EFFECT OF AGROTAIN TREATED UREA ON AMMONIA VOLATILIZATION IN KENTUCKY BLUEGRASS IN THE COLUMBIA BASIN OREGON

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Introduction

With the unavailability of ammonium nitrate, urea has become the most commonly used form for nitrogen fertilization. Urea is inexpensive, safe to handle, and provides a high percent of nitrogen (46%). As any ammonium based fertilizer, it lends itself to nitrogen loss through ammonia (NH_3) volatilization. However, only urea goes through a process called hydrolysis that increases ammonia loss. The hydrolysis of urea has the following basic formula:

urea → ammonium + hydroxide.

The creation of hydroxide increases short term pH, which increases ammonia volatilization risk. Nitrogen loss by volatilization creates both a loss in fertilizer efficiency and a source of atmospheric ammonia.

Historically, in the lower Umatilla Basin there is approximately 20,000 acres in grass seed production (OAIN). Nitrogen fertilizer is applied both late-fall and spring; each application can create an opportunity for ammonia volatilization. Agrotain International, LCC (St. Louis, MO) markets a urease inhibitor N-(n-butyl) thiophosphoric triamide (NBPT) that when added to urea has the potential to limit nitrogen loss through ammonia volatilization. This inhibitor can be applied to both urea and urea-ammonium nitrate solution (UAN or solution 32). This product is designed to protect urea for 7-21 days, giving the urea time to be incorporated by either rainfall or irrigation.

Although there has been published data on ammonia volatilization, losses in pounds per acre on a field scale have not been well documented. The method used in this study allowed us to measure nitrogen loss (lb/a) in the field. Earlier studies could only compare relative nitrogen loss between two products. Knowing lb/a loss allows comparison between nitrogen products to calculate nitrogen savings and economic impact.

The objective of this study was to measure ammonia volatilization from Agrotain treated urea (Agrotain), ammonium sulfate, and urea applied to field burned and unburned Kentucky bluegrass fields in the Columbia Basin in Oregon.

Methods

Research was conducted on four fields of Kentucky bluegrass (*Poa pratensis* L.). Two 125-acre fields that were open field burned after straw was harvested fields near Echo, OR with pH of 6.5 and 5.9, and two 70-acre unburned fields that had straw harvested near Stanfield, OR with pH 7.1 for both fields.

The two fields at the Echo location had 3 surface applied nitrogen treatments: Agrotain (5 qts Agrotain/ton urea), Ammonium Sulfate, and Urea. Nitrogen was applied to a 98 ft diameter circle at a rate of 100 lb nitrogen/acre. The treatments were arranged in a randomized complete block design with three replications. Plots were separated by approximately 230-ft to avoid possible ammonia cross-contamination between treatments. The Stanfield location was set up similarly with 2 treatments: Urea and Agrotain.

Ammonia volatilization losses were measured with a modified passive flux method (Wood et al., 2000), which consists of a rotating ten foot tall mast placed at the center of a circular plot. Ammonia is sampled at five heights (1.47, 2.46, 4.75, 7.38, and 9.84 ft; Leuning et al., 1985). Each passive flux ammonia sampler consisted of a glass tube (each tube 0.28-in i.d. by 7.87 in long), which the inside surface was coated with oxalic acid to trap ammonia out of the air. The mast has a wind vane that keeps the tubes facing into the wind. A background mast was placed upwind of the predominant wind direction. The sampling tubes were initially changed daily, then after a week every other day. Sampling tubes were shaken for 10 minutes with deionized water, then extracted and analyzed colorimetrically for ammonium (NH_4^+) (Sims et al., 1995).

Total ammonia volatilized from applied fertilizer 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; Schjoerring et al., 1992).

An Adcon Telemetry weather station was placed at the study area to measure air temperature, soil surface temperature, humidity, rainfall, and wind speed and direction.

Nitrogen loss by ammonia volatilization was subjected to an analysis of variance (Statistix 8, 2003) using LSD for mean separation.

Results and Discussion

Burned Sites

Agrotain reduced ammonia volatilization at both burned fields compared to urea ($p<0.05$). Ammonium sulfate also reduced volatilization compared to urea ($p<0.05$). There was no difference within dates between Agrotain and ammonium sulfate, however there was a difference in cumulative loss ($p=0.08$). Urea lost an average of 10.25 lb/a more ammonia than either Agrotain or ammonium sulfate (Figure 1). Agrotain limited cumulative ammonia loss over time compared to the urea treatment.

Daily ammonia loss from urea at the field burned sites began immediately after application and increased steadily until it reached its maximum daily loss on October 6, daily loss then decreased. Ammonia loss from Agrotain was linear and lost 0.318 lb/a ammonia each day ($r^2 = 0.973$). Ammonia loss from ammonium sulfate was also linear and lost 0.397 lb/a each day ($r^2=0.903$). Following rain on October 3, 4, 5 (Figure 2), the largest increases in daily loss where measured for the urea treatment. Prior to these rains, urea pellets were still observable. Ammonia loss increased as urea pellets hydrolyzed in addition to the increased urease contact and/or increased urease activity. Subsequent soil profile drying increases ammonia loss as the evaporation process carries ammonium to the soil surface where it is susceptible to volatilization. Ammonium sulfate and Agrotain were unaffected by the rainfall. Agrotain was likely not affected because the urease inhibitor slowed urea hydrolysis even though exposed to the increased urease activity following rainfall. This study demonstrates the importance of getting adequate water to move fertilizer deep enough into the subsoil where it can be held by the soil's cation exchange capacity. Otherwise small amounts of precipitation can increase ammonia loss when urea is surface applied.

Figure 1. Average cumulative nitrogen loss as ammonia on two burned Kentucky bluegrass fields. Bars represent standard error.

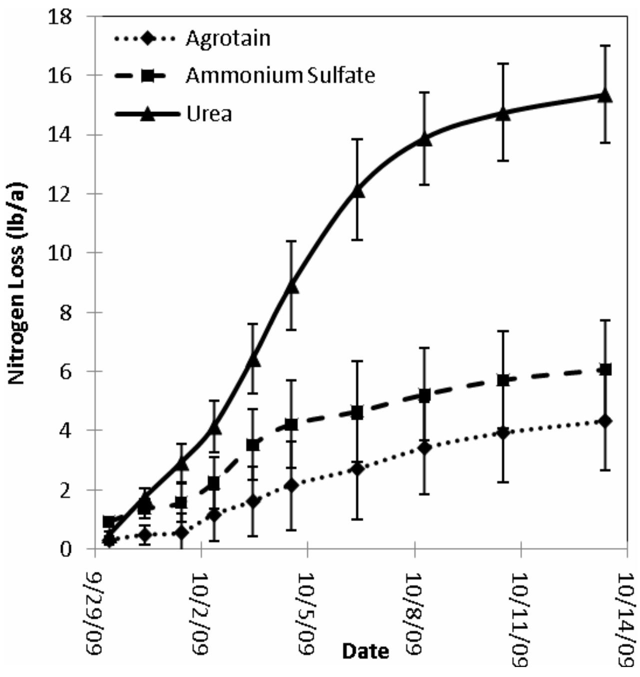
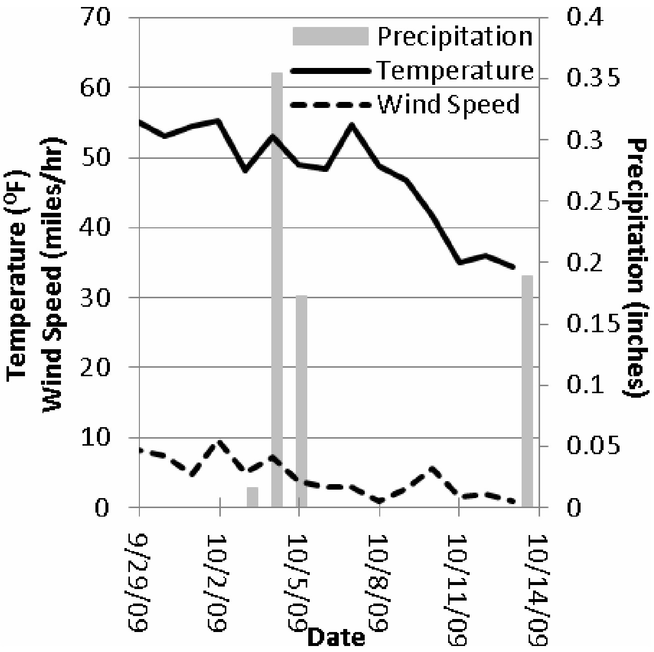


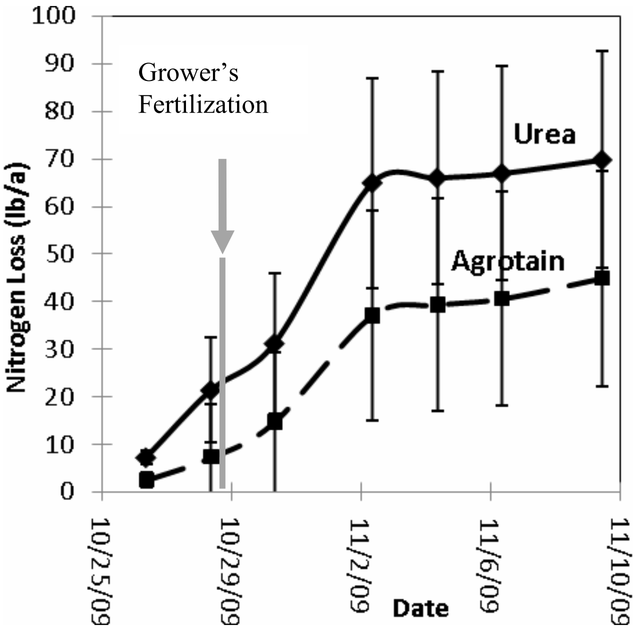
Figure 2. Average daily temperature and wind speed with cumulative precipitation for burned Kentucky bluegrass fields.



Unburned Sites

All data from these locations are confounded by a grower's subsequent fertilizer application. No difference in total ammonia volatilization was observed between urea and Agrotain at either unburned location ($p>0.05$) when comparing individual dates. Ammonia loss differed on total ammonia volatilized only. Ammonia loss started immediately after fertilization and then increased after the first couple days (Figure 3). The large increase on November 2 is due to ammonia from the grower's 150 lb/a nitrogen application that was applied on October 28 and applied over the top of our plots. The grower's fertilization affected ammonia measurements for all treatments. Consequently, after the grower's nitrogen application ammonia measurements were not reflective of the treatments. This makes the data after October 28 misrepresentative of treatment comparison. Only the data prior to the grower's application can be used to determine treatment effects. This leaves only two sampling dates to compare for which there was no difference between treatments. There were also no ammonia volatilization differences in the early sampling at the burned locations. We hypothesize that the time from application to grower fertilization was too short to see a diversion between treatments at the unburned locations. More research on unburned Kentucky bluegrass fields is scheduled in order to quantify the effects of Agrotain on these fields.

Figure 3. Average cumulative nitrogen loss as ammonia on two unburned Kentucky bluegrass fields. Bars represent standard errors.



Ammonia in Smoke

During a preliminary study, a grass seed field burn smoke-event occurred that saturated all the collection devices with ammonia (Table 1). After subtracting background levels, treatment ammonia losses were undetectable for the sampling period. This demonstrated that the ammonia was associated with the smoke. These findings suggest that field burning results in nitrogen being lost from the system as ammonia in the smoke.

Table 1. Average ppm nitrogen (N) as ammonia for the sampling period before (Aug. 6), during (Aug. 7), and after (Aug. 10) the smoke event. Samplers refer to height of ammonia collection.

Height of samplers	Before Aug. 6	Smoke Aug. 7	After Aug. 10
(feet)	------------------- (ppm N)	-------------------	
9.84	2.68	1.94	0.92
7.38	1.13	2.20	1.05
4.75	1.79	2.96	0.96
2.46	2.64	6.45	1.47
1.47	5.24	10.97	2.43
Total	13.49	24.51	6.85

Diurnal Ammonia Loss

Also during this preliminary study, ammonia measurements were taken twice a day to measure diurnal ammonia loss. Immediately after fertilizer application a diurnal effect was measured (Figure 4). Ammonia losses peaked in the daylight hours and were lowest during the night. Increased loss is related to higher temperatures, wind speeds, and decreased humidity during the afternoon hours (Table 2).

Figure 4. Average diurnal nitrogen loss as ammonia across treatments on wheat stubble.

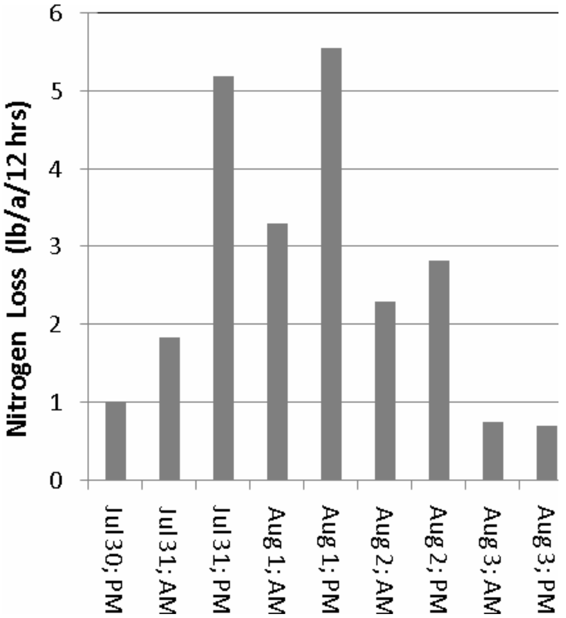


Table 2. Average 12-hour weather data for diurnal wheat stubble data. No precipitation occurred.

Date 2009	Air temp.	Soil temp. at 2 in.	Wind speed	Rel. hum.
	------- (°F)	-------	(mi/hr)	(%)
7/30; PM	92.8	89.5	5.2	21.8
7/31; AM	75.5	80.8	2.7	45.6
7/31; PM	95.6	90.3	4.6	21.3
8/1; AM	77.1	81.1	3.1	40.3
8/1; PM	99.9	91.5	3.9	20.1
8/2; AM	82.1	83.7	3.3	39.4
8/2; PM	94.9	92.6	3.5	18.1
8/3; AM	81.0	84.1	5.9	36.5
8/3; PM	91.3	91.4	8.1	18.8

Conclusions

Ammonia loss from urea at the burned field sites accounted for 15.3% of nitrogen applied. Agrotain at the burned field sites accounted for 4.3% of nitrogen applied, which is a 71.8% reduction of ammonia loss compared to urea. Urea that is left on the surface without being incorporated or watered into the soil profile could benefit from the use of Agrotain when just nitrogen loss is considered. However, Agrotain may not be suited for all conditions. Ammonia loss follows a diurnal pattern with more ammonia being lost during the day than at night. Ammonia loss increases during the day as a result of higher temperatures and wind speeds. Preliminary studies also suggest that a substantial amount of nitrogen in smoke from field burning is ammonia; however, this was not quantified. These results confirm the method used is able to measure nitrogen loss (lb/a) and can be used to calculate the value of retained nitrogen compared to the expense of the product being applied, e.g., urea vs. Agrotain.

Acknowledgements

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