10-22-2001

Why 50 degrees Fahrenheit?

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Abstract
So you are considering making anhydrous ammonia applications this fall. Why the fuss over waiting until 50°F and lower soil temperatures?

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. 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 a nitrogen gas).

Keywords
Agronomy

Disciplines
Agricultural Science | Agriculture | Agronomy and Crop Sciences

INTEGRATED CROP MANAGEMENT

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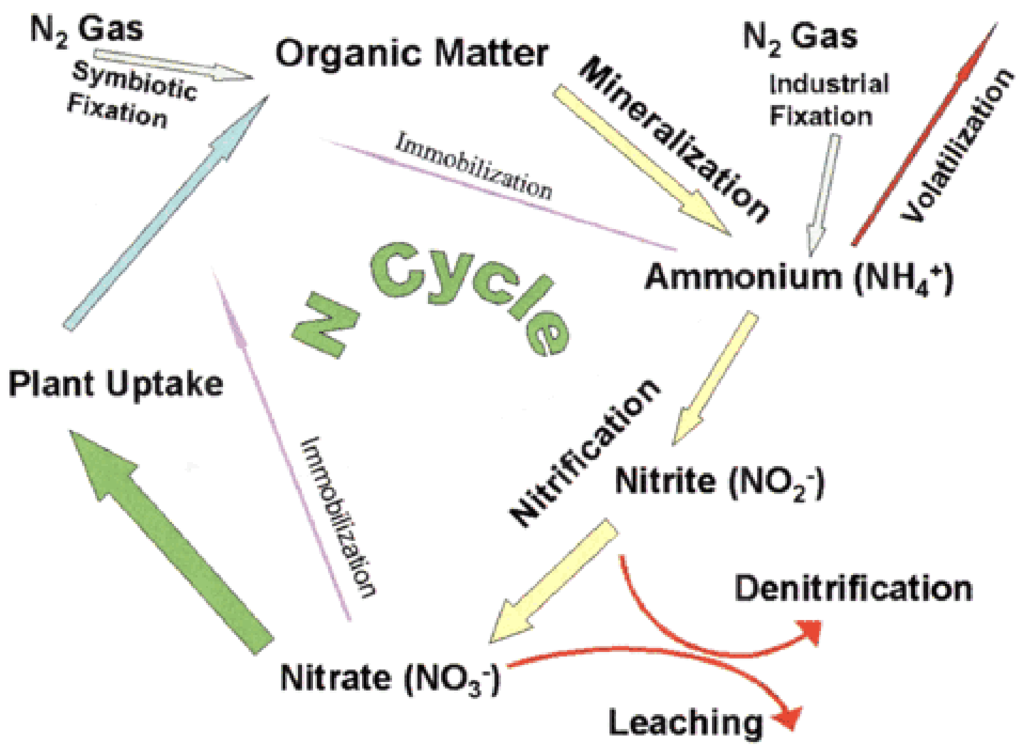
Figure 1. **Simplified soil nitrogen cycle.**



All would be well with fall ammonia application except that ammonium does nitrify to nitrate. Because 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, with 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 Table 1 and Figures 2 and 3). The optimum temperature for nitrification is approximately 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 ammonia application is held off, then nitrification in the fall is reduced. The later you wait 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.**

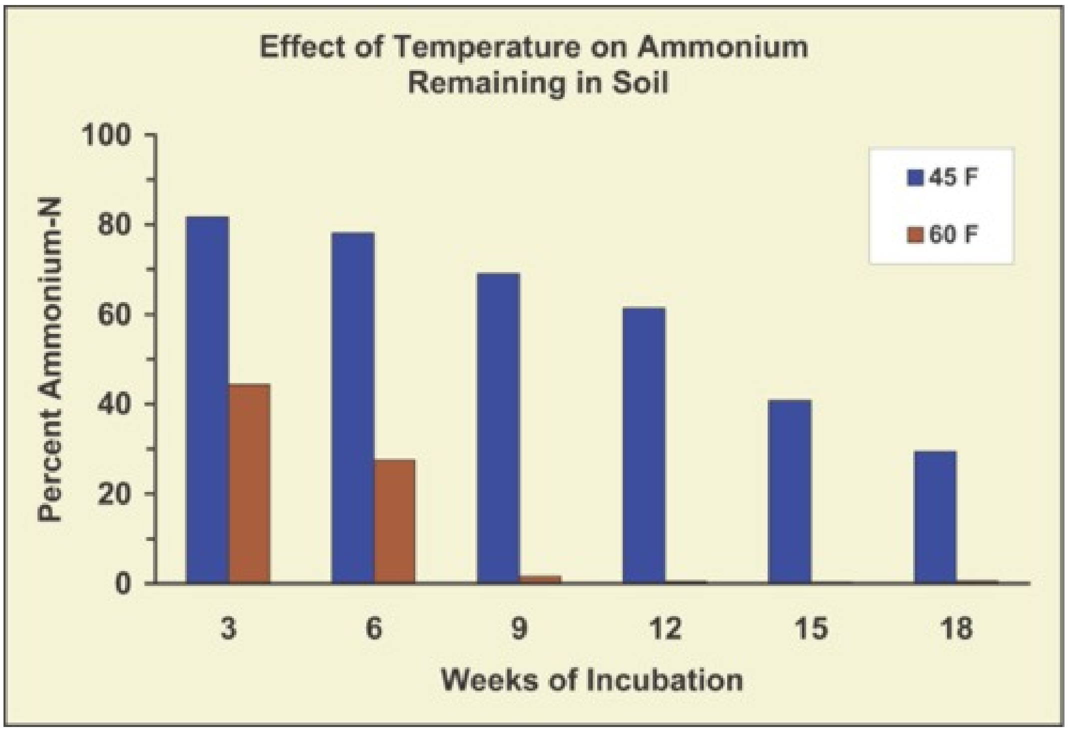
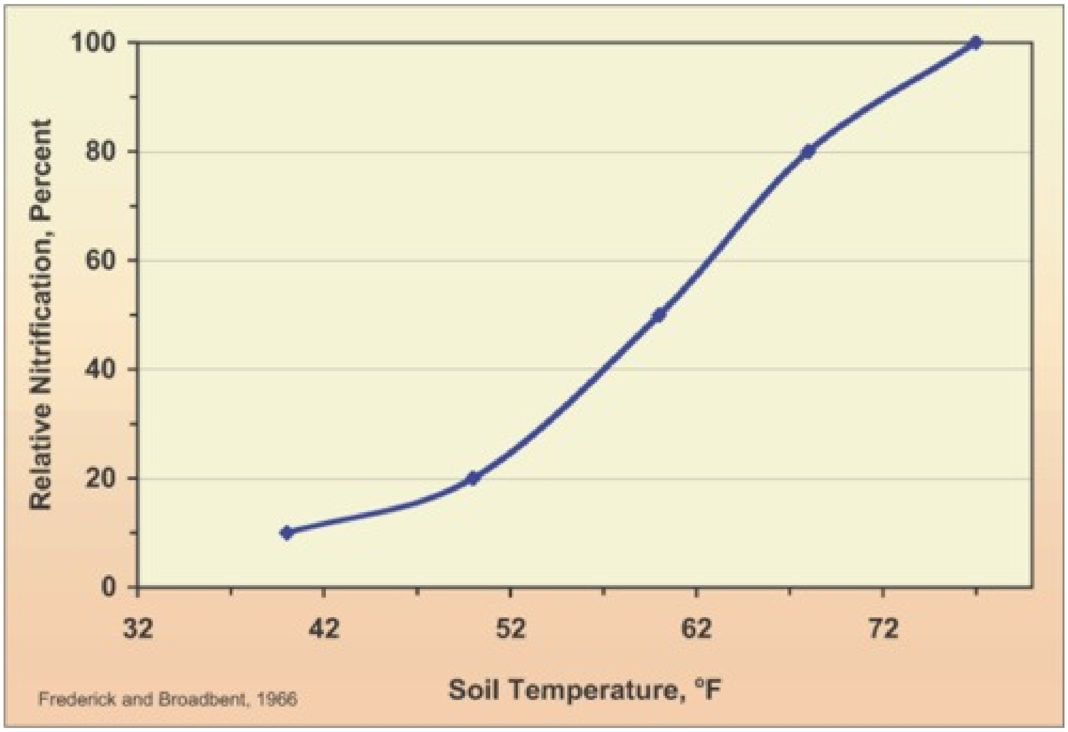


Figure 3. **Effect of soil temperature on nitrate formation (adapted from Fredereick and Broadbent, 1966).**



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 (Figure 1). 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. An example of the effect of fall application timing (and late fall soil temperature) on ammonium remaining from anhydrous ammonia application with and without nitrapyrin is shown in Table 2 (this is one example, and the amount of ammonium remaining can change dramatically depending upon the soil, time of application, and soil temperature in the fall and spring). Also, the impact of a nitrification inhibitor on nitrogen loss is solely dependent on substantially more ammonium being present during an excessively wet period. If wet soils occur after the inhibitor looses its ability to effectively enhance ammonium remaining (for instance, often by early- to mid-May for fall ammonia application) then it will have no real impact.

Waiting for cold soils or use of a nitrification inhibitor does not guarantee that fall-applied ammonia 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 through June). However, if you decide to apply anhydrous ammonia in the fall then waiting until soils are cold is better than applying early.

Table 1. **Influence of soil temperature on nitrification.**

Temperature Sequence	% Nitrification
Continuous at 80°F for 24 days	100
12 Days at 80°F-12 days at 40°F	96

8 Days at 80°F-8 days at 60°F-8 days at 40°F	74
12 Days at 40°F-12 days at 80°F	62
Continuous at 60°F for 24 days	59
8 Days at 60°F-8 days at 80°F-8 days at 40°F	56
8 Days at 40°F-8 days at 60°F-8 days at 80°F	45
Continuous at 40°F for 24 days	29

Ammonium sulfate nitrification after 24 days. Soils held at either constant temperature (80, 60, or 40°F) for 24 days, or the temperature varied (between 80, 60, and 40°F sequences) by 8- or 12-day intervals over the 24 days.

Adapted from Chandra, P. 1962. Note on the effect of shifting temperatures on nitrification in a loam soil. Can. J. Soil Sci. 42:314-315.

Table 2. **Example of ammonium remaining from fall anhydrous ammonia application.**

		Sample Date		
		Dec. 8	**Apr. 2**	**May 3**
Application	**Nitrapyrin**	**% NH_4-N Remaining**		
Nov. 7 (>50°F)	No	39	19	3
	Yes	63	28	17
Nov. 18 (<50°F)	No	40	33	7
	Yes	57	58	26

Adapted from Sawyer, J.E. 1984. Nitrification of ammonium nitrogen as affected by the time of application, location, temperature, and nitrification inhibitors. M.S. Thesis, Univ. of Illinois, Urbana, IL.

This article originally appeared on pages 191-192 of the IC-486(23) -- October 22, 2001 issue.
