Using Nitrification Inhibitors in Missouri

November 21, 2005

Purpose: This technical note provides technical guidance for using nitrification inhibitors in Missouri.

Situation: Fall application of nitrogen (N) fertilizer is a common strategy for Missouri farmers. Soil conditions often are better than at other times during the year, and fertilizer prices may be lower than in the spring. Another, and probably the most important, advantage is that fall N applications reduce farmers' workload the following spring. However, weather-related conditions can lead to large losses of applied fertilizer. These losses have negative environmental and economic impacts.

The major form of nitrogen that is lost from soils is nitrate (NO_3^-), so a reasonable strategy would be to try to keep ammonium fertilizers in the ammonium (NH_4^+) form rather than allowing it to be transformed into mobile nitrate. Nitrification inhibitors are a class of soil-applied chemicals that are one proven strategy to keep applied ammonium-containing fertilizers in the ammonium form in soil.

Background

Nitrogen added as commercial fertilizer comes in both ammonium- and nitrate-containing compounds. Although both forms have been used for many years, the trend is toward more ammonium-containing fertilizers, mainly anhydrous ammonia and urea. This is because the primary manufacturing process for nitrogen fertilizer produces ammonia from atmospheric nitrogen. The primary source of nitrate is sodium nitrate deposits that must be mined, and these sources are limited.

Losses of Soil Nitrogen

Although research has shown that some N can be taken up by plants in organic forms, plants take most of their N up as inorganic forms, either anions (chiefly nitrate, NO_3^-) or cations (NH_4^+). From their chemical form it is not surprising that the soil's cation exchange complex repels nitrate but attracts and retains ammonium. This mobile property of nitrate is something fertilizer users need to recognize. Nitrate in soil can be leached into groundwater or moved from the field to water bodies by surface and subsurface flows. These losses are of concern both environmentally and economically. Contamination of groundwater has led to health concerns for nursing infants, and losses to surface waters have been blamed for hypoxic (low oxygen) zones in the Gulf of Mexico.

One solution might be to avoid nitrate fertilizers and simply apply only ammonium-containing materials. Unfortunately this is not a solution, because certain soil microorganisms (nitrifying bacteria) convert ammonium to nitrate:

$$NH_4^+ \xrightarrow[\textit{Nitrosomonas}]{} NO_2^- \xrightarrow[\textit{Nitrobacter}]{} NO_3^-$$

This nitrification process is biological and is affected by temperature, moisture, aeration, and pH. When ammonium is converted to nitrate, it becomes mobile and is subject to loss. The activity of nitrifying bacteria is zero in frozen ground, but increases exponentially as soil temperature increases. The commonly accepted rule of thumb is that it is safe to apply anhydrous ammonia when the 4-6-inch soil temperature is below 50ºF. However, this is not fool-proof. Nitrifying bacteria are active in these colder soils, but at a reduced rate. The assumption underlying the 50ºF soil temperature guideline is that soil temperatures will continue to drop to near 32ºF or lower.

Anhydrous Ammonia Fertilizer

Anhydrous ammonia (82% N) is a popular N fertilizer for corn production in Missouri. One management practice is to apply anhydrous in the fall after harvest. Because soil temperatures are lower, most of the N applied as anhydrous will remain in the soil for the next crop season. However, there is reason to question the assumptions underlying fall-applied anhydrous applications. Recent observations by researchers and corn growers appear to indicate that losses of fall-applied N can be severe—enough to result in yellow corn and lost yield.

Fortunately, there are products called nitrification inhibitors (NI) that help retain anhydrous ammonia in the soil, reducing the losses of N. The most popular of these products is nitrapyrin, a bactericide that specifically inhibits *Nitrosomonas* species bacteria, the soil organisms responsible for the conversion of ammonium to nitrite/nitrate. Nitrapyrin can retain N in the ammonium form for 4-6 weeks longer than in its absence.

Nitrapyrin is especially useful under conditions conducive to high N losses. These include coarse-textured soils and regions where early spring rains leach and (or) denitrify soil nitrate. These losses can be reduced by maintaining applied ammonium fertilizers in the ammonium form.

Special Consideration for Missouri

States north of us usually can count on soil temperatures remaining low, often below freezing, during most of the over wintering period. In Missouri, we have no such assurances. This is an important issue, because the conversion of ammonia to nitrate increases rapidly as temperature rises into the 50ºF range and higher. Nitrapyrin can indeed slow down this process. However, soil microbes also metabolize nitrapyrin, and this process increases as the temperature rises. So, just when the nitrapyrin is needed most, it is disappearing from the soil. Missouri has distinct climate zones from north to south, and it is not surprising that the “window of safety” for fall anhydrous application is wider in North Missouri than in South Missouri. In fact, extension specialists at the University of Missouri do not recommend any fall anhydrous applications south of I-70, with or without nitrification inhibitor. The Commercial Ag Program at the University of Missouri has provided some useful soil temperature data at the AgEBB website:

http://agebb.missouri.edu/weather/reports/soysoil6.asp

This site provides 6-inch soil temperature data for automated weather stations in North Missouri. Producers can get a good idea of the soil temperature trend from these monitoring sites. There are plans to include a graph for each weather station that will give a trend line that can predict when the temperature will remain below 50º. As resources permit, it may also be possible to equip existing weather stations in South Missouri with 6-inch soil temperature probes. However, because 6-inch soil temperatures do not vary appreciably regionally, the soil temperatures recorded at one of the automated stations can be expected to represent soil temps within a 150-mile radius around that station.

Some locations have a nearby weather station with a 6-inch soil temperature probe to predict when soil temperatures will drop into the “safe zone” where anhydrous can be applied. In the absence of this kind of information, a reasonable compromise is to divide the state into climatic zones based on latitude. The map below has divided the state into three climatic zones. For Zone 1, anhydrous ammonia with nitrification inhibitor can be applied any time after November 15. For Zone 2, anhydrous ammonia with NI can be applied anytime after December 1. For Zone 3, anhydrous with NI should be delayed until after January 1. This guidance should be used in the absence of 6-inch soil temperature data. If soil temperatures *are* available, the application date for the Zone may be advanced by up to two weeks. For example, anhydrous ammonia applied with nitrification inhibitor may be applied anytime after November 1, after November 15 for Zone 2, and after December 15 for Zone 3 when justified by current information and trend lines.