CORN MANAGEMENT AFTER LOSS OF SOIL NITROGEN

Nitrogen levels are critical for optimal corn yield. But excessive rainfall after planting can nullify the benefits of N applications. Insufficient N can affect development at each growth stage and may decrease yield potential. Corn plants with an inadequate supply of N are less vigorous and often transfer all of their energy into grain production, creating weak stalks that are vulnerable to stalk rot and stalk lodging. The largest reduction in yield potential can occur in response to stress during silking and can continue through the dough stage of grain development. Nitrogen and phosphorus uptake are rapid at this time. Nutrient concentrations in the plant are highly correlated with final grain yield and response to previously applied fertilizer can be seen. Nutrient deficiencies during this stage can result in unfilled kernels or chaffy ears.

To manage a corn crop after heavy rains, it is important to know why N losses occur and what can be done about it.

How Soil Nitrogen is Lost

Excess moisture in the soil profile is one of the major causes of nitrogen loss. These losses are due either to leaching or denitrification of the nitrate form of N. Leaching occurs when excess water, moving downward through the soil profile, flushes nitrate below the root zone. Denitrification is a process that occurs when saturated, anaerobic soil conditions stimulate microbes to convert nitrate to forms of N gas that move up through the soil and can be lost to the atmosphere. The amount of nitrate-N loss is influenced primarily by the length of time soils are saturated as well as by soil temperature. The University of Illinois estimates that when soils are saturated, daily nitrate-N loss by denitrification can be 1 to 2% at soil temperatures less than 55°F, 2 to 3% if soil temperatures are between 55 and 65°F, and 4 to 5% at soil temperatures above 65°F.[1]

Factors that Affect Available Nitrogen

When extreme rain events occur during the growing season, deciding whether to make a supplemental N application is complex. Several factors impact the extent to which N losses occur after heavy rainfall and suggest that caution is a good strategy in decision making. Factors that affect available nitrogen include:

- The amount of nitrate already present during rain events which is influenced by the form of N applied, the timing and rate of application, and the possible use of a nitrogen inhibitor.
- The stage of crop development when rain events occur.
- The length of time soils are saturated.
- Soil drainage patterns that affect the potential for leaching and denitrification.

Crop Stage: The stage of crop development when extreme rain events happen impacts the degree of N loss. When heavy rainfall events take place later in the growing season, much of the N needed for the crop may have already been taken up by the plants. Corn in the silking stage (R1), for example, has already taken up approximately 60 percent of required nitrogen, while corn in the blister stage (R2) has taken up 75 percent.[2] Additional nitrogen requirements at these growth stages may come from what is left of fertilizer applied earlier in the season or from N mineralized from organic sources such as manure applications or cover crop residues.

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Type of N Applied: The type of N fertility program used can also make a difference. The severity of N losses from in-season heavy rainfall events will be greater when inorganic forms of N are used in contrast to the use of organic forms of N. For inorganic N fertility, much of the N applied has been converted to the nitrate form by the approximate V12 growth stage.[2] The use of a nitrogen inhibitor can extend protection against the conversion of N from ammonium to nitrate forms for approximately six more weeks.[2] But any nitrate left in the soil can be vulnerable to leaching and denitrification during extreme rain events. In contrast, N fertility that is coming from organic forms such as manure or a previous legume crop will continue to create the ammonium form of N longer in the growing season (mineralization) making N available to corn before it is nitrified and susceptible to loss. Rainfall later in the season can also provide conditions that support mineralization and possibly provide additional available N.

Soil Type and Drainage Patterns: How much water a particular soil type can hold is another important factor that can impact the degree of leaching. By the nature of their texture, sandy soils cannot hold as much water as clay soils. Therefore, leaching of nitrates will occur more easily in a sandy soil compared to a clay soil. Soil drainage patterns can also impact the amount of leaching. For leaching to occur, enough precipitation must be present in the soil profile to flush nitrates below the root zone. This means that enough water is present to exceed field capacity as well as to exceed the amount of water that is removed by the corn crop itself through evapotranspiration.

How to Determine if Nitrogen has been Lost

There is no simple way to determine the amount of N lost from leaching or denitrification, but there are steps a grower can take to help make a good decision on whether to apply supplemental N.

Crop Assessment: Scouting the field is one of the best ways to determine N availability from the soil. Pay close attention to signs of N deficiency, especially before silking. Corn plants exhibiting N deficiency may appear to be stunted, spindly plants with a yellowish green color. The older, lower leaves will have a V-shaped yellowing that starts at the leaf tip (Figure 1). However, keep in mind that yield potential already may be reduced by the time N deficiency is visible.[3] Also, apply a certain amount of caution to visual symptoms. It is common to see off-color corn in wet spots, but not necessarily the result of N deficiency. In addition, consider the potential for productivity after soils dry. Yield potential may be reduced from stand damage due to waterlogged soils instead of N loss.[4]

Figure 1. Corn leaf showing N deficiency.

Photo is provided courtesy of the International Plant Nutrition Institute (IPNI) and its IPNI Crop Nutrient Deficiency Image Collection.

A Pre-Sidedress Nitrate Test (PSNT): The PSNT is a useful tool for fields that may have N loss from leaching and denitrification. The test provides a measure of the amount of N mineralized from organic N plus the amount of carryover N still present in the soil. Mineralization is the process by which organic N is converted to ammonium-N and nitrate-N, which is then available for plant uptake. Adequate soil moisture and warm temperatures are beneficial for mineralization. However, if late spring temperatures are below normal, the test may underestimate soil N (lower soil test values) because of slower mineralization rates. Sampling for the PSNT should be done when corn is 6 to 12 inches tall.[1] Soil cores should be taken at a depth of 12 inches, with one sample containing 15 to 20 cores. Although some differences exist in university recommendations for interpreting PSNT results, a general rule of thumb is that if soil test results are over 23 to 25 ppm, additional nitrogen is probably not needed.[5] A change of approximately 10 lbs N/acre is recommended for each 1 PPM change in PSNT test levels.[6]

Other Tools: Additionally, there are other available tools, such as chlorophyll leaf meters (SPAD meters), crop sensors, and remote sensing/aerial imagery to detect N deficiencies in season.[1] Remote sensing requires good canopy development mid-season and can be accomplished effectively using NDVI (normalized difference vegetative index) cameras on aerial drones or sensors fitted to high clearance N application equipment. The NDVI or NDRE (normalized difference red edge) index for any part of the field is compared to the highest readings in the field (considered the "high N reference") and variable rate N adjustments can be made to areas of the field N deficient.[7] These tools may provide information to aid in determining late-season nitrogen application rates.

How to Correct a Nitrogen Deficiency

Based on the results of assessment and testing, it may be necessary to apply remedial N applications to improve deficiencies and to maintain corn yield potential. Corrective applications will be most effective prior to silking, when corn plants require the most nitrogen. Maximum N uptake in corn occurs approximately from growth stages V9 to V18, corresponding to the major period of growth. It is important to match the best nitrogen source to the method of application to achieve the best results.

Sidedress N applications can be very effective in remediating nitrogen deficiency earlier in the season. All common N fertilizers can be used for sidedress applications. Sidedress applications from the most to least desirable are as follows:[8,9]

- Injection of anhydrous ammonia or urea-ammonium nitrate solutions between rows
- Broadcast dry ammonium sulfate
- Dribble banded UAN
- Broadcast urea

*Broadcast UAN should be avoided because it can burn corn foliage, especially with large corn.

For larger corn, standard N application equipment may not be practical. Nitrogen may be applied to tall corn by high-clearance equipment that uses either a solid shank applicator to inject N into a coulter slit a couple of inches deep into the soil or uses fitted drop nozzles for application. A split hose, or 'Y' drop nozzle, may be used to dribble liquid N fertilizer close to the plant.[10] To reduce the chance of injury from fertilizer, additional weight to the drop nozzle can be added to reduce bounce and fertilizer splash onto plants. Anhydrous applications should be limited as corn reaches the V7 growth stage. This is because anhydrous ammonia can quickly move from the injection point into the growing root zone and potentially injure roots. Granular urea is another option for late-season N. It can be applied by a high-clearance box spreader or by airplane.[10] Irrigated corn also provides a method for applying remedial N to corn. Injecting urea-ammonium nitrate into irrigation water is convenient when available.[10] The remedial effect of N applied late in the season by any methods to N deficient corn will be impacted by the health of the plant roots. Damaged roots will have only a limited ability to take up N applied late in the season.

Split applications of N can also be used as a management practice to minimize N loss and provide nitrogen closer to when the corn plant needs it. When N is applied as a single application preplant or at planting, there is an increased likelihood of more N loss from a heavy rain event. The risk of N loss can be reduced by splitting N applications, with one application at preplant or at planting, followed by a second application in-crop.

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Performance may vary, from location to location and from year to year, as local growing, soil and weather conditions may vary. Growers should evaluate data from multiple locations and years whenever possible and should consider the impacts of these conditions on the grower's fields.