Influences of Urea-Nitrogen Stabilizers on Ammonia Volatilization and Nitrous Oxide Emissions From Two Contrasting Soils

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INTRODUCTION

- Urea-treated soils are important source of gaseous N (NH_3 and N_2O) losses to the atmosphere.
- Urea-N stabilizers (urease and/or nitrification inhibitors) and slow-release N-fertilizer have the potential to decrease soil emissions of NH_3 and N_2O, however their effects can vary with soil texture.

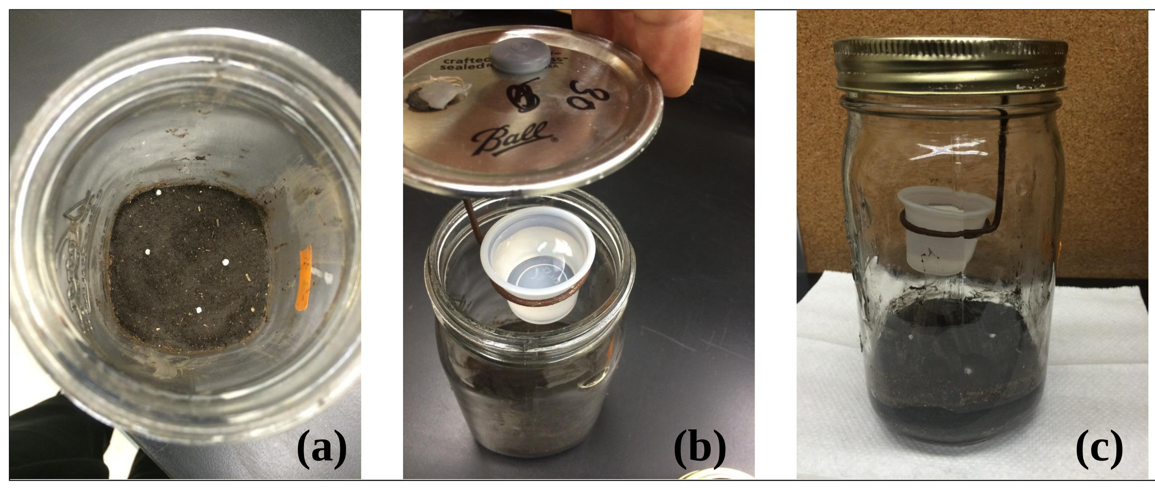
OBJECTIVES

- To evaluate the effects of urea-N stabilizers and slow-release N-fertilizer on NH_3 volatilization and N_2O emissions from two contrasting soils, representative of large agricultural areas in ND and MN, where urea is widely used.

METHODS

- Two surface soils (0-15 cm) - Ulen sandy loam and Fargo silty clay -were collected, air dried, and ground to pass a 2 mm sieve.
- In 1-L mason jars, each soil (100 g air-dry-equivalent) was amended with 36 mg N (except control, 0 N applied) of respective N sources: (1) Urea, (2) Urea with urease inhibitor (NBPT), (3) Urea with nitrification inhibitor (NP), (4) Urea with urease (NBPT) and nitrification inhibitor (DCD), and (5) Polymer coated urea (PCU).
- De-ionized water was added to adjust soils at 60% WHC.
- The jars were closed with airtight lids and the soils were incubated at 20°C for 126 days in the laboratory. A cup with 20 mL of 0.5 *M* H_3PO_4 (acid trap to capture NH_3) was hung above soil surface from the lid (Singurindy et al., 2006).
- Headspace air sample was collected from a sampling port (with a butyl rubber septum) using 30 mL syringe. Air samples were analyzed for N_2O concentrations using a DGA-42 Dani Master gas chromatograph fitted with ^{63}Ni-electron capture detector (Parkin and Venterea, 2010).
- Following gas sampling, acid traps were collected and replaced with fresh traps. The traps were extracted with 2 *M* KCl, and NH_4^+ concentrations were analyzed using an automated Timberline TL2800 ammonia analyzer.
- Soils were analyzed for inorganic N contents at the end of the incubation.
- The rates of NH_3 volatilization (and N_2O emissions) were calculated from the time elapsed headspace gas concentration and volume, and soil mass.
- Cumulative emissions of NH_3 (and N_2O) during the incubation was computed from the summation of NH_3 (and N_2O) emitted in each sampling period.
- $\% EF_{(NH_3 \text{ or } N_2O)} = (C_f - C_c)$/N-applied x 100 where, C_f and C_c are cumulative NH_3 (or N_2O) emissions from N-amended and control treatments, respectively (Jumadi et al., 2008).

<u>Abbreviations</u>: ND, North Dakota; MN, Minnesota; NBPT, N-(n-butyl) thiophosphoric tiramide; NP, Nitrapyrin; DCD, Dicyandiamide; WHC, water holding capacity; %EF, percent emission factor.



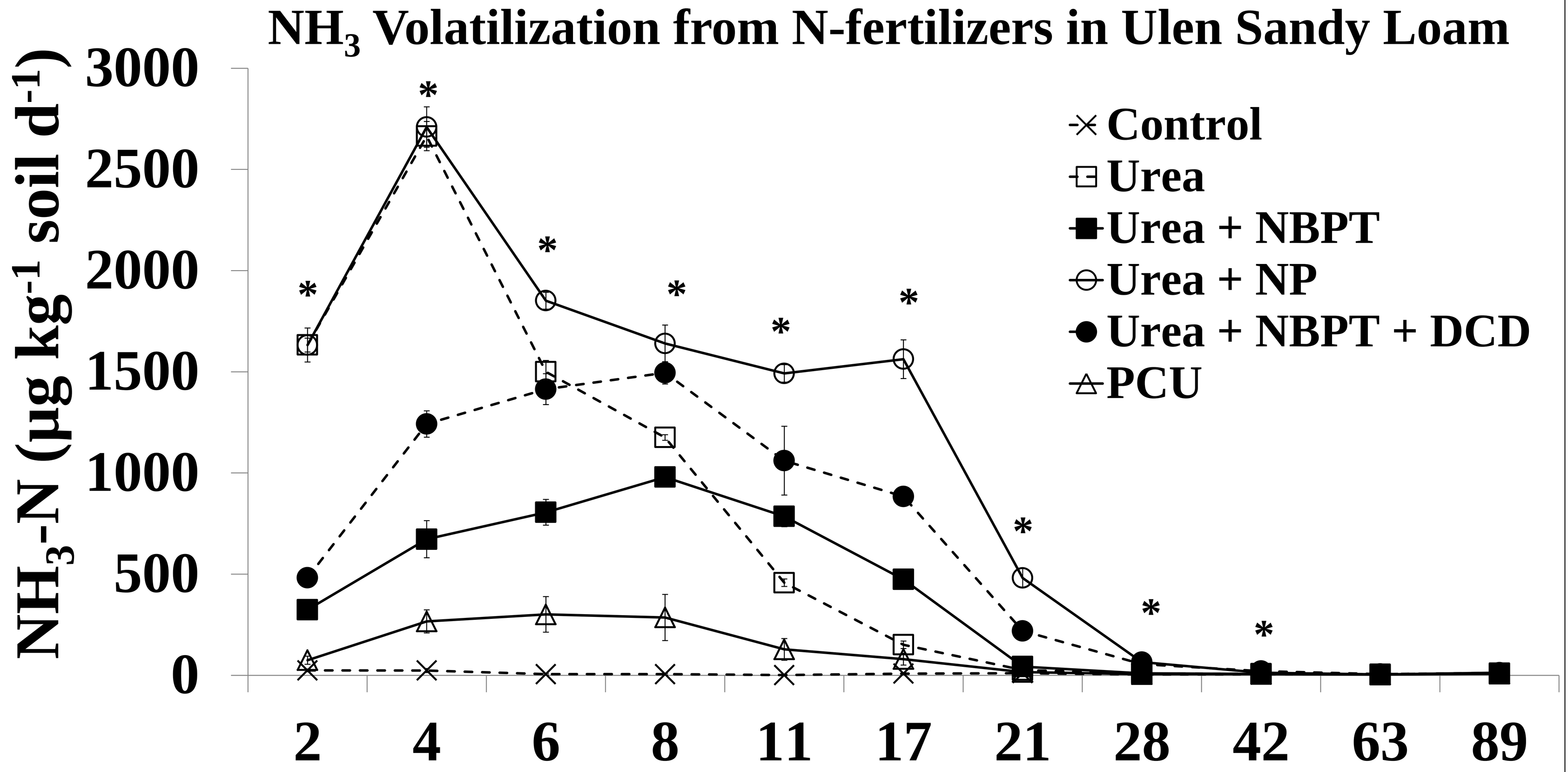
Pictures showing (a) amendment of treatment, (b) installation of H_3PO_4 trap, and sampling port (butyl rubber septum) on the lid, and (c) a complete experimental unit.

Physical and Chemical Properties of Soils used in the Study

Soils	pH	EC (ds m^{-1})	Sand (g kg^{-1})	Silt (g kg^{-1})	Clay (g kg^{-1})	OM (%)	NO_3^--N (mg kg^{-1})	CEC (cmol kg^{-1})
Ulen	8.29	0.13	814	103	93	3.4	2.12	10.4
Fargo	7.27	1.16	62	454	494	10.3	34.8	43.4

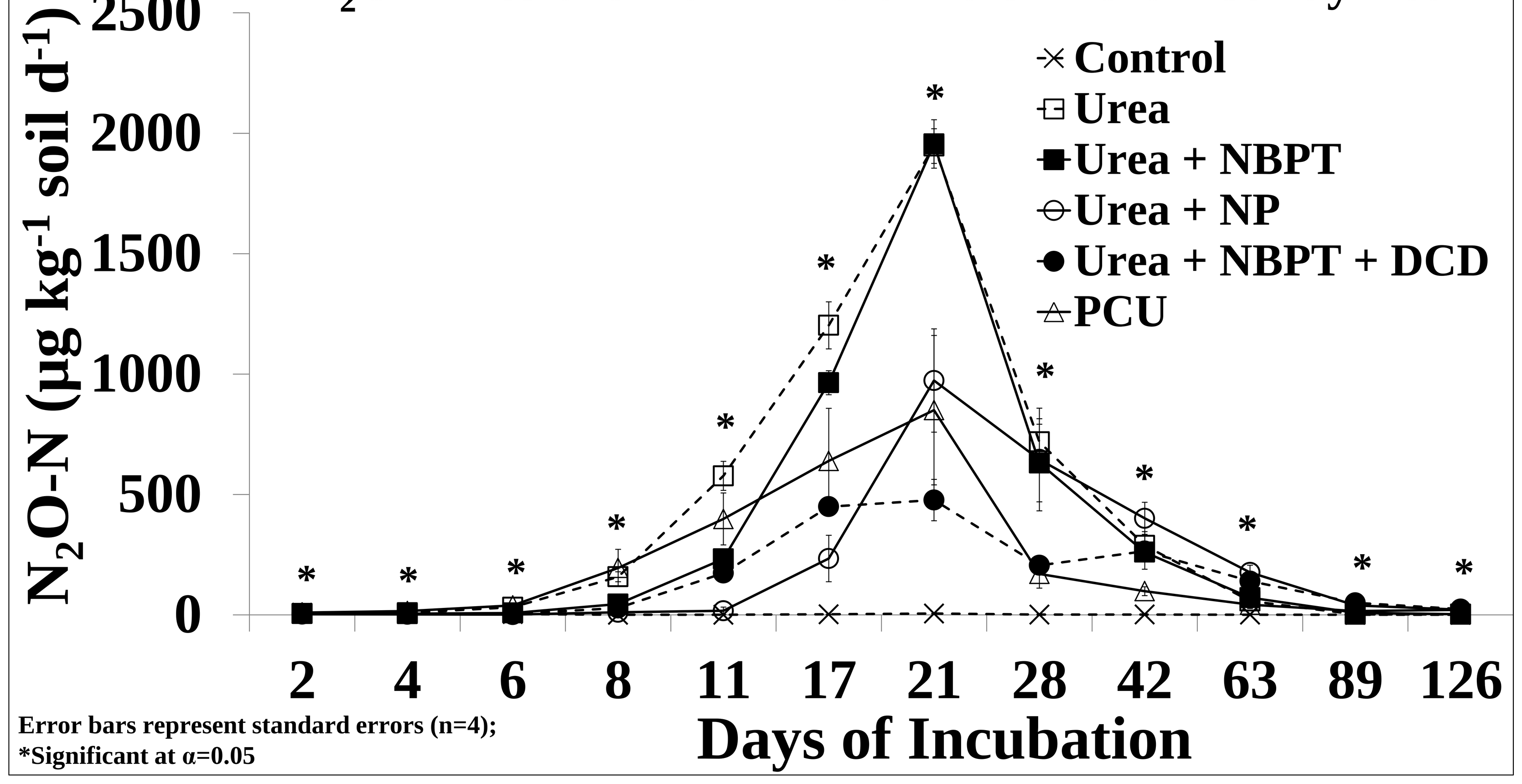
RESULTS

NH_3 Volatilization from N-fertilizers in Ulen Sandy Loam



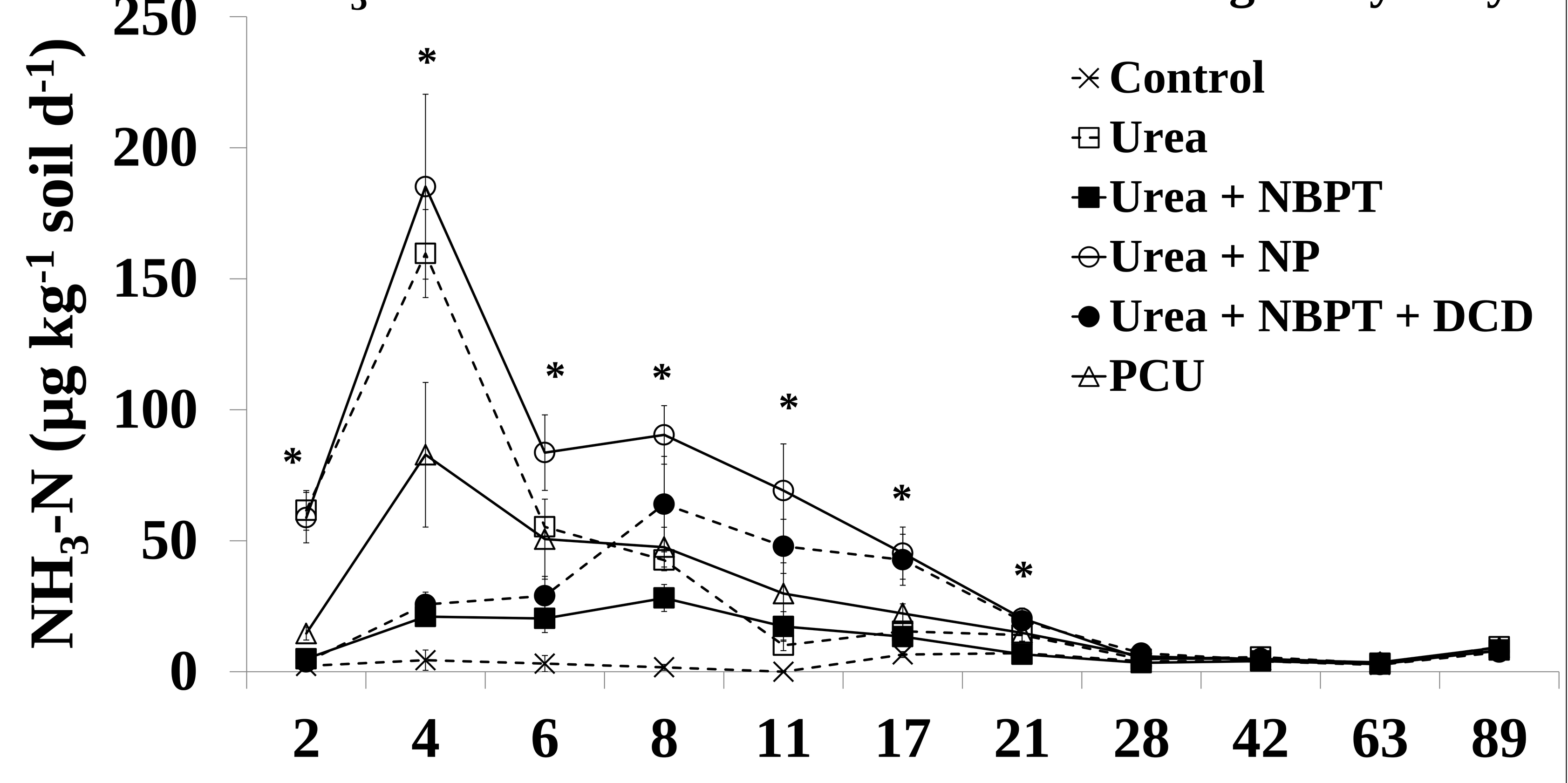
Error bars represent standard errors (n=4);
*Significant at α=0.05

N_2O Emissions from N-fertilizers in Ulen Sandy Loam



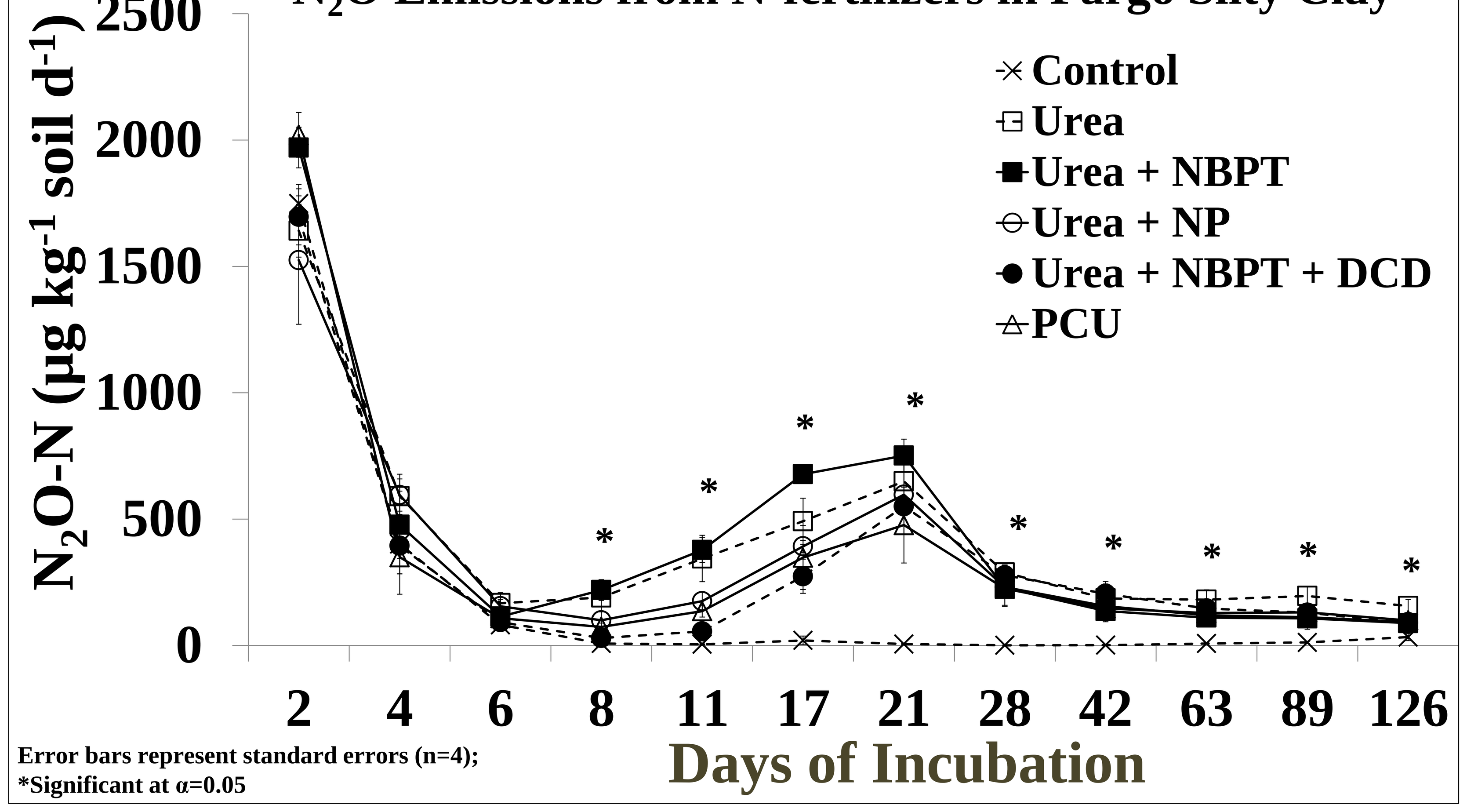
Error bars represent standard errors (n=4);
*Significant at α=0.05

NH_3 Volatilization from N-fertilizers in Fargo Silty Clay



Error bars represent standard errors (n=4);
*Significant at α=0.05

N_2O Emissions from N-fertilizers in Fargo Silty Clay



Error bars represent standard errors (n=4);
*Significant at α=0.05

Cumulative Emissions of Ammonia and Nitrous Oxide, and Emission Factors for Various N-fertilizers in Two Soils

Treatments	Cumulative NH_3	NH_3 emission factor	Cumulative N_2O	N_2O emission factor
	---mg kg^{-1}---	------%------	---mg kg^{-1}---	------%------
		Ulen Sandy Loam		
Control	0.7 ± 0.2 ^{f†}	-	0.1 ± 0.0 ^{e}	-
Urea	16.5 ± 0.4 ^{c}	4.3 ± 0.1 ^{c}	27.3 ± 2.6 ^{a}	7.4 ± 0.7 ^{a}
Urea + NBPT	11.4 ± 0.3 ^{d}	2.9 ± 0.1 ^{d}	24.0 ± 3.4 ^{ab}	6.5 ± 0.9 ^{a}
Urea + NP	32.1 ± 0.9 ^{a}	8.6 ± 0.2 ^{a}	20.9 ± 2.4 ^{bc}	5.7 ± 0.6 ^{ab}
Urea + NBPT + DCD	19.7 ± 0.9 ^{b}	5.2 ± 0.3 ^{b}	15.4 ± 1.3 ^{cd}	4.2 ± 0.4 ^{bc}
PCU	3.2 ± 1.0 ^{e}	0.7 ± 0.2 ^{e}	13.5 ± 2.4 ^{d}	3.7 ± 0.7 ^{c}
		Fargo Silty Clay		
Control	0.5 ± 0.1 ^{d}	-	6.0 ± 0.8 ^{b}	-
Urea	1.2 ± 0.2 ^{ab}	0.2 ± 0.0 ^{ab}	30.6 ± 2.8 ^{a}	6.8 ± 0.9 ^{a}
Urea + NBPT	0.7 ± 0.1 ^{cd}	0.1 ± 0.0 ^{b}	25.1 ± 2.0 ^{a}	5.2 ± 0.6 ^{a}
Urea + NP	1.8 ± 0.3 ^{a}	0.4 ± 0.1 ^{a}	22.2 ± 5.4 ^{a}	4.5 ± 1.3 ^{a}
Urea + NBPT + DCD	1.1 ± 0.2 ^{bc}	0.1 ± 0.0 ^{b}	22.5 ± 2.9 ^{a}	4.5 ± 0.6 ^{a}
PCU	1.1 ± 0.1 ^{bc}	0.2 ± 0.0 ^{ab}	22.4 ± 2.0 ^{a}	4.5 ± 0.7 ^{a}

†Means (± standard error) within each soil type denoted by a different letter in the same column differ significantly ($p < 0.05$).

Residual Inorganic-N Contents in Two Soils

Treatments	Ulen Sandy Loam	Fargo Silty Clay
	------------------mg kg^{-1}	------------------
Control	0.3 ± 0.0 ^{c†}	3.6 ± 1.2 ^{b}
Urea	17.6 ± 2.6 ^{b}	27.5 ± 5.8 ^{a}
Urea + NBPT	18.3 ± 3.6 ^{b}	36.5 ± 2.3 ^{a}
Urea + NP	15.4 ± 2.5 ^{b}	36.7 ± 4.5 ^{a}
Urea + NBPT + DCD	18.0 ± 2.4 ^{b}	35.8 ± 3.8 ^{a}
PCU	29.1 ± 2.4 ^{a}	34.5 ± 1.8 ^{a}

†Means (± standard error) followed by different letters in the same column differ significantly ($p < 0.05$).

SUMMARY AND CONCLUSIONS

- Application of urease inhibitor (NBPT) can reduce NH_3 volatilization losses from urea-applied soils.
- Slow-release N-fertilizer (PCU) has a potential to reducing both NH_3 and N_2O emissions, particularly in sandy loam soils.
- Nitrification inhibitors (NP and DCD) were effective in reducing N_2O emissions from urea application in sandy loam soils.
- Efficiencies of urea-N stabilizers and slow-release N-fertilizers in mitigating gaseous N-emissions vary with soil texture.

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