Maximizing Grain Protein and Revenue

Golden Triangle Crop School
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Objectives Today

- Discuss factors and practices that affect N losses
- Discuss how to select right rate, right source, right timing, right placement, and right rotation (5 Rs)
- Show research results on effects of practices on grain yield and protein

Potential losses

- Volatilization (ammonium → ammonia gas)
- Leaching
- Denitrification (nitrate → nitrogen gas)
- Immobilization (tie up by microbes; temporary)

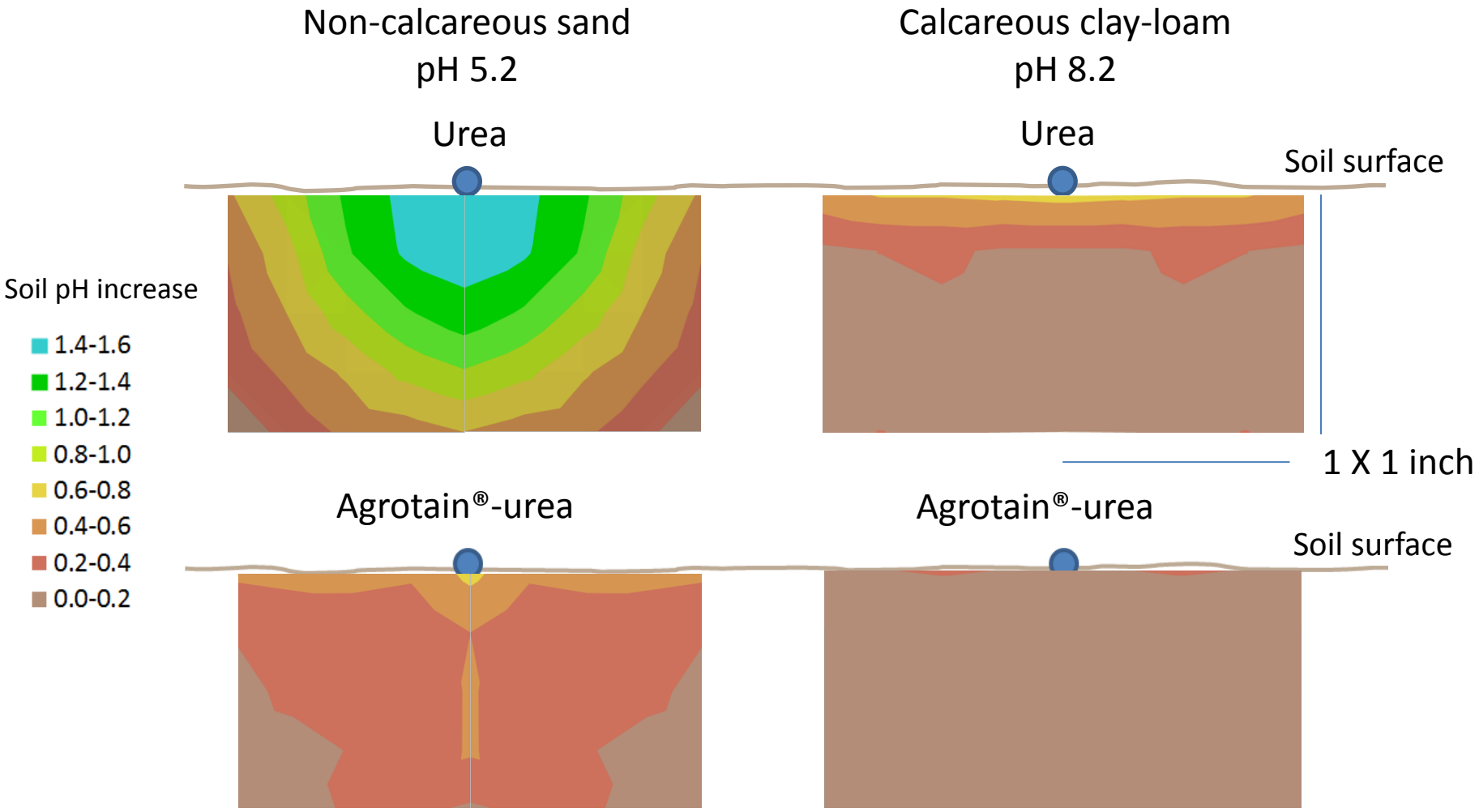
High risk conditions for urea volatilization

- Moist soil or heavy dew
- High soil pH (>7.0)
- High soil temperature (>70 °F) or frozen soil
- Crop residue, perennial thatch or sod
- Low cation exchange capacity soil (sandy)
- Poorly buffered soils (low soil organic matter, low bicarbonate content)

The risk of volatilization increases as the number of high risk conditions increase, with soil moisture likely being the most important.

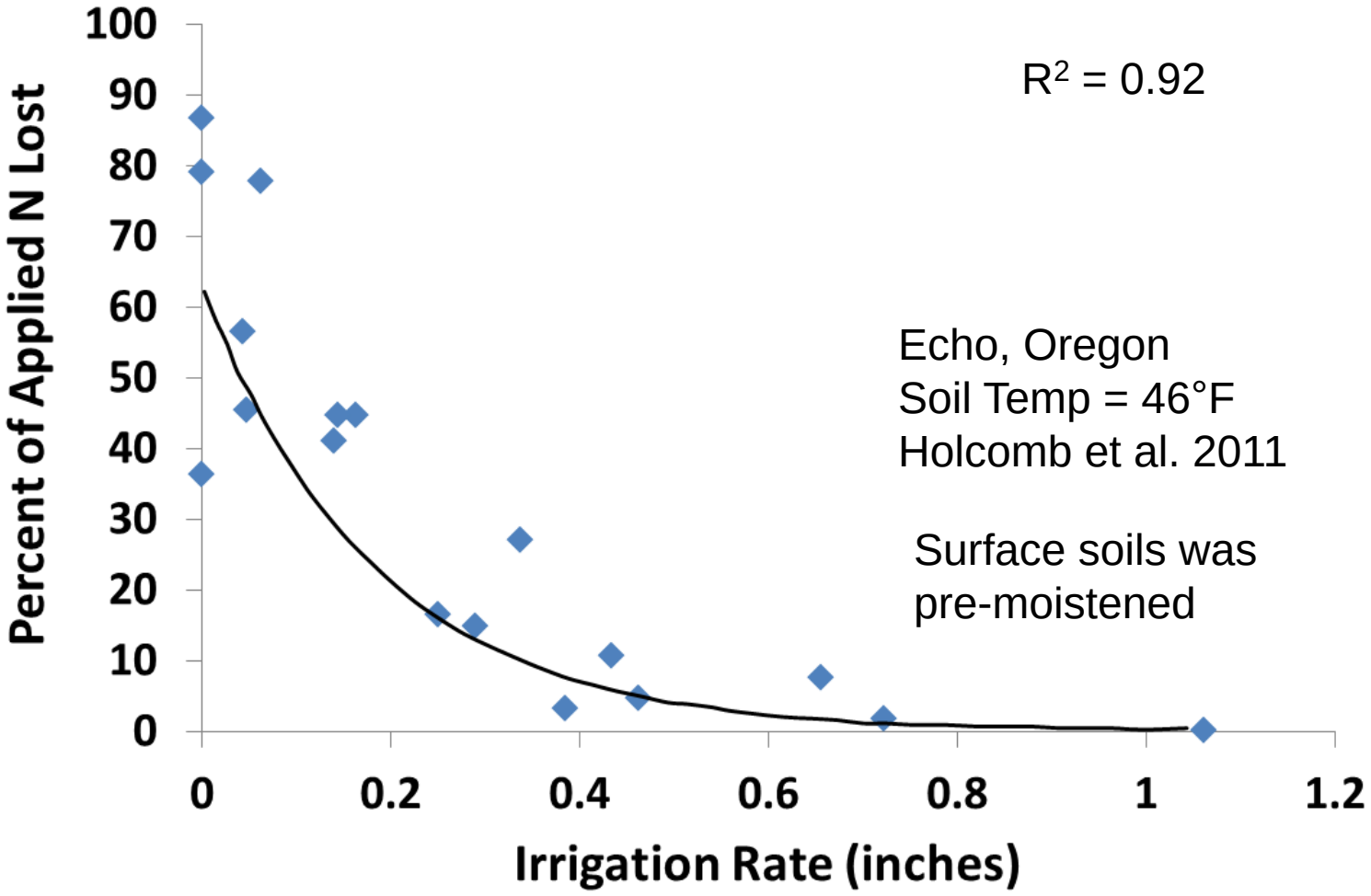
Practices to decrease volatilization from N fertilizers, especially urea

- Incorporate with tillage if possible
- Apply to dry, cool, but thawed ground
- Apply prior to a large (> 0.5”) moisture event
- Use a protected product (e.g. Agrotain ® = NBPT) if can’t apply during low risk periods

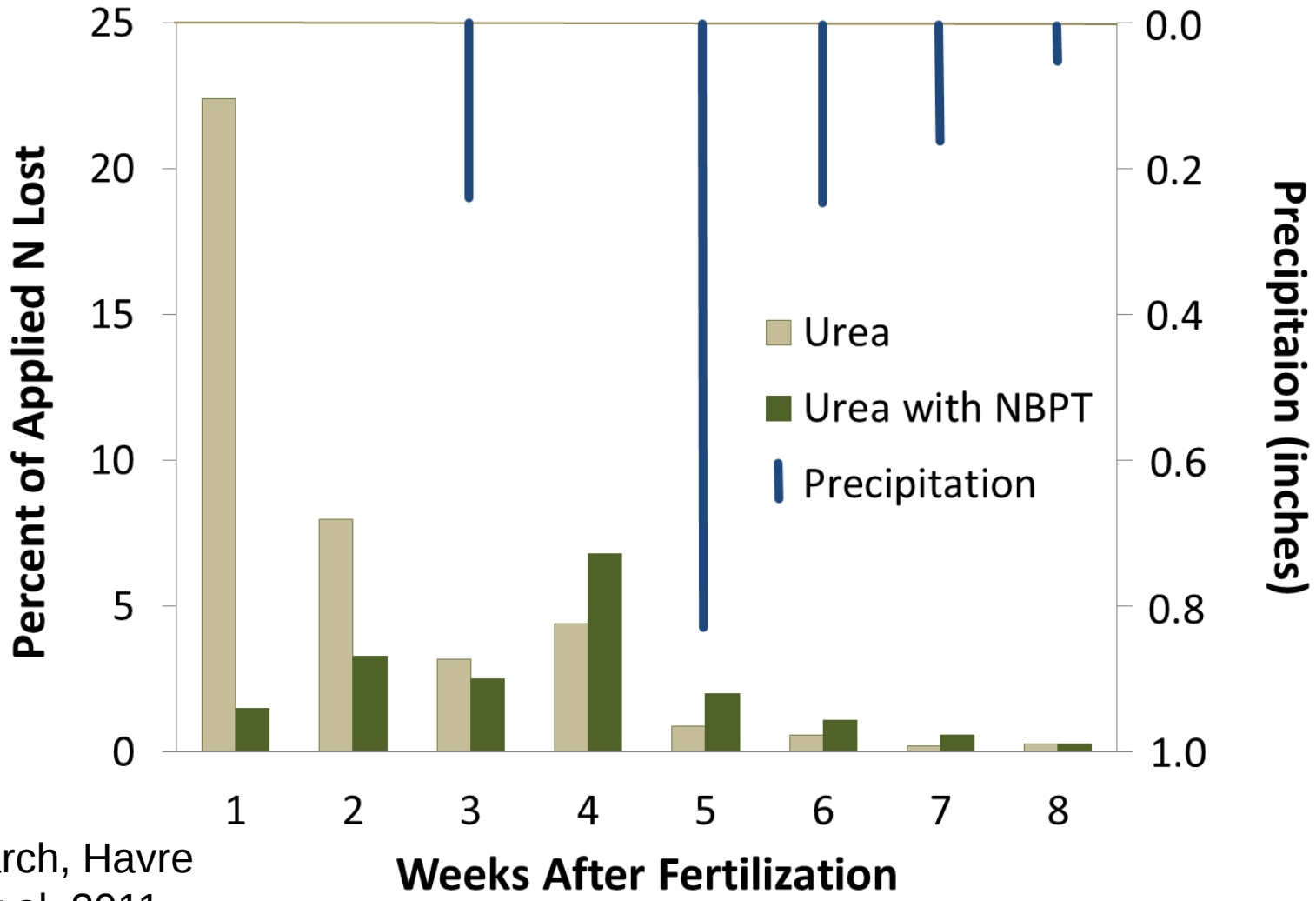


Change in soil pH from the original pH by distance and depth 6 days after urea with and without Agrotain® is placed on soil surface. Adapted from Christianson et al. 1993.

Effect of irrigation amount on urea volatilization



Effect of rainfall on urea volatilization



Late March, Havre
Engel et al. 2011

N volatilization loss (%) in Montana

Broadcast

Season	No. trials	Fertilization dates	Urea	Agrotain®
Fall	6	Oct 6 – Nov 29	3.1 – 31.3	1.4 – 5.9
Winter	5	Dec 30 – March 5	13.0 – 44.1	4.1 – 11.9
Spring	6	March 25 - April 24	6.1 – 39.9	1.7 – 18.1
Average			**18.8**	**6.7**

wide range in N loss amounts

For specifics see Fertilizer Facts 59 and 60

North-central, central and southwest MT
Engel et al. 2011

Crop management factors to decrease N leaching

- Carefully manage irrigation, especially on coarse soils
- Recrop rather than fallow
- Reduce tillage
- Diversify to include perennial and/or deep rooted crops
- Consider legumes since don’t need to fertilize w/ N

N management factors to decrease N leaching

- Apply N based on spring soil test ESPECIALLY if have > 50 lb N/acre in fall AND soils less than 2 ft deep
- Split N application to match plant needs
- Consider applying less N in areas that yield less or have soils that are shallow or pond (variable rate application)
- Use an enhanced efficiency fertilizer?

QUESTIONS ON N LOSSES?

Optimize fertilizer N rate

How?

- Use a conservative pre-plant N rate based on:
  spring soil sample
  realistic yield potential
  economic rate calculator

http://landresources.montana.edu/soilfertility/small%20grains%20economic%20calculator.html

- Apply a 2nd application if needed

http://www.montana.edu/softwaredownloads/software/WW Fertilizer Economics.swf

Introduction | WW Yield Response | WW Protein Response | Net Revenue From Fertilizer | Net Revenue Versus Yield

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Economic Analysis of Fertilizer Application Rates for Winter Wheat in Montana.

- Steps to Use Program
- Introduction
- Step 1 - Yields
- Step 2 - Protein
- Step 3 - Net Revenue
- Step 4 - Revenue vs Yield

This program was developed to aid the agriculture industry in optimizing nitrogen fertilizer application on Winter Wheat after fallow. The model used to estimate the economic optimal allocation of nitrogen fertilizer requires the user specify a minimal set of input values for their location. The model was developed as a statewide application, but the user must keep in mind that many variables will affect their final results and this model can not incorporate all of those individual variables. Because the model allows the user to set their expected yield goal, it allows the individual user to determine a cap on the estimated yield response from the application of nitrogen fertilizer, considering ALL of the user specific knowledge and conditions for an individual producer's site. The yield and protein models are based on a best fit regression analysis of plot research performed in Montana from 1970 to 2006 on research plots, and included approximately 70 site years for winter wheat. Actual N needed to optimize yield on your farm/site may vary from that predicted due to differences in soil depth, texture, and climate.

This model is not valid for recrop winter wheat.

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N Sources

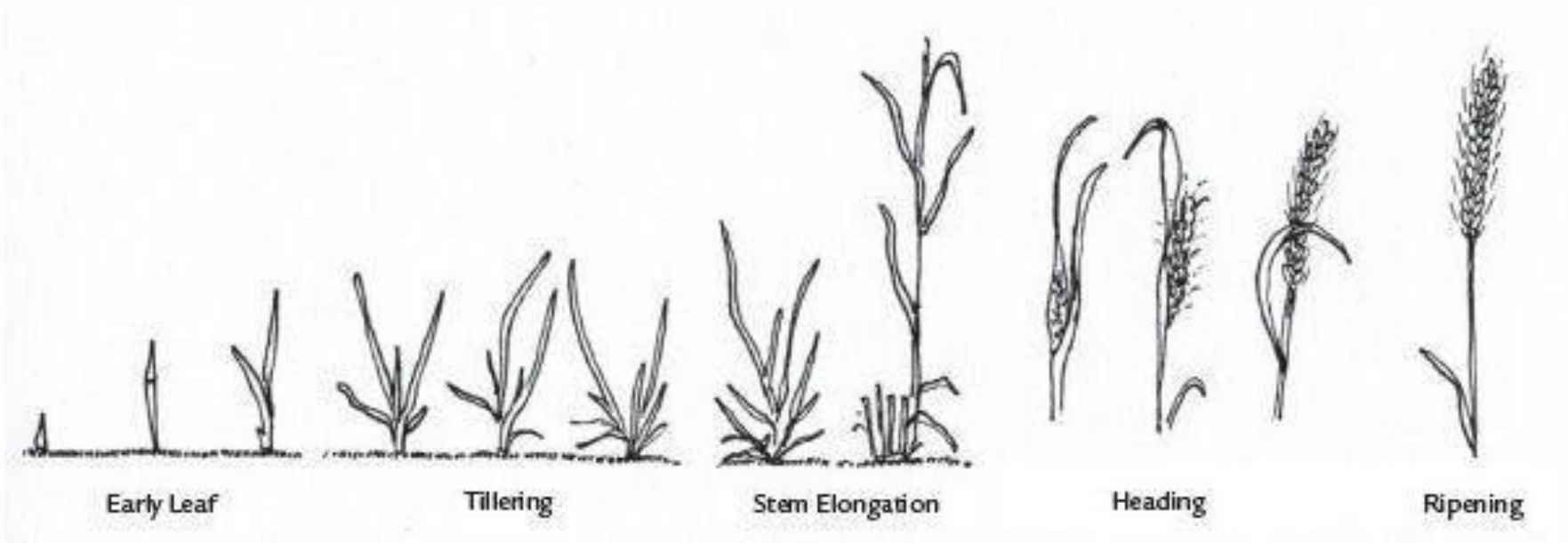
- Enhanced efficiency fertilizers
  - Urease inhibitors (ex: Agrotain® = NBPT)
  - Nitrification inhibitors (ex: N-serve®=nitrapyrin; Super-U® = NBPT + DCD)
  - Controlled release (ex: ESN® – polymer coating)
  - Slow release (ex: N-Demand, slowly degraded N)
  - Enhanced availability (ex: NSN®, NRG®)
- Urea vs Ammonium Nitrate vs Ammonium Sulfate vs 28 or 32 Solution (UAN)
  - Often similar responses per pound of N
  - Ammonium nitrate is immediately available and doesn't volatilize but more expensive per lb of actual N than urea.

Effects of source will be shown later in this presentation

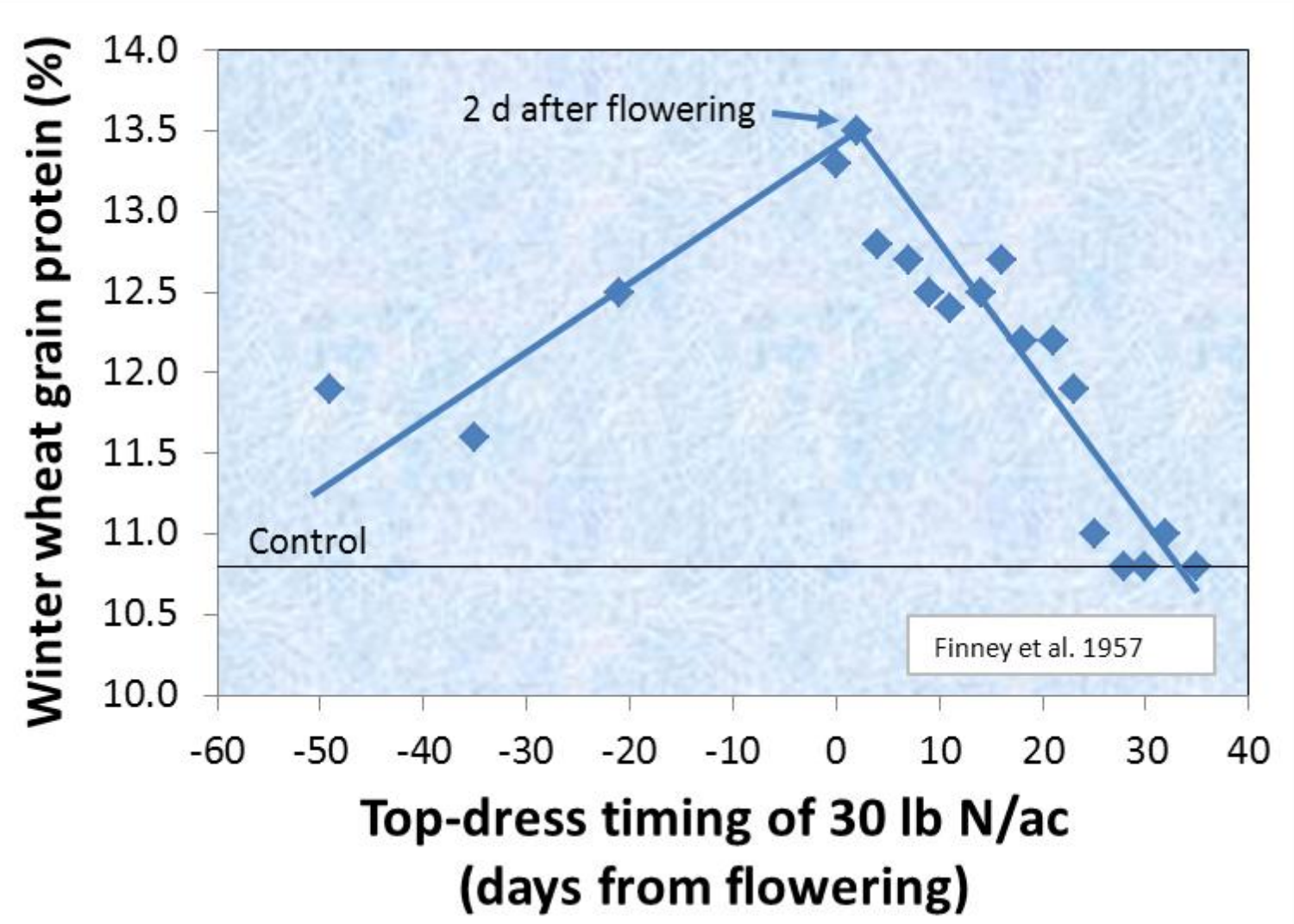
Timing: N availability affects yield and protein

Added N increases no. tillers and kernels per head
Grain will use N from stems/leaves to make protein

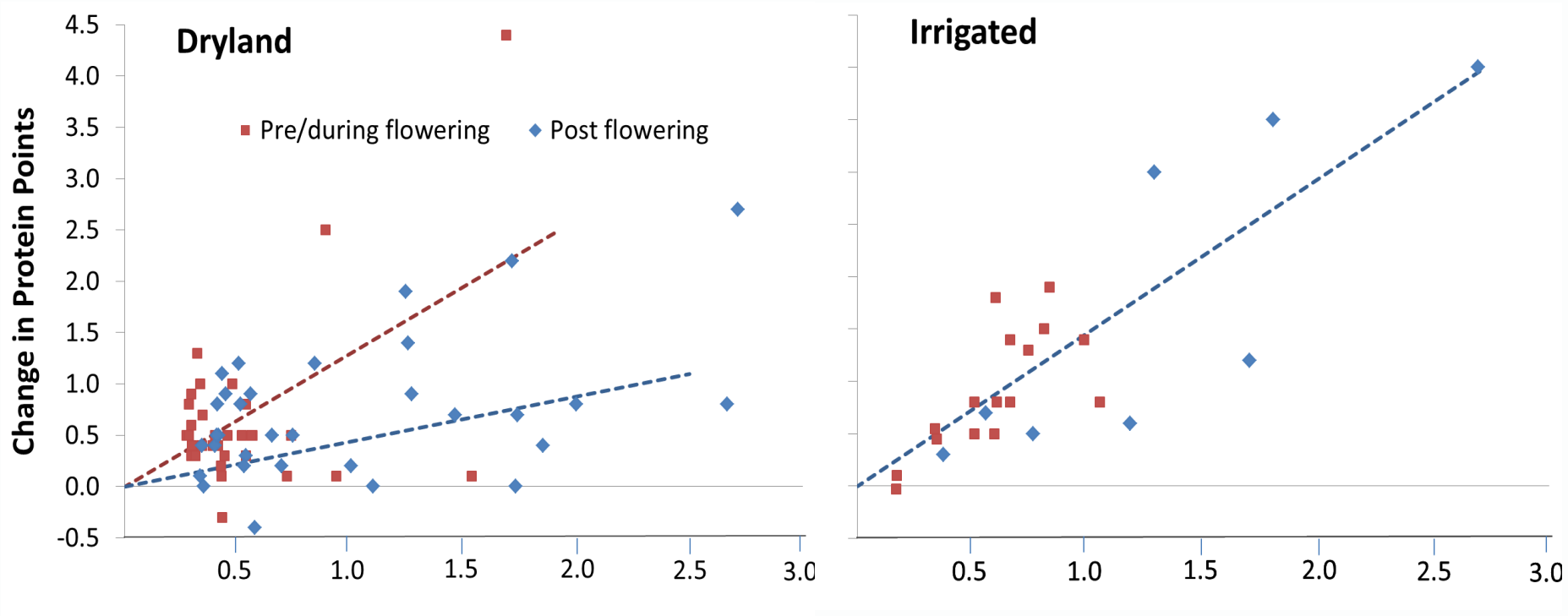
Added N goes to protein



When should late-season N be applied to maximize grain protein?



In-season N rate, timing, and dryland vs irrigation affects protein boost



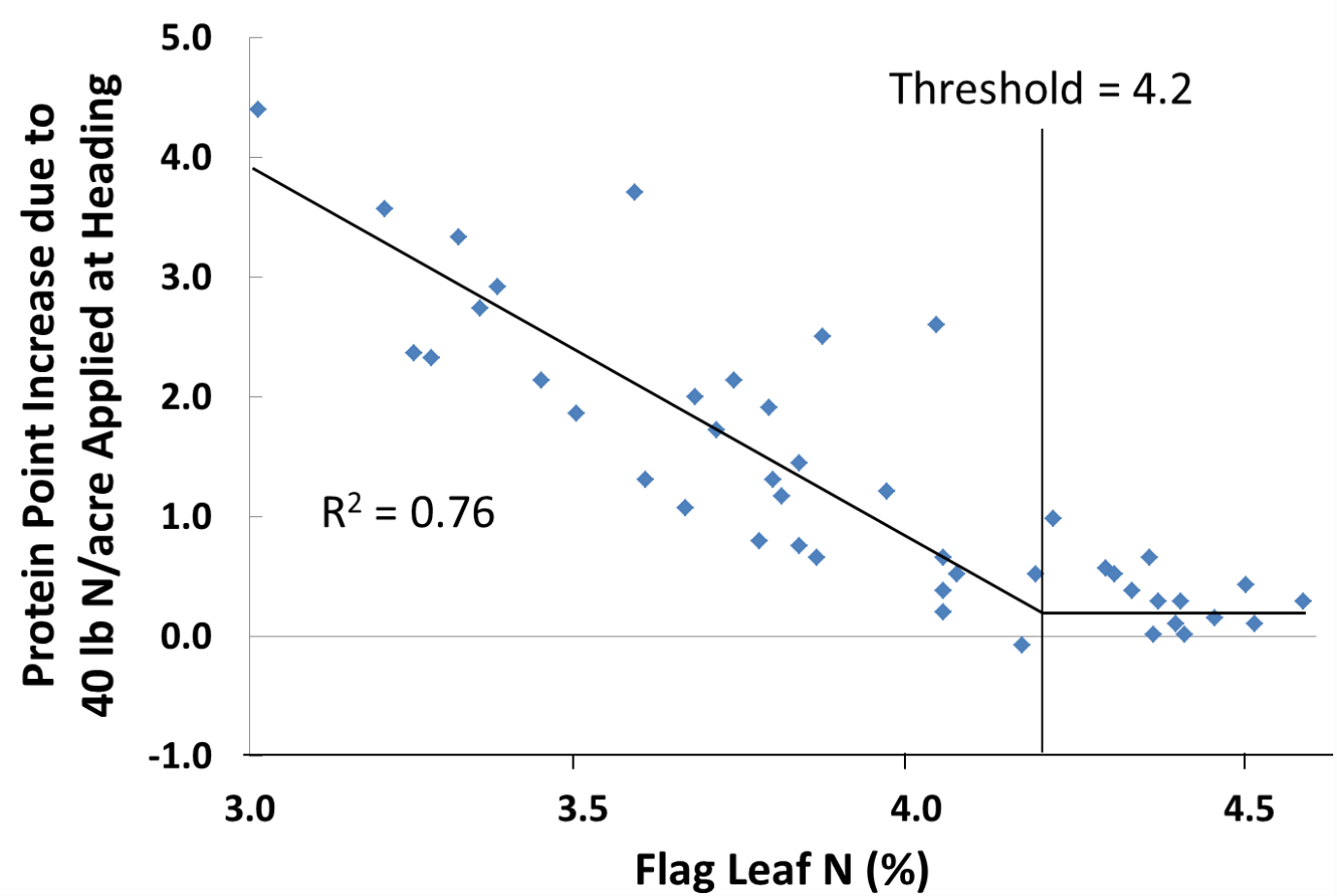
Ability to incorporate with rain or irrigation more important than exact timing at flowering

How should a grower decide whether to apply late-season N?

Ask:

1. Does grower have a way to apply N without severely damaging crop? (e.g. fertigation, high clearance weed sprayer, fly it on)
2. Are protein discounts sufficiently high to justify cost? (calculation will depend on expected % protein boost)
3. What is the flag leaf N concentration?

Effect of top-dressing 40 lb N/acre at heading on spring wheat grain protein increase as affected by flag leaf N



Relationship between protein response to N top-dressed and flag leaf N in irrigated sw. Fertilizer Fact 12

What is the ‘critical flag leaf N’?

- Critical FLN = FLN below which should top-dress N to maximize profit (and above which should result in a loss).
- Critical FLN = 4.2 – 13.33(N cost in $/lb N)/((protein discount per point)(expected yield))

  -13.33 is application rate from study (40 lb N/ac) divided by slope of response on previous figure (-3)
- Example 1: If ratio of N cost to discount = 1.5 (May 2012) and yield = 50 bu/ac, critical FLN = 3.9%.
- Example 2: If ratio of N cost to discount = 4 (current) and yield = 50 bu/ac, critical FLN = 3.2% (rarely this low).
- Bottom line: need far lower FLN to justify top-dressing for protein IF ratio of fertilizer cost to discount is high.

How much N should be top-dressed at flowering?

- Will depend on flag leaf N (if measured), protein discounts, and cost of application. About 20 to 30 lb N/ac is typical.
- No more than 30 lb N/ac of UAN (b/c of burn)
- If determined that should add N, then add as much as possible w/o burning for best economic rate (b/c 'dilutes' cost of application)

Foliar N

- Only 1-16% of foliar N taken up through leaf
- Apply with ½ inch water to move into soil
- If scab risk, do not irrigate within 5 days of flower
- No more than 45 lb N/ac of liquid urea to minimize burn and yield loss (Brown and Long, 1988)
- Leaf damage increased with:
  - Surfactant + more than 20 lb N/ac of 28-0-0 UAN
  - Urea + Agrotain®

QUESTIONS ON SPLIT APPLICATIONS OR TOP-DRESSING?

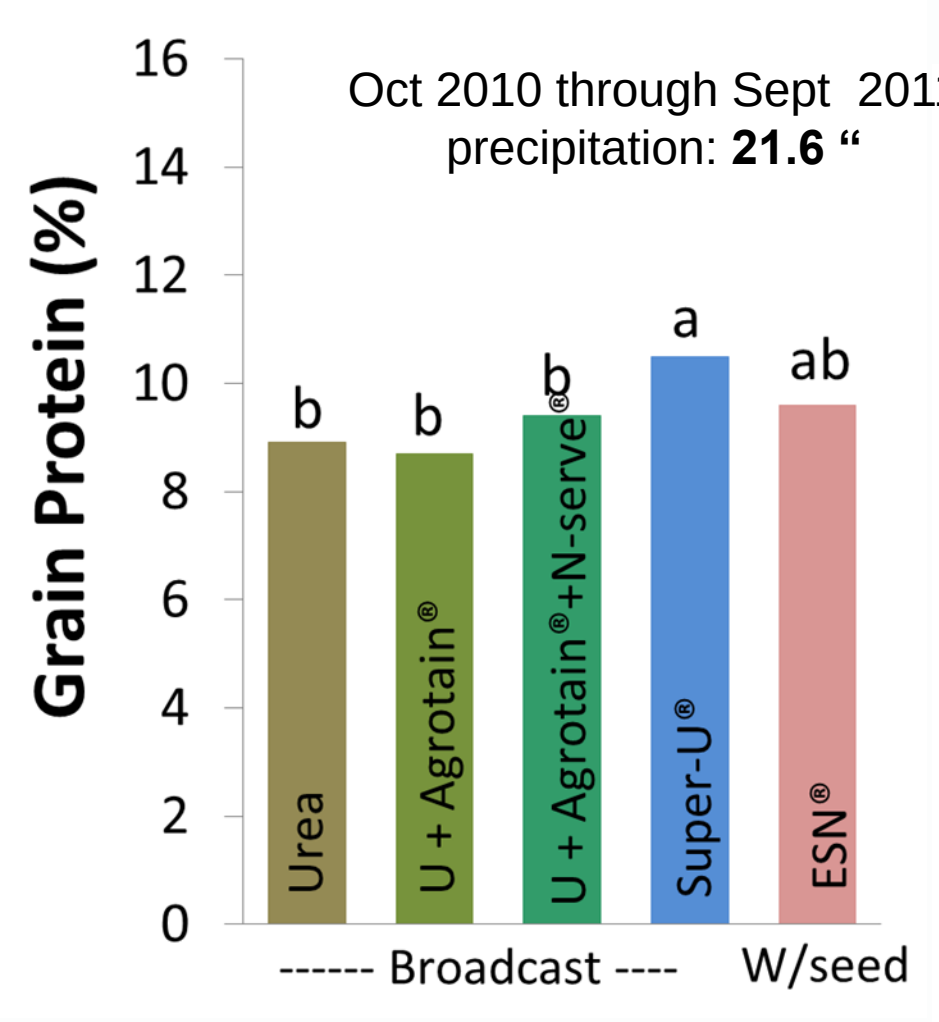
Right placement

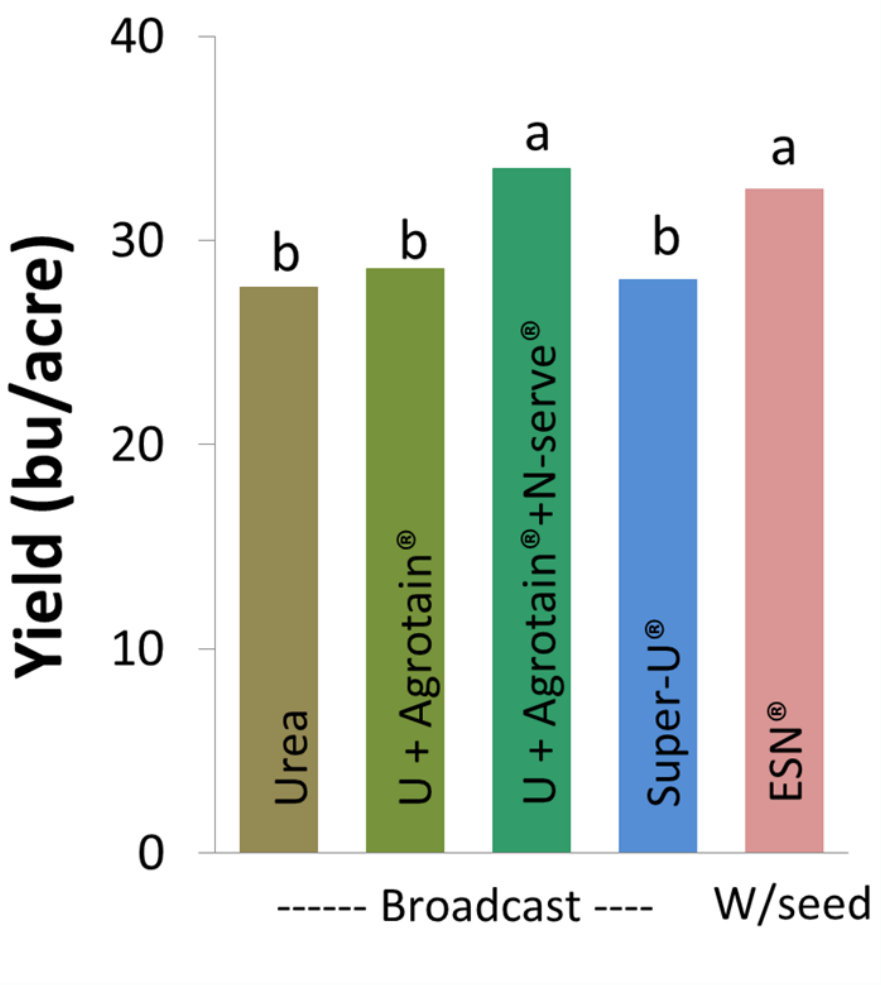
- In general, subsurface placement/incorporation of N fertilizer decreases losses and increases availability
- Caution needs to be used when applying urea directly with the seed (10 lb N/ac max especially at wide row spacing)

Placement, timing, and source study at Moccasin

- Worst-case scenario for leaching – soils ~ 18” deep. 21.6 inches of precipitation from Oct 2010 to Sep 2011
- Timing: Fall vs spring
- Placement: Broadcast, seed-placed
- Sources (selected, for all see Fertilizer Fact 62):
  - Regular urea
  - Super U (w/ urease and nitrification inhibitors)
  - Urea mixed with Agrotain and N-serve (nit inhib)
  - ESN with seed (only in fall)

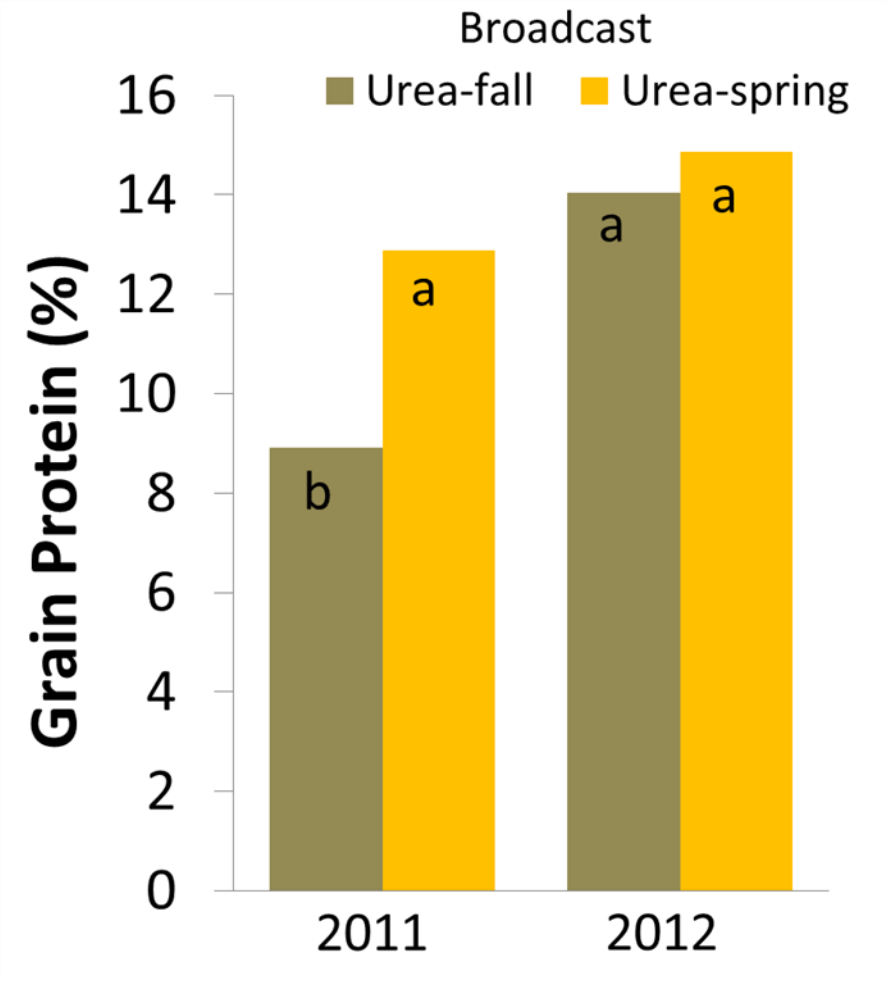
Effect of source and placement (fall applied) on grain yield under high risk leaching conditions



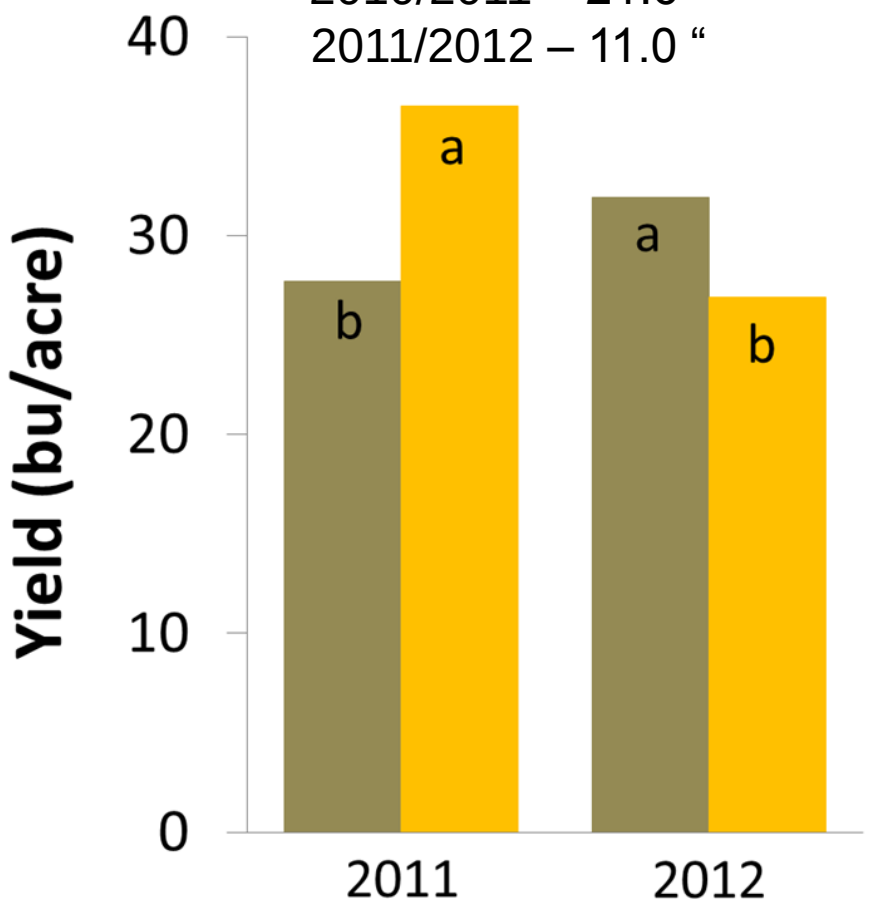


Fertilizer Fact 62, Moccasin, MT

Effect of N application timing on winter wheat grain protein and yield



Oct through Sept precipitation
2010/2011 – 21.6 “
2011/2012 – 11.0 “



Fertilizer Fact 62, Moccasin, MT

Take home messages of Moccasin Study

- In wet year, enhanced efficiency fertilizers produced similar or higher yields and protein as conventional urea
- In dry year, yields and protein were similar for EEFs and conventional urea (data not shown)
- In wet year, spring application greatly increased yield and protein compared to fall application
- In dry year, the reverse was true

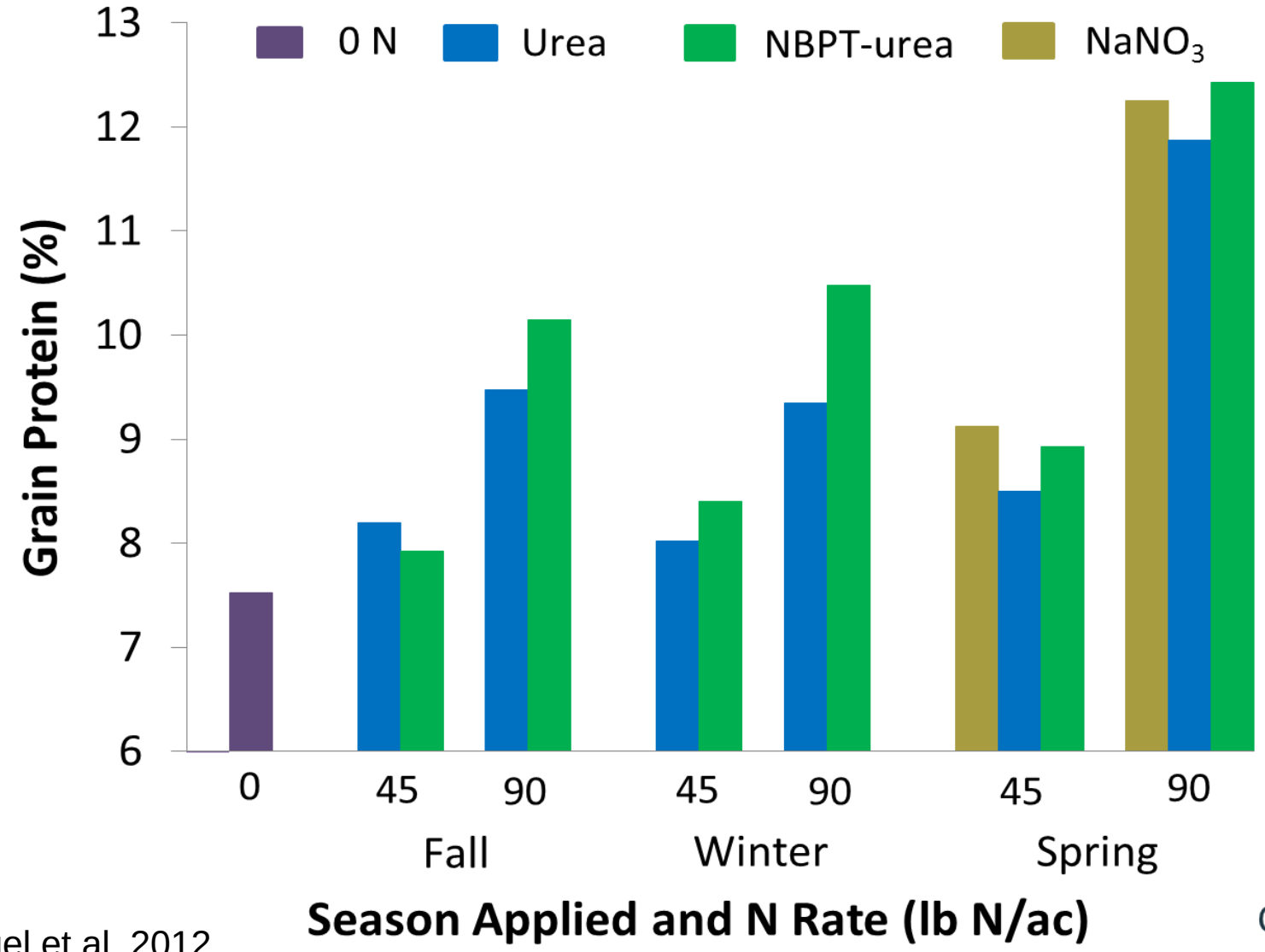
Are yield and protein affected by application timing, source, or volatilization loss?

- Location: Central MT (Coffee Creek)
- On the same field in 2011/2012, compared:

  Timing: Fall, winter, spring
  Source: Urea vs. NBPT–urea (Agrotain®) vs. $NaNO_3$ (doesn't volatilize)

- Measured in plots:
  Winter wheat grain yield
  Grain protein

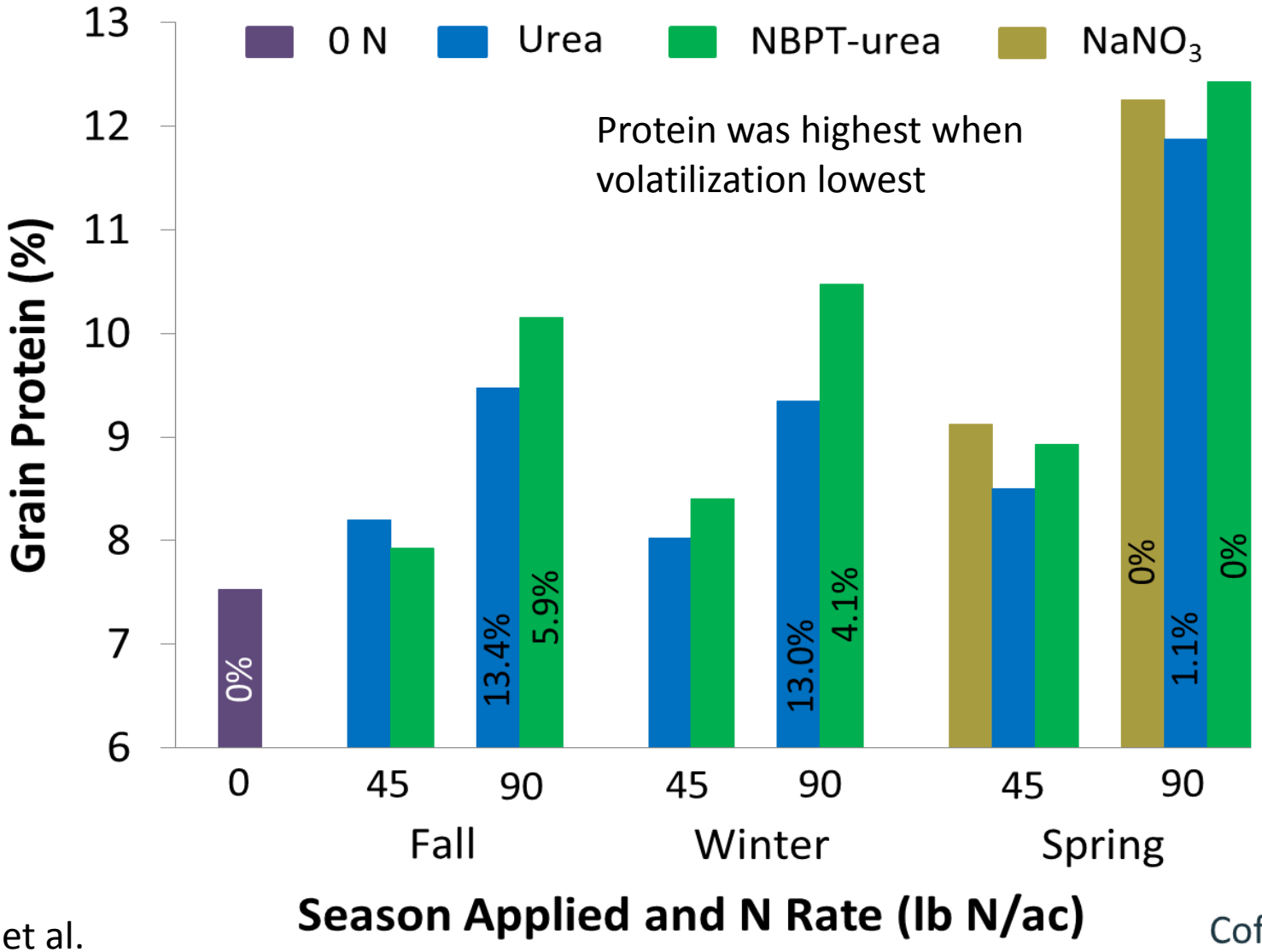
Source, application rate and timing affect protein



Engel et al. 2012
unpub data

Coffee Creek,
MT, 2012

Volatilization affects protein



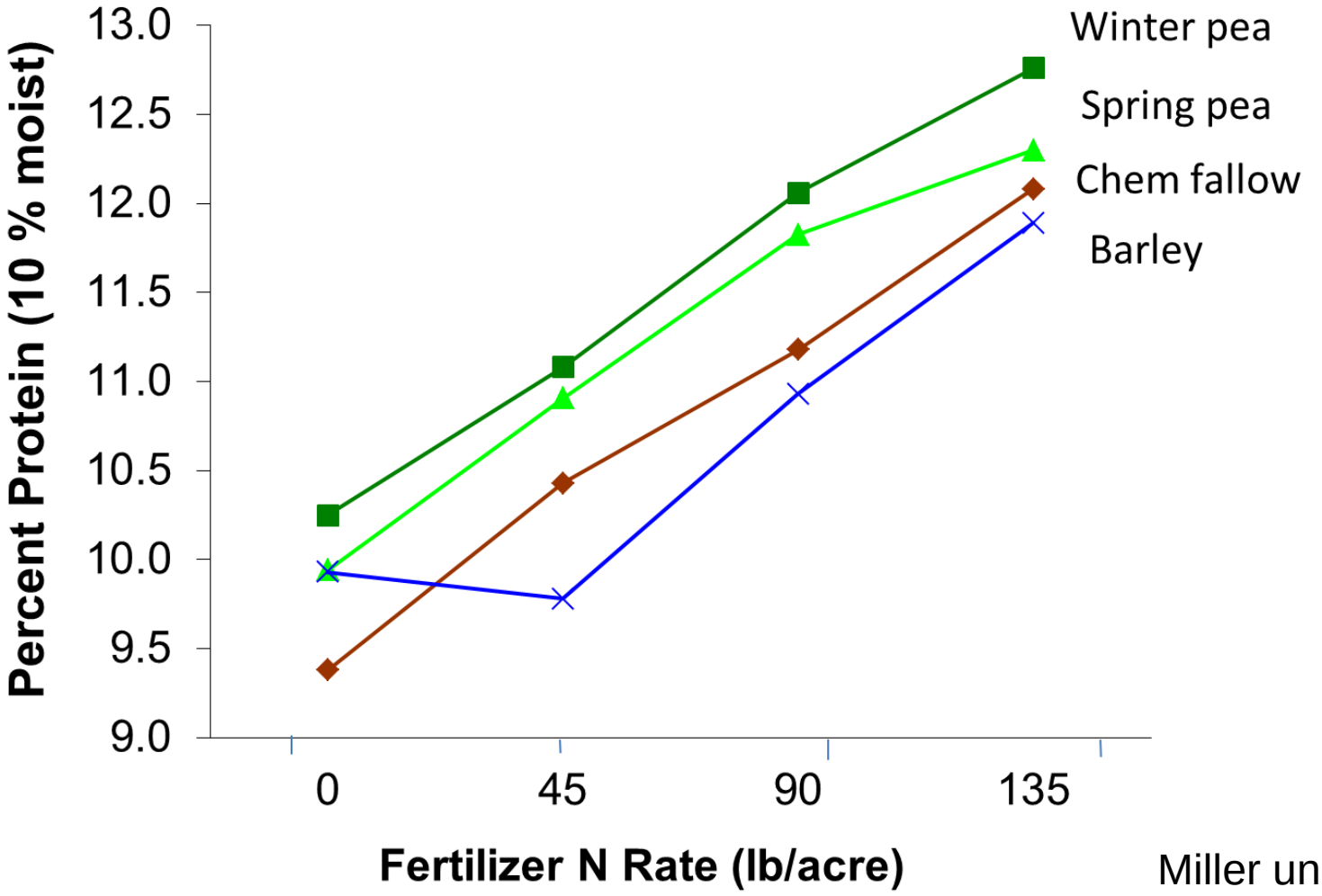
Engel et al.
unpub. data

Coffee Creek, MT, 2012

Timing and source affect volatilization, yield and protein

- Yield and protein both higher from spring application
- Spring application produced highest protein - had lowest volatilization loss (1%) probably because rained ¾ inch shortly after application
- NBPT increased protein by reducing volatilization N losses
- NBPT did not affect yield (water may have limited grain yield more than N due to dry summer)

Right rotation: Do legumes grown prior to winter wheat increase grain protein?



Miller unpub data

Conclusions

- Supplying sufficient pre-plant N and top-dressing at flowering are the two most consistent strategies to boost grain protein.
- Enhanced efficiency products may or may not increase grain protein and should be used cautiously given additional expense.
- Minimizing N losses and growing wheat after annual legumes should in general both increase protein.
- Legumes rather than fallow or continuous small grain in rotation *may* increase protein similar to about 25 lb N/ac of fertilizer.

Additional info at:
http://landresources.montana.edu/soilfertility

Practices to Increase Wheat Grain Protein (bulletin)
Ammonia Volatilization (2 bulletins coming soon)
Other soil fertility publications
Go to “Extension Publications”

Fertilizer Facts and economic model:
Go to “Fertilizer Information”
MT research data on volatilization: FFacts 59 and 60

Ammonia volatilization taped presentation:
Go to “Ammonia Volatilization”

This presentation: Go to “Presentations”

QUESTIONS?