Basics of Nitrogen Management

Greg Binford
302-831-2146
binfordg@udel.edu

University of Delaware

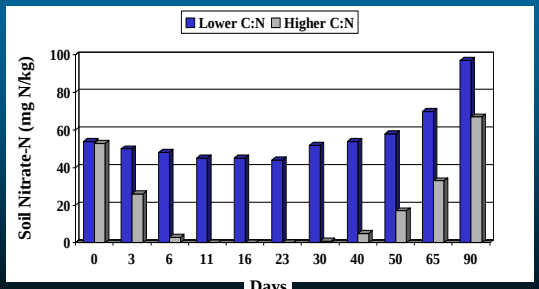
Organic Nitrogen

1) Plant residues, manures, soil OM
2) Plants CANNOT use until mineralizes
3) Mineralization: Biological Process
   Organic N => Ammonium (NH_4^+)
4) Soil Organic Matter: 5% = 3,000 lb N/ac
5) SOM can supply 50 to 150 lb N/ac per year

IMMOBILIZATION

1) This is NOT a net loss of N?
2) This is a TEMPORARY "tie-up" of N
3) Influenced by the C:N ratio of residue
4) Microorganisms break down residue
5) >30:1 = immobilization (N is unavailable)
6) <20:1 = mineralization (N is released)
7) Important when broadcasting N onto residue with high C:N ratio

Effect of C:N Ratio on Immobilization



Blackmer and Green, 1995 (SSSAJ)

Ammonium N (NH_4^+)

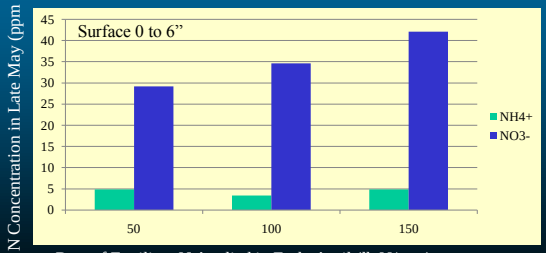
1) Plant available form of N
2) Held in soils on CEC
3) What happens to Ammonium in a soil?
   – Taken up an utilized by the plant
   – MAIN thing is…

NH_4^+

NITRIFICATION

1) Conversion of Ammonium to Nitrate
2) $NH_4^+ + 2O_2 \Rightarrow NO_3^- + H_2O + 2H^+$
3) Biological Process
4) Nitrification is temperature dependent
5) Nitrification insignificant below 50 °F
6) How fast does the conversion occur?

Nitrification of Ammonium Sulfate



UNIVERSITY OF DELAWARE

Nitrate N (NO_3^-)

1) Plant available form of N NO_3^-
2) NOT held in soils on CEC
3) Due to nitrification, NO_3^- most common
   Nitrification: NH_4^+ => NO_3^-
4) Nitrate is lost relatively easily from soils

UNIVERSITY OF DELAWARE

How is Nitrogen Lost?

THREE ways N is lost from soils:

1) LEACHING
2) DENITRIFICATION
3) VOLATILIZATION

UNIVERSITY OF DELAWARE

LEACHING

1) Primary form of N lost this way? NO_3^-
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) Minimize amount of time that N is present in soil without plants growing

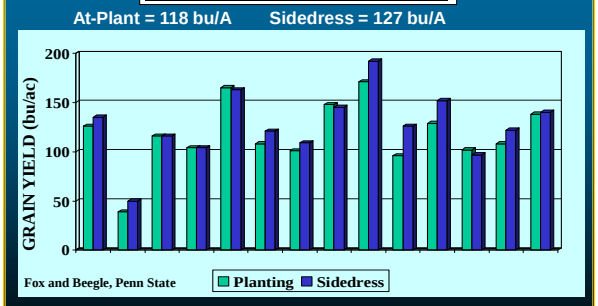
UNIVERSITY OF DELAWARE

DENITRIFICATION

1) Form of N lost this way? NO_3^-
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) Minimize amount of time that N is present in soil without plants growing

UNIVERSITY OF DELAWARE

Time of N Application

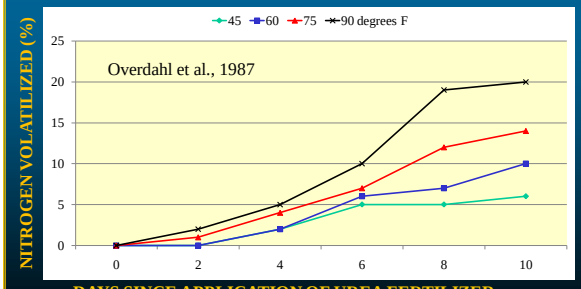


UNIVERSITY OF DELAWARE

VOLATILIZATION

1) Form of N lost this way? NH_4^+
2) Ammonium in high pH environment
3) Soil pH is THE major influence
4) $NH_4^+ <=> NH_3(g) + H^+$
5) Other important factors: CEC, wind, and TEMPERATURE

Ammonia Volatilization



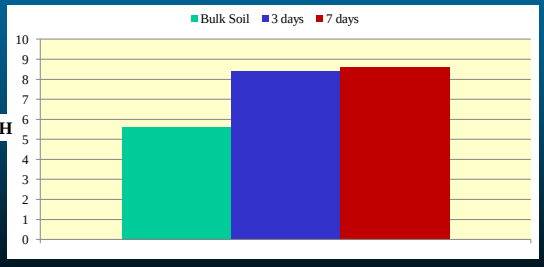
VOLATILIZATION

1) Form of N lost this way? NH_4^+
2) Ammonium in high pH environment
3) Soil pH is THE major influence
4) $NH_4^+ <=> NH_3(g) + H^+$
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

Urea Fertilizer in Soils

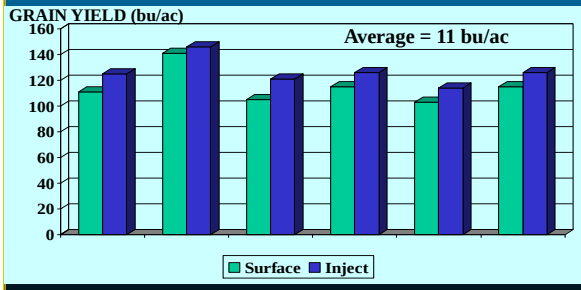
1) Urease is the enzyme that breaks down urea
2) Urea ($NH_2 – CO – NH_2$) => NH_4 Carbonate
3) NH_4^+ in a high pH environment goes to $NH_3(g)$
4) $NH_4^+ <=> NH_3(g) + H^+$
5) Urease inhibitors keep N as urea until in soil
6) If urea gets into the soil (rain or tillage), then there is no need for a urease inhibitor

Urea Prill Microsite pH



Hauck, 1984

Volatilization of Urea



Source: Fox and Beegle, Penn State

NITROGEN TECHNOLOGY

1) Products designed to improve NUE
2) Nitrification Inhibitors
3) Urease Inhibitors
4) Slow Release Products

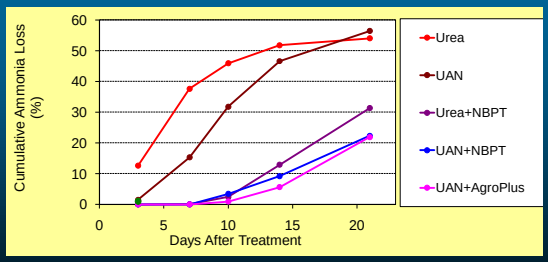
UNIVERSITY OF DELAWARE

NITROGEN TECHNOLOGIES

1) Agrotain: urease inhibitor
2) Agrotain Plus: urease + nitrification inhibitor
3) Super U = urease + nitrification inhibitor
4) Nutrisphere-N = urease + nitrification inhibitor?
5) ESN = polymer-coated urea fertilizer
6) N Serve = nitrification inhibitor
7) Instinct = nitrification inhibitor

UNIVERSITY OF DELAWARE

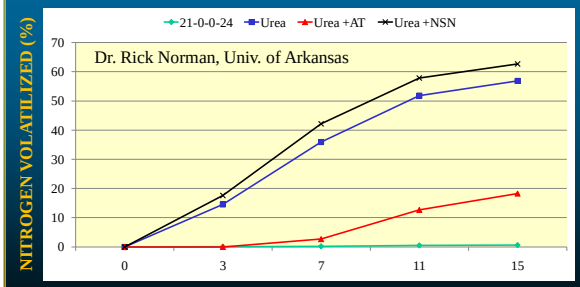
Ammonia Losses: AGROTAIN



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

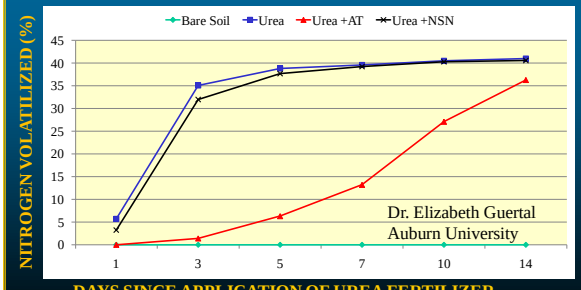
UNIVERSITY OF DELAWARE

Ammonia Volatilization: AT/NSN



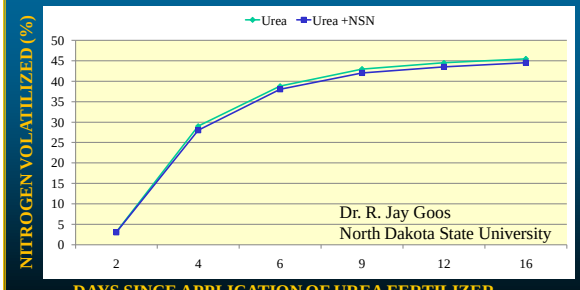
UNIVERSITY OF DELAWARE

Ammonia Volatilization: AT/NSN



UNIVERSITY OF DELAWARE

Ammonia Volatilization: NSN

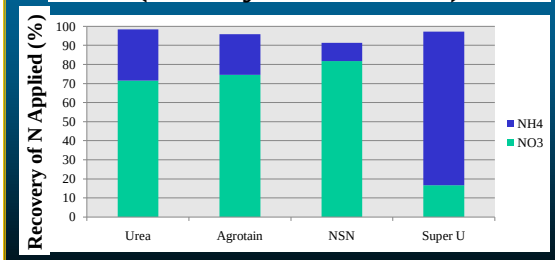


UNIVERSITY OF DELAWARE

Nitrification Inhibitor Technology

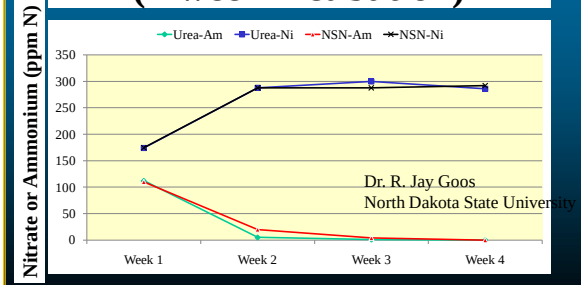
1) Slows conversion of ammonium to nitrate
2) $NH_4^+ + 2O_2 \Rightarrow NO_3^- + H_2O + 2H^+$
3) Reduces N loss potential
4) Some studies have shown a benefit
5) Potential benefit greater in today's fertilizer market
6) Potential value increases with length of time between application and plant demand

Effect on Nitrification (14-day incubation)

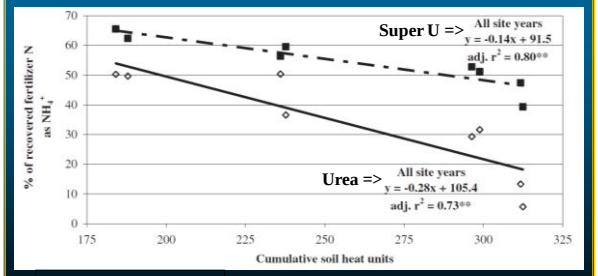


Rick Norman, Univ. of Arkansa

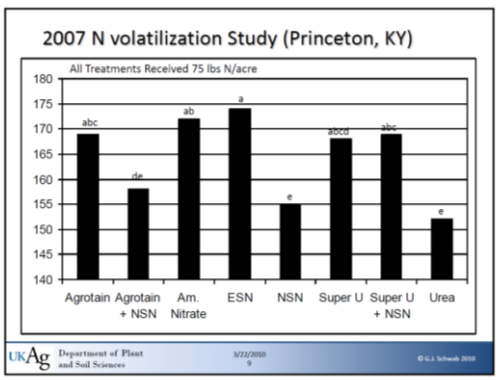
Effect on Nitrification (4-week incubation)

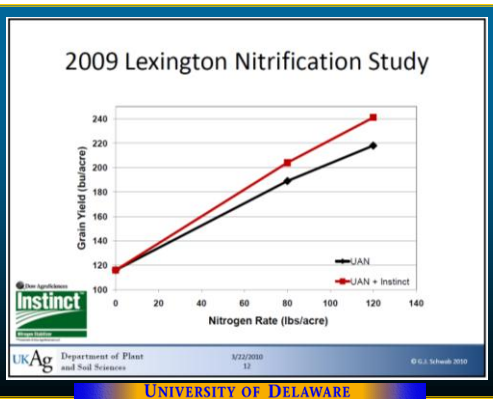


Nitrification with Super U

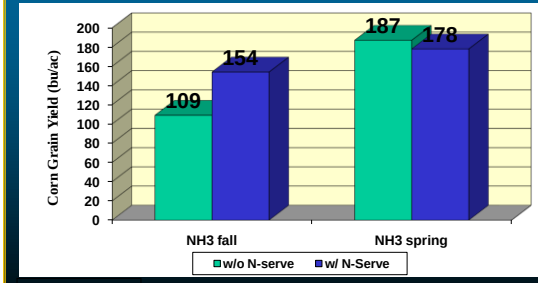


Tiessen et al., 2006 (AJ)





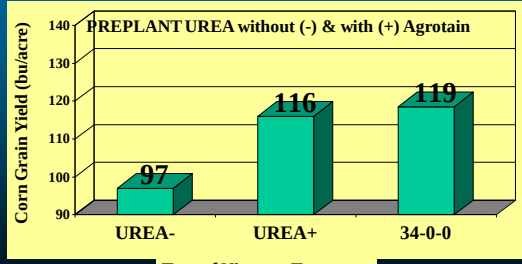
Minnesota: N-Serve 1999



Randall and Vetsch

UNIVERSITY OF DELAWARE

PA Study (Fox & Piekielek, 1993)

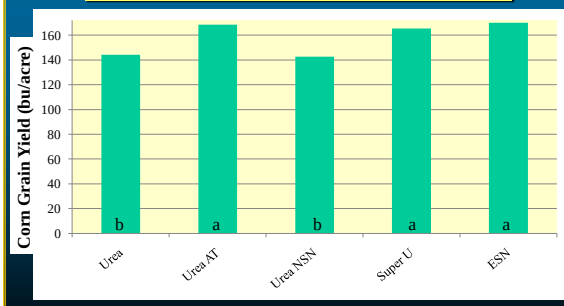


3-year study

Avg. 100 + 150

UNIVERSITY OF DELAWARE

No-Till Corn in 2007: Illinois

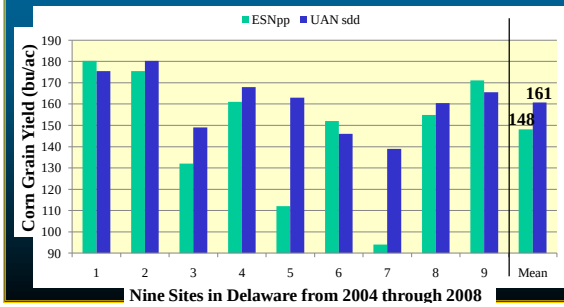


Silt Loam Soil

Steve Ebelhar: University of Illinois

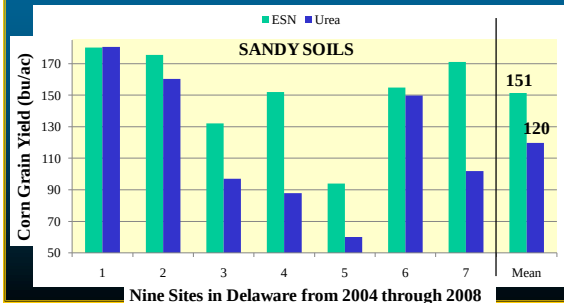
UNIVERSITY OF DELAWARE

ESN preplant vs UAN sidedress



Nine Sites in Delaware from 2004 through 2008

ESN vs Urea BOTH preplant



Nine Sites in Delaware from 2004 through 2008

SUMMARY

1) The N cycle is a dynamic system
2) Understanding = improved management
3) Improved management = ↓ loss potential
4) Improved management = ↑ profitability
5) Products for improving N efficiency
   - Know mechanism (urease/nitrification/slow)
   - Do you need that?
   - Does it really do what's claimed?

UNIVERSITY OF DELAWARE