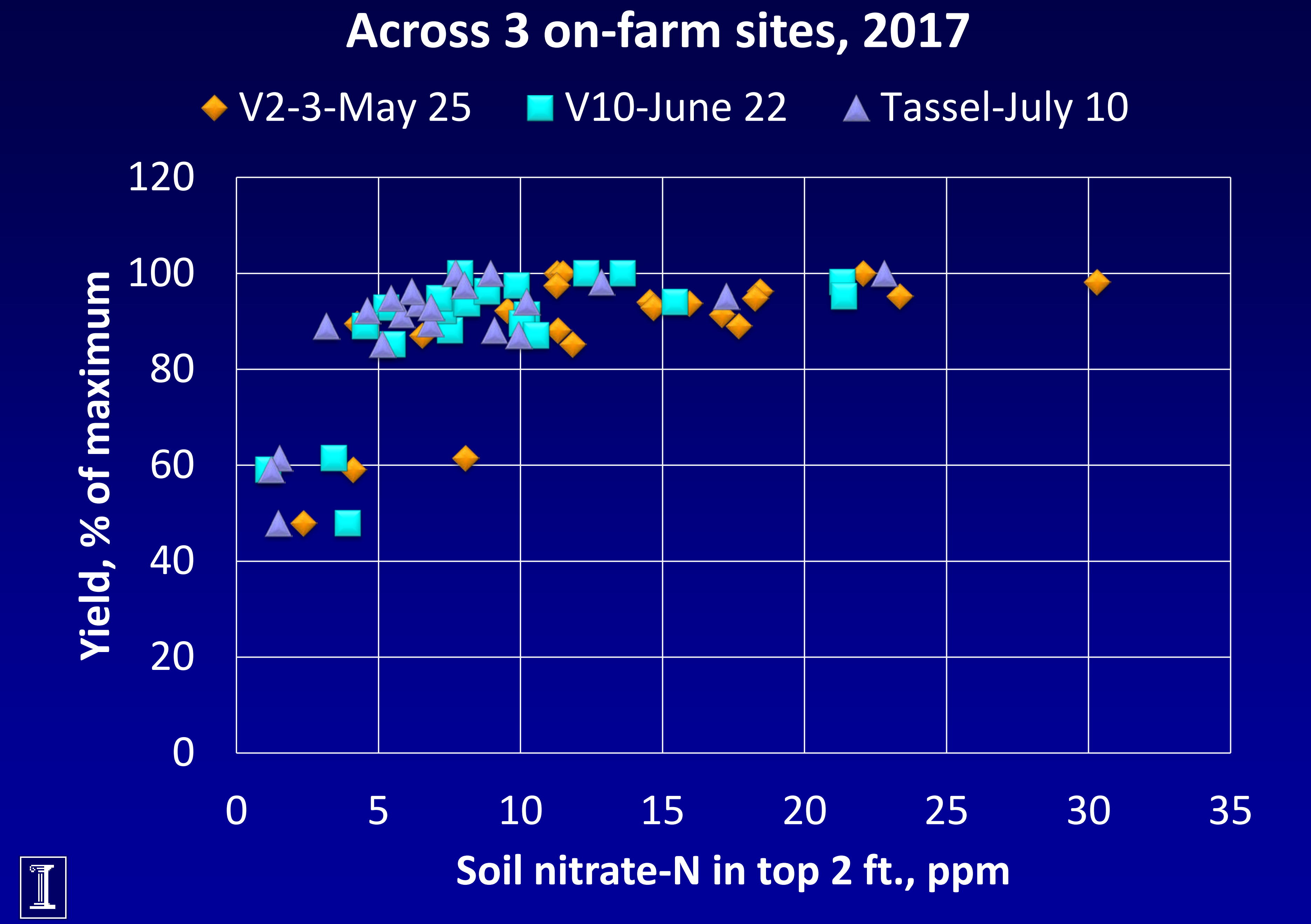


Monmouth N-tracking yields, 2017



Soil N after harvest, Monmouth, 2017





Across 3 on-farm sites, 2017
V2-3-May 25
V10-June 22
Tassel-July 10
Yield, % of maximum
0
20
40
60
80
100
120
0
5
10
15
20
25
30
35
Soil nitrate-N in top 2 ft., ppm

Can soil N work as an indicator?

- Probably not very well:
  - Crop need, N mineralization, and access of roots to N vary greatly with weather; **high-yield conditions tend to increase soil supply of N**
  - It is becoming clear that N “losses” associated with wet weather are less (or less “permanent”) than many think, at least in many soils
  - The strategy of delayed application brings additional costs and risks – especially the risk of timeliness of availability of N to the crop
  - It may be more critical to have enough N available in the soil as root systems start to develop (V3-V6) than in mid- or late vegetative growth

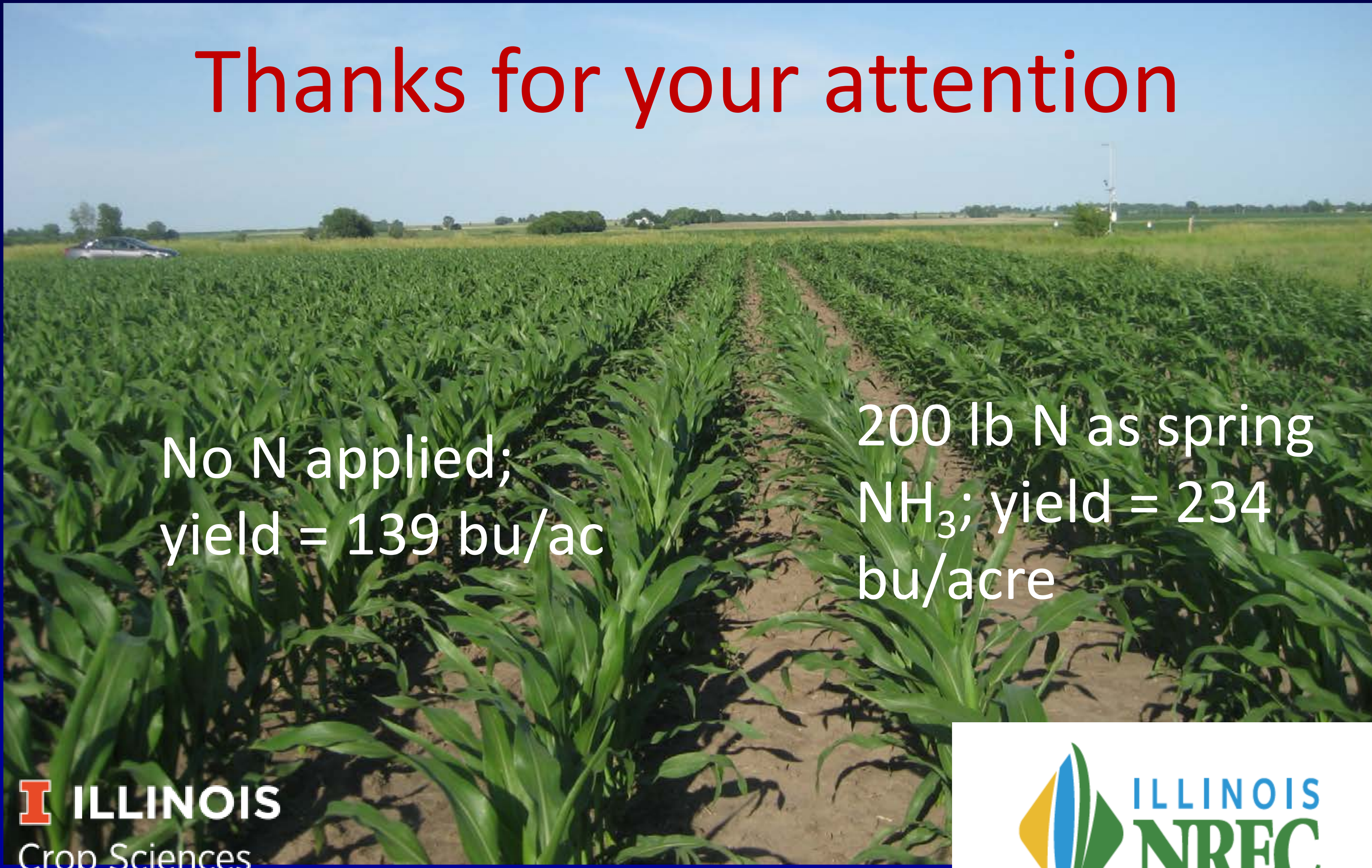
Variable-rate N?

- Our ongoing lack of ability to predict N rate for a zone or field before (or early in) the season will continue to be a barrier
- Basing N rate on expected yield for a soil or zone is not reliable
  - Yield potential and soil N supply are both related directly to soil organic matter; good conditions increase both yield and N supply
  - Might using lower N rates where SOM (and maybe yield expectation) is higher make sense?
- The return to VRN is likely to be modest at best, and so it can't cost much

Variable-rate nitrogen

- Using canopy sensing to decide how much N to apply has been a major effort, but getting the right amount of “deficiency” to appear is more a matter of luck than of skill
- Risk of delayed or prevented N availability is real, and likely underrated
- Even if we can determine what a “best” rate is for part of a field, it looks like the return to doing this will be fairly small
- Should we consider the use of normal (MRTN) rates and to have “rescue” applications in reserve for times when this is needed?

Thanks for your attention



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