Science Societies

When to use a single or split application of nitrogen fertilizer in corn

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Photo by Brad Bernhard.

One strategy to reduce the risk of N loss is to apply N fertilizer in amounts and at timings that closely match the water and N uptake pattern of corn. This article looks at results from a 49 site-year study across eight U.S. Midwestern states to provide examples of the influence of soil properties and weather on the effectiveness of split vs. single at-planting N applications.

Nitrogen (N) is the essential nutrient that most often limits corn yield. The two main sources of N for corn are N coming from the decomposition of organic N in the soil organic matter into inorganic forms such as nitrate-N and ammonium-N (N mineralization) and N from application of synthetic N fertilizers. The difficulty in knowing how much N fertilizer to apply is that it is hard to predict the quantity of N that the process of mineralization will supply as it can vary between 20 to 100% of the corn's N requirement. Predicting the quantity of N mineralization within this range each year is challenging because it depends on the quantity and quality of soil organic matter along with precipitation and temperature, which are difficult to predict. Some may simply say to err on the side of caution and overapply N fertilizer to make sure the corn crop has enough N to optimize yield regardless of the amount of N supplied through mineralization. However, mineralized or fertilizer N not used by the corn crop has the potential to negatively impact the environment.

One way to lessen potential negative environmental impacts from the application of N fertilizer is to reduce the potential of N loss (leaching and denitrification), which may be accomplished by better understanding when and in what quantities corn takes up and utilizes N. In the U.S. Midwest, corn is normally planted from mid-April to mid-May. From planting to about the V6 corn development stage (six horizontal leaves; approximately mid-June), plant growth above- and belowground is slow, and the amount of water and nutrients corn requires is low (Abendroth et al., 2011). Annual precipitation is also normally highest during this period (March to June). It is during this period of high rainfall and low water and nutrient uptake by corn that precipitation often exceeds evapotranspiration and soil water storage capacity, leading to the greatest period of annual water drainage and N loss. For example, it was during this March-to-June period where approximately 62% of the annual water drainage and 70% of the N lost to subsurface drainage occurred in Minnesota (Randall et al., 2003a; b; Randall & Vetsch, 2005; MPCA, 2013). Near the V6 corn development stage, corn begins to rapidly grow and take up larger amounts of water and nutrients, and this trend continues until the R3 corn development stage (August). During this period, the corn plant will take up 50 to 75% of its total N needs (Randall et al., 2003a; Ma et al., 2003). This greater uptake rate of water and nutrients after V6 reduces the potential for water and N losses (Jokela & Randall, 1997; Randall et al., 2003a; Ma et al., 2003).

Splitting Up Nitrogen Applications

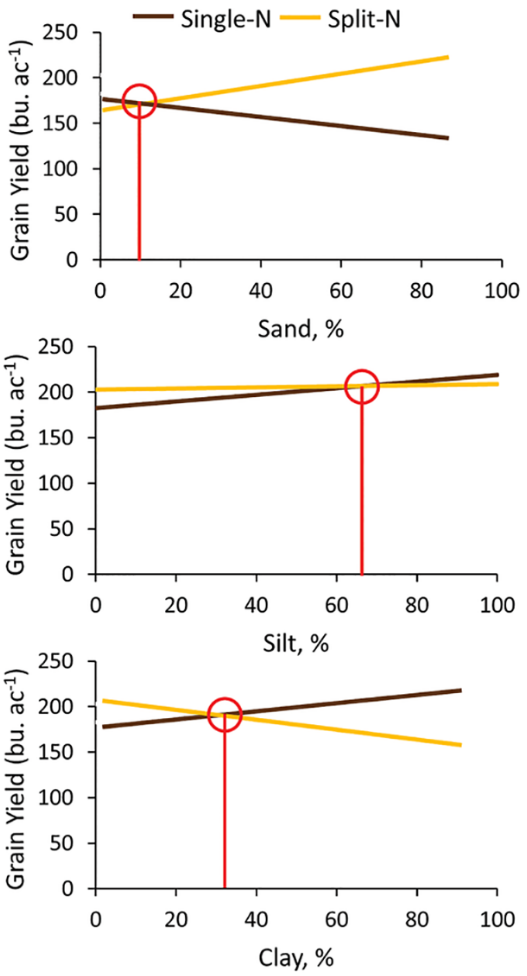

***Figure 1**, Corn grain yield of single and split N application timings as a function of sand, silt, and clay content across 49 site-years in the U.S. Midwest.*

One strategy to reduce the risk of N loss is to apply N fertilizer in amounts and at timings that closely match the water and N uptake pattern of corn (Dinnes et al., **2002**; Gehl et al., **2005**; Jones & Olson-Rutz, **2011**). To match corn's N uptake pattern, a small amount of N fertilizer is applied near planting (i.e., 20–30% of the total), and the remainder is applied at one or more later times when corn is taking up larger amounts of N (i.e., near or after V6). Applying N fertilizer in this manner has the potential to lower the amount of N fertilizer in the soil that can be lost during the high-loss potential part of the season and increase the amount of N in the soil when the rate of corn uptake is high and loss potential is low. However, the effectiveness of splitting up the N fertilizer application on corn yield and reducing nitrate-N in the soil after the growing season has been variable.

The variability of the effectiveness of splitting up N applications on improving corn grain yield and minimizing post-harvest soil nitrate-N is partially due to the differences in N loss susceptibility of different soil textures and the precipitation pattern in that year. Results from a 49 site-year study across eight U.S. Midwestern states (North Dakota, Minnesota, Wisconsin, Nebraska, Iowa, Illinois, Indiana, and Missouri) will be used to provide examples of the influence of soil properties and weather on the effectiveness of split vs. single at-planting N applications (Kitchen et al., 2017). In our study across eight U.S. Midwestern states, we observed that split-applying N led to similar corn grain yields and post-harvest soil nitrate-N levels in most sites (76–84%). These results indicate that farmers can normally use split or single N applications without reducing corn grain yield or increasing post-harvest soil nitrate-N. However, split or single N applications can increase corn grain yield or post-harvest soil nitrate-N over the other under certain soil and weather conditions. It is important to know these conditions because differences in grain yield due to N application timing were as high 68 bu/ac.

> *"Split or single N applications can increase corn grain yield or post-harvest soil nitrate-N over the other under certain soil and weather conditions."*

Nitrogen Application Timing Depends on Soil, Weather

In general, we observed that split relative to single N applications increased corn grain yield in areas with consistent precipitation around the time of sidedress application that incorporated the fertilizer as well as in soils with greater potential for N loss early in the growing season (i.e., sandy soils that have greater leaching potential [sand content > 4–10%] [Figure 1]). On the other hand, we observed that single relative to split N applications increased corn grain yield in areas where precipitation was not reliable at the time of sidedress N application to incorporate the N fertilizer. Further, single relative to split N applications increased corn grain yield in soils with greater potential for mineralization throughout the season (i.e., greater total N content [>2.1–2.4 g/kg] and better nutrient and water retention capability as indicated by greater CEC [>27–31 meq 100 g^{-1}], silt content [>66–74%], or clay content [>24–37%]). If we take the sand silt and clay content values where single or split N applications began to be greater or less than the other, we can determine what type of N application timing should be used for a field given its texture as shown in Figure 2.

The use of split N applications can leave more nitrate-N in the soil that can be lost before it is used by next season's crop. However, in our study, split N applications had greater post-harvest soil nitrate-N than single N applications only 22 to 24% of the time. This result was attributed to the amount and timing of precipitation events before and after the sidedress N application and not differences in plant N uptake. Sites with less rainfall before the sidedress N application (less chance of N loss from at-planting N application) and more after (greater chance of N loss of both the at-planting and split N applications) tended to have similar post-harvest soil nitrate-N levels. Split N applications tended to have greater post-harvest soil nitrate-N levels than single N applications in those sites with greater precipitation before sidedress (greater chance of N loss from at-planting N

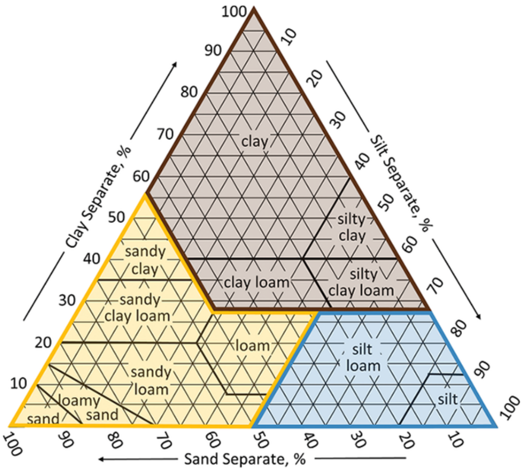

Figure 2, Texture triangle showing which N application timing (single, split, or either) optimizes corn yield. Yellow: Split N applications tend to yield better than single N applications. Brown: Single N applications tend to yield better than split N applications. Blue: Single or split N applications optimize yield.

application) and less precipitation after sidedress N application (less chance of N loss from split N application). Overall, these study results show that N application timing decisions should be made based on soil properties and weather conditions because they influence the effect of N timing on corn grain yield and post-harvest soil nitrate-N.

Dig deeper

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