ESTIMATING NITROGEN LOSSES (PART 2)

John Sawyer, Professor, Department of Agronomy, Iowa State University

One method to judge 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. Excess rainfall this spring occurred in two "periods." The first arrived early. Loss during that time should have been moderate compared to the same situation that has occurred this late spring. In the early spring, soils were colder, so conversion to nitrate and denitrification was slower. However, wet soils in late spring are warmer and have been saturated for a prolonged period. This significantly increases the chance for loss.

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 heavier textured soils) or an excess of 6 inches of water was applied over an 8-day period (which saturated soils for 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 heavier 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 due to leaching.

Nitrate loss via tile drainage does increase with wet conditions. 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 time period, 9 lb in the 1994-1999 time period, and 39 lb in the 2000-2004 time 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. The climatic conditions in years prior to tile flow can significantly affect nitrate loss and corn responsiveness to applied N in subsequent years. For example, dry years preceding years with considerable tile flow will increase concentration and loss. The 1990 year followed several dry years, and that year had the highest nitrate-N loss of the years studied. In 1993, the wettest year of those studied and with a somewhat similar spring to this year, the annual nitrate-N loss was 53 lb nitrate-N/acre.

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 like this year 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 loss per day). Loss increases with warmer soils. Research conducted in Illinois with late May to early June (soil temperatures greater than 65 degrees F) 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 the end of May this year (cooler than normal), one might assume late fall anhydrous ammonia and manure ammonium to be 60 percent or more converted to nitrate and with early April preplant N application, approximately 50 percent or more 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 present during the same time period. 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 an early spring application of UAN solution and the wet conditions encountered this late spring. If 85 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 85% nitrate/100) x (4% per day/100) x (10 days) = 40 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 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.

(*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)