Management Practices to Minimize Urea Volatilization

Malta, MT November 16, 2010

Snowed out, given by streaming video in Feb 2011

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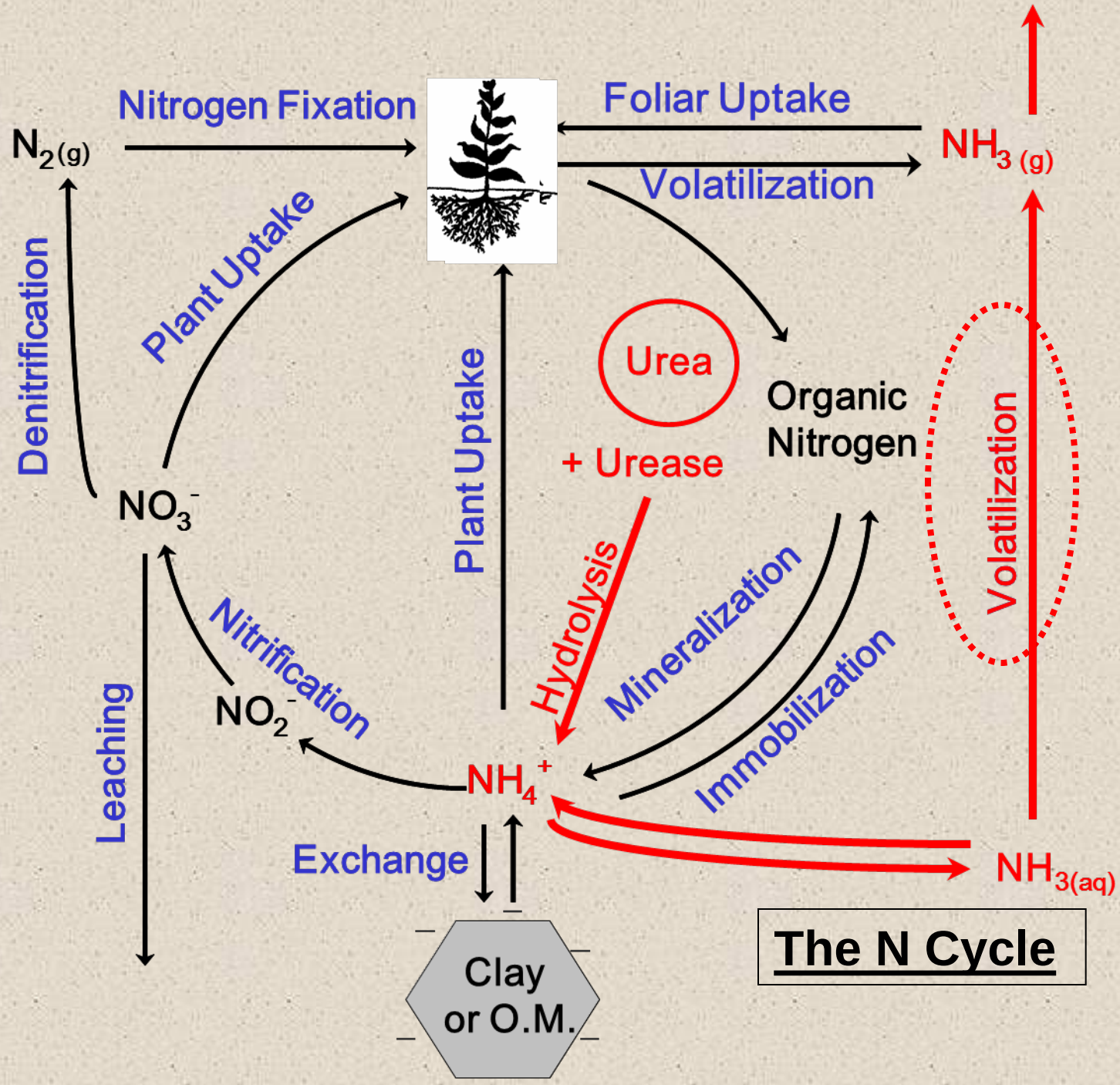
MONTANA STATE UNIVERSITY EXTENSION

AGRICULTURE

MAKING A DIFFERENCE IN MONTANA COMMUNITIES

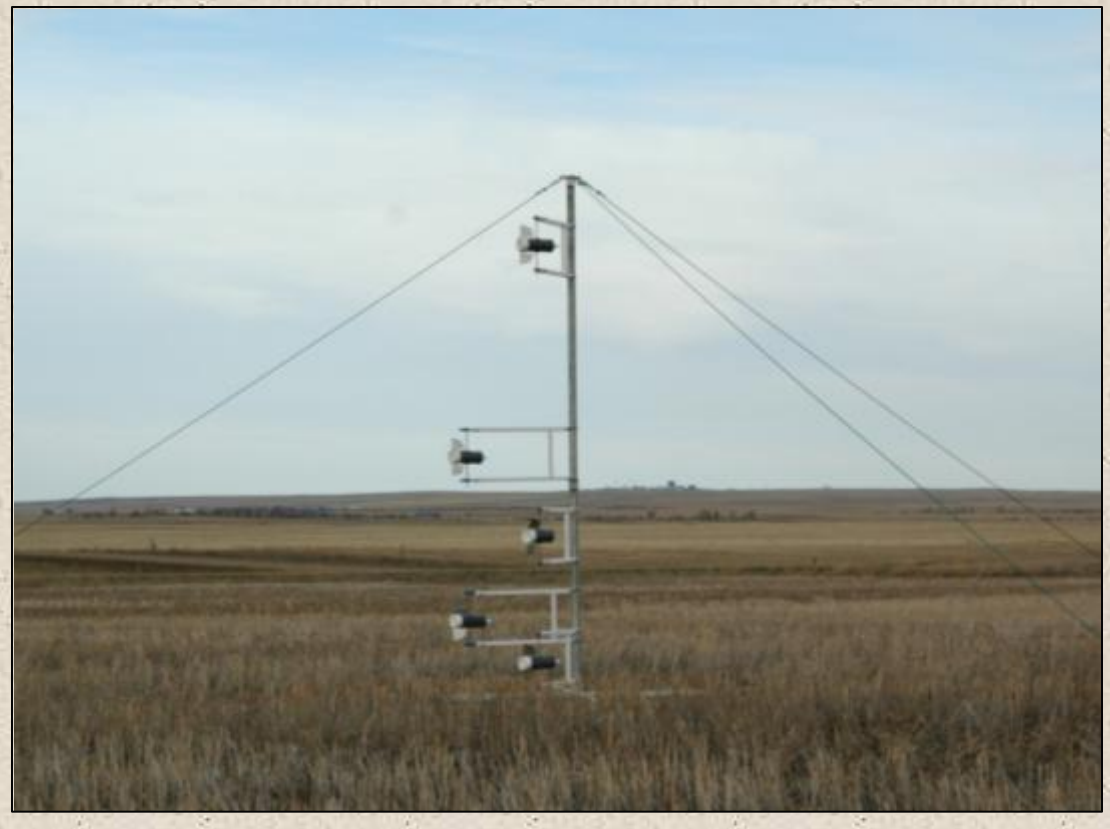

Nitrogen Fixation
$N_{2(g)}$
Foliar Uptake
$NH_{3\,(g)}$
Volatilization
Denitrification
Plant Uptake
Plant Uptake
Urea
+ Urease
Organic Nitrogen
Volatilization
NO_3^-
Hydrolysis
Mineralization
Immobilization
Nitrification
NO_2^-
Leaching
NH_4^+
Exchange
$NH_{3(aq)}$
Clay or O.M.
The N Cycle

Factors Increasing Volatilization

1. High Soil pH and Temperature
2. Windy
3. Low Cation Exchange Capacity (CEC). WHY?
4. Low buffering capacity (resistance to pH change)
5. High soil moisture/humidity
6. Little Rainfall/Irrigation following fertilization
7. High Ground cover/vegetation/residue. WHY?
8. Low Soluble and Exchangeable Calcium

Bottom line: Large number of factors make volatilization amounts VARIABLE and difficult to predict.

A first look at ammonia volatilization losses from surface-applied urea



Richard Engel, Clain Jones, Jeff Whitmus
Montana State University

Project Objectives

- How much N as ammonia are we losing from applications of surface urea (fall, winter, and early spring)?
- Is this a significant economic loss to Montana producer?
- If losses are significant, then how do we mitigate losses?

Research approach

- conduct on-farm trials – no till systems
- focus on Triangle Region
- diversity of soils (texture, pH)
- ammonia emissions quantified over 8-wk gas sampling campaign following fertilization (urea, NBPT-coated urea)

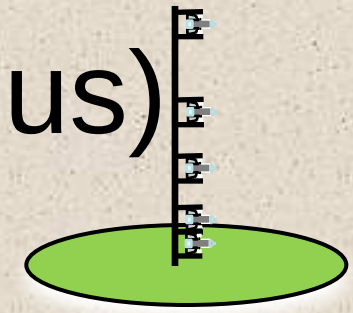
Integrated horizontal flux method

- preferred approach for quantifying gas loss
- moderate size plots (~0.3 acre)
- continuous measurement of ammonia loss over time

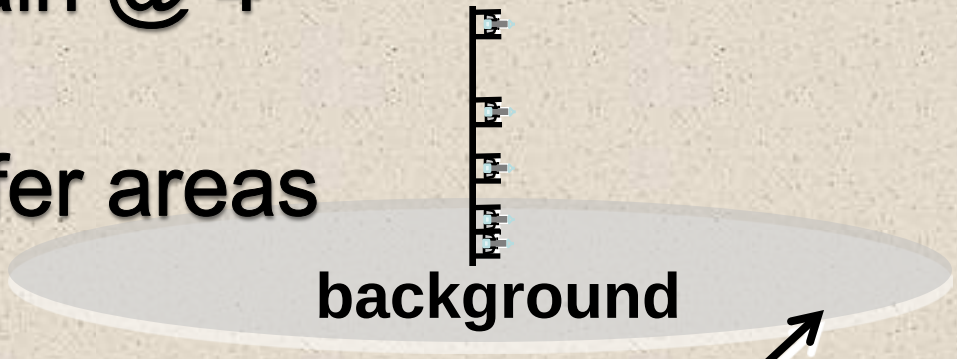
mast and shuttles ➡

Circular plots (22 yard radius)

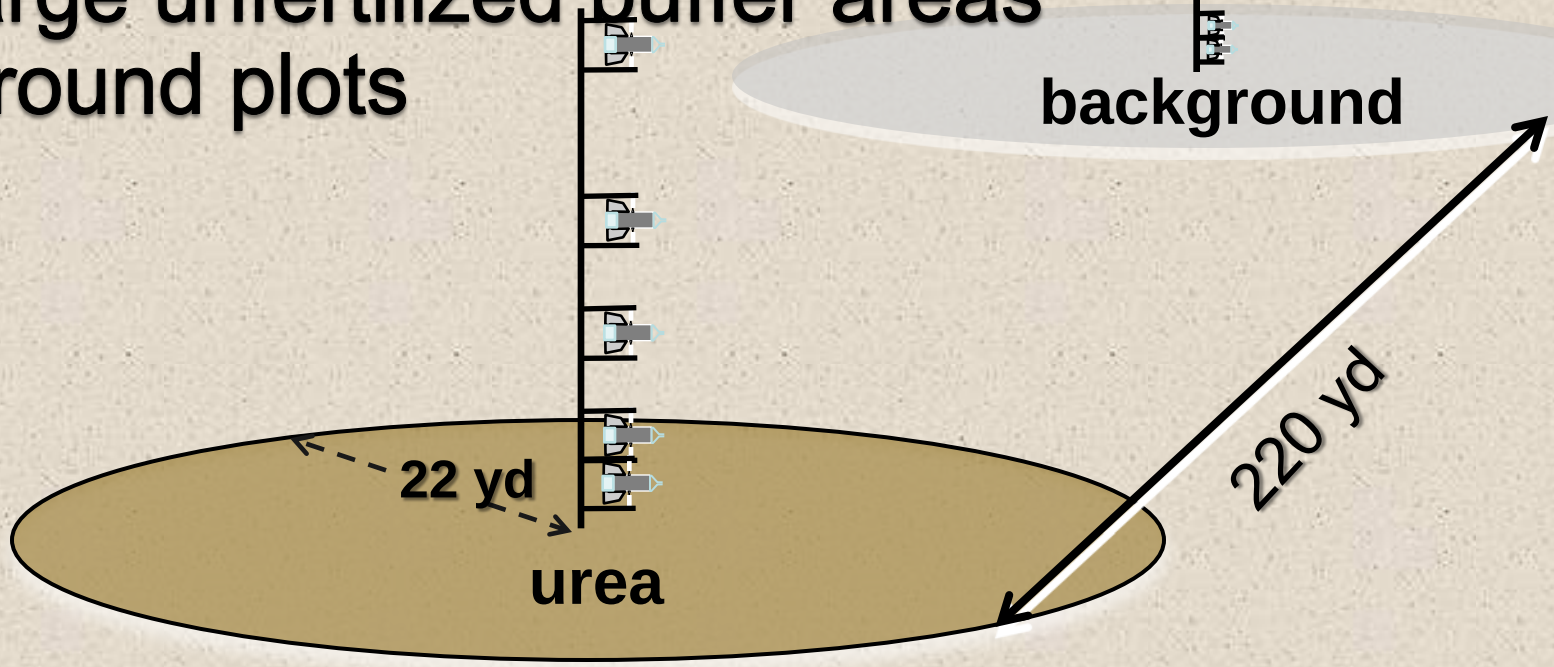
- urea (90 lbs N/acre)
- urea + NBPT (Agrotain @ 4 quarts/ton)
- large unfertilized buffer areas around plots



urea + NBPT

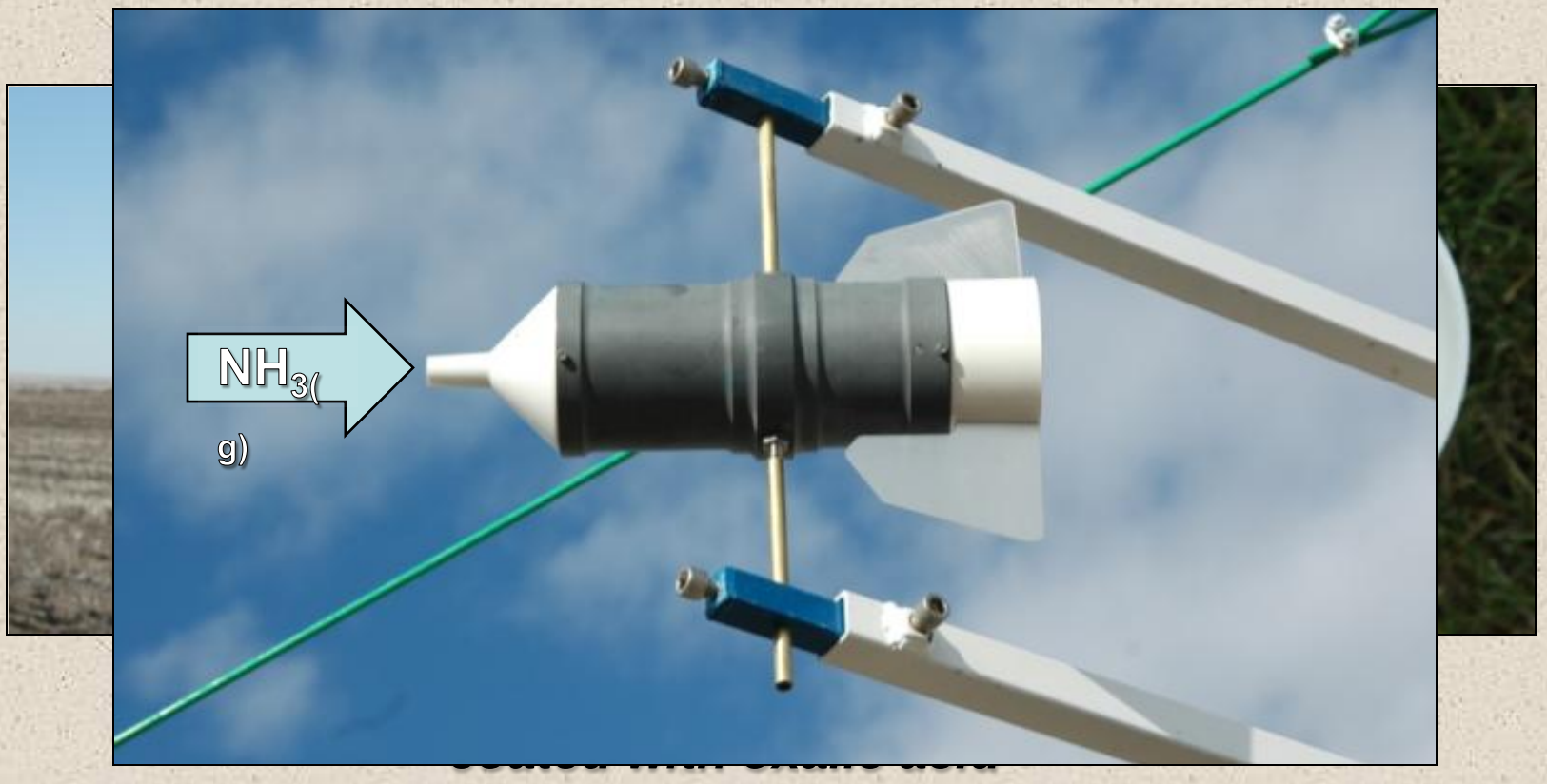


background



Shuttles

- traps for collecting ammonia, idea & design developed in Australia (Leuning et al., 1985. Atmos. Environ)



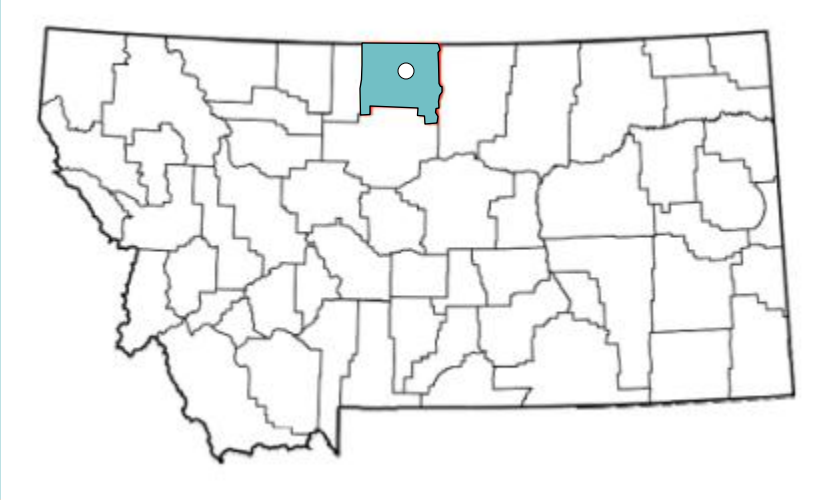
rotate on pivot & face into wind

Two examples of field trial results from west Havre field site (Kaercher farm)

- Hill County
- Phillips-Elloam silt loam
- pH 6.0
- no till winter wheat
- Campaigns 2 and 5 - conducted in the identical field

Campaign 2: October 9, 2008.
Air temp = 45 F, Soil temp = 43 F

Campaign 5: March 26, 2009. Air temp = 21 F, Soil temp = 34 F



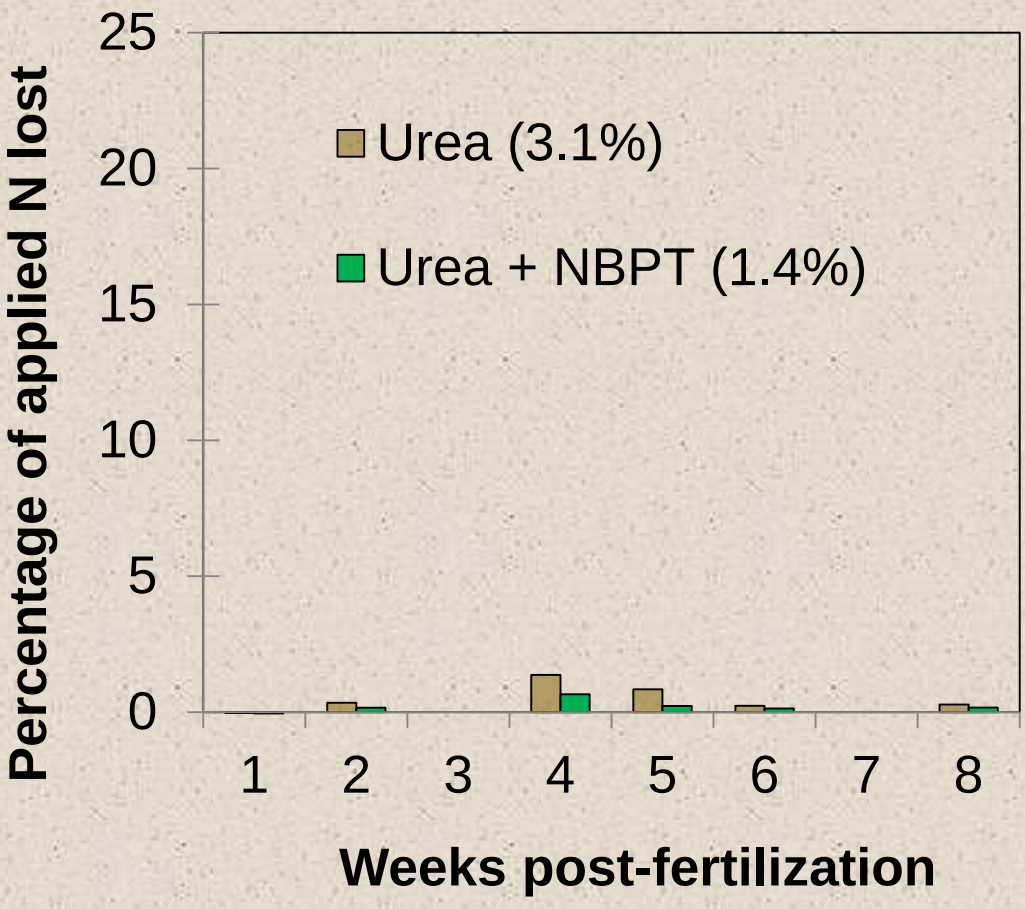
Questions so far?

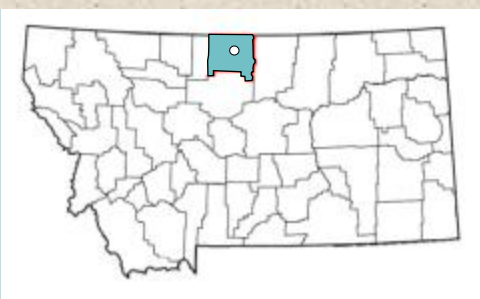
Campaign #2 – low NH_3 losses observed

- October 9, 2008 application, air-temp. 45 °F, dry soil surface
- no rain for 24 days and then Nov. 2-5 field site received 0.98”ppt.

1 wk post-fertilization
prills not dissolved

Campaign #2 - Kaercher farm

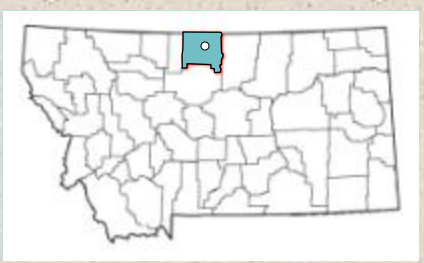




Mean Air Temp ~ 42 F

Mean Soil Temp ~ 41 F

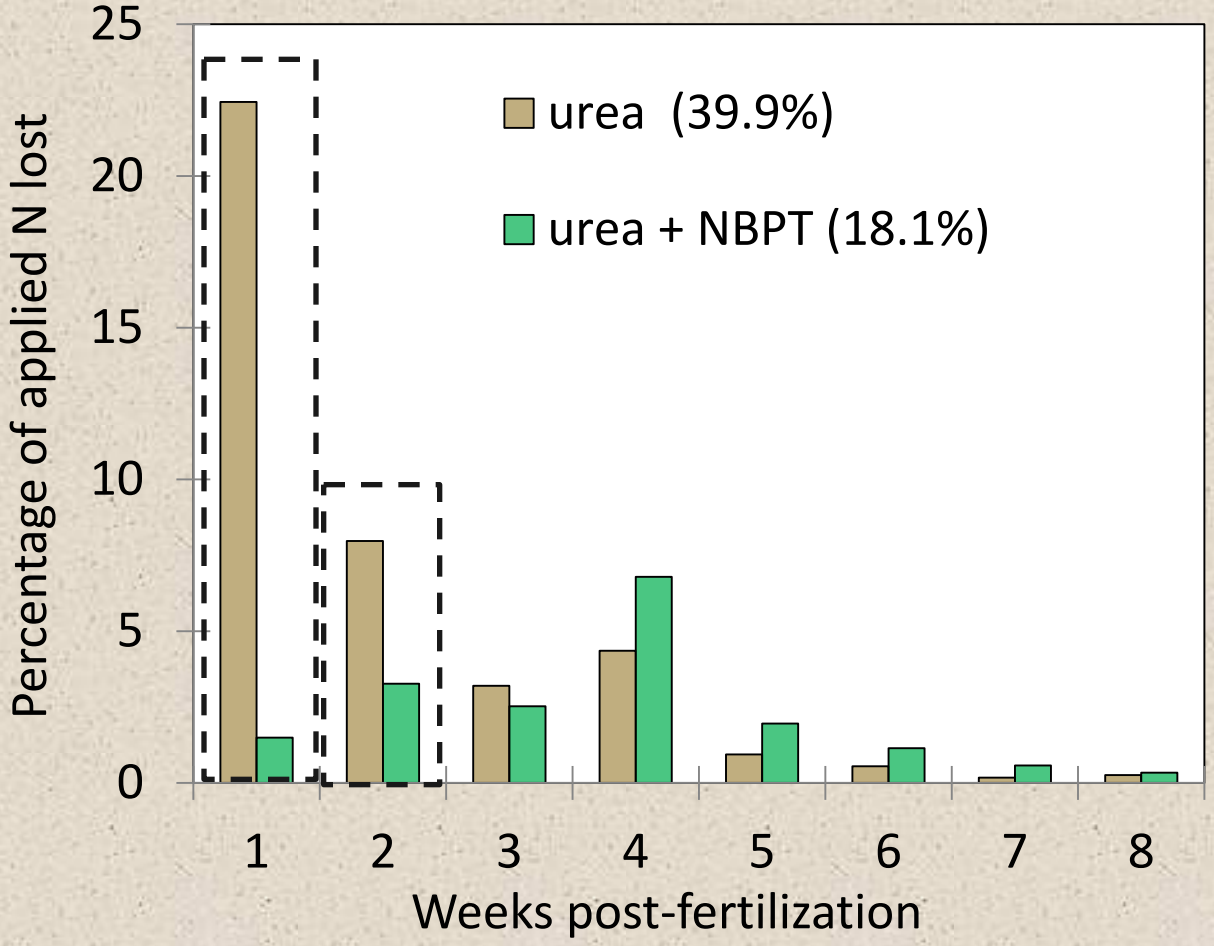
Campaign #5 - high NH_3 losses observed



Fertilizer applied on Mar 26, 2009 light snow on soil surface and air temp = 21 F

soil surface with fertilizer prills beginning to dissolve

Campaign #5 - Kaercher farm



Precipitation

no rain 0-2 wks

1.54" 2-8 wks

Mean temperature

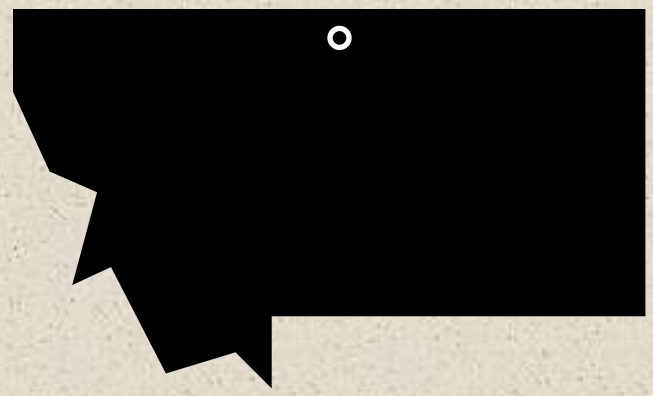
Soil = 38 °F

Air = 39 °F

Conclusion: High losses observed even though temperatures were cold!

Peterson farm site - background

- 28 miles NW of Havre
- Telstad-Joplin loam
- pH 5.5
- no till winter wheat
- Campaigns 3, 4, and 8

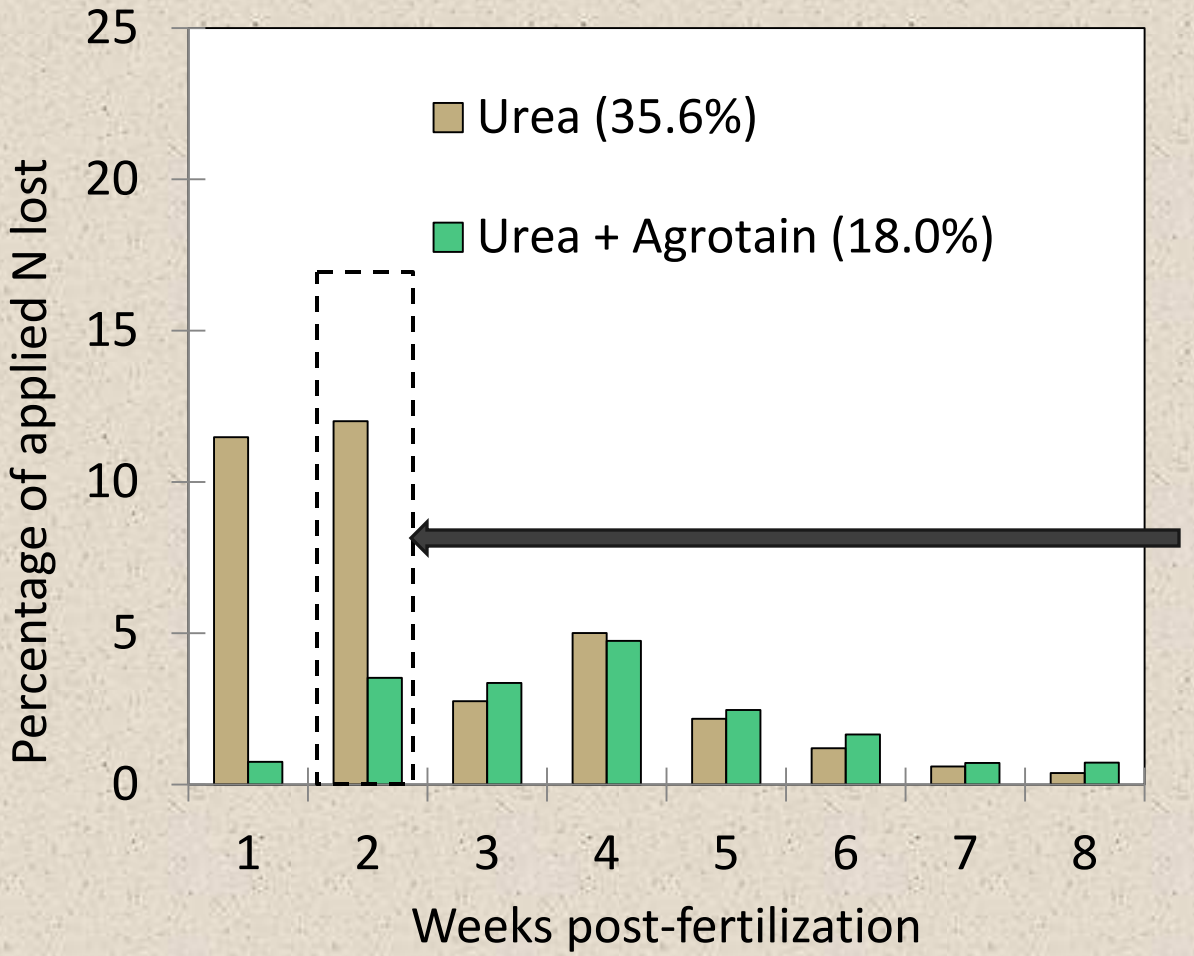


Campaign #4 – Peterson farm

Fertilized applied – March 25, 2009
"light snow & air-temp. 18 °F"

soil surface frozen, 30 °F

Campaign #4 –Peterson farm



Precipitation

0.01” = 0-2 wks

0.89” = 2-8 wks

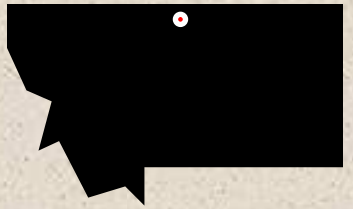
Soil temp = 30 F

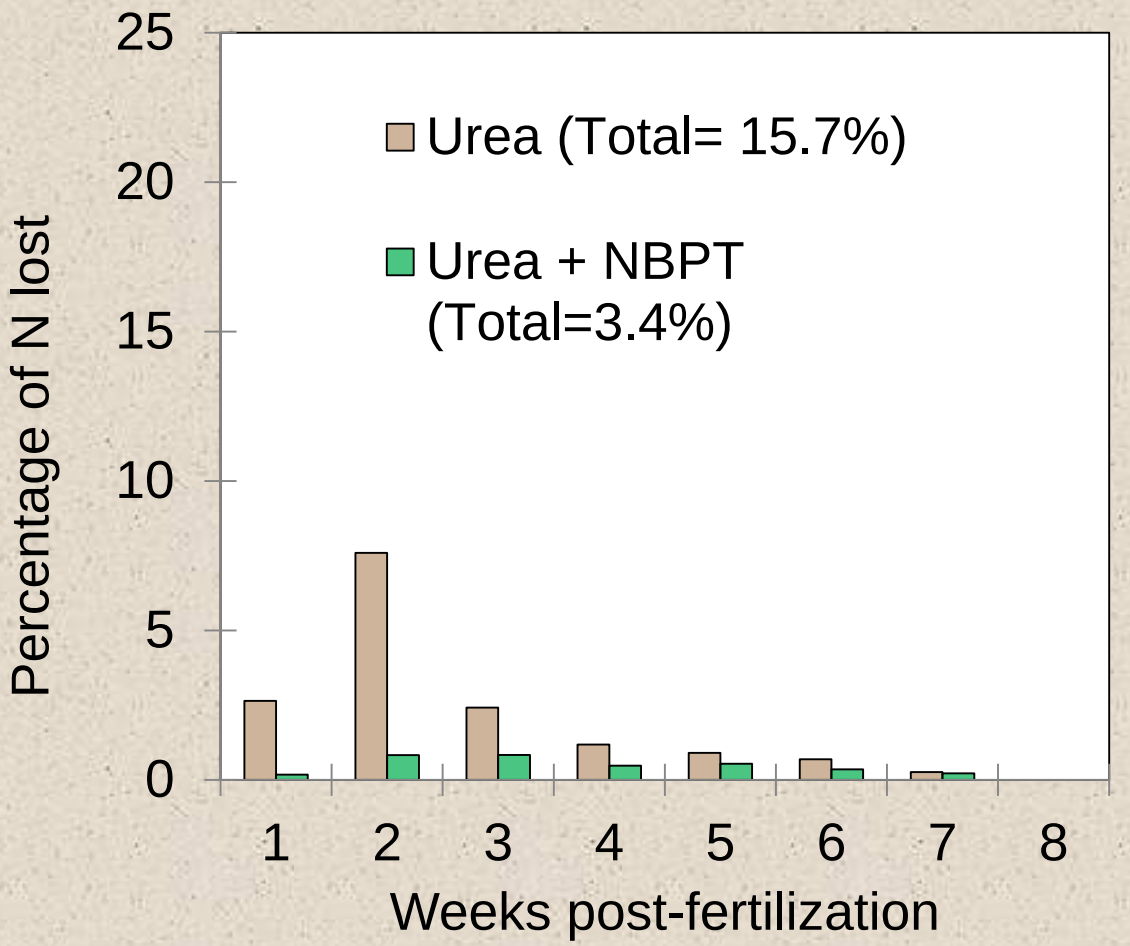
Air temp. = 18 F

Campaign #8 – Peterson farm

Fertilizer applied - October 19, 2009
air-temperature = 43 °F
soil surface dry

Campaign #8 – Peterson farm





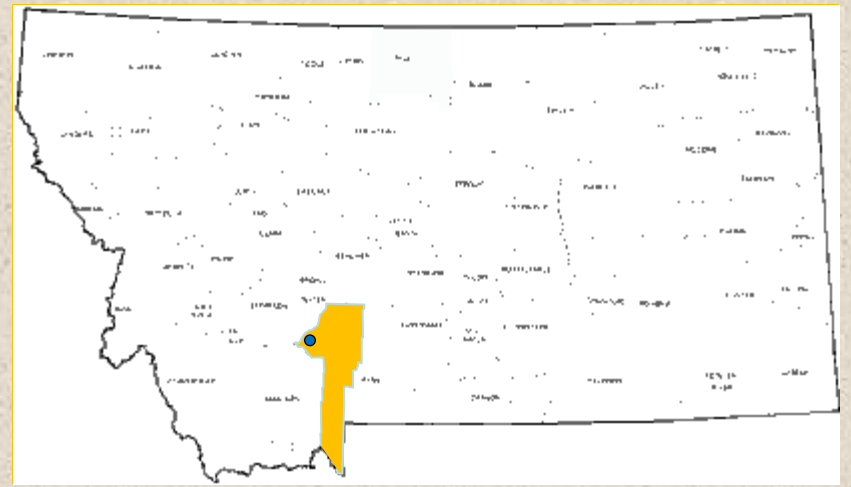
Precipitation

only 0.25” over 8 wks
(7-8 days post-fertilization)

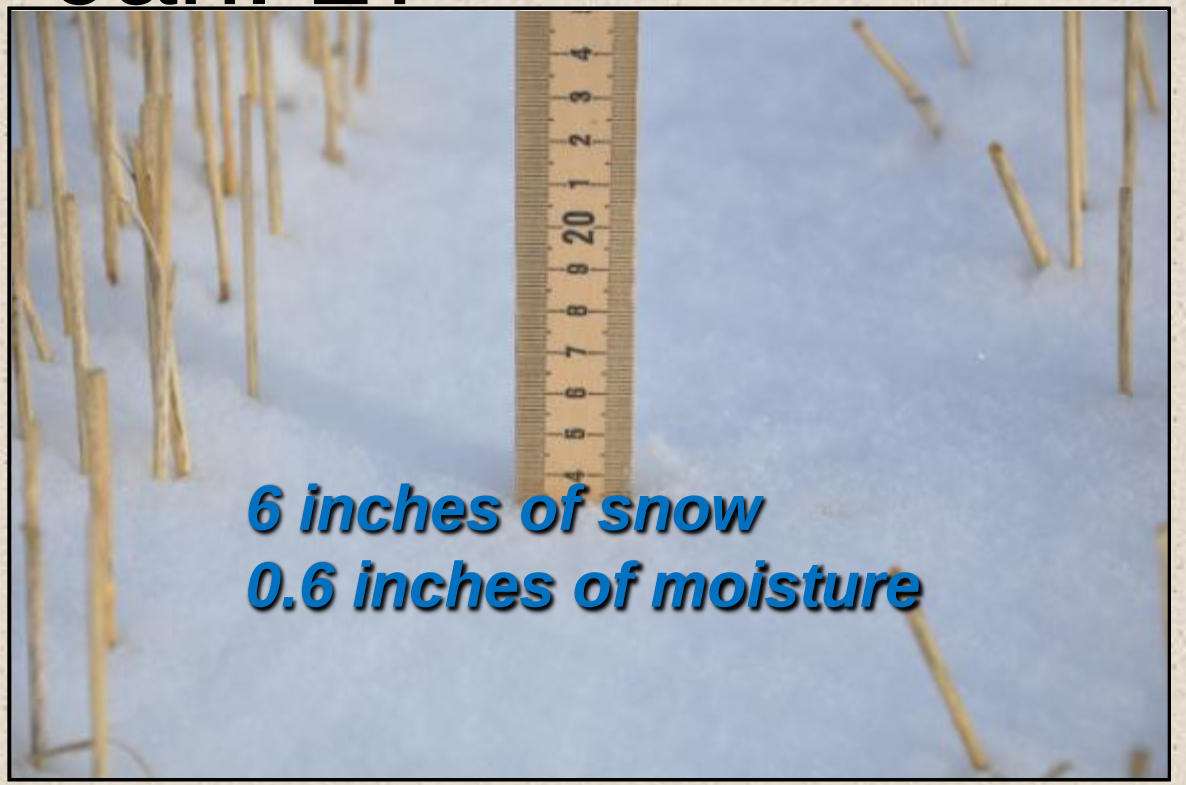
Questions so far?

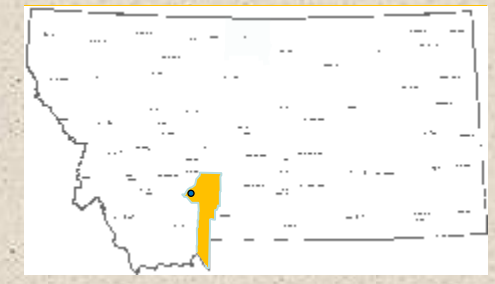
Campaign 9 & 10 – Willow Creek Brocko silt loam

Calcareous soil, pH 8.3

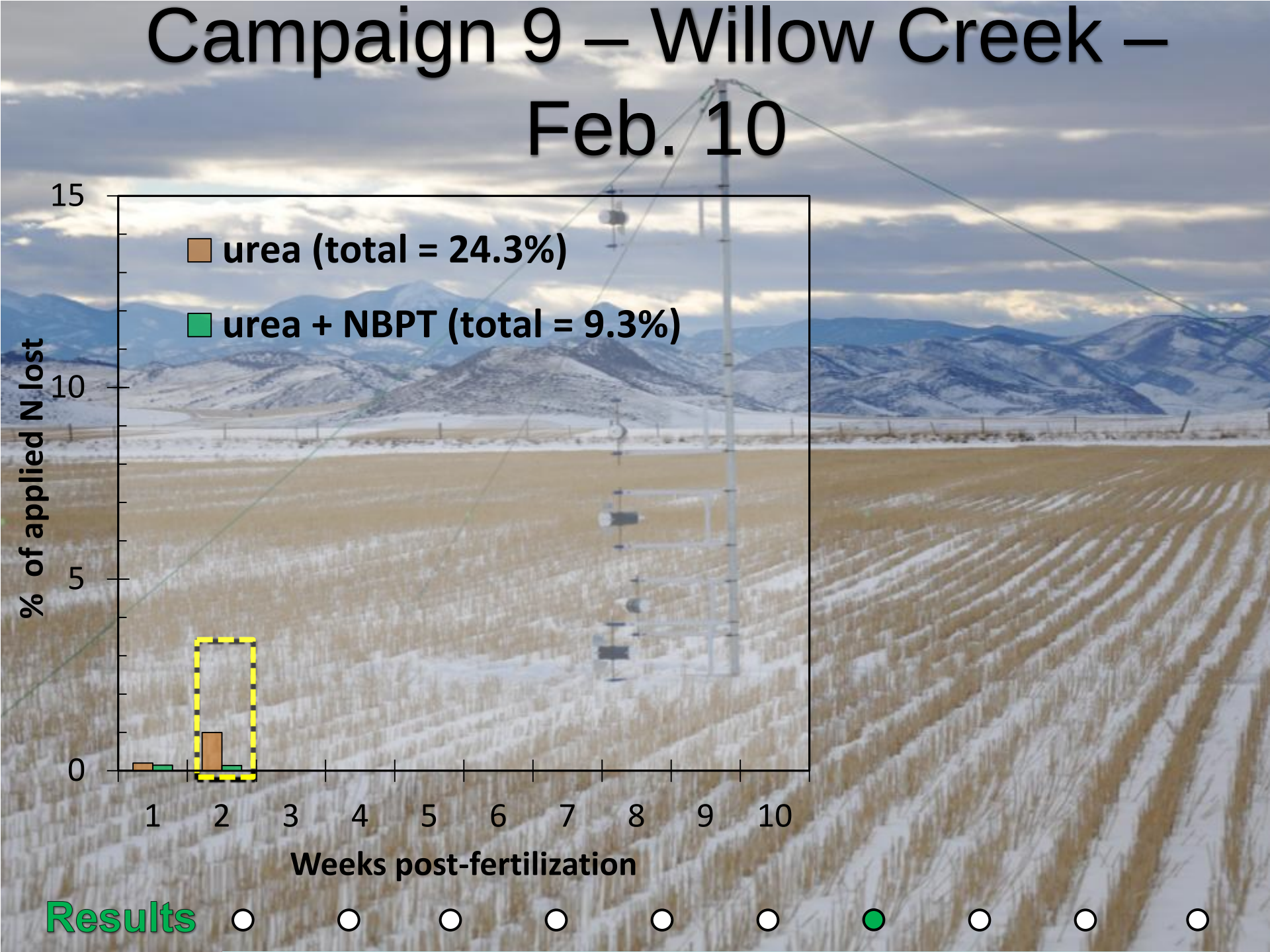


Campaign 9 – Willow Creek – Jan. 27



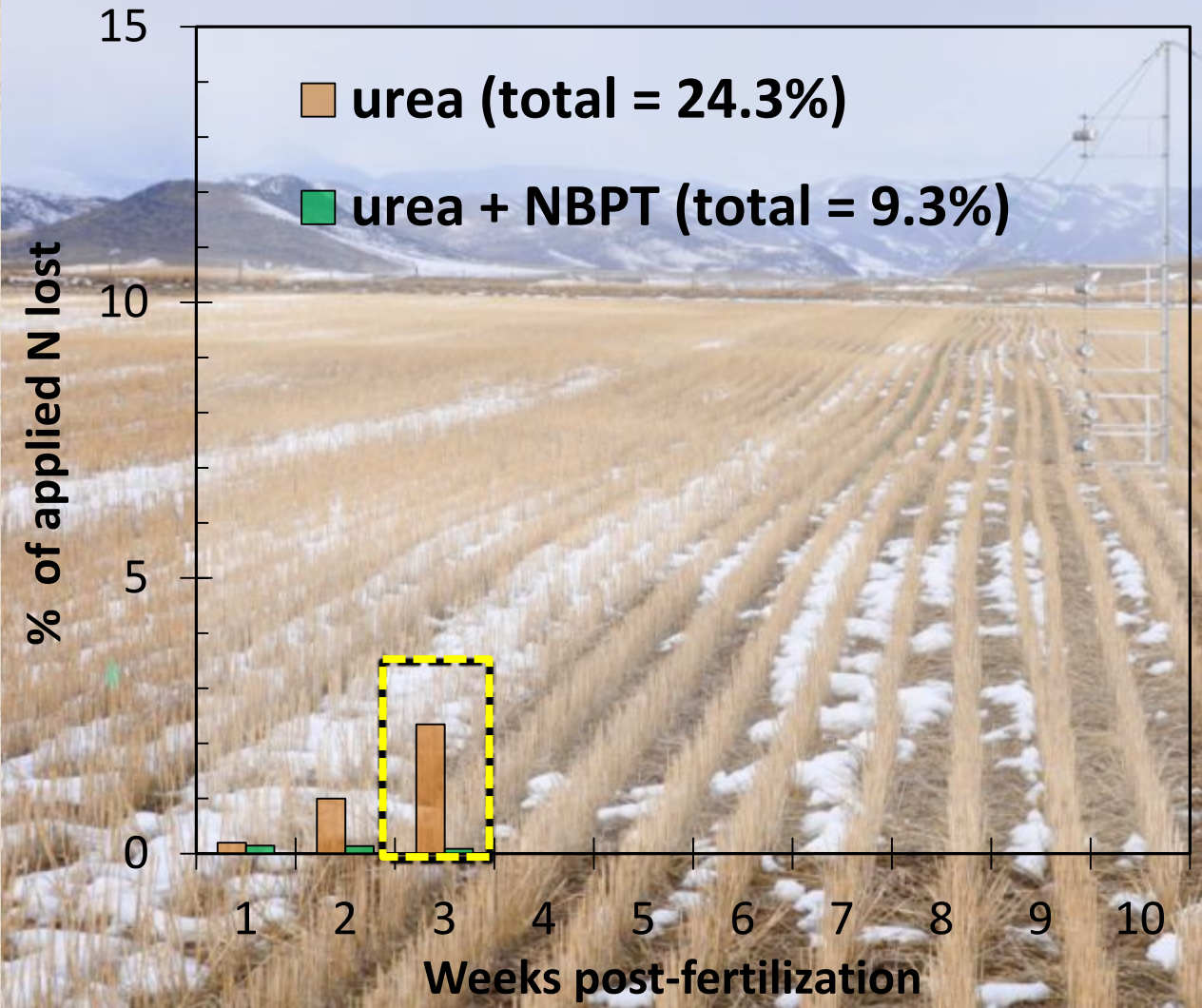


Campaign 9 – Willow Creek – Feb. 10



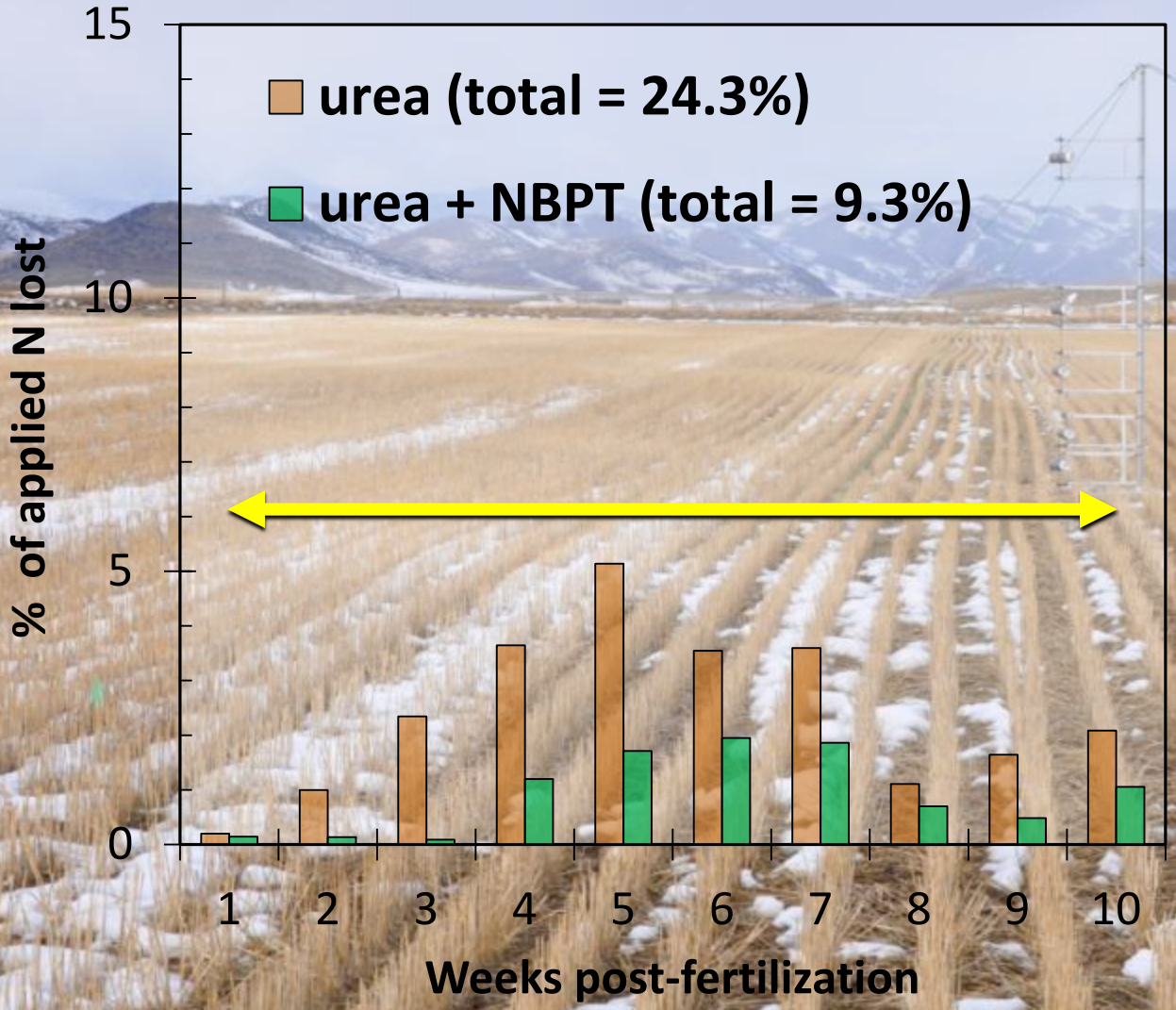
Results

Campaign 9 – Willow Creek – Feb. 17

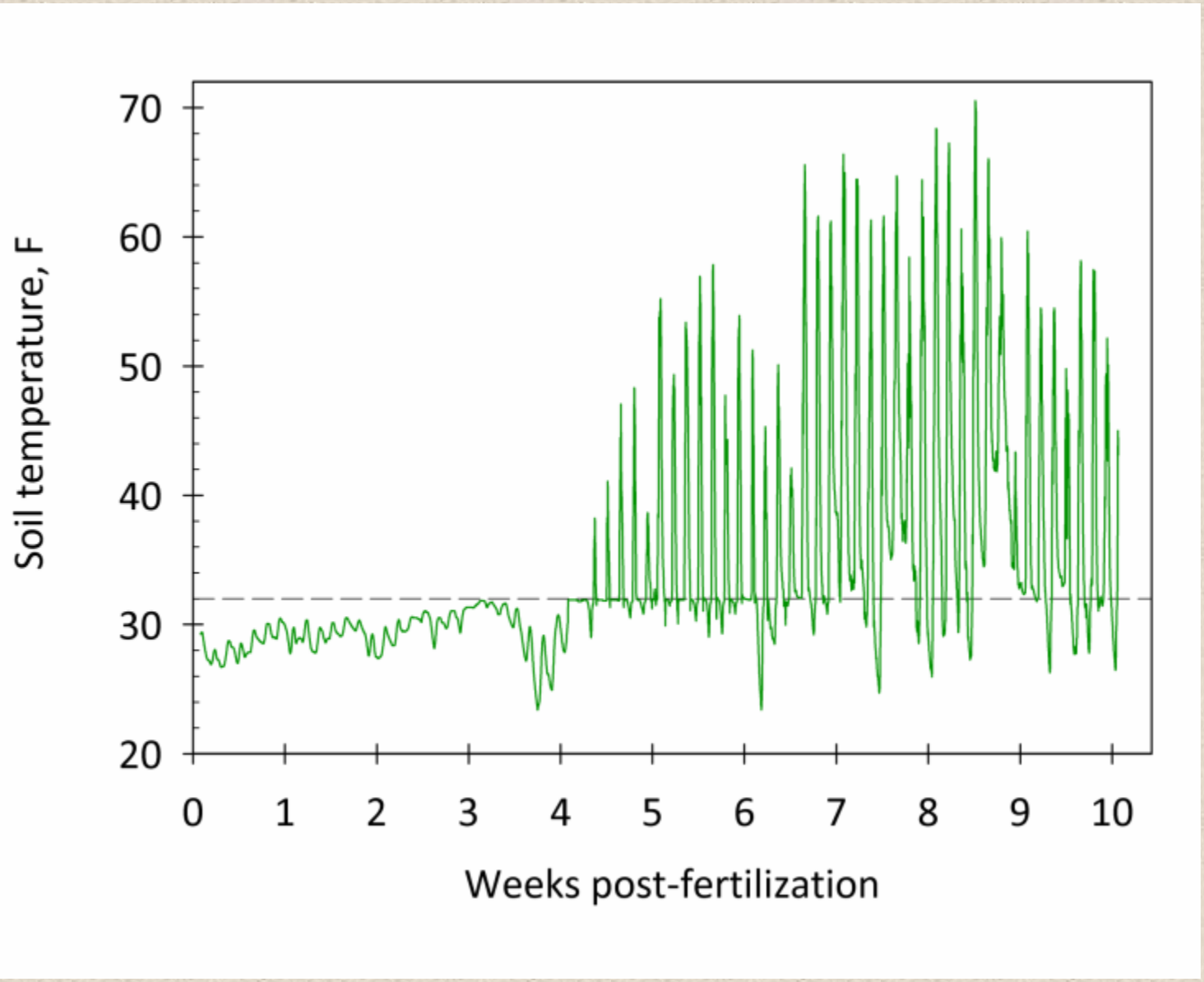


- no runoff

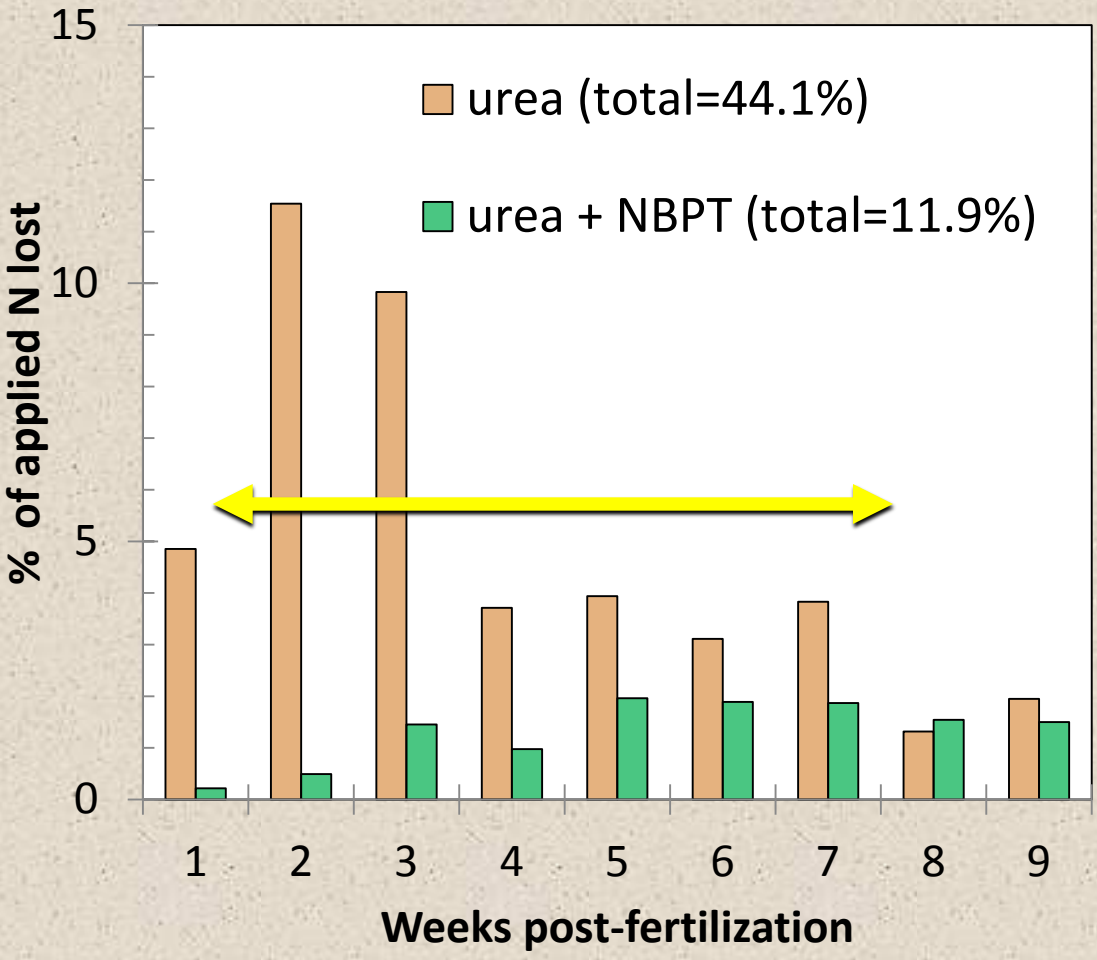
Campaign 9 – Willow Creek – Feb. 17



- no runoff
- NBPT < urea (10 wks activity)


Soil temperature, F
70
60
50
40
30
20
0
1
2
3
4
5
6
7
8
9
10
Weeks post-fertilization

Campaign 10 – Willow Creek



- ***Feb 26 application (no snow)***
- ***ppt (0-9 wks) = 0.9 inches***
- ***NBPT - 7 wks activity***

Campaign Summary (% N loss)

Campaign	Fertilization date	Urea	NBPT-urea
1	April 3, 2008	8.4	4.4
2	Oct 8, 2008	3.1	1.4
3	Nov 14, 2008	31.5	4.0
4	March 25, 2009	35.6	18.0
5	March 26, 2009	39.9	18.1
6	Oct 6, 2009	10.7	3.3
7	Oct 13, 2009	10.4	4.8
8	Oct 19, 2009	15.7	3.4
9	Jan 27, 2010	24.3	9.3
10	Feb 26, 2010	44.1	11.9
11	March 29, 2010	6.3	1.7
12	April 20, 2010	14.7	1.4
Average		**20.4**	**6.8**

wide range in N loss amounts

http://landresources.montana.edu/ureavolatilization

Summary – take home messages

- ✓ Significant ammonia losses (30-40% of applied N) from surface-applied urea can occur even though soil temperatures are near freezing!
- ✓ Soil moisture conditions at surface that dissolve urea granules (i.e. prolonged damp) without rain promote high ammonia losses (*more common to find these conditions in MT during late fall or early spring*)
- ✓ NBPT (Agrotain) reduced losses 62% over untreated urea

Questions so far?

If ~20% of broadcast urea is lost, why didn't MT research from the 1990s show large yield/protein losses compared to ammonium nitrate and/or subsurface banding? (Jones et al. 2007)

1. Adequate precipitation may have occurred after application.

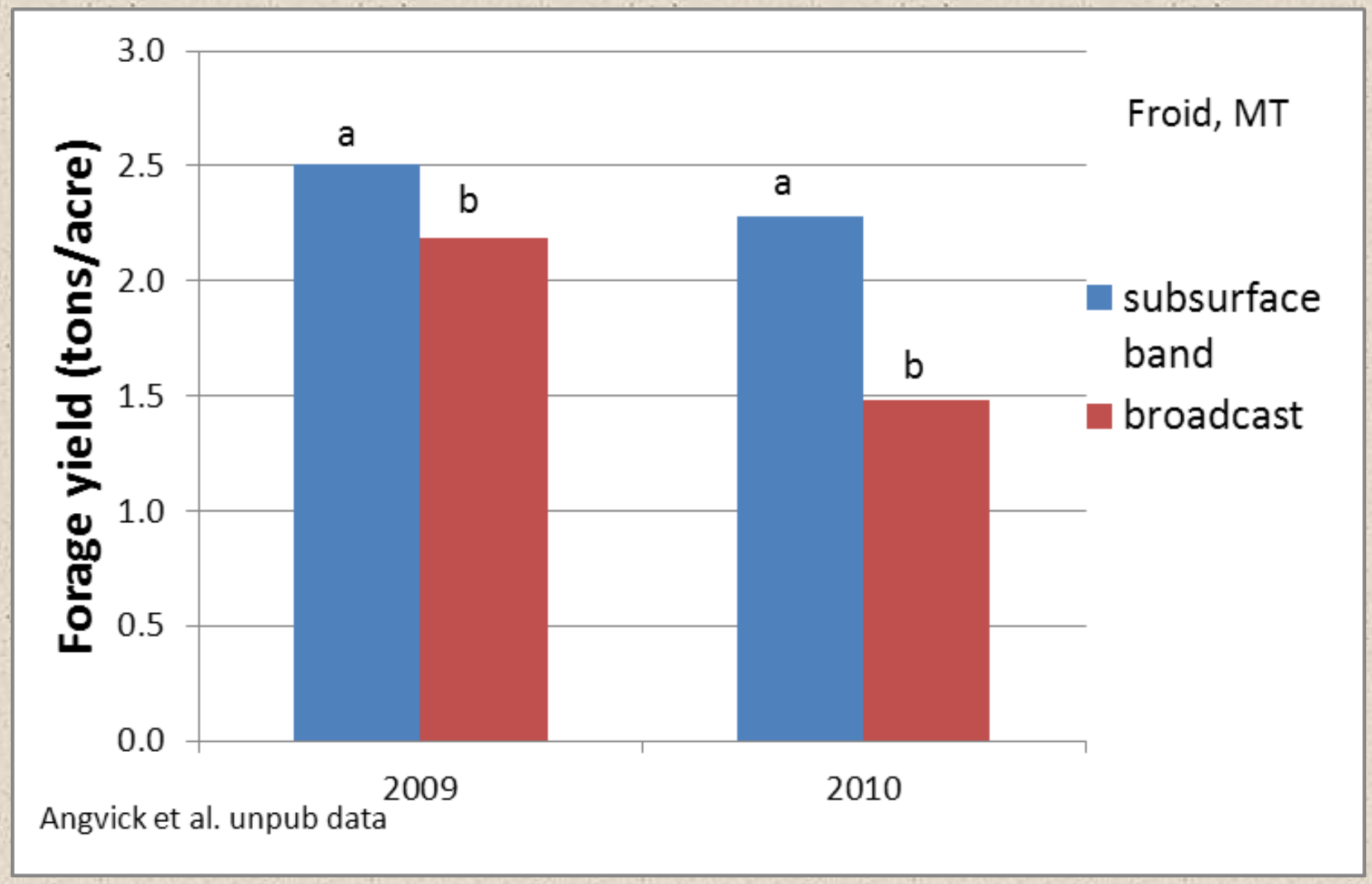
2. Urea takes 2 - 5 weeks to become available whereas AN is immediately available for plants and for other losses-urea's 'slow release' property may increase its efficiency, making up for loss.

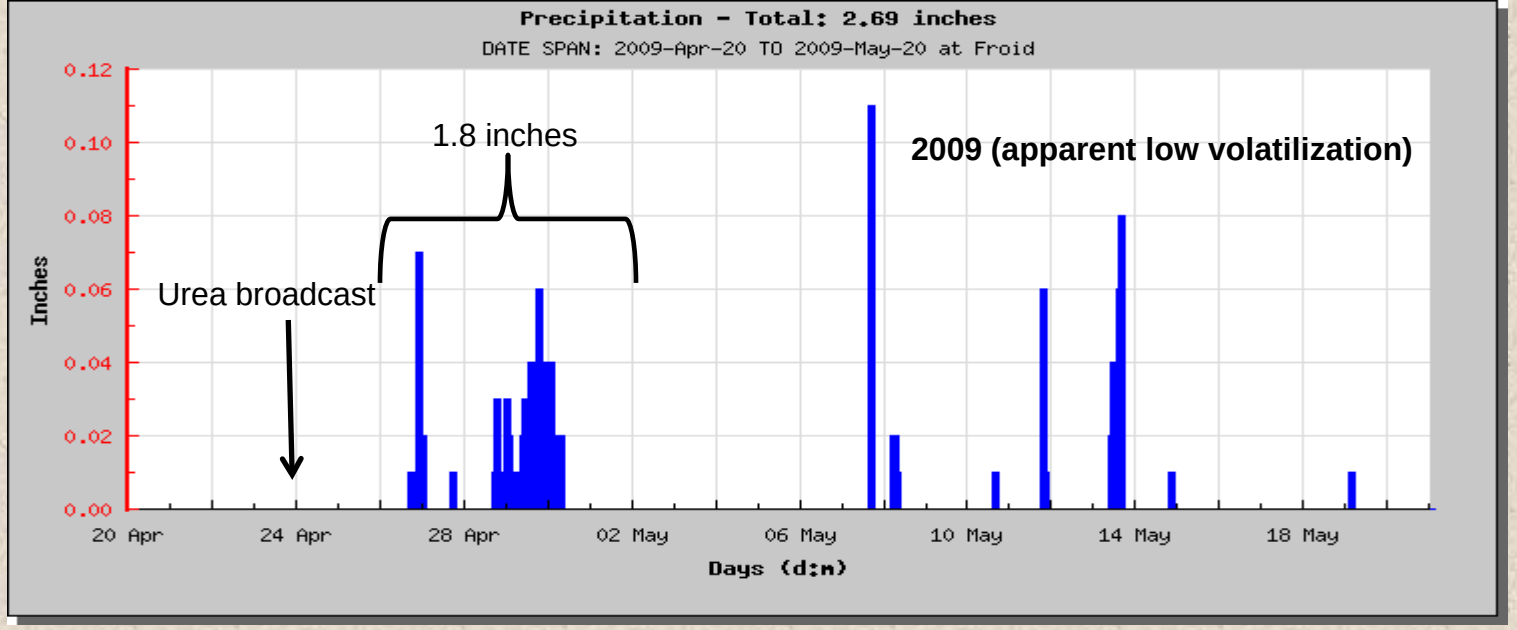
3. About 50% of N uptake comes from fertilizer (rest from soil). So 20% of 50% is 10% difference in N availability-might not make a statistically SIGNIFICANT difference (though still a bottom line difference).

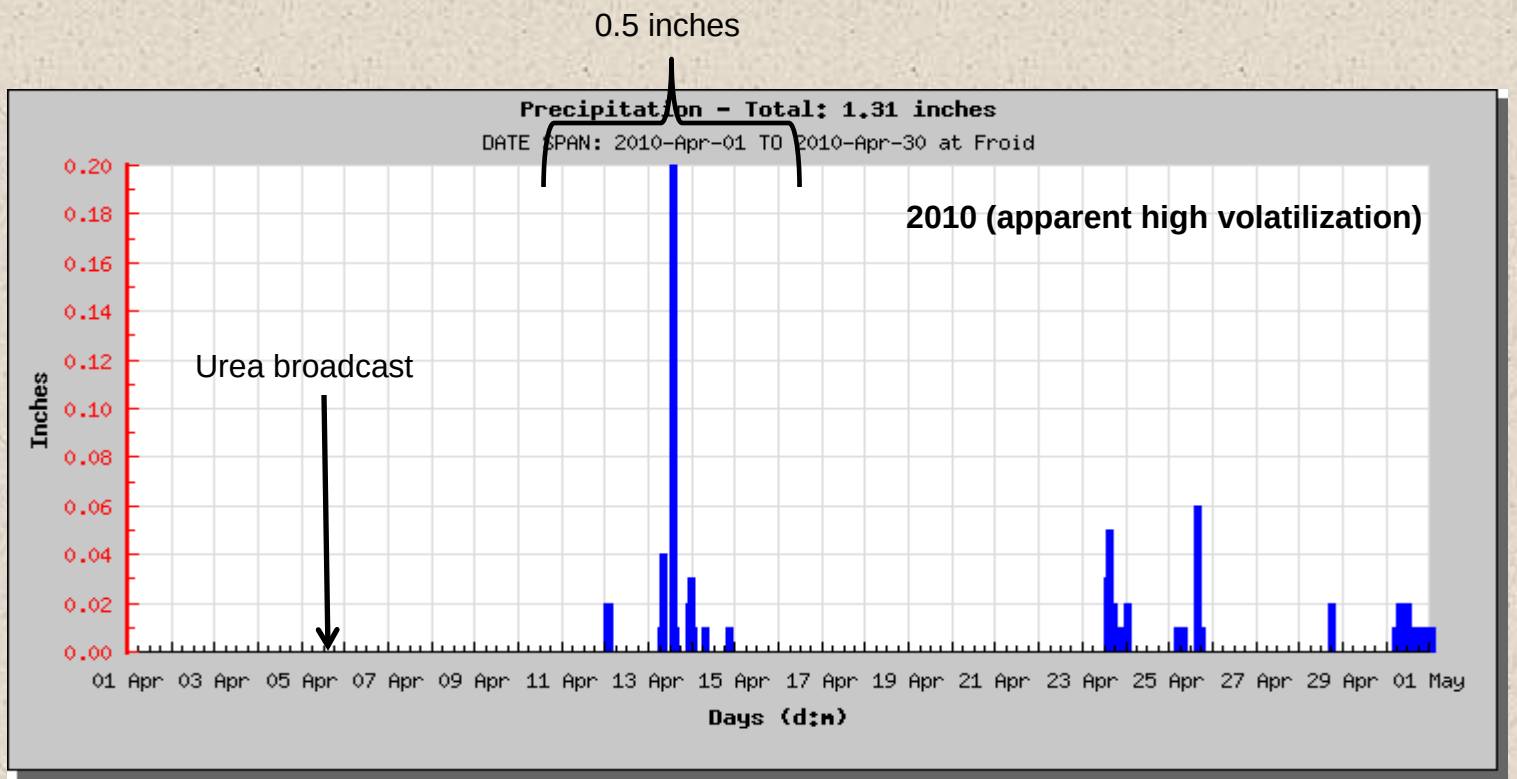
4. With longer term no-till could 'urease' enzyme concentrations have increased? It is known that residue contains more urease than bare soil.

5. With longer term no-till, some calcium has likely leached out of surface soil. Calcium is known to decrease volatilization and most source studies were conducted last decade.

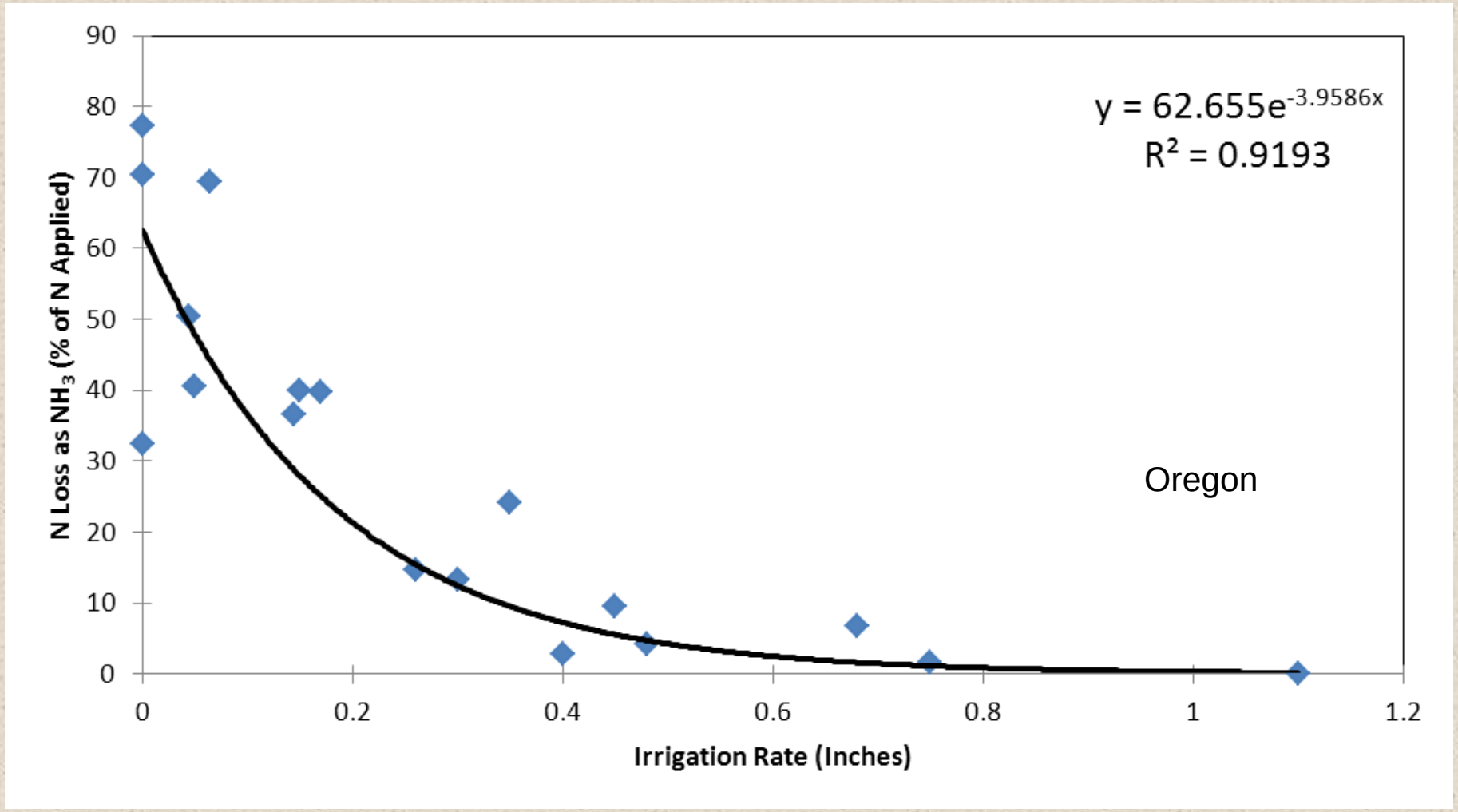
Effect of Urea Placement on Hays Annual Forage Yield



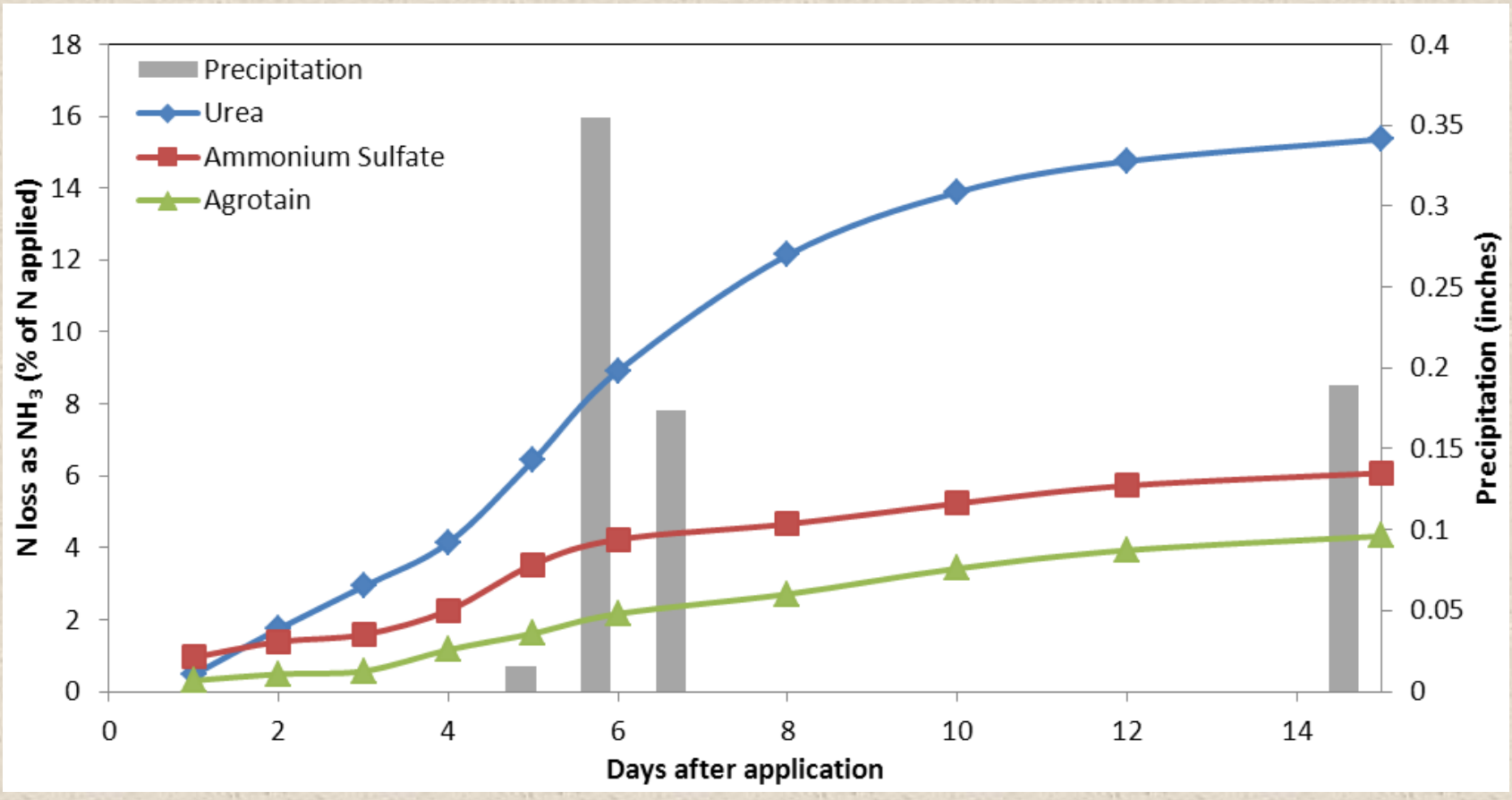

Precipitation - Total: 2.69 inches
DATE SPAN: 2009-Apr-20 TO 2009-May-20 at Froid
1.8 inches
2009 (apparent low volatilization)
Urea broadcast
Inches
0.12
0.10
0.08
0.06
0.04
0.02
0.00
20 Apr
24 Apr
28 Apr
02 May
06 May
10 May
14 May
18 May
Days (d:m)


0.5 inches
Precipitation - Total: 1.31 inches
DATE SPAN: 2010-Apr-01 TO 2010-Apr-30 at Froid
2010 (apparent high volatilization)
Urea broadcast
Inches
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
01 Apr
03 Apr
05 Apr
07 Apr
09 Apr
11 Apr
13 Apr
15 Apr
17 Apr
19 Apr
21 Apr
23 Apr
25 Apr
27 Apr
29 Apr
01 May
Days (d:m)

Effect of irrigation rate on urea volatilization (Horneck, unpub data)

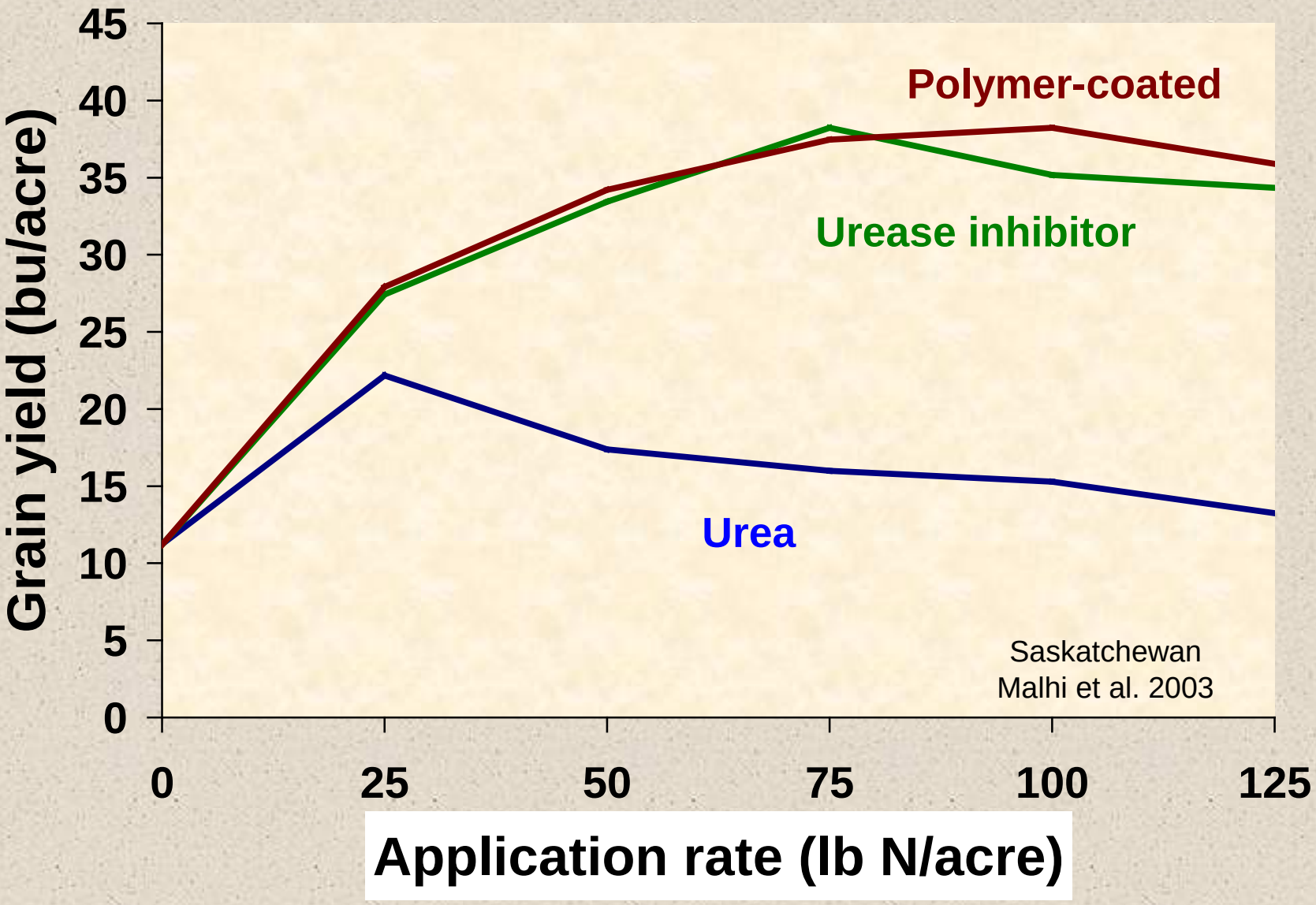


Does ½ inch of rain also stop volatilization? (Horneck unpub data)



Not if spread out over 3 days

Effect of N source applied with the seed on dryland spring wheat yield



What should you do to minimize volatilization?

1. Do not apply urea on moist ground UNLESS a snow or rainstorm is forecast to drop at least ½ inch of rain in a day. Preferably more (unlikely unfortunately!).
2. If you irrigate, apply ½ inch of irrigation after urea application.
3. Apply urea below the surface – either in a midrow band, 2 inches from the seed or with the seed with a 'protected' product.
4. Consider seeding right after urea application to cover some urea; wider openers will help with this. (We're currently testing effectiveness of this practice)
5. Consider using Agrotain or ammonium nitrate (if available) if can't apply during a low risk time.

Other Resources

- Soil Fertility information: http://landresources.montana.edu/soilfertility

Questions?