

Nitrogen Application Timing in Corn Production

The goal of timing nitrogen (N) applications to corn is to supply adequate N when the crop needs it, without supplying excess that can potentially be lost. Corn takes up, in the grain and stover, about **one pound of N per bushel of grain produced**. Only a fraction of this is needed during the seedling stage, but corn's requirements escalate rapidly by V8. During the next 30 days, corn can advance from approximately knee-high to the tassel stage of development if conditions are favorable, requiring over half its total N supply (Figure 1).

N deficiency at any time during a corn plant's life will subtract from yield, but if the deficiency occurs during its rapid vegetative growth phase beginning at V8, yield losses may be severe. Thus, the primary goal of timing N applications is to ensure N is sufficient at this time. Recommendations to side-dress N by V4 to V6 are to provide some margin of safety in case weather and soil conditions delay N application or N movement to the roots.



Corn Plant Develops).

Meeting Corn Needs for N

To help avoid weather-related pitfalls to corn N supply, growers can spread their risk by **applying N at multiple times**, and/or using products that help protect specific N fertilizers from rainfall-related losses. This is especially important on soils subject to N loss, such as sandy soils prone to N leaching, or heavier soils in high rainfall areas that may become saturated and subject to denitrification losses. Nitrogen may be applied by growers at several times during the year, including early spring (preplant), at planting, and in-season (sidedress). Note that not all products may be available in your area.

Early spring (preplant) application is commonly used in areas where growers are able to complete this practice without delaying planting beyond the optimum window. Because this N is applied well ahead of major crop uptake, it too is at risk of loss if warm soil temperatures and excessive rainfall occur. Use of ammonium forms of N can reduce loss potential. Depending on the time of application relative to planting, as well as expected weather conditions (determined by climate history) a nitrification inhibitor may also be advantageous.



Figure 2. Severe nitrogen deficiency symptoms are evident in this field that remained saturated due to excessive rainfall.

At-planting application has one distinct advantage – when the field is fit to plant, it is also fit for N application, unlike pre-plant or sidedress applications that may be disrupted by weather. However, the amount of N that can be applied by the planter is limited, and may slow the planting process. Application in a separate field trip immediately following planting may be preferable.

In-season (sidedress) applications allow for adjustments to planned N supply based on weather variations. If wet spring conditions result in N losses, sidedress rates can be increased. If warm temperatures and moderate rainfall result in high N mineralization and an N-sufficient crop, sidedress rates can be reduced. This process of determining crop sufficiency or need can be aided by various methods of soil testing or plant sensing.

In-season N applications can supply N to the crop near the time of maximum plant uptake. However, if wet conditions develop, sidedress applications may be delayed beyond the optimum application date. Extremely dry conditions can result in a delay in availability of sidedressed N to the plant. Because of these risks, soil fertility specialists often recommend that only one-third of total crop supply should be targeted for sidedress application. In addition, growers should be well-prepared to apply sidedress N as quickly as possible when the window of opportunity arises, and a backup plan should be in place should weather interfere with the original plan.

N-timing Research Results Vary

The effect on yield of N application timing has been widely studied for decades. Common types of nitrogen timing studies include preplant vs. split between preplant and sidedress, and different types of N fertilizers applied at various timings. Other studies also tested N application timing, multiple rates of N, and different proportions of total N applied at various times. **These studies show a wide range of results that often vary according to the weather conditions encountered during the study.** For this reason, understanding the relationship between N supply, weather conditions, and corn needs is more important to developing successful N management strategies than research results per se.

Ammonium Forms of N More Stable

The most common nitrogen fertilizers are anhydrous ammonia, urea-ammonium nitrate (UAN) solutions, and granular urea. Other forms include ammonium nitrate and ammonium sulfate. Ammonium (NH_4^+) forms of N bind to negatively charged soil particles and are not subject to leaching or denitrification losses. Applying N fertilizers that include more ammonium and less nitrate forms of N reduces their potential for loss in the short-term. However, over time, nitrifying soil bacteria convert ammonium to nitrate (NO_3^-), a form which is readily lost when excessive rainfall leaches or saturates soils. These bacteria have minimal activity when soil temperatures are below 50°F, so cool or cold temperatures naturally help protect ammonium forms of N from losses.

Urea-containing fertilizers have yet another mechanism of loss: they are subject to volatilization when surface applied. However, once urea is taken into the soil by rainfall, irrigation, or tillage, volatilization potential ceases.



Figure 3. Sidedress application of anhydrous ammonia at the V5 to V6 corn growth stage. *Photo courtesy of John Deere.*

Nitrogen Stabilizers

To help reduce N losses, nitrogen "stabilizers" or "additives" can be applied along with N fertilizers. These products must be matched with specific N fertilizers in order to be effective. Several common products include Instinct[®], N-Serve[®], Agrotain[®], Agrotain Plus[®] and ESN[®]. For these products, read and follow all label instructions carefully.

N-Serve and Instinct contain the chemical nitrapyrin. These products are nitrification inhibitors that act against bacteria responsible for nitrification, thus slowing the conversion from ammonium to nitrate and reducing the risk of loss. According to the manufacturer, N-Serve is an oil-soluble product that may be used with anhydrous ammonia, and dry ammonium and urea fertilizers. Research studies over many years have proven the effectiveness of N-serve when used with anhydrous ammonia.

Instinct is a new encapsulated formulation of nitrapyrin for use with urea ammonium nitrate (UAN) and liquid manure. Instinct can be applied with liquid manure, liquid fertilizer or tankmixed with a herbicide or insecticide application prior to or at planting.

Agrotain, the compound NBPT, is used primarily with urea and secondarily with urea ammonium nitrate (UAN) solutions. Agrotain inhibits urease, a naturally occurring soil enzyme involved in the conversion of urea to ammonia. Agrotain Ultra is a more concentrated formulation of Agrotain. These products are useful when urea is broadcast and not incorporated into the soil with tillage or irrigation. When urea is broadcast in contact with crop residue, high losses may result, as the urease enzyme is abundant in plant material. Research shows that N loss from surface-applied urea can range from 0 to 50 percent. The amount of loss depends on weather conditions; loss is greatest with warm, windy weather and a moist soil surface.



Figure 4. Application of anhydrous ammonia to field previously in soybeans. *Photo courtesy of Case-IH.*

Agrotain[®] Plus is an additive specifically for UAN solution, containing both a urease inhibitor that prevents ammonia volatilization from synthetic or organic urea, and a nitrification retardant. Thus, it acts against both the volatilization and nitrification processes that lead to N losses from urea, but does not protect the nitrate portion of UAN solution.

ESN[®], Environmentally Smart Nitrogen is another type of nitrogen stabilizer. According to the manufacturer, ESN contains a urea granule within a micro-thin polymer coating, which releases the N as soil warms. This time-release method is an alternative way to help reduce nitrogen losses due to volatility.

Developing Your N-Supply Strategy

Applying N at multiple times, including the time of maximum crop uptake, is a good way to spread risks and reduce costs, but the extent to which this is practical depends on prevailing weather conditions in your area. Historical weather data can be used to determine how much applied N may be lost in typical months, and also to indicate how many days may be available for field work when sidedress applications need to be made.

Using historic weather information, growers should develop an N-timing strategy with a high probability of implementation most years. Such strategies should be weighted heavily for soil type and topography, which impact retention of applied N and the ability to apply additional N. Regions and individual fields vary in those properties, so many growers should have multiple N-management strategies in their farming operation. In addition, growers must be ready to implement a "plan B", when excessive or prolonged rainfall disrupts original plans.

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