Quantifying Ammonia Volatilization from Surface-applied Fertilizers in Kentucky Bluegrass Grown for Seed

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Abstract

Kentucky bluegrass seed fields in central Oregon, Hermiston, and in the dryland conditions of eastern Washington all use surface-applied nitrogen. Volatile nitrogen loss as ammonia is an economic and environmental concern. The objective of this study was to quantify as pounds per acre ammonia volatilization from urea, Agrotain-coated urea, solution 32, CAN 27, and ammonium nitrate applied to the soil surface in the fall under commercial field conditions. Ammonia volatilization losses were measured with a modified passive flux method (Wood et al. 2000), which consists of a rotating 10-ft-tall mast placed at the center of each 100-ft-diameter circular plot. Nitrogen loss due to ammonium volatilization was highest with urea followed by solution 32. Agrotain-coated urea, CAN 27, and ammonium nitrate provided similar low levels of volatilization.

Introduction

Kentucky bluegrass seed fields in central Oregon, Hermiston, and in the dryland conditions of eastern Washington all use surface-applied nitrogen (N). The areas have diverse characteristics from high elevation of central Oregon, low elevation of the lower Columbia Basin, and rolling terrain of eastern Washington. Differences in winter temperatures and production practices create different risks for N loss. Soil characteristics and residue management vary between regions, as well as within regions. All three production areas receive their primary N application as topdress in mid- to late fall. When ammonium nitrate was available and N fertilizer cost low, volatile N loss was not a major concern. Recent observations by field representatives raise questions about the amount of N loss from volatilization of ammoniacal fertilizers such as urea.

Volatile N loss costs Kentucky bluegrass growers, wastes resources, and is an environmental concern. Ammonia in the air reacts with nitrous oxides and sulfur dioxide to form an aerosol product that produces smog and is a PM-2.5 particulate (U.S. Environmental Protection Agency designation). Quantitative measurement of volatile ammonia loss is necessary to define conditions where loss is minimal, and to put a cost to the loss and account for the N in fertilizer efficiency.

The objective of this study was to quantify as pounds per acre ammonia volatilization from urea and Agrotain-coated urea applied to the soil surface in the fall under commercial field conditions, and compare ammonia volatilization from urea, Agrotain-coated urea, ammonium nitrate, CAN27, and Solution 32 to identify potential improvements in fertilizer management in grass seed production systems.

Materials and Methods

Research in central Oregon was conducted on two Kentucky bluegrass (*Poa pratensis* L.) fields, one 60-acre field near Culver and the other a 120-acre field on the Agency Plains north of Madras. The last irrigation of the season had been completed just prior to fertilizer application at both locations. The Culver location was treated with three surface-applied N fertilizers, urea, Agrotain®-coated urea (5 qt/ton), and ammonium nitrate on October 11. Four treatments consisting of urea, Agrotain-coated urea, CAN 27, and solution 32 were applied on October 19 to the Agency Plains location north of Madras.

Fertilizers were applied to a 100-ft- diameter circle at a rate of 150 lb N/acre. Plots were arranged in a randomized complete block design with four replications. Plots were separated by a minimum of 300 ft to avoid possible ammonia cross-contamination between treatments. Dry fertilizer was applied with a 3-ft Gandy turf spreader and solution 32 was applied using a CO_2 backpack sprayer with StreamJet SJ3 fertilizer nozzles.

Ammonia volatilization losses were measured with a modified passive flux method (Wood et al. 2000), which consists of a rotating 10-ft-tall mast placed at the center of each circular plot. Ammonia was sampled at five heights (1.5, 2.5, 4.8, 7.4, and 9.8 ft; Leuning et al. 1985). Each passive flux ammonia sampler consisted of a glass tube (0.28 inches diameter by 7.87 inches long). The end of the tube facing the wind was capped with a small opening to control airflow through the tube. The inside of the tube was coated with oxalic acid to trap ammonia from the air. The mast includes a wind vane that keeps the tubes facing into the wind. Two background masts were placed upwind of the predominant wind direction. The sampling tubes were changed daily during the first week, then every-other day thereafter.

Sampling tubes were collected, capped at both ends to prevent any further collection of ammonia, and stored at 5ºC until processing at Hermiston. Processing began by shaking the tubes for 10 min with deionized water, then extracting and analyzing colorimetrically for ammonium (NH4 +) (Sims et al. 1995). Total ammonia volatilized from applied fertilizers was quantified by subtracting the background ammonia measurements. Vertical flux of ammonia was determined by summing horizontal flux at each measurement height (Wood et al. 2000).

Remotely operated weather stations (Campbell Scientific, Logan, UT) were placed on the edge of each field to collect data related to air temperature, soil temperature, humidity, rainfall, and wind speed and direction during the duration of the project at each location.

Results and Discussion

Comparison of Nitrogen Sources

Nitrogen loss due to ammonium volatilization was highest with urea followed by solution 32. Agrotain-coated urea, CAN 27, and ammonium nitrate provided similar low levels of volatilization. Over a 16-day period at Culver, ammonia volatilization was 49 lb N/acre for urea compared to 8 lb N/acre for Agrotain-coated urea and 11 lb N/acre for ammonium nitrate. At Agency Plains the level of ammonia volatilization over a 13-day period was nearly 25 lb N/acre for urea, 22 lb N/acre for solution 32, and 10 lb N/acre for both Agrotain-coated urea and CAN 27.

Culver Location: When the project was initiated on October 11 the high temperature was 66oF and increased to 75oF on day 5 (Fig. 3). Nighttime temperatures were near freezing, with relative humidity rising to 95 percent and creating heavy dew that lasted until early afternoon (Fig. 4). A cooling trend started on day 6 with a daytime high of 54oF on day 7, followed by a steady rise to 70oF on day 12. Over an inch of rain fell on day 13, holding the daytime high temperature at 59oF. Highs steadily declined to 46oF by day 16. The rain event increased wind speed to an average of 8 mph and the associated cloud cover raised nighttime low temperatures and relative humidity during daylight hours.

Ammonia loss from urea began immediately after application and continued over the 16 days of collection (Fig.1). From day 3 to 5, ammonia loss from urea increased dramatically, with an estimated 30 of the original 150 lbs N/acre lost during the first 5 days. The curve flattens from day 5 to 11, and flattens further through day 16, with a total loss near 50 lbs N/acre (Fig. 1). One would expect that an inch of rain in a 24-hour period (Oct. 23-24) would have an effect on the rate of volatilization, but no significant change due to the rain event was readily apparent.

In addition to rain, temperature and/or heavy dew are also known to significantly affect the rate of volatilization. Thirty-eight lbs/acre of ammonia were lost from urea by day 8 at Culver when there was heavy dew and warm temperatures. This compares to 15 lbs/acre in the first 8 days the following week at Agency Plains when daytime highs were cooler and minimal dew was present.

Agency Plains Location: Daily high temperatures had dropped by October 19 when fertilizer was applied to plots at Agency Plains (Fig. 5). Morning dew was light, high temperatures were in the mid-60s, and lows were near freezing until day 5 when 1 inch of rain fell (Fig. 6). It is difficult to determine the role of the rain event compared to other weather factors on the reduced rate of volatilization on day 6 and thereafter (Fig. 2). One would expect some significant effect based on recent work by Holcomb and Horneck (2009), who found that 0.5 inches of irrigation was adequate to minimize volatilization. However, sprinkler irrigation provides a constant application of water to the soil surface, whereas the intensity of rain events ebb and flow as waves of moisture move across the landscape, more similar to surge irrigation.

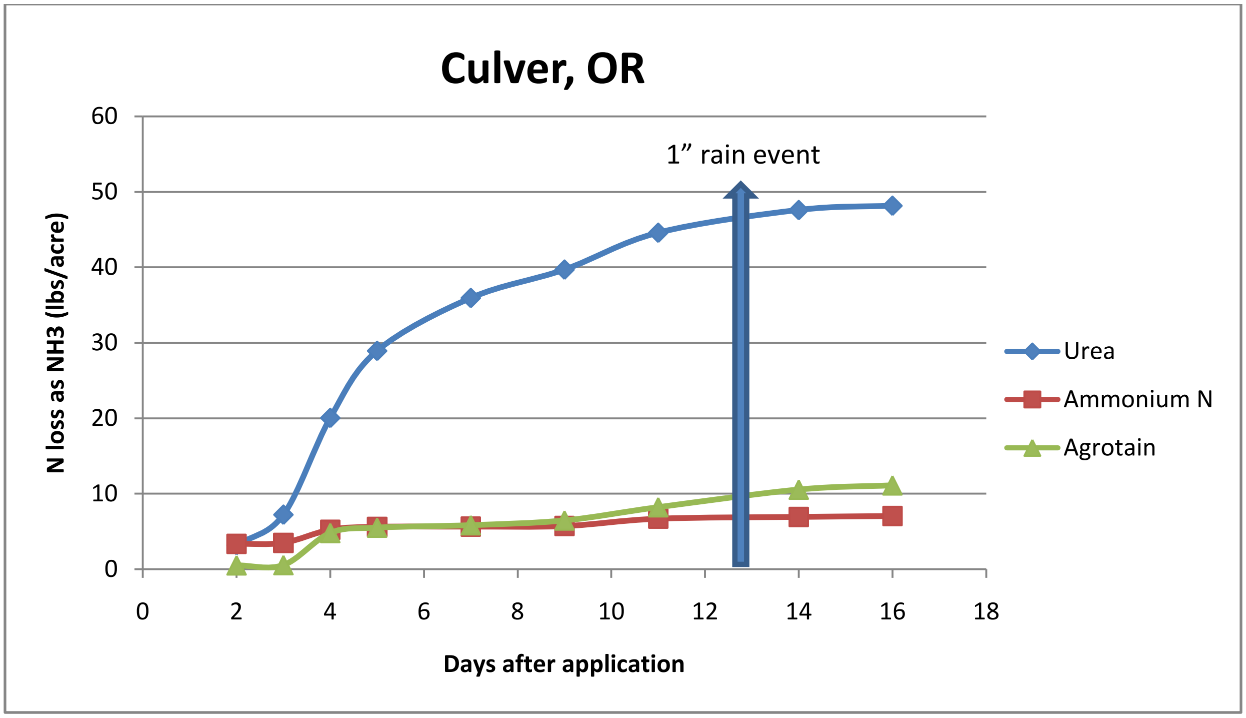

Figure 1. Ammonia volatilization loss from three nitrogen sources at Culver. Plots received 1 inch of rain over a 24-hour period on the 13^{th} day after application.

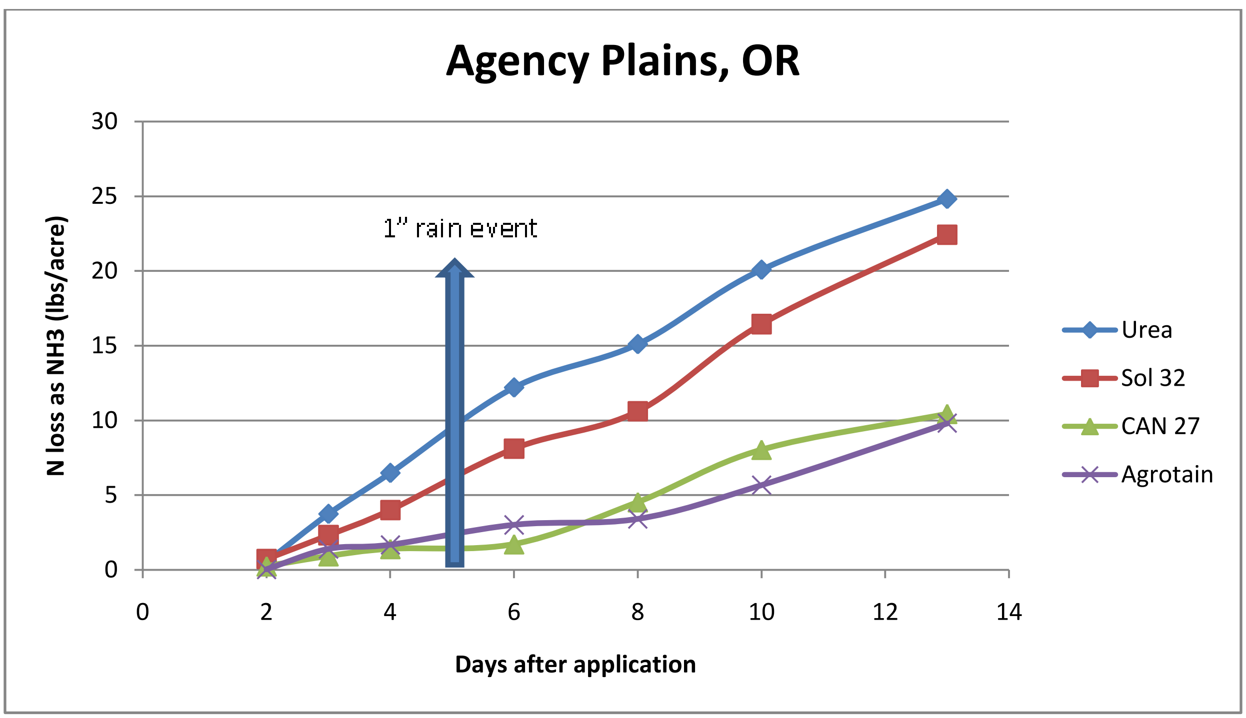

Figure 2. Ammonia volatilization loss from four nitrogen sources at Agency Plains. Plots received 1 inch of rain over a 24-hour period during the fifth day after application.

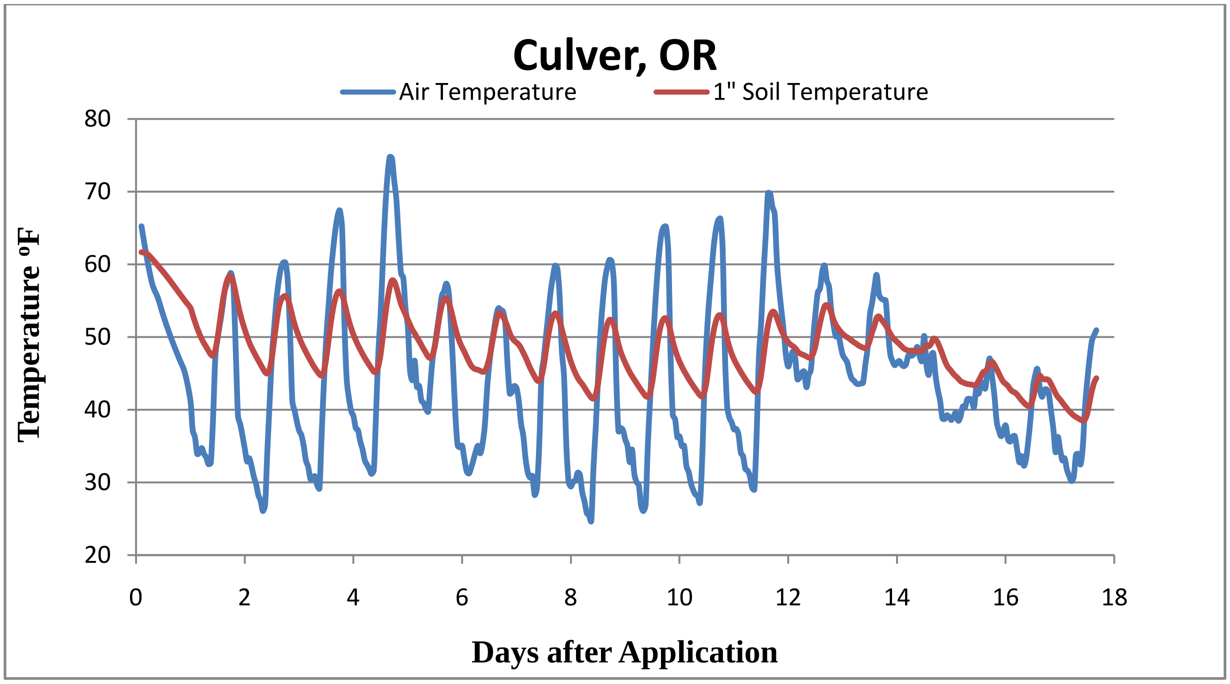

Figure 3. Air and soil temperatures during the ammonia volatilization research project near Culver.

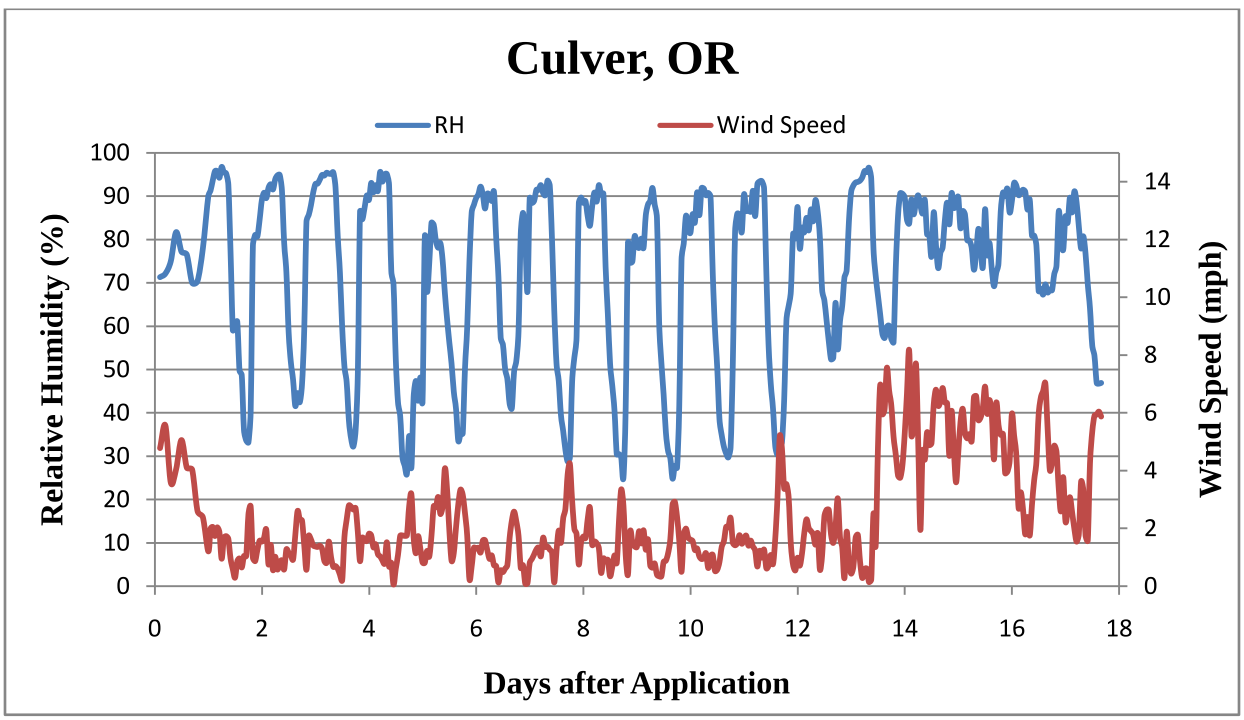

Figure 4. Percent relative humidity and wind speeds during the ammonia volatilization research project near Culver.

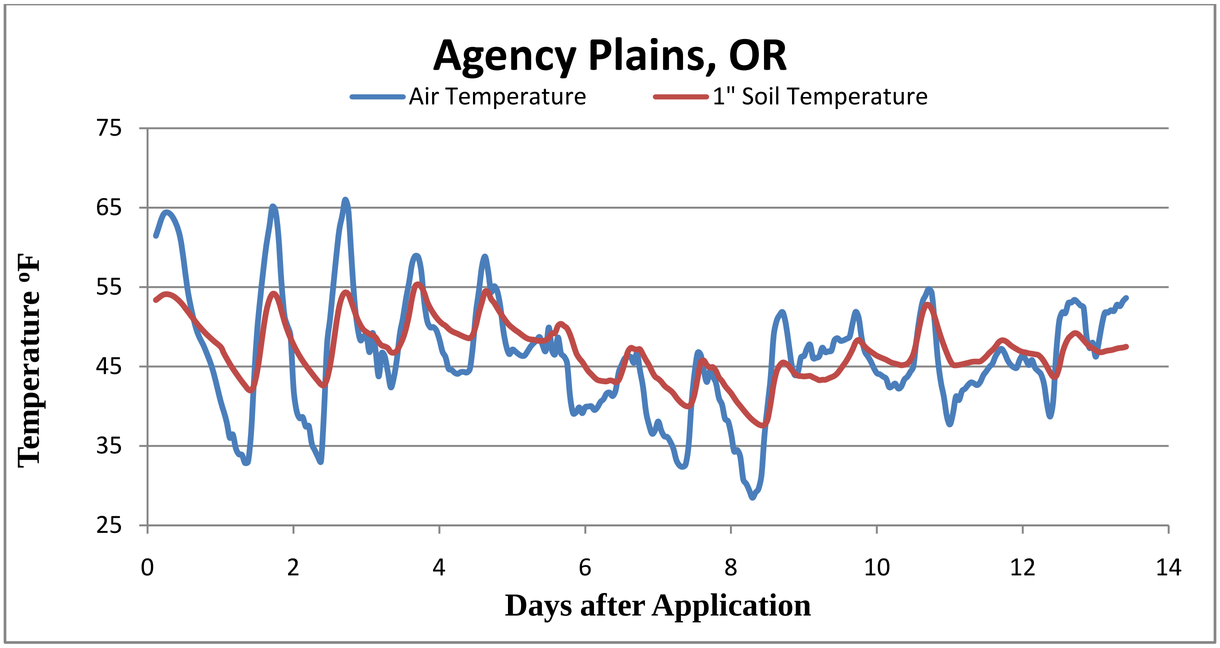

Figure 5. Air and soil temperatures during the ammonia volatilization research project at Agency Plains.

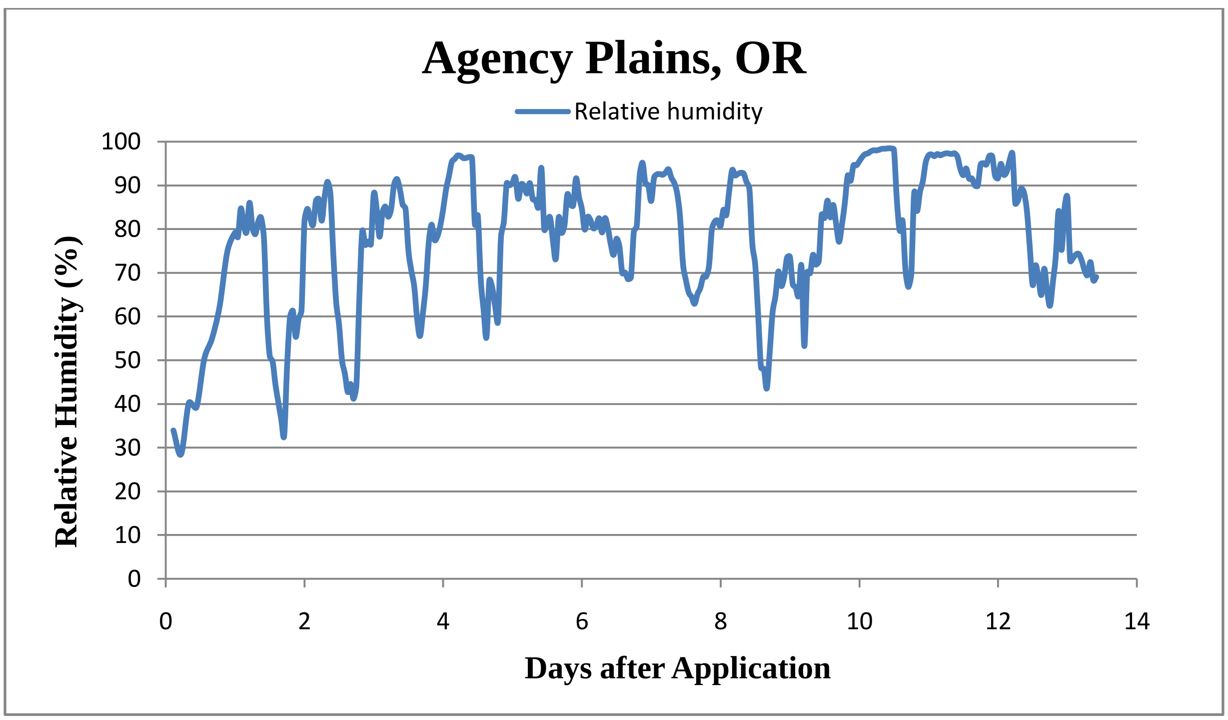

Figure 6. Percent relative humidity during the ammonia volatilization research project at Agency Plains.

References

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