The Importance of Nitrogen Additives, N timing and …. What Happened in 2010

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Topics

- Background
  - Pathways of N loss
  - Conditions for N loss
  - Review of N cycle
- Nitrogen Products
  - Properties and how they work
  - Instinct, Agrotain/Super U, NSN, ESN
- Crop response data
  - Dryland and irrigated conditions with a focus on 2010
- Comments on handling and application methods for ESN

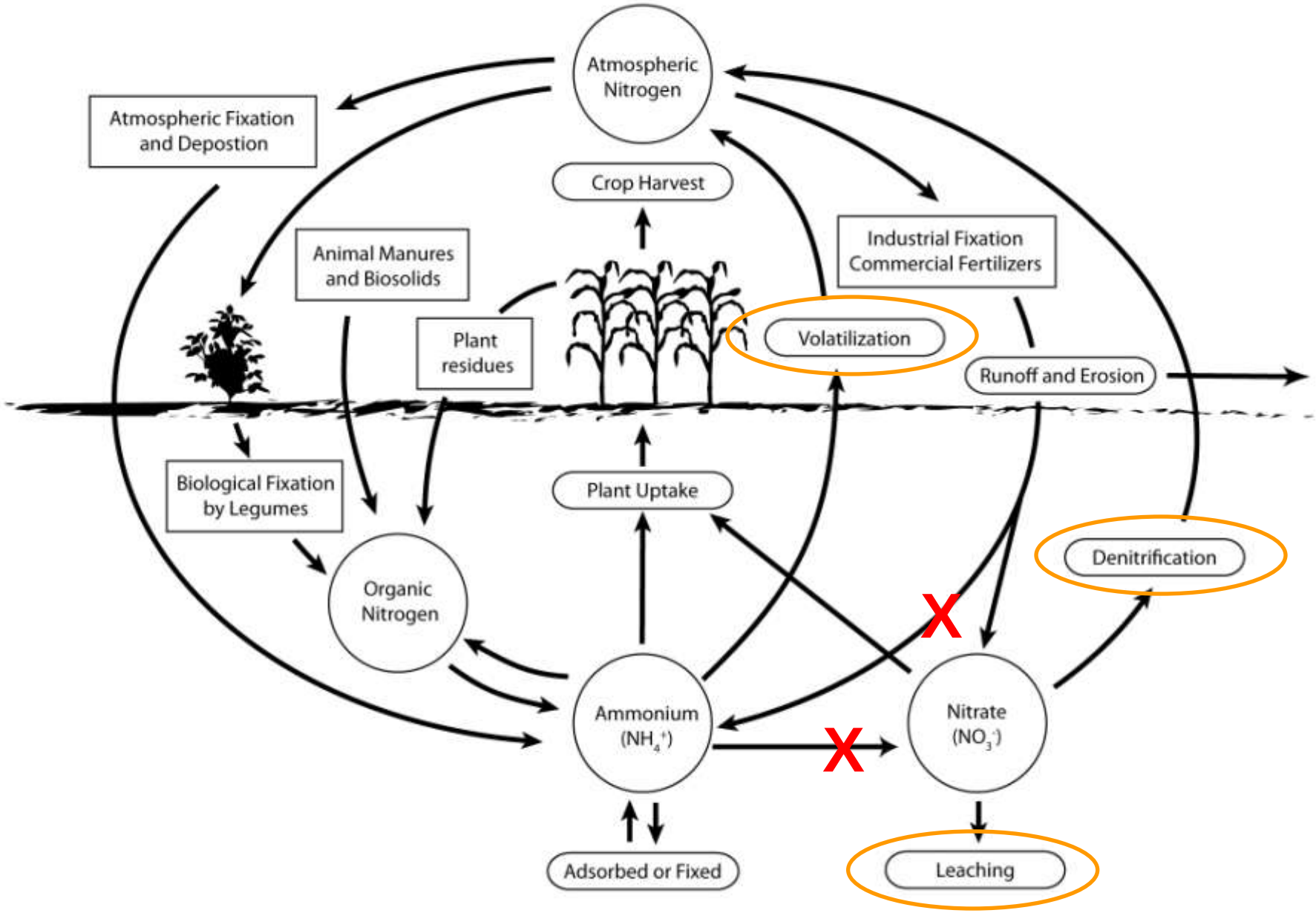
Background

- Numerous products have been developed recently with claims of enhancing fertilizer use efficiency
- Modes of action and effectiveness vary with the product
- Most are nitrogen products, some are phosphorus products
- All will be more expensive than the conventional product
- Benefits, if any, will depend on a number of factors

Factors to Consider

- What is the potential for nutrient loss (N) in your production system?
- What is the cost of the product vs. effects on yield?
- Application method – is there a cost savings?
- Are research results from independent entities available? (do not rely on testimonials)
- What is the mode of action? (relate to N cycle)

The Nitrogen Cycle



Urea Decomposition

$$(NH_2)_2CO + H_2O \xrightarrow[urease]{} 2NH_{3(gas)} + CO_{2(gas)}$$

urea + water → ammonia + carbon dioxide

$$NH_{3(gas)} + H_2O \rightarrow NH_4^+ + OH^-$$

ammonia + water → ammonium + hydroxide

- Ammonia loss can occur though volatilization
- Surface applications and high soil pH promote losses
- If urea is incorporated, ammonia losses are minimal
- Urea can be lost by leaching prior to ammonium conversion

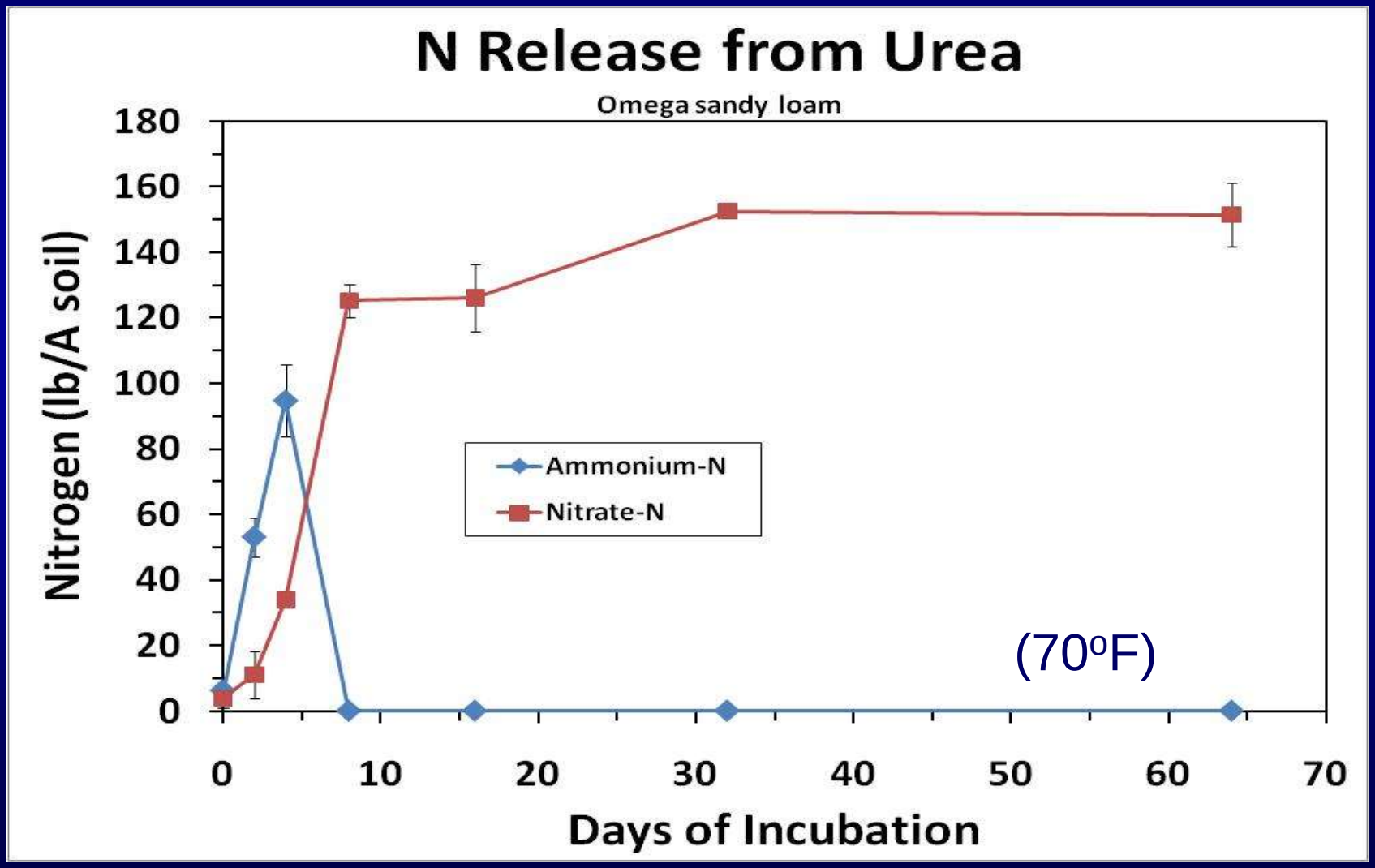
Ammonium Transformation - Nitrification

$$NH_4^+ + O_2 \xrightarrow{\textit{Nitrosomonas}} NO_2^- \xrightarrow{\textit{Nitrobacter}} NO_3^-$$

ammonium + oxygen → nitrite → nitrate

- Ammonium is relatively immobile in soil
- Nitrate losses can occur through:
  - leaching
    - sandy or tiled soils
  - dentrification (conversion to N_2O or N_2)
    - saturated soils
  - fall applied N (subject to leaching and denitrification)

Incubation Study
150 lb N/A Added as Urea



Possible Modes of Action to Improve Use Efficiency

- Stabilized nitrogen
  - Slow down conversion of urea to ammonium (urease inhibitor)
  - Slow down conversion of ammonium to nitrate (nitrification inhibitor)
- Slow release nitrogen
  - Formation of long chain N compounds
    - Methylated urea (generally expensive to produce)
- Controlled release nitrogen
  - Physical or chemical barrier to slow down solubility
    - Polymer coating around fertilizer prill (usually urea)
    - Sulfur coating around prill

Nitrogen Products

- urea/UAN based -

- Instinct
- Agrotain/SuperU/Agrotain Plus
- Nutrisphere Nitrogen (NSN)
- Polymer coated urea
  - Environmentally Smart Nitrogen (ESN)

Instinct

- Instinct is manufactured by Dow AgroSciences and register for corn
- Nitrapyrin or 2-chloro-6-(tirchloromethyl) pyrine – same compound as N-Serve except formulated for UAN
- Mode of action – Nitrification inhibitor

Agrotain

- Agrotain is the company name and trade name for NBPT, or N-(n-butyl) thiophosphoric triamide
- Mode of action - Urease inhibitor
- Slows down conversion of urea to ammonia
- Reduces ammonia volatilization
- Benefits reported with surface application of urea or UAN (No-till)

NT Corn-Corn Responses with Agrotain (180 lb N/A; 4 yr average)

N Source	Application method	Site 1	Site 2
		bu/A	
Urea	broadcast	106d	98d
Urea + Agrotain	broadcast	134c	112ab
Ammonium nitrate	broadcast	151b	118ab
UAN	broadcast	123c	103cd
UAN + Agrotain	broadcast	128c	107bcd
UAN	injected	172a	123a
Check	----	34e	62e

Means followed by the same letter are not significantly different at p=0.05; Data adapted from Varsa et al.

http://www.cropsci.illinois.edu/research/rdc/dixonsprings/proj_reports/eval_nitro_practices.cfm

Urea+A = UAN+A = UAN broadcast > Urea broadcast

UAN injected > AN broadcast > UAN broadcast > Urea broadcast

Super U and Agrotain Plus

- Manufactured by Agrotain
  - Super U formulated for urea
  - Agrotain Plus formulated for UAN
- Mode of action - urease inhibitor & nitrification inhibitor
  - NBPT, or N-(n-butyl) thiophosphoric triamide
  - DCD, or dicyandiamide
  - Slows down conversion of urea to ammonium
  - Slows down conversion of ammonium to nitrate
- Reduces ammonia volatilization and nitrate leaching

NSN

- Nutrisphere Nitrogen: 46-0-0
- Specialty Fertilizer Products
- Water soluble polymer coated urea
  - Dicarboxylic copolymers – high CEC (same compound as Avail)
  - Originally developed to improve phosphorus availability
- The co-polymer is biodegradable and water soluble

NSN Polymer Characteristics

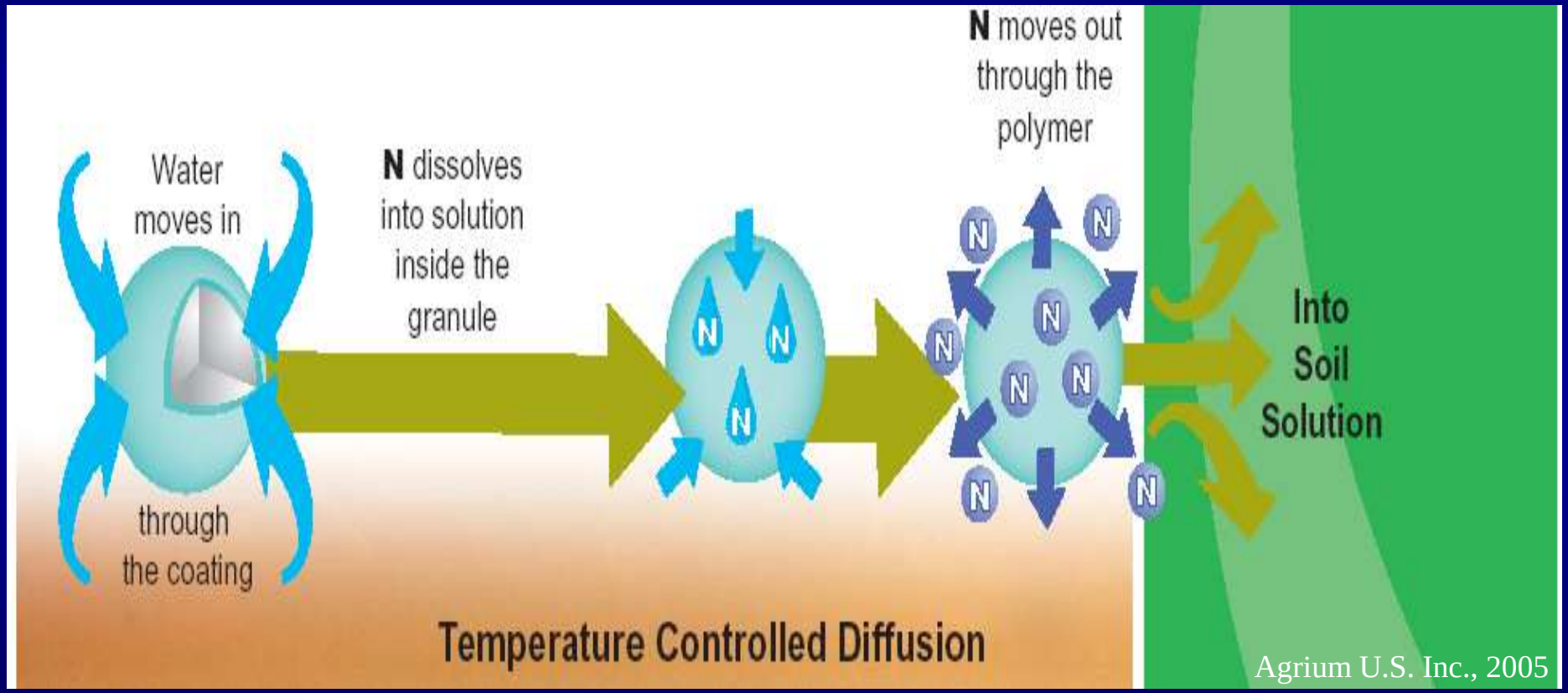
- Compounds have an extremely high exchange capacity – approximately 1.8 eq/100 g
- Polymeric structure is very specific to attracting and adsorbing multivalent cations
- Functionality is not affected by pH, temperature ranges or ionic strength
- Mode of action – urease inhibitor ??

ESN

- Environmentally Smart Nitrogen, 44-0-0

- Manufactured by Agrium Co.
  - Coated urea - mode of action - lowers solubility
  - Release rate depends on soil moisture and temperature

Polymer Coated Technology



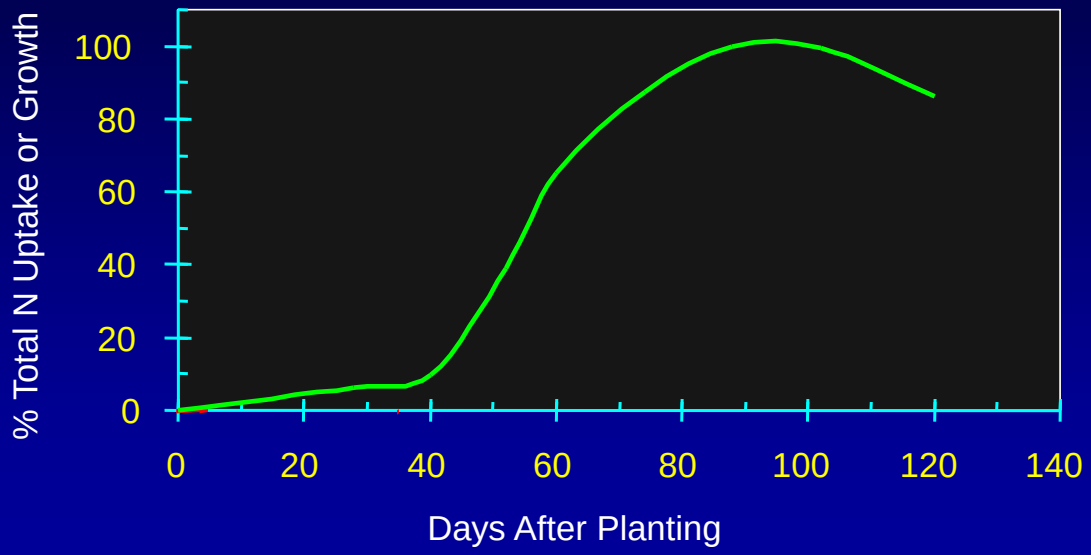
Release rate depends on: coating thickness, temperature, and moisture

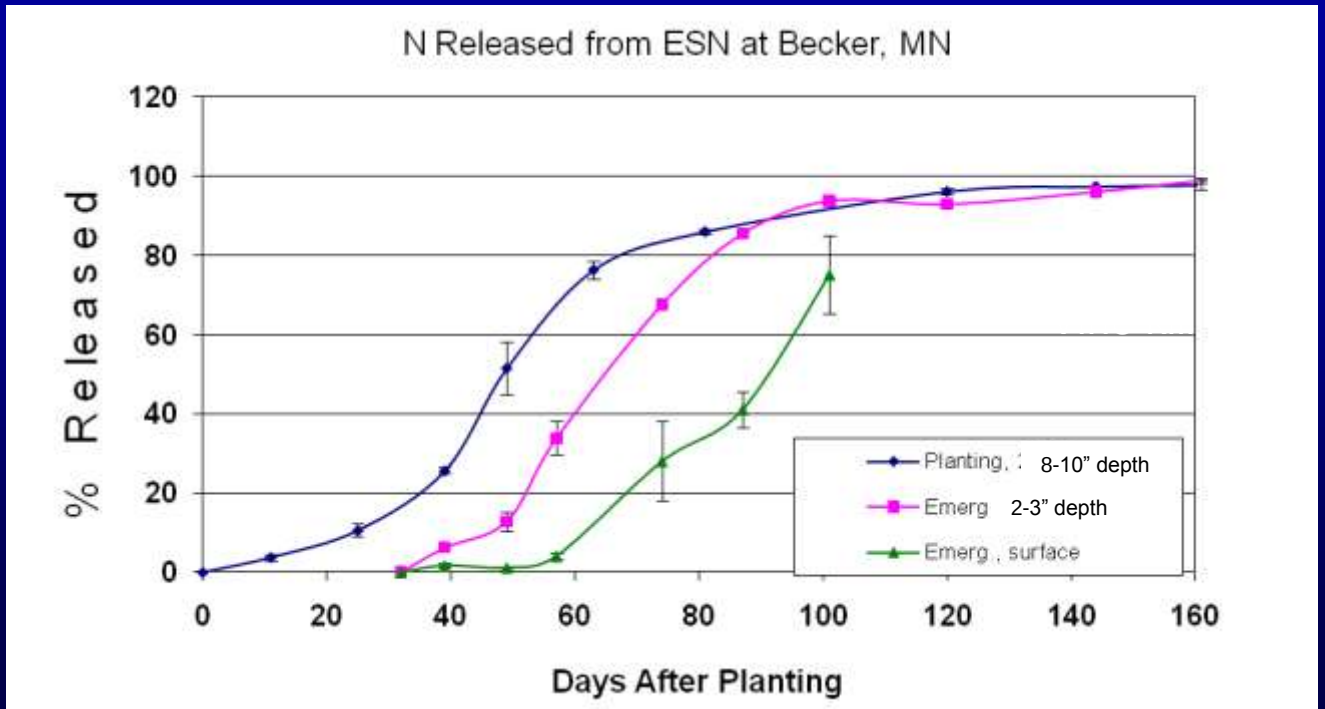
N Release from ESN

- "Mesh Bag" Method -

Visual assessment of ESN granules through the growing season

Nitrogen Uptake and Growth





What Happened in 2010?

Inches of Rainfall at Waseca and Becker, MN in 2009 and 2010

Month	Waseca		Becker	
	2009	2010	2009	2010
April	2.4	1.6	1.2	1.8
May	1.9	3.3	0.8	2.6
June	2.8	9.6	3.4	10.1
July	1.5	6.6	2.1	2.8
August	3.3	2.4	5.1	3.4
September	1.5	12.7	0.4	7.9
October	7.1	1.0	4.1	2.3
November	0.9	2.5	0.3	1.4

Clay loam

Loamy sand

Minnesota Field Trials with Instinct, ESN, NSN, Super U

- Instinct, NSN, & ESN - dryland corn, Waseca
  - Randall and Vetsch, 2008-2010
- ESN & NSN – irrigated corn, Staples
  - Moncrief and Rosen; 2008 & 2009
- ESN & Super U – irrigated corn, Becker
  - Rosen, Lamb, and Venterea; 2009-2010

Instinct on Dryland Corn, Waseca

Randall and Vetsch, 2008-2010

- Webster/Nicolette clay loam
- Corn-soybean (2008 & 2010)
  Corn-corn (2009)
- Instinct Treatments (spring applied preplant & incorporated)
  - UAN @ 80 lb N/A
  - UAN @ 80 lb N/A + Instinct (35 fl oz/A)
  - UAN @ 120 lb N/A
  - UAN @ 120 lb N/A + Instinct (35 fl oz/A)

Instinct Effects on Dryland Corn

2008-2010

N Rate	Inhibitor Rate	2008	2009	2010
lb N/A	fl oz/A	bu/A		
80	0	138	178	173
80	35	141	178	181
120	0	157	196	178
120	35	159	199	191
Instinct effect		NS	NS	**
Rate effect		**	**	**
Interaction		NS	NS	NS

2008 & 9 – dry years; 2010 wet year

2008 & 9: Only N rate significant

2010: N rate and Instinct significant

ESN & NSN on Dryland Corn, Waseca

Randall and Vetsch, 2009-2010

- Webster/Nicolette clay loam
- Corn following soybean
- Treatments
  - Urea fall applied and incorporated @ 100 lb N/A
  - ESN fall applied and incorporated @ 100 lb N/A
  - NSN fall applied and incorporated @ 100 lb N/A
  - Urea spring applied preplant and incorporated @ 100 lb N/A
  - ESN spring applied preplant and incorporated @ 100 lb N/A
  - NSN spring applied preplant and incorporated @ 100 lb N/A
  - Check

ESN and NSN, Waseca

2009 dry; 2010 wet

Source	Timing	Rate lb N/A	2009	2010
			bu/A	
Check	----	0	176d	156b
Urea	Fall	100	233ab	200a
ESN	Fall	100	232abc	199a
NSN	Fall	100	226abc	197a
Urea	Spring	100	223abc	198a
ESN	Spring	100	220bc	203a
NSN	Spring	100	236a	205a

Means followed by the same letter are not significantly different at p=0.10

2009: Spring NSN > Spring NSN

2010: No effect of timing or additives

Irrigated Corn, Staples

Moncrief and Rosen, 2008 and 2009

- Verndale sandy loam
- Corn following corn
- Treatments
  - Urea spring applied preplant @ 160 lb N/A
  - Urea 40% spring applied preplant & 60% sidedress, 6 leaf @ 160 lb N/A
  - ESN spring applied preplant and incorporated @ 160 lb N/A
  - NSN spring applied preplant and incorporated @ 160 lb N/A
  - Check
- Simulated leaching in 2008
  - Extra 2.2” of irrigation water applied at the end of June
  - All plots received leaching rain in 2009 (3.8” 3rd week in June & 3” on July 15)

Staples, 2008

Extra Irrigation

Treatment	Grain Yield bu/A
Check	54c
Urea pp	150b
Urea split	155ab
ESN	175a
NSN	141b

Normal Irrigation

Treatment	Grain Yield bu/A
Check	57c
Urea pp	161b
Urea split	173ab
ESN	188a
NSN	181a

Means within an irrigation treatment followed by the same letter are not significantly different at p=0.10

Extra Irrigation: ESN > NSN = pp Urea

Normal Irrigation: ESN = NSN > pp Urea

Staples, 2009

cold spring & wet June/July

Treatment	Grain Yield bu/A
Check	45c
Urea pp	114b
Urea split	135a
ESN	128ab
NSN	125ab

Means followed by the same letter are not significantly different at p=0.10

Urea split > Urea pp; Urea split = ESN = NSN

Irrigated Corn, Becker

Rosen, Lamb, and Venterea, 2009 & 2010

- Hubbard loamy sand
- Corn following small grain
- Treatments
  - Check
  - Urea split applied at 6-8 leaf, 10-12 leaf at 160 lb N/A
  - Urea preplant at 160 lb N/A
  - ESN preplant at 160 lb N/A
  - Super U preplant at 160 lb N/A

Becker- Irrigated Corn, 2009 & 2010

2009 dry; 2010 wet

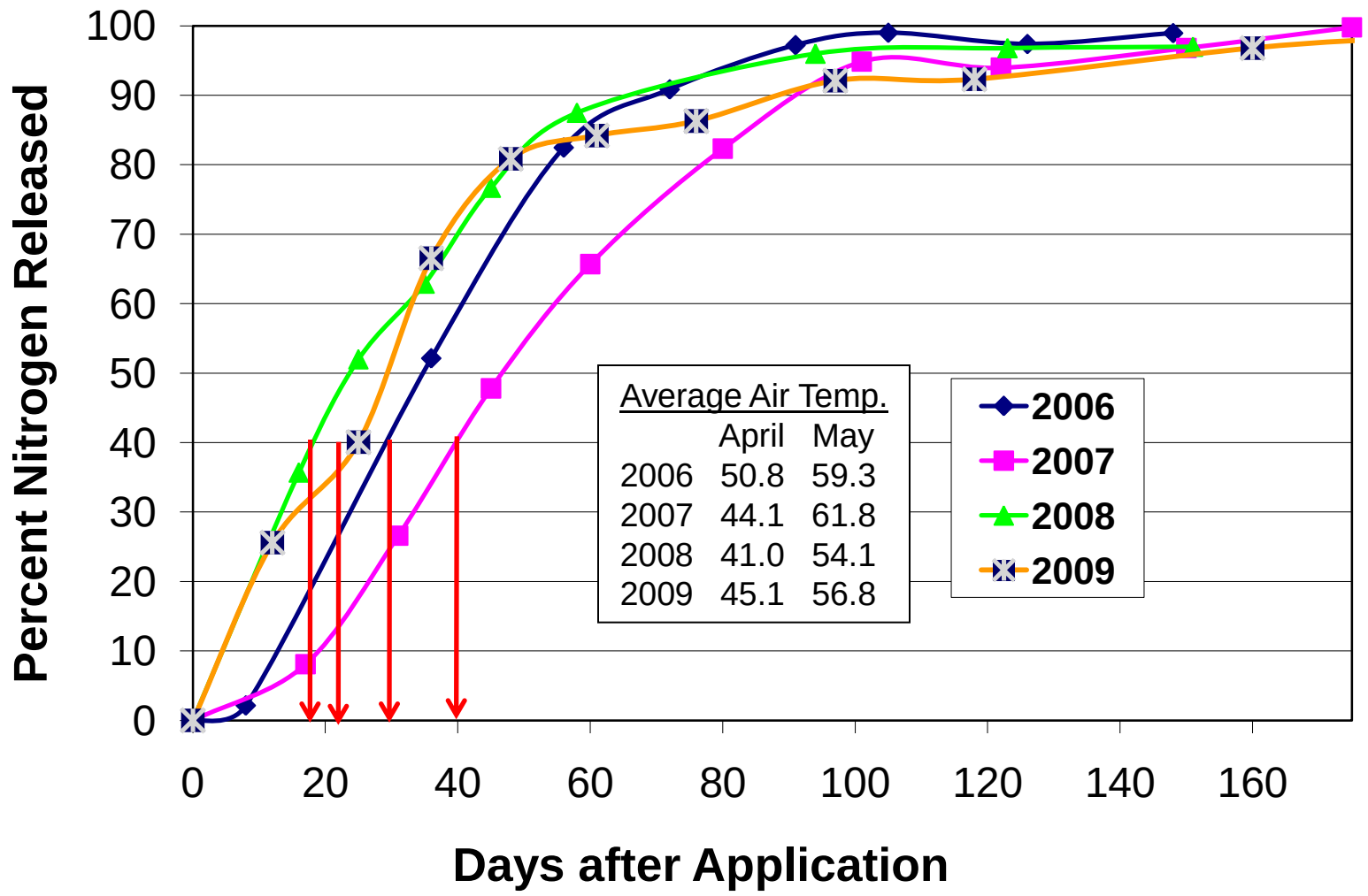
Source	Timing	Rate lb N/A	2009	2010
			bu/A	
Check	----	0	93d	85d
Urea	split	160	218a	197a
Urea	preplant	160	160c	135c
ESN	preplant	160	185b	167b
SuperU	preplant	160	187b	167b

Means followed by the same letter are not significantly different at p=0.10

Split Urea > pp ESN = pp Super U > pp Urea

ESN Handling Issues

2006-7 lab grade; 2008-9 dealer grade



Evaluation of ESN Prill Damage

- 24 hour test
- Weigh 3-4 grams in beaker
- Add 400 mL water
- Screen out prills after 24 hours
- Dry and then weigh
- Weight loss due to leaky prills

ESN Damage Lab vs. Dealer Grade (24 hr test)

Sample	% released
2006 (lab)	0.9
2007 (lab)	1.3
2008 (dealer)	11.3
2009 (dealer)	6.7

Evaluation of ESN Damage during Handling

ESN Damage Increases with Handling

Stage of Handling	% N released
ESN in Truck from Dealer	6.9
ESN in Spreader Hopper	9.5
ESN from Boom Deflector	28.8

What About a Spinner Spreader?

ESN Damage is Less with a Spinner Spreader

Stage of Handling	% N Released
ESN from Bin	6.9
ESN after Spreading with Spinner, 150 lb/A rate	17.4
ESN after Spreading with Spinner, 400 lb/A rate	16.9
ESN from Air Boom Deflector	28.8

Summary & Key Points

- Newer products have been developed to help improve fertilizer use efficiency
  - Insurance
  - Convenience
- They come at a cost
- Understanding how the product works will help to determine situations where a benefit may be obtained
- Polymer-coated urea products such as ESN can be damaged with rough handling especially with air boom spreaders

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Summary & Key Points

- These products may not be effective in all conditions, often weather dependent, specific recommendations are difficult to make
  - positive results are more probable when conditions are conducive for N losses
- Base decisions to use a product on sound research
- Don’t expect miracles…

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