A Comprehensive Corn Nitrogen Research Program for Illinois
2015 Annual Report to the Nutrient Research & Education Council

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This project includes as a primary objective gathering data on the response of corn grain yield to N fertilizer rates with replicated, field-scale N rate trials at numerous on-farm locations throughout Illinois, representing the large diversity of soils and weather in the State. In some cases these trials include comparing fall-applied and spring-applied or early spring and sidedressed fertilizer N rates. It includes as possible an evaluation of variable-rate N. The second primary objective is to evaluate combinations of fertilizer N rate, form, inhibitor treatments, and application timing on corn yield and economic return using smaller-plot trials on UI research centers.

On-Farm Trials

In 2015 a total of 51 trials were completed under this project, including 9 strip trials at the six UI Crop Sciences Research & Education Centers, done using the same design as in producer fields. This exceeded the goal of completing 30 to 35 trials in 2015.

Figure 1 shows the response curves from 35 sites with corn following soybean in 2015. Each response was fitted with an appropriate function and the point at which return to N was maximized (the economically optimum N rate, or EONR) was calculated using a price of $0.375 per lb of N and a corn price of $3.75 per bushel. In addition, we used the N MRTN N rate from the N rate calculator at these same prices, and for each curve we show that rate and the yield at that N rate. Averaged across all 35 sites, the EONR was 25 lb/acre higher than the MRTN N (191 v 166 lb N) and the yield at EONR rates averaged 9 bushels per acre more than the yield estimated at the MRTN rate (220 v 211 bu/acre). The net effect was that that return to N was about $24 per acre using the MRTN rate rather than the actual EONR calculated from the N response in each field. This reflects the wet June weather that both damaged the crop and perhaps led to some loss of plant-available N.

Figure 2 shows the response curves from 15 on-farm sites with corn following corn. Averaged across all sites, the EONR was 16 lb N/acre more than the MRTN N rate (213 v 197 lb N), and yield at the EONR averaged 5 bushels more than at the MRTN rate (195 v 190 bu/acre.) The net return to N averaged about $15 more at the EONR than at the MRTN. These disparities would have been larger had the EONR not been limited to the highest rate of N used in a trial; this occurred in 7 of the 15 sites in 2015.

Trials in which N application was split to compare fall versus spring or early spring versus sidedress N rates showed inconsistent responses to N timing. In one case spring-applied N produced a higher yield at a lower N rate than fall-applied N (Figure 3.) This is what we might expect with above-normal spring N loss, although yield from fall-applied N leveled off before the highest N rate, and under N loss we would have expected it to keep rising. Splitting N in the spring likewise tended to have little effect on N response or yield, as shown in Figure 4.

Variable-Rate N

In-season variable-rate N application was assessed in a trial with corn following soybean at a site in Livingston County (Figure 5.) Unfertilized strips were left and the remainder of the field was fertilized with UAN broadcast at the rate of 60 lb N per acre before planting. A high-N reference strip was established using a rate of 300 lb of N. At stage V6-7, uniform rates of 60, 120, and 180 were applied, and the Greenseeker® was used to assess canopy color in real time and to apply N according to the company's algorithm. Color differences were visible in the strips at sidedress application time. While the Optrix canopy-sensing system applied a reasonable average N rate of 148 lb N/acre (60 base plus 88 at sidedress) and produced a yield of 208 bushels per acre. But this site, like many in 2015, showed a response to N up to the highest N rate used, and the VRN system was unable to anticipate that. More importantly, the VRN application produced exactly the same yield as predicted with uniform application of the same N rate, so did not improve N use efficiency.

N Rate, Timing, and Form

Small-plot trials were conducted according to the project plan at DeKalb, Monmouth, and Urbana in 2015. All were planted on time and managed well, with treatments applied as planned. Corn followed soybean at all locations. The base N response (against which other treatments were compared) was generated with UAN applied by injection at planting at rates ranging from 0 to 250 lb N per acre in 50-lb increments. The response to sidedressing N was tested using 50 lb of N at planting plus 50, 100, or 150 lb N at stage V5-V6, with corn 12 to 16" tall. An additional 17 treatments were applied at the rate of 150 lb N/acre using a range of timings, forms, and inhibitors; this includes 4 treatments added in 2015. Table 1 lists the treatments.

Figures 6-8 show N responses at the DeKalb, Monmouth, and Urbana sites. Responses and EONR values were relatively consistent among sites, with EONR values of 195, 159, and 188 lb N and yields at the EONR of 197, 2221, and 244 at DeKalb, Monmouth, and Urbana, respectively. Applying N as 50 lb at planting and the rest as sidedressed UAN showed no benefit at any of the three sites compared to applying all of the N at planting. June rainfall was above normal at all three sites, so it's a little surprising that splitting N with much of it applied at sidedress did not improve yields, at least at the lower rate.

The different timings and forms of N compared at 150 lb N per produced different yields, without great consistency in treatments among sites (Table 1.) The yield range among these treatments was 33, 17, 31, and 16 bushels per acre at DeKalb, Monmouth, Urbana, and averaged across all three sites, respectively. These ranges are larger than we saw in 2014, with the exception of Monmouth, where the yield without N was relatively high, the response to N fairly flat, and the EONR was only 9 lb more than the 150 lb applied to compare N forms and timing. The trial at DeKalb was damaged to some extent by conditions and there was a lot of variability, so it took 15 or 16 bushels of difference between treatments to be statistically significant. In contrast, the trial at Urbana showed low variability and a lot of statistical differences among treatments.

Over sites in 2015, the highest yields were from SuperU broadcast at planting, and 100 lb as UAN at planting + 50 lb UAN dribbled at V9, 50 UAN dribbled in the row at VT, and 50 lb urea + Agrotain broadcast at V5 (Table 1.) Variability among sites was substantial, and only four treatments yielded significantly less than the highest-yielding treatment. These included NH_3 with and without N-Serve at planting time, all of the N applied at UAN dribbled between the rows at planting time, and UAN with Agrotain broadcast at planting time. In 2015 we moved NH_3 application to early spring (April 6, 17 days before planting at Urbana) instead of at planting time, and it's possible that the poor performance of these treatments was due to N loss before plant uptake began. If that was the case, N-Serve had little effect on N loss.

Two of the four treatments added in 2015 – UAN with Instinct broadcast at planting and 100 lb N as UAN at planting + 50 lb N dribbled in the row middle at VT – were average treatments across locations. The other two – 100 at planting + 50 dribbled in the row at either V9 or VT – were among the best treatments. Still, compared to the check treatment of 150 lb N as injected UAN at planting, neither of these split N treatments increased yield by more than 3 bushels. In fact, splitting N between planting time and any other time and form, including at the three different rates (shown in Figures 6-8) had much effect on yield, and there was certainly no clear advantage to splitting N even with the wet June.

Across the three sites and two years, two dry N forms – urea with Agrotain and SuperU – broadcast at planting produced the highest yields, but eight other treatments, including the check (UAN injected at planting) produced yields that were not statistically different from the highest yields (Table 2). The two lowest yields – UAN applied as a dribble between rows at planting and UAN with Agrotain broadcast at planting – yielded 10 and 11 bushels per acre less than the highest-yielding treatments. Seven other treatments, including four of those that did not yield significantly less than the highest-yielding treatments, did not yield significantly more than the lowest-yielding treatments. This reflects the fact that treatments tend not to "hold rank" very well among sites, and points to the fact that finding "best" N management treatments may not be easy.

Outreach

Results of this work were made known through the Extension presentations, including the AgMaster's conference in December 2015, the IFCA Conference in January 2016, and at the Crop Management Conferences in January and February 2016; audience totals for all of these was estimated at 1,800.

Budget

The budgeted amounts were spent as planned in 2015, with the exception that funds were not spent during the fiscal year to make payments to farmer-cooperators involved in on-farm N rate studies managed by Dan Schaefer. These payments are being processed now for 2015, and are to be shifted out of this project for the work to be done in 2016.

Plans for 2016

We plan to add two more treatments to the set of treatments in the large N management studies being conducted at the research center locations. We will also add Orr Center to the three RECs where this study is being done. The smaller trials being conducted in southern Illinois will continue at two sites, both in farmer fields due to closure of the Brownstown and Dixon Springs research centers. These (and the trial at Orr Center) were coordinated with Dr. Rachel Cook at SIU-Carbondale; she is leaving SIU and does not plan to run this study at Carbondale in 2016.

Table 1. Effect of N form and timing on yield at three Illinois sites in 2015, and averaged across sites. All plots received 150 lb of N. Numbers followed by the same letter are not statistically different. PT = planting time; AT = Agrotain®. Means were separated at alpha = 0.10.

Treatment	DeKalb		Monmouth		Urbana		3-site avg	
UAN injected at planting time (check)	198	ab	217	abcd	228	cdefgh	214	ab
PT UAN 50 bdcst + V5 UAN 100 inj	184	abcde	219	abcd	220	ghi	208	abc
PT 0 + V5 UAN 150 inj row mid	194	abc	223	abc	226	efgh	214	ab
PT 0 + V9 UAN 150 drbl row mid	190	abcd	218	abcd	227	defgh	211	abc
PT UAN 100 inj + V5 UAN 50 inj	198	a	219	abcd	227	defgh	215	a
PT UAN 100 inj + V5 U/AT 50 bdcst	188	abcde	225	ab	231	bcdef	215	ab
PT UAN 100 inj + V9 UAN 50 drbl row	198	ab	213	cd	230	bcdefgh	214	ab
PT UAN 100 inj + V9 U/AT 50 bdcst	182	bcde	219	abcd	232	bcdef	211	abc
PT UAN 150 dribbled between rows	173	ef	211	d	222	fghi	202	c
PT Urea/AT 150 broadcast	190	abcd	213	cd	237	abcde	213	ab
PT SuperU 150 broadcast	193	abc	216	bcd	245	a	218	a
PT ESN 150 broadcast	183	abcde	213	cd	237	abcd	211	abc
PT UAN/AT 150 broadcast	174	def	212	cd	226	efgh	204	bc
Early spring NH_3 150 injected	165	f	223	abc	219	hi	202	c
Early spring NH_3/NS 150 injected	180	cdef	219	abcd	214	i	204	bc
PT UAN/Inst 150 broadcast	178	cdef	225	ab	229	bcdefgh	211	abc
PT UAN 100 inj+V9 UAN 50 in-row drbl	194	abc	223	abc	233	bcde	217	a
PT UAN 100 inj+VT UAN 50 mid-row dr	173	ef	215	bcd	241	ab	210	abc
PT UAN 100 inj+VT UAN 50 in-row drbl	183	abcde	228	a	238	abc	216	a

Table 2. Effect on N form and timing on yield at three Illinois locations over two years, 2014-2015. All treatments included N at a total rate of 150 lb N/acre. Means were separated at alpha = 0.10.

Treatment	**Avg 6 sites**	
PT UAN injected	216	abc
PT UAN 50 bdcst + V5 UAN 100 inj	214	abcd
PT 0 + V5 UAN 150 injected	218	ab
PT 0 + V9 UAN 150 dribbled row mid	214	abcd
PT UAN 100 inj + V5 UAN 50 injected	217	ab
PT UAN 100 inj + V5 U/AT 50 broadcast	214	abcd
PT UAN 100 inj + V9 UAN 50 dribbled	216	abc
PT UAN 100 inj + V9 U/AT 50 broadcast	212	bcd
PT UAN 150 dribbled between rows	208	d
PT Urea/AT 150 broadcast	219	a
PT SuperU 150 broadcast	219	a
PT ESN 150 broadcast	211	cd
PT UAN/AT 150 broadcast	209	d
PT NH_3 injected	210	cd
PT NH_3 with N-Serve injected	214	abcd

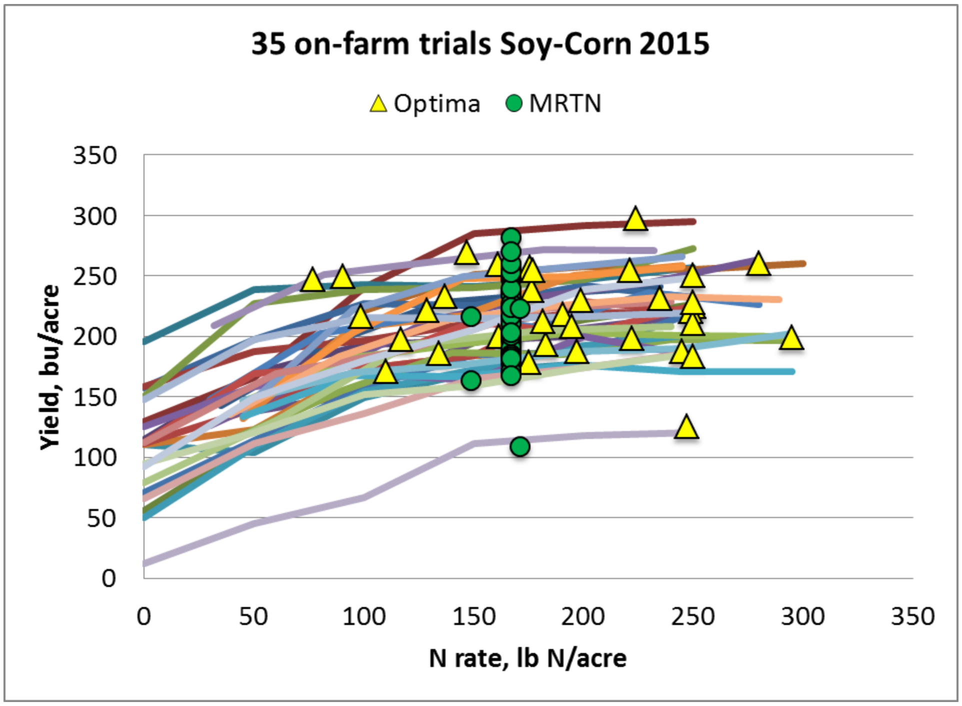

Figure 1. N responses in 35 on-farm N rate trials in Illinois in 2015. Yellow triangles indicate the optimum N rate for each curve, and green circles show yield at the MRTN N rate.

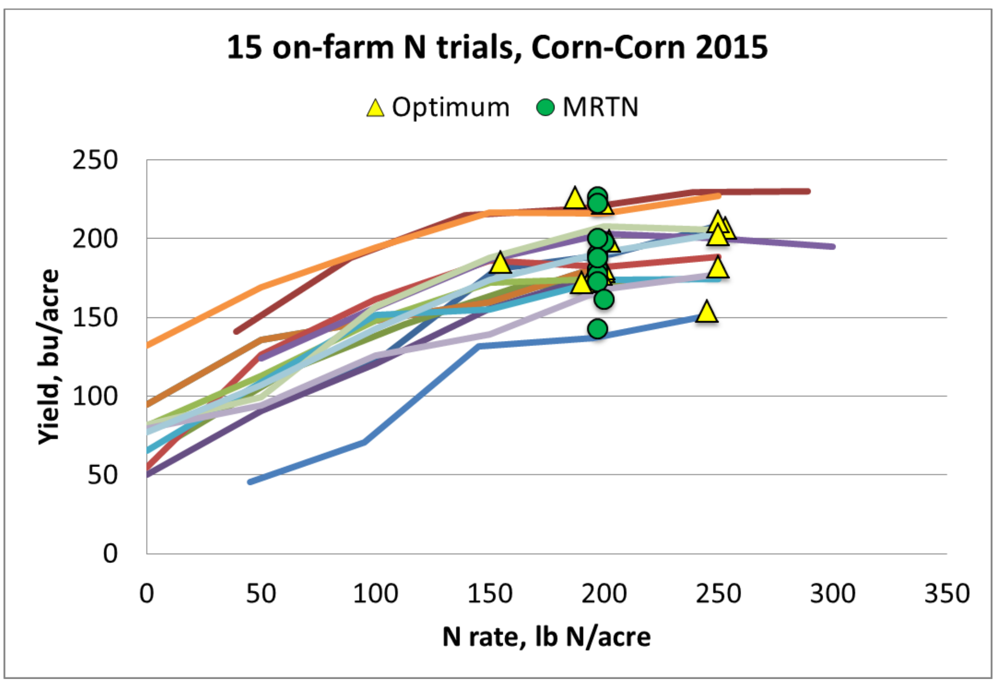

Figure 2. N responses from 13 on-farm N rate trials in Illinois in 2014. Yellow triangles indicate the optimum N rate for each curve, and green circles show yield at the MRTN N rate.

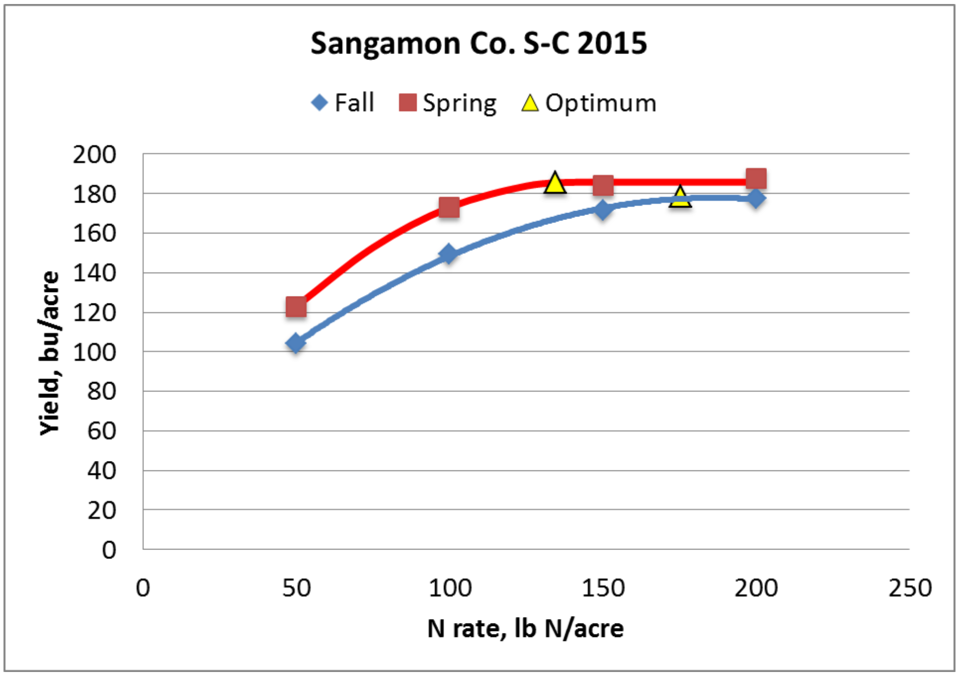

Figure 3. A comparison of fall versus spring N application at an on-farm site in central Illinois in 2015. The yellow triangles mark the N rates and yields at points of maximum return to N.

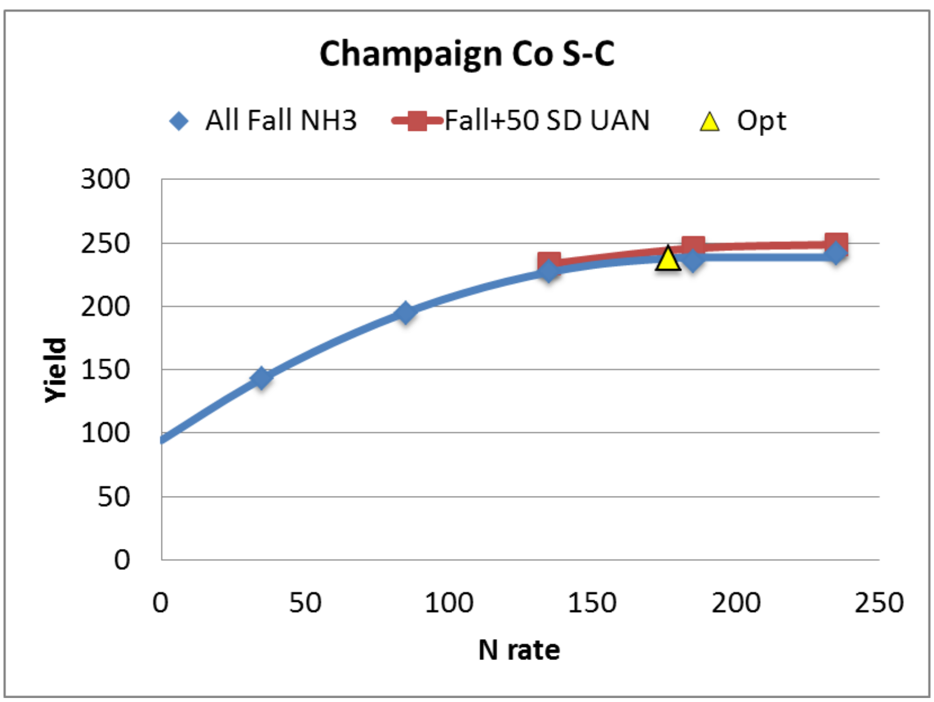

Figure 4. Response to N applied at NH_3 in the fall compared to applying the same rate split, with all but 50 lb applied in the fall and the remaining 50 lb applied as UAN sidedressed, in an on-farm trial in 2015.

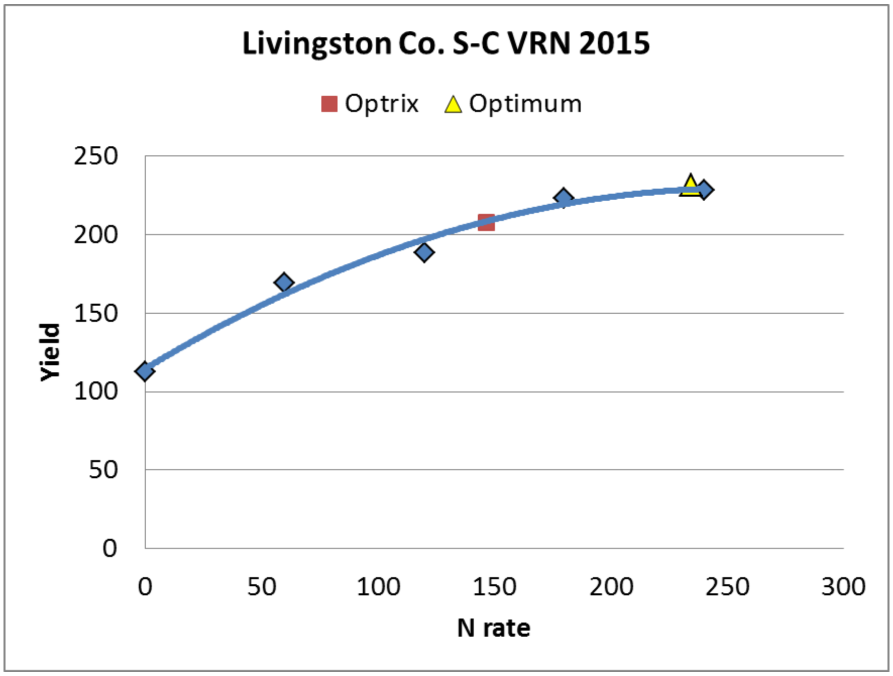

Figure 5. A comparison of variable-rate N (VRN) applied using Greenseeker® technology with uniformly-applied N in a trial in Livingston County, Illinois in 2015. Uniform rates were applied as 60 lb N at planting plus additional N at V7-V8, at the time the VRN application was made.

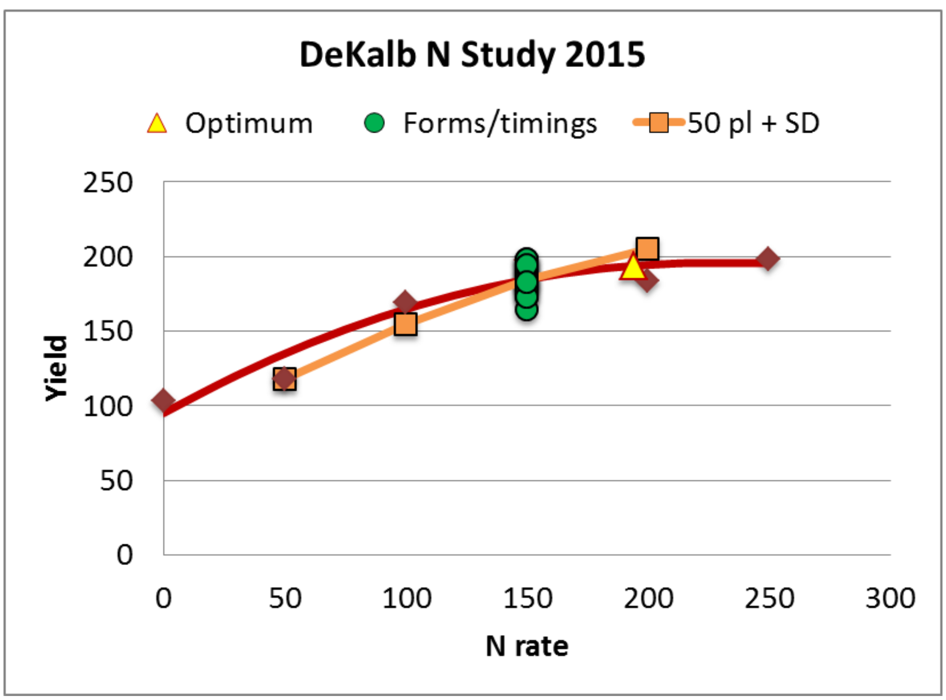

Figure 6. Responses to N rate, form, and timing at DeKalb, Illinois in 2015. Base rates were applied as UAN at planting time, and sidedress (SD) as 50 lb N at planting plus UAN at V5-V6. Form and timing treatments and yields are listed in Table 1.

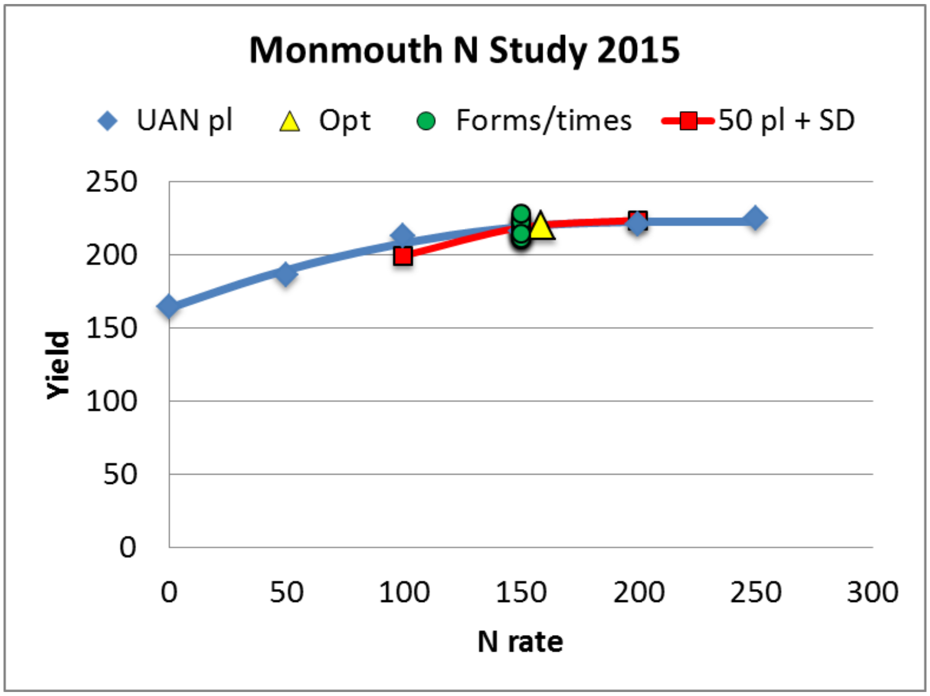

Figure 7. Responses to N rate, form, and timing at Monmouth, Illinois in 2015. Base rates were applied as UAN at planting time, and sidedress as 50 lb N at planting plus UAN at V5-V6. Form and timing treatments and yields are listed in Table 1.

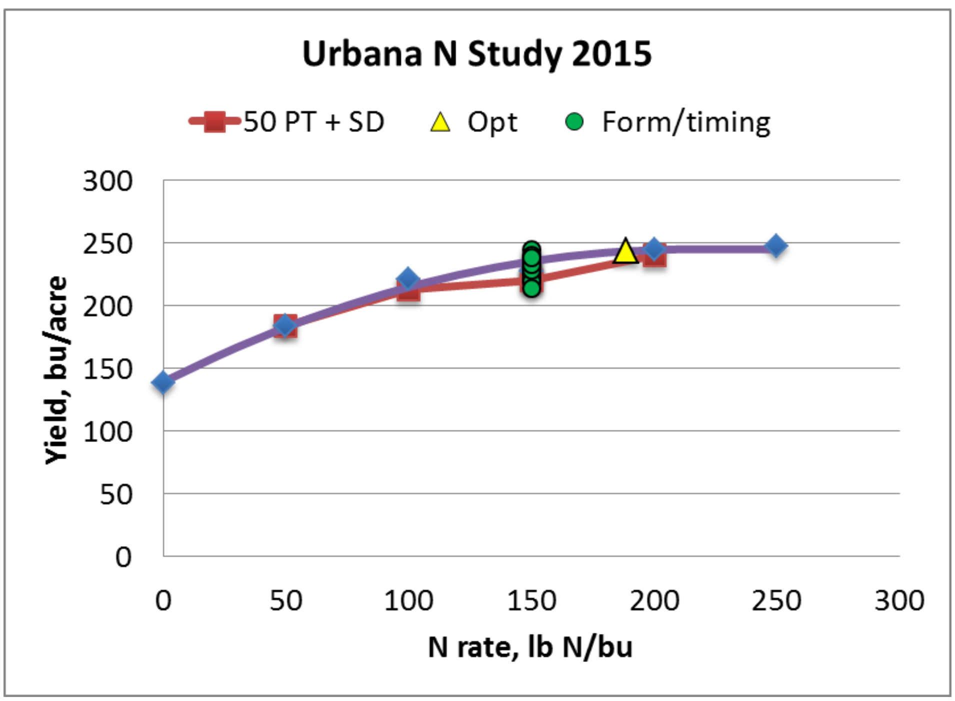

Figure 8. Responses to N rate, form, and timing at Urbana, Illinois in 2015. Base rates were applied as UAN at planting time, and sidedress as 50 lb N at planting plus UAN at V5-V6. Form and timing treatments and yields are listed in Table 1.