MANAGING UREA-CONTAINING FERTILIZERS

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OVERCOMING NITROGEN VOLATILIZATION LOSSES

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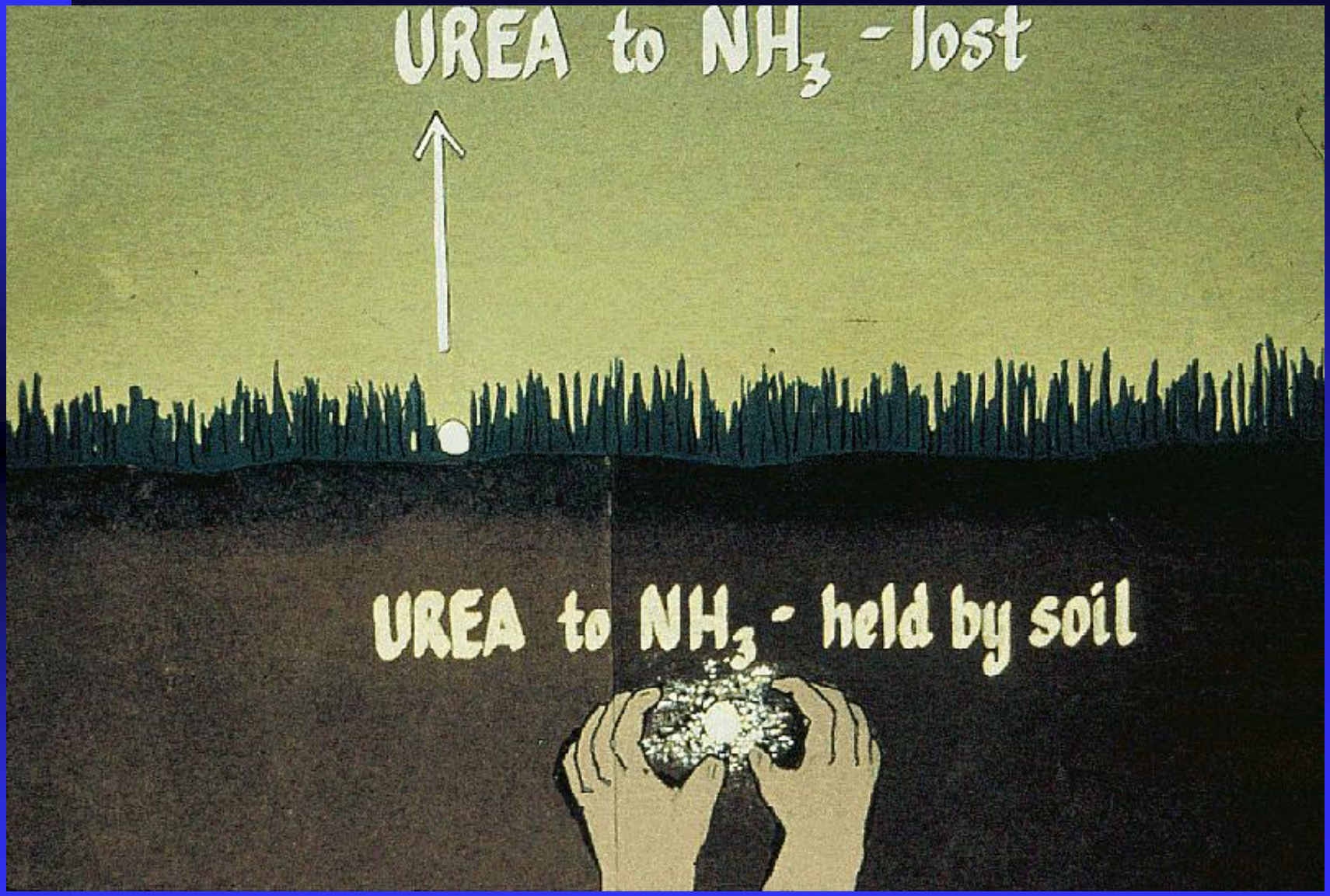
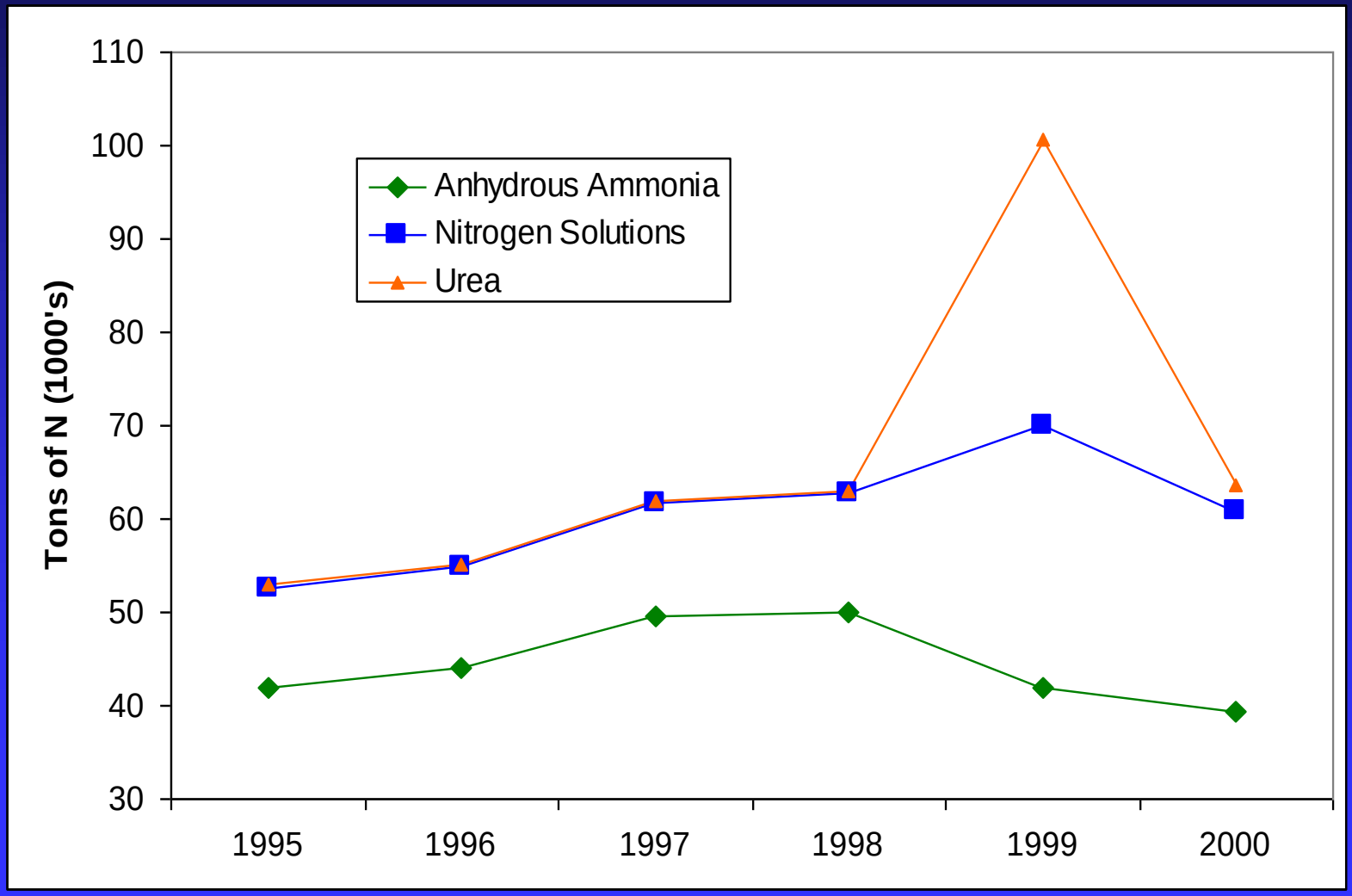

UREA to NH_3 - lost
UREA to NH_3 - held by soil

Nitrogen Fertilizer Use in Wisconsin, 1984 and 2000.

	Tons of N (1000's)		% of N use	
N source	1984	2000	1984	2000
NH_3	75	41	44	25
Urea	45	63	27	38
UAN	50	61	29	37
Total	170	165		

N fertilizer use in Wisconsin (tons of materials)



Reactions of urea in soil

Equation 1.

Urea Hydrolysis

$$(NH_2)_2CO + 2H_20 \xrightarrow[\text{Urease}]{\text{Soil}} (NH_4)_2CO_3$$

Urea — Water — Ammonium Carbonate

Equation 2.

$$(NH_4)_2CO_3 + 2H^+ \longrightarrow 2NH_4^+ + CO_2\uparrow + H_20$$

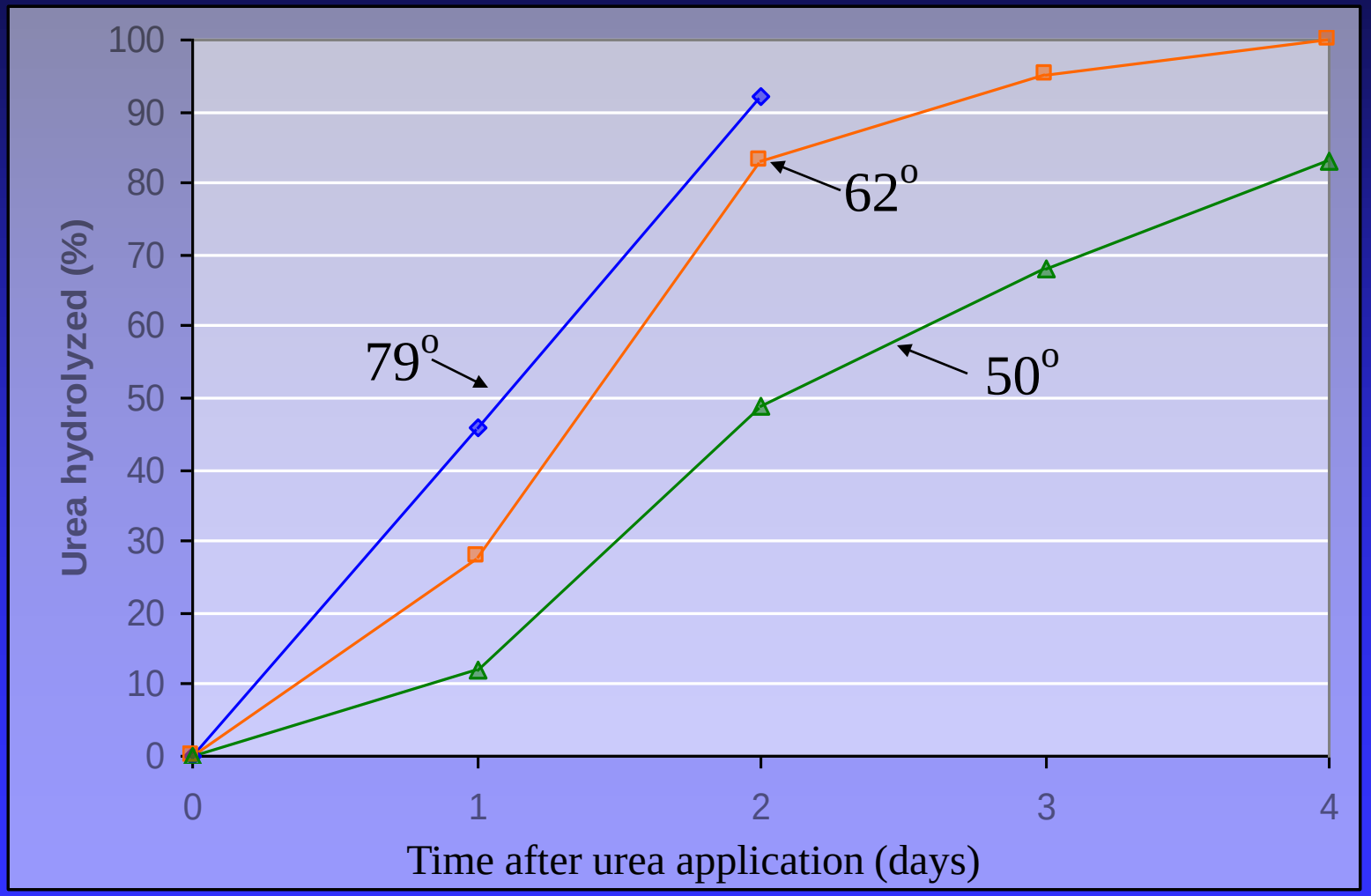
Ammonium Carbonate — Ammonium — Carbon Dioxide (gas) — Water

Equation 3.

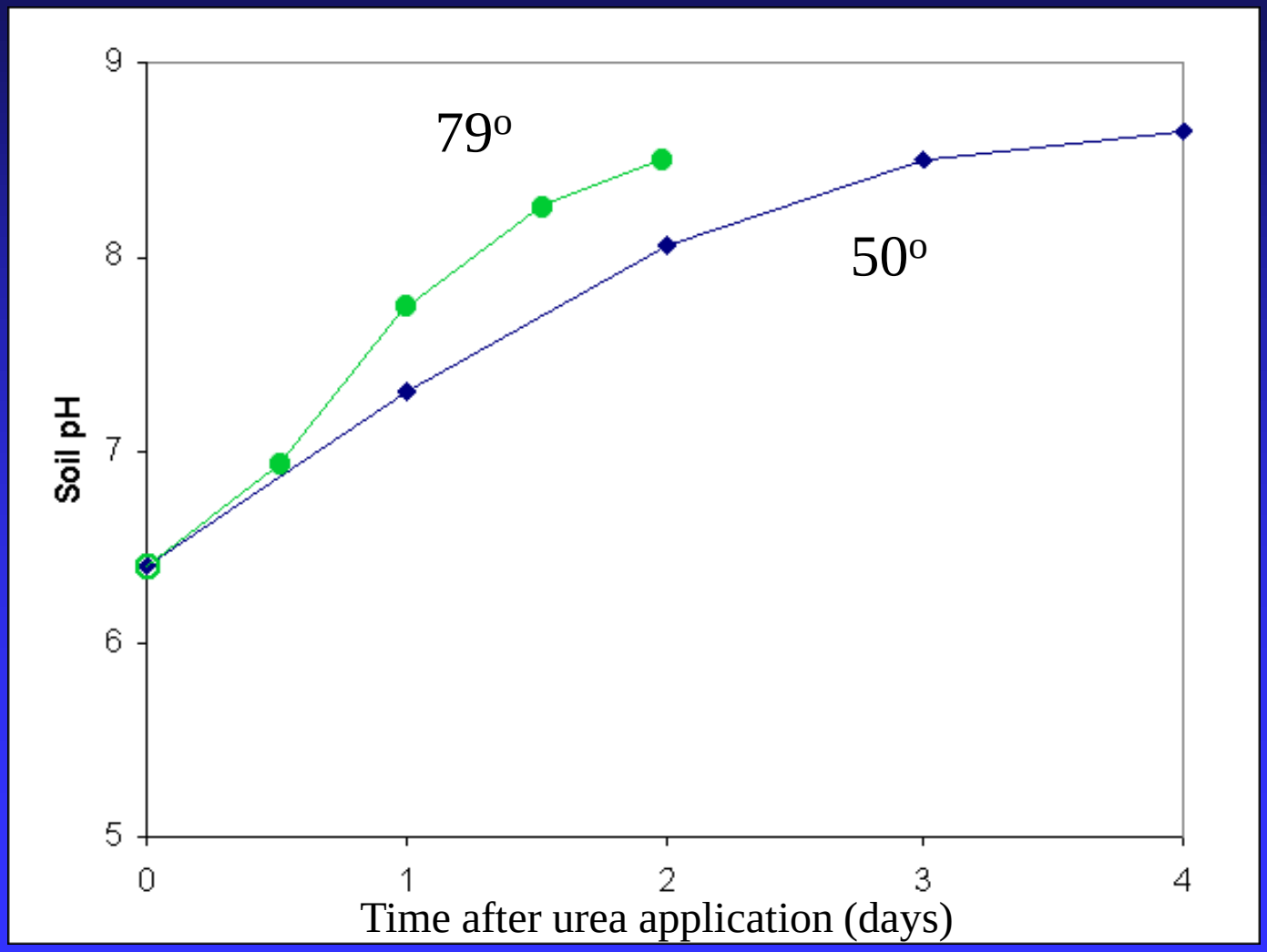
$$NH_4^+ + OH^- \rightleftharpoons NH_3\uparrow + H_2O$$

Ammonium — Hydroxyl — Ammonia — Water

Rates of urea hydrolysis in a silt loam soil at three temperatures



Change in soil pH in a urea-treated silt loam at two temperatures



Soil pH effects on percentages of N present as ammonia and ammonium

	Ammoniacal N	
Soil pH	Ammonia	Ammonium
	----------% ----------	
6	0.058	99.94
7	0.57	99.43
8	5.4	94.6
9	36.5	63.5

Ammonia Volatilization Losses

- Urea and urea-containing fertilizers
- Surface applications only
- Tillage or rain in 2-3 days controls loss
- Large losses are rare
- Maximum loss = 20-30 % of N

Factors Favoring Ammonia Loss

- No rain or irrigation after application
- Crop residue on the soil surface
- High temperatures
- High soil pH
- Low clay & organic matter (low CEC)
- Initially moist soil followed by drying

Extent of Ammonia Volatilization Losses

Effect of ammonia loss from surface-applied fertilizers on corn yield, Lancaster, WI

N source	Ammonia loss (%)	Yield (bu/acre)
None	--	83
Urea	16	122
UAN solution (28%)	12	125
Ammonium nitrate	2	132

Oberle & Bundy, 1988. Data from one of four experiments.

Effect of ammonia loss from surface-applied fertilizers on grass pasture yield, Lancaster, WI

N source	Ammonia loss (%)	Yield (tons/acre)
None	--	0.74
Urea	19	1.09
Ammonium nitrate	1	1.30

Oberle & Bundy, 1988. N rate = 60 lb N/acre.

Nitrogen Source and Management Comparisons

Nitrogen Source Comparisons in No-till Corn

Nitrogen source and placement effects on no-till corn yield and ear leaf N concentration[1]

Treatment	Yield	Ear leaf N
	bu/acre	%
Ammonia, inj.	138	3.06
UAN injected	135	2.85
UAN surface	118	2.48
Urea surface	123	2.57

[1] Ave.of seven expts. Mengel et al., 1982 (Indiana)

Effect of N source and application method on corn yield, Janesville and Winnebago, WI[1]

Application method	Yield	
	Winnebago	Janesville
	-------- bu/acre --------	
UAN surface broadcast	163	146
UAN surface band	153	139
Anhydrous ammonia	165	146

[1] Bundy et al., 1992. Yields are means of 3 yr, 2 N rates, and 4 tillages

Effect of N source & application method on corn yield, Arlington, WI[1]

N source & method	Year		
	1993	1994	1995
	---------- bu/acre ----------		
Ammonium nitrate	118 a	177 a	163 a
UAN spray	94 bc	140 b	152 a
UAN spray + rain	105 ab	139 b	159 a
UAN sprinkle	86 bc	148 b	--
UAN injected	--	--	157 a
Urea	83 c	155 b	160 a

[1] Bundy & Andraski, 1997, Rain = 0.5 inch

Treatments in Nitrogen-Residue Decomposition Study

- Times and rates of N (UAN and ammonium sulfate)
- Sulfur as gypsum applied to equalize sulfur
- Treatments applied to residue of previous corn crop.

Nylon mesh bag for residue quantity & composition measurements

Nitrogen timing, source, & rate effects on corn grain yield, Arlington, 1999-2001

N timing & rate (lb N/acre)		Yield 1999	Yield 2000	Yield 2001
Fall	Spring	---------- bu/acre ----------		
0	0	167 b	63 e	105 e
30 UAN	160 UAN	219 a	146 abc	191 b
30 AS	160 AS	220 a	158 a	202 ab
0	190 UAN	219 a	148 ab	194 b
0	190 AS	216 a	160 a	208 a
100 AS	90 UAN	220 a	136 bc	207 a

Nitrogen Source and Management Comparisons

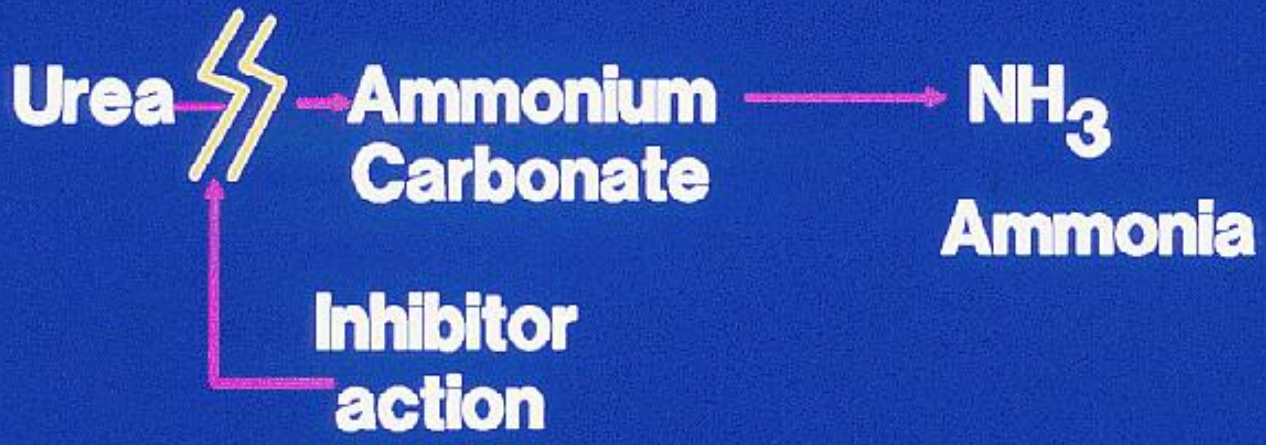
Urease Inhibitors to Control Ammonia Loss

Urease Inhibitor

N-(n-butyl) thiophosphoric triamide (NBPT)

Commercial product - Agrotain

Soil Urease Inhibition



Grain yield increase from use of a urease inhibitor with urea-containing fertilizers

Experimental sites	No.of sites	Yield increase	
		Urea	UAN
		------- bu/acre ------	
All sites	78	4.3	1.6
N responsive	64	5.0	2.8
Significant NH_3 loss	59	6.6	2.7

1/ Hendrickson, 1992

Nitrogen Source and Management Comparisons

Winter Applications of Urea

Effect of nitrogen source, time, and rate on corn yield, Illinois[1]

Nitrogen treatment		Nitrogen rate			
Source/method	Time	0	120	180	240
		------- Yield (bu/acre) -------			
None (control)		89			
Urea/surface	Winter		94	123	126
Urea/Incorp.	Spring		140	157	165
Anhydrous ammonia	Spring		149	157	158

[1] Illinois Agronomy Handbook, 2001-2002.

Nitrogen Source and Management Comparisons

Preplant Urea Applications on Sandy Soils

Effect of N source and timing on corn yield, Hancock, WI (2-yr ave.)

N rate	Inhibitor	Preplant	
		Urea	NH_3
lb/acre		--------- bu/acre ---------	
0		35	
70	-	61	87
	+	80	99
140	-	101	124
	+	109	134
210	-	98	142
	+	119	137

Effect of N source and timing on corn yield, Hancock, WI (2-yr ave.)

		Sidedress	
N rate	Inhibitor	Urea	NH_3
lb/acre		--------- bu/acre ---------	
0		35	
70	-	99	89
	+	106	104
140	-	127	127
	+	129	125
210	-	135	137
	+	142	133

Summary

- Urea-containing fertilizers are widely used (75-80% of the N in Wisconsin).
- Ammonia loss can occur from surface applied urea fertilizers
- Soil and climate factors influence ammonia loss.
- Maximum losses seldom exceed 20% of applied N.

Summary

- N source comparisons sometimes show better performance with non-urea materials
- Factors other than ammonia loss may contribute to these results.
- Urease inhibitors can reduce ammonia loss from urea fertilizers.
- Economic benefits from inhibitors is uncertain.

Summary

- Winter applications of urea on frozen soils subject to N losses
- Preplant applications of urea on sandy soils should be avoided

Controlling Nitrogen Volatilization Losses

- Incorporate or inject urea-containing fertilizers
- Use non-urea N sources for surface applications
- Consider a urease inhibitor where risk of volatile loss is high

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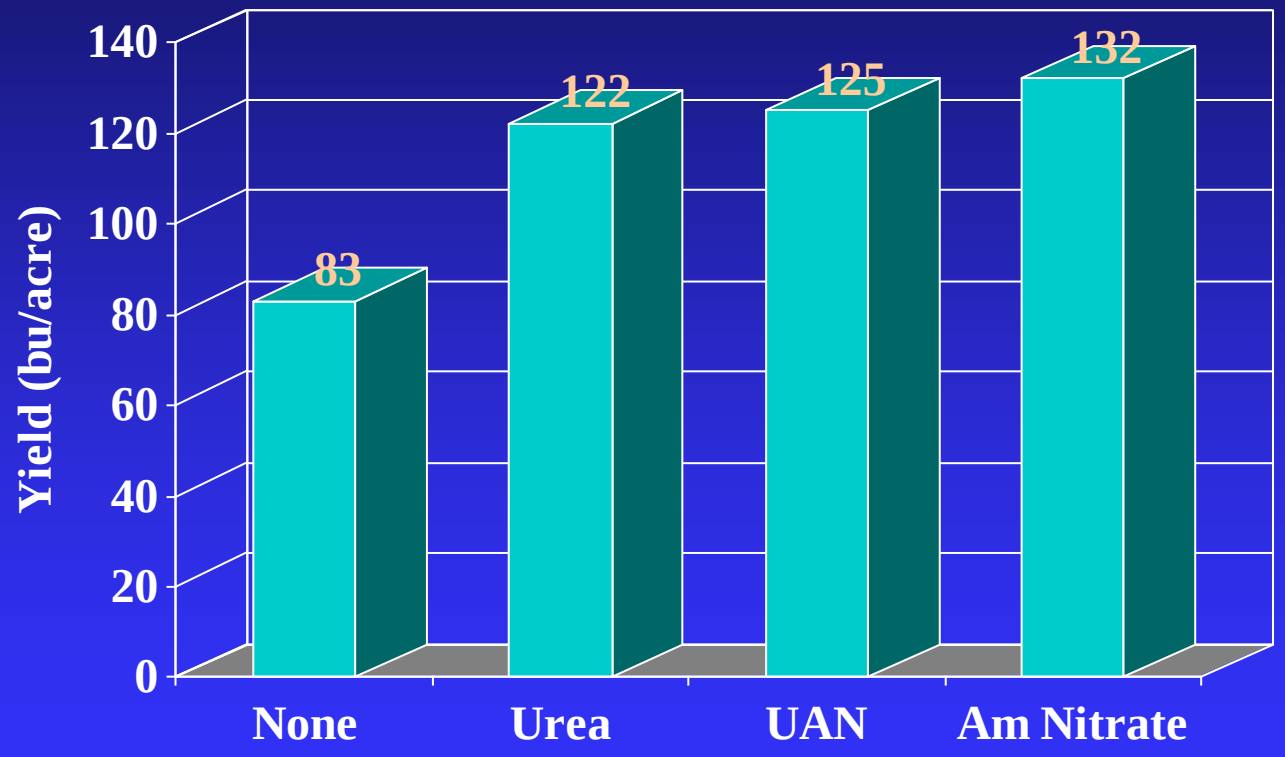
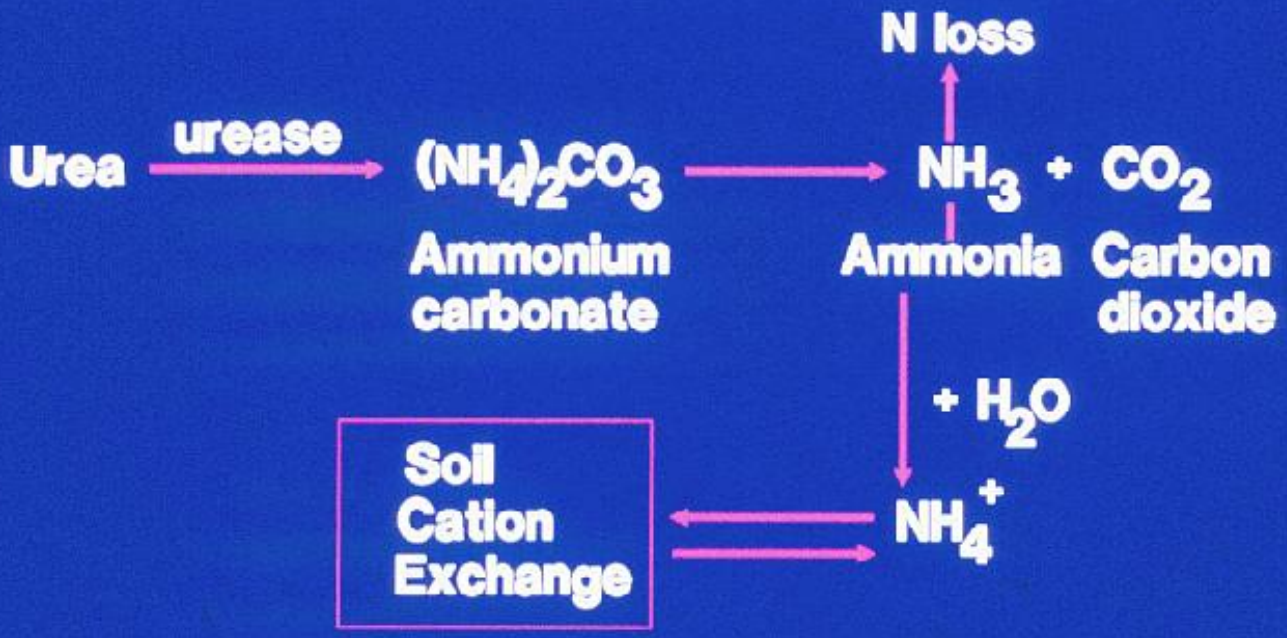
Corn Yield with surface applied N sources, Lancaster, WI



Ammonia Volatilization



Effect of N source and timing on corn yield, Hancock, WI

N rate	Inhibitor	Preplant		Sidedress	
		Urea	NH_3	Urea	NH_3
lb/acre		---------- bu/acre ----------			
0		35			
70	-	61	87	99	89
	+	80	99	106	104
140	-	101	124	127	127
	+	109	134	129	125
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	+	119	137	142	133

Plant Nutrient Consumption in the USA. (1960-2000)