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Remember 50 °F

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Abstract
Why wait? If you are considering applying anhydrous ammonia or manure with a high ammonium N content this fall, remember to wait until temperatures cool to 50 °F and will continue to get colder. Why is this important? The form of nitrogen that can potentially be lost from soils due to wet conditions is nitrate (NO_3^-) (Figure 1). The form applied as anhydrous ammonia is NH_3, which is quickly converted to ammonium (NH_4^+) when it comes in contact with water in soil. Ammonium can also be already present at high levels in some manure sources, such as liquid swine manure. Because ammonium is a positively charged ion, it is attracted by electrostatic forces to negatively charged soil. Ammonium is not leached or lost by denitrification (conversion to nitrogen gas). Therefore, it will stay in soil even if the soil becomes excessively wet. Nitrate, which is produced by soil microbes from ammonium in a process called nitrification, is a negatively charged ion and is leachable and subject to denitrification.

Disciplines
Agriculture | Agronomy and Crop Sciences

Soil Fertility

Remember 50 °F

by John Sawyer and Elwynn Taylor, Department of Agronomy

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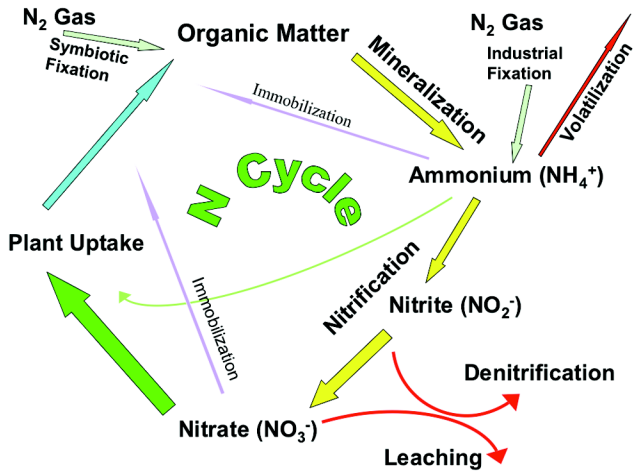

Figure 1. Simplified soil nitrogen cycle.

All would be well with fall application except that ammonium does nitrify to nitrate. Since nitrification is a microbe-mediated process, the rate is influenced by several factors that affect biological activity, such as ammonium supply, temperature, soil aeration (only occurs in aerobic soils); soil pH—range from 4.5 to 10.0 (optimum at pH 8.5); and soil moisture (highest at field capacity), but the largest influence is soil temperature. Therefore, an easy way to slow conversion of ammonium to nitrate is to have cold soil temperatures (examples of soil temperature effect on nitrification are shown in Figures 2 and 3). The optimum temperature for nitrification is around 90 °F. Below 50 °F the rate slows rapidly, but nitrification continues until 32 °F. Soil temperature cannot be controlled, but because soils cool in the late fall, and if application is held off, then nitrification in the fall is reduced. The later one waits to apply the better—colder soils mean less nitrification and the greater the probability that soil temperature will not rebound to warm levels.

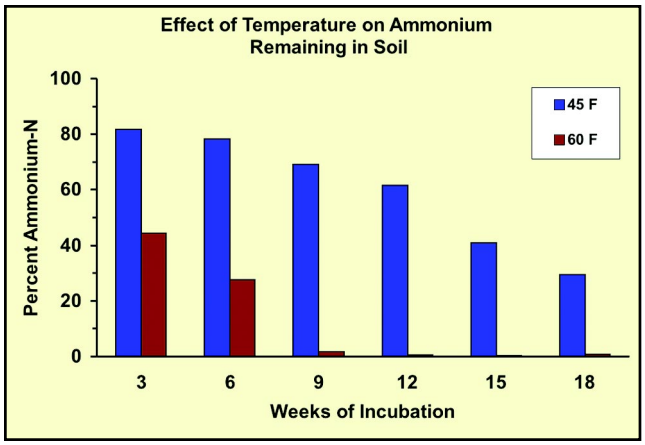

Figure 2. Aqua ammonia incubated in soil at controlled temperature. Adapted from Sawyer, J. E. 1984. Nitrification of ammonium nitrogen as affected by time of application, location, temperature, and nitrification inhibitors. M.S. thesis, University of Illinois, Urbana.

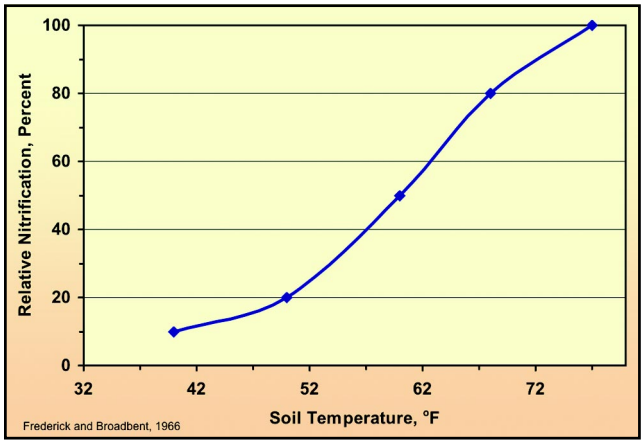

Figure 3. Effect of soil temperature on nitrate formation. Adapted from Frederick, L. R. and F. E. Broadbent. 1966. Biological interactions, p. 198–212. *In* M. H. McVicker et al. (ed.). Agricultural anhydrous ammonia technology and use. ASA, Madison, WI.

One material is labeled as a nitrification inhibitor to slow the conversion of ammonium to nitrate. Nitrapyrin, the active ingredient in N-Serve™ and Stay N 2000®, inhibits (temporarily slows but does not stop) the nitrification process at the conversion of ammonium to nitrite. By slowing nitrification, nitrapyrin slows the formation of nitrate. If more ammonium remains in the soil during a wet period, then less nitrate is present and subject to loss. Nitrapyrin is not foolproof. It is degraded predominantly in soil by chemical hydrolysis, which lessens effectiveness over time. Degradation is temperature dependent, so warm soils that speed nitrification also speed nitrapyrin breakdown, which means effectiveness is lower, nitrification reestablishes more quickly, and longevity is shorter. Also, the impact of a nitrification inhibitor on N loss is solely dependent on substantially more ammonium being present during an excessively wet period. If wet soils occur after the inhibitor loses its ability to effectively enhance the ammonium remaining, then it will have no real impact.

Waiting for cold soils or use of a nitrification inhibitor does not guarantee that fall-applied N will be a successful application practice. Warm fall conditions might occur, or warm and wet conditions may occur the next spring (a time period with historically high potential for wet soils and nitrate loss is May–June). However, if one decides to make applications in the fall, then waiting until soils are cold is better than applying early.

Where to find soil temperature information

Soil temperatures can be found at several Web sites. One that shows the 3-day, 4-inch depth soil temperature estimates for each Iowa county is located at **http://extension.agron.iastate.edu/NPKnowledge/**. The site also can be accessed through the Agronomy Extension Soil Fertility Web site (**http://extension.agron.iastate.edu/soilfertility/**), either from the weather page or nitrogen topic page. You can access the average daily soil temperatures from yesterday, two days ago, and three days ago, and you can get the 6- to 10-day weather forecast. The 4-inch soil temperatures are estimated for each county based on interpolation of observed soil temperatures at 14 locations. The estimates are for soil temperatures on level, bare soils. The reliability of the estimates is within 3 °F with normal conditions in Iowa. The variation in soil temperature within a locality is generally more than 8 °F depending on the slope of the land and condition of the soil. Also, dates during the past 5 years when soils cooled to below 50 °F are listed. Four-inch soil temperatures for the previous day at specific recording sites in Iowa can be found at this Iowa Environmental Mesonet Web site at **http://mesonet.agron.iastate.edu/agclimate/display.php?src=/agclimate/daily_pics/4in-temp-out.png**.

Remember, the trigger date for fall N application is not the first day that temperatures reach 50 °F, rather when the trend is for sustained soil temperatures below 50 °F and continued cooling. During the past 5 years the dates when soils cooled below 50 °F varied considerably, from late October to late November. Therefore, don't get fooled by a temporary cold spell, especially if it occurs early in the fall. Also watch the 6- to 10-day weather forecast, noting that a forecast for "above" average temperature may signal soil warming.

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