Ammonia Volatilization and Rice Growth as Affected by Rainfall Amount and Urease Inhibitor

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Introduction

Urea is the most common N source used in the direct-seeded, delayed-flood method of rice (*Oryza sativa* L.) production in Arkansas. Urea has a high potential for ammonia (NH_3) volatilization if not quickly incorporated into the soil by timely rainfall or flooding. Cumulative NH_3 losses from urea applied 5 to 10 d preflood may account for 17 to 24 % of the applied N (Norman et al., 2009). Literature suggests that a minimum of 7.6 mm of rainfall is required to significantly reduce NH_3 volatilization of surface-applied urea (Holcomb et al., 2011). If a permanent flood cannot be established quickly, fertilizer-N may undergo nitrification followed by denitrification after the flood is established. Nitrification of hydrolyzed urea-N may occur when rainfall occurs between the time that urea is applied and the field is flooded.

Our research objective was to compare the effects of simulated rainfall amounts and a urease-inhibiting amendment on NH_3 volatilization, rice N uptake, and grain yield.

Materials and Methods

- Two field experiments conducted in 2013
  - Pine Tree Research Station (Colt, AR) on an alkaline Calhoun silt loam
  - Trial A and B
    - Planted: (A) 16 May and (B) 4 June
    - N application: (A) 28 May and (B) 25 June
- Two N sources (112 kg N ha^{-1})
  - Untreated urea (Urea)
  - NBPT-treated urea (Urea-NBPT; 0.88 g NBPT kg^{-1} urea)
    - NBPT = N-(n-butyl) thiophosphoric triamide
- Simulated rainfall amounts
  - 0, 3.2, 6.4, 12.7, 19.1, and 25.4 mm
  - Applied with a portable rainfall simulator
  - Simulated rainfall started 5 hr after urea application
- Ammonia volatilization (Trial A)
  - Semi-static chamber method (Griggs et al., 2007)
  - Foam sorbers replaced 2, 3, 5, 8, and 11 d after N application and simulated rainfall
- Permanent flood
  - 12 d (A) and 6 d (B) after N application and simulated rainfall
- Aboveground N uptake
  - 0.9 m linear row sample taken at early heading
  - Analyzed for N content using combustion method
- Statistical analysis (comparisons made at α = 0.10)
  - RCBD as a 2 × 6 full factorial
  - NH_3 volatilization, N uptake, and grain yield were regressed across simulated rainfall amount
  - Regression analysis allowed for linear, quadratic, and cubic terms with coefficients depending on N source with model terms removed at α = 0.15

Table 1. Analysis of variance for cumulative NH_3-N volatilization loss as influenced by N source, simulated rainfall amount, and their interaction.

Source of Variation	Degrees of Freedom	NH_3-N Vol. p-value
N Source (NS)	2	< 0.0001
NS × Rainfall Amount (RA)	2	< 0.0001
NS × RA × RA	2	< 0.0001

Photo 1. Portable rainfall simulator used to apply water to plots.

Table 2. Analysis of variance for N uptake as influenced by trial, N source, simulated rainfall amount, and their interactions.

Source of Variation	Degrees of Freedom	N Uptake p-value
N Source (NS) x Trial	4	< 0.0001
NS × Rainfall Amount (RA)	2	0.0589
NS × RA × RA	2	0.0302
NS × RA × RA × RA	2	0.0211

Photo 2. Distribution of simulated rainfall applied to plots.

Table 3. Analysis of variance for grain yield as influenced by trial, N source, simulated rainfall amount, and their interactions.

Source of Variation	Degrees of Freedom	Grain Yield p-value
N Source (NS) × Trial	4	< 0.0001
NS × Rainfall Amount	2	0.0004

Photo 3a. View of semi-static volatilization chamber placed after simulated rainfall (left). **Photo 3b.** Trimmed plots ready for harvest (right).

Fig. 1. Cumulative N loss as influenced by the interaction of N source and simulated rainfall amount.

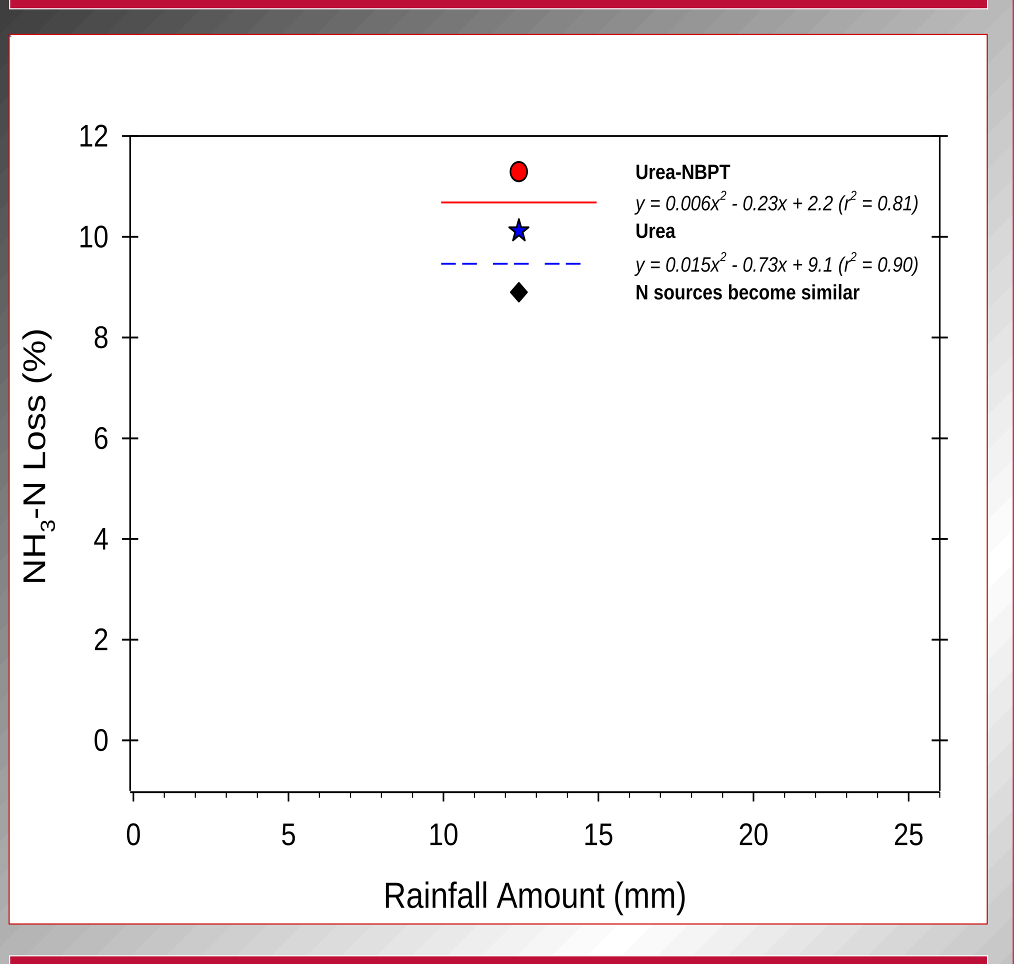


Fig. 2. Rice N uptake as influenced by the interaction of trial, N source, and simulated rainfall amount.

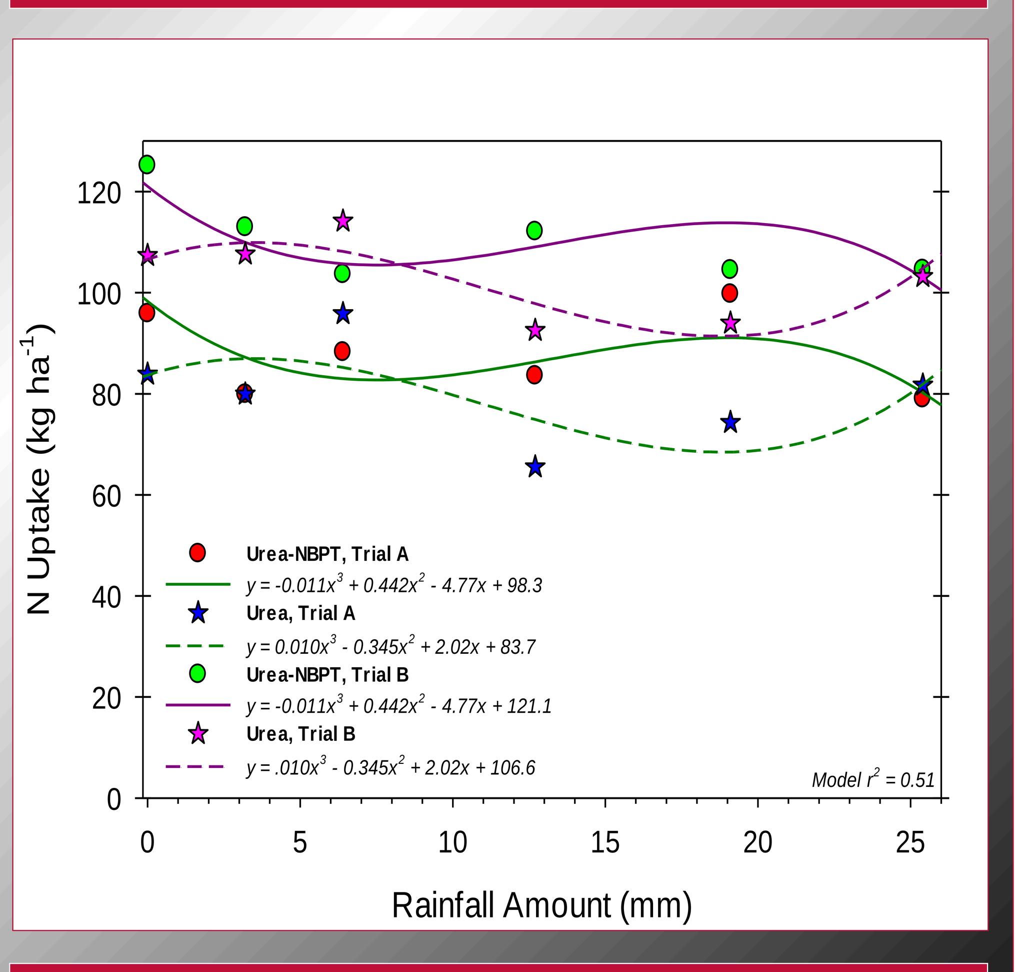
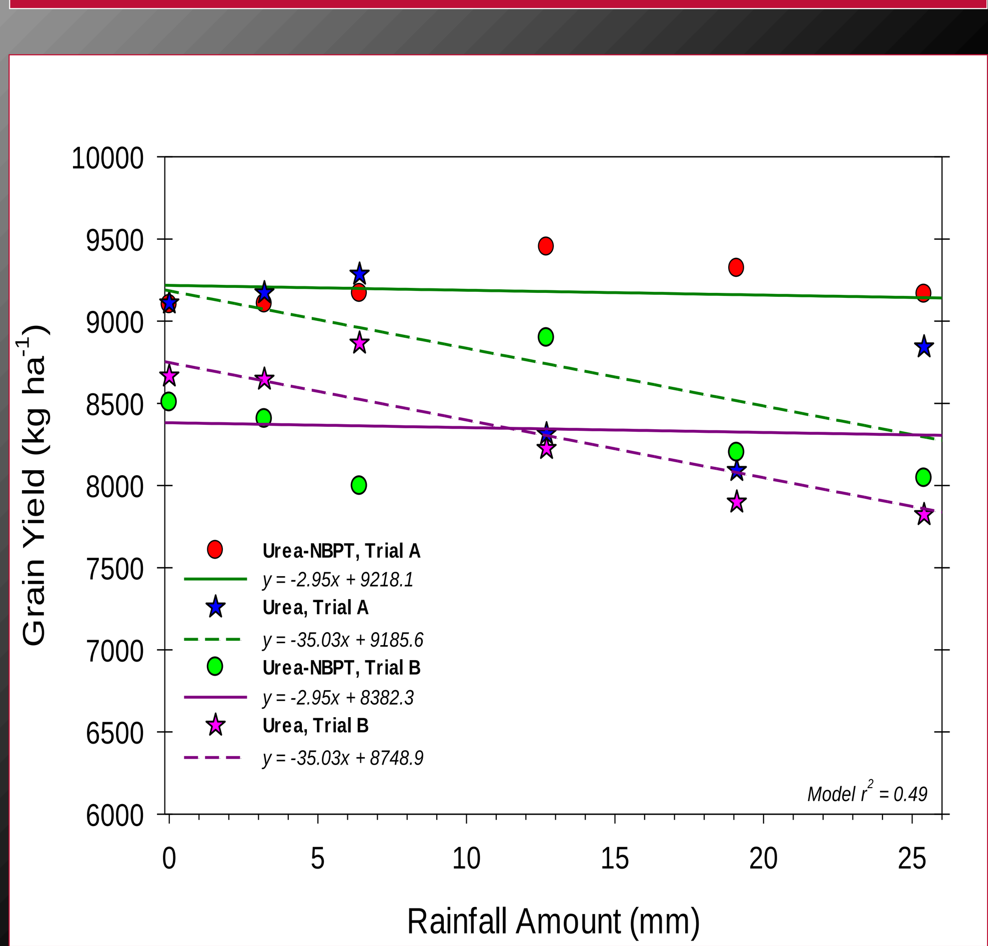


Fig. 3. Rice grain yield as influenced by the interaction of trial, N source, and simulated rainfall amount.



Acknowledgements

Research funded by Arkansas Rice Check-Off funds administered by the Arkansas Rice Research and Promotion Board and the University of Arkansas Division of Agriculture

Results

Cumulative NH_3 volatilization

- Significant quadratic N source by simulated rainfall interaction (Table 1 & Fig. 1)
- As simulated rainfall amount increased, NH_3 volatilization (inside chamber) decreased for both N sources
- NH_3-N loss was greater for Urea than for Urea-NBPT at simulated rainfall amounts of 0 to 19.1 mm
- The predicted amount of simulated rainfall required to prevent NH_3-N loss (predicted loss not different than 0) was
  - 9.8 mm for Urea-NBPT
  - 20.5 mm for Urea

Rice N uptake

- Significant cubic N source by simulated rainfall amount interaction (Table 2 & Fig. 2)
- Within each trial, N sources were significantly different when simulated rainfall amounts were < 0.5 mm and between 12.5 and 23.0 mm
- The cubic response was unexpected, but trends to simulated rainfall amount were similar in both trials. While the reasons are not clear, the results may be attributed to the cumulative N loss from two N loss mechanisms (NH_3 volatilization and denitrification).

Rice grain yield

- Significant linear N source by simulated rainfall amount interaction (Table 3 & Fig. 3)
- For Urea-NBPT, rice yields were constant across simulated rainfall amounts in both trials.
- For Urea, rice yields decreased linearly with increasing simulated rainfall amount.
- For Trial A, yields from rice fertilized with Urea-NBPT were greater than Urea with ≥ 7.5 mm simulated rainfall
- For Trial B, yields between N sources were similar with 2 to 26 mm of simulated rainfall

Practical Application

Ammonia volatilization and denitrification may interact to influence cumulative N loss when rainfall occurs between urea application and the establishment of the permanent flood. Results from these trials suggest that the urease inhibitor, NBPT, may reduce NH_3 volatilization and, perhaps, delay nitrification under favorable soil moisture conditions. Additional research is required to better understand the processes that are occurring across a range of rainfall amounts and frequencies between the time of urea-N application and establishing the permanent flood.

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