International Conference on Enhanced-Efficiency Fertilizers

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AGRONOMIC EFFECTIVENESS OF ENHANCED EFFICIENCY FERTILIZERS

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Agronomic effectiveness of enhanced efficiency fertilizers

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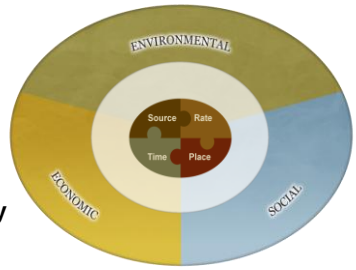
Presentation outline

- **Enhanced efficiency (EE) fertilizer *versus* enhanced efficiency fertilization**
- **EE fertilizer definition and brief history**
- **General classes and characteristics of common EE (N) fertilizers**
  - **coated**
  - **slowly soluble**
  - **stabilized**
- **Conclusions**

Enhanced efficiency fertilization
…consider 4R nutrient stewardship



- Right rate
  - Appropriate yield goal
  - Soil testing and recommendations
  - Nutrient removal and budgets
  - Nutrient interactions and balanced fertility
- Right place
  - Band, broadcast, fertigation, foliar, etc.
- Right time (improving synchrony between supply and demand)
  - Split applications
  - Enhanced efficiency fertilizers
- Right source
  - Balanced fertility (N, P, K, etc.)
  - Nutrient form (urea, UAN, etc.)
  - Enhanced efficiency technologies

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Enhanced efficiency fertilizers

- Enhanced Efficiency is a term describing fertilizer products with characteristics that allow increased plant uptake and reduce the potential of nutrient losses to the environment such as gaseous losses, leaching, or runoff, as compared to an appropriate reference product (AAPFCO, T-70)
- Traditionally used in specialty applications (e.g., turf, ornamentals, etc.), but have been gaining in use and popularity in production agriculture
- Most EE technologies are applied to N, but some exist and are being developed for other nutrients

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History of slow-release N

Year	%N	Product
1924	12-40	Urea-formaldehyde (European patent)
1955	12-40	Urea-formaldehyde (commercial use in USA)
1961	32-38	Sulfur-coated urea (TVA)
1960's	32-34	Crotonylidene diurea (32-0-0)
1960's	31	Isobutylidene diurea (31-0-0; IBDU)
1967	9-19	Osmocote®
1985	14-22	Nutricote®, Meister®, Prokote®, Escote®
1990	37-44	Polyon®
1990	10-42	Multicote®
1990's	44	VCote®, TR2®, ESN®, Duration®

Adapted from Dr. James Robbins, University of Arkansas, 2005

Enhanced efficiency N

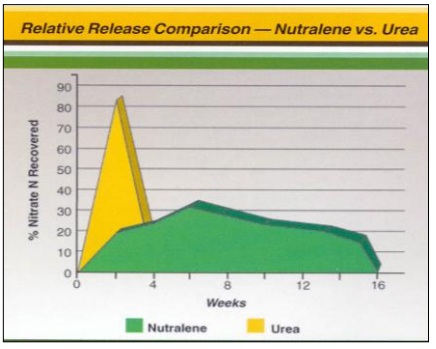
- **Uncoated slowly available fertilizers containing N**
  - **e.g., urea-aldehyde condensation products (e.g., urea-formaldehyde reaction products, IBDU), triazines, etc.**
- **Physical coating or barrier around soluble N fertilizer**
  - **e.g., SCU, PCU, combination products**
- **Stabilized materials**
  - **e.g., nitrification and urease inhibitors**

Uncoated slowly available

Methylene Ureas
(urea- formaldehyde reaction products)

Factors Affecting N Release Rate (biological degradation, microbial)

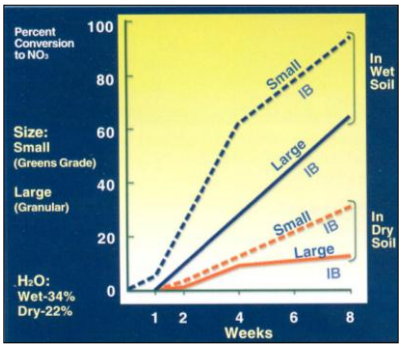
- Temperature
- Soil pH
- Soil Moisture



IBDU
(isobutylidene diurea)

Factors Affecting N Release Rate (chemical degradation, hydrolysis)

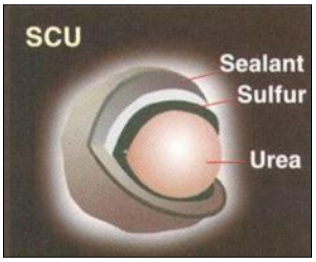
- Particle size
- Soil moisture
- Soil pH
- (Temperature)



Coated materials

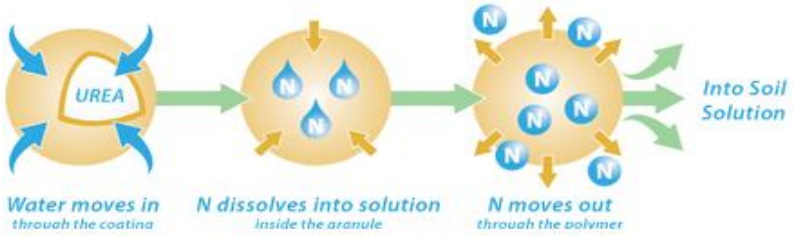
Sulfur Coated Urea

- **Mechanisms of N Release**
  - **pin holes, cracks**
  - **Microbial degradation**
  - **Is the result of the average behavior of many particles**



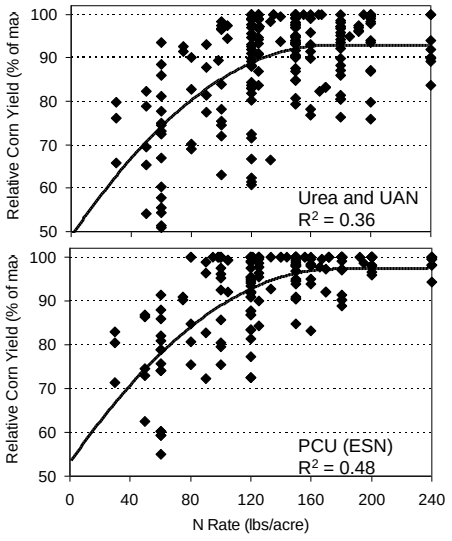
- **Factors affecting N release**
  - **Coating thickness and uniformity**
    - ~ **effective coating thickness is equal to thinnest area of coating**
  - **Temperature**
  - **Moisture**

Polymer coated urea



- **N release controlled by diffusion**
- **Major factors affecting release**
  - **coating thickness**
  - **temperature**
  - **moisture**

Relative yield versus rate of N applied from PCU and urea/UAN



Relative yield plateau occurred at 93% of maximum

Relative yield plateau occurred at 98% of maximum

Compilation of data from source-rate studies and trials in the US Corn Belt, 2000-2004
Blaylock and Tindall. 2006.

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Stabilized materials

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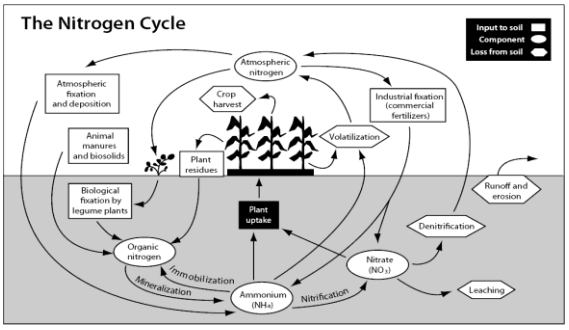
Nitrification…a natural process in soils



$$NH_4^+ \underset{+H^+}{\overset{-H^+}{\rightleftharpoons}} NH_3 \xrightarrow{Nitrosomonas} NO_2^- \xrightarrow{Nitrobacter} NO_3^-$$

- Nitrification inhibitors interfere with activity of *Nitrosomonas* bacteria, slowing the nitrification process
- This leaves more N in ammoniacal form, thus reducing the chance of leaching and denitrification

Urea hydrolysis

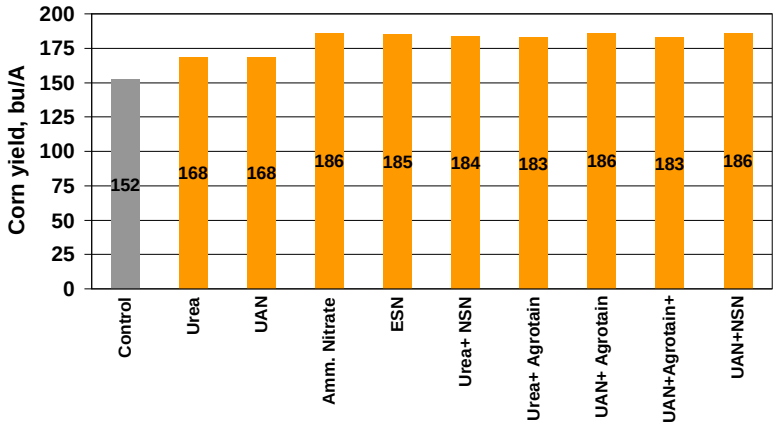
$$CO(NH_2)_2 + H^+ + H_2O \xrightarrow{urease} 2NH_4^+ + HCO_3^-$$

$$NH_4^+ \longrightarrow NH_3 \uparrow + H^+$$

- Urease inhibitors interfere with the process of urea hydrolysis
- The slowing of conversion of urea to ammoniacal N can significantly reduce the potential for NH_3 volatilization

Effect of N source on irrigated no-till corn yield

Kansas, Crete silt loam



Gordon. KSU Fertilizer Report. 2010.
3-year average

N applied broadcast preplant
Average across 3 rates (80, 160, 240 lb/A)

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Conclusions

Enhanced efficiency fertilizer best suited for

- **Traditional applications**
  - **Turf, ornamentals, nurseries, etc.**
- **Production agriculture**
  - **High value crops**
  - **In crops with shallow root systems**
  - **Where there is high potential for nutrient loss or fixation**
- **Environmentally sensitive circumstances**

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Conclusions

- **Potential benefits of EE fertilizers include**
  - **match the kinetics of nutrient release with the kinetics of plant growth (from Robbins, 2005)**
  - **improved yields**
  - **more applied nutrient used by plant**
  - **reduction in nutrient loss (leaching, atmospheric, soil reactions, etc.)**
  - **reduced application frequency**
  - **more uniform plant growth**
- **Familiarity with mechanisms of EE function is necessary for informed decisions**
- **"Everything's on the table" in today's marketplace**