

Novel N Fertilizer Products

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Enhanced-Efficiency N Fertilizers

Products designed to improve the nitrogen-use efficiency when using nitrogen fertilizers.

In other words, the goal is to get more nitrogen into the crop and less lost to the environment.

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Enhanced-Efficiency N Fertilizers

Is there a need for “Enhanced-Efficiency Fertilizers”?

Numerous studies have shown that up to 50% of the N fertilizer applied to corn is not taken up by the crop

How is Nitrogen lost from soils after application?

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Forms of N Present in Soils

THREE major forms of N?

- 1) Organic N (e.g., plant residues, manures, SOM)
- 2) Ammonium (NH_4^+)
- 3) Nitrate (NO_3^-)

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Ammonium N (NH_4^+)

- 1) Plant available form of N
- 2) Held in soils on CEC
- 3) What happens to Ammonium in a soil?
 - Taken up and utilized by the plant
 - MAIN thing is...

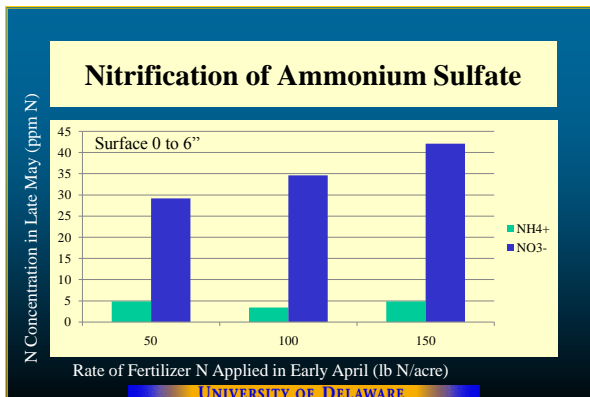


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NITRIFICATION

- 1) Conversion of Ammonium to Nitrate
- 2) $\text{NH}_4^+ + 2\text{O}_2 \Rightarrow \text{NO}_3^- + \text{H}_2\text{O} + 2\text{H}^+$
- 3) Biological Process
- 4) Nitrification is temperature dependent
- 5) Nitrification insignificant below 50 °F

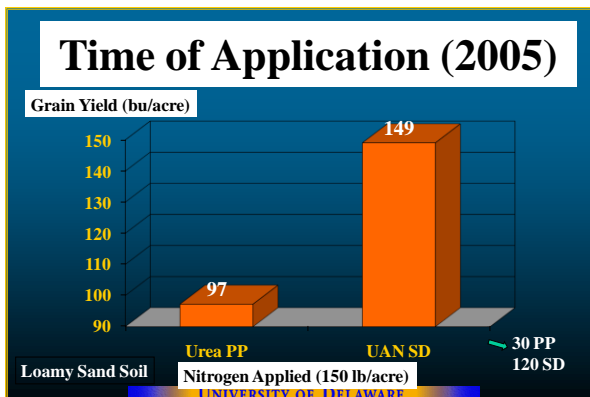
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- ### Nitrate N (NO₃⁻)
- 1) Plant available form of N
 - 2) **NOT held in soils on CEC**
 - 3) Due to nitrification, NO₃⁻ most common
Nitrification: NH₄⁺ => NO₃⁻
 - 4) **Nitrate is lost relatively easily from soils**
- NO₃⁻ {
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- ### How is Nitrogen Lost?
- THREE ways N is lost from soils:**
- 1) LEACHING
 - 2) DENITRIFICATION
 - 3) VOLATILIZATION
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- ### LEACHING
- 1) Primary form of N lost this way? NO₃⁻
 - 2) **Nitrate with Excess Water = Leaching**
 - 3) Soil Type is a major influence
Greater Sand content = Greater leaching
 - 4) **Leaching can occur in most soils**
 - 5) How can this be MINIMIZED?
 - 6) **Application Timing, Fertilizer Technology**
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- ### DENITRIFICATION
- 1) Form of N lost this way? NO₃⁻
 - 2) **Nitrate with no oxygen = denitrification**
 - 3) Soil Type is a major influence
Poor drainage = Greater denitrification
 - 4) **Fine-textured soils = greater potential**
 - 5) How can this be MINIMIZED?
 - 6) **Application Timing, Fertilizer Technology**
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VOLATILIZATION

- 1) Form of N lost this way? NH_4^+
- 2) Ammonium in high pH environment
- 3) Soil pH is THE major influence
- 4) $\text{NH}_4^+ \rightleftharpoons \text{NH}_3(\text{g}) + \text{H}^+$
- 5) Other important factors: CEC, wind, and TEMPERATURE
- 6) Prevent by incorporation of ammonium
- 7) Two big concerns: Surface applications of Manures and UREA containing fertilizers

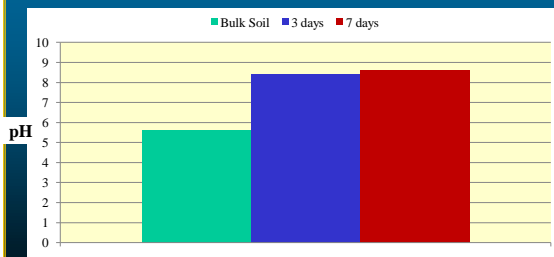
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Urea Fertilizer in Soils

- 1) Urease is the enzyme that breaks down urea
- 2) Urea ($\text{NH}_2 - \text{CO} - \text{NH}_2$) \Rightarrow NH_4 Carbonate

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Urea Prill Microsite pH



Hauck, 1984

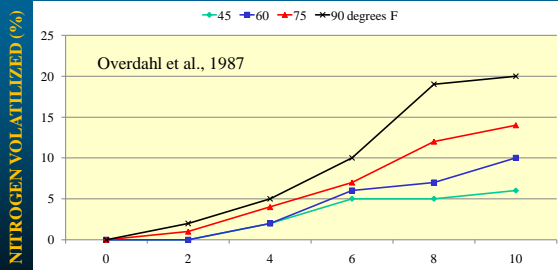
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Urea Fertilizer in Soils

- 1) Urease is the enzyme that breaks down urea
- 2) Urea ($\text{NH}_2 - \text{CO} - \text{NH}_2$) \Rightarrow NH_4 Carbonate
- 3) NH_4^+ in a high pH environment goes to $\text{NH}_3(\text{g})$
- 4) $\text{NH}_4^+ \rightleftharpoons \text{NH}_3(\text{g}) + \text{H}^+$
- 5) Urease inhibitors keep N as urea until in soil
- 6) If urea gets into the soil (rain or tillage), then there is no need for a urease inhibitor

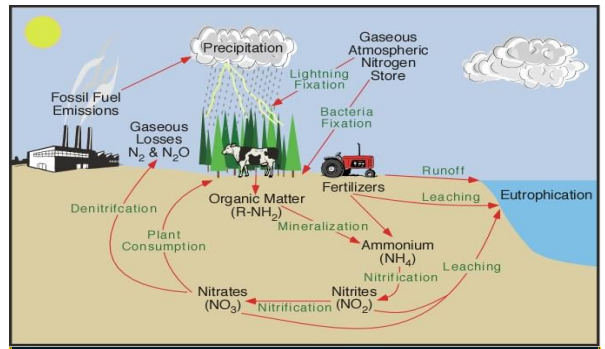
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Ammonia Volatilization



Overdahl et al., 1987

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<http://www.physicalgeography.net/fundamentals/9s.html>

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Enhanced-Efficiency N Fertilizers

- 1) Mechanisms for reducing potential N loss?
- 2) Urease Inhibitors
- 3) Nitrification Inhibitors
- 4) Slow release through "Coatings"
- 5) Slow release through chemical formulation
- 6) **IMPORTANT: Data should demonstrate that the mode of action does work**

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Urease Inhibitors

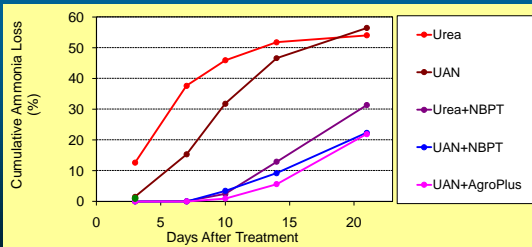
Temporarily blocks the function of urease enzyme
Provides a "window" of time for rain to move the urea molecule down into the soil

Agrotain®, also known as NBPT, which is:

N-(n-butyl) thiophosphoric triamide
(registered product of Agrotain International in St. Louis, MO)

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Ammonia Losses: AGROTAIN



Source: Dr. W. Thornberry, Sturgis, KY; Dr. S. Ebelhar, Univ of Illinois Laboratory incubation

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Nitrification Inhibitors

Temporarily blocks the process of nitrification

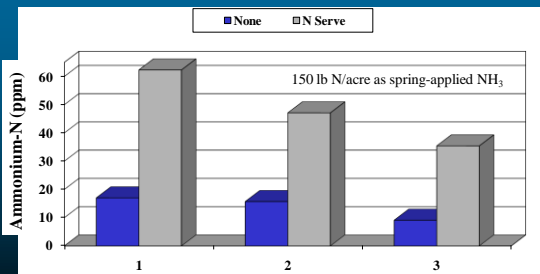


Nitrapyrin: N-SERVE® and INSTINCT®
(registered products of Dow AgroSciences)

DCD (dicyandiamide): Guardian®

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Effect of N Serve on Nitrification

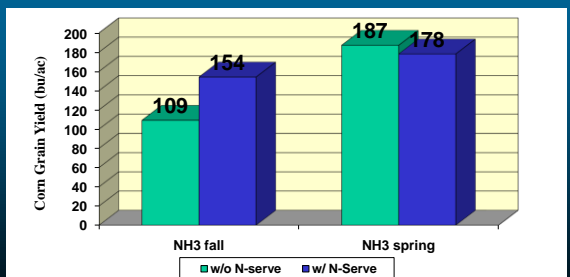


Maddux et al., 1985 (SSSAJ)

Three Sites in Kansas

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Minnesota: N-Serve 1999

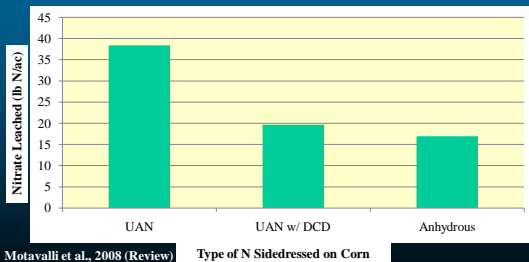


Randall and Vetsch

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Effect of DCD on Nitrate Leaching

Averaged fall nitrate leaching losses over three growing seasons in Canada



Motavalli et al., 2008 (Review)

Type of N Sidedressed on Corn

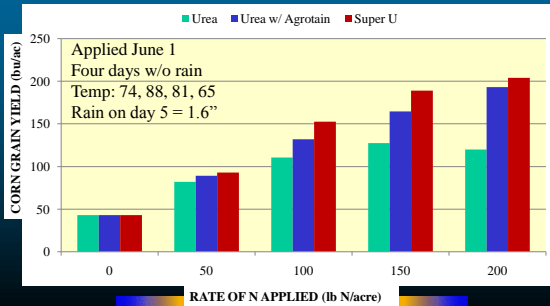
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Urease AND Nitrification Inhibitors

- 1) Agrotain Plus: Agrotain + DCD for UAN
- 2) Super U: dry urea product (Agrotain + DCD)
- 3) Nutrisphere-N: maleic-itaconic copolymer that "combines with Ni to decrease urease activity and combines with Fe and Cu to decrease microorganism metabolic activity delaying nitrification"
- 4) N Zone: tested in Arkansas in rice and found that it showed no benefit

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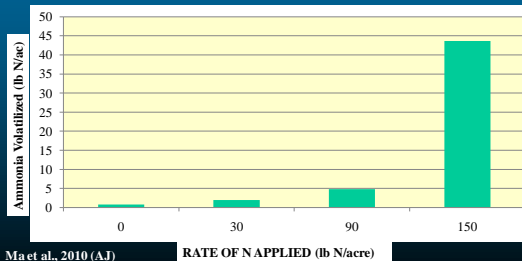
High Volatilization Potential



RATE OF N APPLIED (lb N/acre)

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Rate of N on NH3 Volatilization

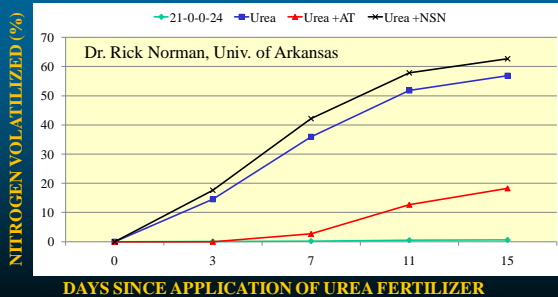


Ma et al., 2010 (A.J)

RATE OF N APPLIED (lb N/acre)

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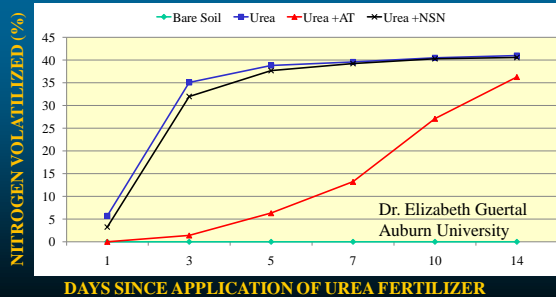
Ammonia Volatilization: AT/NSN



DAYS SINCE APPLICATION OF UREA FERTILIZER

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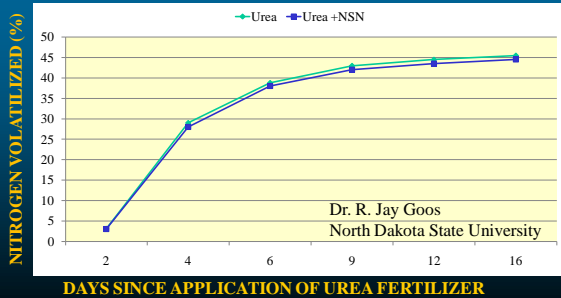
Ammonia Volatilization: AT/NSN



DAYS SINCE APPLICATION OF UREA FERTILIZER

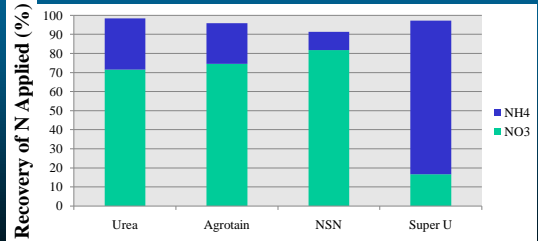
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Ammonia Volatilization: NSN



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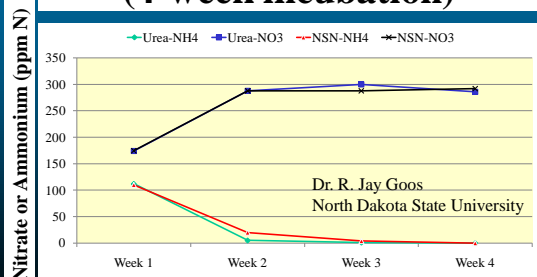
Effect on Nitrification (14-day incubation)



Rick Norman, Univ. of Arkansas

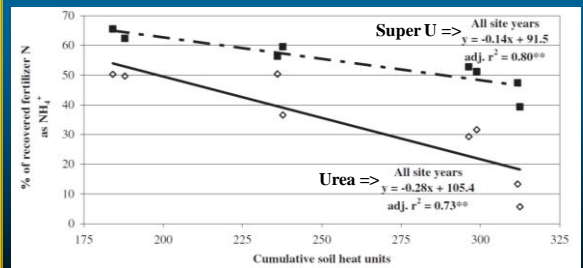
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Effect on Nitrification (4-week incubation)



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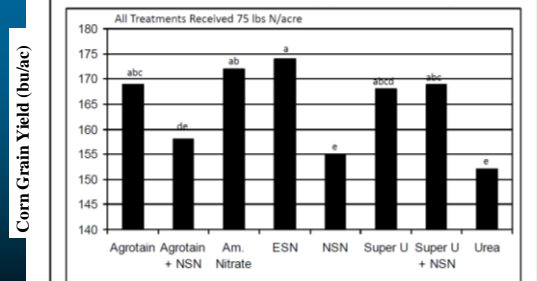
Nitrification with Super U



Tiessen et al., 2006 (AJ)

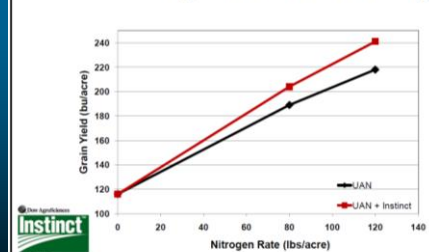
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2007 N volatilization Study (Princeton, KY)



UKAg Department of Plant and Soil Sciences 3/22/2010 © G. J. Schaub 2010

2009 Lexington Nitrification Study



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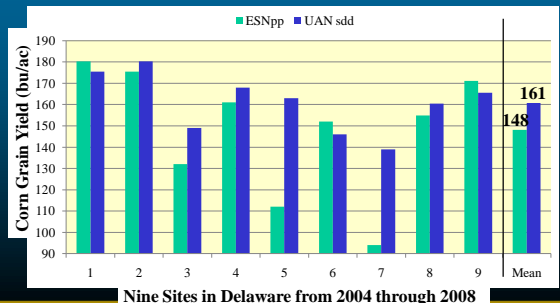
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Slow-Release N Fertilizers

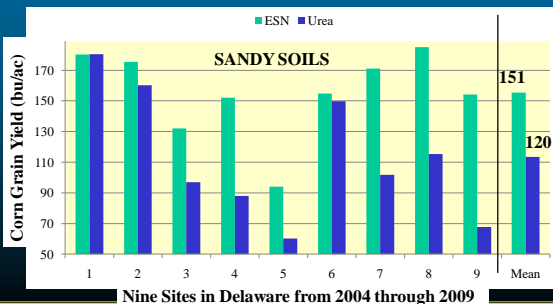
- 1) Polymer-coated urea product: ESN
- 2) Chemical control: urea formaldehyde/methylene urea
 - Nitamin, CoRon, Nutralene, Nitroform
 - release controlled by chain length of molecules
- 3) Sulfur-coated urea: used primarily in turf
- 4) Organic N fertilizers: mineralization of N

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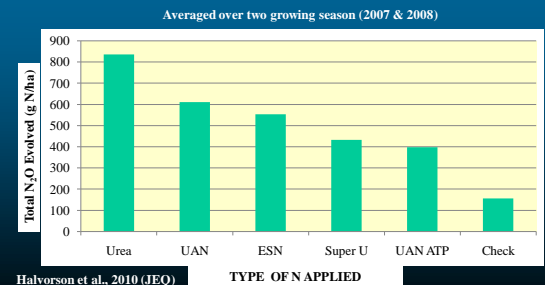
ESN preplant vs UAN sidedress



ESN vs Urea BOTH preplant



Rate of N₂O Emissions



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Criteria for EE Fertilizers

- 1) Know the mode of action
- 2) Determine where greatest value should be obtained
- 3) Consider the rate of nitrogen applied?
- 4) Data that demonstrates the mode of action
- 5) Evaluate cost-to-benefit with on-farm trials
- 6) Remember that the product will only provide increased value when conditions exist that induce losses of nitrogen
- 7) Value of enhanced efficiency fertilizers increases as nitrogen fertilizer prices increase

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CONCLUSIONS

Agrotain clearly reduces ammonia volatilization when conditions exist for volatilization
 Agrotain Plus, Super U, N-Serve, and Instinct* reduce N loss potential in wet conditions
 Nutrisphere-N data suggest not much impact on volatilization or nitrification
 ESN is a slow-release product that reduces N loss potential
 There is NO product that should be recommended on all soils, under all conditions, and provides season-long control of nitrogen losses!

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