Nitrogen Loss in Flooded Corn Fields

Nitrogen (N) loss can result from heavy rainfall or flooding events through denitrification and/or leaching.

- The variables that impact loss include N sources, temperature, and amount of precipitation.
- Assessment of potential loss should be estimated by farmers to determine if additional N is needed to help maximize yield potential.

Soil N loss via denitrification and leaching

Nitrogen loss can occur by denitrification (microbial process of reducing nitrate and nitrite to gaseous forms of nitrogen) and by leaching (loss of nitrate N as water drains through the soil profile). Denitrification is common in flooded fields because flooding removes oxygen from the soil which creates ideal conditions for denitrification. The rate of denitrification is determined by temperature, the rate accelerates when temperatures are above 60 °F.[1] Heavier textured soils tend to exhibit more denitrification, whereas leaching is more prevalent in sandy soils. Denitrification may begin after soils have been saturated for 2 to 3 days.[1] Research conducted in Illinois indicated approximately a 4 to 5% nitrate-N loss via denitrification for each day that silt loam and clay loam soils were saturated during late May and early June.[2]

Soil N loss via nitrification

Nitrogen loss can occur via nitrification which is the conversion of ammonium by microbes first to nitrite and then to nitrate. Nitrate is more prone to leaching and denitrification which results in loss of availability to the plant. The type of fertilizer can impact the nitrification process, fertilizers that are ammonium based (anhydrous ammonia, urea, or ammonium sulfate) are less prone to nitrification under saturated soil conditions. Nitrogen fertilizers with N partly in the nitrate form (urea-ammonium nitrate (UAN) solution or ammonium nitrate) are more susceptible to loss because a portion of the fertilizer is already in the nitrate form.

- **Ammonia volatilization.** Urea products are converted to ammonium by a soil enzyme called urease. The process is hastened with higher soil moisture. Urease inhibitors can be used to stall the breakdown and usually last about two weeks, depending on soil moisture and temperature. Products containing N-(n-butyl) thiophosphoric triamide (NBPT) and N-(n-propyl) thiophosphoric triamide (NPPT) are common urease inhibitors.
- **Nitrification inhibitors.** These inhibitors temporarily reduce populations of Nitrosomonas and Nitrobacter bacteria which are the major microbes that convert ammonium to nitrite. The inhibitors reduce both denitrification and leaching by retaining fertilizer N in the ammonium form. Products with known efficacy for inhibiting nitrification are dicyandiamide (DCD), nitrapyrin, and pronitradine.

Management

Determining exactly how much N has been lost in a large rain event or flooding situation is usually not possible; however, an estimate of loss can be helpful in providing a guide for the need and amount of additional N. When excess moisture occurs in the early spring when soil temperatures are still relatively cool, the loss of N by denitrification is quite low. However, in late spring or early summer when soil temperatures are higher, the risk of loss is higher.

Calculating an estimate of N loss

A study on saturated soil and soil types found that silt loam and clay loam soil lost 4 to 5% of the N daily by denitrification, particularly if an all-nitrate fertilizer has been used. This translated to 60 to 70 lb N/acre. In course textured soils leaching was the major factor for N loss. By applying 50 lb N/acre the final yield was comparable to where the soil was not subjected to excess water.[3] An additional consideration is when tiling is used to help with field drainage. A study in Iowa found that yearly N loss ranged from as little as 1 lb nitrate N/acre to 75 lb of nitrate N/acre, wet years following extremely dry years had the greatest loss and the highest loss rate occurred in the spring. The authors estimated that in wet springs, the loss rate via tile flow would be 40 to 50 lb of nitrate N/acre.[2]

The estimated denitrification loss of nitrate at soil temperatures of 55 to 60 °F is 10% when the soil is saturated for 5 days and 25% when saturated for 10 days (2 to 2.5% loss per day) and losses increase with warmer soil temperatures. In a study conducted when soil temperatures were greater than 65 °F, an excess application of water on silt loam and clay loam soils resulted in a 4 to 5 % loss of nitrate.

The first step is to estimate the amount of ammonium converted to nitrate-N. If the application of anhydrous ammonia was applied in the fall, about 60% would be converted to nitrate by early spring and with an early spring anhydrous ammonia application about 50% would be converted to nitrate. If a nitrate inhibitor was used, the conversion would be less. The second step is to determine the rate of conversion to nitrate. If soils are cool, an estimate of 2 to 2.5% per day could be used, if soils are warm, a rate of 4 to 5% could be used.[2]

Scenarios

An application of UAN was applied pre-plant and wet conditions occurred in the late spring. The estimated percent of UAN converted to nitrate is 80%, 130 lb N/acre was applied, soils are warm 65 °F, and saturated for 7 days.

- (130 lb N per acre x 85% nitrate/100) x (4% per day/100) x (7 days) = an estimated 31 lb N per acre loss.
- An application of anhydrous ammonia was applied in the fall without an inhibitor. Wet conditions occurred when soils were cool, soil was saturated for 10 days, and 70% of the applied 150 lb/acre of N was converted to nitrate.
- (150 lb N per acre x 70% nitrate/100) x (2.5% per day/100) x (10 days) = an estimated 26 lb N per acre loss.

If the field is tiled, losses could be higher due to water flow through the tile lines. Additionally, with very coarse textured soils, bountiful rainfall (>4 inches) added to already saturated soils could result in most if not all the nitrate being leached out of the root zone.

Sources

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[3]Torbert, H.A., Hoeft, R.G., Vanden Heuvel, R.M., Mulvaney, R.L., and Hollinger, S.E. 1993. Short-term excess water impact on corn yield and nitrogen recovery. Journal of Production Agriculture. pp 337-344. https://www.ars.usda.gov/ARSUserFiles/60100500/csr/ResearchPubs/torbert/torbert_93b.pdf

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