Nitrogen Applications for the 2010 Corn Crop

Unfavorable conditions this spring meant that a lot of fields were planted late and some not at all. In addition, a summer that was cooler and wetter than normal for much of Illinois has made the 2009 season a challenging one. Whether you had a good or not-so-good season this year, everyone is, or soon will be, making plans for 2010. Every year during the fall, those who apply nitrogen worry that if they wait too long for temperatures to drop sufficiently to apply nitrogen (N), soils might become too wet to do the application or to perform tillage operations. While the window of opportunity for doing all these fall field operations is not very large, it is important to exercise good judgment to realize their full potential. The management of N is important because this nutrient is both one of the most expensive inputs in today's farming operations and one that can pose environmental concerns. Whether we think of cost, environmental implications, or both, we simply cannot afford poor N management. Being smart about N use can pay large dividends. To achieve that goal, it is important to understand some key factors. The following are recommendations that will enhance the efficiency of N management this fall.

When to apply nitrogen in the fall. Some forms of N are more susceptible to loss than others. Chemically speaking, ammonium (NH_4^+) is a positively charged ion that behaves similarly to potassium K^+ ions. Ammonia stays in the soil, held by the negative charges of clays and organic matter, and is not susceptible to leaching or denitrification. However, through the nitrification process, NH_4^+ can convert to nitrate NO_3^-, which is susceptible to leaching and denitrification (conversion to N_2 or N_2O gas). These conversions are all mediated by soil organisms. Since temperature has an important impact on the activity of these organisms, it is critically important to wait to apply N until soil temperature at the 4-inch depth is below 50°F and is maintained at or below this value through the winter. In most years, the 50°F temperature allows for N applications before soils become too wet or frozen.

Application of anhydrous ammonia with a nitrification inhibitor (see the discussion below) can start after soil temperature at 4 inches is below 60°F. Although the rate of nitrification is significantly reduced when soil temperature is below 50°F, microbial activity continues until temperatures are below 32°F. Since air temperatures can fluctuate substantially during the early fall, even if air temperatures are getting cooler, do not apply N before the second week of October in northern Illinois or the third week in central Illinois. Because of temperature considerations, fall N application should not be done south of a line roughly parallel to Illinois Route 16. In areas near this boundary, soil characteristics should be evaluated to determine whether fall application is appropriate. Soils with high potential for NO_3^- leaching in the fall or early spring (sandy soils or those with excessive drainage) should not receive fall N applications. Daily maximum 4-inch bare-soil temperatures for Illinois this year at the end of September to the beginning of October were in the upper 60s to lower

70s. Up-to-date soil temperatures can be accessed at www.sws.uiuc.edu/warm/soiltemp.asp. However, it is strongly recommended that temperatures of soils in individual fields be monitored prior to N application.

What to use and not to use. Anhydrous ammonia is a preferred N source for fall application because it has a slower nitrification rate than other sources. Once applied in the soil, ammonia (NH_3) reacts quickly with soil water and is converted to NH_4^+. Nitrification inhibitors (such as dicyandiamide [DCD] and nitrapyrin, also known by the trade name N-serve) are chemicals that inhibit the activity of bacteria responsible for the first step in the process of nitrification (conversion of NH_4^+ to nitrite [NO_2^-]); this intermediate can then be quickly converted to NO_3^-. Proper use of these inhibitors will reduce the rate of nitrification, thus maintaining for a longer period a greater proportion of the applied N in the NH_4^+ form. Since nitrification rates increase under warm temperatures and moist conditions, nitrification inhibitors are especially useful when those soil conditions prevail. To avoid volatilization losses during application, make sure the soil is neither too wet nor too dry to secure adequate closure of the soil behind the applicator knife. Also, it is important to apply at the proper depth; for fine-textured soils, 6 to 8 inches is sufficient to keep NH_3 gas from escaping the soil.

Another source that can be used for fall applications is ammonium sulfate ($[NH_4]_2SO_4$). Just like for anhydrous ammonia, this source should be applied late in the fall when soil temperatures are below 50°F. This material is an excellent source for no-till fields, where broadcast applications are preferred. It can also be applied on frozen ground as long as the slope of the field is less than 5% and the potential for surface water runoff is very low. Ammonium sulfate is more acidifying than any other N source. This is not a problem as long as the pH of the soil is maintained at adequate levels. As a general rule, 5 pounds of lime is needed to neutralize 1 pound of N from ammonium sulfate compared to 2 pounds of lime per pound of N from ammonia or urea.

As mentioned, ammonium is a stable form of nitrogen that is readily adsorbed to exchange sites in the soil particles and organic matter. On the other hand, NO_3^- does not attach to exchange sites but remains in the soil solution and can be lost through denitrification and leaching. The source of N used for fall applications is thus an important consideration. Nitrogen sources containing nitrogen in the NO_3^- form (such as ammonium nitrate [NH_4NO_3] or urea ammonium nitrate [UAN]) should not be used in the fall to provide N for corn because part of the N is already in a form that can be easily leached or denitrified.

Urea ($CO[NH_2]_2$) converts to NH_3 and then to NH_4^+ within a few days of application. However, the use of urea in the fall is discouraged because it has been shown to be less effective than fall-applied anhydrous ammonia. The lower efficiency of urea is mainly due to greater risk of NO_3^- losses before rapid nutrient uptake by the crop the following spring.

Slow-release, controlled-release, and polymer-coated urea (PCU) are all common names for products that have been designed to control or reduce the conversion of urea to NH_4^+ and thus limit the potential transformation to NO_3^-. While the concept makes sense, I am currently researching it; the data is limited for determining whether such products could be used in the fall or should not be. Some of the most important considerations regarding the effectiveness of these products are the thickness of the coating, the time required for degradation of the coating, and the integrity of the coating after handling and application. Since research data is still considered preliminary, these products are not presently being recommended for fall application in Illinois. After testing ESN, a PCU product, researchers in Minnesota have indicated that fall application of this product is acceptable, but it is a high-risk operation.

In recent years there has been renewed interest in using manure, poultry litter, and other organic fertilizer forms to supply not only N but also phosphorus and potassium. These animal products are excellent nutrient sources, but they should be incorporated to avoid N loss by volatilization. Most of the N is in uric acid and NH_4^+ forms that can rapidly transform to NO_3^-, so the soil temperature recommendations already discussed also apply here. Due to the length of time between application and utilization by the crop, applications should be done as far as possible from environmentally sensitive areas, such as on steep slopes and near bodies of water. If the application cannot be accomplished in late fall, do not apply on frozen soils in the winter; it is better to wait until spring. Before application, these fertilizers should be analyzed for nutrient content. Typically, if these sources are applied to meet the N needs of the crop, an overapplication of phosphorus will result. For this reason, most often the rate of application should be based on meeting the crop's phosphorus requirements rather than N requirements. Knowing the soil phosphorus level and nutrient contents of the fertilizer are a must to determine the appropriate application rate.

How much to apply. To determine the economically optimal N rate at various corn and nitrogen prices, use the N rate calculator at extension.agron.iastate.edu/soilfertility/nrate.aspx. Just remember that the calculator does not account for carryover nitrogen. This year, since it was so wet in the spring, it is unlikely that much N will be carried over even if yields were lower than expected. However, if you applied manure, you will need to adjust the values from the calculator to reflect what will be available next year. If you are planning to plant corn into a field coming off of alfalfa, chances are high that there is enough N in the soil to produce a crop without any addition of N. Once you determine how much N you will need, it is important to remember that it is not necessary to make the entire application in the fall. Some producers might find it beneficial for their production system to apply a portion of the total rate in the fall and reserve the rest for a later application in spring.

Applying N to increase crop residue breakdown. With more acres planted to corn following corn, there is great interest in corn residue management. One

common question has been whether application of N, such as UAN, on the residue this fall would help with the breakdown of corn stalks. Research has shown no benefit in fall application of N to increase microbial decomposition of corn residue in order to improve corn planting operations and N for the next corn crop. Typically low temperature, and not N levels, is the limiting factor for microbial decomposition of residue.

Evaluating your situation. Overall, research on N application timing has shown that application in the spring, close to the time of rapid N uptake, maximizes yield because there is less chance for leaching or denitrification. This is especially true for years like 2009, where early spring conditions are warm and wet and corn planting is delayed in many fields. However, late-fall application of some N sources (previously discussed) is adequate, especially for medium- to fine-textured soils where cold winter temperatures prevail and early springs are not excessively wet and warm. If a full rate preplant application is not an option for you, a possibility would be to apply a portion of the total N needed in the fall and wait until the spring to apply the rest as a preplant or sidedress application. In some years sidedress applications are more effective than preplant, but the results depend on weather. Most often, though, under normal spring conditions there is little or no difference between the two times of application.

Fall applications have both economic and logistic advantages. Soil conditions are typically more conducive to application, there is more time available than during the busy planting season, equipment and labor are better distributed, and often there are price incentives to buy anhydrous ammonia. The spring typically is wet, and soil compaction, especially for manure application, is of greater concern. Also, waiting until the spring to apply fertilizer can delay planting, damage crops, and delay application of fertilizer to meet early nutrient uptake needs of the crop. Unfortunately, since spring weather conditions have a large influence on N efficiency, it is impossible to know for any given year how safe, or risky, it is to apply N in the fall. If the spring is dry, there is little risk of N loss from fall application (assuming N was applied correctly). On the other hand, if the spring is wet, the chance of N loss increases. All these points should be considered carefully to make the best possible decision. If you don't like taking big risks, but a fall application makes sense, it may be better to apply part of the N in the fall and wait until spring to apply the rest. This approach is like buying an insurance policy--it gives peace of mind but costs money, and you can never be certain whether the investment will pay off.

In a nutshell. In summary, if you are planning to apply N in the fall, heed the following guidelines:

- Wait until soil temperatures at the 4-inch depth are below 50°F, or below 60°F if you are using a nitrification inhibitor.

- Do not apply N before the third week of October in central Illinois, or the second week in northern Illinois, even if air temperatures are getting cooler.
- Do not apply N, or N with a nitrification inhibitor, if you are south of Illinois Route 16 or if soils are prone to leaching.
- Use a nitrification inhibitor with anhydrous ammonia applications. Ammonium sulfate is an acceptable source.
- Do not apply urea or nitrate-containing fertilizers.
- If using animal manure, make sure it is incorporated into the soil, and follow the time of application guidelines discussed for commercial N management.
- Apply the appropriate rate, taking into account leftover N when applicable, and consider applying only a portion of the total N needed in the fall and the rest in the spring.
- Do not apply N to increase residue breakdown.
- Consider the risks and benefits of fall N application. If fall application is appropriate, follow the recommendations here to help increase the efficiency.