Enhanced Efficiency Fertilizers

M. M. Alley
Dept. of Crop & Soil Environmental Sciences
Virginia Tech
Blacksburg, VA

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Enhanced Efficiency Fertilizers

- Controlled release, slow release, and/or "stabilized" fertilizers
- Delays the nutrient availability for plant uptake for some period of time after application
- The nutrient is available to the plant significantly longer than a reference "rapidly available nutrient fertilizer" such as ammonium nitrate, urea, or ammonium phosphate or potassium chloride (AAPFCO*, 1995)

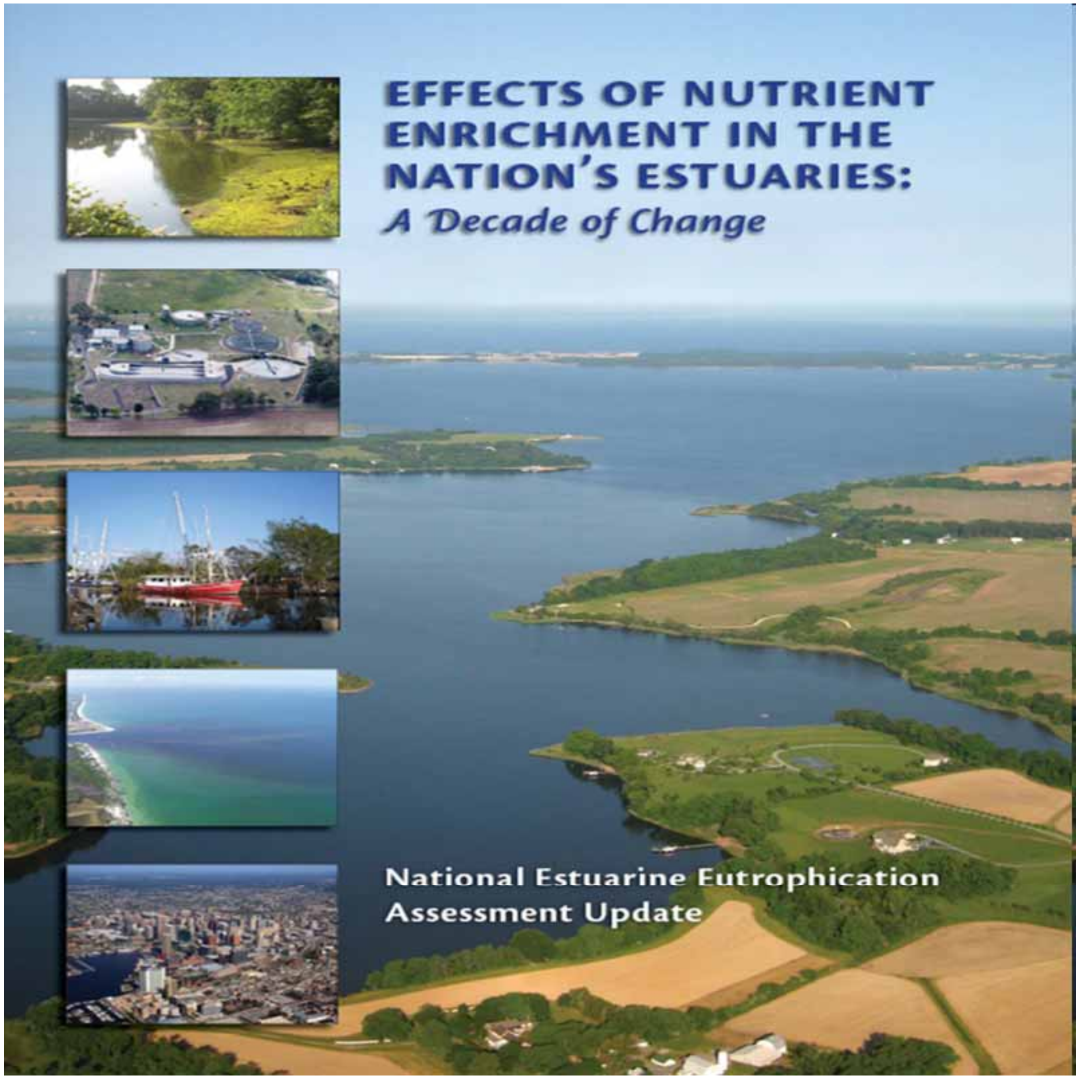
Need for Enhanced Efficiency Fertilizers?

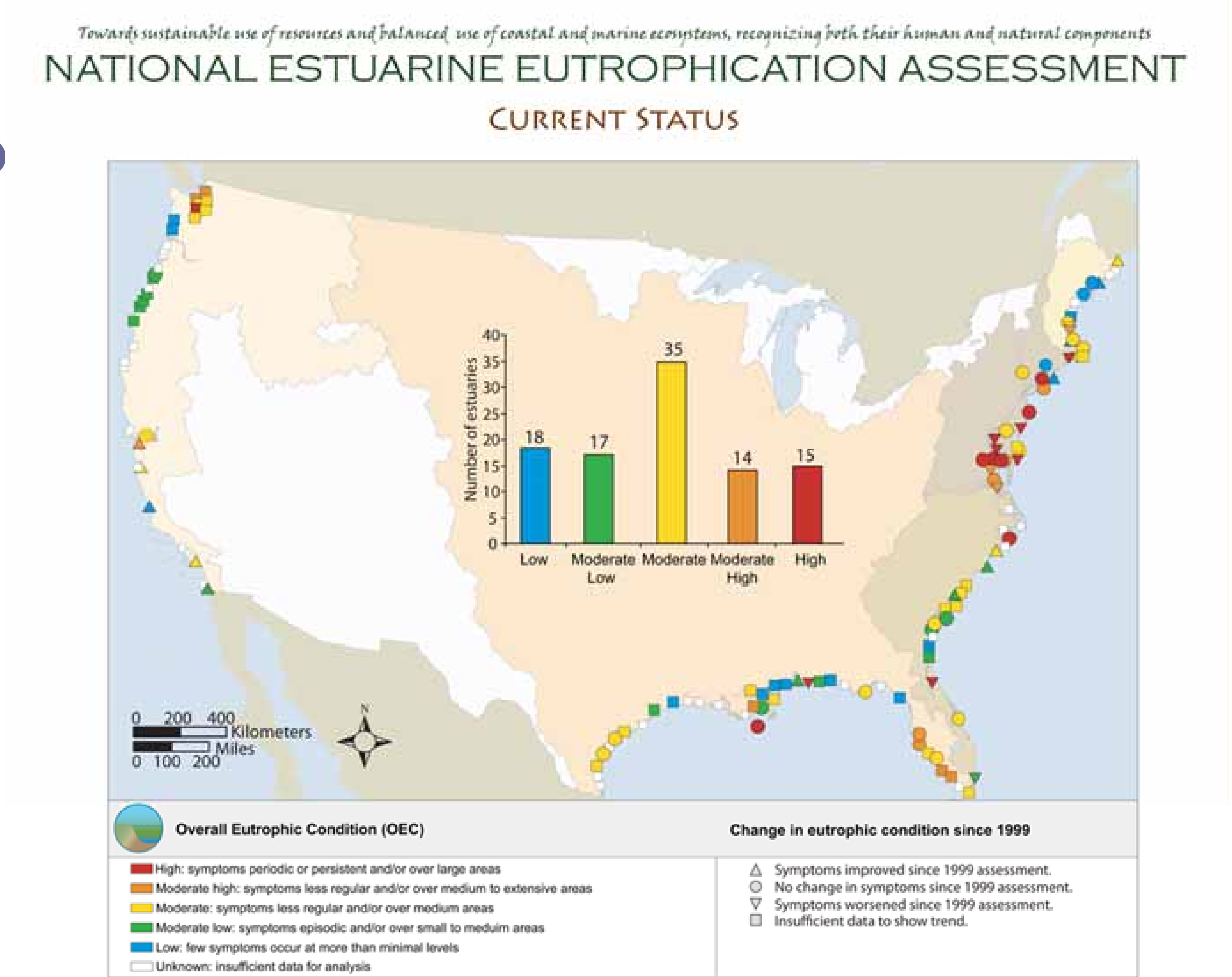
- Fertilizer Use Efficiency
  - Definition
    - Lbs of nutrient in harvested yield per lb of applied fertilizer
    - Lbs of nutrient in total crop biomass per lb of applied fertilizer
    - Lbs of nutrient in crop biomass plus that retained in the soil with potential for future crop use

Need for Enhanced Efficiency Fertilizers?

- Fertilizer Use Efficiency
  - Varies depending soils, climatic conditions, fertilizer source, crop and application method
  - N – 30-60%
  - P – low recovery in year, but long-term residual effects, 20-80%
  - K - 20-80%, immediate and residual effects

Need for Enhanced Efficiency Fertilizers?





http://www.noaanews.noaa.gov/stories2007/s2898.htm (accessed 6 Nov 2008)

Enhanced Efficiency Fertilizers – Information Sources

- Controlled-release and Stabilized Fertilizers in Agriculture, 1997. Martin E. Trenkel, IFA, Paris
- International Workshop on Enhanced-efficiency Fertilizers, 2005. IFA, Paris
- Journal of Controlled Release. Elsevier. “original research involving the controlled release and delivery of drugs and other biologically active agents”

Vast majority of Enhanced Efficiency Fertilizers Are Focused on Nitrogen

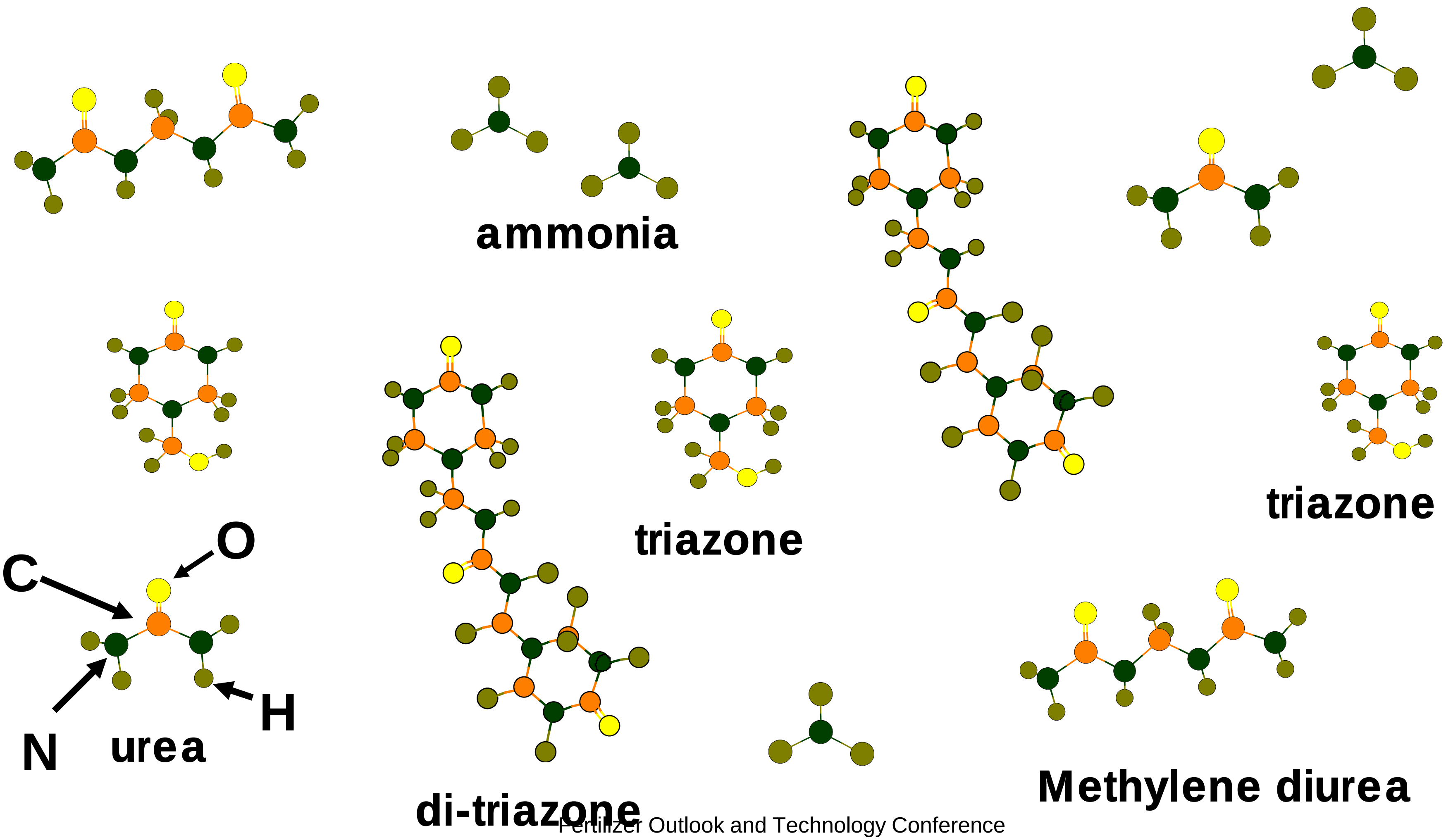
Enhanced Efficiency Fertilizer Technologies

- Controlled Release
  - Reduced solubility
    - Urea formaldehyde or urea forms
    - Methylene ureas
    - Isobutylidene diurea (IBDU)
  - Coatings
    - Sulfur
    - Polymer
    - Resins

Low-Solubility Compounds (UF, MU)

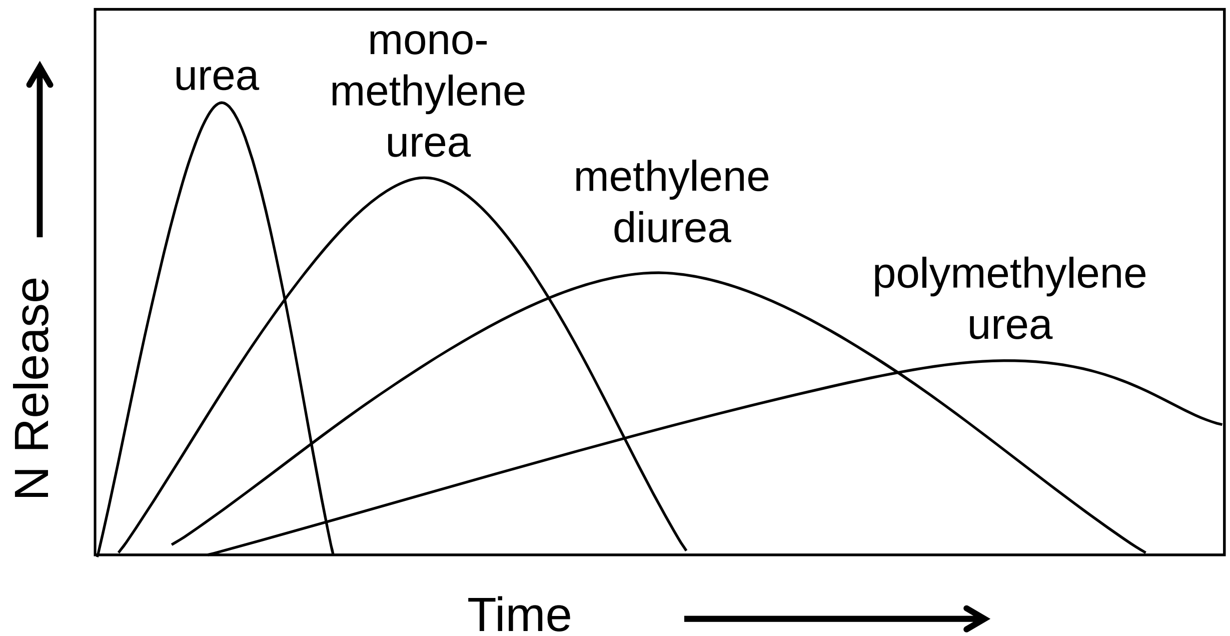
- Urea-formaldehyde reaction products
  - Discovered in 1930s
  - First fertilizer use in 1940s
  - Mixture of urea and UF polymers of various chain lengths
  - Solid and liquid products
    - Solubility dependent on chain length
- Products: Nutralene, Nitroform, Nitamin, CoRoN

Structural Compositions



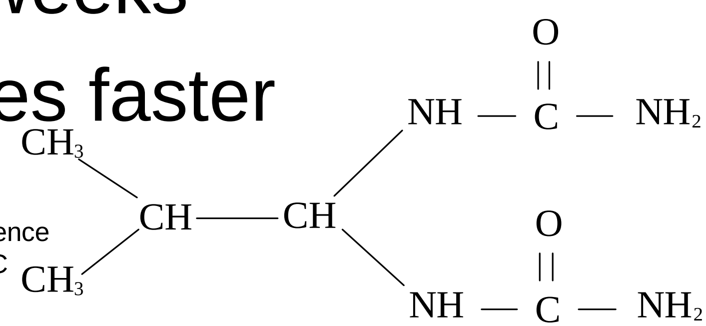
Low-Solubility Compounds (UF, MU)

- N release by microbial mineralization (soil temperature, moisture, pH, etc)
- Longer, complex chains = slower release



Low-Solubility Compounds (IBDU)

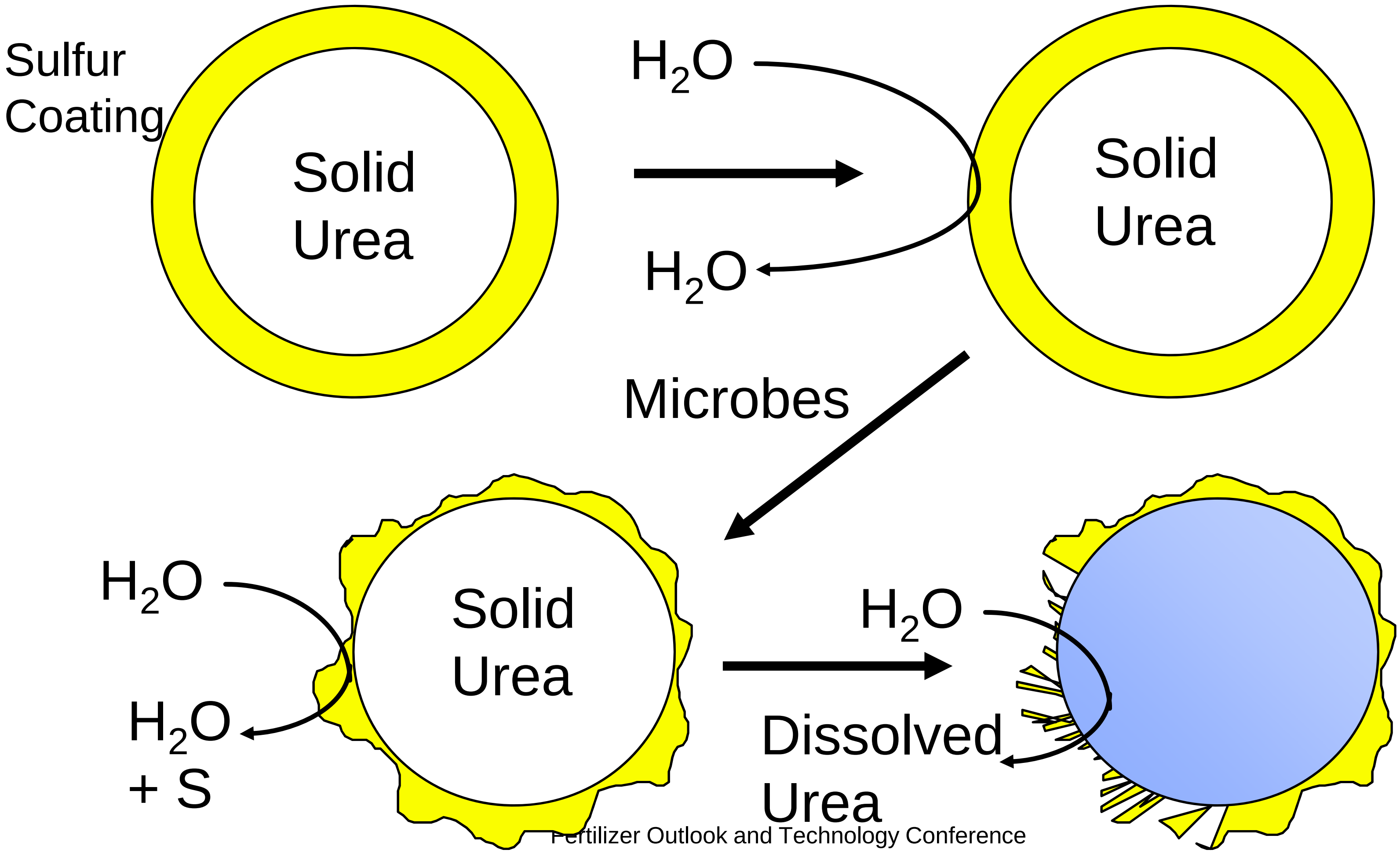
- Isobutylidene diurea – IBDU (Solid)
- No free urea
- Release by slow dissolution and hydrolysis
  - IBDU reacts with water to release urea
  - Typical release 8-12 weeks
  - Finer material dissolves faster



Coated Water Soluble Fertilizers

- Sulfur coated urea
  - N availability from urea depends on the destruction of the sulfur coating and dissolving of the urea.

Decomposition of Sulfur Coating



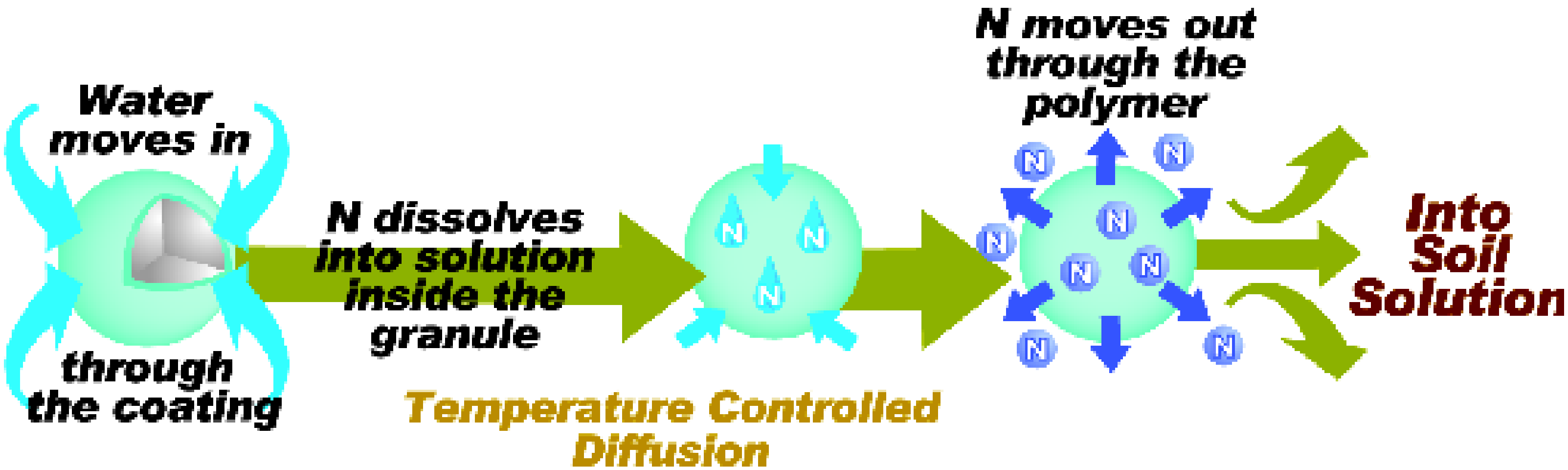
Coated Water Soluble Fertilizers

- Sulfur coated urea
  - N availability from urea depends on the destruction of the sulfur coating and dissolving of the urea.
    - Biological oxidation
    - Physical breakage
  - Release rate
    - Thickness of coating
    - Environmental conditions
    - Slow compared to water soluble fertilizer

Coated Water-Soluble Fertilizers – <u>Polymer-Coated Fertilizers</u>

- Polymer coatings applied to soluble fertilizer
- Release by diffusion through coating
- Release rate determined by
  - Polymer chemistry, thickness, coating process
  - Temperature
- Release can be highly controlled with the polymer
- Osmocote in 1967
- Products: Trikote, Polyon, Duration, ESN

Polymer-Coated N Mechanism



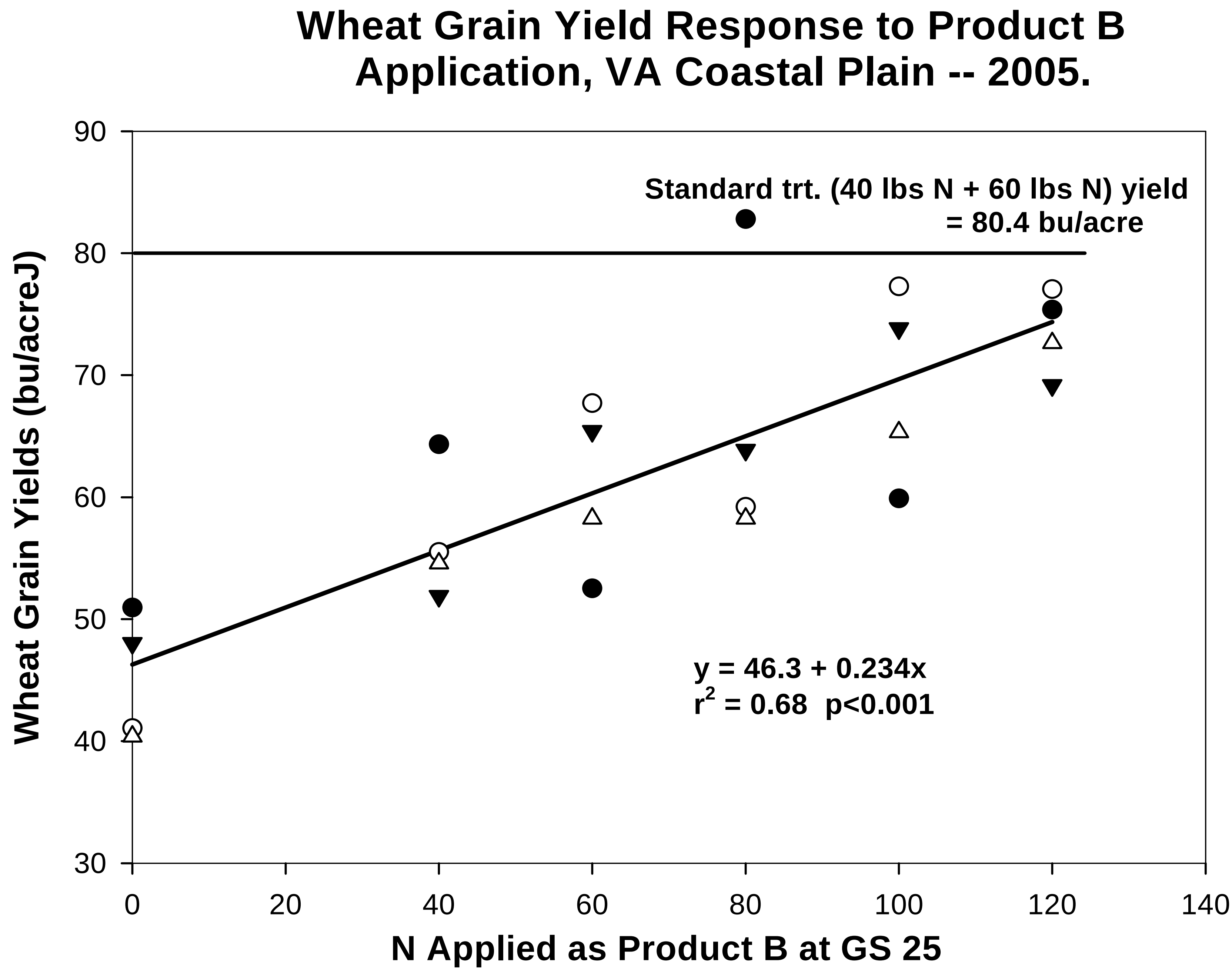
Moisture is required!

Crop Performance in Terms of Yield and Quality

Corn Grain Yield Response to At-Planting Applications of Product A (urea forms)

N Source	N Rate (lbs/ac)	Site 1 Yield (bu/ac)	Site 2 Yield (bu/ac)
Product A	0	76 d*	129 c
Product A	50	126 c	161 b
Product A	100	150 c	184 ab
Product A	150	180 b	189 ab
Product A	200	207a	184 ab
UAN (30%)	40+160	209 a	201 a

*Values followed by different letters differ significantly at the 5% (site 1) and 10% (site 2) levels of probability. Site 1 irrigated.


Wheat Grain Yield Response to Product B Application, VA Coastal Plain -- 2005.
Standard trt. (40 lbs N + 60 lbs N) yield
= 80.4 bu/acre
y = 46.3 + 0.234x
r2 = 0.68 p<0.001
Wheat Grain Yields (bu/acreJ)
N Applied as Product B at GS 25
30
40
50
60
70
80
90
0
20
40
60
80
100
120
140

Product A & B Performance

- Product A – urea forms with mixtures of molecules including urea and single chain and ring structures from urea formaldehyde
- Product B – urea forms mixture and physical coating
- Performance based on environmental conditions and placement
  - Temperature and moisture
  - No-tillage

Stabilized Fertilizers

- Nitrification Inhibitors
  - Nitrapryin (N Serve)
    - Used with anhydrous ammonia (volatile)
  - Dicyandiamide (DCD/Guardian)
    - Formulations for use with granular and liquids
  - Dimethylpyrazole phosphate (DMPP or ENTEC)
- Urease Inhibitor
  - NBPT (Agrotain)
    - Formulations for use with granular and liquids
- **MEHCANISMS HAVE BEEN PUBLISHED IN SCIENTIFIC LITERATURE**

Product Performance Mechanism(s)

N Serve® - Nitrification Inhibitor, volatile

- **Higher CEC soils, greater potential to hold N as ammonium**
- **Specific for soil bacteria converting ammonium to nitrate, will be affected by temperatures and moisture**
- **Can not use with surface applications**

Products without published mechanism(s) for performance

- Claims
  - Eliminates fixation of fertilizer by soil
  - Fertilize the plant not the soil\
  - Lasts for entire growing season
  - Average yield increases of 10-15% consistently
  - Protects nutrients from soil loss
  - Increase plant root function
  - Improves nutrient availability by 25%
  - “You can reduce your fertilizer cost without reducing yield”

Corn Grain Yield Response to Product C in Starter Fertilizer, VA 2008

	Rep 1	Rep 2	Rep 3	Rep 4	Average
Treatment	--------------Yield (bu/acre)-----------------				
Check	171	173	177	173	173.5
Product C	170	171	173	174	172.0

*No statistical difference at 10% level of probability.

- **Lack of a valid published mechanism**
  - **-prevents interpretation of why the lack of performance;**
  - **-should product have been used in this situation?**

Plant Growth and Plant Nutrition are Complex!

"Providing adequate plant nutrients to growing crops is not rocket science, it is a lot more complex!"

– Dr. Jerry Hatfield, National Soil Tilth Lab, USDA-Ames Iowa.

University Perspective on Development of Fertilizers

- **Publish the basis for the fertilizer material or additive!**
  - How does it work?
  - Environmental effects on fertilizer or additive.
    - Temperature
    - Moisture
    - Microbial or non-microbial
    - Other factors??

University Perspective on Development of Fertilizers

- Enlist cooperators in areas that are likely to benefit from the new fertilizer or additive
  - Everyone would like to recommend the “silver bullet” for a nutritional problem or to increase efficiency.
  - Availability of cooperators and financing can be a challenge.

University Perspective on Development of Fertilizers

- Realize that we are dealing with complex biological and environmental conditions
  - No material is going to provide benefits in every situation!
  - Establish the conditions for maximum performance!
  - Identify situations when performance is unlikely to occur!
- Develop these boundaries prior to large scale marketing!


Innovative Products, Established Modes of Action, Identified Situations for Successful Performance and Cooperation Are Essential for Success!