2018 Final Report Summary Sheet

Grantee Information

Project Title: A comprehensive corn nitrogen research program for Illinois

Institution: University of Illinois

Primary Investigator: Nafziger

NREC Project # 2014-3-360422-398

[redacted]

Is your project on target from an IMPLEMENTATION standpoint? ☒ Yes ☐ No
If you answered "no" please explain:

Is your project on target from a BUDGET standpoint? ☒ Yes ☐ No
If you answered "no" please explain:

Based on what you know today, will you meet the objectives of your project on-time and on-budget? ☒ Yes ☐ No
If you answered "no" please explain:

Have you encountered any issues related to this project? ☐ Yes ☒ No
If you answered "yes" please explain:

Have you reached any conclusions related to this project that you would like to highlight? ☒ Yes ☐ No
If you answered "yes" please explain:

A number of these are distributed throughout the report. The most conclusive finding to date are in regard to late-split N, planting-time versus split/sidedressed N: if there is enough N applied before or at planting, keeping some of the N back to apply in-season is unlikely to increase yields unless there is heavy rain between planting and mid-June. Results from on-farm trials are also noteworthy; there were responses to high N rates in some sites, including much of southern Illinois, in 2018, and in most of these cases, yields at optimum N rates were high. We also have further evidence of the need to have enough N available early in the season.

Have you completed any outreach activities related this project? Or do you have any activities planned? ☒ Yes ☐ No
If you answered "yes" please explain and provide details for any upcoming outreach:

These are detailed under "Outreach" on p. 5

Additional Notes:

I have received a no-cost extension for this project, and the small amount of funds left over will enable further work on the data and preparation of manuscripts for publication.

A COMPREHENSIVE CORN NITROGEN RESEARCH PROGRAM FOR ILLINOIS

2018 Annual Report to the Nutrient Research & Education Council

Emerson D. Nafziger, Department of Crop Sciences, University of Illinois, Urbana, phone 217 333-9658, email ednaf@illinois.edu and Dan Schaefer, IFCA Field Research Coordinator.

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. 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: EONR versus MRTN

In 2018, 69 trials were completed under this project, including 8 strip trials at UI Crop Sciences Research & Education Centers, done using the same design as in producer fields, but with slightly smaller plots. This exceeded the goal of completing 40 on-farm trials in 2018, not including the research center trials.

Figure 1 shows the N response data from 45 sites with corn following soybean in central and northern Illinois in 2018. 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 MRTN N rate from the N rate calculator, run for the appropriate Illinois region and previous crop for each trial, and for each trial we calculate the yield at that (MRTN) N rate. Averaged across these 45 sites, the average EONR value was 179 lb N/acre, and the average yield at the EONR was 240 bushels per acre. The average MRTN value across trials (the MRTN was 175 lb/acre in central and 157 lb/acre in northern IL) was 174 lb N/acre, and at the MRTN N rate, yields averaged 238 bushels per acre across the 45 sites. The actual "best" N rate averaged over these trials was 179 lb N/acre, or 5 lb. more than the average MRTN value, and the average yield at the EONR (240 bushels per acre) was 5 bushels more than the average yield that would have resulted from using the MRTN at each site.

At 5 lb. more N and 5 bushels more yield, using the EONR (if we could somehow have known what it was going to be for each field beforehand) would have returned on average about $16 per acre more than using the MRTN in 2018. By definition, using the EONR produces the higher net return (to N) per acre; the issue is that we can never know what the exact EONR will be. In one trial in 2018, the EONR was only 3 lb more than the MRTN, and in that field, using the MRTN would have produced income of only about 5 cents per acre less than using the EONR. On the other extreme, one trial in northern Illinois in 2018 needed 81 lb N more than the MRTN, and yielded 25 bushels more at the EONR than at the MRTN; in that field, using the EONR instead of the MRTN would have increased net income by $63.

In 2017, across 51 trials (including those in southern Illinois, which I'm separating out in 2018), using the actual EONR in each trial instead of the MRTN would have resulted in the use of 4 lb. more N and a yield of 4 bushels more, or about $11 more income per acre. In 2016, where dry weather early contributed to the soil N supply, the EONR averaged about 17 lb. N less and yielded only about 1 bushel more than using the MRTN rate, for an advantage of about $10 per acre over the MRTN. In 2015, with the very wet June, the crop needed about 25 lb. more N that the MRTN and would have yielded 9 bushels more, for an advantage of using the EONR of some $25 per acre. The ability to look across years and fields with N responses in this project has been very beneficial in lending perspective on predicting best N rates going forward. The 2018 data will be added (and some older data deleted) from the N rate calculator database in March, 2019, new numbers will be available to help guide Illinois N rates in 2019. The fact that responses in 2018 were not too different than those already in the database means that the updated numbers will not be greatly different that those produced in 2018 by the N rate calculator.

Figure 2 shows the N response from 10 on-farm sites with corn following corn in 2018. Averaged across sites, the EONR was a whopping 40 lb. N/acre less than the MRTN N rate (160 v 200 lb. N/acre), and average yield at the EONR was almost identical (220 bu/acre) to that at the MRTN rate. The net return to N averaged about $17 more at the EONR than at the MRTN, almost entirely due to the fact that the MRTN rate was so much higher than the amount of N that was actually needed. These results were similar to those in 2017, when using the MRTN across 10 corn-following-corn sites had no effect on average yield, but the MRTN was 18 lb. higher than the EONR. It's not clear why we're seeing what looks like more N coming from the soil in corn following corn these past two years than before.

John Pike worked with IFCA to establish 14 trials (all corn following soybean) in southern Illinois in 2018. These showed very high yields for southern Illinois, and also showed more response to N than we have seen in most years in southern Illinois (Figure 3.) In 11 of the 14 trials, the EONR was higher than the MRTN N rate; the average EONR was 34 lb N more than the MRTN (180 lb N/acre). Yield at the EONR averaged some 12 bushels more than the yield at the MRTN, and the return to N at the EONR averaged about $33 more per acre than the return to N at the MRTN N rate. Almost a third of this average increase in net return from using the EONR came from one trial, in which the response to N rate was linear; with linear responses, the EONR is usually the highest N rate used, which in this case was 285 lb/acre. On Figure 3, it's the yellow triangle farthest to the right. A few trials over the years—especially in wet years—have shown a linear response, so we can't dismiss this one as a fluke.

In 2018 there were 5 on-farm sites in which fall-applied and spring-applied NH_3 were compared in N rate trials. At one site in 2018, spring-applied N produced a response to a slightly higher N rate than did fall-applied N, and the yield at the EONR was also about 25 bushels higher from spring-applied compared to fall-applied N (Figure 4). This is not what we would expect: if some of the fall-applied N is not available to the crop in the spring, we would expect the largest yield advantage for spring-applied N to be at the lower N rates, with the lines moving together at higher N rates, rather than moving apart like they did. Yields in this trial are the highest we have seen in these on-farm trials, so N demand was high, but there is no good explanation for the higher yields coming at higher N rates. At their optimum N rates, spring-applied N produced 332 bushels per acre and fall-applied N produced 308 bushels per acre. In most of the other fall v. spring x rate trials in 2018 and previous years, we have found nearly identical responses to N, as shown in the example in Figure 5.

N Rate, Timing, and Form

Small-plot trials were conducted according to the project plan at DeKalb, Monmouth, Urbana and Perry in 2018, all corn following soybean. All were planted on time and managed well, with treatments applied as planned. 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. N at planting plus 50, 100, or 150 lb. N as UAN injected between the rows at stage V5-V6, with corn 12 to 16" tall. An additional 19 treatments were applied at the rate of 150 lb. N/acre using a range of timings, forms, and additives. Table 1 lists these treatments.

Figures 6 to 9 show N responses in the N form/timing studies at DeKalb, Monmouth, Urbana, and Perry. Yields were generally high in these trials in 2018, although dry weather limited N responses and yields some at Perry. Except at that site, optimum N rates were higher than we've seen in previous years; EONR values were 186, 184, and 250 (the highest rate used) at DeKalb, Monmouth, and Urbana, respectively, and yields at the EONR ranged from 239 to 250 bushels per acre. The EONR at Perry was only 120 lb N, and yield was 197 bu/acre; these are typical of sites where early dryness limits kernel number and so yield. Yields without N fertilizer, which is an indicator of the amount of N supplied by the soil, were 117, 166, 92, and 142 bushels per acre at DeKalb, Monmouth, Urbana, and Perry. Differences among forms and timing of N application at the same rate (150 lb N/acre in this case) tend to be more pronounced when the optimum N rate is higher than this rate, and this was apparent at Urbana, where the EONR exceeded he "test" rate by 100 lb. With EONR values only 30 or 40 lb higher than the 150-lb rate at DeKalb and Monmouth, we don't see this expanded range in yield at the test rate at those sites.

While different timings and forms of N compared at 150 lb. N per produced different yields, these differences were not very consistent among sites in 2018 (Table 1.) The yield range among these treatments was 30, 28, 40, and 24 bushels per acre at DeKalb, Monmouth, Urbana, Perry, respectively, and 22 bushels per acre when averaged across sites. These ranges were generally similar to what we found in 2017, with the exception of the wide range at Urbana. The smaller the range in yields, of course, the less likelihood of statistical differences, and the less "weight" yield rankings have when looking across sites. Conversely, a site where the yield range among treatments is large (as was the case at Urbana in 2018) has an oversized influence on the overall yield rankings. Still, inconsistency of performance among sites means less ability to declare differences to be statistically significant, so when averaged across sites there are few "significant" differences among treatments.

Across the four sites in 2018, the highest yield was from SuperU broadcast at planting (Table 1). The treatments ranked (across sites) from 2 through 9 all had an "a" in the letters behind them, meaning that they did not yield significantly less than the highest-yielding treatment. SuperU has been, somewhat unexpectedly, the highest-yielding treatment over 15 site-years of this work over the past 4 years (Table 2.) The "check" treatment of UAN injected between the rows at planting has been more or less average over site-years (ranked 10 out of 19 treatments – Table 2), but across sites in 2018, this treatment ranked only 15 out of 19, with below-average yields at Urbana and Perry (Table 1.) Few treatments have been consistently among the best or consistently among the worst in this research, but waiting until V5 or, especially, until V9 to apply the N has consistently produce low yields, as has broadcasting 50 lb N as UAN at planting (simulating use of UAN as a herbicide carrier) then 100 lb at V5 has also consistently underperformed. Other treatments with yields consistently in the lower half of this set of treatments include UAN applied to the soil surface, either dribbled at planting or broadcast with Agrotain, even though this latter treatment produced the highest yield across sites in 2017 (Table 2.) Those treatments with 100 lb N injected at planting and the remaining 50 lb applied in-season have shown overall good performance (Table 2), although the one we would consider most common – injecting the 50 lb as UAN at V5 – did not do very well in 2018 (Table 1.)

We continue to see evidence from these results that corn needs to have a good amount—we think half or more—of its N in the soil and available to the root system early, perhaps by stage V3, which is the stage when corn's nodal root system is developing. We believe that when soil N levels near the roots are low at this point, plants can suffer a loss in yield potential that cannot be corrected by later applications, even at high rates.

Evidence from this research project that supports this hypothesis include the following: 1) waiting until V5 to apply all of the N decreases yield, and waiting until V9 to apply all of the N decreases yield even more; 2) broadcasting 50 lb N at planting then sidedressing with 100 lb yields less than applying 100 lb at planting then 50 lb in-season; 3) NH_3 injected between rows to be planted, a week to several weeks before planting, with or without N-Serve, has, with a few exceptions, been a surprisingly poor treatment in this study, and we think the most likely explanation is that the N in the ammonia band isn't close enough to the row to allow small plants access this N until after the critical stage. Adding nitrapyrin to ammonia or (as Instinct) to UAN injected at planting does not improve performance, and occasionally lowers yield, perhaps because keeping more of the N immobilized as ammonium longer means more delay in the plant's getting access to the N; and 4) UAN dribbled on the surface between rows or broadcast on the surface at planting with a urease inhibitor, has not produced high yields. Dribbled N remains far from the rooting zone, and surface-applied UAN may be late reaching the rooting zone, the nitrate might move down past the rooting zone, or the N may be too diluted to adequately supply the small plants as their roots develop.

As additional evidence, we have in other studies observed substantial yield loss from having cover crop cereal rye with extensive root systems present when corn is planted; even if the rye has been killed earlier, it depletes soil N and may well leave the roots without N at the critical time. In one of the on-farm trials in 2018, corn followed corn, with N rates (without any other N) applied as UAN directed onto the soil surface at stage V6. This corn responded to N rates up to about 150 lb N, at which rate it yielded about 150 bushels. In the field surrounding this trial, corn following soybean yielded more than 230 bushels with less than 200 lb of N. We think that in the trial, the late application meant that plants did not have the N early enough to prevent yield loss. Finally, we have found in our N-tracking research that 50 lb N as UAN injected at planting followed by 150 lb N as UAN injected at sidedress time often fails to produce yields as high as those with spring or fall-applied ammonia at 200 lb.

Until we have better evidence to explain this yield loss with delayed N in a way that allows us to prevent it otherwise, we need to manage N in a way that assures that the plants will have an adequate supply of N available by stage V2 or V3; that is, applied before, during, or right after planting. This could be done with planter-applied N, but the rates would need to be higher than in-furrow placement allows. We believe that if a lot of the water the plant takes up during this period is low in N, even having some of the root system in, say, a 2x2 band may not be adequate. When soils have warmed and have adequate water as this stage approaches, mineralization can probably supply all of the N that the plants need to take up, although this may not be adequate if it turns wet, which dilutes the N and may lower root uptake.

Planting-time versus split/sidedressed N

In 2016 and 2017, we completed a set of trials at 15 site-years designed to see if keeping back 50 lb. of N to apply (by dribbling into the row) at tasseling time would increase yields or lower optimum N rate without sacrificing yields. We found basically the same response to N regardless of whether we applied all early or kept 50 lb. back to apply at tassel. Derek Rapp completed his MS degree in spring 2018, using the late-split N trials as his thesis project. We hope to submit this for publication soon.

Because we saw virtually no response to keeping back the last 50 lb of N to apply at tasseling, we revised this study in 2018 to move the last application (50 lb) to normal sidedress time instead. We still applied the last 50 lb as in-row dribble, by hand, like we did with the tassel-time application previously. Eight trials were conducted in 2018, in corn following soybean at DeKalb, Monmouth, Urbana, Perry, and Neoga, and in corn following corn at Monmouth, Urbana, and Perry. These trials differed from most of our small-plot trials in that plots lengths are typically 100 feet or more, more like on-farm strip trials.

Applying N rates at planting or keeping 50 lb. N to apply at sidedress produced virtually identical N responses in both corn following soybean and in corn following corn. The only example shown here is the corn following soybean trial at Urbana (Figure 10); the others all look much like this one. Over all 8 sites, the average EONR when all of the N was applied at planting was 164 lb N/acre, and with the split-sidedress treatment the average EONR was 167 lb N, or 3 lb more. The average yield at the EONR with all N applied at planting averaged 236 bushels per acre, about 3 bushels more than for the split-N treatment. The “return to N” (RTN) is calculated by taking the yield at the EONR minus the yield without N, multiplying that difference by $3.75 per bushel, and then subtracting the EONR times $0.375 per lb of N. In every trial, split-sidedress N showed a lower RTN than the all-early N treatment; the range was from $1.55 to $28.51 per acre less for the split-sidedress system, and the average was $8.55 per acre. That’s not very much, but it’s clear that even if we knew exactly how much N to use, or if we simply use the MRTN N rate in all cases, splitting N to apply the last increment at sidedress did not, in any of these trials, increase yield. Including the cost of sidedress application would have meant lower net income at each of these sites in 2018.

Our small-plot studies under this project include a comparison of N at three rates – 100, 150, and 200 lb. N/acre – applied either as UAN injected at planting or with 50 lb. N injected at planting and the remaining 50, 100, or 150 lb N sidedressed at V5-V6. Data from 18 site-years comparing N responses between these two methods of application show that yield at the 100-lb. rate was higher (by 13 bushels) with all-early application than with split application (Figure 11). At the two higher N rates, the yield difference was about 3 bushels per acre, higher with early application at both rates. The optimum N rates were exactly the same (184 lb N/acre) for the two application treatments, and yield at that rate was 4 bushels per acre higher for all-early N than for split/sidedressed N. Such differences are small, but it is clear that our expectation that split N with a sidedress application might require less N, and perhaps yield more, was not supported by these results. Finding a lower yield with split application at the low rate (100 lb. of N) supports the idea (detailed above) that not having enough of the N in the soil early might sometimes result in N deficiency and yield loss that can't be overcome by later application of N.

DAP as an N source

This 3-year study was added to this project in 2016, and consisted of applying N rates of 100 (the base rate using UAN only), 120, 140, 160, and 180 lb. N/acre using three N source/timing combinations: 1) DAP broadcast in the fall after soybean harvest 2) DAP broadcast in the spring before secondary tillage; and 3) UAN + Agrotain injected in the spring before secondary tillage. TSP (0-45-0) was used to bring the P rate to the same for each treatment. Rates were assigned to main plots, and source to subplots, with 6 reps to better detect small differences.

These trials were done exactly according to plan, at Monmouth and Urbana, in each of the three years, including 2018. Results from all six site-years are shown in Figure 12. Although results were somewhat inconsistent within some individual sites, across all six sites we found that all three sources of N in this experiment produced the same yields and same responses to N. The clear message from this experiment is that the N from DAP should all be counted as part of the N supply for the corn crop. A possible exception might be when DAP is applied in the fall soon after soybean harvest, to soils that are warm and likely to stay warm (and occasionally wet) for a month or more after application. Such conditions will allow the N to move into the soil, where some nitrification is likely to take place before soils cool down. While it would be difficult to measure such small differences after DAP application, it makes sense to subtract 20 or 30% of the N applied as DAP from the N supply when the DAP is applied in late September or early October, while soils are still warm.

Outreach

Results of this work were made known through the Extension presentations, including the IFCA Conference in January 2018, and webinars in February and October, 2018. Several Bulletin articles addressing N management were published in 2018, and these were also provided to IFCA for addition to their website, and to Farmdoc Daily, which provides a wider audience. I spoke at meetings using results from this research project in Ontario (CN) in February, 2018; at a nutrient management conference in Mankato, MN organized by University of Minnesota Extension in February, 2018; in Livingston County, IL, at the Crop Management Conferences (4 around Illinois) in January-February, 2018; at Manhattan, KS (NUE conference); Baltimore, MD (ASA meeting); the 4R field event at Auburn, IL in the fall of 2018, and to a number of individuals with questions about N management. Credit was given to NREC for funding in each presentation. Audience totals for in-person presentations over the past year is estimated at 1,500.

Although the field phase of this research has ended, I plan to continue to write and speak throughout 2019 on topic related to this research.

Budget

Expenditures throughout the 5 years of this project (initially 3 years, extended through 2018) are listed below, against budgeted amounts. I was recently granted a no-cost extension through 2020, and plan to use the funds to provide myself (in retirement) a small percentage as I continue to assemble and to write up results of this research over the next 18 months or so. As part of this, I plan to continue to report on findings of this research as they come out, and I will remain active in speaking and writing in a small-percentage Extension appointment over the next year.

The financial summary of this project (NREC 2014-3-360422-398) from its beginning in 2014 through February 25, 2019 is provided below. More than 95% of the budget will have been spent by March 1, 2019.

Line Description	Budget	Expenditures	Encumbrances	Balance
Total Salaries and Wages	257,017	245,184	17,576	9,820
Total Fringe Benefits	74,828	75,374	277	-823
Total Travel	10,500	12,661	0	-2,162
Total Other Direct Costs	86,104	71,731	2,500	11,873
Total Indirect Costs	47,456	44,950	532	1,974
Project totals	**475,905**	**449,900**	**5,322**	**20,683**

Table 1. Effect of N form and timing on yield at four Illinois sites in 2018, and averaged across sites. All plots received 150 lb. of N per acre. Treatments are ranked (1=highest yield to 19) by site and across sites. The same letter following averages across sites means that two numbers aren't significantly different (10% level).

Treatment	DeKalb		Monmouth		Urbana		Perry		4 sites, 2018		
	Yield	Rank	Yield	Rank	Yield	Rank	Yield	Rank	Yield	Rank	Sep 0.1
All N applied at planting:											
UAN injected mid-row (check)	232	4	243	10	208	16	186	19	217	15	efg
UAN dribbled mid-row	220	12	249	7	210	14	197	12	219	12	def
Urea/Agrotain broadcast	219	13	251	3	210	13	195	15	219	13	def
SuperU broadcast	230	8	250	4	231	2	205	3	229	1	a
ESN broadcast	217	14	257	1	226	5	197	11	224	6	abcde
UAN/Agrotain broadcast	216	16	244	9	200	17	199	7	215	16	fg
NH3 injected mid-row	222	11	241	13	232	1	198	9	223	8	abcde
NH3/N-Serve injected mid-row	230	7	253	2	228	3	199	6	228	4	abc
UAN/Instinct II injected	217	15	240	15	214	11	198	8	218	14	defg
Split N application (1st at planting):											
UAN 50 broadcast+UAN 100 injected V5	213	18	237	17	192	19	198	10	210	18	gh
UAN 100 inj+UAN 50 injected V5	228	9	242	11	212	12	197	13	220	11	cdef
UAN 100 inj+Urea/AT 50 broadcast V5	230	6	247	8	216	9	207	2	225	5	abcd
UAN 100 inj+UAN 50 dribbled in-row V9	232	5	250	6	215	10	196	14	223	9	abcde
UAN 100 inj+Urea/AT 50 broadcast V9	235	2	250	5	228	4	199	5	228	2	ab
UAN 100 inj+UAN 50 dribble in-row V5	235	1	242	12	224	7	210	1	228	3	ab
UAN 100 inj+UAN 50 dribble mid-row VT	222	10	239	16	225	6	194	16	220	10	bcdef
UAN 100 inj+UAN 50 dribble in-row VT	234	3	241	14	221	8	200	4	224	7	abcde
All N sidedressed:											
UAN injected mid-row V5	206	19	236	18	193	18	190	18	206	19	h
UAN dribbled mid-row V9	214	17	229	19	209	15	190	17	211	17	gh

Table 2. Effect of N form and timing on yield ranked averaged over three Illinois sites in 2015 and four sites each in 2016, 2017, and 2018. All treatments included N at a total rate of 150 lb. N/acre. Means across all 15 site-years were separated at p=0.1.

Treatment	Rank (1 to 19)					Yield	
	2015	2016	2017	2018	2015-18	bu/acre	
All N applied at planting:	(3)	(4)	(4)	(4)	(15)		
UAN injected mid-row (check)	7	7	11	15	10	224	bcde
UAN dribbled mid-row	19	13	4	12	15	222	cde
Urea/Agrotain broadcast	9	1	18	13	12	224	bcde
SuperU broadcast	1	2	7	1	1	229	a
ESN broadcast	12	3	19	6	7	225	abcd
UAN/Agrotain broadcast	17	18	1	16	16	221	def
NH3 injected mid-row	18	11	6	8	13	223	bcde
NH3/N-Serve injected mid-row	16	15	15	4	14	223	bcde
UAN/Instinct II injected	13	16	17	14	17	221	def
Split N application (1st at planting):							
UAN 50 broadcast+UAN 100 injected V5	15	9	13	18	18	220	ef
UAN 100 inj+UAN 50 injected V5	4	14	10	11	9	224	bcde
UAN 100 inj+Urea/AT 50 broadcast V5	5	10	3	5	2	227	ab
UAN 100 inj+UAN 50 dribbled in-row V9	8	5	2	9	3	227	ab
UAN 100 inj+Urea/AT 50 broadcast V9	11	8	5	2	4	227	ab
UAN 100 inj+UAN 50 dribble in-row V5	2	6	14	3	5	226	ab
UAN 100 inj+UAN 50 dribble mid-row VT	14	4	9	10	8	225	bcd
UAN 100 inj+UAN 50 dribble in-row VT	3	12	12	7	6	226	abc
All N sidedressed:							
UAN injected mid-row V5	6	17	8	19	11	224	bcde
UAN dribbled mid-row V9	10	19	16	17	19	217	f

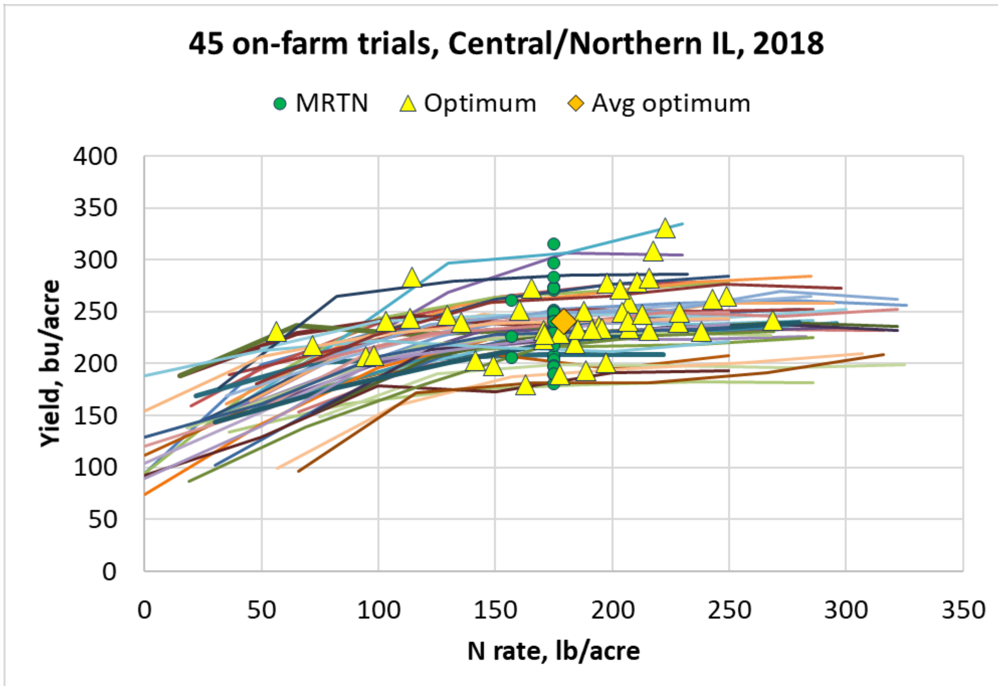

Figure 1. N responses in 45 on-farm N rate trials in central and northern Illinois where corn followed soybean in 2018. Yellow triangles indicate the optimum N rate for each trial, and the orange diamond is the average of these values. The green circles show MRTN N rate and yield at that N rate. The three MRTN circles on the left are for northern Illinois sites; the others are for central Illinois.

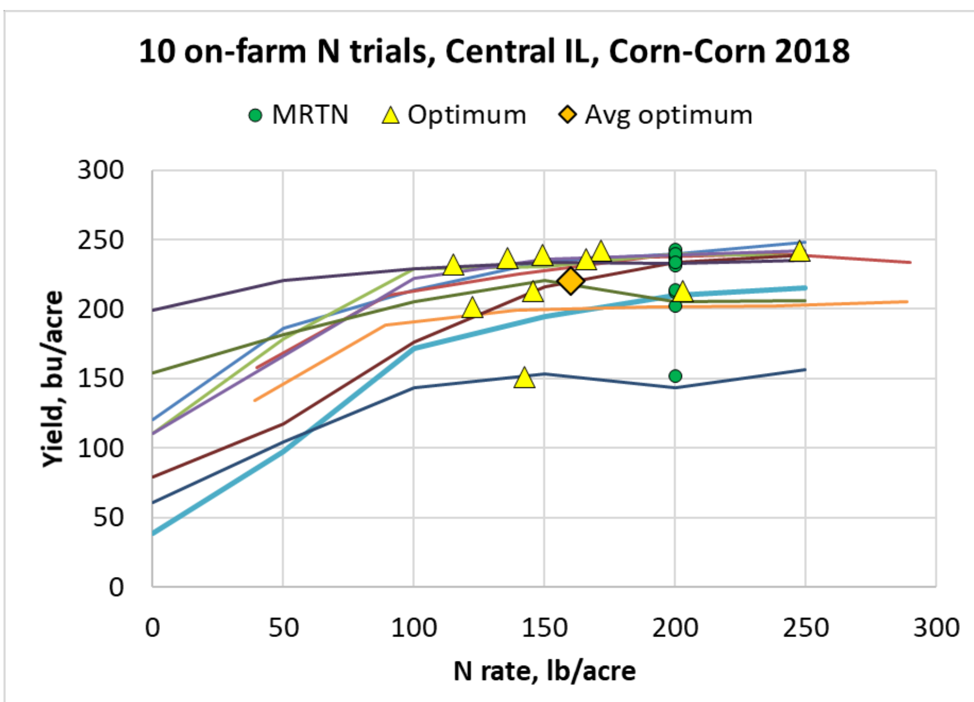

Figure 2. N responses from 10 on-farm N rate trials with corn following corn in Illinois in 2018. Yellow triangles indicate the optimum N rate for each curve, and the orange diamond is the average of these values. The green circles show the MRTN N rate yield at that N rate for each trial.

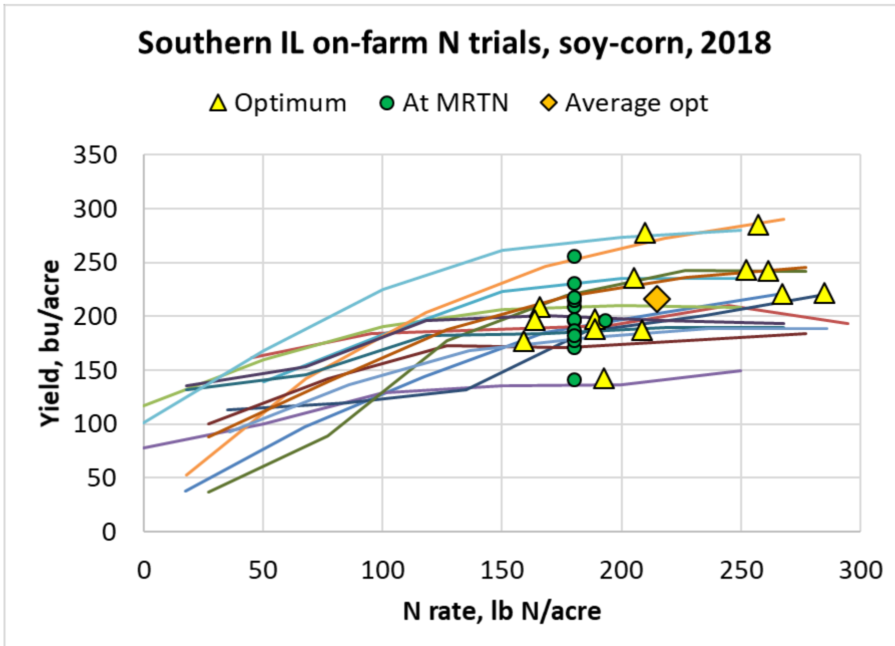

Figure 3. N responses from 14 on-farm N rate trials with corn following soybean in southern Illinois in 2018. Yellow triangles indicate the optimum N rate for each curve, and the orange diamond is the average of these values. The green circles show the MRTN N rate yield at that N rate for each trial.

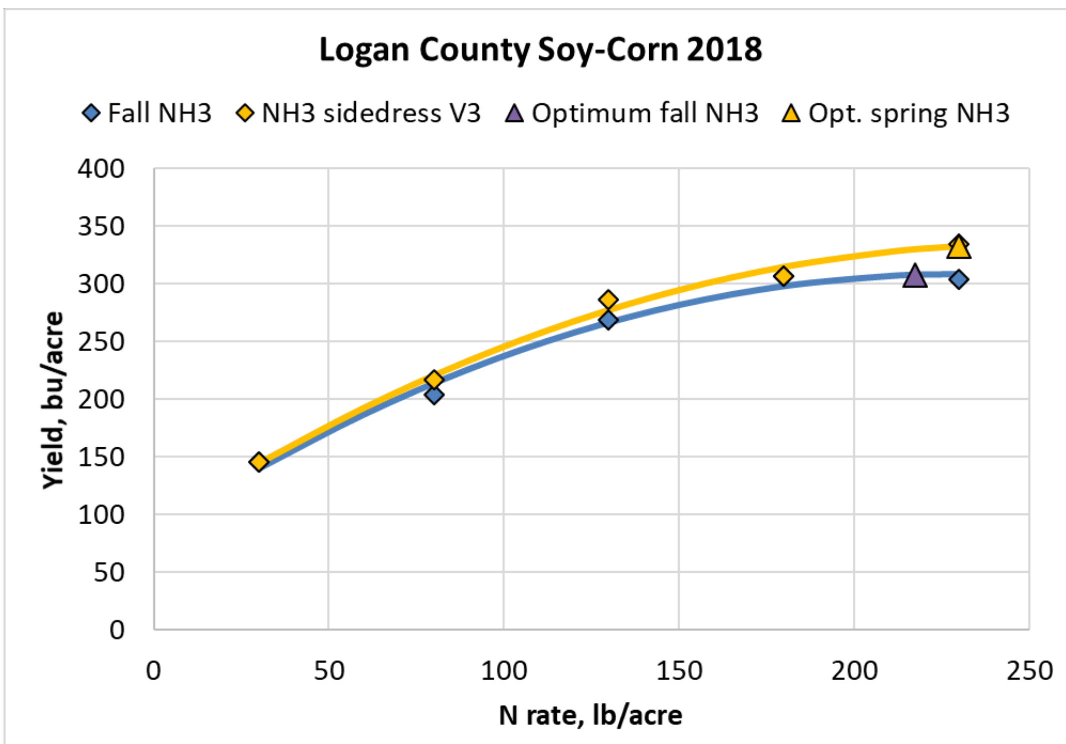

Figure 4. A comparison of fall versus spring N application at an on-farm site in central Illinois in 2018. The blue triangle marks the N rate and yield at the point of maximum return to N for fall-applied NH_3, and the orange triangle does the same for spring-applied NH_3.

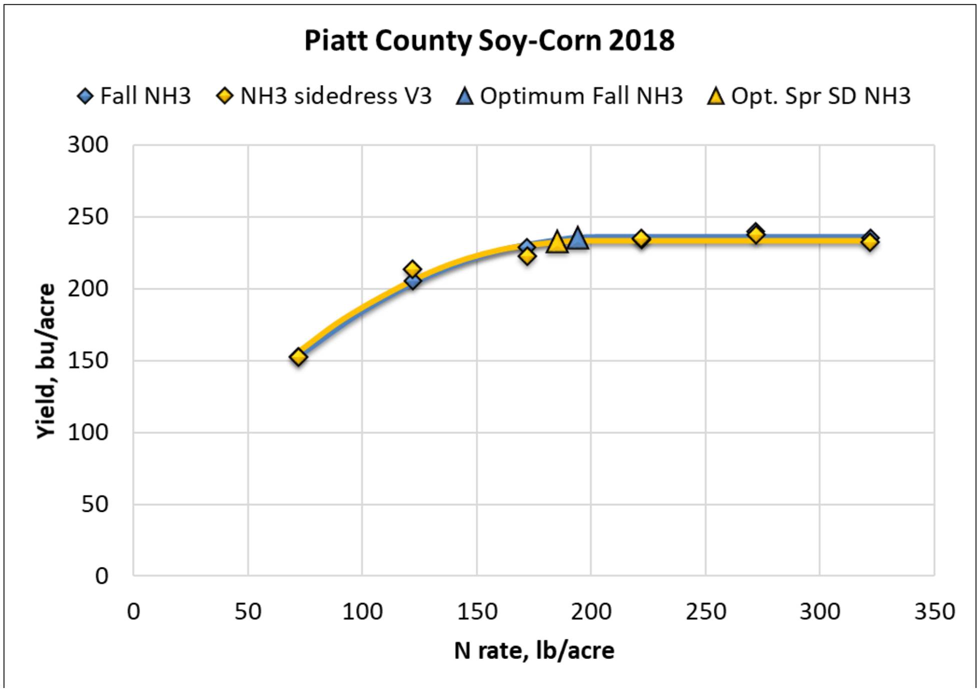

Figure 5. A comparison of fall versus spring N application at an on-farm site in east-central Illinois in 2018. The blue triangle marks the N rate and yield at the point of maximum return to N for fall-applied NH_3, and the orange triangle does the same for spring-applied NH_3.

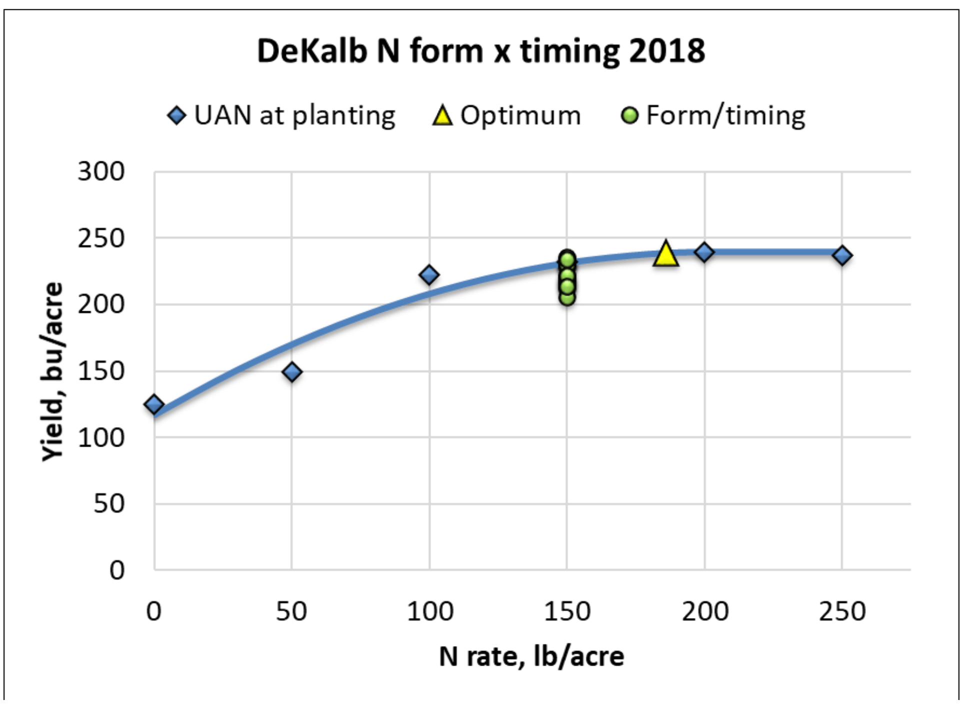

Figure 6. Responses to N rate, form, and timing at DeKalb, Illinois in 2018. Base rates were applied as UAN at planting time. Form and timing treatments and yields are given in Table 1.

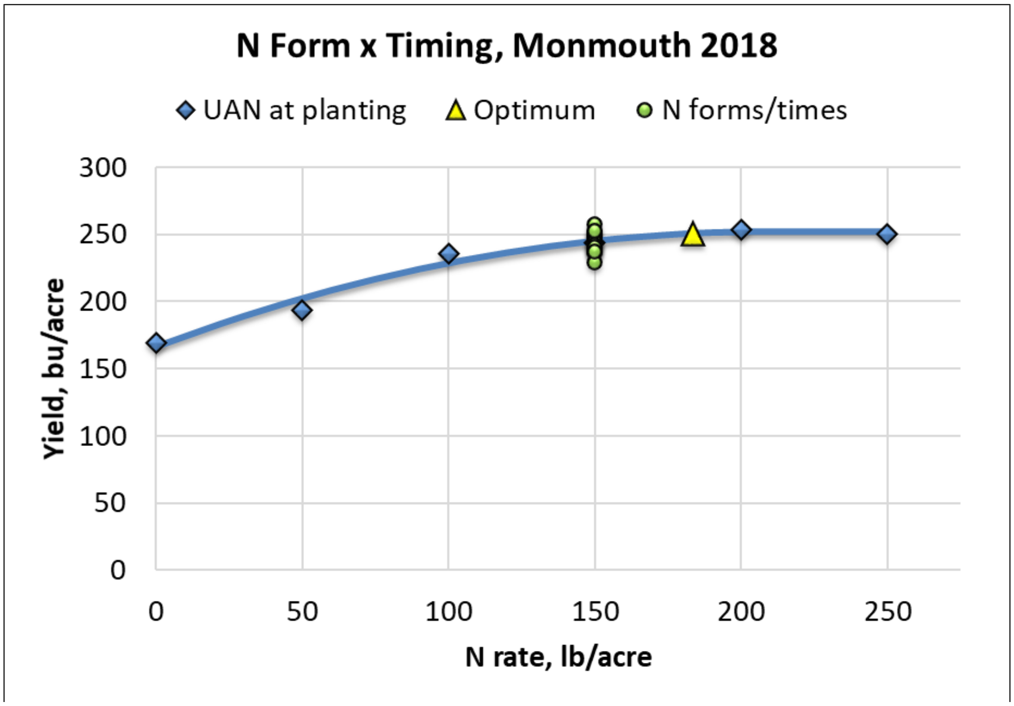

Figure 7. Responses to N rate, form, and timing at Monmouth, Illinois in 2018. Base rates were applied as UAN at planting time. Form and timing treatments and yields are given in Table 1.

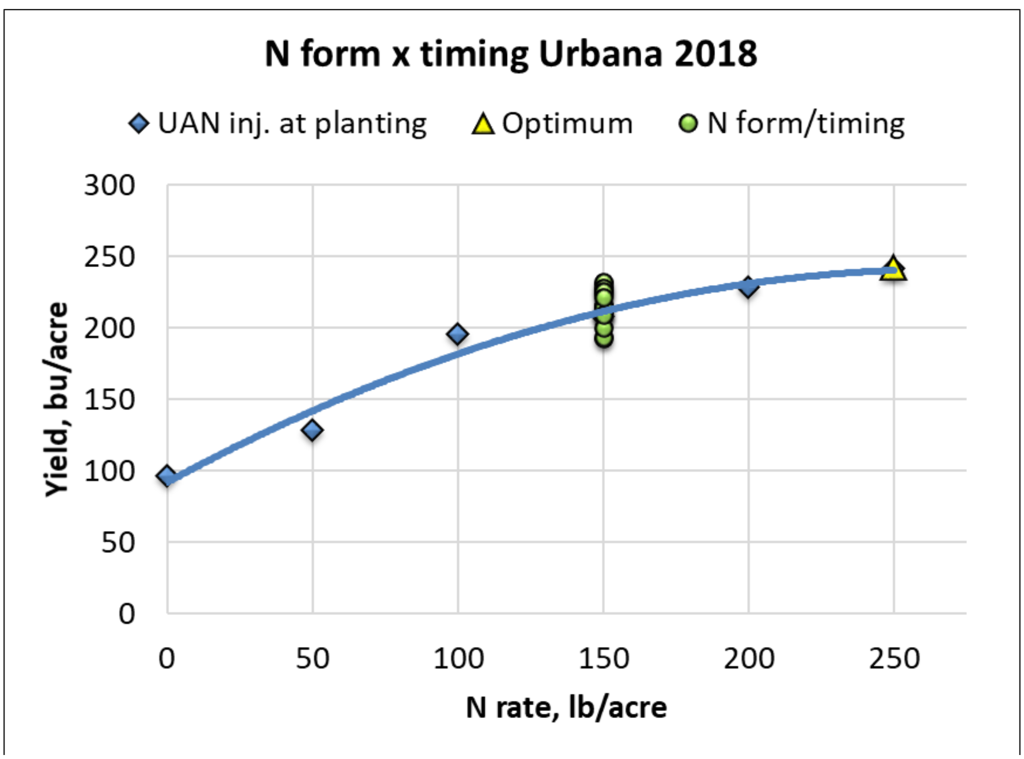

Figure 8. Responses to N rate, form, and timing at Urbana, Illinois in 2018. Base rates were applied as UAN at planting time. Form and timing treatments and yields are given in Table 1.

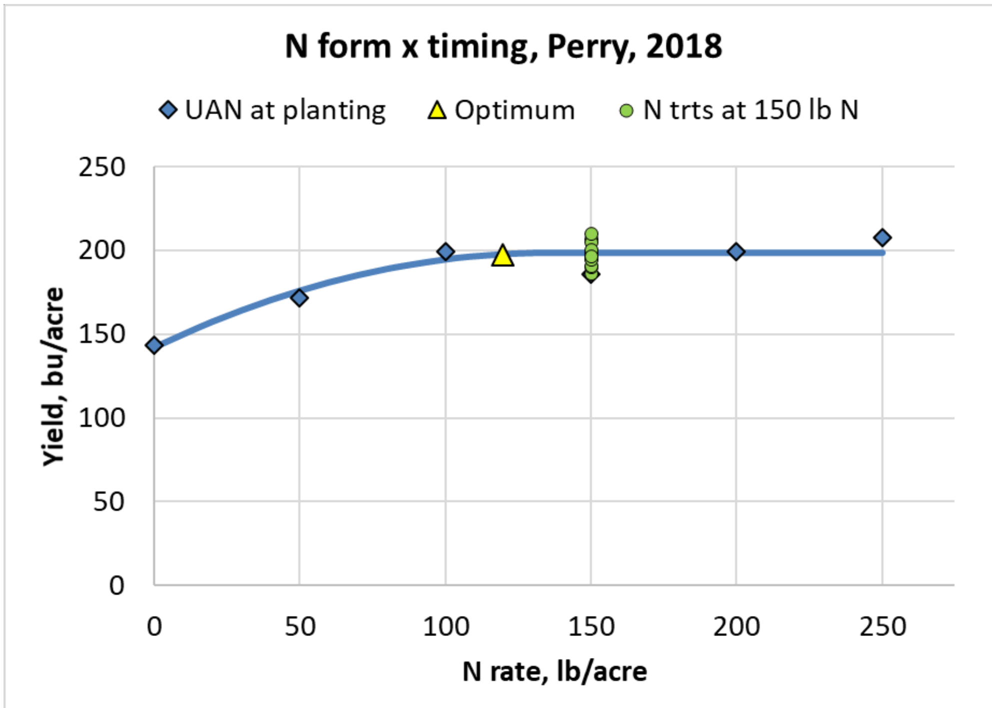

Figure 9. Responses to N rate, form, and timing at Perry, Illinois in 201. Base rates were applied as UAN at planting time, and sidedress as 50 lb. N at planting plus UAN at V5-V6. Form and timing treatments and yields are given in Table 1.

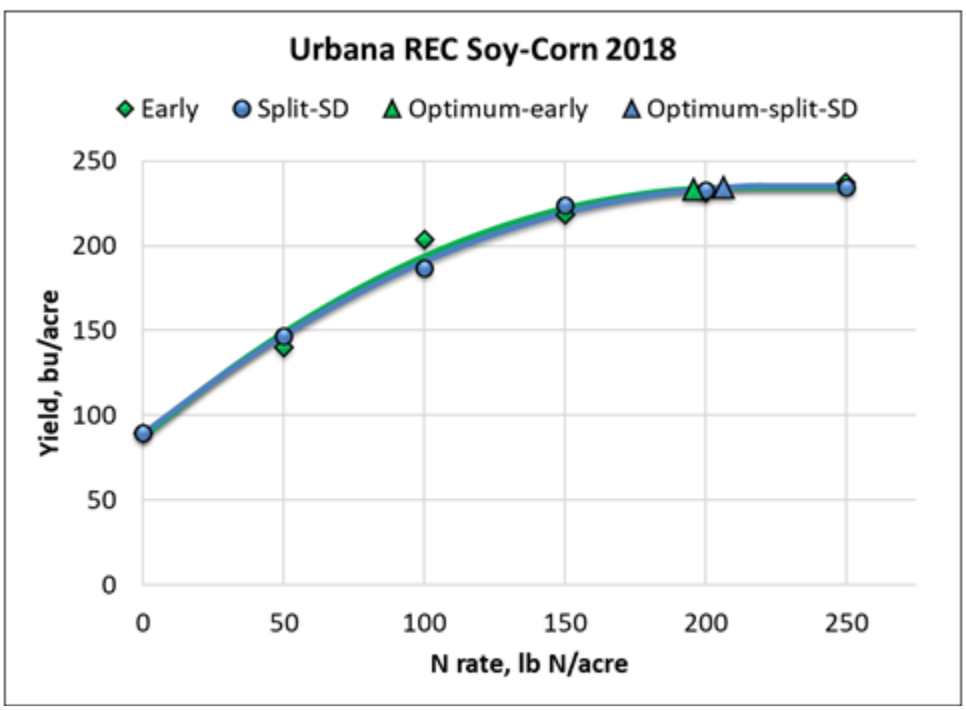

Figure 10. Response from N applied at planting time compared to N split into planting-time and 50 lb. N as UAN dribbled into the row at sidedress time (stage V5-V6). Data are from a corn following soybean trial at Urbana, Illinois in 2018.

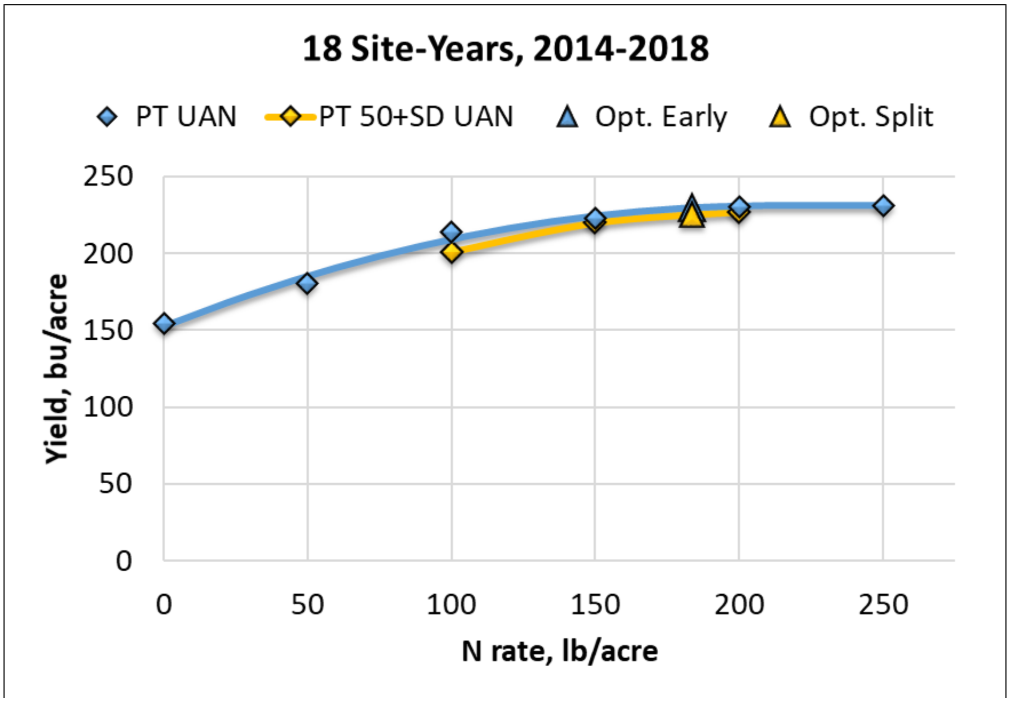

Figure 11. Responses to N rate for N applied as injected UAN at planting compared to 50 lb. N injected at planting and the remaining N sidedressed at V5-V6. Data are averages over 18 Illinois site-years, 2014-18.

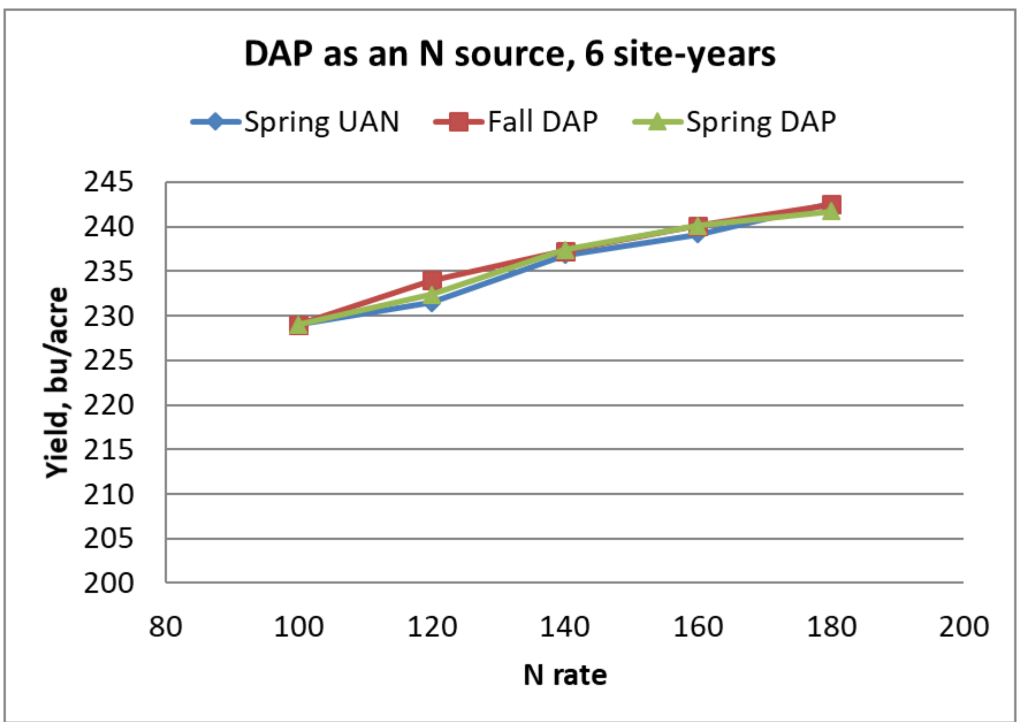

Figure 12. N responses to N rates supplied as fall-applied DAP, spring-applied DAP, or injected UAN in the spring. The base of 100 lb N/acre was supplied as UAN injected at planting, and the amount of P applied was leveled across plots using 0-46-0. Data are from six trials, at Urbana and Monmouth for three years, 2016-2018.