NITROGEN FERTILIZER ADDITIVES, WHICH ONES WORK?

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Abstract

Nitrogen fertilizer additives were evaluated in nine different studies. In the first study, Nutrisphere had no effect on urea hydrolysis when applied with a urea solution. In a second study, Nutrisphere had no effect on nitrification when applied with a urea solution. In a third study with urea granules, Nutrisphere had little effect on ammonia volatilization. In a fourth study with urea granules, Nutrisphere had no effect on nitrification. In a fifth study, Nutrisphere was found to be less effective than Agrotain, ammonium thiosulfate (ATS) or calcium thiosulfate (CaTS) in the reduction of ammonia volatilization after surface application of urea-ammonium nitrate (UAN). In a sixth study with granular urea, Agrotain reduced ammonia loss, but Nutrisphere, OAC+, NZone, StayN, and NStay had no effect. In a seventh study with granular urea, dicyandiamide (DCD) and nitrapyrin slowed nitrification, but Nutrisphere, OAC+, NZone, StayN, and NStay had no effect. In an eighth study with granular urea, Agrotain and OAC+ slowed urea hydrolysis, but Nutrisphere, NZone, StayN, and NStay had no effect. In a ninth study with urea solutions, Agrotain significantly inhibited soil urease at rates as low as 2 mg kg^{-1}, but Nutrisphere, NZone, StayN, and NStay had no effect, even at a rate of 200 mg kg^{-1}. In these nine studies Nutrisphere, NZone, StayN, and NStay demonstrated little value as fertilizer additives for the purpose of inhibiting urea hydrolysis, nitrification, or ammonia loss from soil.

Introduction

Nitrogen fertilizer can be lost from the soil by many mechanisms. The most common modes of loss are ammonia volatilization, nitrate leaching, and denitrification. Urease inhibitors slow the conversion of urea to ammonia and are used to slow ammonia loss after a surface application of urea. The compound NBPT, sold as Agrotain, is an established urease inhibitor (Hendrickson, 1995). Amending UAN with ammonium thiosulfate (ATS) can also slow urea hydrolysis, especially if the fertilizer droplet size is large and the soil is relatively dry (Goos and Fairlie, 1988). Nitrification inhibitors slow the conversion of ammonium to nitrate, and can be helpful in reducing losses due to leaching and denitrification. Established nitrification inhibitors include nitrapyrin and DCD (Brady and Weil, 2002).

Recently, new nitrogen fertilizer additives have been introduced. A "maleic-itaconic" polymer called Nutrisphere is promoted as "...the most advanced dual-action urease and nitrification inhibitor on the market..." (Specialty Fertilizer Products, 2011). Also, three new products have been introduced, NZone, StayN, and NStay. These three products list Ca-aminoethylpiperazine and Ca-heteropolysaccharides as active ingredients for reducing N loss when applied with nitrogen fertilizer. The Simplot company also has an experimental fertilizer additive called OAC+, perhaps similar to the additive OAC tested by Holcomb (2011). The composition of OAC+ is unknown.

A total of nine different studies were performed to evaluate these new fertilizer additives. Because of the large number of studies, a complete discussion of the methods and results is not possible here. For the sake of brevity, one graph from each of these nine studies follows. Below each graph is a short explanation of how each study was conducted, and a summary of the findings. For those wishing to use any of the graphics in this paper, the graphics have been combined into a single zipped file in high resolution format. Please contact the author via e-mail if interested in obtaining the graphics.

Acknowledgements

Study 5 was supported by Tessenderlo-Kerley, and Studies 6-9 were supported by Agrotain International. Thanks to Jerry Hatfield, USDA-ARS, for the Iowa soil used in studies 7 and 9.

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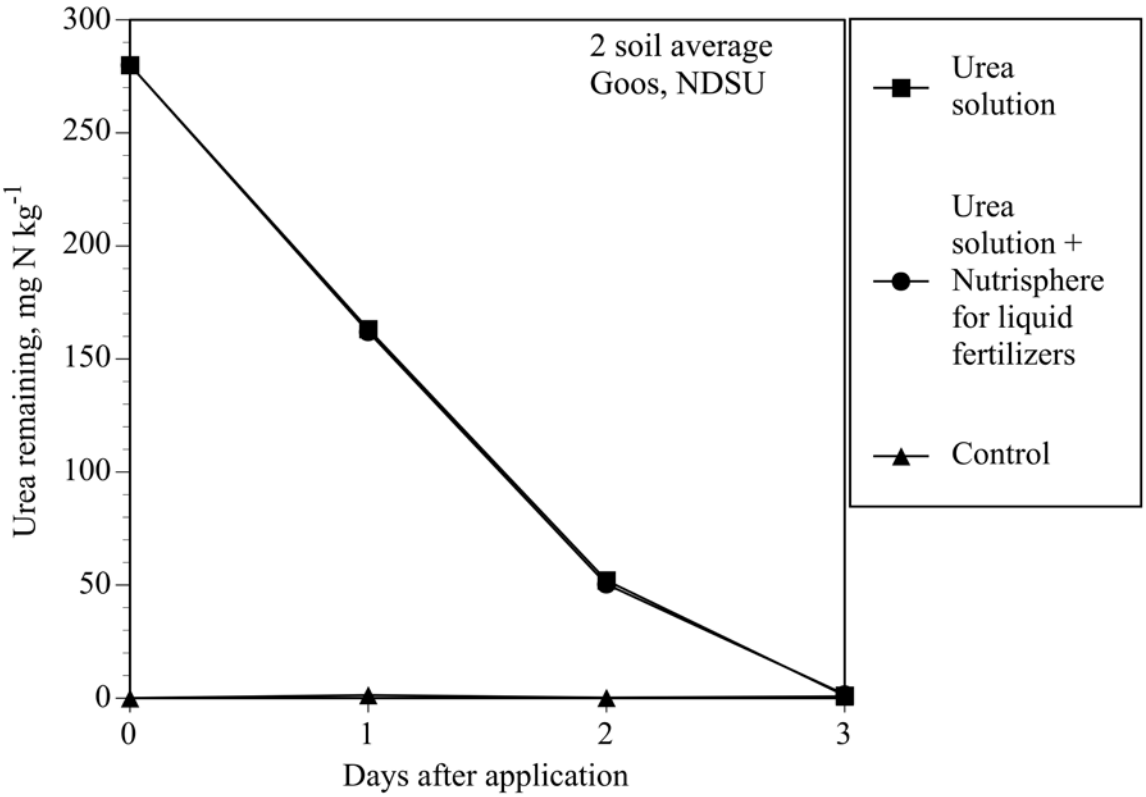
Study 1. Rate of urea hydrolysis when a droplet of a urea solution, or urea solution plus Nutrisphere for liquid fertilizer was placed on soil.

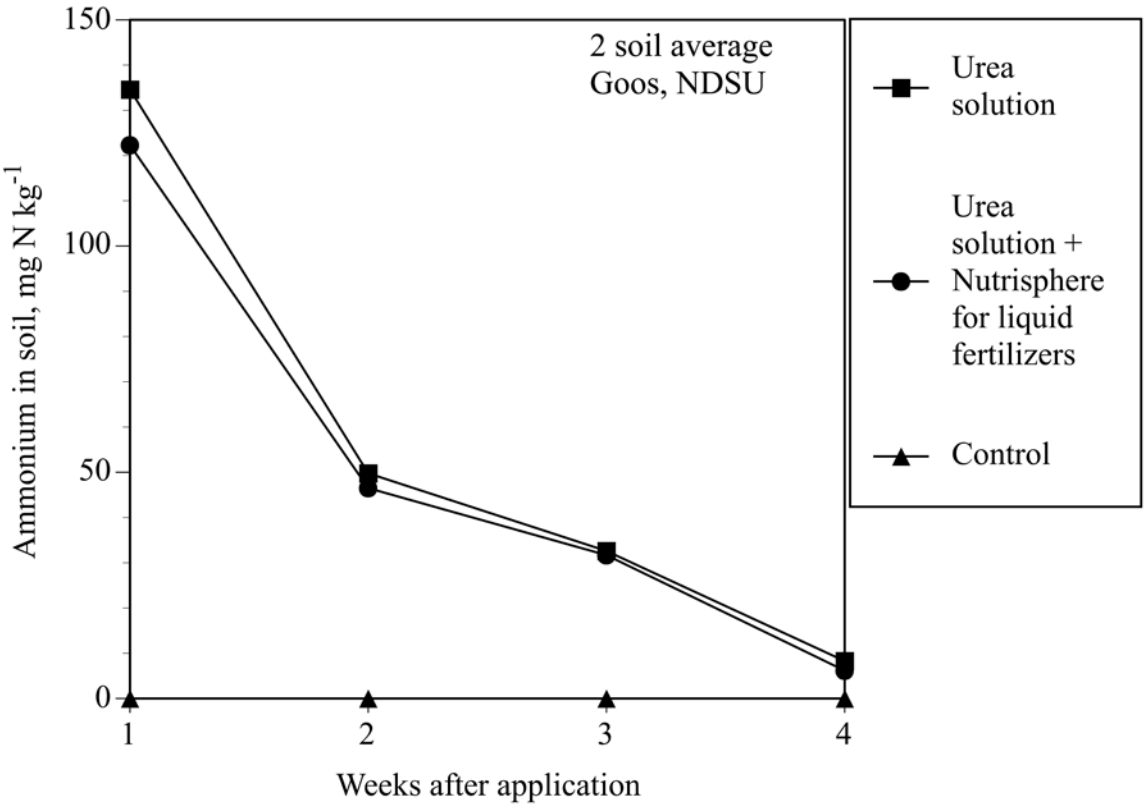


Procedure: In this laboratory study, 25 grams of a sandy loam or clay loam soil were moistened to near field capacity. A 0.1 mL droplet of a urea solution (150 g of urea L^{-1}) or a urea solution plus Nutrisphere for liquid fertilizers (50 mL L^{-1}) was applied to the soil surface, providing for an initial N rate of about 280 mg N kg^{-1}. The amount of urea in the droplet, 15 mg, was chosen to simulate the reaction of a single 15 mg urea granule with soil. After 1, 2, or 3 days, the soil was extracted, and urea determined.

Result: Urea hydrolysis was complete after three days. Adding Nutrisphere to the liquid fertilizer at the labeled rate of 0.5% by volume had no effect on the rate of urea hydrolysis.

Source: Franzen et al., 2011.

Study 2. Rate of nitrification when a droplet of a urea solution, or urea plus Nutrisphere for liquid fertilizers was placed on soil.

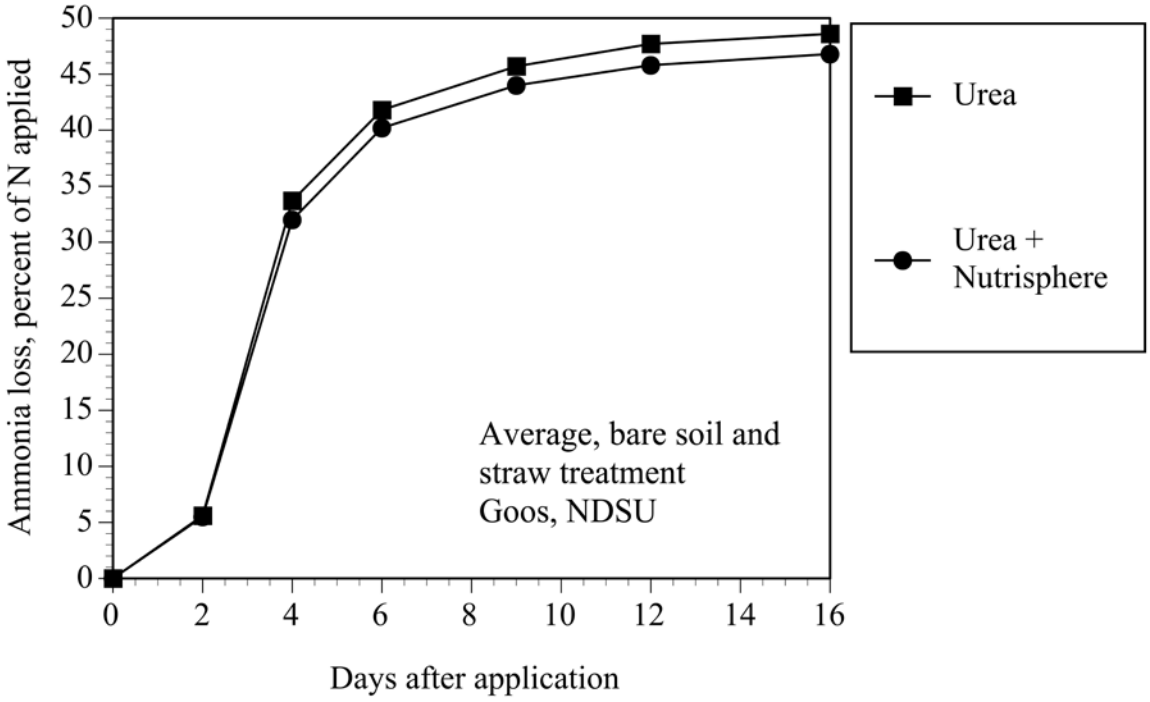


Procedure: In this laboratory study, 25 grams of a sandy loam or clay loam soil were moistened to near field capacity. A 0.1 mL droplet of a urea solution (150 g of urea L^{-1}) or a urea solution plus Nutrisphere for liquid fertilizers (50 mL L^{-1}) was applied to the soil surface, providing for an initial N rate of about 280 mg N kg^{-1}. The amount of urea in the droplet, 15 mg, was chosen to simulate the reaction of a single 15 mg urea granule with soil. After 1, 2, 3, and 4 weeks, the soil was extracted with a KCl solution, and ammonium determined.

Result: Nitrification was essentially complete after four weeks. Adding Nutrisphere to the urea solution at the labeled rate had no effect on nitrification.

Source: Franzen et al., 2011.

Study 3. Ammonia loss from soil surfaces after treatment with granular urea, or granular urea treated with Nutrisphere.

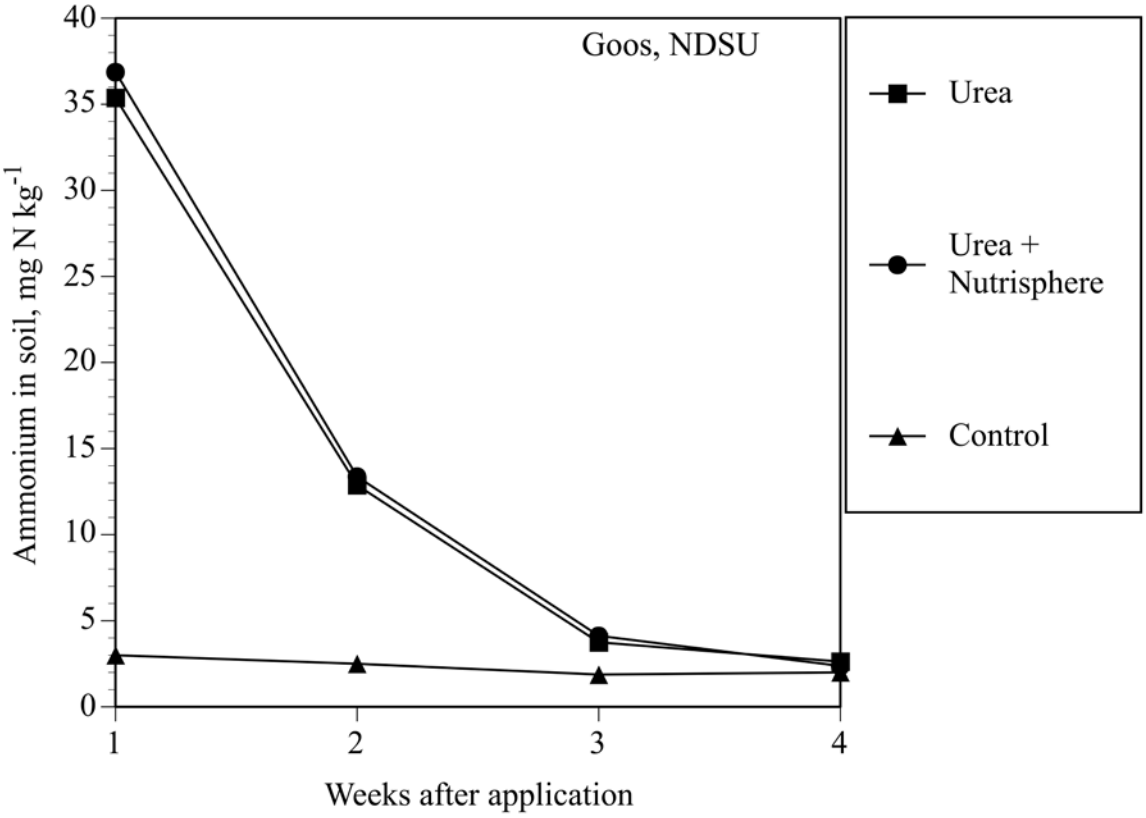


Procedure: Urea granules, and urea granules treated with Nutrisphere were obtained from the Simplot company. Bare soil, or bare soil with a ~50% cover with wheat straw was treated with fertilizer granules at a rate of 100 kg N ha^{-1}. Ammonia volatilizing from the surface was trapped with phosphoric acid, and determined via the steam distillation method. This was a greenhouse study.

Result: Over 45% of the applied urea-N was lost over 16 days. Treatment with urea granules with Nutrisphere had only a slight effect on ammonia loss.

Source: Franzen et al., 2011.

Study 4. Residual ammonium and nitrate in soil after treatment with granular urea, or urea treated with Nutrisphere.

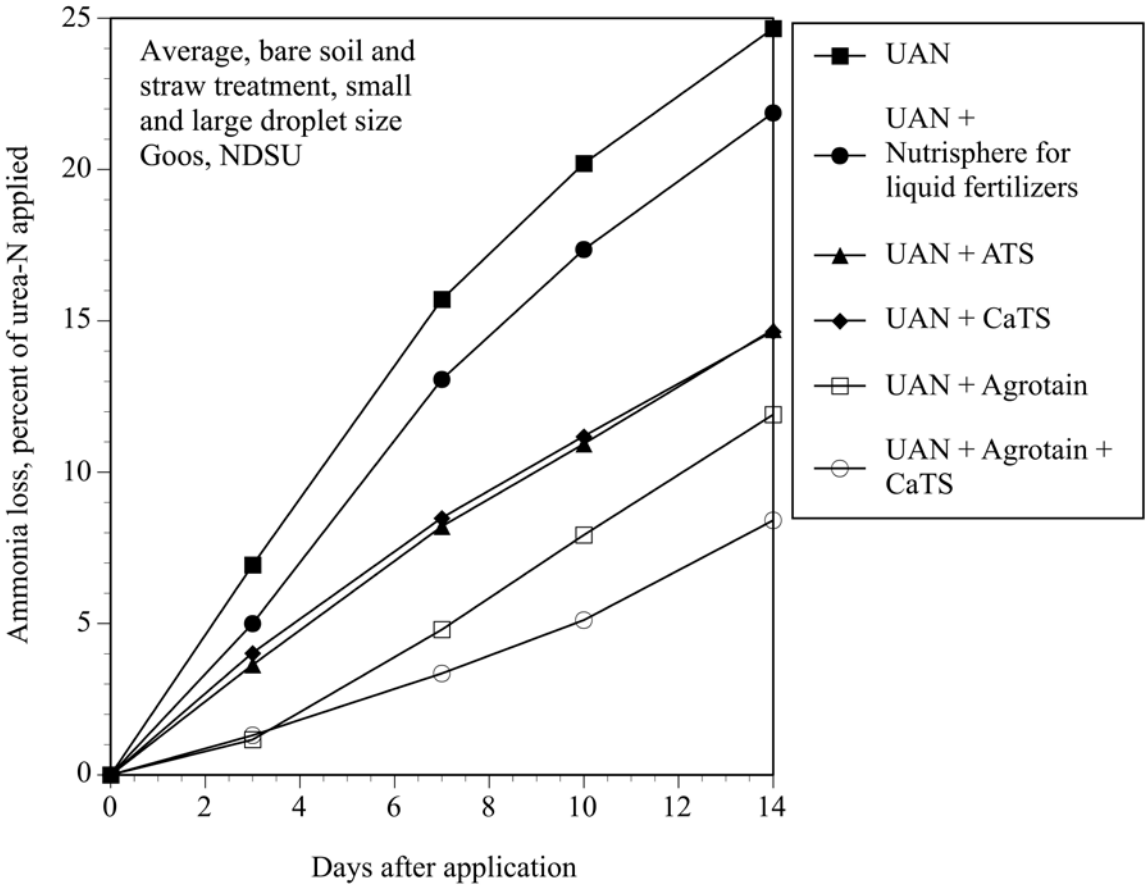


Procedure: Urea granules, or urea granules treated with Nutrisphere, were obtained from the Simplot company and used in a greenhouse study. Granules equivalent to 100 kg N ha^{-1} were mixed with a sandy loam soil, and allowed to incubate for up to four weeks with minimal water movement. The initial N application to the soil was about 91 mg N kg^{-1}. The soil was dried, sieved, and analyzed for KCl-extractable ammonium.

Result: Nitrification proceeded rapidly in this soil, and was complete after four weeks. Treating the urea granules with Nutrisphere had no effect on the apparent nitrification rate.

Source: Franzen et al., 2011.

Study 5. Ammonia volatilization from soil surfaces after treatment with UAN, or UAN amended with various additives.

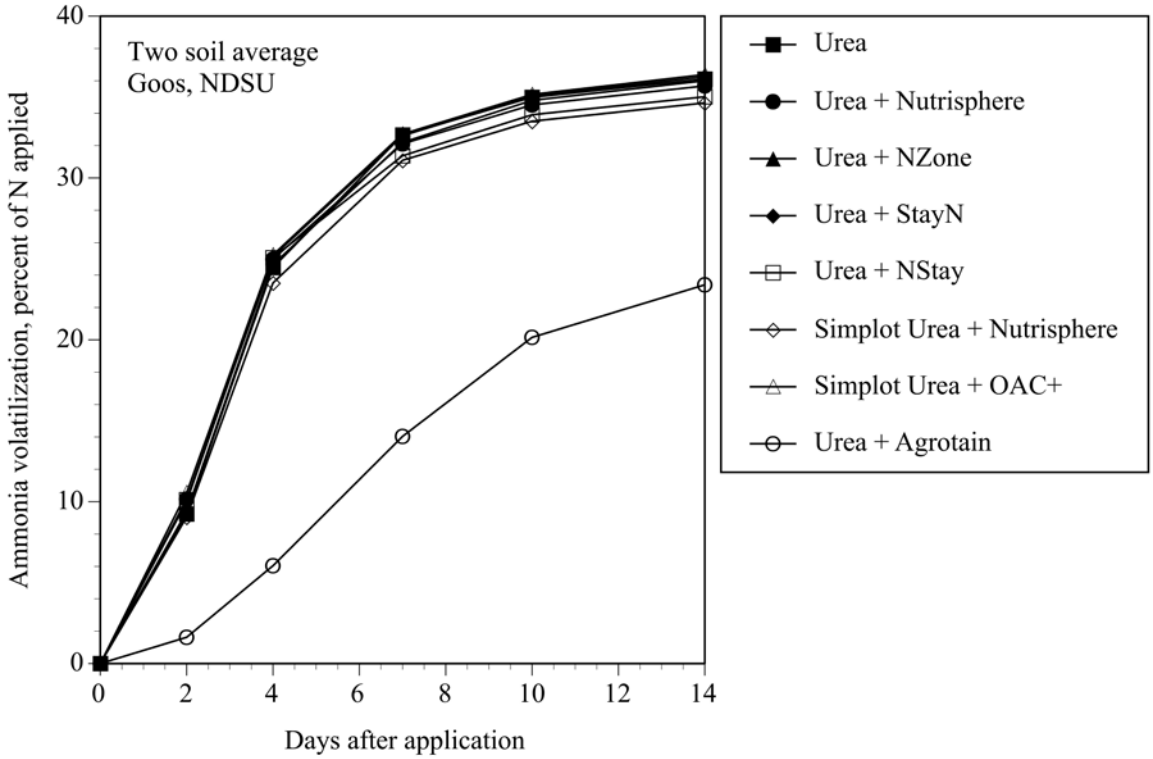


Procedure: UAN was amended with different additives and applied to the soil surface under greenhouse conditions. Four runs of the study were performed, bare soil with small droplets (0.05 mL), bare soil with large droplets (0.5 mL), soil with 50% wheat straw cover with small droplets, and soil with 50% wheat straw cover with large droplets. The N rate was 100 kg N ha^{-1}. Ammonia volatilizing from the soil surface was trapped with phosphoric acid and analyzed by steam distillation. The graph above shows the average of the four runs.

Results: Ammonia loss representing about 25% of the urea in the UAN was observed for unamended UAN. The effectiveness of the additives, from most to least effective, was Agrotain + CaTS > Agrotain > ATS = CaTS > Nutrisphere. The Nutrisphere for liquid fertilizers is an acidic product and suppressed the pH of the UAN to about 3.5, which is a likely explanation for its effect on ammonia loss.

Source: Goos 201x.

Study 6. Ammonia loss from soil surfaces after treatment with granular urea, or granular urea treated with various additives.

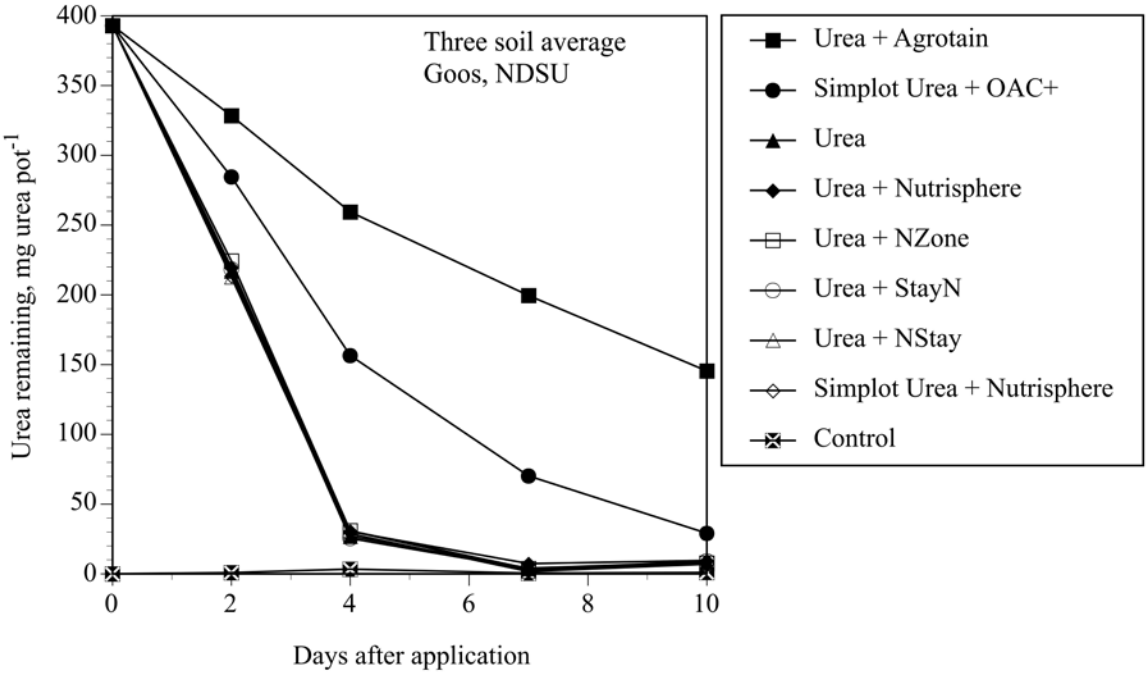


Procedure: This was a greenhouse study. Urea granules, or amended urea granules, were placed on the soil surface at a rate of 100 kg N ha^{-1}, and ammonia volatilizing from the soil surface trapped into phosphoric acid and determined by steam distillation. We applied the additives to the granules, except for two products provided already treated by the Simplot company. The experiment was performed twice, with a non-calcareous sandy loam and a calcareous sandy clay loam soil.

Result: Most of the products were ineffective in slowing ammonia loss. Agrotain was the only additive to give a significant reduction in N loss.

Source: Goos (unpublished).

Study 7. Urea hydrolysis after treated with granular urea, or granular urea treated with various fertilizer additives. Source: Goos, unpublished.

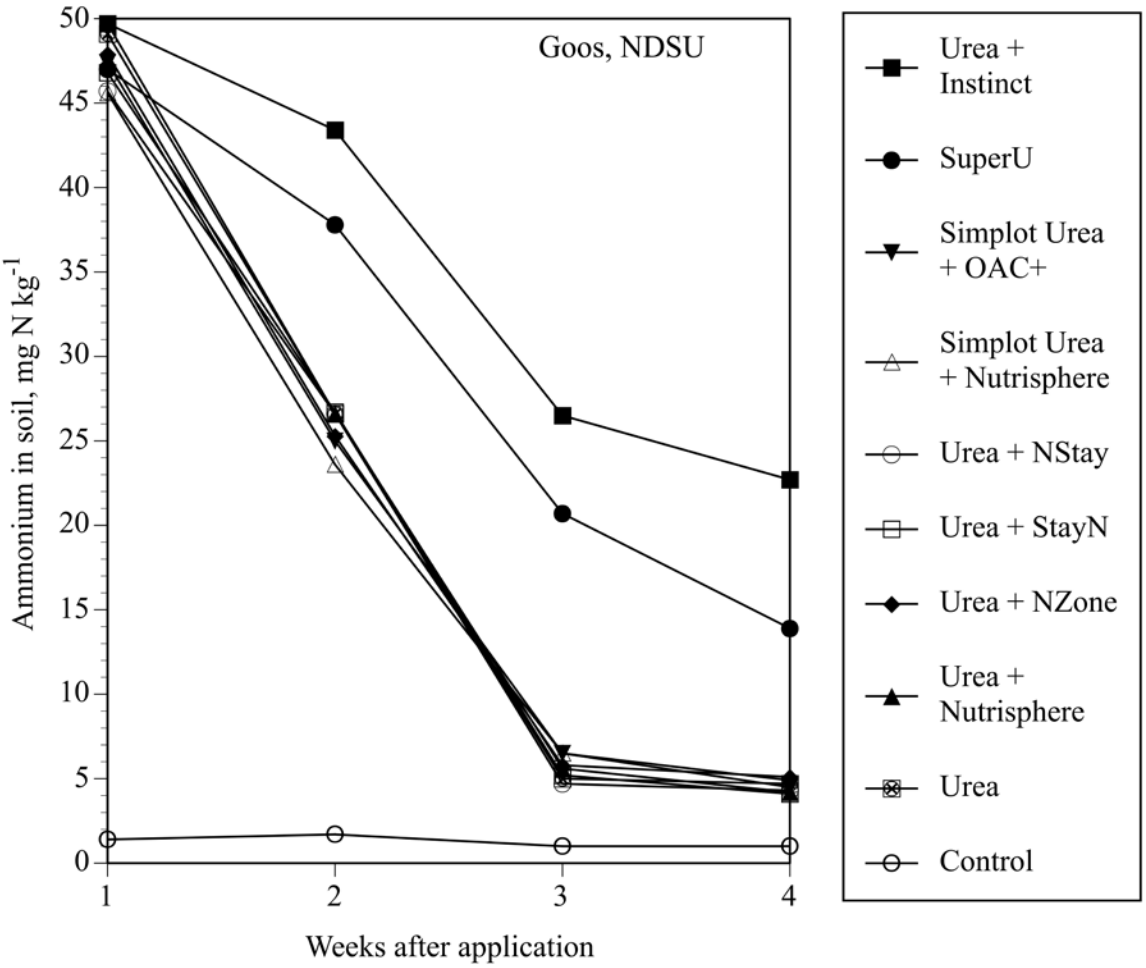


Procedure: Urea granules, or amended urea granules were used in this laboratory study. We applied the additives to the granules, except for two products provided already treated by the Simplot company. The urea was applied at 393 mg of urea per pot, or about 100 kg N ha^{-1}. The granules were applied to a moist soil surface, and the rate of urea hydrolysis followed for 10 days. There were three runs of this experiment, each with a different soil, a sandy loam and calcareous sandy clay loam from North Dakota, and a clay loam from Iowa.

Result: Agrotain and Simplot's OAC+ slowed urea hydrolysis. The other products did not.

Source: Goos (unpublished).

Study 8. Nitrification of urea granules, or urea granules amended with various fertilizer additives.

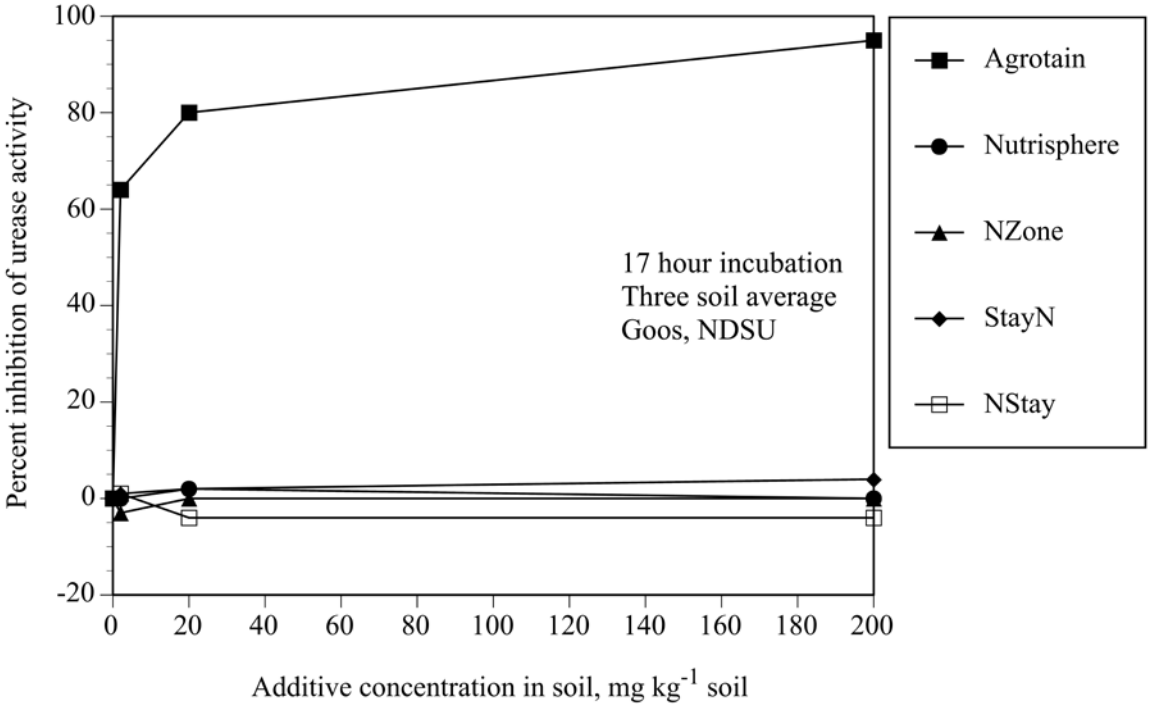


Procedure: Urea granules, or amended urea granules were incorporated into soil at a rate of 100 kg N ha^{-1} in this greenhouse experiment. We applied the additives to the granules, except for two products provided already treated by the Simplot company, and the SuperU provided by Agrotain International. The initial N rate was about 88 mg N kg^{-1} of soil. After 1, 2, 3, and 4 weeks, the soil was dried, sieved, and analyzed for KCl-extractable ammonium. The experiment was performed with a non-calcareous sandy loam soil from North Dakota.

Results: Instinct (nitrapyrin) and DCD (SuperU) inhibited nitrification. The other materials did not.

Source: Goos (unpublished).

Study 9. Percent inhibition of urease given by different rates of various fertilizer additives.



Procedure: Ten gram portions of soil were treated with five additives at rates equivalent to 0, 2, 20, or 200 mg kg^{-1} of the additive in the soil. The additives and soil were allowed to react for six hours. Then, a urea solution was added to the soil and incubated for 17 hours at 25 C. The use of excess water was avoided and the soils were incubated aerobically. The remaining urea was determined, and the percent inhibition of urease activity calculated. Three soils were used, two from North Dakota, one from Iowa.

Results: Agrotain significantly inhibited urease at concentrations as low as 2 mg kg^{-1}. The other additives had no effect on urease, even at rates of 200 mg kg^{-1}. Under the conditions of this test, Nutrisphere, NZone, StayN, and NStay had no effect on urease activity of these three soils.

Source: Goos (unpublished).

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Volume 27

November 16-17, 2011
Holiday Inn Airport
Des Moines, IA

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Published by:
International Plant Nutrition Institute
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Brookings, SD 57006
(605) 692-6280
Web page: www.IPNI.net