SPRING 2011 – NITROGEN AND SULFUR ISSUES

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Many areas of Iowa, especially southern to southeastern Iowa, have experienced well above normal rainfall this spring, with several recent large rainfall events. This is now the fourth year in a row with excessively wet conditions. In the early spring, the cold soils helped reduce potential for nitrate loss due to slow accumulation of nitrate and slow denitrification. However, wet soils in June are much more conducive to nitrate loss as soils are warm, and with prolonged saturation and tile flow losses mount.

Estimating nitrogen losses

One way to determine nitrogen (N) loss is to calculate an estimate. Predicting the exact amount is quite difficult as many factors affect losses. However, estimates can provide guidance for supplemental N applications.

Research Measurement of Nitrate Loss

Research conducted in Illinois* indicated approximately 4 to 5 percent loss of nitrate-N by denitrification per day that soils were saturated. An all-nitrate fertilizer was applied when corn was in the V1 to V3 growth stage (late May to early June). Soils were brought to field capacity and then an excess 4 inches of water (above ambient rainfall) was applied by irrigation evenly over a 3-day period (which maintained saturated soils for 3 to 4 days on the finer textured soils) or an excess of 6 inches of water was applied over an 8-day period (which saturated soils an additional 3 to 4 days).

The excess water application resulted in loss of 60 to 70 lb N/acre on silt loam and clay loam soils, due to denitrification loss. On a very coarse-textured, sandy soil, virtually all nitrate-N was moved out of the root zone by leaching. On the finer textured soils, an addition of 50 lb N/acre after the excess water was sufficient to increase corn yields to approximately the same level where no excess water was applied. This was not the case on the sandy soil because considerably more N was lost due to leaching.

Nitrate loss via tile drainage does increase with above normal rainfall. At the Gilmore City, Iowa ag-drainage research site where tile-flow nitrate has been monitored since 1990, nitrate loss is greatest in years with higher precipitation and hence greater tile flow. At N fertilization rates of 150 to 160 lb N/acre, the annual nitrate-N loss per acre was 52 lb in the 1990-1993 period, 9 lb in the 1994-1999 period, and 39 lb in the 2000-2004 period (average nitrate-N losses for the combined corn-soybean sequence). The range in yearly nitrate-N loss for the years studied was 1.0 lb nitrate-N/acre in 1997 to 75 lb nitrate-N/acre in 1990.

Typically a high portion of tile flow and associated nitrate-N loss occurs in the springtime. The impact of excess precipitation on potential for nitrate remaining in the soil for crop use in wet springs is that more nitrate-N is lost via tile flow, and overall the annual loss would be in the range of perhaps twice the "normal" loss amount, increasing from around 15-25 lb N/acre to 40-50 lb N/acre.

Estimating Nitrate Loss

According to research at the University of Nebraska, the estimated denitrification loss of nitrate when the soil temperature is 55 to 60 degrees F is 10 percent when soil is saturated for 5 days and 25 percent when saturated for 10 days (2 to 2.5 percent per day). Loss increases with warmer soils. Research conducted in Illinois with late May to early June (soil temperatures greater than 65 degrees F) with excess application of water on silt loam and clay loam soils indicated approximately 4 to 5 percent loss of nitrate present per day that soils were saturated.

To estimate N loss, the first step is to estimate the amount of ammonium converted to nitrate-N. By now, one could assume late fall anhydrous ammonia and manure ammonium to be nearly converted to nitrate, and with early April preplant N applications a majority converted to nitrate. Less conversion to nitrate would occur with use of a nitrification inhibitor. Recent ammonium applications (within the last two weeks) would still be predominantly in the ammonium form, especially for anhydrous ammonia. Recent application of nitrate-containing fertilizers would result in more nitrate being present. Urea-ammonium nitrate solutions (28 or 32 percent UAN) contain one-quarter nitrate-N, and nitrify more rapidly. The second step is to estimate the percentage of nitrate-N loss as described in the research above. The amount of N loss is calculated from these two estimates.

Example

The following might be an example of a situation with a spring preplant application of UAN solution and the wet conditions encountered this year. If 95 percent of a 120 lb N application is converted to nitrate, and soils were then saturated for ten days when warm, the N loss estimate would be (120 lb N per acre x 95% nitrate/100) x (4% per day/100) x (10 days) = 45 lb N per acre. Add in increased tile flow on tile-drained fields, and the loss estimate could be 60 lb N per acre. Variation of lower or higher losses could easily occur depending on warmer or cooler conditions, different forms of applied N, more or less time from N application to wet conditions and more or less time and frequency soils are saturated. The same will occur for different landscape positions and soils. With very coarse-textured/sandy soils, significant rainfall events (4 to 6 inches or more) in addition to already moist soils could easily result in all nitrate leaching out of the crop rooting zone.

Measuring corn nitrogen status

Tools are available that can aid decisions about applying supplemental nitrogen (N) when there have been losses of applied fertilizer or manure N. These can provide more site-specific information than estimating losses and can also provide N rate application guidance.

Late spring soil nitrate test

Details about this test can be found in ISU Extension publication PM 1714, *Nitrogen Fertilizer Recommendations for Corn in Iowa*. Soil samples are collected when corn is 6 to 12 inches tall, often in late May to early June. This year the corn growth is behind and soils have been cool, and with the current wet soils, some fields will be sampled later than normal. Soil conditions should allow the collection of good samples from the entire one-foot depth and with no excess water "leaking" from the sample bag. With the current wet conditions, this could be difficult. A large number of cores are needed, especially in fields with band-injected N. Test interpretations are adjusted when spring rainfall is well above normal. In fields where less than full rates of N were applied preplant, lower the critical concentration from 25 ppm to 20–22 ppm when rainfall from April 1 to time of sampling is more than 20 percent above normal. With full rates of N applied preplant (fall or early spring) or with manured soils, the suggested critical concentration is 15 ppm if May rainfall exceeds 5 inches. In these fields, if tests are between 16 and 20 ppm, consider a small N application. In situations where manure or full rates of N were applied, a suggestion is to limit additional N application to 60–90 lb N per acre, even if the test result is 10 ppm or less.

Corn plant nitrogen status
A method to determine the N status of corn plants is explained in ISU Extension publication PM 2026, *Sensing Nitrogen Stress in Corn*. The corn plant expresses N shortage through reduced leaf greenness and plant biomass, which can be seen as you look at corn plants and measured with sensors such as a chlorophyll meter, active canopy sensors, or remote images. Measurements need to be compared with adequately fertilized (non-N limiting) reference areas in order to reduce bias due to different growing conditions, soils, hybrids, or factors affecting corn plant color and growth other than N deficiency (like plant yellowing in response to wet soils or sulfur deficiency).

If you are concerned about N losses, then apply two or three supplemental N strips across fields or in targeted field areas and watch the corn. These will be the reference areas that can be compared with the rest of the field. When corn gets some size to it, around the V8–V10 growth stages, and you see differences in the color between the strips and the rest of the field, then additional N should be applied to the field or field areas showing deficiency. These applications should be made as quickly as possible in order for the corn to have best chance to respond to the supplemental N.

Quantifying N deficiency stress and the amount of N to apply can be accomplished by monitoring the crop with a chlorophyll meter or active canopy sensors. Relative sensing values (readings from the field area of interest divided by readings from the reference area) give an indication of the severity of deficiency; that is, the lower the relative value the greater the N deficiency and the larger the N application rate needed.

Sensing the plant N status can aid in confirming suspected N-loss situations and need for supplemental N. This is especially helpful when corn has recovered from wet conditions, resumed good growth, and is putting pressure on the available N supply in the soil. The later into the growing season sensing is conducted, the more it can indicate deficiencies and the better related to total crop N fertilization need. Small plants usually do not reflect potential N shortages because the amount of N taken up is small, and easily met by soil N or N fertilization. Therefore, corn plant sensing is more reliable with larger plants. Measurements from approximately V10 to

VT stages should provide similar results. Suggested N rates to apply based on sensing can be obtained from ISU Extension publication PM 2026 for the chlorophyll meter. For active canopy sensors, recent evaluation and research calibration for specific active sensors and relative indices can be found in the conference publication *Quantifying Nitrogen Deficiency and Application Rate with Active Canopy Sensors*, or refer to company provided guidelines based on their specific sensor operation and canopy index.

An advantage of plant N stress sensing or visual observation, and comparison with reference areas, is the ability to monitor the crop multiple times as the season progresses to see if the N supply is adequate, remains adequate, or N stress develops. Wet soils will cause corn to have poor coloration and rooting, and can also limit yield potential. Therefore, it is important to allow plants to recover fully from wet conditions before assessing the N status. Another advantage to plant N stress sensing is that plants integrate N supply across a period of time. Since mineralization of N from soil organic matter is an important source of N for crop growth, waiting to determine the N status allows the plant to respond to N accumulated in the soil from mineralization. Warm, moist soils with high organic matter levels can have considerable mineralization (even when flooded), and this source of N can help offset N losses. Plant sensing and comparison to reference areas is a way to determine this contribution, as well as nitrate located deeper in the soil profile.

Applying additional nitrogen (and sulfur) after wet conditions

When conventional application equipment can be moved through the field (i.e., the soils are dry enough and the corn is short enough), then injection of anhydrous ammonia or UAN solutions would top the list of best options. Next would come urea-ammonium nitrate solution (UAN) surface dribbled between corn rows, and then broadcast urea, ammonium sulfate, or ammonium nitrate. If there is a sulfur deficiency, and plants are small, then ammonium sulfate would also supply plant available sulfate. If injecting or surface dribbling UAN, then addition of ammonium sulfate or ammonium thiosulfate would supply sulfur. If only sulfur deficiency is a problem, then broadcast calcium sulfate could supply plant available sulfate. Ammonium thiosulfate should not be broadcast onto plant tissue. Preplant application of sulfur products is preferred, but if caught early rescue sulfur applications can increase yield. Application is best when plants are still small, and a sulfate containing product is needed for an immediate available sulfur form.

Broadcast UAN solution should be avoided on corn larger than the V7 growth stage. With tall corn, supplemental UAN will need to be applied with high-clearance equipment. Injection coulters or drop tubes between every other row or every row should work equally well. Dry nitrogen materials can be broadcast with buggy or high clearance dry box spreaders if they can be driven between corn rows, or aerially applied. For broadcast urea, use of a urease inhibitor can help slow volatile N loss from warm wet soils. A urease inhibitor would not be needed with injected UAN, and low probability of need with surface dribbled UAN due to limited UAN surface contact. With broadcast dry products, some material will fall into plant whorls, but will cause only cosmetic damage to leaf tissue. That will show as spots or streaks on leaf margins when the leaf grows out of the whorl. Of course to get benefit from surface applied nitrogen or sulfur it needs to be moved into the root zone with rainfall.

Yellow Corn Plants

The early 2011 growing season has had considerable cool and wet conditions. Many fields have corn plants showing various shades of yellowing and interveinal leaf stripping. What's may be the cause?

1. Cold temperatures. Not uncommon with early planting. Entire small plants can show lack of green color.
2. Wet soils. Corn roots need aerated soil for metabolic processes and nutrient uptake. Entire plants can show yellowing and many different symptoms, including phosphorus deficiency.
3. Slow soil organic matter mineralization. With cold temperatures, microbial conversion of organic N compounds to inorganic N (ammonium and nitrate) is slow. If the corn plants are dependent on that source of plant available N, then plants could show N stress. Entire plants can show yellowing.
4. Sulfur deficiency. This is related to item 3, that is, slow organic matter mineralization and lower supply of plant available sulfate-S (the form of S taken up by plants). Soil organic matter is the largest reserve of S in most soils, so slow mineralization can limit available S, especially in the upper soil profile. There have been several examples of early season S response (greener plants) in on-farm S strip trials and research plots at experiment stations this spring (Kanawha, Muscatine, central Iowa). In some cases, these early S deficiency symptoms may disappear with time and there would be no yield consequence. Our research the past few years indicates this does not always occur, and about 60% of the research trials have had yield increase with S application, especially when the deficiency symptoms are severe. For more information on Iowa sulfur research in corn, see the ICM conference report, Dealing with Sulfur Deficiency in Iowa Corn Production. Classic S deficiency is the older leaves are green and the new leaves show yellowing and interveinal stripping. With severe deficiency, the entire plant will be yellow.
5. Continuous corn. In many springs, and again this year, corn following corn tends to show more yellowing than corn following soybean, especially in reduced till and no-till. This is related to many factors, such as same crop allelopathy and less mineralization (for N and S).
6. Potassium deficiency. It typically begins to show on larger plants, about calf to knee high. Symptoms appear first on older leaves, with yellow to brown coloration on the leaf margins.
7. Corn hybrid. Some hybrids tend to show interveinal stripping more than other hybrids, and hybrids have different levels of greenness.

Nutrient deficiency symptom pictures and descriptions can be found in ISU Extension publication IPM 42, Nutrient Deficiencies and Application Injuries in Field Crops.

**Reported in the 1993 Iowa State University Integrated Crop Management Conference proceedings, pp. 75–89, and in Torbert et al., 1993, "Short-term excess water impact on corn yield and nitrogen recovery," Journal of Production Agriculture 6:337–344.*