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Soggy Soils Lead to Questions About Supplemental Nitrogen Fertilizer

R.L. (Bob) Nielsen
Agronomy Dept., Purdue Univ.
West Lafayette, IN 47907-2054
Email: rnielsen@purdue.edu

- **Bottom Line:** Reasonably little nitrogen loss has likely occurred from denitrification and leaching to date this spring because fertilizer application timing and soil temperatures have not been conducive for significant conversion of ammonium nitrogen to nitrate nitrogen.
- Where nitrogen loss has occurred, the remaining soil nitrogen levels are likely sufficient to support the expected lower yield potential of the plants surviving lengthy periods of saturated soil conditions or that of a yet-to-be replanted crop.
- Read on only if you want the gory details that back up this opinion.

Pre-plant nitrogen fertilizer applications followed by frequent periods of intensive rainfall in April and May often cause corn growers to question whether supplemental nitrogen fertilizer may be required because of a concern that some of the pre-plant nitrogen may have been "lost" by leaching or denitrification. The question is a valid one because soil nitrogen in the nitrate form can disappear at rates as high as 5% per day of ponding or saturated soil conditions.

Unfortunately, the answer to the question is often clouded by many complicating factors. Among them are nitrogen fertilizer source, time of fertilizer application, soil temperatures since the time of application, use or not of a nitrification inhibitor, use or not of an urease inhibitor, calendar time since time of application, amount of rainfall, timing of rainfall, duration of saturated soil conditions, soil temperatures during the period of saturated soil conditions, and soil texture.

Since the nitrate form of soil nitrogen is the one vulnerable to loss by leaching or denitrification, estimating how much of the applied nitrogen fertilizer was in the nitrate form when the rainy period began is important to estimating how much nitrogen may have been lost. Nitrogen fertilizer exists in several forms; including ammonium, urea, and nitrate.

The ammonium and urea forms eventually convert to the nitrate form via soil microbial processes. The rates of conversion are dependent on soil temperature and aeration. About one-fourth of urea-ammonium-nitrate solutions (UAN) is already in the nitrate form and is susceptible to leaching or denitrification loss as soon as the material is applied to the field.

In warm soils (60F or warmer) with ample soil oxygen, conversion of non-anhydrous ammonium forms of nitrogen will occur in only one to two weeks (Brouder & Joern, 1998). The process will take much longer when soil temperatures are in the 50's and eventually slows down to zero as soils cool from 50F to freezing. Conversion of anhydrous ammonia to nitrate occurs more slowly because the anhydrous band itself is toxic to the soil microbes responsible for the conversion. The soil microbial population must rebuild over a several week period before the conversion to nitrate can begin and so nitrification is delayed from two to six weeks (Brouder & Joern, 1998). Finally, recognize that conversion of ammonium to nitrate is interrupted when soils become saturated.

Having said all that, let's return to the question of how much nitrogen loss has likely occurred so far this spring. The good news is that essentially none of the anhydrous or UAN applied this spring was likely converted to the nitrate form before the "monsoon" season began in late April. Soil temperatures through mid-April were simply too cool in most areas of the state to encourage much soil microbial activity. The exception may be UAN applications in the far southwestern part of Indiana where warmer soils may have enabled nearly complete conversion of UAN applied in late March or early April to nitrate before the end of April.

Fall-applied anhydrous programs occur most commonly in northern Indiana. The conversion of fall-applied anhydrous to nitrate depends on fall and spring soil temperatures and whether a nitrification inhibitor was used. From 50 to 100% of fall-applied ammonia generally converts to nitrate by May 1 of the following year (Hoeft, 2001, 2002a; Sawyer, 1999). Given the rapid cooling of soils by mid-October 2002 and the slow soil warm-up this spring, the conversion rate is likely closer to the 50% value than the 100% value.

So, the three candidate scenarios for possible nitrogen losses this spring are:

- Southwestern Indiana, UAN applications in late March or early April: Likely 100% of nitrogen in nitrate form by end of April.
- Northern Indiana, fall-applied anhydrous: Approximately 50% of nitrogen in nitrate form by end of April.
- All of Indiana, UAN applications this spring: At least 25% of the nitrogen in UAN is already in the nitrate form.

The next step in this tortuous estimation process is to predict the likely rate of denitrification loss this spring. According to Univ. of Illinois data (Hoeft, 2002b), denitrification rates range from 1 – 2 % per day at soil temperatures less than 55F, 2 – 3 % per day at soil temperatures between 55 and 65F, and 4 – 5 % per day at soil temperatures greater than 65F. The higher rates are applicable to southwestern Indiana this spring since the rains began in late April. The intermediate rates are applicable to the remainder of Indiana since late April.

Remember that the estimate of nitrogen loss is equal to the multiplication of the likely denitrification rate by the likely pounds of available soil nitrate by the estimated number of days of saturated soil conditions. Example calculations of N loss for the three scenarios, each assuming an initial nitrogen fertilizer application rate of 180 lbs. N per acre and seven days of saturated soils, are listed here.

- Southwestern Indiana, UAN applications in late March or early April
    - Amount of nitrate nitrogen ~ 180 lbs total N x 100 % = 180 lbs
    - Daily denitrification ~ 180 lbs nitrate x 4 % = 7.2 lbs per day
    - Total nitrogen loss ~ 7.2 lbs per day x 7 days = 50.4 lbs N
- Northern Indiana, fall-applied anhydrous
    - Amount of nitrate nitrogen ~ 180 lbs total N x 50 % = 90 lbs
    - Daily denitrification ~ 90 lbs nitrate x 2 % = 1.8 lbs per day
    - Total nitrogen loss ~ 1.8 lbs per day x 7 days = 12.6 lbs N
- All of Indiana, UAN applied this spring
    - Amount of nitrate nitrogen ~ 180 lbs total N x 25 % = 45 lbs
    - Daily denitrification ~ 45 lbs nitrate x 2 % = 0.9 lbs per day
    - Total nitrogen loss ~ 0.9 lbs per day x 7 days = 6.3 lbs N

These estimates of nitrogen loss can then be used to determine the rates of supplemental nitrogen that could be applied to the corn crop. As you might expect by now in this discussion, this decision is not straightforward either because of uncertainties involved with the health of corn that has been subjected to ponding or saturated soils.

Frankly, the prospects for corn that has been ponded or subjected to saturated soils for more than three or four consecutive days are not positive at all. Similarly, corn that has suffered repeated ponding or flooding events would not be in good shape. Root death due to oxygen deprivation and/or disease will stunt or kill the waterlogged plants.

The worst of the wet holes or river bottoms will require replanting or will remain barren the remainder of this season. In many cases, the yield potential of the corn crop will be dramatically lower than hoped for and the remaining soil nitrogen levels are probably adequate to support that now lower yield level. Supplemental nitrogen fertilizer application would probably not be beneficial.

If you decide to apply supplemental nitrogen, remember that the very nature of flooding or ponding is spatial in its variability. If supplemental nitrogen fertilizer application was deemed to be economically valuable for the affected crop, the application itself will also need to be spatial and not performed over the entire field. The tire traffic involved with applying supplemental nitrogen to the affected spots in the field may damage otherwise healthy plants in the remainder of the field and create undesirable soil compaction.

You could elect to pull soil samples for a Pre-sidedress Soil Nitrate Test (PSNT) that may help predict the need for supplemental nitrogen. Information about this soil sample test can be found in the Purdue Extension publication AY-314-W (Brouder, 2003). Be aware, however, that the PSNT is best suited for estimating soil nitrogen availability in high organic matter soils or fields that have received manure applications. Use of the test for other situations has its limitations, including the fact that the standard 1-foot soil sample depth will not identify soil nitrate that may have leached to greater depths but is still available to plant roots. Additionally, the challenge of pulling representative soil samples in fields where pre-plant nitrogen fertilizer has already been applied is daunting because of the need to sample sequentially across the nitrogen applicator row widths. For suggestions on soil sampling such fields, read the 2002 Illinois Pest & Crop Bulletin article "*Predicting/Measuring Nitrogen Loss*" (Hoeft, 2002b).

Finally, you could forget all about the discussion up to this point and instead monitor the surviving or replanted plants near the time of sidedressing opportunities. Knee-high plants that exhibit distinct symptoms of nitrogen deficiency (yellowing, especially lower leaves) may benefit from roughly 50 lbs of sidedressed nitrogen.

Related References:

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