Ammonia Loss from Urea Surface-Applied to Cold Soils

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Introduction

Broadcast application of urea fertilizer during the late fall, winter, or early spring is a common management practice for dryland winter wheat production in Montana. Soil temperatures during this time are often cold (<40 °F). Although the effectiveness of surface-applied urea is known to be affected by ammonia (NH_3) volatilization, it has been assumed that cold weather applications minimize volatilization losses. In 2008, we began a multi-year study to quantify NH_3 losses from surface-applied urea during this time period, and to validate whether cold soils provide protection against realizing large volatilization losses. This article shares a portion of the results.

Methods

Ammonia volatilization losses were quantified using a micrometeorological mass-balance approach with circular plots (0.3 acre), a center mast, and samplers that continuously measured NH_3 losses. Field trials were conducted on private farms in Hill, Fergus, and Gallatin Counties. Soil emissions of NH_3 were followed during 8 to 10 weeks following fertilization.

Results

Total cumulative NH_3 losses, expressed as a percentage of the applied N rate (90 lbs N/acre), averaged ~20% over 13 trials but were quite variable (Table 1). Surface moisture conditions at the time of fertilization and subsequent precipitation had a great impact on NH_3 loss. Losses exceeded 30% of applied N at Trials 3, 4, 5, and 10. Soil surfaces at these four trials were moist or high in water content such that urea granules dissolved at the surface shortly after fertilization. Precipitation events following fertilization were light (≤0.2 inches) and scattered at least through the first 30 days. Cumulative NH_3 losses > 30% occurred on both acidic and alkaline soils. Volatilization is often characterized as being more problematic on high pH soils. The results of this study suggest soil pH and temperature may be secondary to soil moisture, if the surface is high in water content at the time of fertilization. This is supported by the results from Trials 9 and 16 where urea was applied to a soil surface covered with a light snow pack. Cumulative NH_3 losses were moderated, or <20%, when urea was applied to dry soil surfaces such that urea granules did not dissolve until the first measurable precipitation event (Trials 1, 2, 6, 7, 8, 11, and 12). If the post-fertilization precipitation events exceeded 0.7 inches, as they did in Trials 1, 2 and 11, then NH_3 losses were mitigated to <10% of applied N.

Previous studies on NH_3 volatilization from fertilizers have found that large NH_3 losses are associated with an initially wet surface soil followed by several days of slow drying with little or no precipitation. Our results are consistent with these observations; however, they are unique in that we found cold soil temperatures did not provide protection from large volatilization losses. For example, NH_3 losses >10% of the applied N rate occurred over the first week post-fertilization in Trials 3, 4, and 5, even though mean daily soil temperature (1 inch depth) over the sampling period averaged only 33, 31, and 34 ˚F, respectively. Particularly large NH_3 losses (22% of applied N) were observed over the first week at Trial 5. Field conditions at the beginning of Trial 5 were characterized by a frozen soil surface with a trace amount of snow, and soil water content (0–3 inch depth) near saturation. During the first week, no precipitation fell and the volumetric soil water content fell from 50% to 25%. Similarly, cumulative NH_3 losses of 24 and 21% of applied N were observed after urea was broadcast onto fields with snow packs of 5 and 4 inches (Figure 1). The period of greatest NH_3 volatilization followed the disappearance of the snowpack, when the surface was drying and soil temperatures were still cold (Figure 1, Trial 9 weeks 4 and 5, Trial 16 week 2).

Implications and Recommendations

In the semiarid northern Great Plains, fertilizer applications that occur fall to early spring will often be made to soil surfaces that are cold or frozen, high in water content, and sometimes covered with a modest snowpack. This study indicates that significant losses of NH3 can occur from urea applied under such conditions, particularly after the surface thaws and dries. To minimize these losses, growers should probably wait until the soil surface is sufficiently dry to limit urea granule dissolution. If precipitation events that follow are light (e.g. <0.3 inches per event)

Fertilizer Facts

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and scattered then NH_3 losses will be in the range of 10 to 20%. If a large precipitation event (>0.7 inch as either rain or snow-equivalent) occurs within a few days after urea application to a dry soil surface then losses will likely be <10% of N applied.

Fertilizer Facts

- Urea applications to moist, high water content surfaces resulted in large NH_3 losses, 30% of applied N.
- Cold soil conditions do not provide protection against large NH_3 losses from surface-applied urea.
- Volatilization losses from urea can be minimized by applying urea to dry soil surfaces, though ideally urea should be incorporated or subsurface applied to minimize losses.

For more information on this study see http://landresources.montana.edu/ureavolatilization/

Table 1. Percentage of applied N lost as NH_3 following broadcast applications of urea at 13 field sites.

Trial	County	Fertilization date	Soil (pH)	% applied N lost as NH_3	Surface water status
1	Hill	03 Apr. 2008	Phillips-Elloam (6.1)	8.4	dry
2	Hill	08 Oct. 2008	Phillips-Elloam (6.4)	3.1	dry
3	Hill	14 Nov. 2008	Telstad-Joplin (5.5)	31.3	moist
4	Hill	25 Mar. 2009	Telstad-Joplin (5.5)	35.6	moist
5	Hill	26 Mar. 2009	Phillips-Elloam (6.4)	39.9	wet
6	Hill	06 Oct. 2009	Phillips-Elloam (6.0)	11.6	dry
7	Hill	13 Oct. 2009	Scobey-Kevin (6.5)	10.4	dry
8	Hill	19 Oct. 2009	Telstad-Joplin (5.5)	15.7	dry
9	Gallatin	27 Jan. 2010	Brocko (8.4)	24.3	snow-cover
10	Gallatin	26 Feb. 2010	Brocko (8.4)	44.1	moist
11	Hill	29 Mar. 2010	Scobey-Kevin (6.5)	6.3	dry
12	Hill	20 Apr. 2010	Scobey-Kevin (6.0)	14.7	dry
16	Fergus	02 Mar. 2011	Danvers (6.8)	20.7	snow-cover

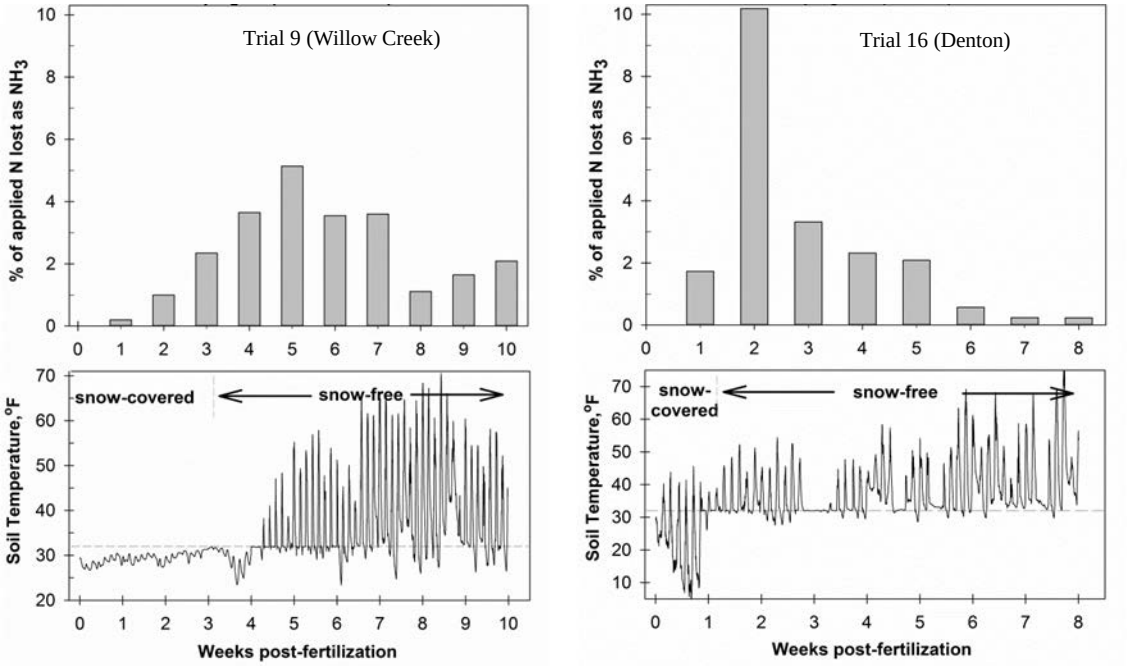

Figure 1. Ammonia losses and soil temperature at two field sites where urea was surface-applied onto snow packs of 5 in. (0.6 in. water) and 3 in. (0.3 in. water) near Willow Creek and Denton.

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