Efficacy of Urease Inhibitor with and without Nitrification Inhibitors in Reducing Ammonia Volatilization from Urea

Theresa Adesanya[1]*, Francis Zvomuya[1], and Ranil Waliwitiya[2]

[1]Department of Soil Science, University of Manitoba, Winnipeg, MB, Canada; [2]Active AgriScience Inc., Saskatoon, SK, Canada

*Presenting author email: Theresa.Adesanya@umanitoba.ca

BACKGROUND

- A significant part of soil-applied urea N is lost through ammonia volatilization, leaching, denitrification, and immobilization.[1]
- Fertilizer placement in the soil influences N loss from fertilizers.[2]
- Urease and nitrification inhibitors (UI and NI) are recent technologies adopted to increase fertilizer efficiency by reducing N losses through volatilization, denitrification, and nitrate leaching.
- N-(n-butyl) thiophosphoric triamide (NBPT) and 3,4-dimethylpyrazol-phosphate (DMPP) are commonly used UI and NI, respectively, in formulations
- New formulations of UI and UI+NI (DIs) from Active AgriScience are sold at lower cost compared to other commercial inhibitors and could potentially reduce volatilization at rates comparable to those of other inhibitors on the market.

OBJECTIVE

To evaluate the efficacy of new formulations of Active AgriScience urease inhibitor products and DIs relative to Agrotain on ammonia volatilization from surface and banded applications of urea.

MATERIALS & METHODS

- **Soil properties:** Texture, sand; pH, 7.9; CEC, 11.3 meq 100g^{-1}; available N, 15.7 mg kg^{-1}; bicarbonate P, 23.3 mg kg^{-1}; organic matter, 2.4%.
- **Experimental design**: CRD with a factorial combination of application method (broadcast and shallow banding) and inhibitor treatments replicated four times.
- **Measurement**: Ammonia volatilization was measured using the static chamber method.[3,4]
- **Microcosms**: PVC columns ,15 cm diam, 30 cm ht; soil ht, 7 cm; bulk density, 1.1 g cm^{-3} ; soil moisture, 60% of field capacity; N application: 120 kg N ha^{-1}.
- **Incubation conditions:** duration, 14 d; temperature, 30 °C; photoperiod, 16 h; temperature, 30 °C; relative humidity, 50%.
- **Application method**: broadcast: urea applied on soil surface; shallow banding: treatments applied 2-cm below soil surface.
- **Inhibitor treatments**: listed in Table 1.
- **Sampling and extraction**: sampling times, 1, 2, 4, 7, and 14 d after fertilizer application; ammonia trapped in the acid charged foam disc was extracted using 250 mL of 2 M KCl, and concentration of the ammonium in the extract was determined colorimetrically.

Calculations

$$NH_3\text{-N (kg ha}^{-1}) = \frac{(Extractant\ (mL) + absorbent\ in\ disc\ (mL) \times NH3\ (mg\ N\ mL^{-1})}{Area\ of\ chamber\ (ha) \times 10^6}$$

Percent reduction: The ratio of the difference between cumulative NH_3-N volatilized from untreated and treated fertilizer to cumulative NH_3-N from untreated fertilizer.

MATERIALS & METHODS (CONTD.)

- **Statistical analysis:** Treatment effects on cumulative ammonia volatilization, percent reduction in volatilization, and residual N in soil were evaluated using PROC GLIMMIX in SAS; mean comparison using the Tukey multiple comparison procedure (α = 0.05).

Table 1. Inhibitor treatments and application rates

Treatment	Formulations	Application rate (L per 1,000 kg urea)
Active stabilizer PLUS (ASP)	12% NBPT + 2 % DMPP	1.2
Active stabilizer PLUS	12% NBPT + 2 % DMPP	1.8
Active stabilizer PLUS	12% NBPT + 2 % DMPP	2.4
Active stabilizer (AS)	12% NBPT	1.2
Active stabilizer	12% NBPT	1.8
Active stabilizer	12% NBPT	2.4
ARM U 18%	18% NBPT	2
ARM U 30%	30% NBPT	1.5
ARM U advanced	30% NBPT, 15% DMPP	1.8
Agrotain advanced 1.0	30% NBPT	2.1

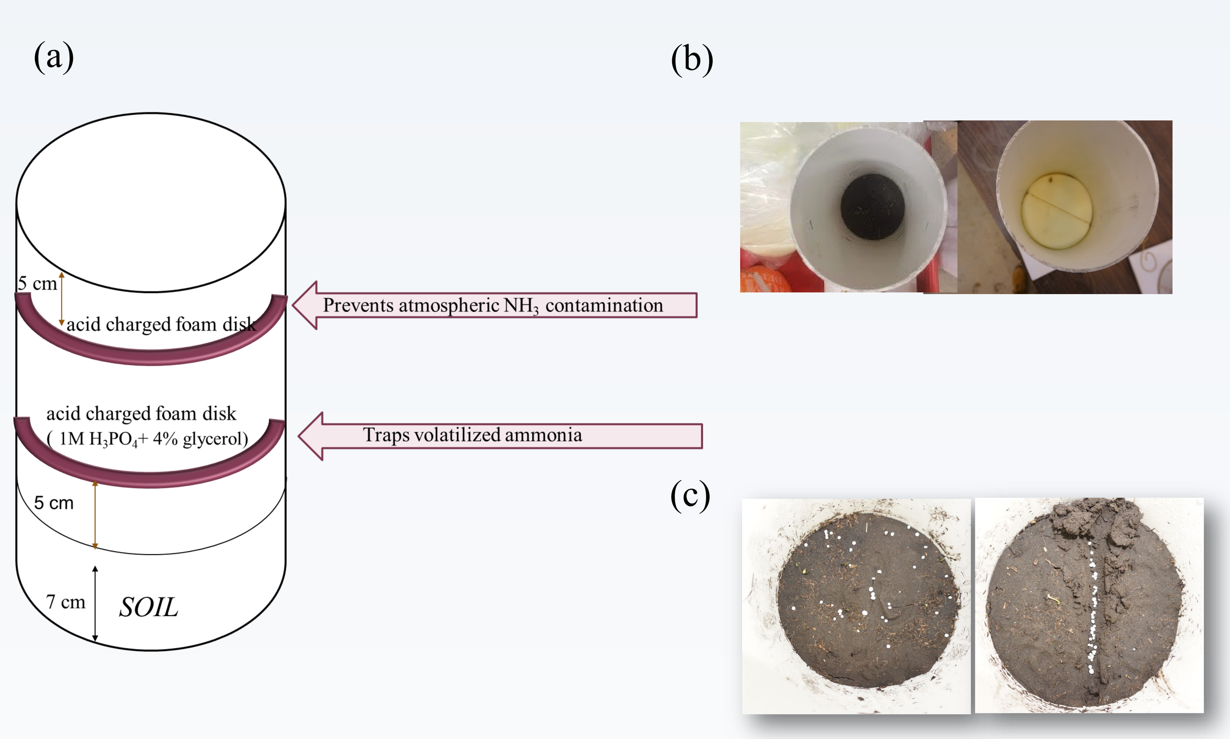

Fig. 1. (a) Microcosm set-up; (b) soil packing and acid charged foam disc; (c) broadcast and shallow banding urea application

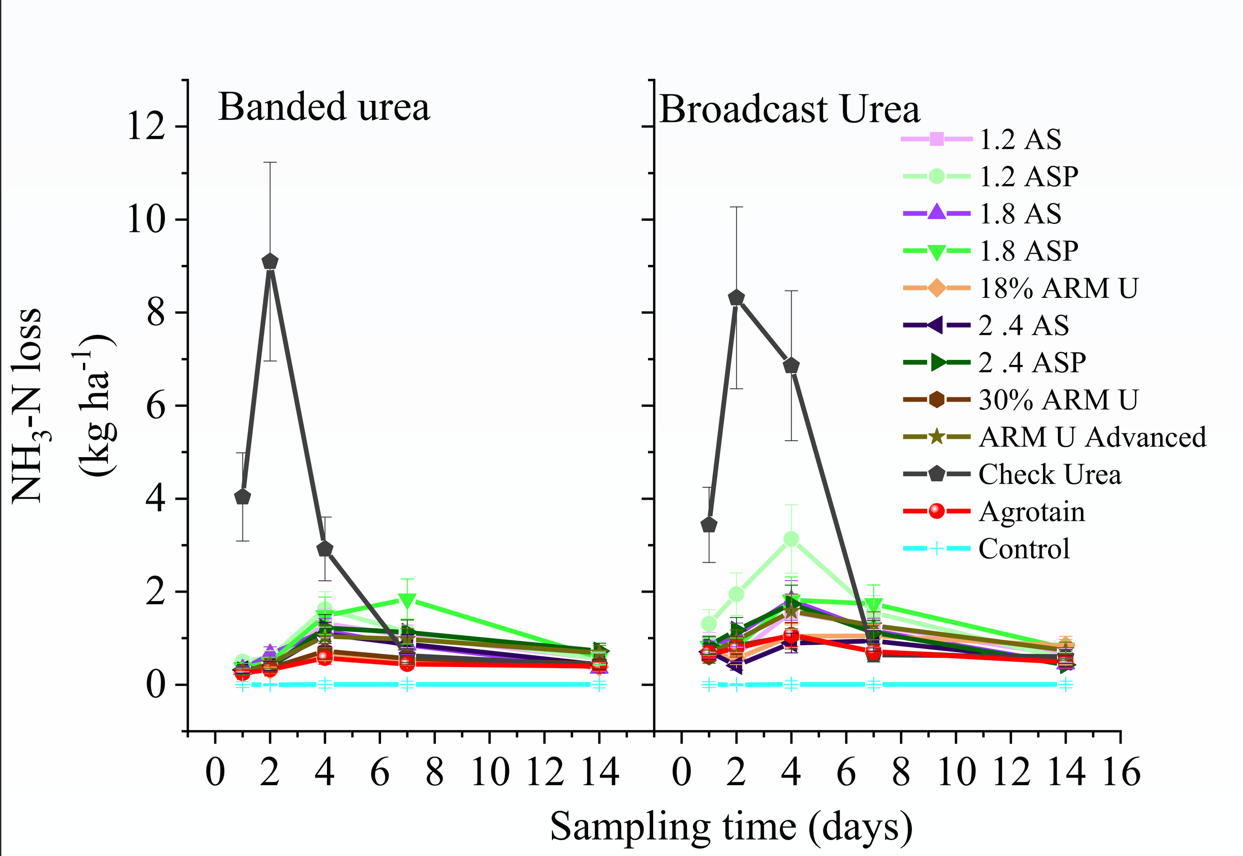

Fig. 2. Inhibitor effects on ammonia volatilization loss following broadcast and banded application of urea

RESULTS

- Ammonia volatilization in untreated urea peaked on Day 2 for banded and broadcast placements, and on days 4 and 7 for inhibitor treatments (Fig. 2).
- Cumulative NH_3-N loss was greatest from untreated urea at 18 kg ha^{-1} (15% of applied N) and lowest for Agrotain treated urea (1.5 kg ha^{-1}, 1.25% of applied N) (Fig. 3) .
- Agrotain reduced ammonia volatilization from urea by 91% (Fig. 4) and the reduction was comparable to 30% ARM U, 18% ARM U and 2.4 AS (90, 88, and 87% reduction, respectively).
- Cumulative ammonia loss was greater for broadcast (4.59 kg ha^{-1}) than banded (2.57 kg ha^{-1}) placement, while percentage reduction in volatilization was greater for banded (87%) than broadcast (78%) placement.

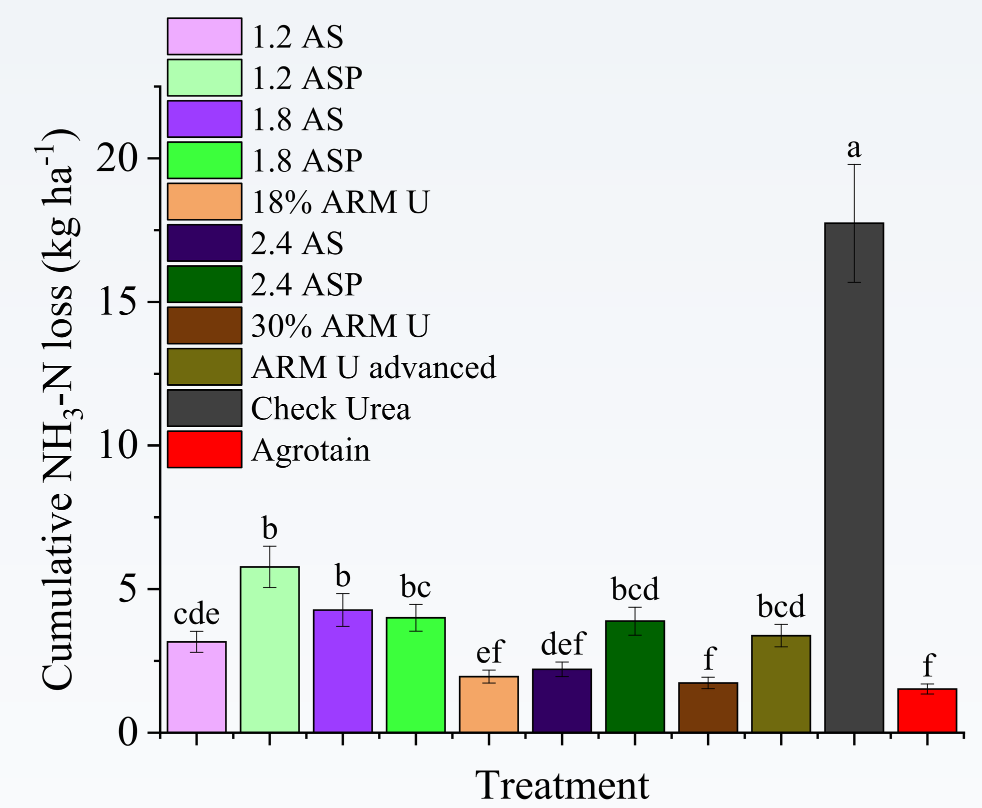

Fig. 3. Cumulative ammonia volatilization losses from urea treatments

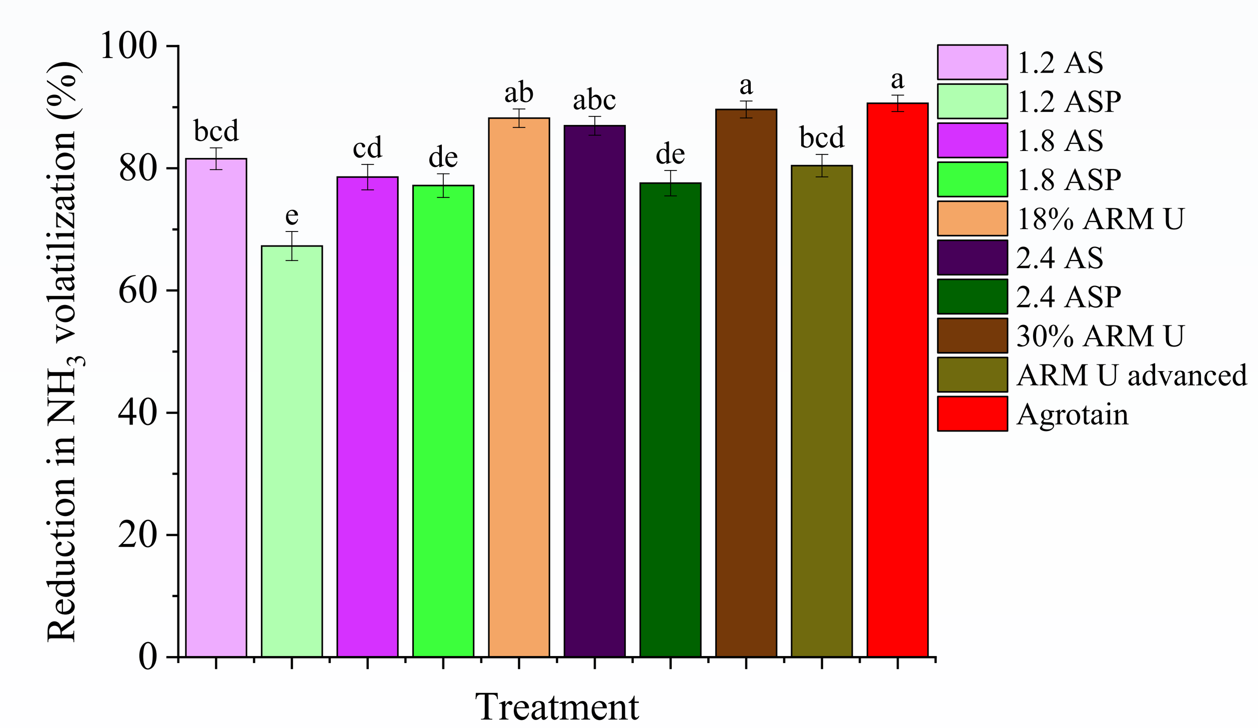

Fig. 4. Percent reduction in ammonia volatilization from inhibitor-treated urea

RESULTS (CONTD.)

- Residual ammonium-N concentration in soil was greater for banded urea treatments (13.4 mg kg^{-1}) than broadcast treatments (8.9 mg kg^{-1}).
- Residual nitrate-N concentration was lowest for untreated urea and highest for 30% ARM U-treated urea (Table 2)
- Residual soil N concentrations for all inhibitor treatments were statistically similar

Table 2. Inhibitor treatment effects on soil residual N at the end of the 14-d study

Treatment	Ammonium N (mg kg^{-1})	Nitrate- N (mg kg^{-1})
Control	4.2	31c
1 AS	13.3	155ab
1 ASP	9.7	154 ab
1.5 AS	9.8	179 a
1.5 ASP	12.3	173 a
18% ARM U	9.8	133 ab
2 AS	10.1	147 ab
2 ASP	11.9	136 ab
30% ARM U	10.4	177a
ARM U Advanced	12.5	144ab
Check-untreated	14.5	110b
Agrotain	8.4	164a

CONCLUSION

- Shallow banding of urea treated with inhibitors significantly reduced cumulative ammonia volatilization.
- The effectiveness of 18% ARM U, 30% ARM U and 2.4 AS in reducing ammonia volatilization from urea was comparable to that of Agrotain.
- Active AgriScience products were as effective as Agrotain, despite their lower concentration of NBPT per kg of fertilizer.
- Lower dosage rates for the Active AgriScience products relative to other products such as Agrotain will likely make them more economical.

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