Warm Winter And Nitrogen Applications

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Now that we are officially in spring, it is old news that this winter was unusually warm. Those who applied anhydrous ammonia last fall are now concerned that they might have lost some of their nitrogen (N). The question is how much?

Anyone with some experience working with N knows that there is no way to provide an answer applicable to every acre of agricultural land in the state. This is because N transformations and eventually N losses are dependent on many variables and complex interactions. Some of these variables are soil temperature, timing of fall N application, use of a nitrification inhibitor, rate of biological activity, drainage, amount and frequency of rain, and soil type. Despite these factors, all of which create uncertainty in predicting how much nitrification has occurred or how much N has been lost in any given situation, I would like to offer some guiding principles for you to consider.

The first question to try to answer is how much of the applied N has been transformed to nitrate (NO3-). When anhydrous ammonia (NH3) is applied, it quickly reacts with soil water to convert to ammonium (NH4+). In the ammonium form, N is held by the soil and cannot be leached out of the root zone or denitrified. However, once ammonium transforms to nitrate, this form of N can be leached out with rainwater moving through the soil profile or denitrified when soils are warm and saturated with water.

Nitrification is a bacteria-mediated transformation. Nitrifying bacteria are most active in aerobic conditions (when soils are not saturated with water) and warm temperatures. Nitrification stops at 32°F and increases slowly as soil temperatures increase to about 50°F. Above 50°F, the activity of nitrifying bacteria increases quickly. Monthly mean soil temperatures have been about 5°F warmer than average this fall and winter in Champaign (Table 1; similar weather and soil temperature information for other parts of Illinois can be accessed at www.isws.illinois.edu). In Champaign, during January and February daily minimum soil temperatures at 4 inches below the soil surface ranged from 35.7 to 45°F. The fact that temperatures never reached 32°F would indicate that nitrifying bacteria have been slightly active most of the fall and winter.

A study from Illinois with a Drummer soil (high organic matter content) showed that with a constant incubation temperature of 39°F, the amount of ammonium recovered (not transformed to nitrate) after 90 days was 60 percent if the nitrification inhibitor N-Serve was not used and 90 percent if N-Serve was used. The same study with a Cisne soil (low organic matter content) showed that only 25 percent of the ammonium was recovered if N-Serve was not used and about 85 percent if it was.

Under the same incubation conditions, degradation of N-Serve in the Cisne soil was pronounced, with only 30 percent present after 90 days, compared with 50 percent in the Drummer soil. The study also showed more nitrification and degradation of N-Serve as temperatures increased to 55 and 70°F. This study clearly illustrated that soil temperature and soil type can have an important influence on the amount of nitrification and the longevity of N-Serve to protect ammonium from nitrification. While the incubation study had constant temperatures, it would be possible to compare the results from the 39°F incubation temperature to field conditions this winter since soil temperatures in Champaign were relatively constant. When minimum soil temperatures in the field were below 39°F, the average fluctuation between daily minimum and maximum temperatures was only 2.2°F, which would not produce a substantial lag in bacterial activity from day to day.

Now that we have some idea of how much of the applied N might have been transformed to nitrate, we need to talk about potential for N loss. Once ammonium is transformed to nitrate, it does not mean N is lost, but it does means a greater loss potential. While it is possible that some of the N that transformed to nitrate over the winter might have been lost, I suspect it is not a large amount. Based on the incubation study results, if the fall application was done carefully (using N-Serve and following recommendations in the Illinois Agronomy Handbook: extension.cropsci.illinois.edu/handbook), a small amount of the total N (10-20 percent) is likely in the nitrate form. Also, there has not been a lot of water present in the soil to move nitrate down the soil profile or to create saturated conditions for denitrification. We started the fall with very dry soils that needed to be replenished before water would start to move down the soil profile. Also, while in general soil surfaces have not been frozen and would allow water to enter the soil, we have not had excessive amounts of rain since the fall (Table 1). Warm temperatures have also created some water evaporation in the soil surface, which creates an upward suction force that moves water and any nitrate that might be present closer to the surface.

Table 1. Average and most recent monthly mean air and soil temperatures and precipitation at Champaign, Illinois.

	Mean air temperature (°F)			Mean soil temperature (°F)			Precipitation (in.)		
Month	30-yr[a]	2011–12[b]	Departure	20-yr[c]	2011–12[b]	Departure	30-yr[a]	2011–12[b]	Departure
Oct	54.3	54.8	0.5	58.5	61.6	3.1	3.3	2.63	-0.67
Nov	42.1	45.7	3.6	46.8	52.3	5.5	3.6	5.05	1.45
Dec	30.2	35.1	4.9	37.7	43.4	5.7	2.7	3.2	0.5
Jan	25.8	31.5	5.7	34.3	39.5	5.2	2	3.48	1.48
Feb	29.8	35	5.2	35	41.5	6.5	2.1	1.43	-0.67

[a]30-year average, 1980–2009.
[b]Fall 2011–winter 2012.
[c]20-year average, 1991–2011.
Source: www.isws.illinois.edu

While I am not too concerned about N loss at present, I am concerned about the potential for it to happen later in the spring. Most years N losses occur in the spring, when there is too much water, too little evapotranspiration, little N uptake by the crop, and the presence of N in nitrate form. If the spring continues to be dry, there will be little reason to worry about N loss, but if the spring is wet (like it usually is), then there might be substantial loss from fall-applied N. I would not apply additional N at this time until we have a better idea of how the crop is growing.

If you have not applied any N yet, soil conditions in many fields are fit to apply anhydrous ammonia at this time. If you do apply N now, remember that this would be considered an early-N application, and the potential for wet conditions and high N loss are still ahead if the spring turns out to be excessively wet. For this reason, I would first determine the total amount of N by using the N rate calculator, and then I would apply only a portion of the total N, reserving the remainder for an application closer to planting or during sidedress. At this time I would only consider using anhydrous ammonia or a slow-release N source. Finally, while N-Serve is not usually recommended for preplant applications close to normal planting time, I would seriously consider it for anhydrous ammonia applications done this early in the spring. Δ

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