Fall Nitrogen Application: What, When, Where, and How

It is once again harvest season! Although combines recently started to roll, it will not be long before most Illinois fields will be cleared of crops, and farmers will start operations to prepare for the next growing season.

Nitrogen application is one of the many decisions to be made at this time of year, and it is an important one. Proper nitrogen management is critical to sustainable corn production, and what is done in this regard can impact farmers' profitability and the environment in which we all live. For these reasons it would be wise to review important guidelines developed through years of research and experience.

I acknowledge that a given recommended practice may not work very well every year—mostly because of environmental conditions beyond our control—but these guidelines, if followed, will ensure the best chance for protecting your nitrogen investment and at the same time enhancing environmental protection.

What to Apply

While many inorganic nitrogen sources are available in the marketplace, for fall application the only recommended sources are *anhydrous ammonia* (NH_3) and *ammonium sulfate* ($[NH_4]_2SO_4$). Ammonia transforms quickly to ammonium (NH_4^+), and nitrogen in ammonium sulfate is already in the ammonium form. Ammonium is adsorbed onto the exchange sites in soil particles and organic matter, and thus it is protected from leaching. By contrast, nitrogen sources containing nitrate (NO_3^-) should not be used in the fall because nitrate does not become adsorbed onto exchange sites in the soil and can be easily leached or denitrified long before corn plants are ready to use it. Common fertilizers that contain nitrate include ammonium nitrate (NH_4NO_3) and urea ammonium nitrate (UAN).

Another common nitrogen source is urea ($CO[NH_2]_2$). Urea converts to NH_3 and then to NH_4^+ within a few days of application. However, research results indicate that this fertilizer should not be used in the fall because it has a greater risk of loss compared with anhydrous ammonia before rapid nutrient uptake by the crop the following spring. The same can be said of polymer-coated ureas. While the coating protects urea for a while, often urea starts to diffuse out of the granule too early, and the loss potential is higher than for anhydrous ammonia.

One of the benefits of anhydrous ammonia is that it kills nitrifying bacteria (which are responsible for the transformation of ammonium to nitrate) at the point of application. In addition, as ammonia reacts with water to form ammonium, the reaction creates an alkaline (high pH) environment in the ammonia retention zone. This high pH also inhibits activity of nitrifying bacteria for a while, but the effects are temporary.

To lengthen the period of bacterial inhibition, it is always a good idea to include a *nitrification inhibitor* with the application of anhydrous ammonia. Many years of research have indicated that nitrification inhibitors, such as dicyandiamide (DCD) and N-serve, can protect fall nitrogen against loss and increase the amount of nitrogen present in the ammonium form the following spring.

As with most practices, the use of a nitrification inhibitor might not pay every year. For example, if the following spring is dry and cool, the inhibitor might not be as beneficial in enhancing ammonium

recovery. However, as I mentioned earlier, this practice will overall ensure the greatest chance to both protect your nitrogen investment and enhance environmental protection.

From the standpoint of production profit, in times when nitrogen prices were low, it was cheaper to buy additional nitrogen rather than the nitrification inhibitor. As nitrogen prices increase and the cost of nitrification inhibitors remains relatively constant, using an inhibitor is becoming more profitable. Still, while an inhibitor represents an added cost, it is important to realize that a reduction in nitrogen efficiency due to losses plus the environmental degradation linked to nitrogen loss also represent added costs. Farmers must carefully consider all these factors when deciding to apply nitrogen in the fall.

Ammonium sulfate is an excellent nitrogen source for no-till fields where broadcast applications are preferred. It is always best to apply it before soils freeze so the fertilizer can be dissolved and incorporated into the soil by rain. In fields with minimal slope (less than 5%) and where the potential for runoff is very low, it is feasible to apply ammonium sulfate on frozen ground because there is no concern of volatilization loss. An important point to remember is that ammonium sulfate is more acidifying than other nitrogen sources, so make sure to keep an eye on soil pH. As a general rule, 5 pounds of lime is needed to neutralize 1 pound of nitrogen from ammonium sulfate compared with 2 pounds of lime needed per pound of nitrogen from anhydrous ammonia.

Last but not least, organic fertilizers derived from animals (manure, poultry litter, etc.) are good for use in the fall. These products supply nitrogen as well as phosphorus, potassium, and other crop nutrients. Often these organic fertilizers represent a less expensive source of nutrients compared with inorganic fertilizers.

When to Apply

This fall, just as in the fall of 2010 to a certain extent, harvest is happening earlier than is typical. In years like this, it is critical to keep in mind that soil temperature can significantly impact the efficiency of fall nitrogen applications and the effectiveness of nitrification inhibitors. Nitrifying bacteria are active until soils freeze (32 °F), but their activity is greatly reduced once soil temperatures go below 50 °F. For this reason, it is recommended that the start of fall nitrogen applications be directed by soil temperature and not by date, when harvest is complete, or any other consideration.

The temperature guideline applies equally for anhydrous ammonia, ammonium sulfate, and manure/organic fertilizers that can be used in the fall. As I mentioned earlier, the efficiency of nitrification inhibitors also decreases with warm temperatures. Higher temperatures result in faster breakdown of the molecule responsible for inhibition of nitrifying bacteria. The cooler the temperature, the greater the efficiency of the inhibitor, and the greater the chance that ammonium does not convert to nitrate.

While I realize that every year anxiety levels rise when soil temperatures are not getting down to 50 °F and falling steadily, I would remind readers that in most years, the 50 °F temperature allows for nitrogen applications before soils become too wet or frozen. There is no need to increase the risk of nitrogen loss by starting applications too early. Also, applying once temperatures are 50 °F does not automatically ensure no nitrogen loss, though it does provide a better chance to protect your investment.

Air temperatures in Illinois can vary substantially during the early fall. Even if temperatures are getting to 50 °F, historically the chance that they will continue to decline without a significant bounceback to warmer levels are very rare before the second week of October in northern Illinois and the third week in central Illinois. On average, soil temperatures reach 50 °F and continue to go down the first week of November in central and northern Illinois. Daily maximum 4-inch bare-soil temperatures for Illinois this week have been bouncing between the 60s and the 70s.

Up-to-date soil temperatures can be accessed at www.isws.illinois.edu/warm/soiltemp/displaymap2.asp?day=0&data=bstmax. However, these values should be used as a reference. Since soil temperatures can be influenced by a number of factors (such as residue cover, soil color, and drainage), it is always best to monitor temperatures in individual fields prior to nitrogen application.

Where to Apply

Because temperatures do not stay below 50 °F long enough during the winter in all of Illinois, fall nitrogen application should not be done south of a line roughly parallel to Route 16. In areas near this boundary, evaluate soil characteristics to determine whether fall application is appropriate. Soils with high potential for nitrate leaching in the fall or early spring (sandy soils or those with excessive drainage) should not receive fall nitrogen applications. Also, regardless of location in the state, do not apply nitrogen in the fall to soils with high potential for nitrate leaching or soils that are very poorly drained.

Given the length of time between application and utilization by the crop, application of manure and other organic nitrogen sources 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.

How to Apply, and How Much

When applying anhydrous ammonia, make sure soil conditions are fit for the application. Soils that are too dry or too wet can result in ammonia loss to the atmosphere because the application knife tracks may not seal properly. When soils are dry, increasing depth of application or reducing application rates typically can help minimize volatilization loss. When soil is wet, little can be done to minimize loss through volatilization. If you use manure, poultry litter, or other animal-derived fertilizers, incorporate them into the soil to avoid volatilization.

To determine the economically optimal nitrogen rate at various corn and nitrogen prices, use the corn nitrogen rate calculator at extension.agron.iastate.edu/soilfertility/nrate.aspx. While the calculator is designed to help you make the most profitable decision for nitrogen management, it does not account for carryover nitrogen that might not have been used by a crop if conditions were dry. Also, if you applied manure or the soil has high potential for nitrogen mineralization (as in the case of a field coming off of alfalfa), you will need to adjust the values derived from the calculator to reflect what will be available next year.

Once you determine how much nitrogen you will need, remember that you don’t have to apply the entire amount in the fall. If you don’t like taking big risks, but a fall application makes sense, it may be better to apply some nitrogen in the fall and the rest in spring. A portion of the total nitrogen

requirement applied in the fall can provide all of what the corn crop will need to get started in spring. Applying the remainder closer to when plant will need the most nitrogen can increase use efficiency because there is less chance for leaching or denitrification. Also, research has shown better efficiency of nitrification inhibitors when lower nitrogen rates are used in the fall. Splitting the total application thus might produce benefits on several fronts.

Finally, be aware that anhydrous ammonia is under a lot of pressure inside the nurse tank, and when released it reacts quickly with water. If ammonia comes in contact with your skin, eyes, or mucous membranes, it will cause dehydration and burns, so please use extreme caution when handling it. Remember that "it is better to lose a minute in life than life in a minute."

Weigh Your Options

While nitrogen does not have to be applied in the fall, this timing has 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 is of greater concern, especially for manure application. Waiting until spring to apply fertilizer also can delay planting, damage crops, and delay application of fertilizer to meet the crop's early nutrient uptake needs.

Unfortunately, though, because spring weather conditions greatly influence nitrogen efficiency, it is impossible to know in any given fall how safe or how risky it is to apply nitrogen. If the following spring is dry, there is little risk of loss from fall application (assuming nitrogen was applied correctly). On the other hand, if the spring is wet, the chance of loss increases. If after considering your options you decide fall nitrogen application is right for you, following the guidelines outlined here will certainly help protect your nitrogen investment and at the same time enhance environmental protection.—*Fabián G. Fernández*