Fall Applied Nitrogen in the Corn Belt: Questions and Answers for Corn

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Risks associated with fall nitrogen (N) applications can be divided into four categories: logistical, agronomic, environmental, and economic. Economic risks are currently tied very closely to logistical, agronomic, and environmental risks and will be discussed in conjunction with them.

Logistical

The primary reason that N is applied in the fall is the flexibility it allows in N management. Fall is typically drier than the spring and offers more days suitable for field work. Farmers considering shifting their N applications from fall to spring must carefully evaluate the additional work load required in spring. There are many field operations that must regularly be performed in the spring within a short time period. If corn is planted too late, significant yield and economic losses can occur. If the spring rush causes equipment to run over ground that is too wet, soils can become compacted, leading to yield and economic losses that can last several years.

Agronomic

Fall applications of N are, at best, equal to in-season applications of N in terms of effectiveness. They are seldom superior. They carry a higher risk of lower production arising from N loss between application and crop need. To minimize agronomic risk, university Extension publications and industry professionals recommend applications when daily soil temperatures are cooler, and typically maintained below 50 °F (Snyder et al., 2000). Nitrifying organisms that convert ammonium (NH_4^+) N to nitrate (NO_3^-) are, for the most part, inactive until temperatures rise above 40 °F (Schmidt, 1982). At temperatures above this level, nitrification rates start out slowly but increase rapidly and can vary by soil (Sabey et al., 1956). So by applying N in the fall when soils are cooler, better chances exist that enough N will still be present for corn production the next year.

Environmental

Compared to in-season applications, applying N in the fall increases the chances that some portion of the N will be lost through leaching, prior to crop uptake. In a multiple year Iowa study (Balkcom et al., 2003), soil NO_3-N concentrations in early June were well related to the amount of total rainfall received in March, April, and May (**Figure 1**). As rainfall during this period increased, less NO_3-N was present in the upper 12 in. of soil, indicating losses had occurred. This study illustrates that probabilities of N loss can be highly related to weather. Consequently, risks of N loss through leaching can be reduced by applying N closer to the time of crop need.

***Higher N prices** and environmental concerns make field application choices more important.*

If in-season N applications are rushed and soils become compacted, risks of N loss through denitrification (gaseous loss as N_2O, NO, or N_2) may increase. The emission of nitrous oxide (N_2O), a greenhouse gas, has been shown to be higher under compacted soil conditions. A study in Germany demonstrated

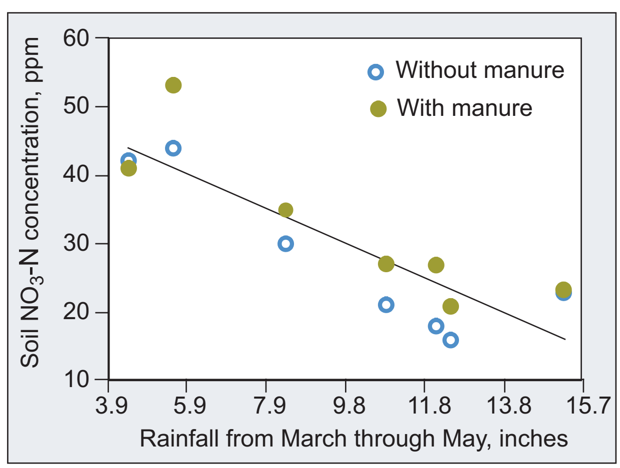

Figure 1. Variation in 0 to 12-in. early June soil NO_3^- levels across different years and for March through May rainfall totals (Balkcom et al., 2003).

that interrows compacted by wheel traffic emitted over 6 times as much N_2O as uncompacted interrows and accounted for 68% of the total N_2O losses from the field (Ruser et al., 1998).

Besides gaseous N losses, compacted soils can also reduce total N uptake by the crop (**Figure 2**). Lower uptake leads to yield losses and increases the quantity of N left in the soil after the cropping season. Depending on conditions, this unused N may be subject to losses.

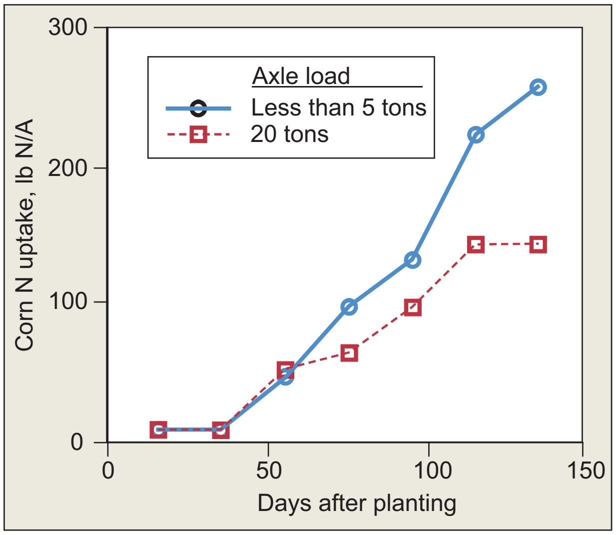

Figure 2. Effects of soil wheel-traffic-induced compaction on N uptake (Wolkowski, 1990).

What N Sources Are Appropriate for Fall?

Nitrate Sources

Sources of N containing NO_3^- are not recommended for fall application for spring-planted corn. Nitrate is not held by soils, but is mobile and moves with water through the soil profile. Such N sources therefore run a high risk of NO_3^- leaching and runoff losses when crops are not present or actively growing for uptake. Common fertilizer products with such restrictions include urea ammonium nitrate (UAN) and ammonium nitrate.

Ammonium Sources

Ammonium is held by the soil and does not readily leach. Ammonium sources are therefore suitable for fall applications. Commonly applied forms of N in this category are ammonium sulfate, diammonium phosphate, and monoammonium phosphate.

Ammonia Sources

Many consider anhydrous ammonia (NH_3) to be the best source to apply in the fall because it can delay nitrification. An early laboratory study (Eno and Blue, 1954) showed that this effect depends, among other factors, on soil type and soil pH (**Table 1**). On a slightly basic Arredondo loamy fine sand, NH_3 nitrified more slowly than ammonium sulfate. However, the reverse was true on a slightly acid Lakeland fine sand. The temporary pH increases following NH_3 applications may be favorable for nitrifying organisms at lower pH levels, but unfavorable at higher soil pH levels.

Urea

Use of urea is acceptable for fall applications in most climates, if it is incorporated soon after application on soils with relatively low leaching and denitrification loss potentials. Once incorporated (by tillage or rainfall), in the presence of adequate moisture, urea readily converts to NH_4^+ because of the action of the urease enzyme that is present in virtually all soils. Movement of urea-N in soils is akin to NO_3^- movement, so fall applications in sandy soils with a high leaching potential is generally not recommended.

Use Inhibitors with Fall-Applied N?

Nitrification Inhibitors

To limit denitrification losses, nitrification inhibitors are recommended in higher rainfall areas of the Corn Belt with poorly drained soils and soils with higher moisture levels near the surface. Throughout the region, fall applications with a nitrification inhibitor have tended to be less effective in reducing the risk of losses as the same rate of N applied in the spring (Randall et al., 2003).

New evidence indicates that pH may also play an important role in determining effectiveness of nitrification inhibitors. **Figure 3** shows that in a year with warmer Dec. and Feb. temperatures, effectiveness of a nitrification inhibitor was greater than in a year with colder Dec., Feb., and Mar. temperatures. In the warmer year, higher soil pH levels probably led to a more rapid recovery of nitrifying organisms from the inhibitor, resulting in a greater amount of nitrification at the time of measurement.

Table 1. Effects of two N sources on NO_3-N and soil pH at two sampling dates on a slightly basic and a slightly acid soil (Eno and Blue, 1954).

Soil	N source @100 lb N/A	NO_3-N (percent of N applied) 14 days	28 days	Soil pH Initial	After N addition	After 14 days	28 days
Arredondo loamy fine sand	Anhydrous ammonia	61	88	7.3	8.4	6.9	7.0
	Ammonium sulfate	87	92	7.3	7.1	6.8	7.0
Lakeland fine sand	Anhydrous ammonia	42	67	6.6	8.5	5.7	4.8
	Ammonium sulfate	21	39	6.6	6.2	5.0	4.6

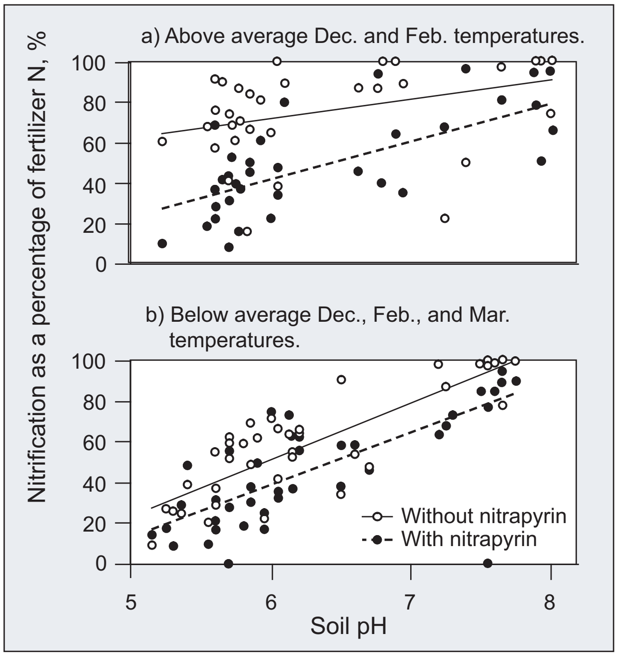

Figure 3. The influence of pH on the percentage of fall applied N that had been nitrified by the following spring, with and without a nitrification inhibitor for years with a) above average spring precipitation and b) below average spring precipitation (Kveryga et al., 2004).

Urease Inhibitors

For urea forms of N, a urease inhibitor may provide benefits when incorporation or 0.3 to 0.5 in. of rain does not occur within 2 to 3 days after application (Fox and Piekielek, 1993).

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