Minimizing N losses and maximizing protein and revenue

2013 Crop Pest Management School

by Clain Jones, Extension Soil Fertility Specialist and Kathrin Olson-Rutz, Research Associate
clainj@montana.edu; 994-6076

MONTANA STATE UNIVERSITY EXTENSION

Potential losses

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

High risk conditions for urea volatilization

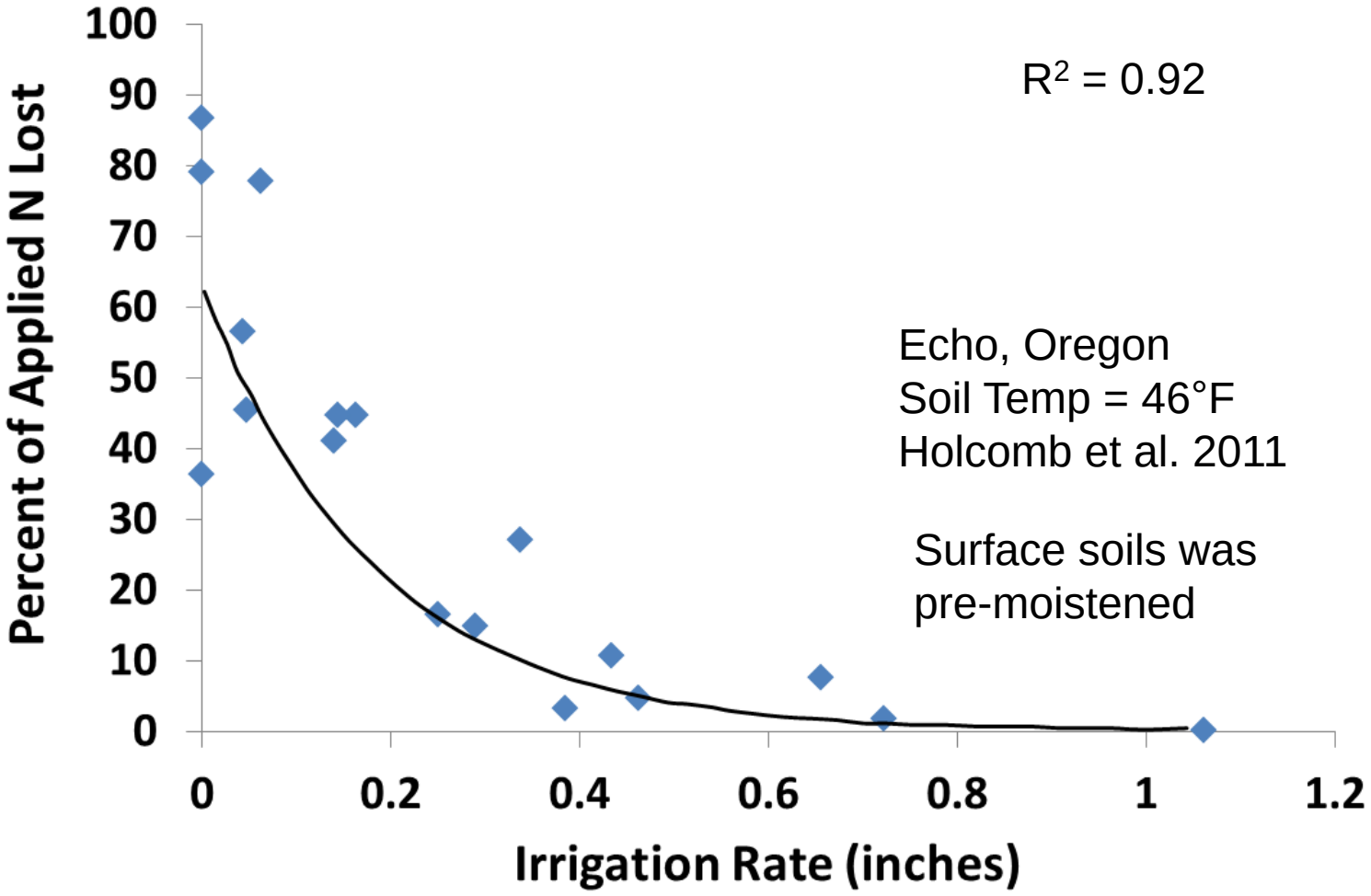
- Moist soil or heavy dew
- High soil pH (>7.0)
- High soil temperature (>70 °F) or frozen soil
- Crop residue, perennial thatch or sod
- Low cation exchange capacity soil (sandy)
- Poorly buffered soils (low soil organic matter, low bicarbonate content)

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

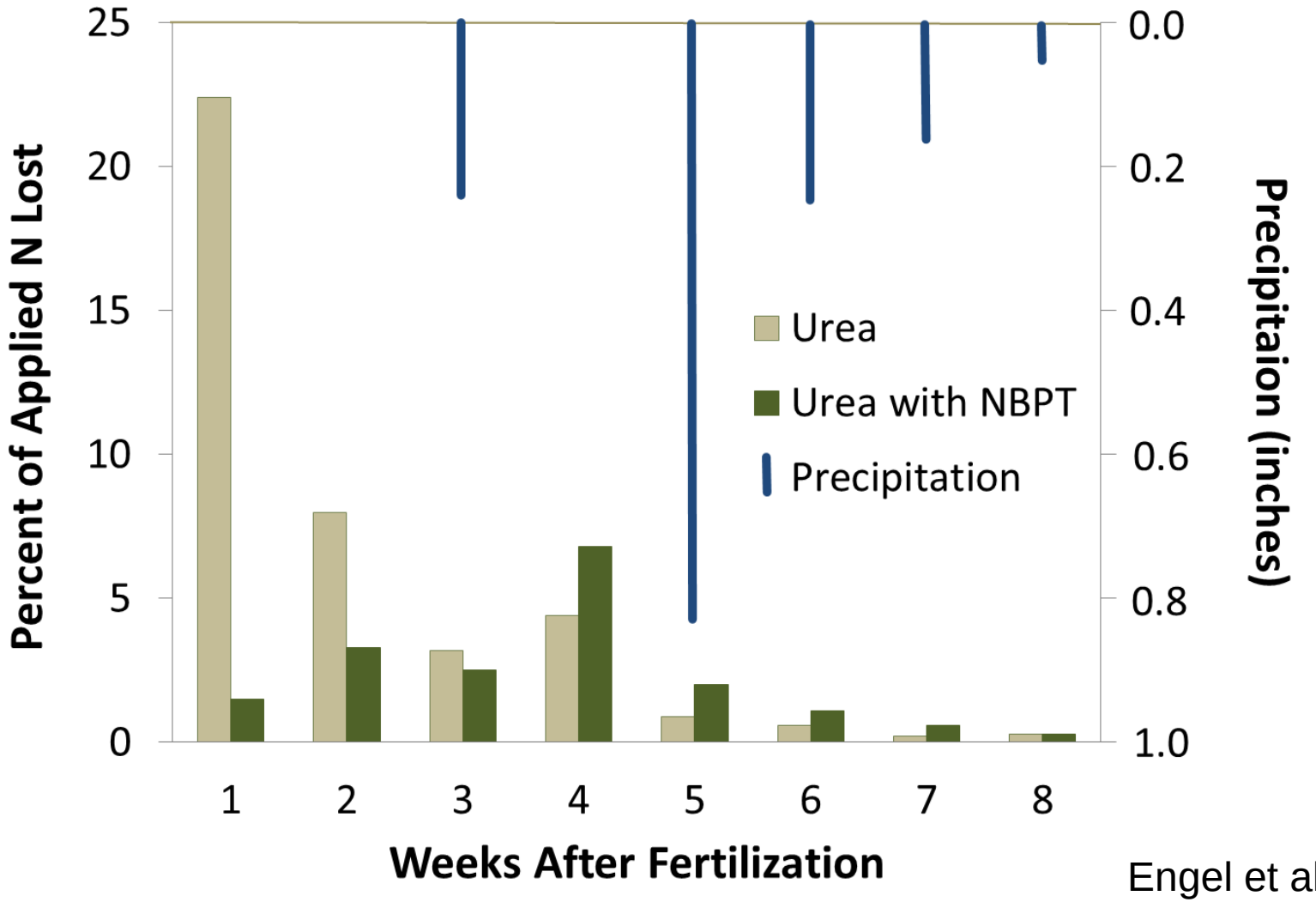
Practices to decrease volatilization from N fertilizers, especially urea

- Incorporate with tillage or irrigation 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 ®) if can’t apply during low risk periods

Effect of irrigation amount on urea volatilization



Effect of rainfall on urea volatilization



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

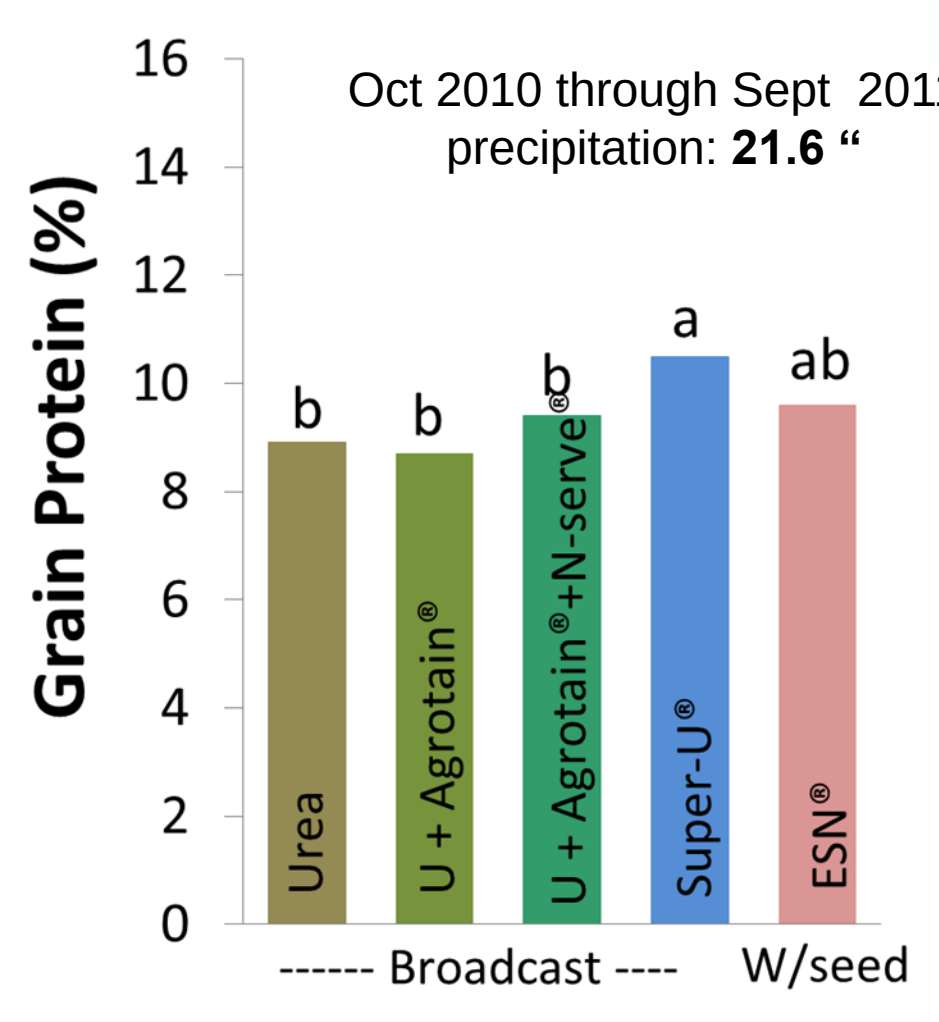
Crop and N management factors to decrease N leaching

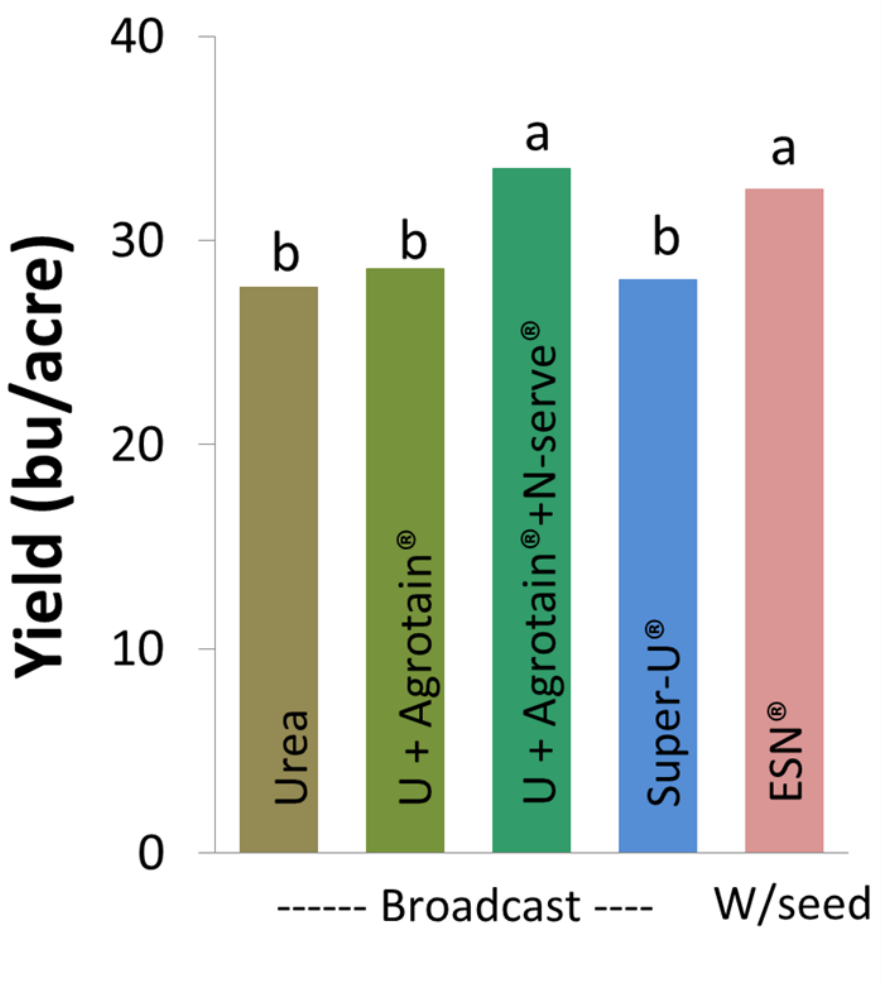
- Carefully manage irrigation, especially on coarse soils
- Recrop rather than fallow
- Reduce tillage
- Diversify to include perennial and/or deep rooted crops
- Consider legumes since don't need to fertilize w/ N
- Apply N in spring according to soil test ESPECIALLY if have greater than 50 lb N/acre in fall AND soils less than 2 ft deep
- Split N application to match plant needs or use slow release N fertilizer
- Consider applying less N in areas that yield less or have shallower soils (variable rate application)

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 urea (w/ urease and nitrification inhibitors)
  - Urea mixed with Agrotain and N-serve (nit inhib)
  - ESN with seed (only in fall)

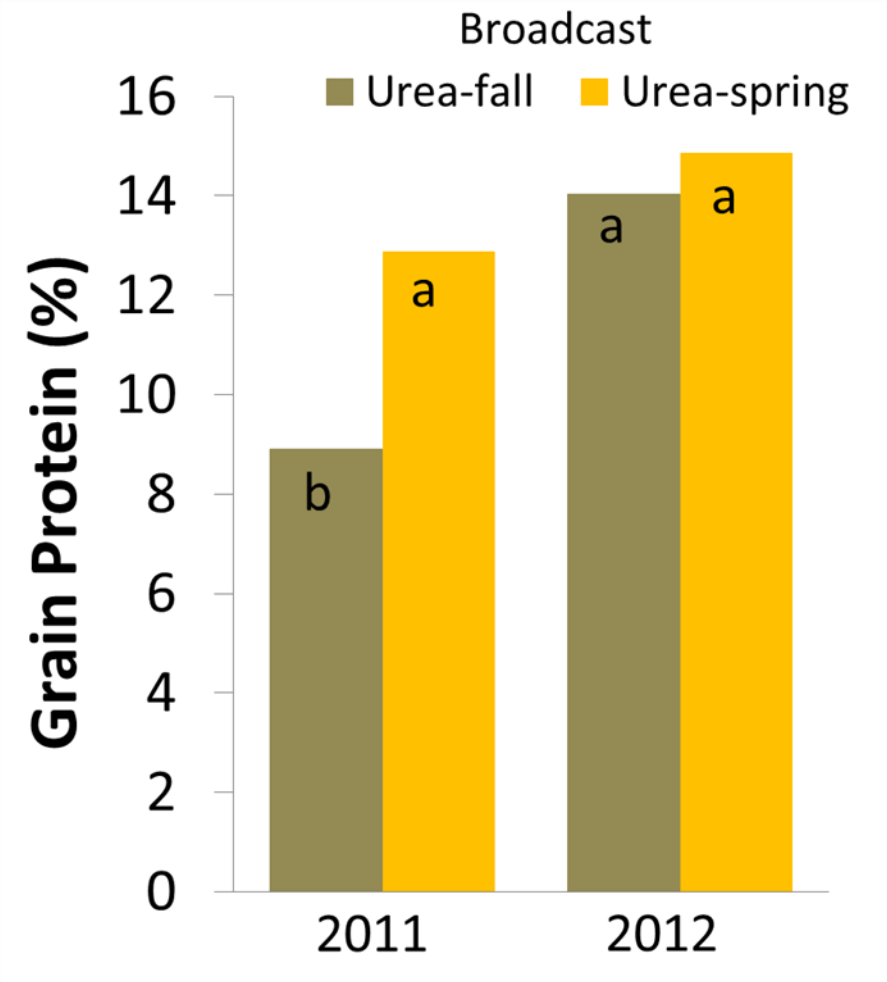
Effect of source and placement (fall applied) on grain yield under high risk leaching conditions



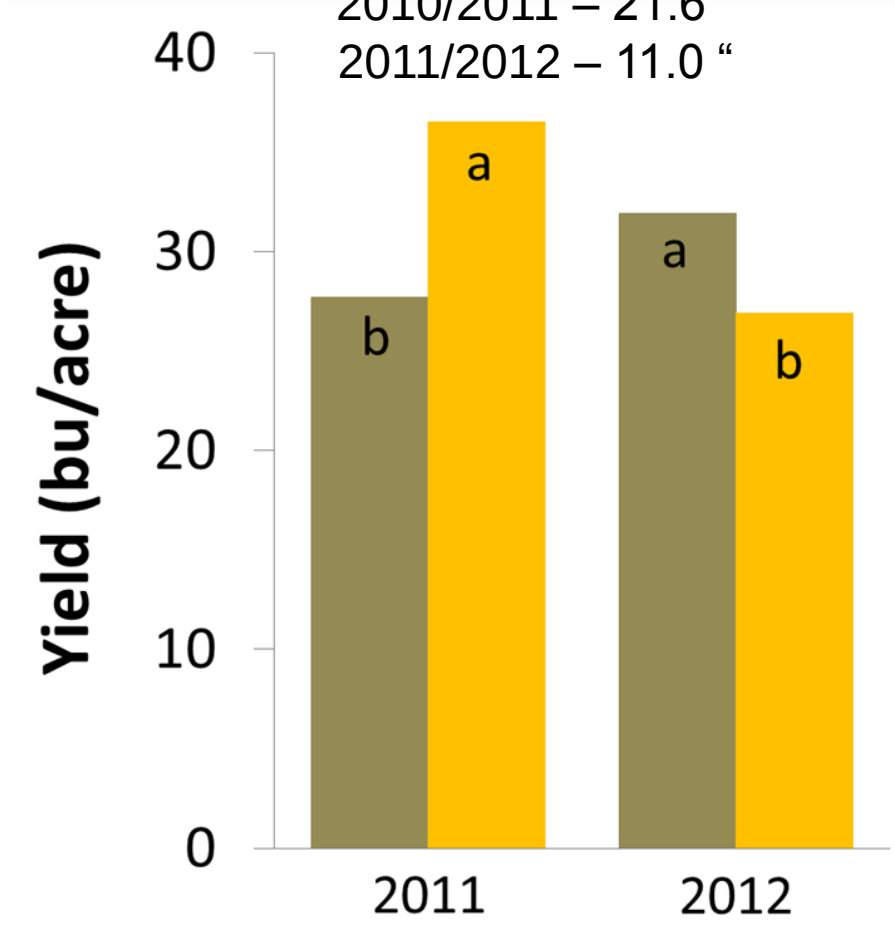


Fertilizer Fact 62, Moccasin, MT

Effect of N application timing on grain protein and yield



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



Fertilizer Fact 62, Moccasin, MT

Questions on minimizing volatilization and leaching losses?

Management practices to optimize grain protein

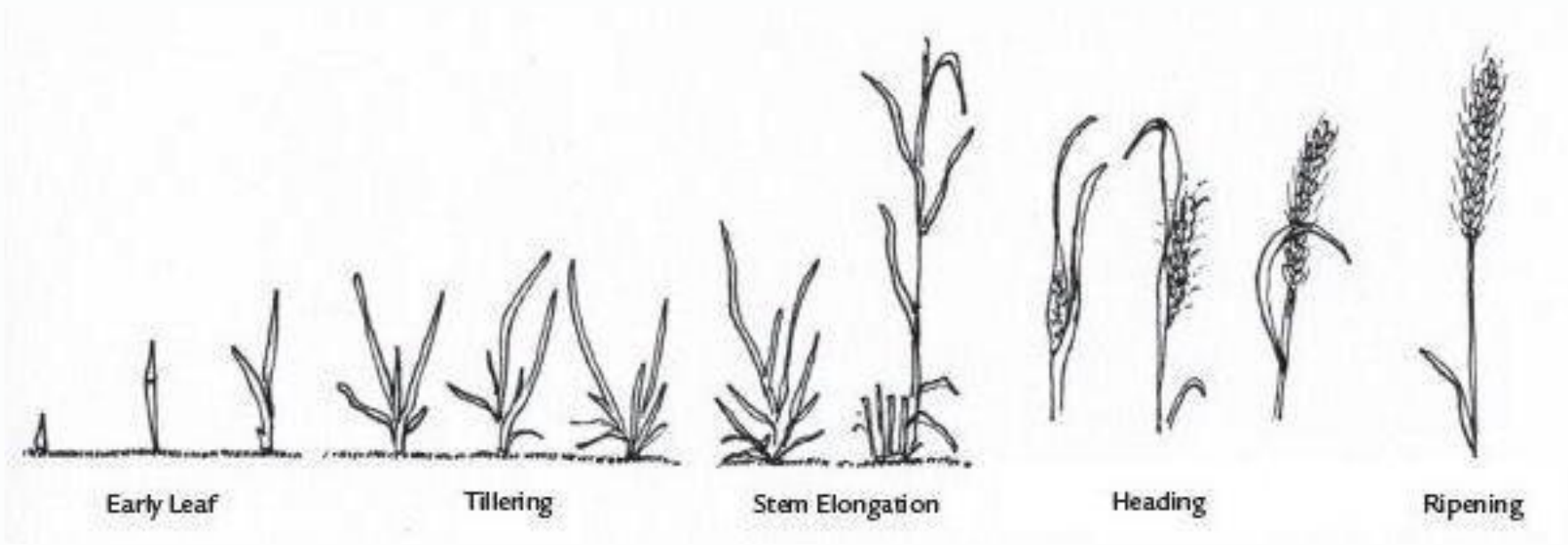
Soil Fertility Management

- Optimize total fertilizer N rate
- Split/in season N applications
- Minimize N losses
- Use an enhanced efficiency fertilizer?
- Use legumes in rotation?
- Sulfur?

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



Optimize fertilizer N rate

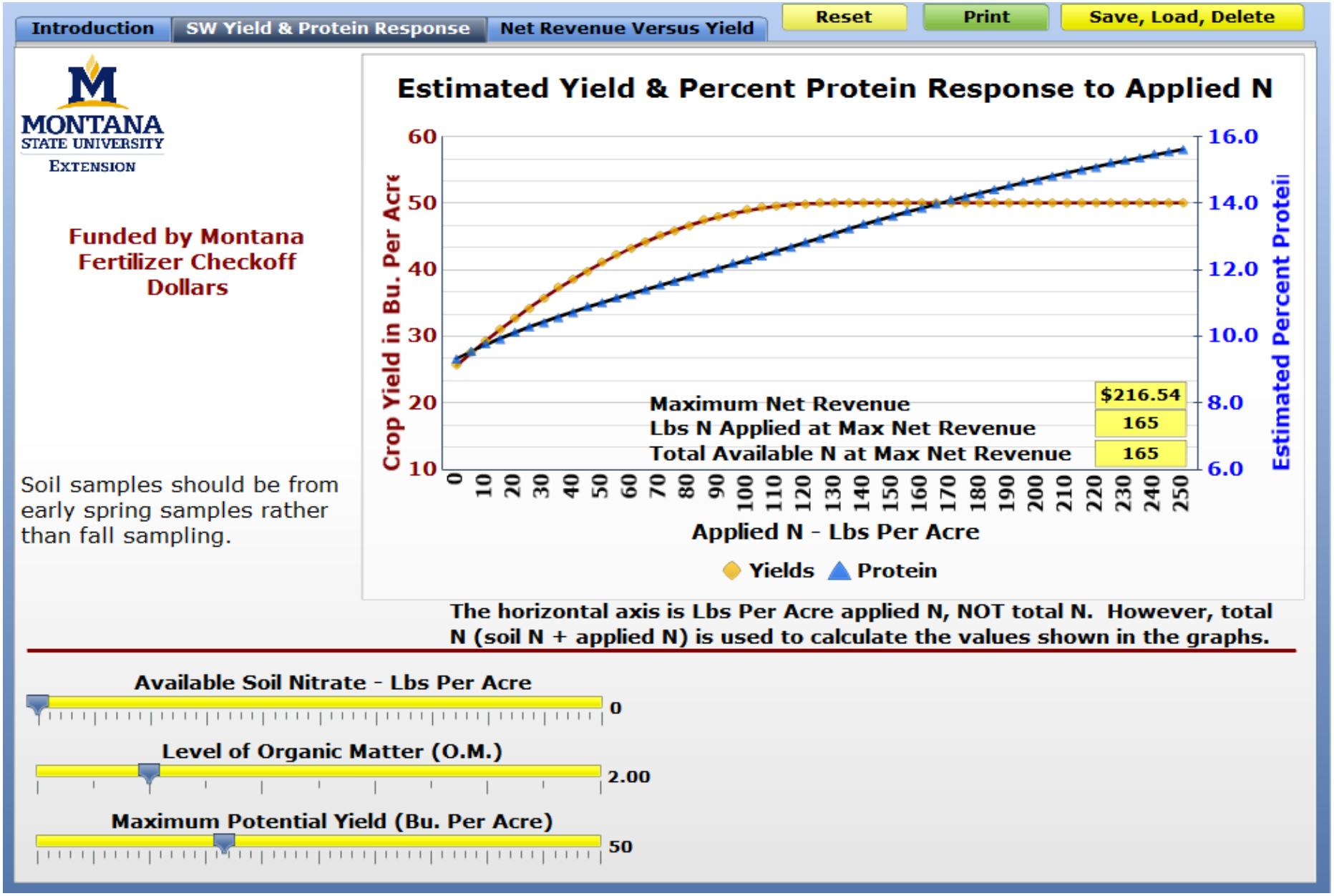
How?

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

http://www.montana.edu/softwaredownloads/software/SWFertilizerEconomics.swf

- Apply a 2nd application if needed

Economic rate calculator



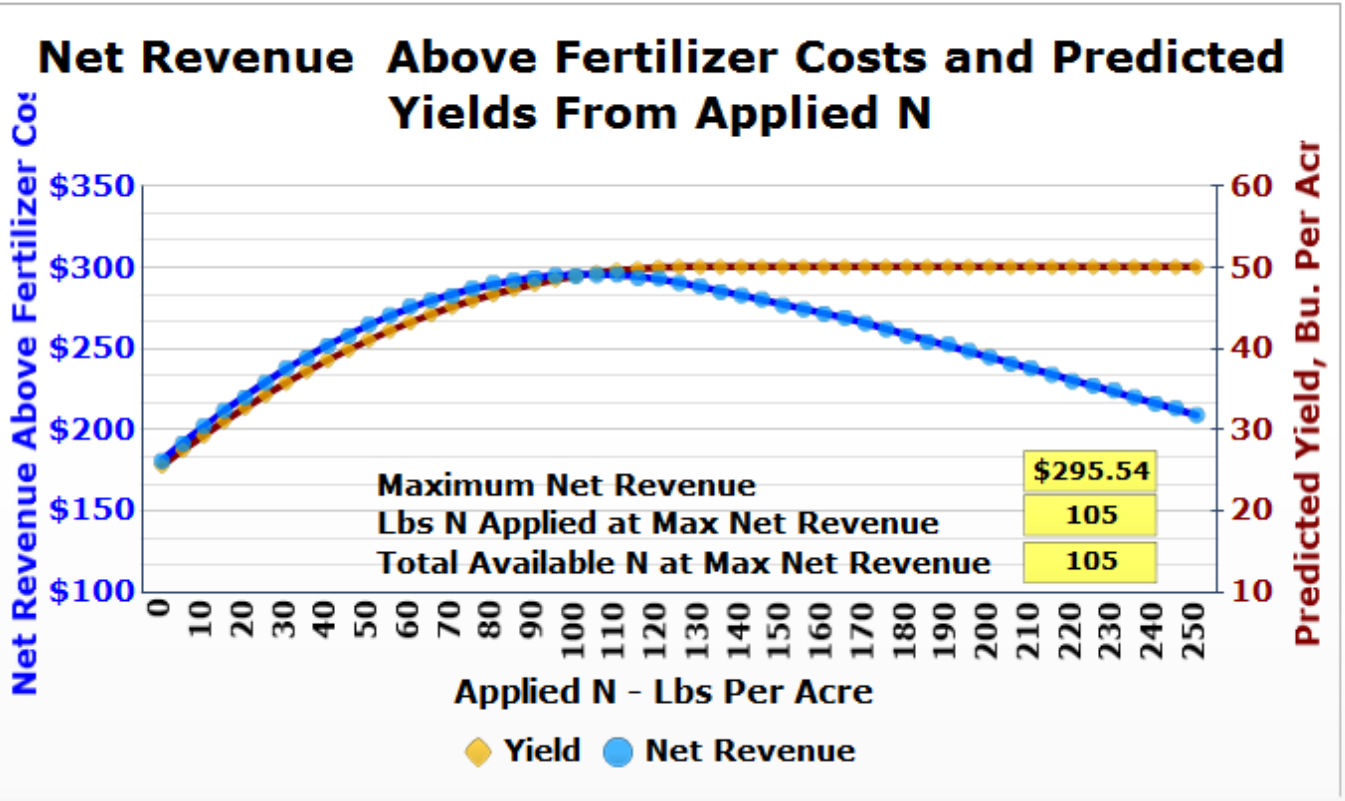
MONTANA STATE UNIVERSITY EXTENSION

Funded by Montana Fertilizer Checkoff Dollars

The buttons below are toggles that display or hide a graph. They are initially set to hide the graph. Click once to display the graph and click again to hide the graph.

Net Revenue Only Graph Off/On

Yield Only Graph Off/On



The horizontal axis is Lbs Per Acre applied N, NOT total N. However, total N (soil N + applied N) is used to calculate the values shown in the graphs.

Available Soil Nitrate - Lbs Per Acre: 0

Level of Organic Matter (O.M.): 2.00

Maximum Potential Yield (Bu. Per Acre): 50

Wheat Price for 14% Protein Spring Wheat: $8.02

Nitrogen Price Per Pound of Active Ingredient: $0.80

Protein Discount Per One Quarter Point: $0.050

Low protein discount and premium

Protein Premium Per One Quarter Point, Max 17%: $0.025

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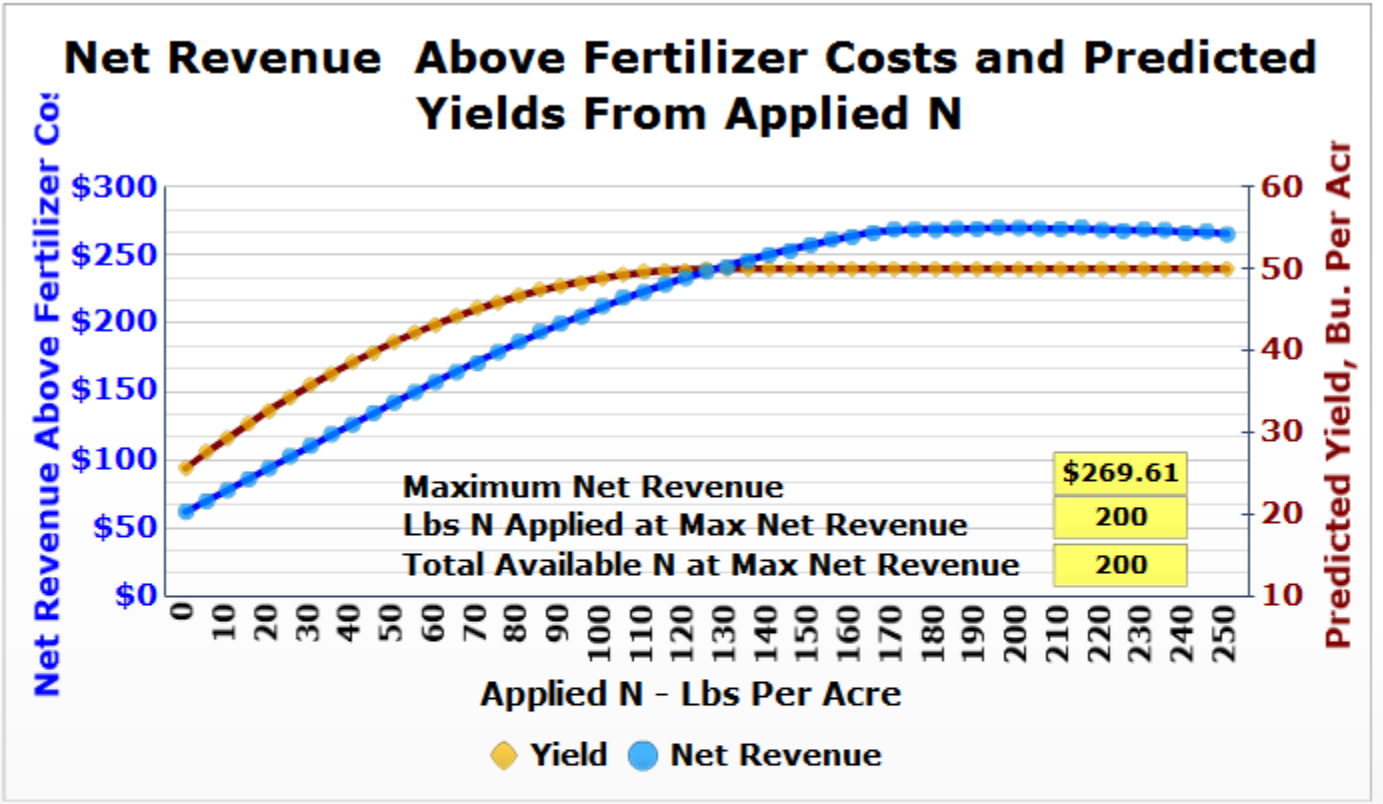

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Level of Organic Matter (O.M.): 2.00

Maximum Potential Yield (Bu. Per Acre): 50

Wheat Price for 14% Protein Spring Wheat: $8.02

Nitrogen Price Per Pound of Active Ingredient: $0.80

Protein Discount Per One Quarter Point: $0.300

High protein discount and premium

Protein Premium Per One Quarter Point, Max 17%: $0.200

MONTANA STATE UNIVERSITY EXTENSION

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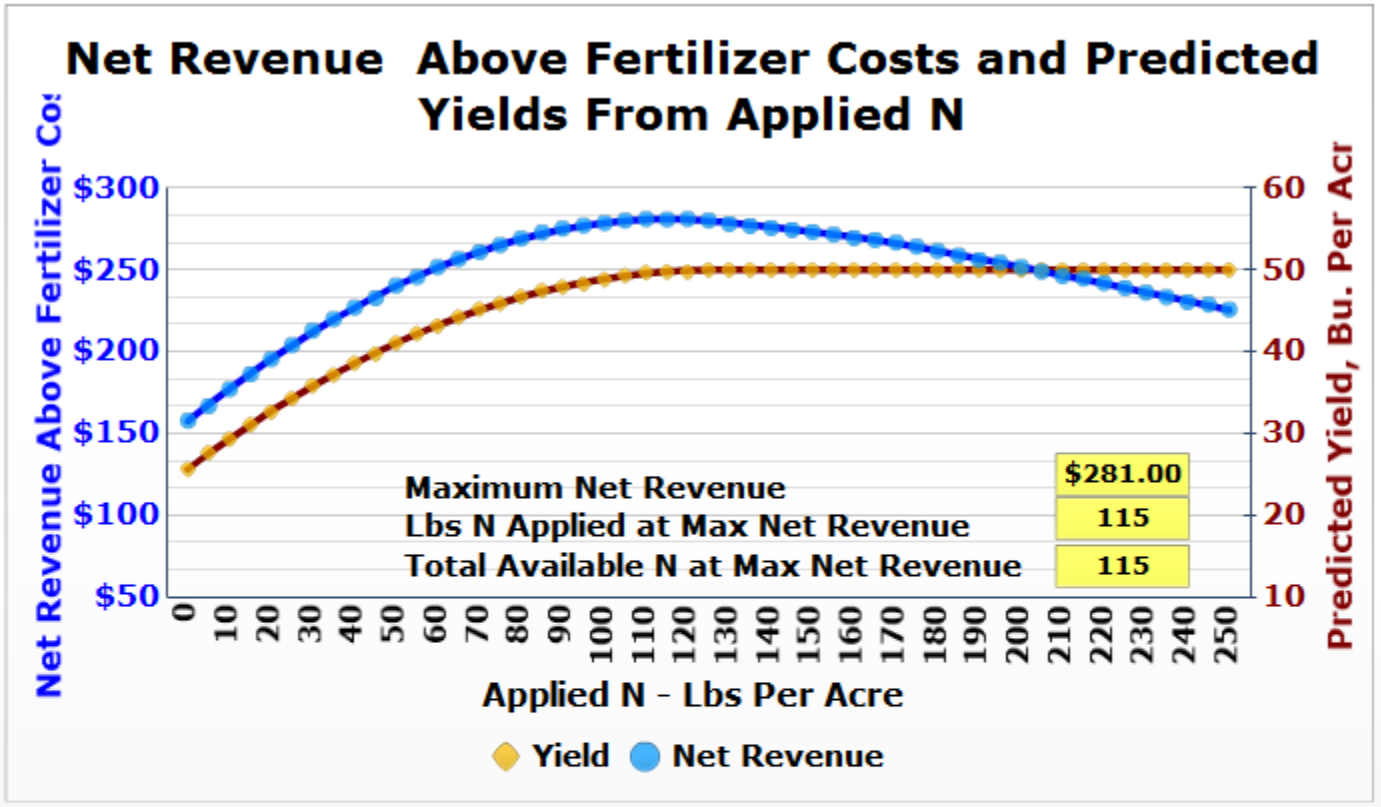
Yield Only Graph Off/On



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Level of Organic Matter (O.M.): 2.00

Maximum Potential Yield (Bu. Per Acre): 50

Wheat Price for 14% Protein Spring Wheat: $8.02

Nitrogen Price Per Pound of Active Ingredient: $0.80

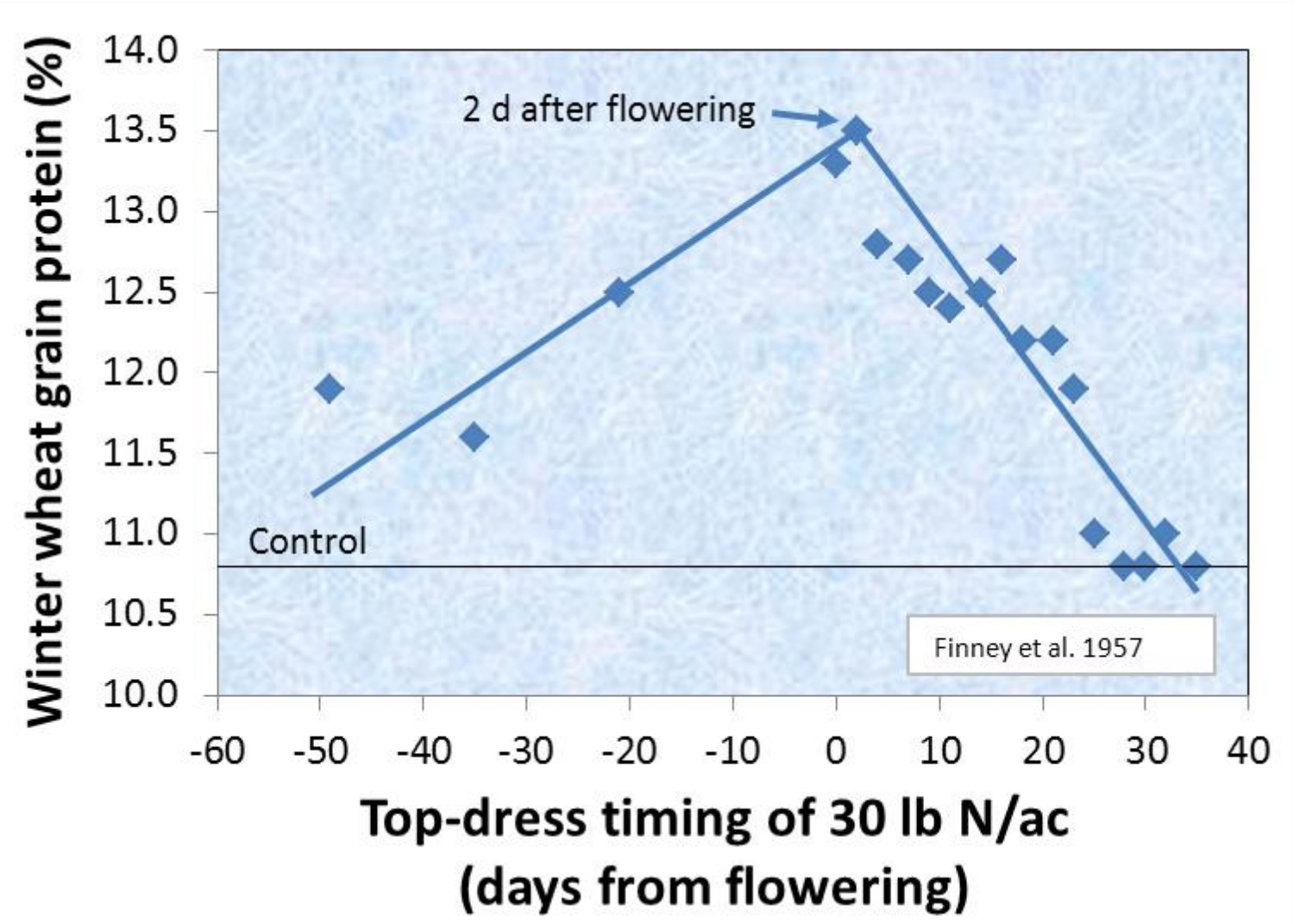
Protein Discount Per One Quarter Point: $0.100

1999-2011 average protein discount and premium

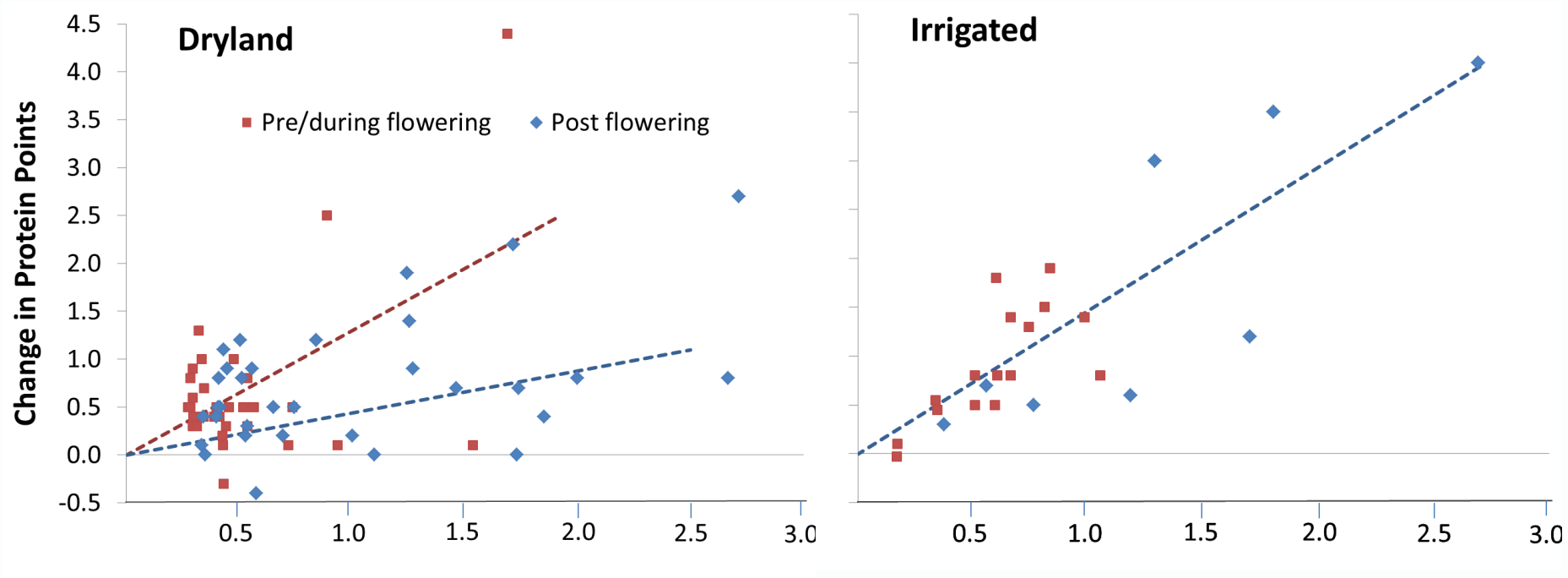
Protein Premium Per One Quarter Point, Max 17%: $0.075

Questions on optimizing fertilizer N rate?

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



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



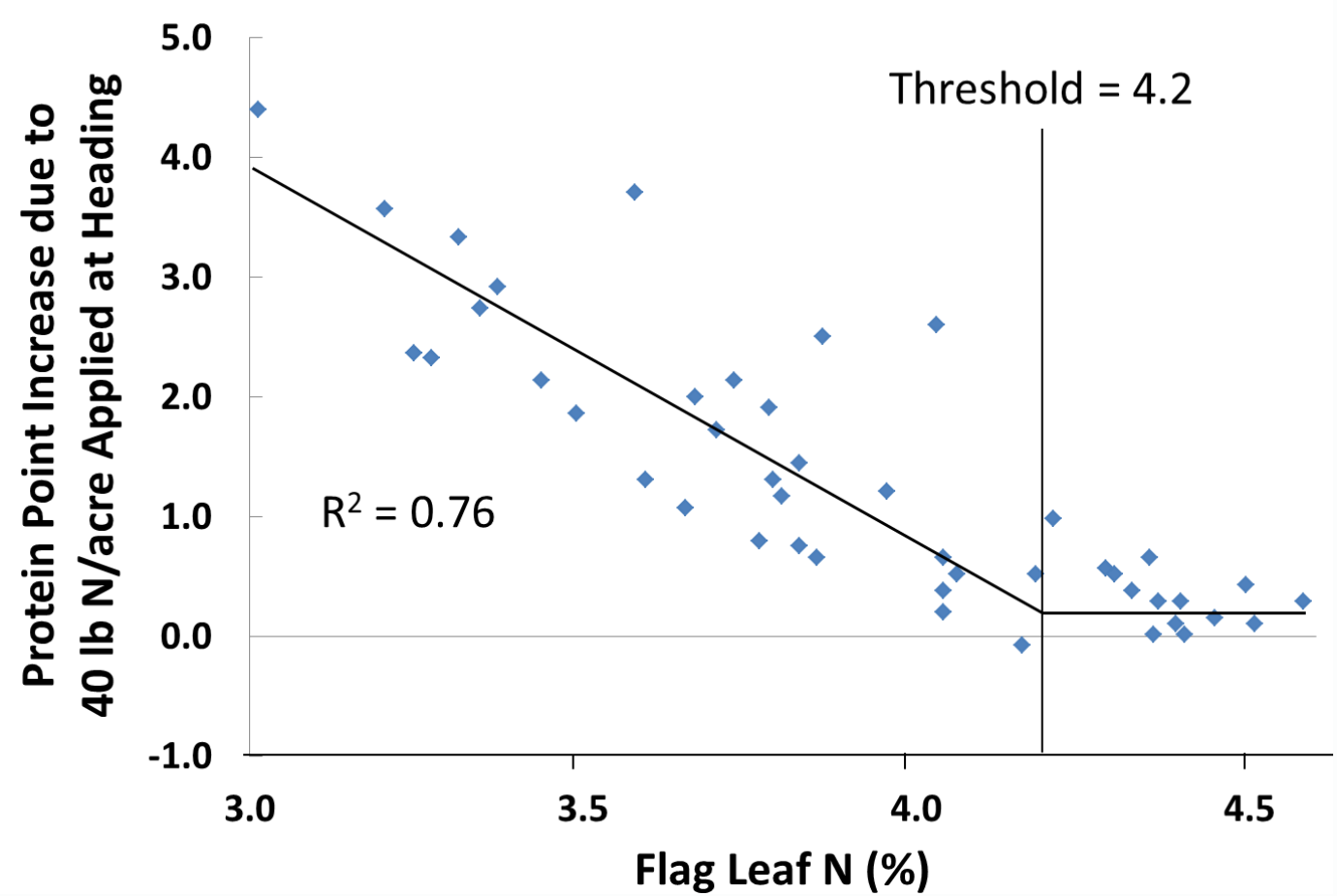
Ability to incorporate with rain or irrigation more important than exact timing at flowering

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 (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 = 3.85%.
- Example 2: If ratio of N cost to discount = 6 (current) and yield = 50 bu/ac, critical FLN = 2.65% (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?

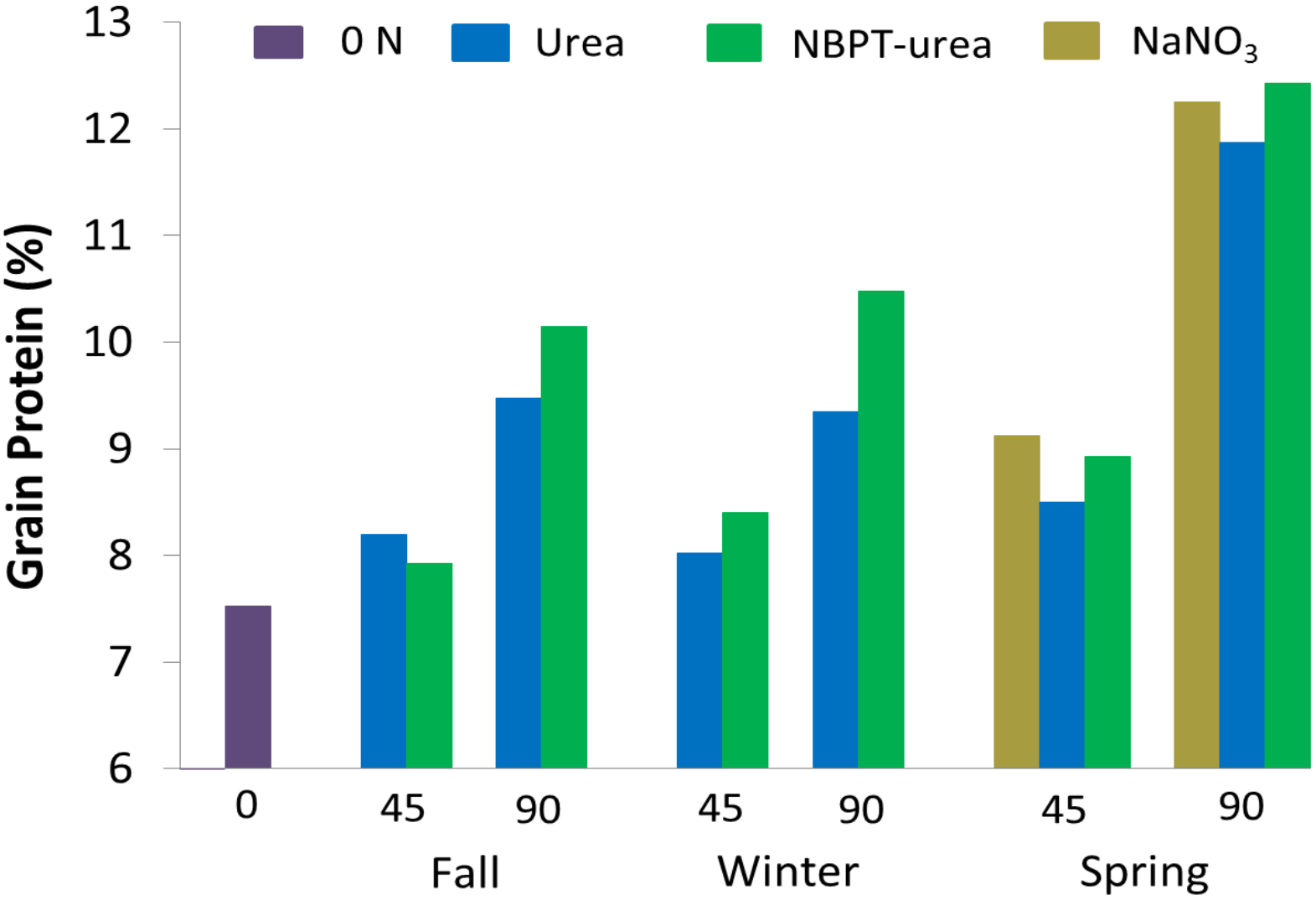
Are yield and protein affected by application timing, source, or volatilization loss?

- Location: Central MT (Coffee Creek)
- On the same field in 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

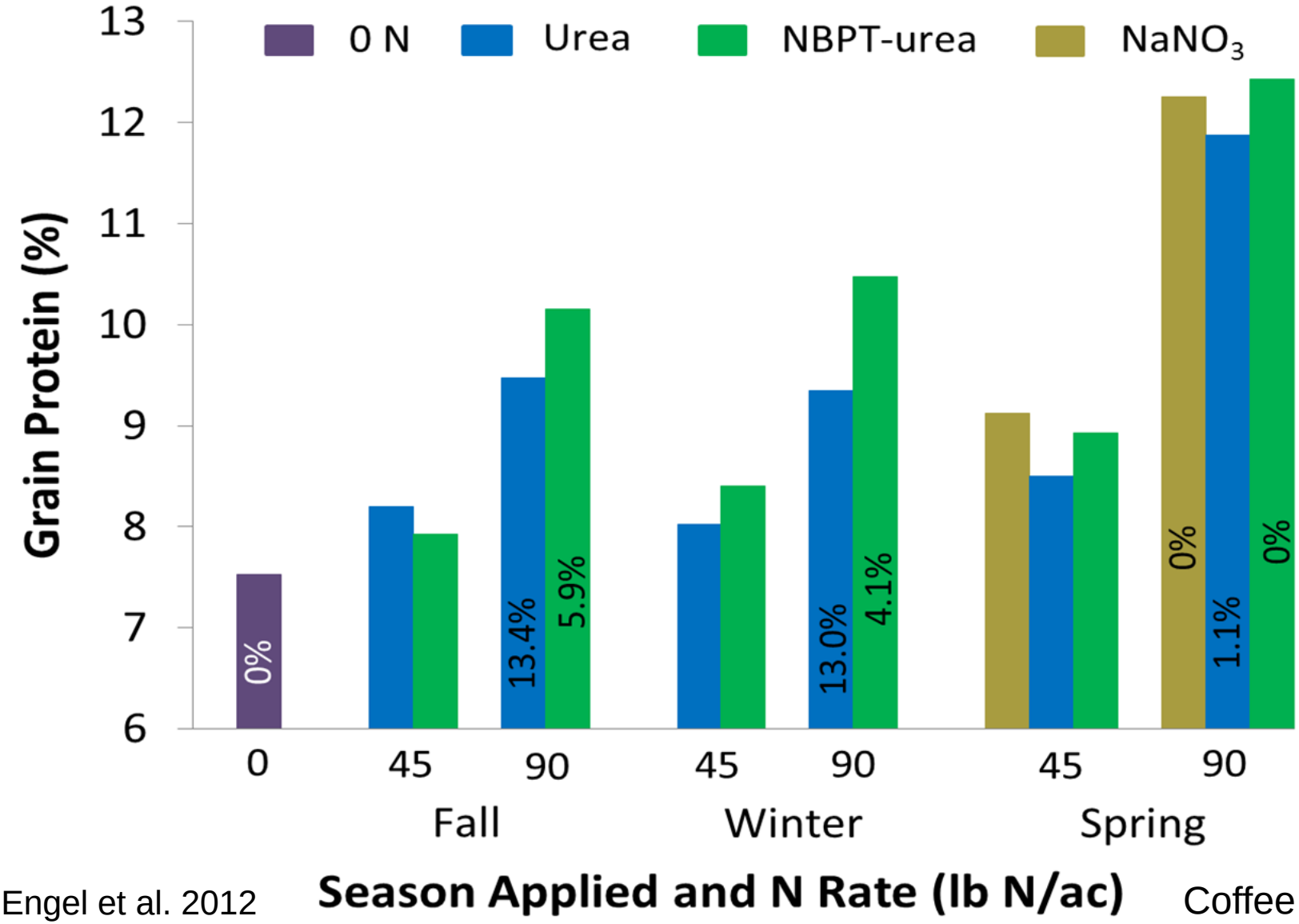
Source, application rate and timing affect protein



Engel et al. 2012
unpub data

Coffee Creek, MT, 2012

Volatilization affects protein



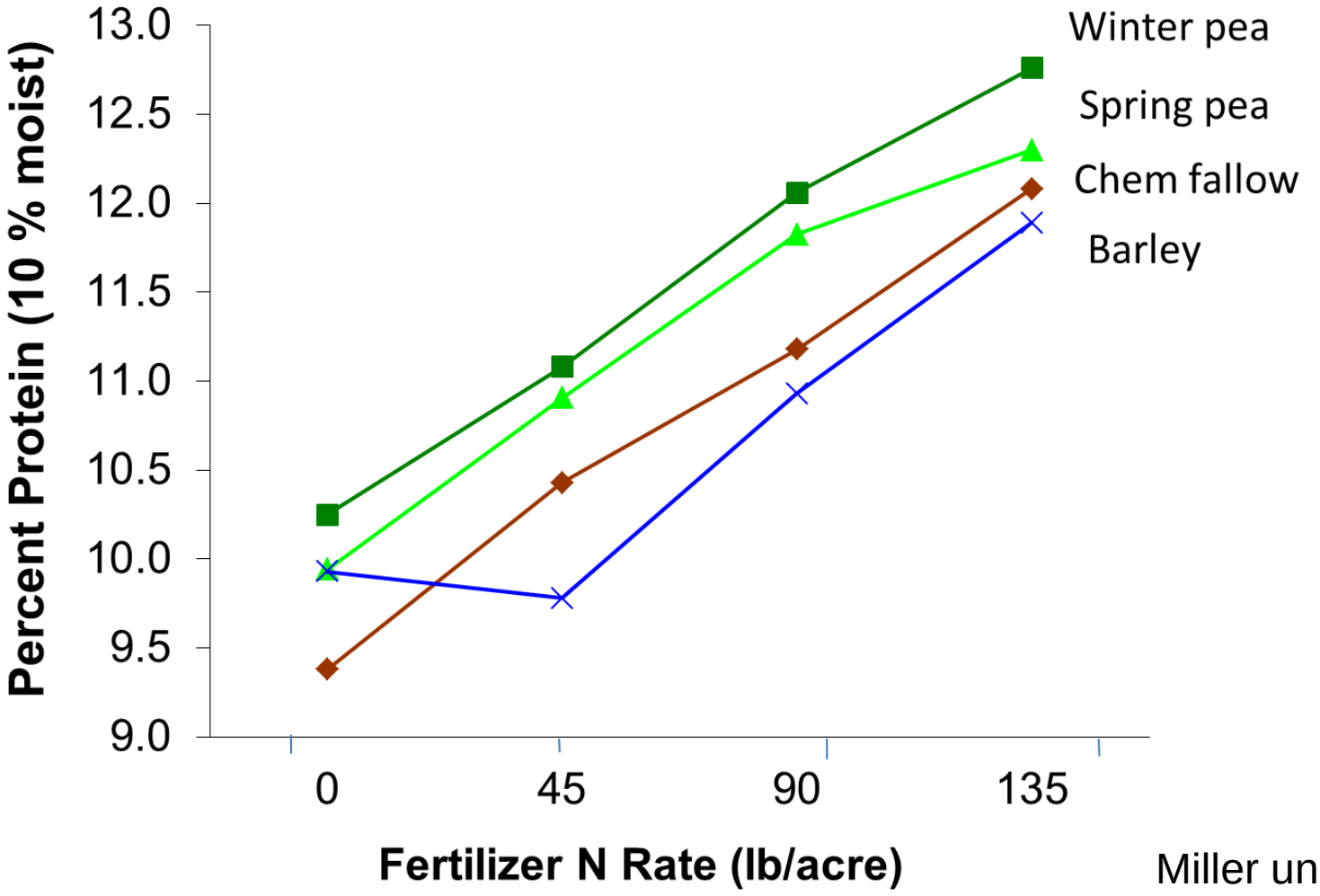
Engel et al. 2012
unpub data

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)

Do legumes in rotation with 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.
- Minimizing N losses and growing wheat after annual legumes should in general both increase protein.
- Enhanced efficiency products may or may not increase grain protein and should be used cautiously given additional expense.
- Legumes rather than fallow or continuous small grain in rotation *may* increase protein similar to about 25 lb N/ac of fertilizer.

QUESTIONS?

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”

Ammonia volatilization taped presentation:
Go to “Ammonia Volatilization”

This presentation: Go to “Presentations”