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Nitrate-Nitrogen: Here Today Gone Tomorrow?

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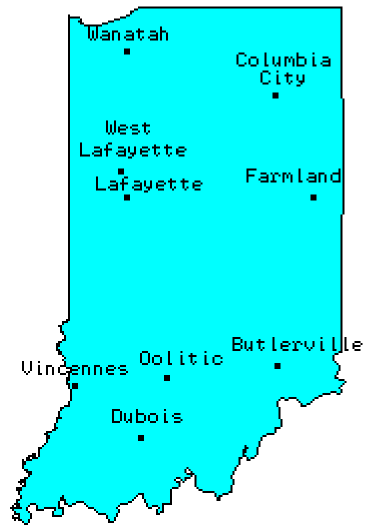
- Leaching of nitrate (NO_3^-) on sandy soils in southwestern Indiana has likely been substantial this spring unless early season fertilizer applications utilized a nitrification inhibitor.
- Some of the NO_3^- applied to sandy soils in northern Indiana has probably been lost from the rootzone as well. However, fertilizer added as ammonium (NH_4^+) in cold northern Indiana soils was likely still in the NH_4^+ form when the rains came and most of the applied NH_4^+ likely still remains in the rootzone.
- Loss of NO_3^- via denitrification in poorly-drained soils has probably been minimal in northern Indiana and low in central to southern Indiana.
- Although warm soil temperatures promoted conversion of NH_4^+ to NO_3^- in late April and early May in central and southern Indiana, these soils were relatively cold (<55 °F) during the rainy periods and this likely limited the amount of denitrification that occurred.

Nitrogen (N) is often the most limiting nutrient for corn production and many factors must be considered when determining the right amount of N to apply for optimum economic yields. One factor is how much N has been lost before the crop can accumulate it. Spring rainfall in particular can reduce the amount of N remaining in the rootzone from pre-plant and at-planting fertilizer applications. The recent rains have many folks wondering how much N has been lost from these applications. While we can not give you field-specific estimates of N loss, we can offer some guidelines to help you estimate these losses based on regional soil temperatures and rainfall

Nitrogen form determines susceptibility to N loss

The form of N present in the soil determines its susceptibility to loss. Nitrogen in the ammonium (NH_4^+) form is attracted to the soil cation exchange sites so it does not leach below the rootzone. Nor is NH_4^+ subject to a process called denitrification [when nitrate nitrogen (NO_3^-) is changed into various gas forms and lost to the atmosphere]. If N stayed in the NH_4^+ form then N losses would be minimal no matter how much it rained. Unfortunately that is not the case. Ammonium is normally converted to NO_3^- by soil bacteria and NO_3^- is both leachable in sandy soils and subject to denitrification in poorly drained soils. The amount of N lost from soils depends on when the NH_4^+ changes to NO_3^-, how much rainfall occurs after the NO_3^- is formed, the water holding characteristics of the soil, the soil temperature when the soil is saturated and the length of time the soil remains saturated.

Although we know the amount of N we already have applied, when it was applied, and what form it was in, we only can make educated guesses on how fast the NH_4^+ changed to NO_3^- and how much NO_3^- has been lost.



Conversion of NH_4^+ to NO_3 - the first step in N loss

Nitrogen applied as anhydrous ammonia is all NH_4^+ once it dissolves in the soil water. Anhydrous is toxic to the NH_4^+-converting bacteria in the injection zone and it takes about 2 weeks for them to repopulate the application zone soil and begin converting NH_4^+ to NO_3^-. Urea ammonium nitrate (UAN) solutions are more susceptible to leaching and denitrification than anhydrous because 25% of the N at application is already in the NO_3^- form. Also, the conversion of NH_4^+ to NO_3^- begins immediately after application if temperatures are warm because the UAN does not reduce soil bacteria populations. Conversion of NH_4^+ to NO_3^- from urea is the same as that from UAN.

Conversion rates of NH_4^+ to NO_3^- are highly dependent on soil temperature. Little conversion occurs when soils are below 50 $^{\circ}$F. At temperatures near 60 $^{\circ}$F complete conversion is estimated to take less than 14 days and at greater than 70 $^{\circ}$F, less than 7 days. Soil temperatures in southern and central Indiana have been above 60 $^{\circ}$F on a regular basis since April 15th (Figure 1a). Average soil temperatures at the 4" depth this spring were greater than 60 $^{\circ}$F on 29, 21, 21, and 18 days at the Purdue Agricultural Centers (PACs) in Vincennes, Butlerville, Lafayette, and Farmland, respectively. Thus, significant amount of N have been converted to $NO3^-$ in these areas already. In northern Indiana at the PACs in Wanatah and Columbia City there have been only 8 and 6 days with average soil temperatures above 60 $^{\circ}$F so much of the N applied as NH_4^+may still be in the NH_4^+ form.

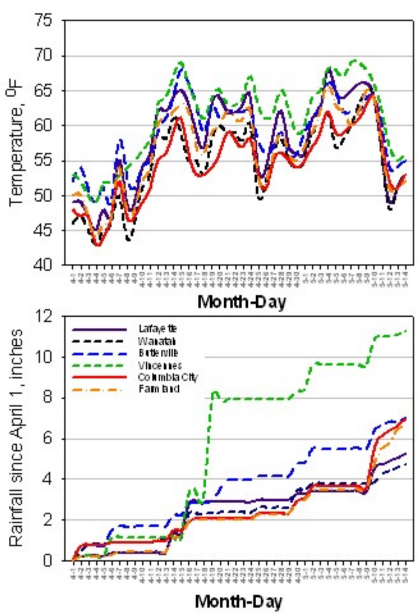


Figure 1. (a) Daily average soil temperature at a 4" depth and (b) cumulative rainfall for Purdue Agriculture Centers. The legend for locations is given in (b) and on the map.

Nitrification inhibitors, such as nitrapyrin, dicyandiamide, and ammonium thiosulfate, slow the conversion of $NH_4^+$to NO_3^- by affecting the soil bacteria. Conversion of NH_4^+ to NO_3^- is limited for approximately 4-6 weeks after application with nitrapyrin or dicyandiamide. Ammonium thiosulfate may also slow conversion about 2-3 weeks.

At the time of these last rains at the end of the 2nd week of May, most of the NH_4^+ applied in northern Indiana was probably still in the NH_4^+ form and not subject to leaching or denitrification. Because of warmer soil temperatures in central and southern Indiana, a significant amount of the N applied as NH_4^+ without a nitrification inhibitor had likely been converted to NO_3^- and has a high potential for leaching and denitrification losses. Ammonium-N applied in April or later with an inhibitor is likely still in the NH_4^+ form.

And then the rains come - the second step in N loss

Leaching from sandy soils

Once NO_3^- is present in the soil its leaching is not temperature dependent. How deep in the soil profile the NO_3^- moves depends on the water holding capacity of the soil, how wet the soil is when it begins raining, and the amount of rainfall. A typical sandy soil in Indiana holds about 1-2 inches of rain in each foot of soil. Therefore the movement of NO_3^- downward is approximately 6 to 12 inches per inch of rainfall if the soil is at field capacity when it begins raining.

Rainfall since the beginning of April has likely caused significant leaching in sandy soils in northwest and southwest Indiana where sandy soils are prevalent (Figure 1b). In southwest Indiana, the Vincennes area has had nearly 12 inches of rainfall. Nitrate in sandy soils in this region was probably leached beyond the maximum rootzone of corn – 3 feet or more. The 4.7 inches of rain at Wanatah in northwest Indiana is likely to have caused substantial NO_3^- leaching from the rootzone as well.

Denitrification in poorly-drained soils

Spring rainfall has been sufficient to saturate poorly-drained soils in most of Indiana. Denitrification will take place in saturated soils if NO_3^- is present and soil temperatures are warm enough. Denitrification is negligible below 50 $^{\circ}$F but increases to as much as 5% of the NO_3-N per day of saturation at soil temperatures of 70 $^{\circ}$F.

Temperatures in southern and central Indiana have been high enough to result in some denitrification in poorly-drained soils, but substantial NO_3^- losses are unlikely because soil temperatures at most locations were around 55 $^{\circ}$F or lower when the rainy period began on May 1 and 11.

Using soil testing to measure NO_3^-

One way to get a somewhat better estimate of soil N supply is to take a soil sample and have it analyzed for NO_3^-. The later in the season this is done the better. Standard recommendations suggest sampling when corn is at the 4- to 6-leaf stage; hence it is called the pre-sidedress soil NO_3^- test or PSNT. The best situation to utilize this procedure is when manure has been broadcast in the fall or early spring. Specific recommendations for preplant N have not been developed and use of the procedure with banded manure or fertilizers is difficult because of sampling issues. Because of the variability in soil N across fields a sampling area of no more than 10 uniform acres is recommended and each sample should consist of 15-25 cores taken 1 foot deep. You should dry the sample before mailing to a soil testing laboratory so your results will reflect the soil condition when it was sampled.

Results of the soil NO_3^- test are typically reported in parts per million (ppm) or milligrams per kilogram (mg/kg) which are equivalent in value. If more than 25 ppm NO_3-N is found in the sample then no additional N is recommended. This amount of NO_3^- is unlikely unless a high rate of preplant fertilizer or manure has been applied. At lower levels of NO_3^-N, adjustments can be made to sidedress N rates. If little NO_3^- is found it might indicate that NH_4^+ had not yet been converted to NO_3^- as well as indicating loss of NO_3^- from the rootzone so some interpretation of the results is needed. More information on the PSNT can be obtained at: http://www.agry.purdue.edu/ext/pubs/AY-314-W.pdf.

How do we stand on early-season N loss?

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Don't forget, this and other timely information about corn can be viewed at the Chat 'n Chew Café on the Web at http://www.kingcorn.org/cafe. For other information about corn, take a look at the Corn Growers' Guidebook on the Web at http://www.kingcorn.org.