Nitrogen Management for Corn Production and Water Quality

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University of Minnesota
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Nitrogen Management 101

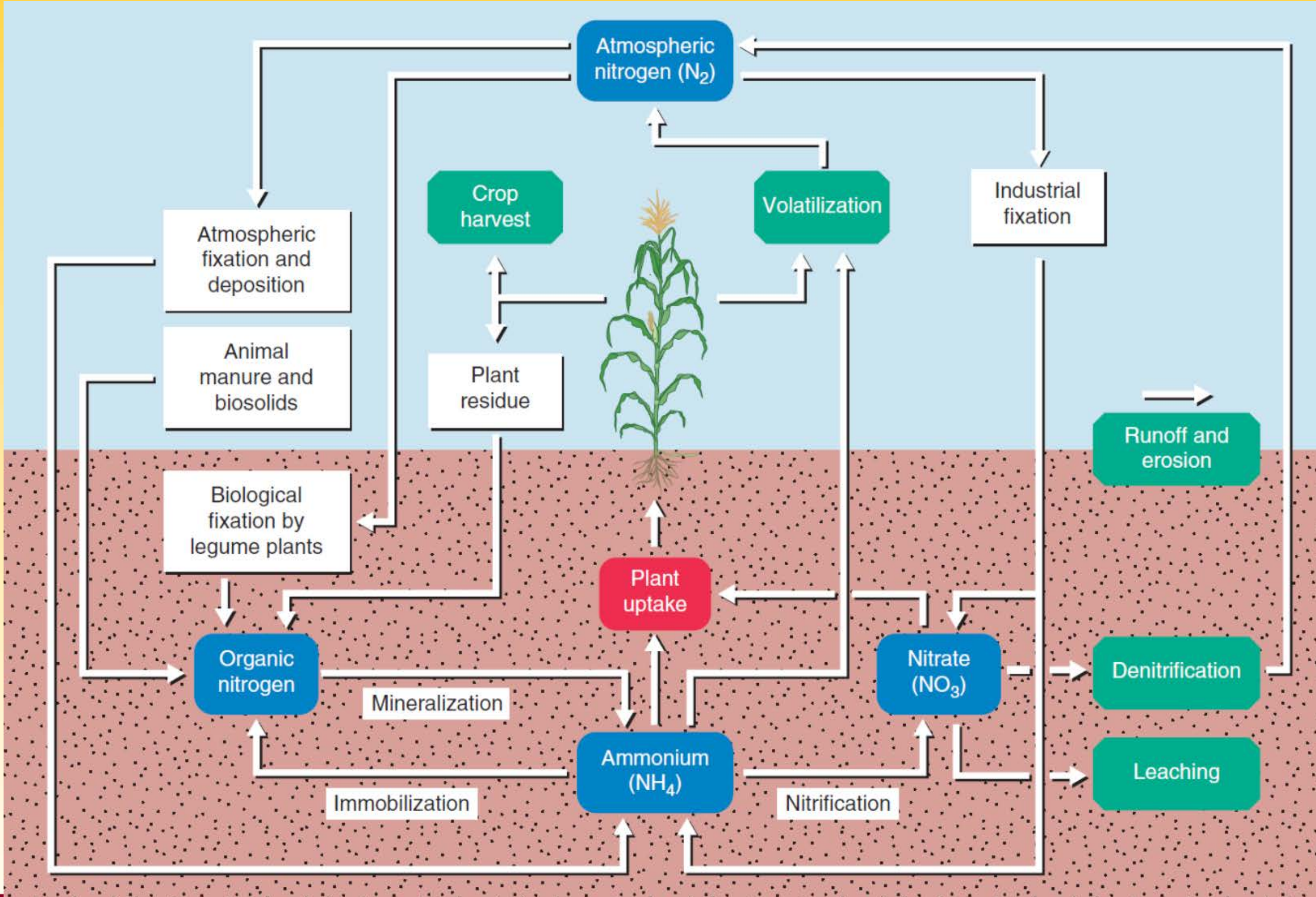
- N is expensive: can't afford to over apply
- Corn needs N: can't afford to under apply
- N can create environmental degradation
  - Under the current regulatory climate N is being heavily scrutinized
  - Show that this nutrient is being used very wisely
  - Ensure we can keep using all tools in the toolbox

Nitrogen Management Made Easy

Apply just what the crop needs, at the best possible time using the proper application method for the nitrogen source being used

Two principles

- **Enhance nitrogen uptake**
- **Minimize nitrogen loss**


Atmospheric nitrogen (N_2)
Crop harvest
Volatilization
Industrial fixation
Atmospheric fixation and deposition
Animal manure and biosolids
Plant residue
Runoff and erosion
Biological fixation by legume plants
Plant uptake
Organic nitrogen
Nitrate (NO_3)
Denitrification
Mineralization
Ammonium (NH_4)
Leaching
Immobilization
Nitrification

Nitrogen Management is Not Just Pounds of N per Acre

- Often discussions on nitrogen management revolve only around the topic of rate of application
  - 1) Adequate availability to the crop
  - 2) Minimize the amount of leftover nitrogen at the end of the season
- Other variables are also important
  - Source, time, application method, prevailing weather conditions, region/soil of the state

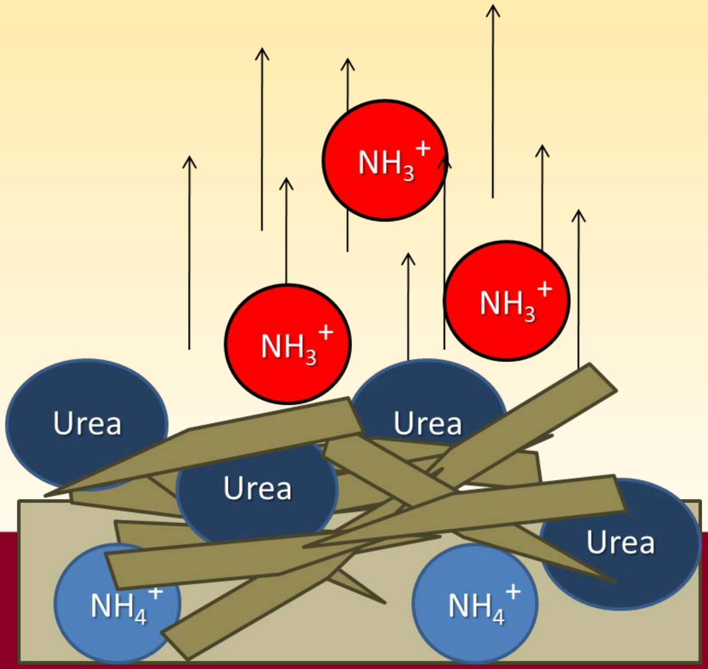
Placement

- All ammonium-based fertilizers have the potential to volatilize

- Topdressed urea or urea-containing fertilizers have the greatest potential (pH >9 develops just under granule as it hydrolyzes to ammonium carbonate)

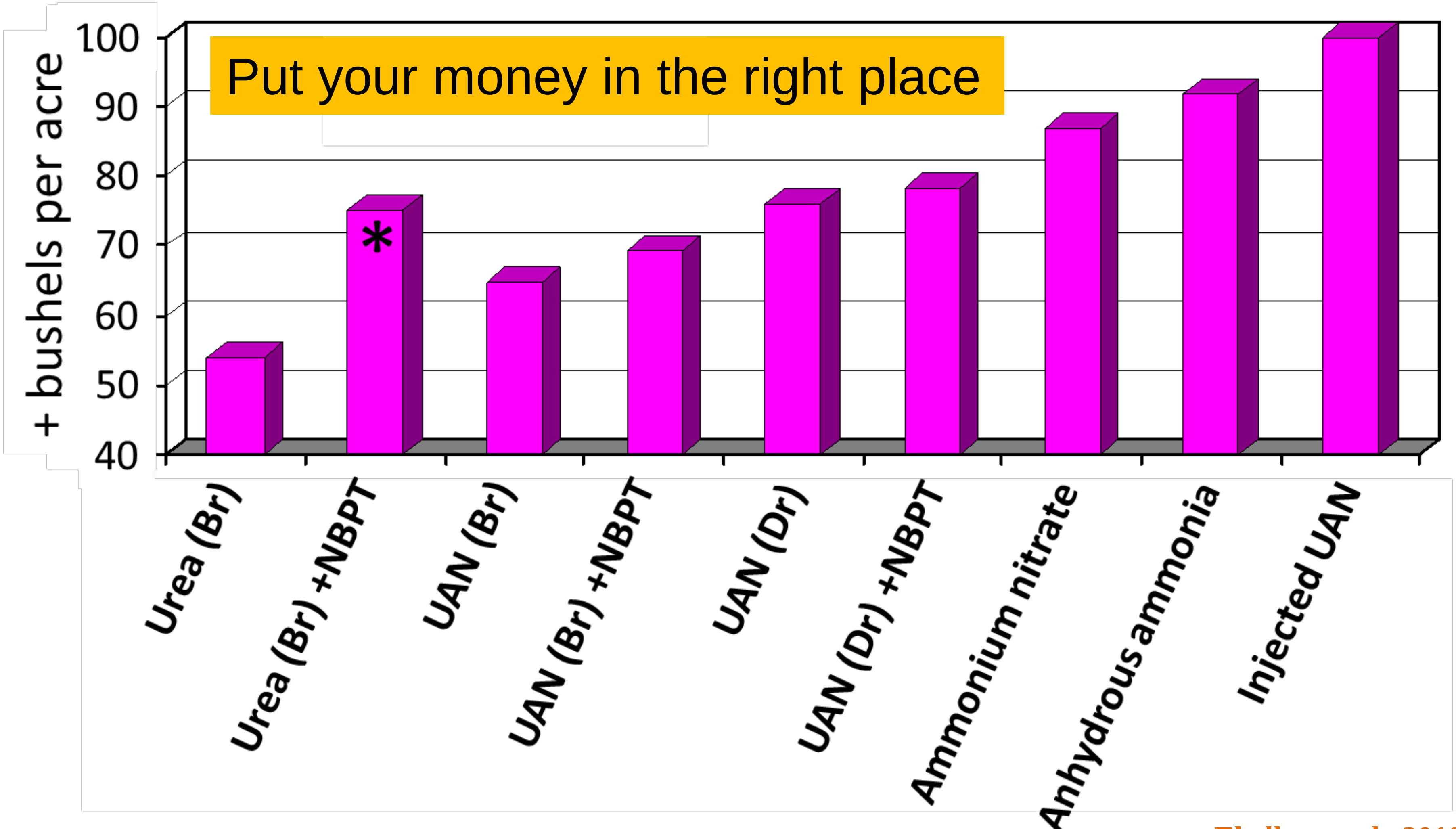
- Most of the volatilization takes place shortly after application if not incorporated (24-48 hrs)

Volatilization



N Sources for No-till Corn

Eight Site-years, 1995-98



Yield benefit compared to check treatment (70 bu/ac)

Ebelhar et al., 2010

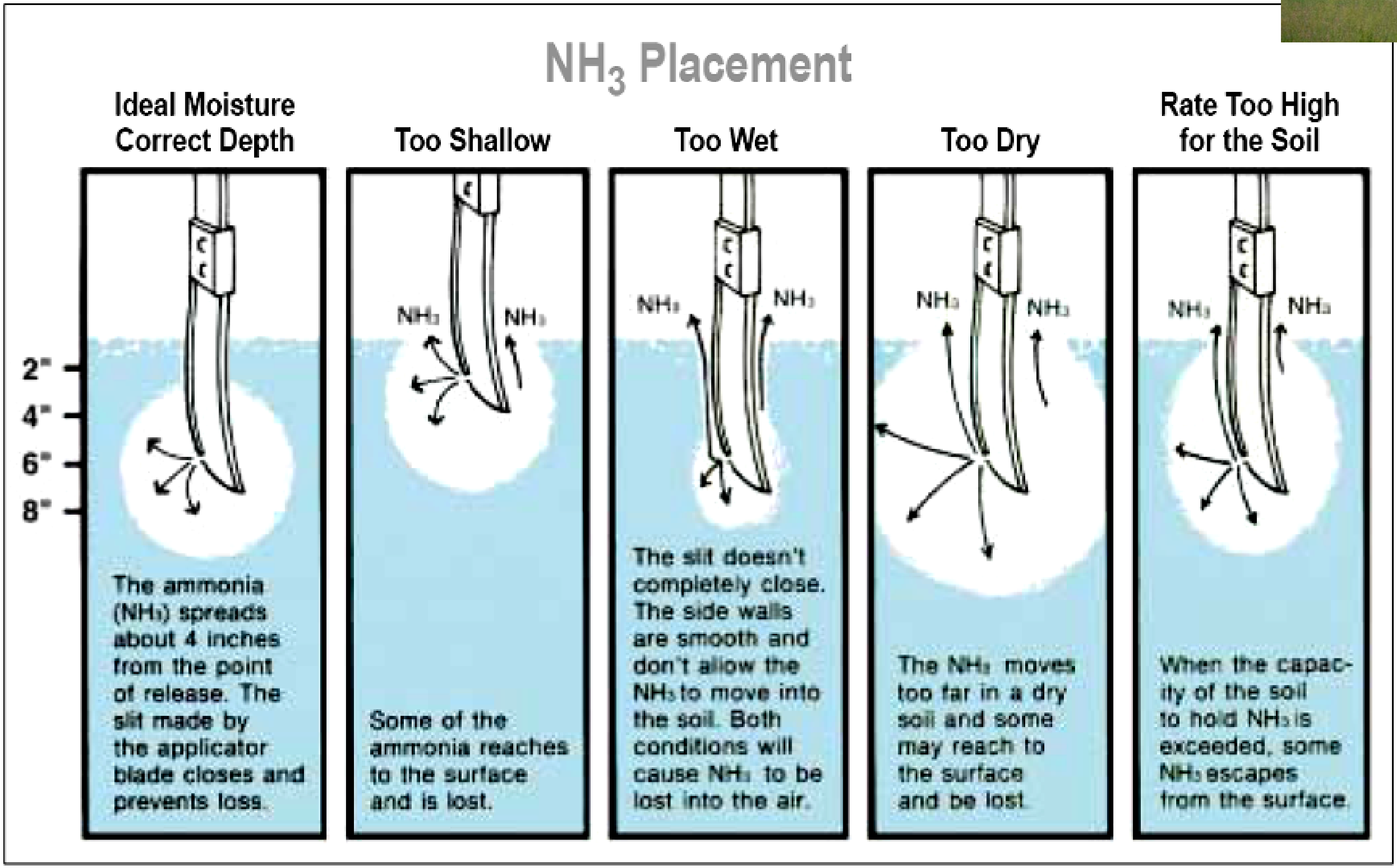
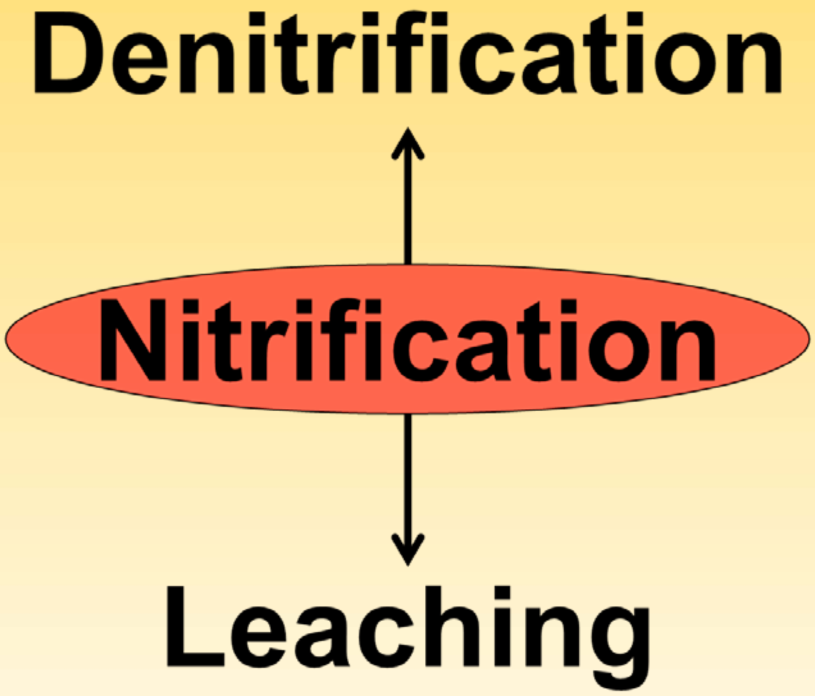
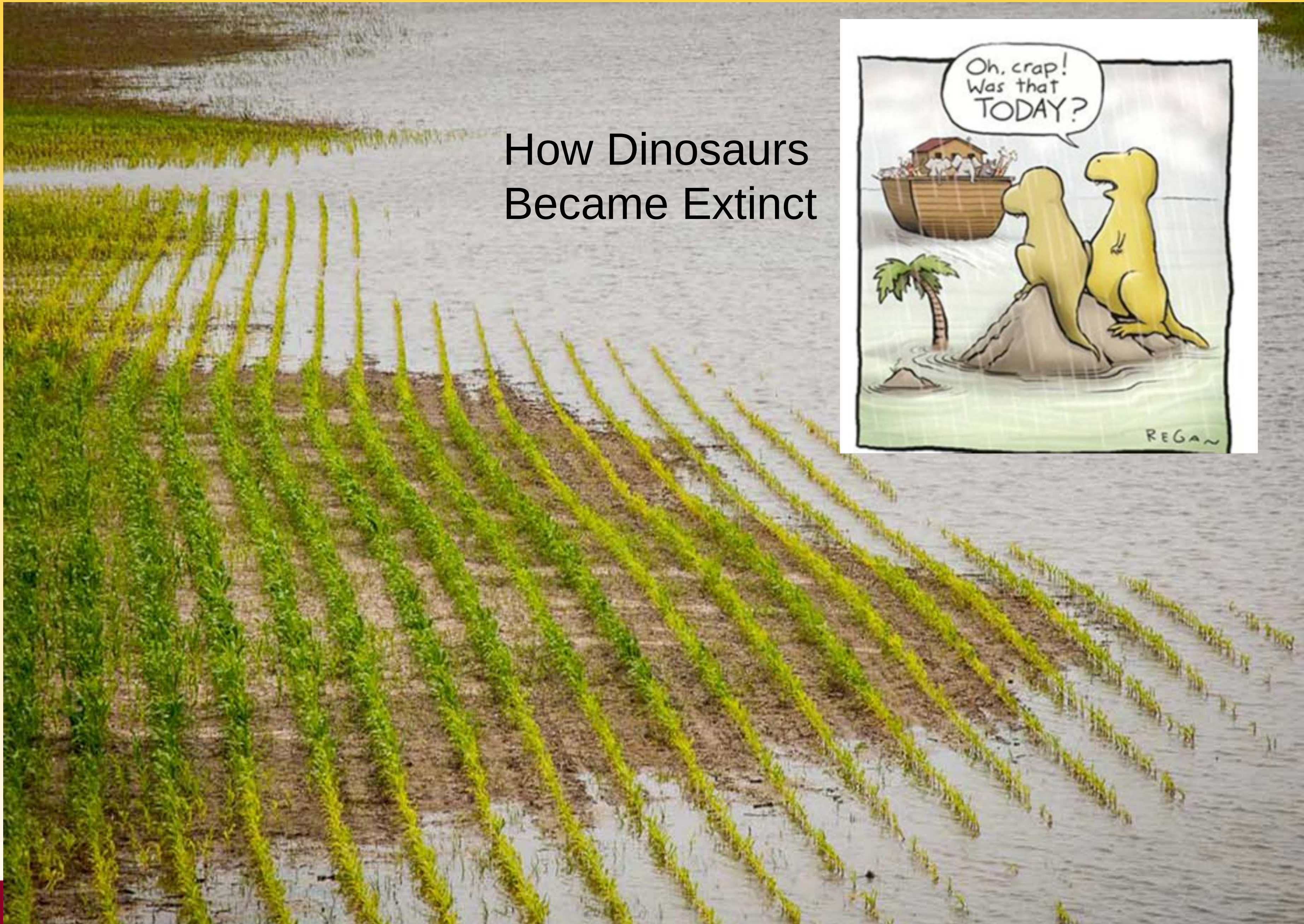


Figure 6.25. Distribution of anhydrous ammonia (white areas) when released in different kinds of soil, at various depths, and under several soil moisture conditions.

Source & Timing



How Dinosaurs Became Extinct



Possible Actions to Improve Use Efficiency

- Stabilized nitrogen
  - Slow down conversion of urea to ammonia (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
- Time of application

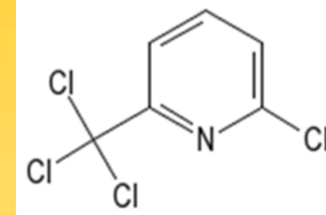
Pre-Plant Application
(100 lb N acre^{-1})

Source	2007-2010	2010
	bu acre^{-1}	
AA	134a	134ab
ESN	139a	140a
Urea	137a	121b
LSD	6	13

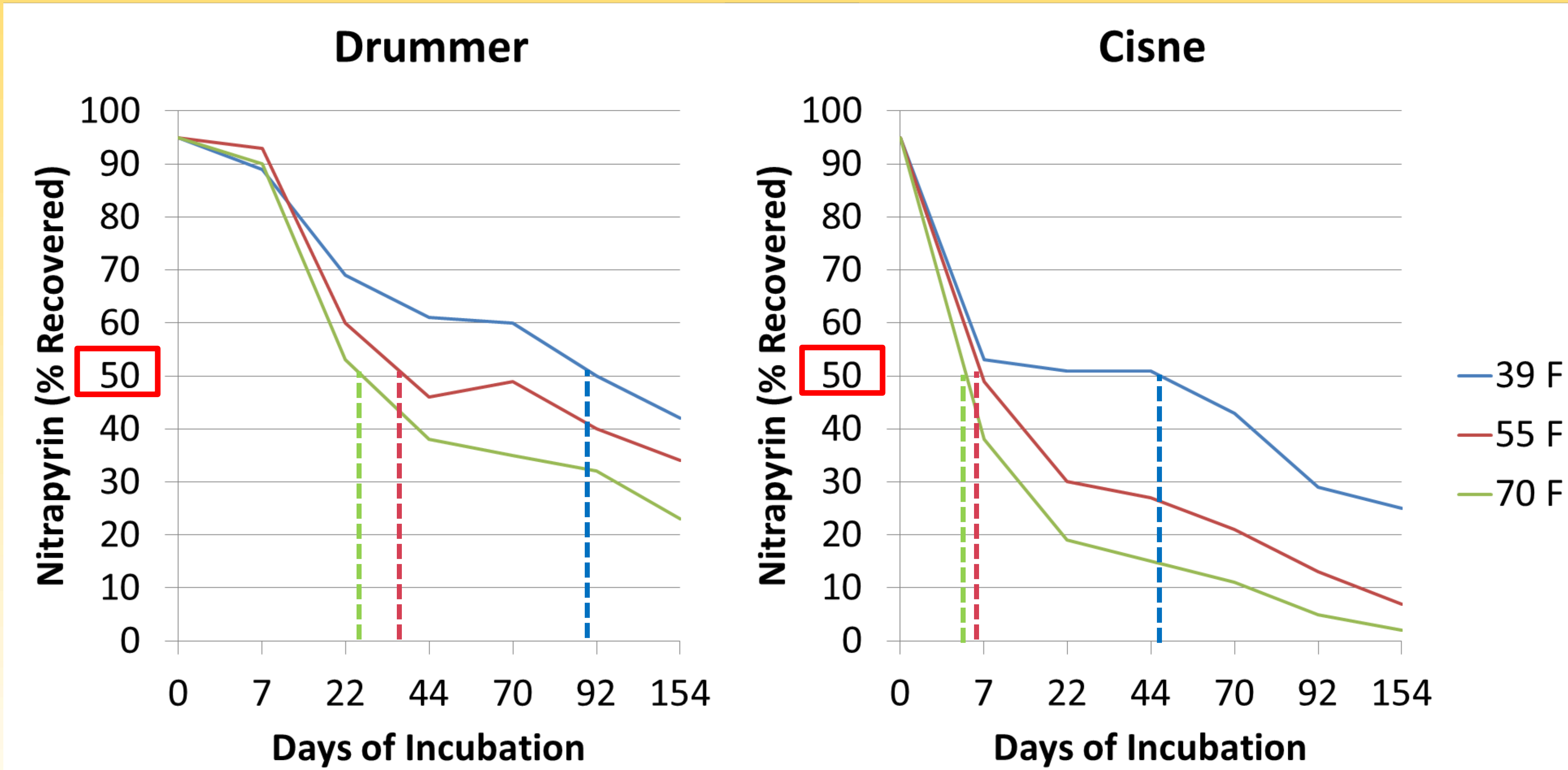
N Form	Application Time	Nitrification Inhibitor	2 weeks After Appl.	4+ weeks After Appl.
			% Appl. N in NO_3 Form	
AA	Fall	No	---	97
AA	Fall	Yes	---	60
$[NH_4]_2SO_4$	Fall	No	---	97
$[NH_4]_2SO_4$	Winter	No	---	95
AA	Spring	No	40	65
AA	Spring	Yes	25	50
Urea	Spring	No	50	75
UAN sol.	Spring	No	60	80
$[NH_4]_2SO_4$	Spring	No	50	75

Temperature and Soil Affects Nitrapyrin Persistence

Cooler Temperatures Reduce 1) Bacterial Activity and 2) Nitrapyrin Breakdown



N-Serve, Instinct



Nitrapyrin applied at 1.77 and 3.54 ppm to Drummer and 1 and 2 ppm to Cisne

Touchton et al., 1979 Agron. J. 71:865-869

Effect of N rate and time of application on nitrate-N losses to subsurface drainage in continuous corn in Minnesota

Ammonium sulfate (lb N acre^{-1})	**Time**	**Annual loss of Nitrate-N in drainage (lb N acre^{-1} year^{-1})**	**Five-year yield average (bu acre^{-1})**
0	0	7	66
120	Fall (Nov.1)	27	131
120	Spring (May 1)	19	150
180	Fall (Nov.1)	34	160
180	Spring (May 1)	26	168

(Adapted from Randall and Mulla, 2001)

Nitrate Leaching

Treatment	Corn	Soybean
	-------------------mg NO_3/L-------------------	
Fall	14.3	10.3
Fall+NP	11.5	9.5
Spring	10.7	10.8
Spring+NP	11.3	11.0

- Adding NP in fall reduces nitrate in tile by 10%, but not in the spring. ***Key is to have little nitrate during Apr-Jun.***
- 71% of annual subsurface drainage during Apr-Jun.
  - 54% of nitrate in drainage during corn crop (77% Apr-Jun)
  - 46% of nitrate in drainage during soybean crop (73% Apr-Jun)

Parameter	Time of Application		
	Fall	Fall + NServe	Spring
15-yr avg. yield (bu/a)	144	153	156
15-yr avg. economic return over fall N ($/a/yr)	---	$9.30	$18.80
7-yr avg. yield (bu/a)	131	146	158
7-yr avg. economic return over fall N ($/a/yr)	---	$22.50	$51.00
15-yr flow-weighted NO_3-N in tile (mg/L) from a corn-soybean rotation	14.1	12.2	12.0
15-yr N recovery in the grain (%)	38	46	47

9 bu/a yld increase, $9.30 greater return, and tile drain NO_3 was reduced 14% relative to the same application without N serve

N rate was 135 lb/a (1987-1993) and 120 lb N/a for 1994-2001
Corn $2/bu, fall N $0.25/lb N (0.125 N:corn), spring N $0.275/lb N, Nserve $7.50/a
7 years where sig. difference occurred (wetter than normal springs)
N recovery = (N in grain – N in grain from check) / fertilizer N rate
Canisteo and associated glacial till soils. N applied at 50F or below

Adapted from Randall and Vetsch, 2005a, 2005b and Randall et al., 2003a, 2003b)

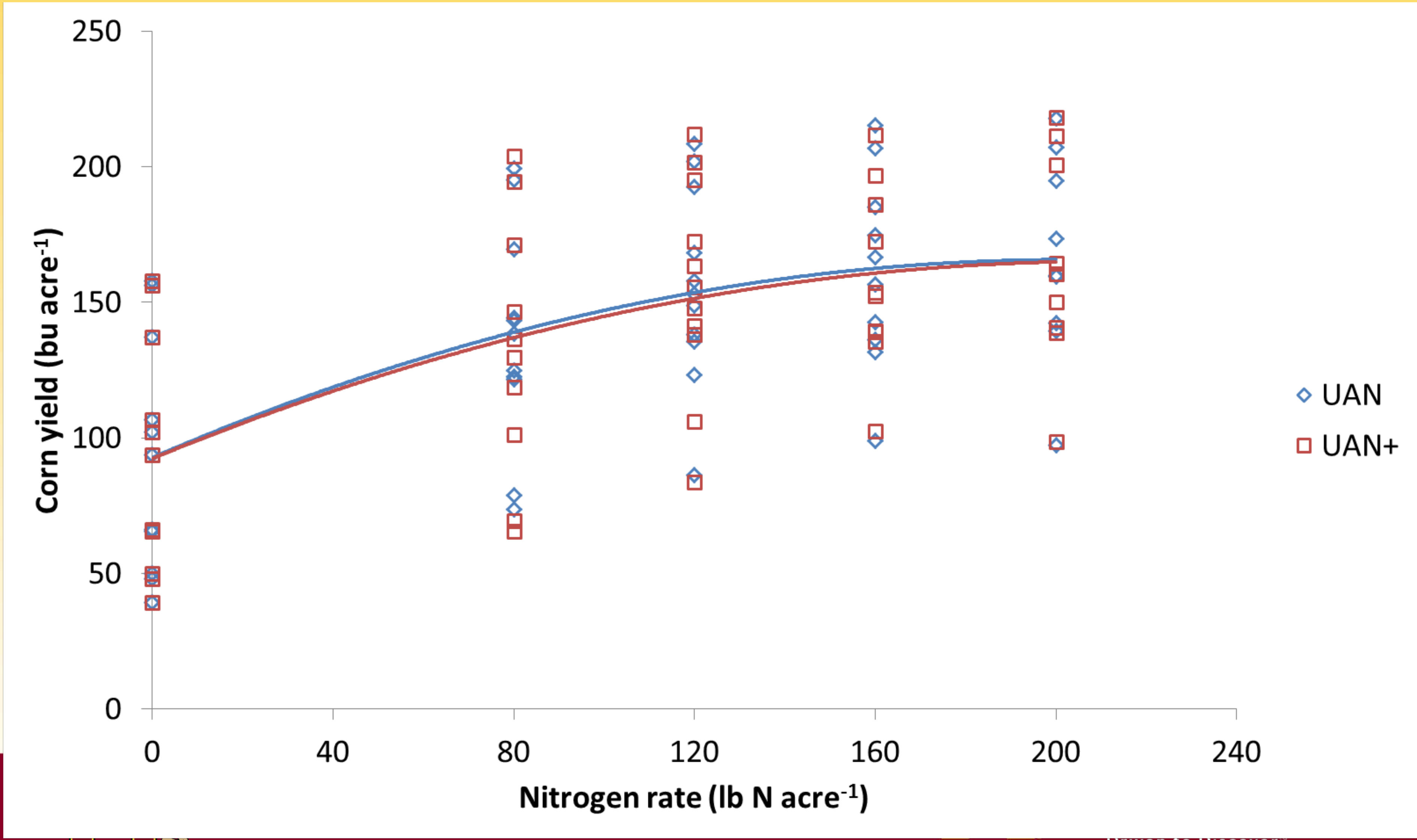
Instinct Effects, Waseca, Webster/Nicolette

All pre-plant incorporated. 2008 & 10 C-S; 2009 C-C
2008 & 9 – dry years; 2010 wet year.

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

Randall and Vetsch, 2008-2010

Instinct trials, 11 Site-Years



Conditions when NI will not increase grain yield

- Seasons and soil types where N loss is minimal
- Seasons and soil types were N loss conditions occur after the NI has become ineffective
- When soil plus fertilizer N far exceeds crop N requirement
- When NI and NH_4^+ become separated in the soil
- When positional availability of NH_4^+ is a factor under dry soil conditions

Effectiveness of NI increases…..

- With cool soil temperatures
  – Less NI breakdown
  – Reduced recovery of nitrifiers
- With low initial soil pH
  – Reduced recovery of nitrifiers
- With low, banded N rates
  – Proximity of NI to NH_4^+
  – High ionic strength reduces nitrifiers and NI decomposition


Leaching

Factors for Leaching

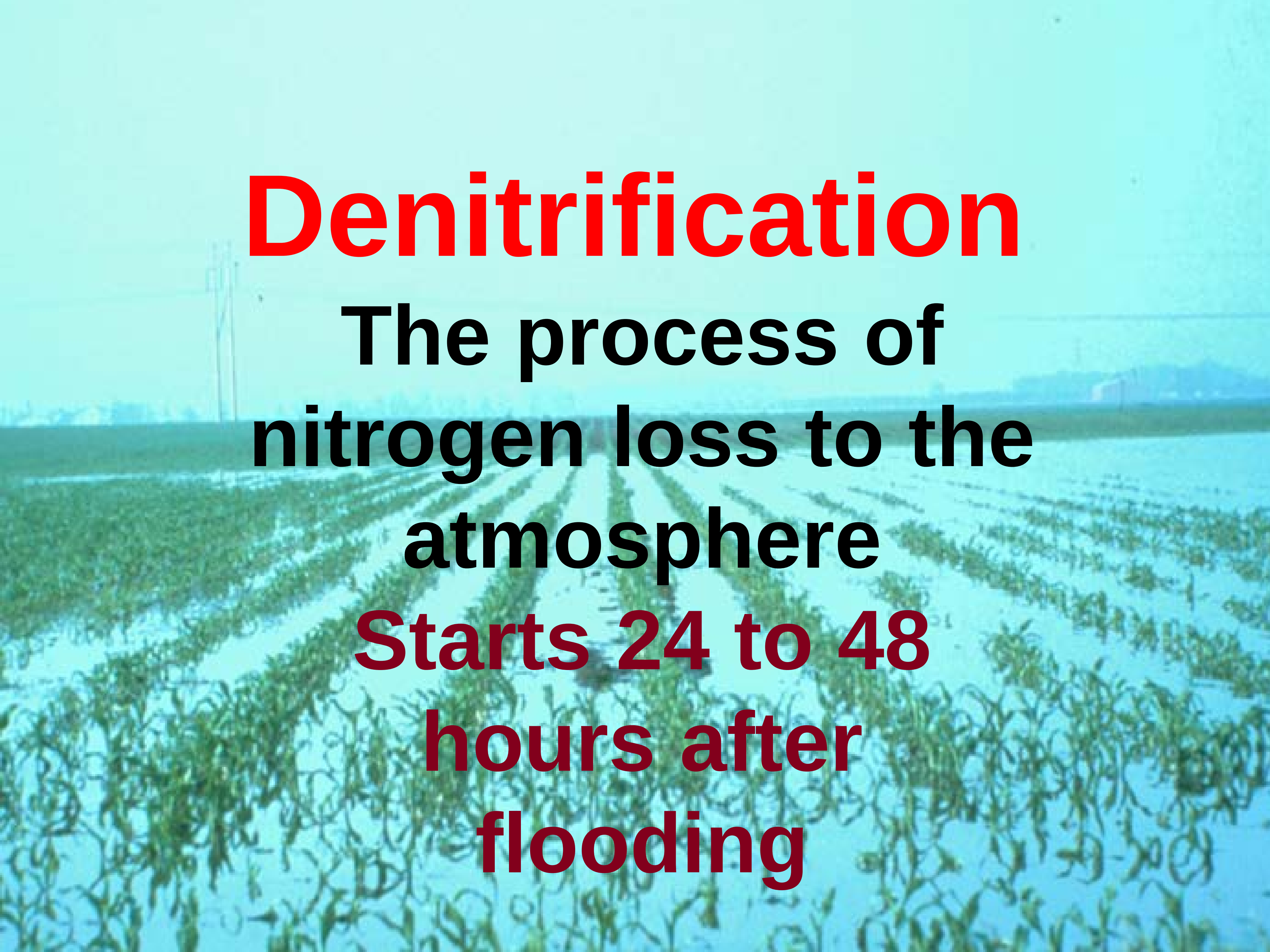
1. **Amount of N in NO_3^- form**
   1. N source can be important.
   2. Bacteria-mediated process (Temperature and Moisture)
2. **Time since urea application**
   1. Urea is highly soluble in water
   2. If leaching rainfall was within 2-4 days after application (time for hydrolysis to NH_4^+) then urea may have leached
   3. If leaching rainfall was more than 4 days after urea application NH_4^+ from urea remains within the root zone

Factors for Leaching

We have created a very leaky agricultural system that allows water (and nitrate) to move quickly out of the field

3. Amount of water and drainage (natural or created)

- In sandy or heavily tile-drained soils: nitrate moves 1’ per 1” of rain
- In clay loam or silt loam soils: nitrate moves 5-6” per 1” of rain
- Upward movement with evaporation and evapotranspiration



Denitrification

The process of nitrogen loss to the atmosphere

Starts 24 to 48 hours after flooding

Denitrification In Water-Saturated Soil Conditions

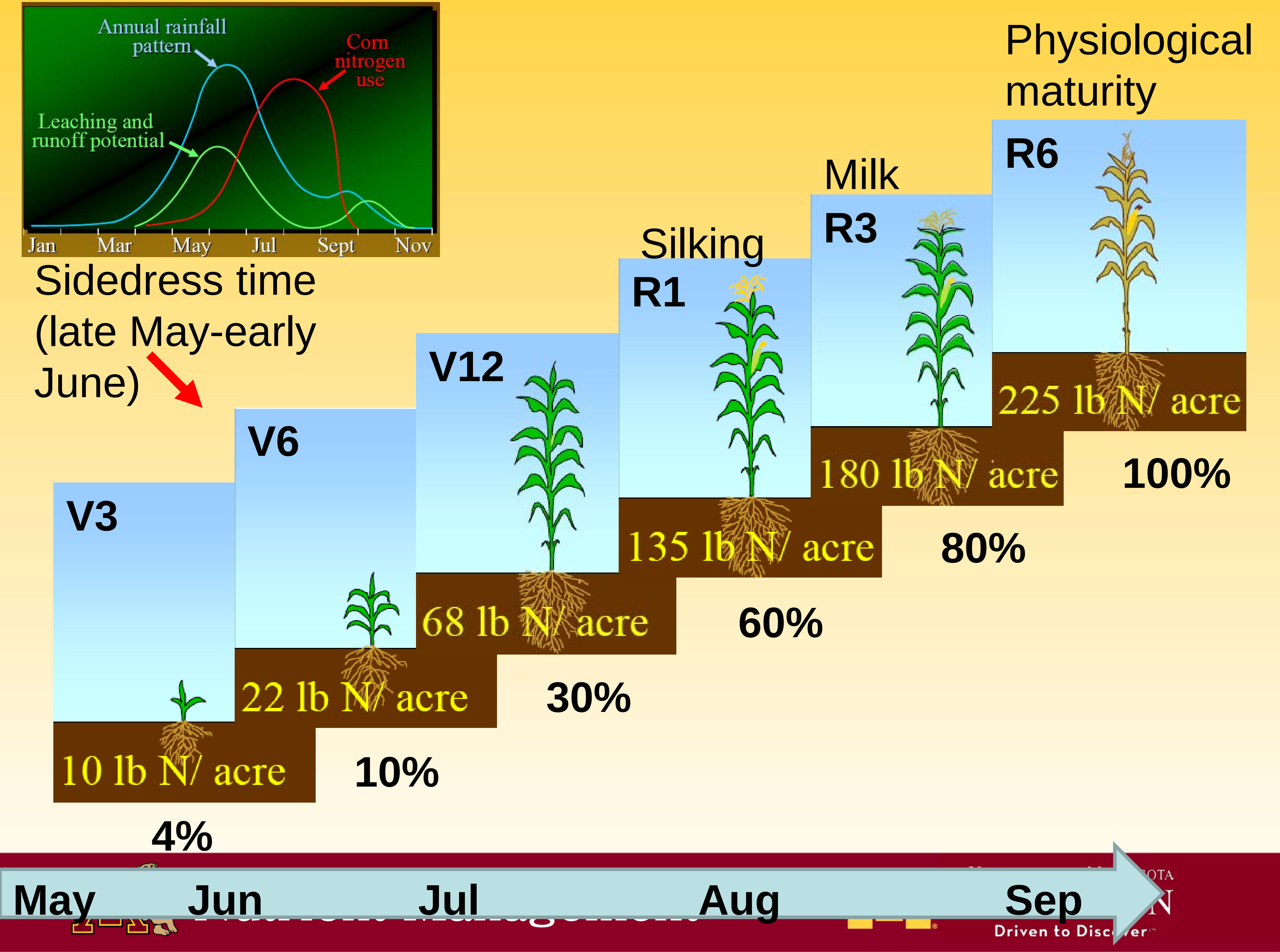
- Amount of NO_3-N (not total nitrogen applied) that will be lost via denitrification for each day that soils are saturated when soil temperatures are:

>65° F to 70° F	4% to 5%.
55° F to 65° F	2% to 3%
<55° F	1% to 2%

How Much N Loss From NO_3 Has Occurred After 9 Days of Saturated Conditions?

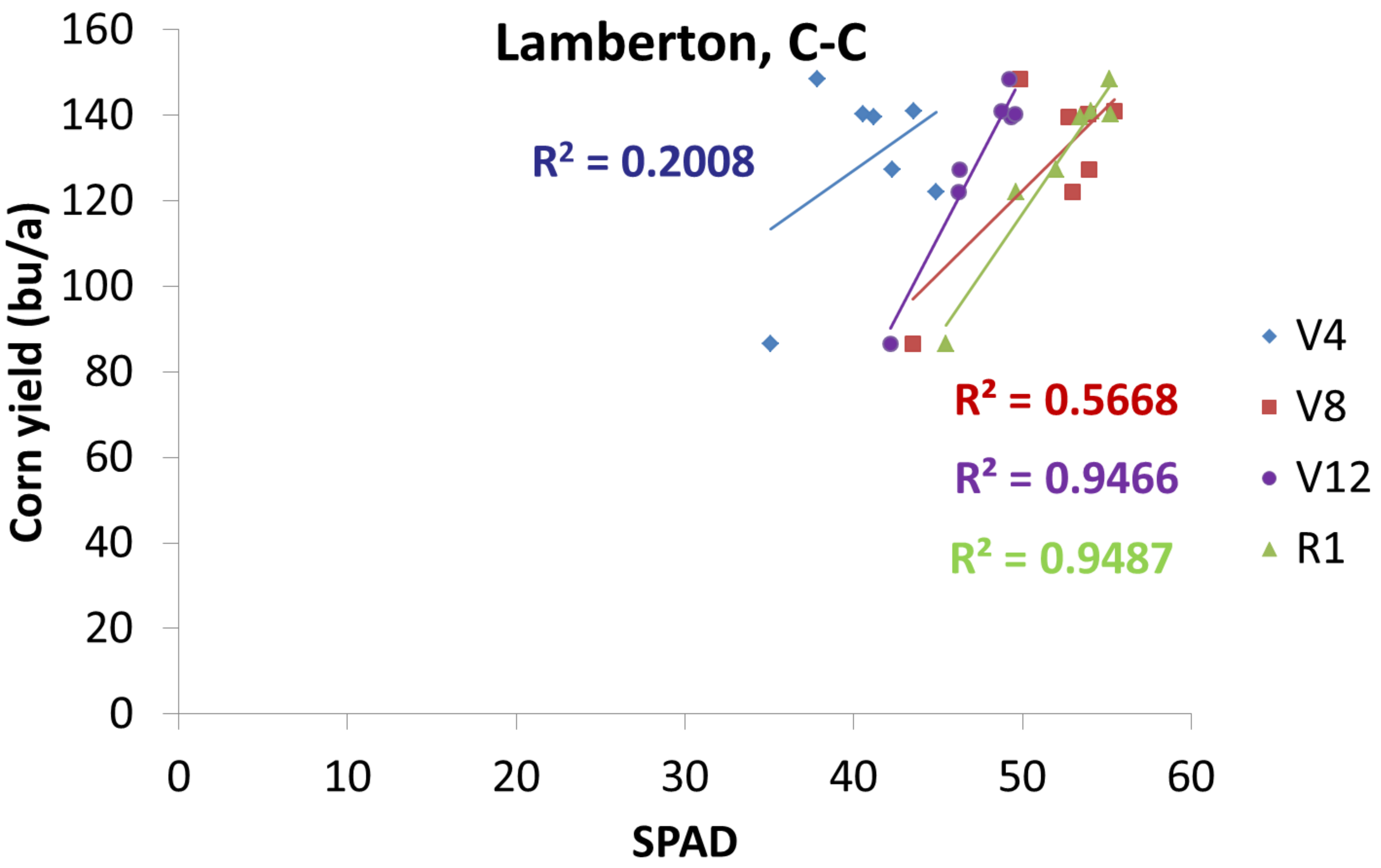
- **Calculate N present as nitrate**
  - N applied x % in nitrate form
  - 180 lb N/acre x 0.65 = 117 lb N/acre
- **Calculate N denitrification**
  - N in nitrate form x % denitrified
  - 117 x 0.27 (9 days x 0.03%/day) = 31 lb N/acre lost


NEW LEADER



Annual rainfall pattern
Corn nitrogen use
Leaching and runoff potential
Jan Mar May Jul Sept Nov
Sidedress time (late May-early June)
V3
10 lb N/ acre
4%
V6
22 lb N/ acre
10%
V12
68 lb N/ acre
30%
Silking
R1
135 lb N/ acre
60%
Milk
R3
180 lb N/ acre
80%
Physiological maturity
R6
225 lb N/ acre
100%
May
Jun
Jul
Aug
Sep

Can We Use Crop Sensors To Improve N Management?

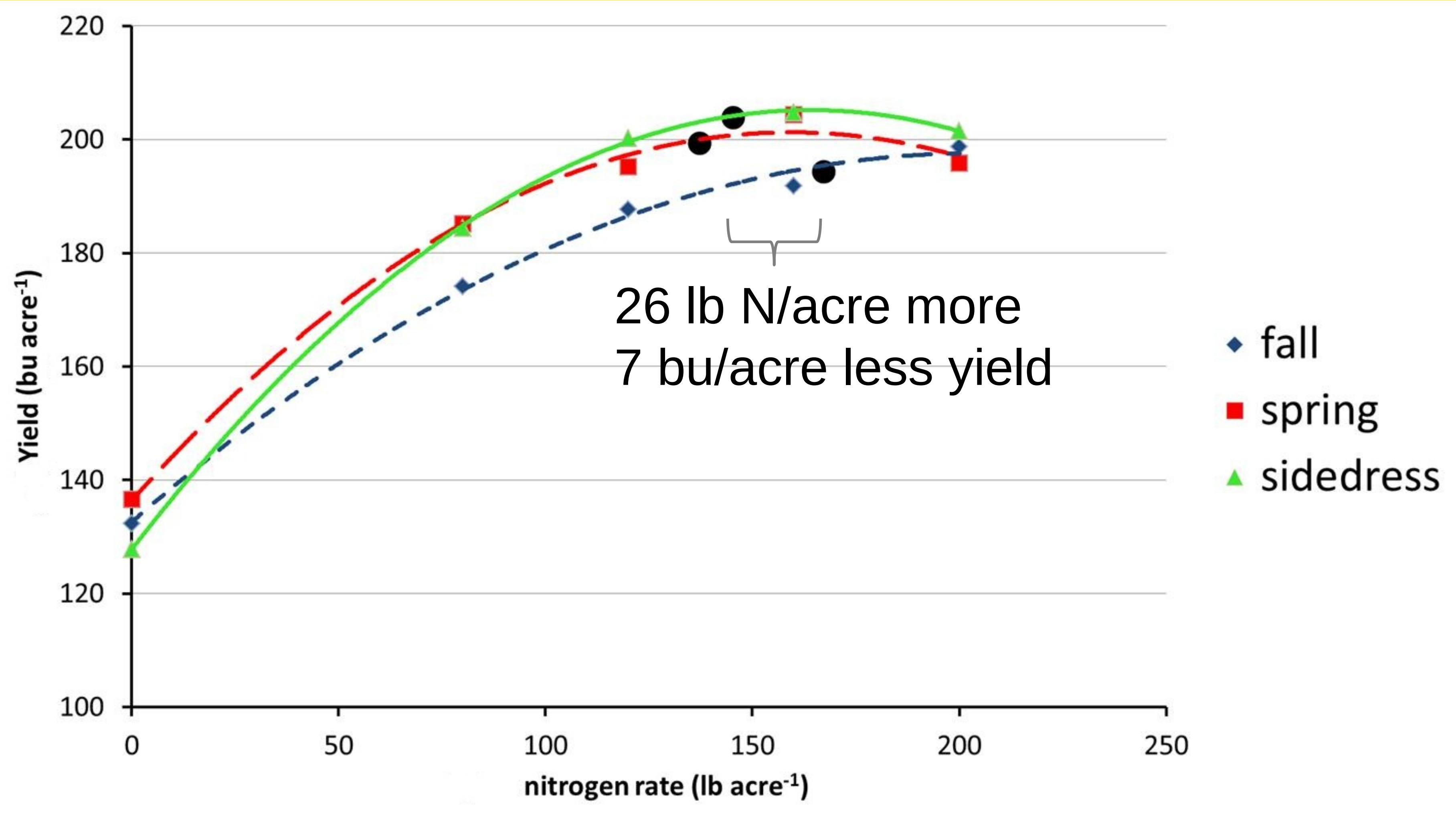


Lamberton, C-C
Corn yield (bu/a)
SPAD
R² = 0.2008
R² = 0.5668
R² = 0.9466
R² = 0.9487
V4
V8
V12
R1
0
20
40
60
80
100
120
140
160
0
10
20
30
40
50
60

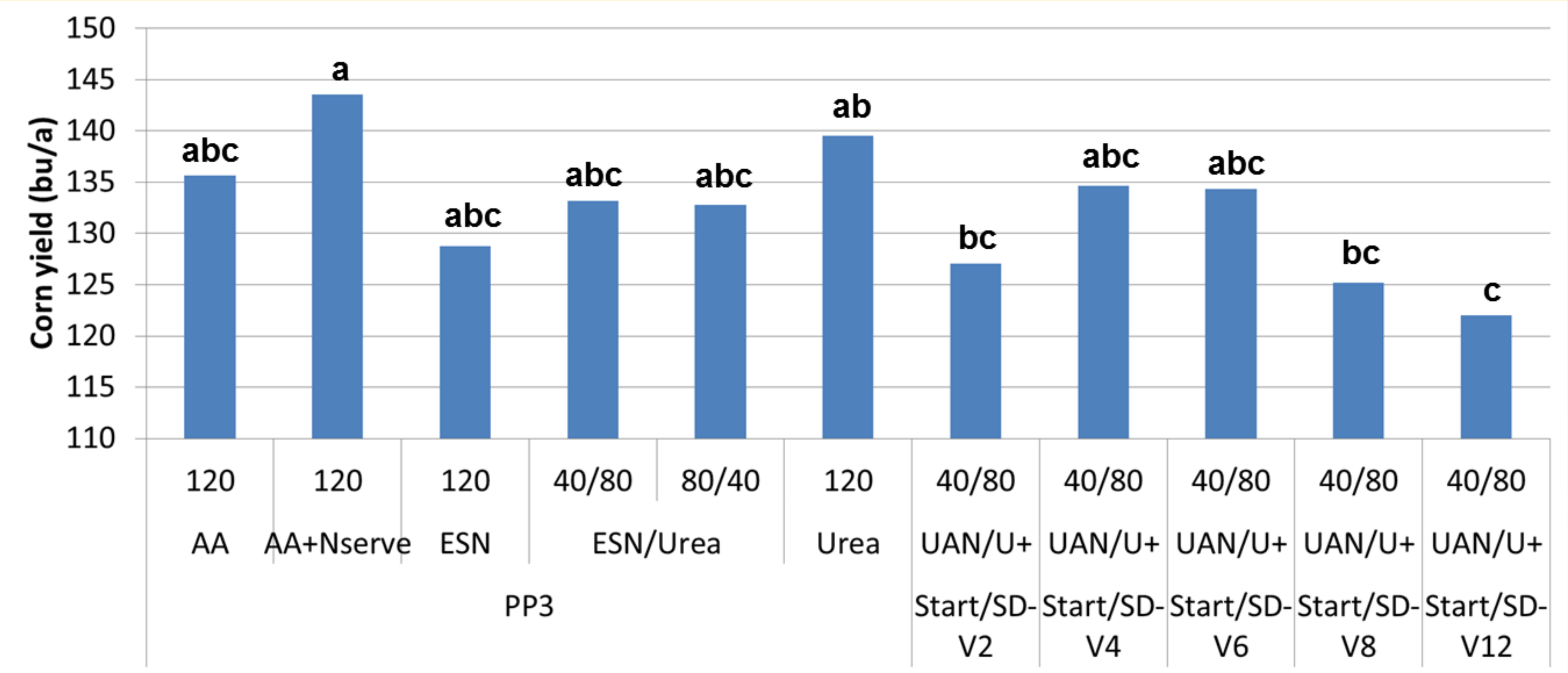
Using Canopy Sensors

- The earlier the sensing the greater the flexibility to apply nitrogen, BUT
- The earlier the sensing the lesser the predictive power
- The later the sensing the greater the predictive power, BUT
- The later the sensing the lesser the flexibility to apply nitrogen and greater potential for yield loss

Anhydrous Ammonia Timing (2-yr study)

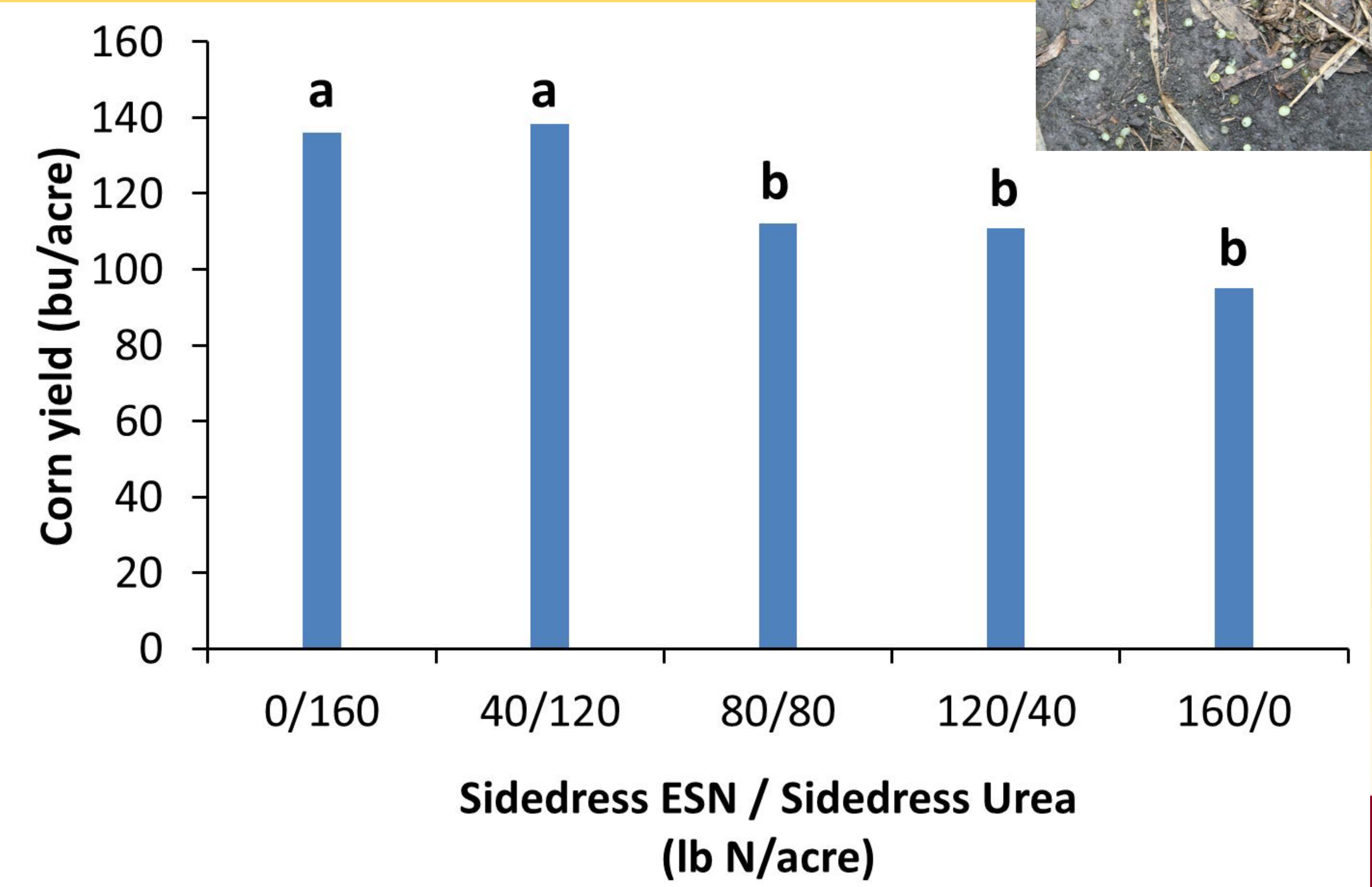


Lamberton, C-C



Ves loam soil

Yield at 160 lb N/acre, 2012



Take Home Message

- Let's be realistic:
- There are many tools in the toolbox but no silver bullets
- Rely on probability to determine what tool is best for the job realizing that often there are no perfect options
- Use Best Management Practices proven by years of unbiased research

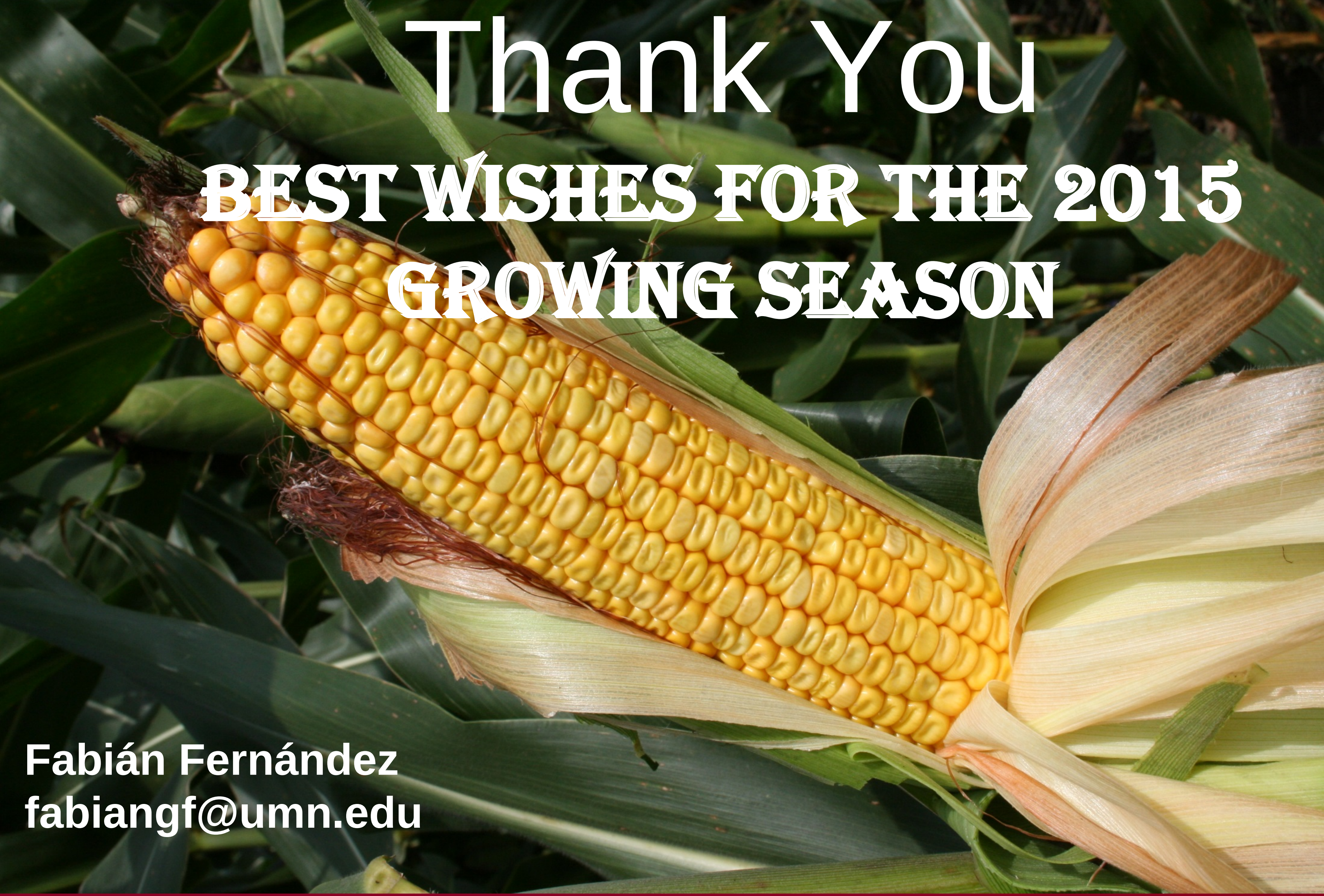
http://z.umn.edu/Nconference

Registration Opens at 8:00 am

Morning Sessions 9:00 am – 12:25pm		Speaker	Organization
9:00-9:05	Welcome	Dr. Fabián Fernández	University of Minnesota
9:05-9:55	Nitrogen Market Update	Dr. Robert Mullen	Potash Corp
9:55-10:45	Climate Trends And Their Implications	Dr. Mark Seeley	University of Minnesota
10:45-11:35	Irrigated Corn N Guidelines - What Are They And Where Did They Come From?	Dr. John Lamb	University of Minnesota
11:35-12:25	Can We Protect Groundwater Supplies Beneath Our Outwash Sands?	Bruce Montgomery	Minnesota Department of Agriculture

12:25-1:15 Lunch *(provided by conference)*

Breakout Sessions 1:15 pm – 3:45 pm		Speaker	Organization
Breakout Session 1. Predicting Nitrogen In-Season			
1:15-2:05	Database-Driven Guidelines To Manage Nitrogen Rate Decisions	Dr. John Sawyer	Iowa State University
2:05-2:55	Utility Of Sensor Technology For Making In-Season Recommendations For N	Dr. Daniel Kaiser	University of Minnesota
2:55-3:45	Opportunities And Challenges When Applying Nitrogen In-Season	Dr. Fabián Fernández	University of Minnesota
Breakout Session 2. Nitrogen Credits			
1:15-2:05	Manure Management To Minimize Nitrogen Loss And Improve Crop Use Efficiency	Kevan Klingberg	University of Wisconsin
2:05-2:55	Nitrogen Management For First- And Second-Year Corn Following Alfalfa	Dr. Jeffrey Coulter	University of Minnesota
2:55-3:45	Interseeded Cover Crops In Corn-Based Cropping Systems	Dr. Scott Wells	University of Minnesota
Breakout Session 3. Nitrogen Management for Sandy Soils			
1:15-2:05	Nitrogen Fertilizer Use Efficiency For Corn And Its Relationship To Groundwater Quality	Dr. Richard Ferguson	University of Nebraska
2:05-2:55	Evaluation Of Nitrogen Technologies For Sandy Soils	Dr. Carl Rosen	University of Minnesota
2:55-3:45	Fertigation As A Management Tool In Irrigated Corn	Joshua Stamper	University of Minnesota



Thank You

Best Wishes for the 2015 Growing Season

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