ARE WE GETTING BETTER AT SUPPLYING CORN WITH NITROGEN?

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INTRODUCTION

While the MRTN approach to making N rate guidelines is an improvement over previous methods, there remains the question about whether or not the database is sufficiently large to support the results adequately. This question is brought into focus when N rates used according to the MRTN guidelines are seen (or at least perceived) as being be inadequate in a given field or area in a given year. Other entities now making N rate recommendations may also market against the MRTN approach by raising doubts about the adequacy of the calculator N rate. Generating additional data from on-farm N rate trials provides a means to both strengthen the basis for the calculator and also to test the performance of the calculator rates against actual EONR values.

On-farm N rate trials, while they provide valuable information, are not well-designed to compare the large number of N management systems from which producers can choose today. Those promoting different systems, often through marketing of hardware, software, and new products related to N form, timing, and application technology. The stated goal of such efforts is generally to help fine-tune N management in order to improve both economic and environmental soundness.

We initiated a research project in 2014, funded by the Nutrient Research & Education Council (NREC) which administers fertilizer checkoff funds in Illinois, to conduct additional on-farm N rate trials and to compare, using small-plot trials, the effect of different N forms, nitrification and urease inhibitors, and N applications times on corn yield.

One major uncertainty in N management is the extent of loss of fertilizer N under wet spring conditions. Such loss can be modeled, but models may not include current N management practices, and outputs from such models are neither widely available nor well-accepted by producers for individual fields. We initiated a second project beginning in 2015 to see if we could track soil N through the spring in order to develop a better understanding of N movement, and perhaps to develop a better guideline concerning the need to apply more N following loss events.

MATERIALS AND METHODS

On-farm trials were conducted using farmer's equipment, typically with rate strips 12 rows wide with 6 rows harvested for yield. The form and timing differed among sites, and in some cases included comparisons between fall- and spring-applied N, or between planting-time and split applications. Comparisons between timings were done by splitting the timing treatment within rate strips. All on-farm trials were conducted with three replications in a RCBD design. Yields were taken using yield monitors or a weigh wagon.

Small-plot trials were used to compare rate, form, and timing of N application at University of Illinois Crop Sciences Research and Educations Centers at DeKalb, Monmouth, and Urbana. The base N response (against which other treatments were compared) was generated with UAN applied by injection at planting, with 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. An additional 13 treatments were applied at the rate of 150 lb N/acre using a range of timings, forms, and inhibitors in 2014, and four additional treatments, including application of the last N at tasseling time, were added in 2015. Table 1 lists these treatments. Treatments were applied in 4-row plots about 50 ft. long, with broadcast and surface-banded (dribbled) treatments applied by hand, and injected treatments applied using a 5-knife applicator. Yields were measured using a plot combine.

In the N-tracking study, treatments were applied as described above. Soil samples were taken from banded treatments using a template, with 11 holes spaced 3 inches apart in a board 30 inches long. This board was placed between rows and soil samples pulled from the 012" and 12-24" depths. Samples from across the template for each depth were combined into a single sample, and sent to Brookside Lab, New Knoxville, OH for analysis of nitrate and ammonium.

RESULTS AND DISCUSSION

On-farm N rate trials

The 2014 growing season was very favorable for corn in Illinois, with a statewide average yield of 200 bushels per acre. The crop was planted at an average pace and developed well. Temperatures were average except that July temperatures averaged about 5 degrees less than normal. There was little stress, but rainfall was somewhat higher than normal from mid-May through mid-June in parts of central Illinois, including in Champaign-Urbana. It's likely, though, that potential for N loss during vegetative development was not much different from average in most parts of the state.

Figure 1 shows the response curves from 18 on-farm sites with corn following soybean in 2014. Each response was fitted with a quadratic or a quadratic+plateau curve, whichever best fit the data, and the point at which return to N was maximized (the economically optimum N rate, or EONR) was calculated for each curve using a price of \$0.45 per lb of N and a corn price of \$3.75 per bushel. In addition, we used the MRTN rate from the N rate calculator at these same prices, and for each curve we show that rate and the yield predicted at that rate. Averaged across all 18 sites, the MRTN N rate was 17 lb N per acre less than the average of the EONR values, and average yield predicted at the MRTN was 6 bushels less than that at the EONR. The net effect was a return to N that was about \$17 per acre less from using the MRTN at each site rather than the actual EONR calculated from the N response in each field.

Figure 2 shows the response curves from 13 on-farm sites with corn following corn. Averaged across these sites, the MRTN rate was 17 lb. N per acre less than the average EONR, and yield from using the MRTN rate was 7 bushels less than actual yields at the EONR. The net return to N averaged about \$20 less using the MRTN than if we could have known and used the EONR for each field. The responses to N for corn following corn included two sites where yield responded linearly to N, up to 250 lb of N. Those both had an EONR of 250 lb N, and of course showed large losses of yield and net return to N at the MRTN rate.

Results from the six sites where N was split to compare fall versus spring or early spring versus sidedress N rates showed little difference yield or in response to N timing in 2014. A typical response to fall versus spring is shown in Figure 3. Splitting N in the spring likewise tended to have little effect on N response or yield (Figure 4.) If we accept that 2014 represented a typical year with regard to potential for N loss, it does not appear that splitting N into two applications will routinely enable producers to lower N rates compared to rates used when applying all of the N early. In this case, "early" appears to include application of NH_3 with N-Serve in the fall.

N form, rate, and timing

Compared to the 2014 cropping season, the 2015 season started out well and produced high yields, but June was very wet, with an average of more than 9 inches of rainfall over the entire state of Illinois, including at the Urbana site. There was a lot of crop damage from standing water in Illinois, but not in these plots. Yields and the N response in 2015 were very similar to those in 2014.

Data from only the Urbana site will be presented and discussed here. The response to N rate generated using UAN injected at planting produced an EONR value of 196 lb. N and yield at the EONR 236 bushels per acre in 2014 (Figure 5); in 2015, with a nearly-identical response, the EONR of 188 lb. N produced a yield of 244 bushels per acre. Applying 50 lb. N as UAN at planting with the remainder sidedressed as injected UAN showed no benefit at any of the N rates compared to applying all of the N at planting in 2014 (Figure 5); this was also the case in 2015.

The different timings and forms of N compared at 150 lb. N per acre produced statistically different yields in both 2014 and 2015 at Urbana, but with considerable inconsistencies between years (Table 1). The yield range among these treatments was 25 bushels per acre in 2014 and 31 bushels in 2015. From the response curve with planting-time UAN, the predicted yield at 150 lb. N was 227 bushels in 2014 and 236 bushels in 2015; both exceeded slightly (by 4 and 8 bushels in 2014 and 2015, respectively) the actual yield at that N rate shown in Table 1. In 2014 the highest-yielding treatment (urea + Agrotain broadcast at planting) yielded 14 bushels more than the predicted yield at 150 lb N; in 2015 the highest-yielding treatment (SuperU broadcast at planting) yielded 9 bushels more than the predicted yield at 150 lb/acre of UAN at planting.

In both years, urea with Agrotain and SuperU broadcast at planting produced the two highest yields (Table 1). This was unexpected, not only because these treatments are uncommon, but also because they do not involve a delayed application of N, which we would have expected to be beneficial especially with the wet June weather in 2015. Surprisingly, NH_3 at planting, which was one of the highest-yielding treatments in 2014, was the one of the lowest-yielding treatments in 2015. Adding N-Serve to NH_3 decreased yields slightly both years.

The tasseling-time split N applications added as treatments in 2015 produced good yields, with no difference between placing the surface band between rows or near the row. Neither of these treatments yielded significantly more than injecting 150 lb N as UAN at planting, however, and they were not much higher-yielding than most other treatments with the same split (Table 1).

N tracking

There is some evidence that the zero-N plots we sampled at Urbana in 2015 might have had more soil N than might be typical; soil N amounts recovered in the top 2 ft. from these plots remained above 100 lb per acre throughout most of the sampling period, and were typically less than 100 lb below those found in treatments that received 200 lb. of N. (Figure 6).

Soil N responded to N application timing, but not quite as we would have predicted: fall-applied NH_3 with N-Serve showed consistently higher soil N through much of the month of May than did plots where NH_3 was applied in early April, several weeks before planting (Figure 6). Soil N in the treatment with UAN split between planting (50 lb N) and sidedress (150 lb N) showed the expected increase in soil N with the later application, and during rapid N uptake after mid-June, this treatment and the fall-applied NH_3 retained the most soil N.

Yields at this tracking site were 165 bushels for the zero N, 234 to 238 for both NH_3 timings and for the fall NH_3-spring UAN split, and significantly higher at 249 for the planting time-sidedress UAN split. With the exception of the fall-applied NH_3, these yields correlate with the amount fo soil N found in the latter half of June.

SUMMARY AND CONCLUSIONS

On-farm N rate trials continue to prove their value as an outstanding means both of providing data to strengthen N recommendations and also to demonstrate to producers that N rates do not need to be raised to very high levels in order to produce high yields. Somewhat surprisingly, we are also finding through on-farm comparisons that timing of N application may be less effective in allowing rates to decrease or in getting higher yields with the same rates than most have thought would be the case.

Results from the comparisons of N forms and application timings are indicating that finding “best” N management practices will likely be challenging; even at the same site, responses to N management are not very consistent between two very similar years. Have the same treatment be one of the highest-yielding in one year and one of the lowest-yielding the next year also illustrates the difficulty we are going to face in identifying N management practices that should be taken off the list of “best” N management practices. Our hope is with continued research, we might be able to begin to identify factors that might predict performance of different systems so that adjustments can be made early in the season that will help improve N use efficiency.

The initial results of tacking changes in soil N through vegetative development are encouraging. It will take a considerable amount of this work, however, before we will be able to estimate with confidence the adequacy of existing soil N at a certain stage of crop development. Until we can do that, it will be difficult to know whether or not supplemental N is likely to be profitable.

Table 1. Corn yields following application of 150 lb. N per acre N using different forms and timings at Urbana Illinois. Means followed by the same letter are not significantly different at P=0.1. Means in bold are not significantly less than the highest yield each year, and those in italics are not significantly better than the lowest yield.

Treatment (all 150 lb N/acre)		2014		2015	
At planting	In-season	--------------bu/acre---------------			
UAN injected		*223*	*cdef*	228	bcde
UAN su-band*		*220*	*ef*	*222*	*def*
Urea/AT** broadcast		**241**	**a**	**237**	**abc**
SuperU broadcast		**233**	**ab**	**245**	**a**
ESN broadcast		226	bcde	**237**	**abc**
UAN/AT broadcast		*221*	*def*	*226*	*cdef*
NH_3 injected		**231**	**abc**	*219*	*ef*
NH_3/N-Serve injected		227	bcde	*214*	*f*
None	V5 UAN injected	*225*	*bcdef*	*226*	*cdef*
None	V9 UAN su-band mid-row	*218*	*ef*	*227*	*cdef*
UAN 50 broadcast	V5 UAN 100 injected	230	bcd	*220*	*def*
UAN 100 injected	V5 UAN 50 injected	*218*	*ef*	227	cde
UAN 100 injected	V5 urea/AT 50 broadcast	*216*	*f*	231	bcde
UAN 100 injected	V9 UAN 50 su-band in row	227	bcde	230	bcde
UAN 100 injected	V9 urea/AT 50 broadcast	*216*	*f*	**232**	**abcde**
UAN/Instinct broadcast				229	bcde
UAN 100 injected	V9 UAN 50 su-band in row			**233**	**abcd**
UAN 100 injected	VT UAN 50 su-band mid-row			**241**	**ab**
UAN 100 injected	VT UAN 50 su-band in row			**238**	**abc**

*su-band = surface-banded **AT = Agrotain

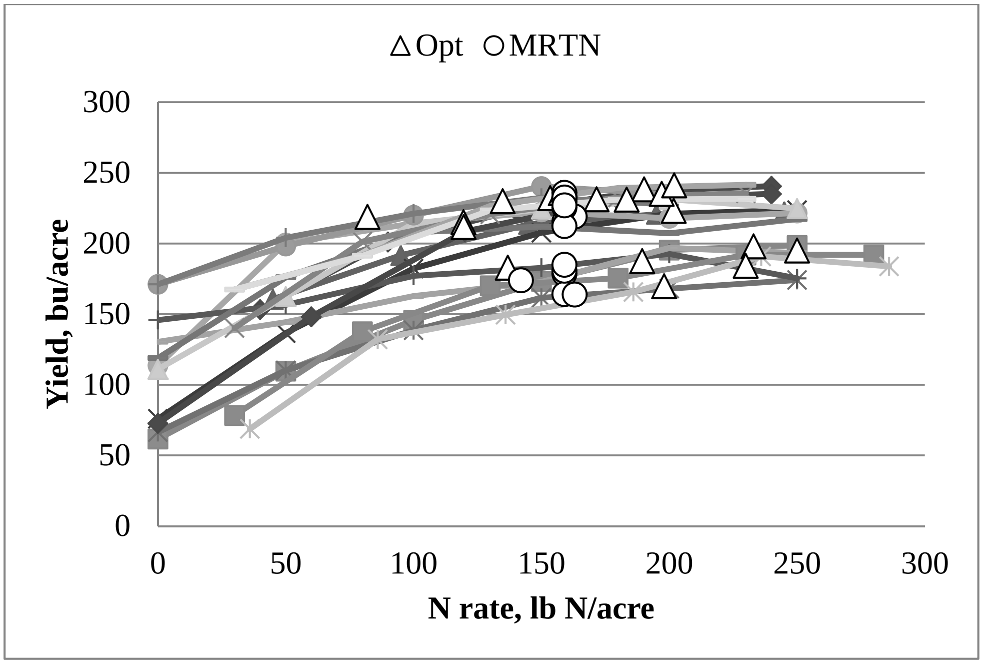

Figure 1. N responses from 18 on-farm N rate trials where corn followed soybean in Illinois in 2014. Open triangles indicate the optimum N rate for each curve, and open circles show the MRTN N rate for that field and yield at that rate.

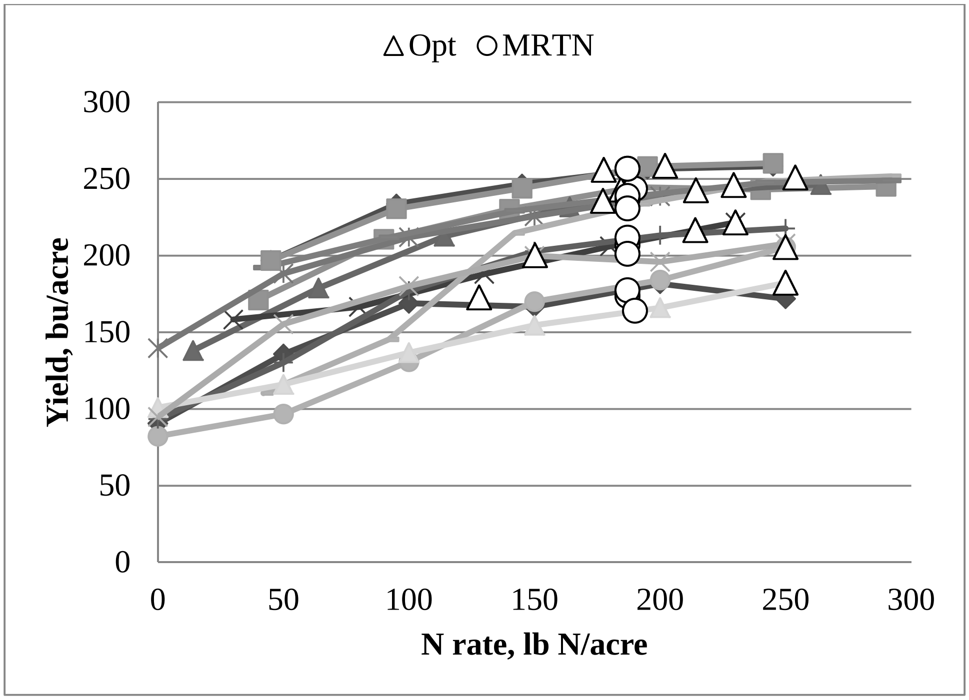

Figure 2. N responses from 13 on-farm N rate trials where corn followed corn in Illinois in 2014. Open triangles indicate the optimum N rate for each curve, and open circles show the MRTN N rate for that field and yield at that rate.

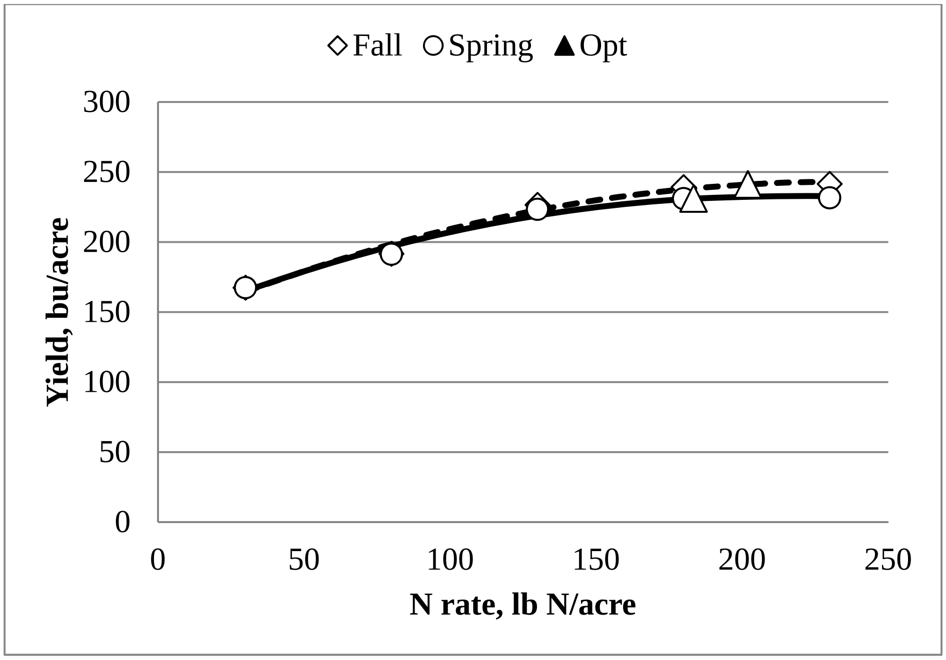

Figure 3. A comparison of fall versus spring NH_3 application at an on-farm site (corn following soybean) in central Illinois in 2014. Triangles mark the N rates and yields at points of maximum return to N; the one on the right is for fall application.

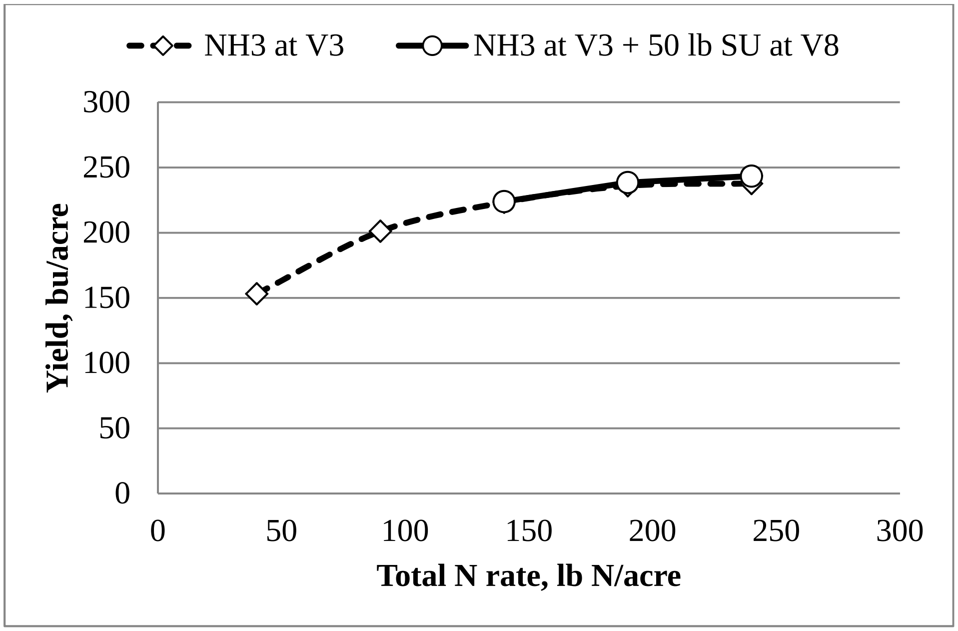

Figure 4. Response to N applied at NH_3 early in vegetative growth (V3) compared to applying the same rate split, with all but 50 lb applied early and the remaining 50 lb applied as SuperU at stage V8. Data are from an on-farm site where corn followed soybean in 2014.

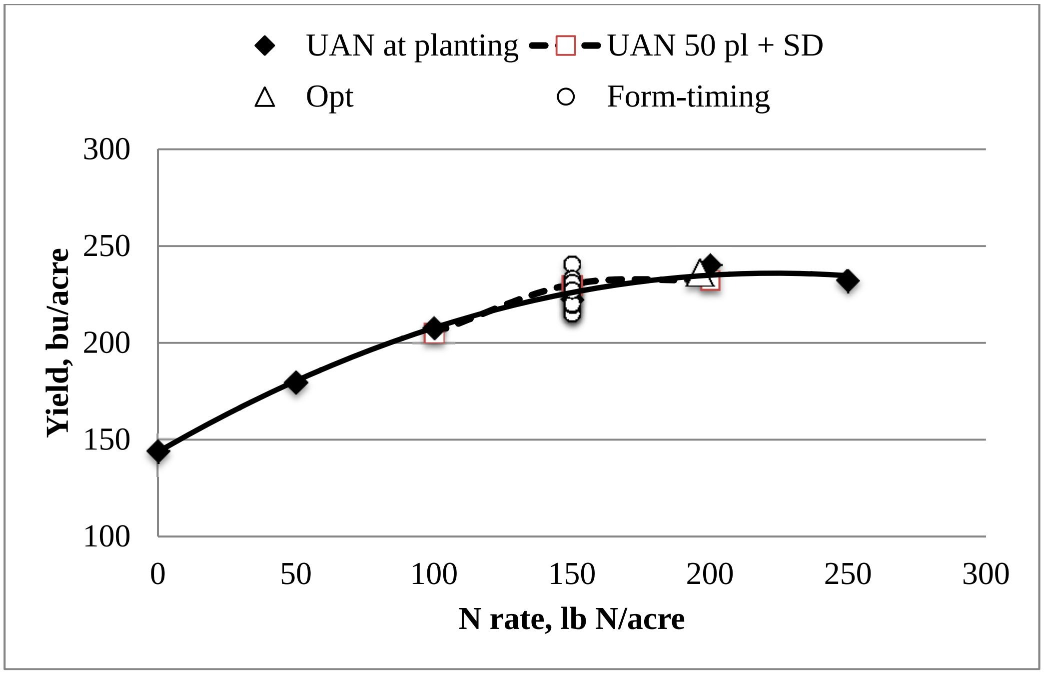

Figure 5. Responses to N rate, form, and timing at Urbana, Illinois in 2014. Base rates were applied as UAN at planting time, and sidedress as 50 lb N at planting plus UAN at V5-V6. Form and timing treatments and yields are listed in Table 1.

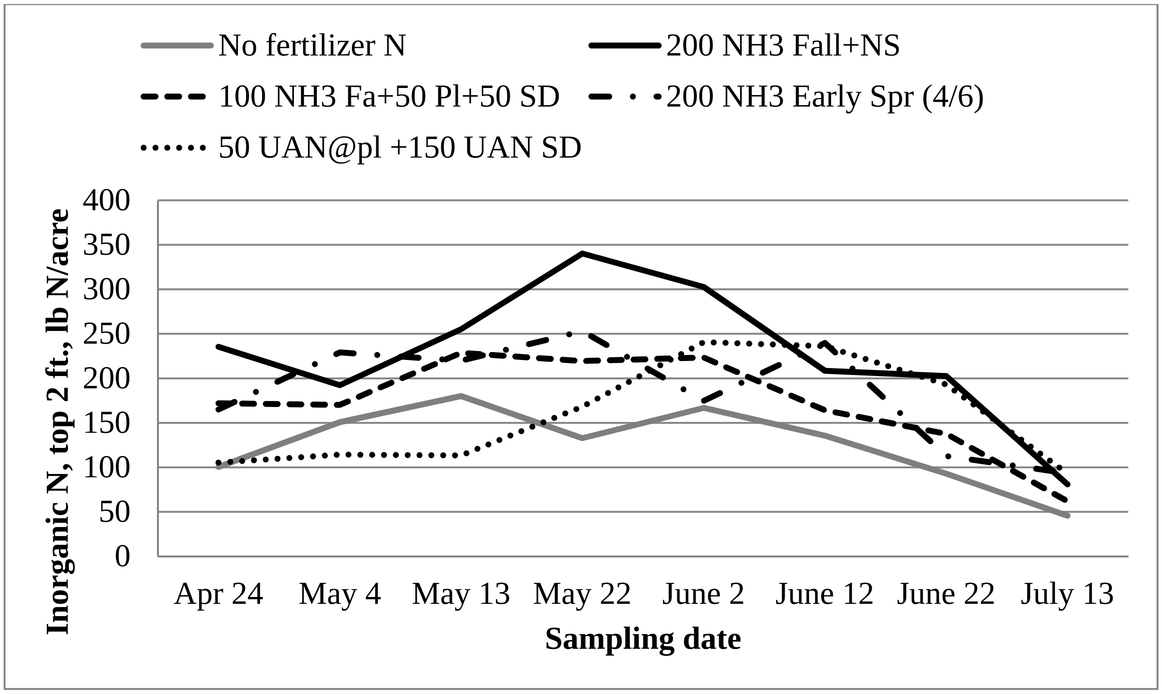

Figure 6. Inorganic soil N (nitrate + ammonium) recovered in the top 2 feet of soil with periodic sampling from planting through tasseling following application of N at different times and forms. Fa is fall, Pl is UAN at planting, and SD is UAN sidedressed at V5. Data are from Urbana in 2015.

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