Is Fall a Good Time to Apply Nitrogen?

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Applying anhydrous ammonia in the fall to provide N to the corn crop the following year has a long history in Illinois and in other parts of the Corn Belt where rotation, tillage, and manure management practices allow it. Fall application means getting a major field operation done when soil conditions are generally more favorable than they are in the spring, and it helps to spread the work load across more months. Historically, the cost of ammonia has also been lower in the fall than in the following spring, which has provided an extra incentive for fall application.

Although fall application remains a common practice in Illinois, it has come under increasing scrutiny in recent decades. Fall application means having N in the soil about six months before the crop will begin to take it up, and soil conditions during these months are not predictable. Ammonia converts to ammonium in the soil after application, and as long as soil temperatures remain low, the microbial conversion of ammonium to nitrate is slow. Once N is in the nitrate form, however, it can move downward with water moving though the soil, and, in tile-drained fields, can leave the soil and move into surface water. Fall-applied ammonia usually has a nitrification inhibitor added to slow this conversion process, but if soils warm up and there's substantial rainfall by May, some of the ammonium will convert to nitrate, and some this nitrate may be lost. Spikes in river and surface water nitrate usually come in the spring, and while much of this N is from residual left after the previous fall's harvest, fall-applied N undoubtedly contributes some to this.

As we might expect, the amount of fall-applied N that is lost (moved out of the field, denitrified, or moved below the rooting zone) before plants can take it up varies widely over years and soils. Measured and modeled estimates of loss show this variability, but as long as guidelines are followed, we do not believe that losses reach the high levels that some models have shown. These guidelines include: 1) no fall application on light or very heavy-textured soil; 2) no application at soil temperatures above 50 degrees; and 3) no fall application in regions without cold winters, including southern Illinois. There can of course be loss of spring-applied N as well, especially if N fertilizer used in the spring contains nitrate (for example, UAN) which can move in the soil without delay. Surface-applied, urea-based N sources can also volatilize (lose N as ammonia gas), dissolve and run off the field with heavy rain, or convert to nitrate rapidly when soil temperatures are warm; such N can be lost to downward movement or to denitrification if water stands in the field.

The best way to measure the actual effect of fall versus spring N application is to compare timings in side-by-side N rate strips in field trials. We are fortunate in Illinois to have a set of such trials, managed by Dan Schaefer of IFCA and conducted, with funding support from the fertilizer tonnage fee through the Illinois Nutrient Research & Education Council, in farm fields from 2014 through 2018. To our considerable surprise, we found that in nearly every case, corn responded to N rate almost the same for fall-applied as for spring-applied N. Figure 1 below shows N responses in one of these trials in which both the optimum N rate and the yield at the optimum N rate were slightly higher for fall-applied N.

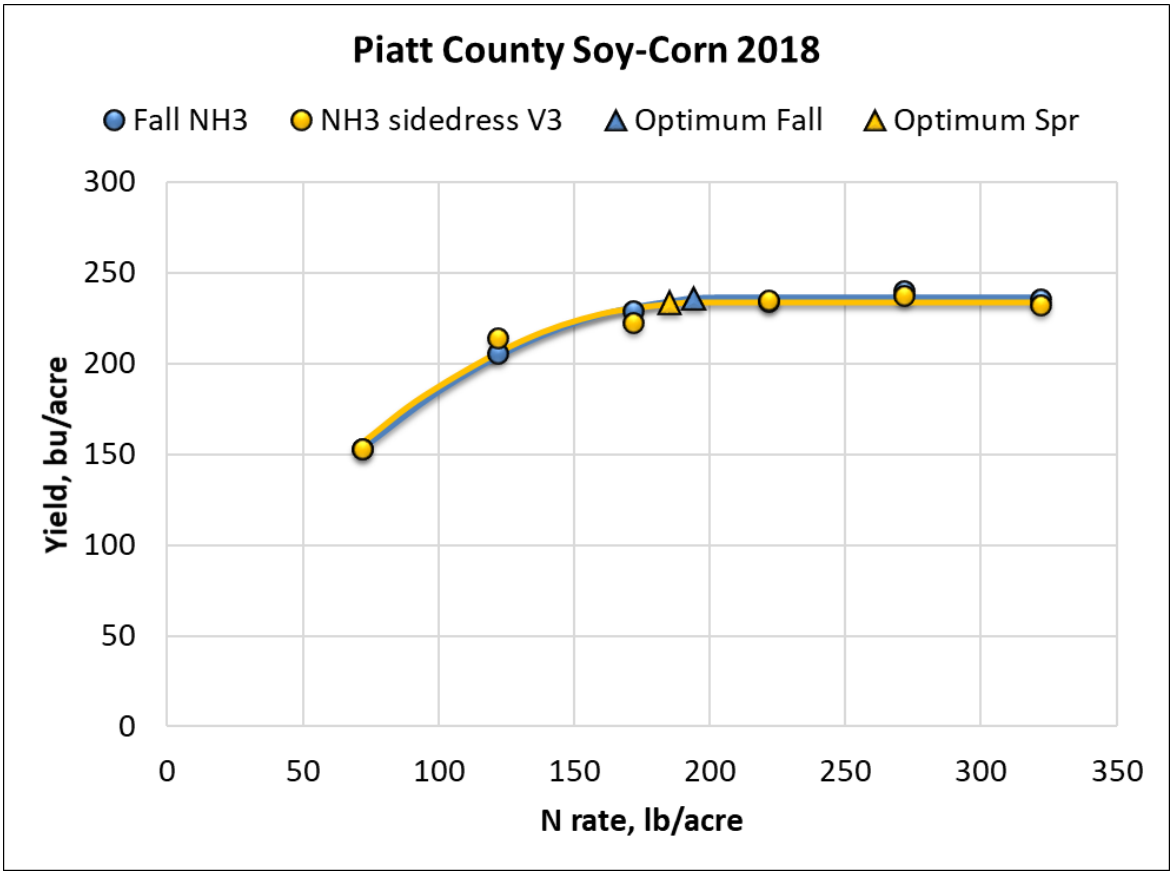

Figure 1. Comparison of fall- versus spring-applied ammonia in an on-farm N rate trial in 2018.

The results found in fifteen other trials were similar to those shown in Figure 1. Most of these trials were with corn following soybeans, and most were in central Illinois. Averaged over these 16 trials, the optimum N rate, using a corn price of $3.75/bushel and an N cost of $0.30/lb ($492 per ton of ammonia) was 186 lb N per acre with fall-applied ammonia and 176 lb N per acre with spring-applied ammonia. The yield at the optimum N rate averaged 235 bushels per acre for fall-applied N and 236 bushels per acre for spring-applied N. We can also use these responses to calculate a "return to N" (bushels added by N × corn price minus N rate × N price); the RTN averaged across these 16 sites was $406 per acre for fall-applied N and $414 per acre for spring-applied N.

We elected to drop one trial from this set of data due to its unusual response. This trial was in the river bottoms near the bluff, and it's possible that the lighter-textured soil there received extra water that moved off the bluff. At that site in 2017, it took 193 lb of N as fall-applied ammonia to produce 227 bushels, while it took only 125 lb of N as spring-applied ammonia to produce 245 bushels. There was a considerable amount of variability in the trial, and using the MRTN rate of 180 lb N/acre for both would have produced yields only 12 bushels higher for spring-applied N. But this does show that when conditions for N loss are high, fall-applied N losses can be substantial. At the same time, these results show that the crop has nearly the same access to fall-applied N as to spring-applied N, and that applying N in the fall is not as economically or environmentally problematic as some have suggested.

So why not continue to apply N in the fall, or even move more application to the fall? In some areas this option has become limited by the fact that some fertilizer dealers no longer offer anhydrous ammonia,

but instead offer other forms, typically UAN solution. Reasons for this often include safety—anhydrous ammonia is more hazardous to transport and apply than other forms of N. Ammonia needs to be injected into the soil, and this requires toolbars, large tractors, and labor when harvest and tillage may still be underway. Soil conditions also need to be dry enough, but not too dry, to allow application and proper sealing. Wet fall weather, the need to wait until about November 1 for soils to be cool enough for safe application, then having a short window to apply before soils freeze are all factors that have acted to nudge N application towards spring. We have found, in recent years when fall application has been limited, that moving a lot of N application to the spring is possible with existing equipment. Although this pushes a lot of extra work into the spring months, dealers and producers have been creative in finding ways to make application and very wet spring weather and late planting, producers managed to get N applied on the crop that got planted.

Despite its limitations, anhydrous ammonia typically remains the lowest-cost source per unit of N, although application costs and safety concerns may decrease that advantage some. More importantly, ammonia is the form of N most likely to stay in the soil and remain available to the plant. Uniformity of application has improved with development of better equipment, and at 82% N, using ammonia means transporting less weight. As I've written many times before, there needs to be some N fertilizer applied near the row at or very soon after planting; UAN is probably a better source than ammonia to place N in this way. A nitrogen management program that includes perhaps a third of the N as preplant or planting-time UAN, then the rest as sidedressed ammonia, may be worth considering.

Going into the fall, the main challenge with ammonia application is to wait until soil temperatures are low enough to keep the nitrification process to a minimum. In a typical fall that means waiting until the end of October. While going a few days early may not seem like a big deal, remember that soil microbial activity doesn't stop completely until temperatures near freezing, and with soil temperatures continuing to fluctuate, soils will usually spend some time at temperatures above 50 even if they're at or below 50 on the day of application.