

AMMONIA VOLATILIZATION IN GRASS FORAGES

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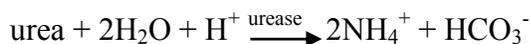
ABSTRACT

Urea is the leading nitrogen (N) fertilizer used in the United States. Although it possesses a high percent of N (46%), the process of hydrolysis lends it to N loss through volatilization. To incorporate urea into the soil will limit volatilization. However; mechanical incorporation is not always feasible so incorporation with irrigation water can substitute. Ammonia volatilization was monitored at six different irrigation rates; 0.0, 2, 4, 8, 12, 18 and 28 mm. The N loss as ammonia 25 days after application was 60.06, 53.91, 38.73, 17.31, 5.55, and 2.8 % of N applied for the above irrigation rates, respectively. Every irrigation rate experienced immediate N loss with volatilization rates increasing through 7 days following application where volatilization rate began to decrease. Nine days following application most treatments showed little to no volatilization losses. Fertilizer product made a difference in ammonia volatilization with urea consistently being the highest in ammonia volatilization varying 17-60% depending on study where N was surface applied on established grass. Urea coated with Agrotain was consistently the lowest in N loss. An incubation study showed agrotain lasted 14 day to 60 days depending on temperature. Where urea is applied to the surface either irrigation or Agrotain should be applied to minimize loss as ammonia to the air.

INTRODUCTION

Little work has been reported on the loss of ammonia from soils where fertilizers have been applied in an undisturbed environment. There are a multitude of studies that have used a chamber of some sort to estimate ammonia loss. The use of a chamber of some sort means that the environment has to be altered making the data derived suspect when translated into a loss number such as kg/ha. The advent of passive vertical flux method by Wood et al., 2000 at Auburn University in Alabama, allows for the measurement of ammonia loss from fertilizer or manure applications without altering the environment.

Urea is especially vulnerable to ammonia volatilization because it hydrolyzes according to the following reaction by Kissel et al. (1988) before it is considered plant available:



further reacting as:



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The consumption of H^+ during hydrolysis results in a pH increase (Zaman et al., 2008). Increased pH results in more NH_3 and increased volatilization (Kissel et al., 1988). Ammonia loss not only represents an agronomic loss of N, but it is also an environmental pollutant. Agriculture is responsible for an estimated 90% of anthropogenic ammonia emissions (Boyer et al., 2002), with 12% resulting from fertilizer application and the remainder from animal production (Ferm, 1998). Up to 85% of atmospheric NH_3 is deposited locally from where it originates (Boyer et al., 2002). The remaining 25% can be transported long distances as secondary aerosol particles (Schjoerring et al., 1992; Boyer et al., 2002).

Nitrogen loss reductions can be obtained through cultural practices or the use of specialty nitrogen products such as Agrotain (Agrotain International) and ESN (environmentally smart nitrogen, Agrium). Cultural reductions in ammonia volatilization can be accomplished by incorporating urea into the soil, either mechanically or with water (Malhi et al., 2003; Harper et al., 1983; Bouwmeester et al., 1985; Black et al., 1987; Mugusha and Pluth, 1995)

METHODS

Three field studies and an incubation study were conducted in 2009 and 2010. For all field studies measurement of ammonia volatilization used the modified passive flux method (Wood et al., 2000; Vaio et al., 2008). This consists of a rotating mast placed at the center of each circular plot. A tripod which did not interfere with the rotation of the mast was placed on the mast in order to stabilize it during high wind events. Each mast was equipped with a passive flux sampler at five heights (0.45, 0.75, 1.50, 2.25, and 3.00 m; Leuning et al., 1985). Flux samplers were extracted by adding 2-mL deionized water and shaken for 10-minutes. Extracts were analyzed colorimetrically for NH_4 (Sims et al., 1995).

Horizontal NH_3 flux (F_x , $\mu g N m^{-2} s^{-1}$) for each flux sampler was calculated by

$$F_x = (C*V)/(\pi r^2 K \Delta t) \quad [1]$$

where C is the concentration of NH_4-N ($\mu g N/ml$) in deionized water used to extract sorbed NH_4-N , V is the volume of deionized water used for extraction (2mL), r is the radius of the hole in the disc on the nozzle (0.0005 m), K is a correction factor (0.77), and Δt is the time at which the sampler was exposed (s) (Schjoerring et al., 1992; Wood et al., 2000; Vaio et al., 2008). Net vertical flux (F_y , $\mu g N m^{-2} s^{-1}$) from each plot was estimated by integrating each horizontal flux with vertical distance for each sampler accounted for: $F_y = (1/R) \sum (F_{x,p} - F_{x,b}) \Delta h$

$$[2]$$

where R is the radius of the plot (15-m), and Δh (m) is the vertical distance corresponding to each sampler.

2009 Grass Seed Fields (4)

Four KBG (Kentucky bluegrass) fields had ammonium sulfate, urea and agrotain applied in the fall of 2009. Two had residue burned and two had the residue harvested. The two fields that had

the residue harvested had a miss-application of fertilizer and will not be reported. The two fields where the residue was burned each had three replications in a randomized block design. Masts were erected and 112 kg N/ha applied. Samples were inserted into the masts immediately following fertilizer application. Ammonia volatilization was measured and loss calculated.

2010 Wheat Field Irrigation Trial (1)

The field was split into 18 wedges of 20°; each wedge contained a circular (30-m diameter) plot with urea surface-applied at 112 kg N/ha and with each plot separated by at least 100 m to avoid contamination of NH₃ between treatments. The pivot was programmed to irrigate wedges with 0.0, 1.25, 3.8, 7.6, 11.4, and 21.6-mm corresponding to treatments, with the treatments (112 kg N/ha) arranged in a randomized complete block design. A rain gauge was placed in each treatment wedge in order to record irrigation rate. Immediately after irrigation, measurement of ammonia volatilization commenced and continued for the next 23 days. Wheat was harvested from each treatment (0.126 m²) at 23 DAA (days after application). Above-ground dry matter was measured and total N was analyzed.

Three of the irrigation treatments in addition to urea had Agrotain and OAC (organic acid complex of malic acid) applied.

2010 Grass Seed Fields (5)

Five fields were set up for ammonia volatilization in three locations Madras (2) Oregon, Hermiston (2) Oregon and Pullman (1) Washington. Urea, Agrotain, UAN solution and CAN-27 (Yara) was applied in 30m circles at a rate of 168 kg N/ha. Each circle at each location had three replications. Ammonia volatilization was measured immediately following the fertilizer application. Only data from one Hermiston field will be discussed here.

Incubation Study

Soil at field capacity was collected from a winter wheat field at the Hermiston Agricultural Research and Extension Center in Hermiston, OR (soil was an Adkins coarse-loamy, mixed, superactive, mesic Xeric Haplocalcids, with pH 6.99) to a depth of 30cm. 0.65 kg of soil (roughly 0.5 kg dry soil) was placed into gallon Ziplock Freezer Bags. Urea, Agrotain, and OAC was added at a rate of 1.05 g N/kg soil. A drinking straw was inserted into the bag then zipped shut around the straw. Samples were placed in incubators at 4.4°C, 15.6°C and 26.7°C. At 1, 3, 6, 13, 20, 28, 34, 48, 63, 76, and 104 DAA bags were sub-sampled and analyzed for ammonia.

RESULTS

Ammonia volatilization was 16% to 60% of nitrogen applied depending on the fertilizer, field and environmental conditions (fig 1, 3 and 5). In all fields urea had the highest ammonia loss. In the irrigation trial OAC had similar ammonia loss to urea at the low irrigation rates (Fig. 4).

At the high irrigation rate OAC had reduced ammonia loss compared to urea. Agrotain had the lowest ammonia loss across all fields and treatments. Most agrotain treatments were less than 5% loss of N applied. In the irrigation study ammonia loss for Agrotain was not effected by irrigation rate (Fig. 4). Soil pH was below 7.0 for all fields. The irrigation study under wheat lost 60% of nitrogen applied where no water or Agrotain was applied. As irrigation rate increased ammonia loss decreased (Fig 2). It took about 13 mm of irrigation water to reduce ammonia loss by 90% in the irrigation study. The KBG field in 2009 (Fig 1) had 16% of nitrogen lost. We suspect this loss was reduced because over 13mm of rainfall fell between day 4 and 6. The rainfall was not as effective at reducing volatilization losses as irrigation.

Temperature has an effect on hydrolysis and the length of time that Agrotain is effective in the soil (Fig 4). Only two temperatures are shown in figure 4, the highest 26 C is not presented. Urea and OAC hydrolyzed nitrogen at identical rates to each other. Agrotain spread hydrolysis over 63 days at the low temperature and 28 days at the warmer temperature. For the high temperature it took 15 days to complete hydrolysis.

CONCLUSIONS

For nitrogen left on the surface soil pH and temperature are not as big a drivers as we once thought. Urea has the capability to raise pH and increase volatilization without being driven by soil pH. When urea is used the benefit of incorporating with irrigation or the use of Agrotain, a urease inhibitor, should be considered. Irrigation after application can reduce volatilization loss by over 90% depending on amount of water applied. The use of Agrotain can also reduce nitrogen loss. Agrotain will last 14 to 60 days depending on rate and temperature. When no water is available Agrotain works where as other products have not been shown to delay hydrolyzation and reduce ammonia loss. Worst case for losing ammonia into the air is to have wet soil that is drying with lots of residue. Pastures and grass hay fields can pose a problem for increased nitrogen loss when fertilizer, particularly urea is placed on the surface and sits there for several days. Time at the surface needs to be minimized.

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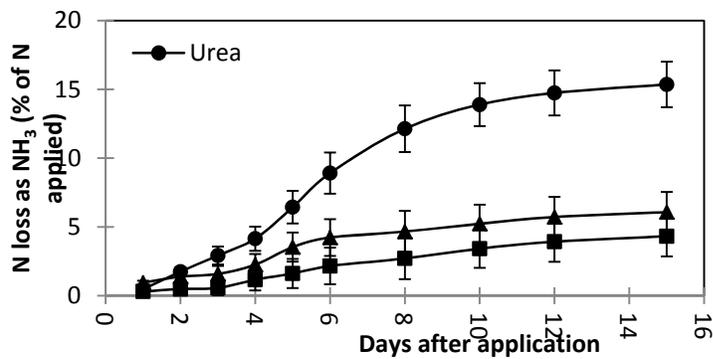


Figure 1. Cumulative loss of NH₃ during the period of 28 September to 13 October 2009 following application of 112 kg N/ha to Kentucky bluegrass as affected by N source.

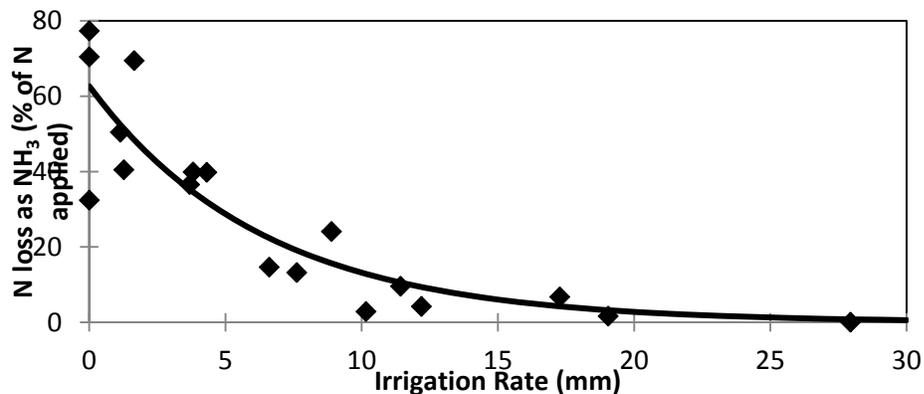


Figure 2. Cumulative loss of NH₃ during the period of 9 March to 2 April 2010 following application of 112 kg urea-N/ha to Winter Wheat as affected by rate of irrigation application.

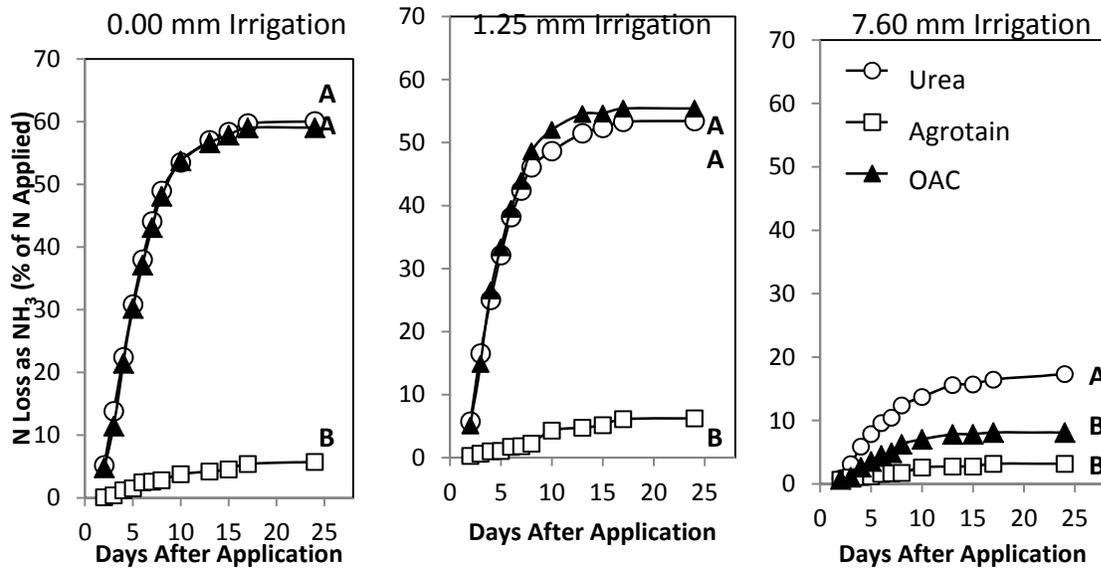


Figure 3. Cumulative loss of NH₃ within irrigation rates for the period of 9 March to 2 April 2010 following application of 112 kg N/ha to Winter Wheat for urea, Agrotain, and OAC.

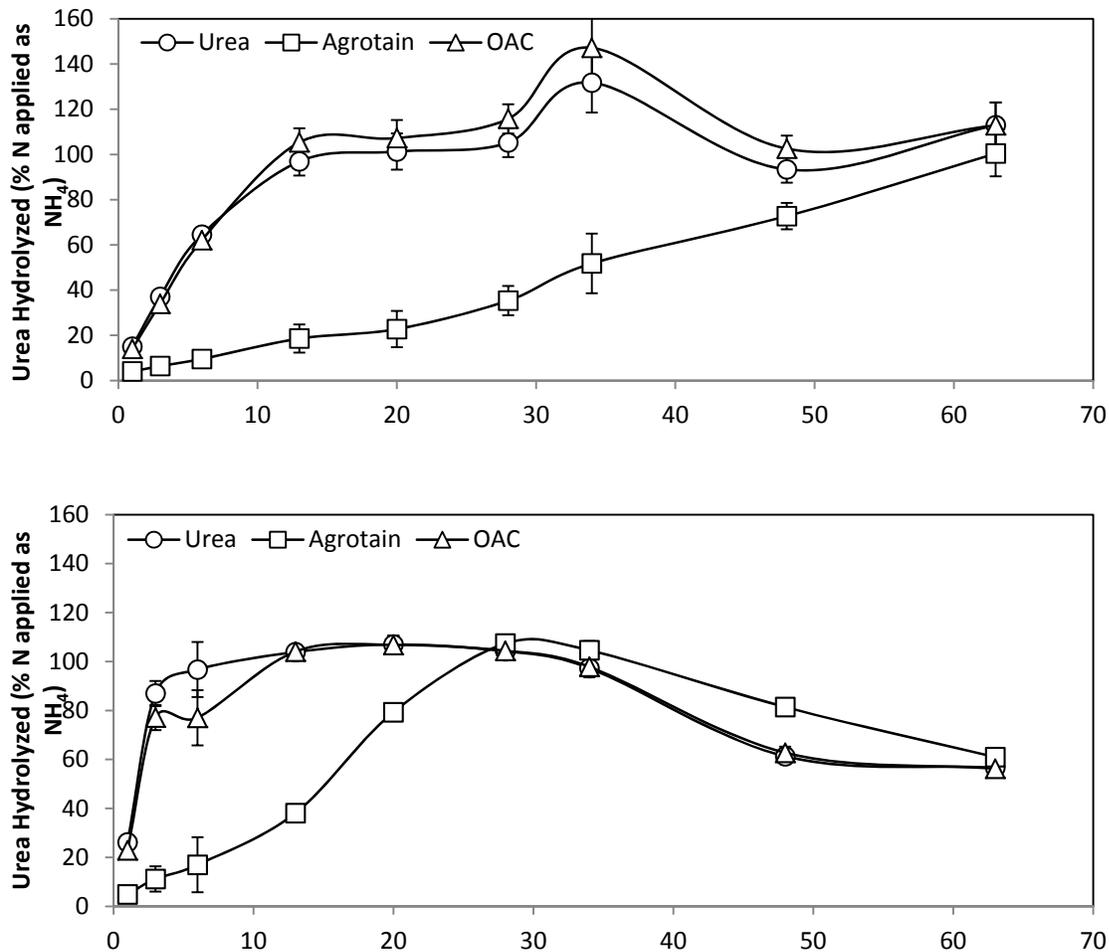


Figure 4. Formation of NH₄ in incubation as % N applied as NH₄, as affected by N treatment at incubation temperature (a) 4.4°C, (b) and 16.6°C. Bars represent standard error.

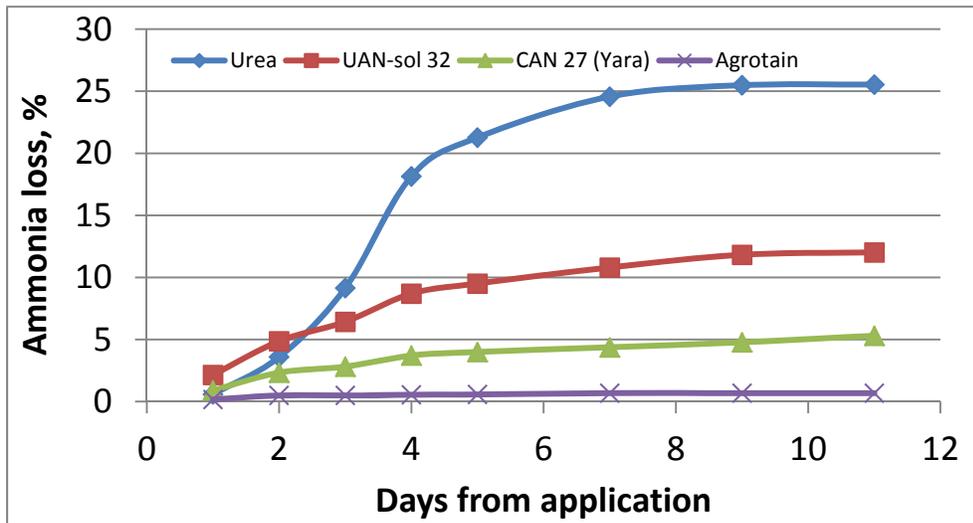


Figure 5. Ammonia loss for urea, UAN, Can-27 and Agrotain for fall of 2010 in Hermiston Oregon. Nitrogen applied at 168 kg N/ha