Best Management Practices for Fertilizer

Gallatin Valley Crop School

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MONTANA STATE UNIVERSITY
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AGRICULTURE

MAKING A DIFFERENCE IN MONTANA COMMUNITIES

Objectives today

- Discuss factors and practices that affect nutrient losses and thus grain yield/quality.
- Discuss how to select right source, and then right rate, right timing, right placement for that source, plus right rotation (5 Rs)
- Show research results on effects of nutrient management practices on grain yield and protein

Nutrient sources are not equally plant available

Nutrient	"Immediately" available	Growing season	Several Years
N	Urea (46-0-0), UAN (28-0-0, 32-0-0), CAN (27-0-0), AS (21-0-0-24)	ESN, SuperU	Legume residue manure
P	Phosphate (MAP, DAP, APP 10-34-0)*		Phosphate rock Ca-phosphate
K	Potash (KCl 0-0-60)		
S	Sulfate		Elemental sulfur Ca-sulfate

* Get tied up in mineral form and unavailable to plants
Those more plant available are more easily lost
Plant availability affects timing and placement

Potential N losses

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

Different N Sources have different loss potential

	***POTENTIAL* loss compared to urea**	
Source	Volatilization	Leaching
Conventional		
Ammonium nitrate, CAN, ammonium sulfate	less	≈
UAN (solution 28 or 32)	less	≈
Enhanced Efficiency Fertilizers		
Urease inhibitors (Agrotain)	less	≈
Nitrification inhibitors (DCD, N-Source, N-Serve, Instinct)	≈	less
Combinations (SuperU)	less	less
Controlled release polymer coated (ESN)	less	less
Slow release (Nitamin, N-Sure, N-Demand)	≈	less?

High risk conditions for urea and UAN volatilization (Engel et al. 2011, FF59 & 60)

Based on recent MSU research, 3-44% of fall/winter broadcast urea N can be lost to volatilization. Worse under:

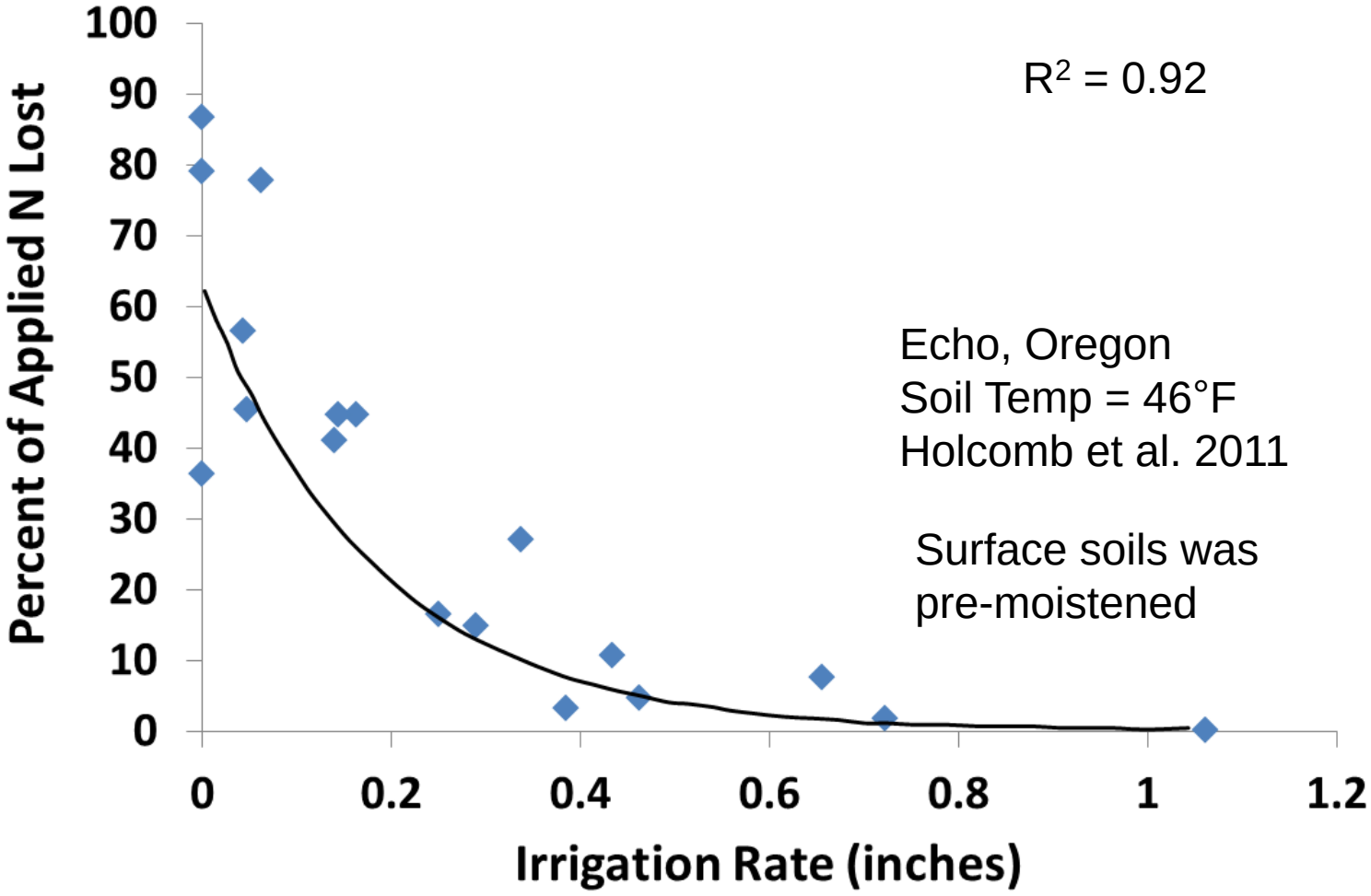
- Moist soil or heavy dew
- High soil pH (>7.0)
- High soil temperature (>50°F) or frozen soil
- Crop residue, perennial thatch or sod
- Low cation exchange capacity soil (sandy)
- Poorly buffered soils (low soil organic matter, low bicarbonate content) because urea increases pH around prill, increasing loss.

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

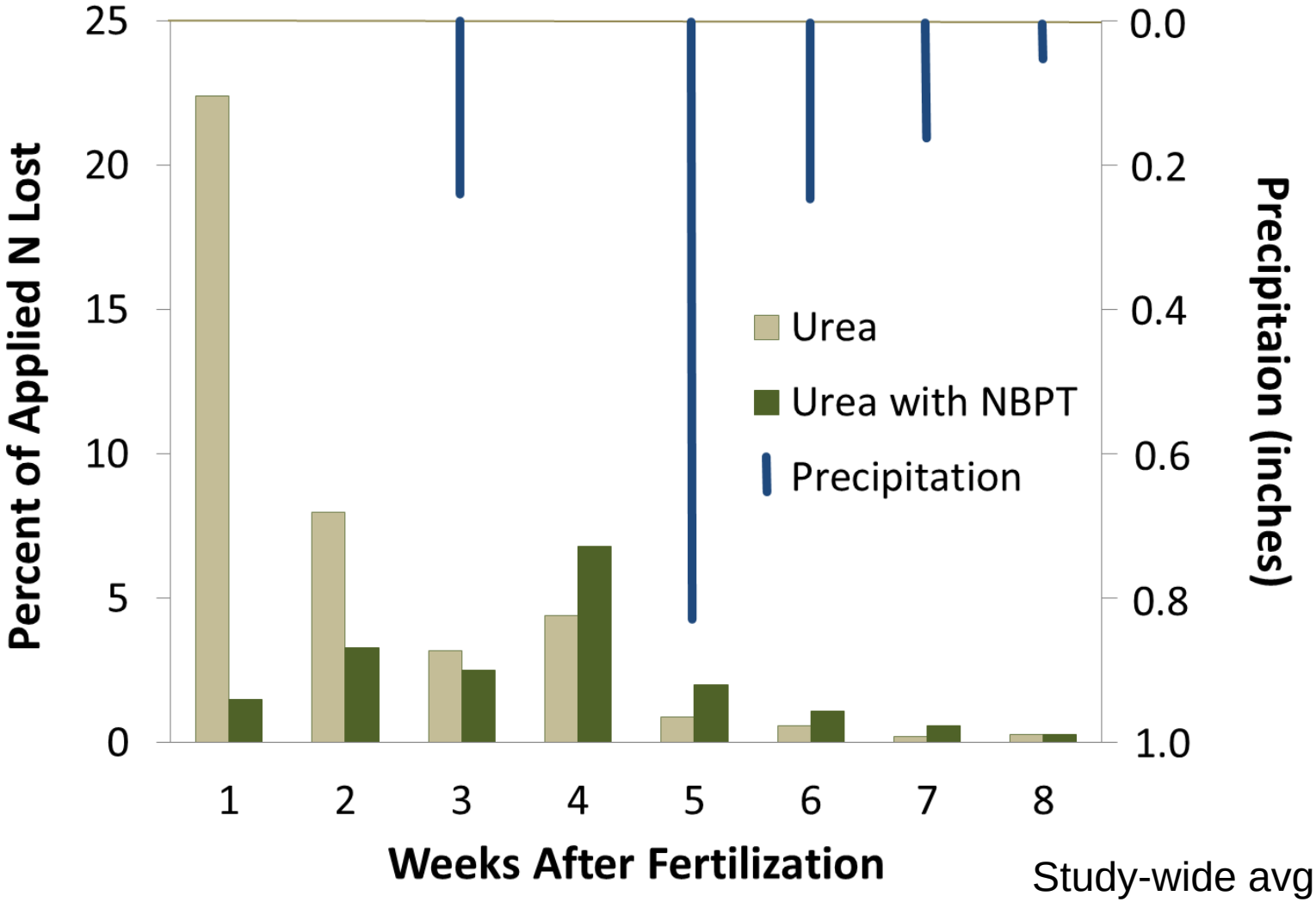
Practices to decrease volatilization from N fertilizers, especially urea

- Incorporate with tillage if possible
- Apply to dry, cool, but thawed ground
- Apply prior to a large (> 0.5”) rain or irrigation event
- Use a protected product (with NBPT, e.g. Agrotain®, Arborite Ag, Nutrogain) or ammonium nitrate (34 or 27-0-0) if can’t apply during low risk periods
- Consider using ESN® (Environmentally Smart Nitrogen). This is a slow release product that is recommended to be applied beneath surface.

Effect of irrigation amount on urea volatilization



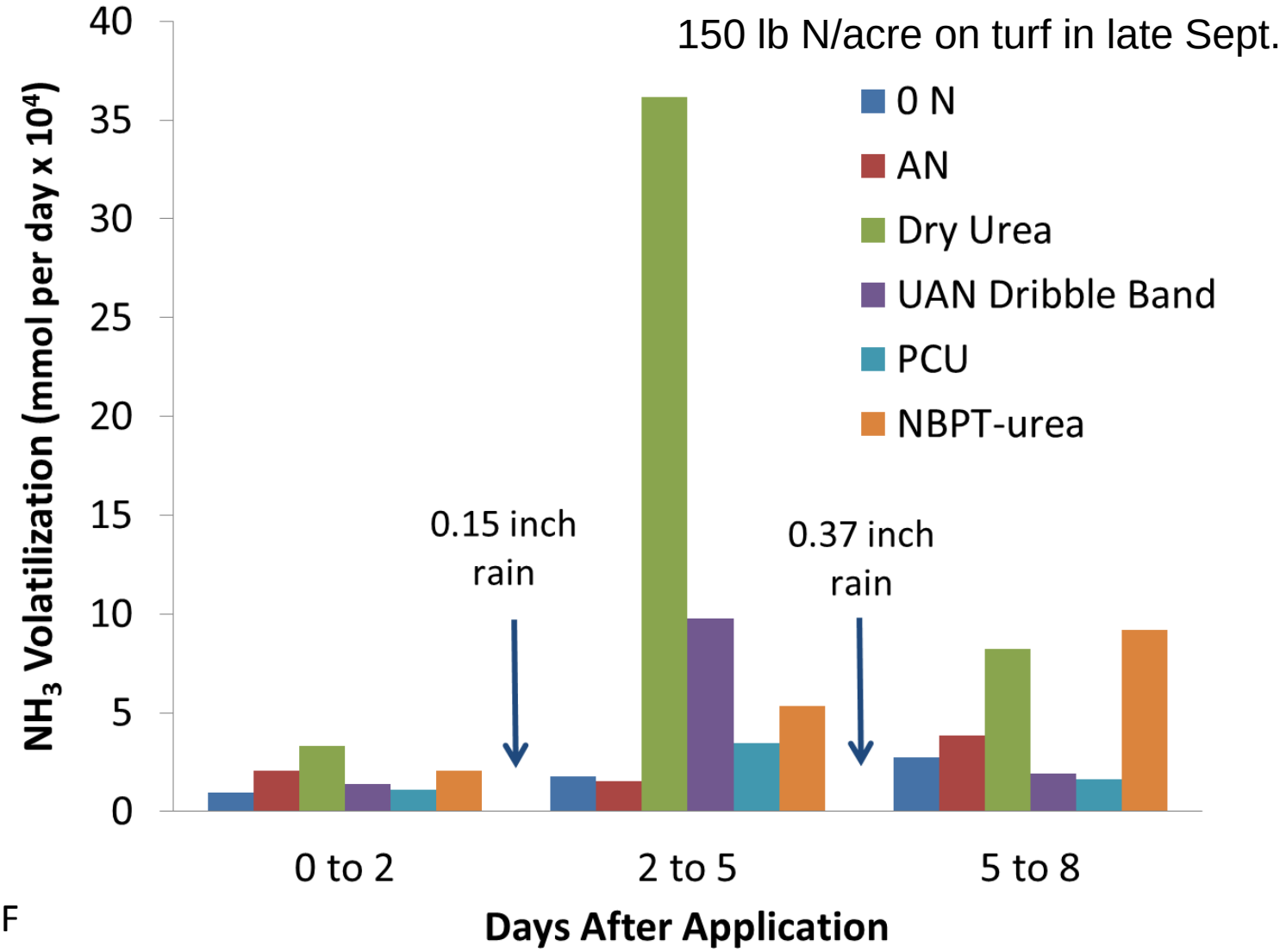
Effect of rainfall on urea volatilization



Study-wide avg. N loss
Urea 18.8%
Agrotain 6.7%

Late March, Havre
Engel et al. 2011

Effect of N source on volatilization



Washington
Soil Temp = 50°F
Koenig unpub. data

Crop management factors to decrease N leaching (applies to all N fertilizers)

- 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 they require less N fertilization
- See *Crop and Fertilizer Management Practices to Minimize Nitrate Leaching* (MT201103AG)

N management factors to decrease N leaching

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

Questions on N losses?

Optimize fertilizer N rate based on economics

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 – based on adjusted yield potential, consider using in-season sensor-based technology

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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

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The F11 key will toggle (switch on and off) the screen space from normal to maximum viewable area.

MSU Soil fertility recommendations

http://www.sarc.montana.edu/php/soiltest/

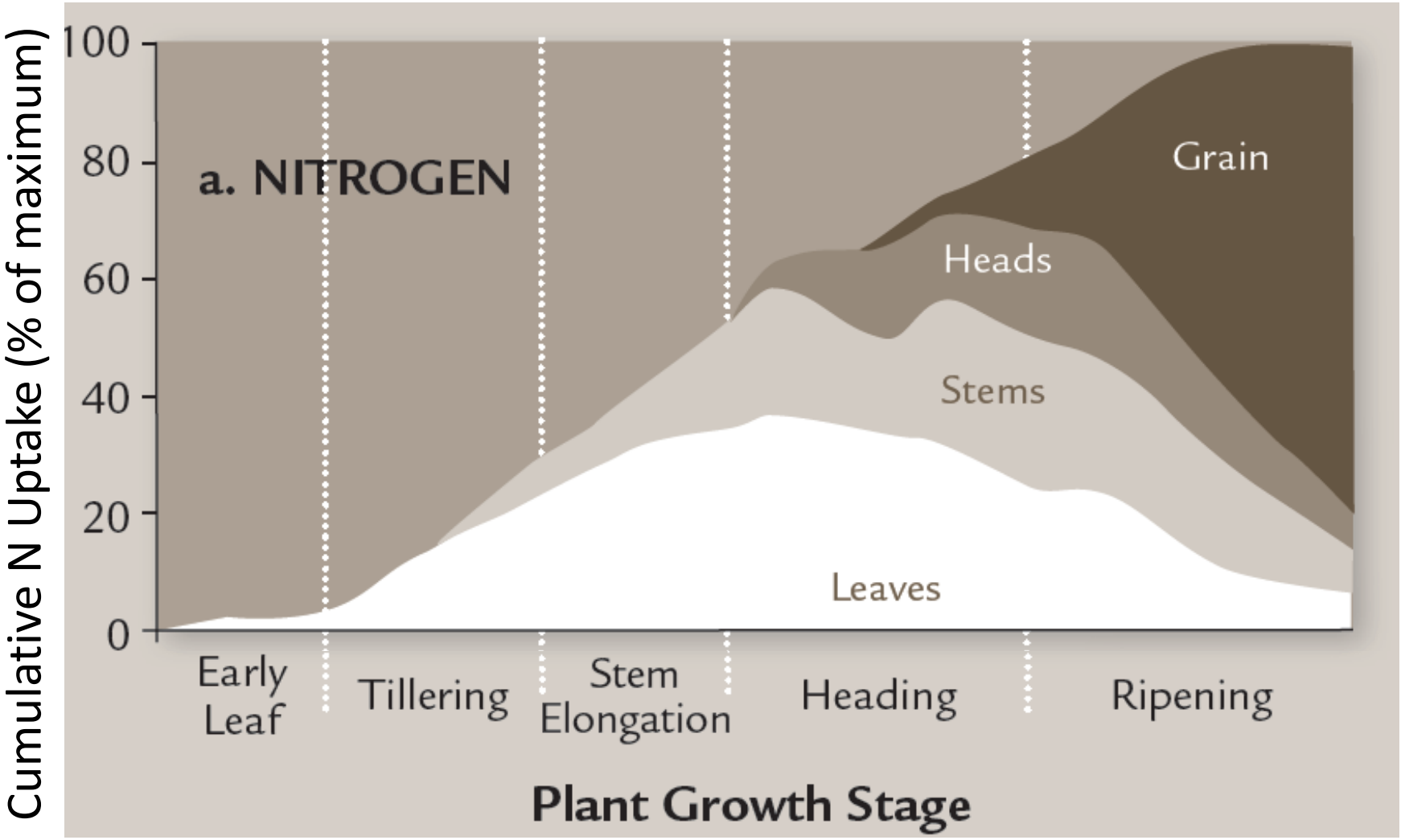
Submit Clear form

1. Topsoil sample results:			*2. Soil Nitrate Results:*				
Olsen P	6	ppm	Sample #	top	bottom	Soil test value	
Extractable K	50	ppm	1	0	6	60	ppm
Soil Organic Matter	1.5	%	2	6	12	65	
			3	0	0	0	
			4	0	0	0	

3. Crop Management:		
Last year's crop: sugarbeet	New Crop barley-malt	Yield goal of 80 bu/acre

Submit

N Timing: N uptake as wheat grows



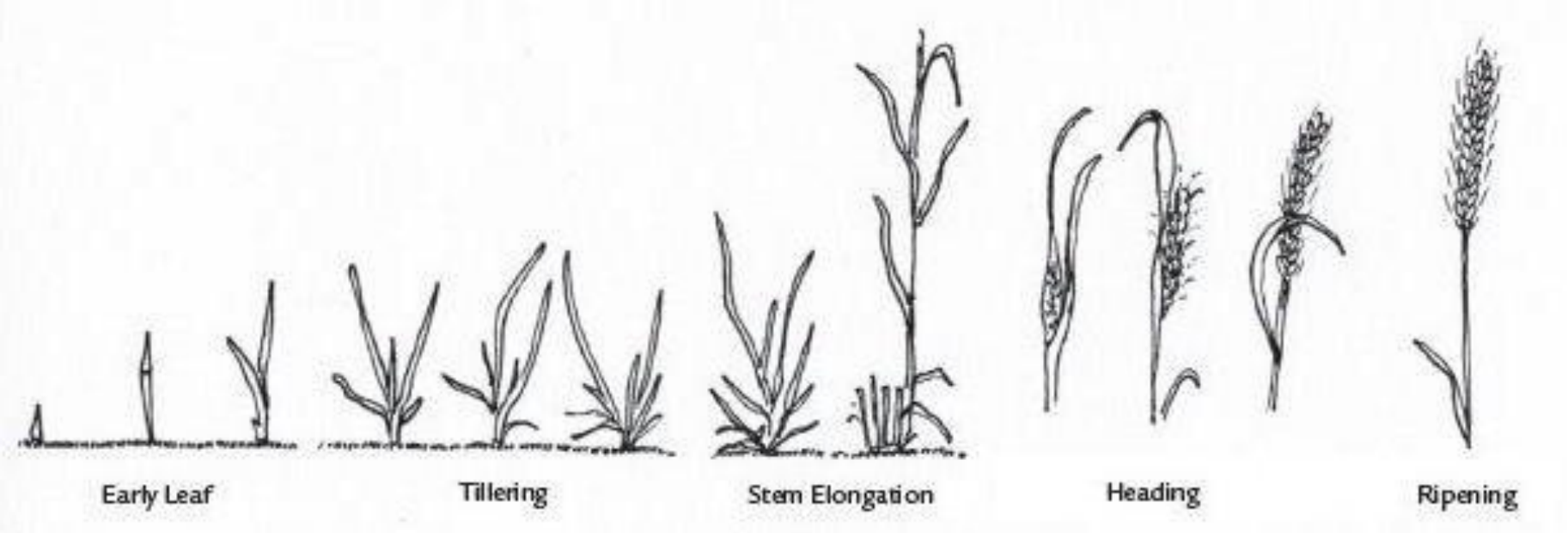
Nutrient Uptake Timing by Crops (EB0191; Miller 1994)

Gallatin Valley, irrigated

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

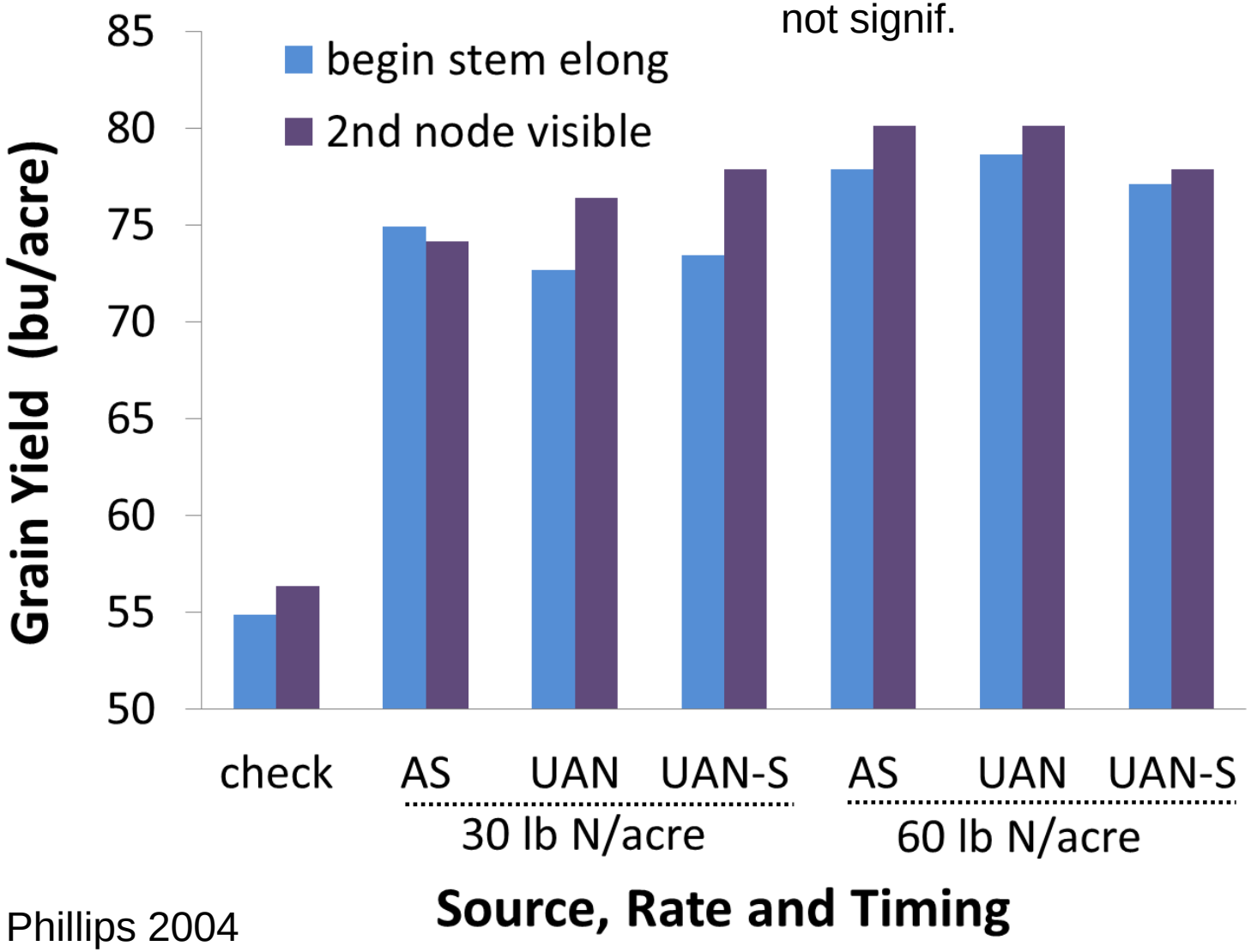


Take home message on N timing

- Need sufficient N at tillering/stem elongation because of high N demand
- For protein boost, consider applying additional N
  - If you have a way to apply without physically damaging crop
  - If indicated by flag leaf N level
  - Irrigated – ideally during flowering
  - Dryland – more important to get incorporation with > 0.5” rain event than “correct” timing
- In-season foliar
  - No more than 30 lb N/ac of UAN (b/c of burn)
  - Reduce to 20 lb N/ac max, if combined with herbicide
  - Less leaf burn at beginning of stem elongation than at 2nd node visible, and with added S, but may not translate to increased yields (Phillips 2004)

Foliar N rate and timing and addition of S on WW grain yield

If applied by 2nd node, timing is not signif.



Virginia, Phillips 2004

AS (21-0-0-24) UAN (30-0-0) UAN-S (29-0-0-4)

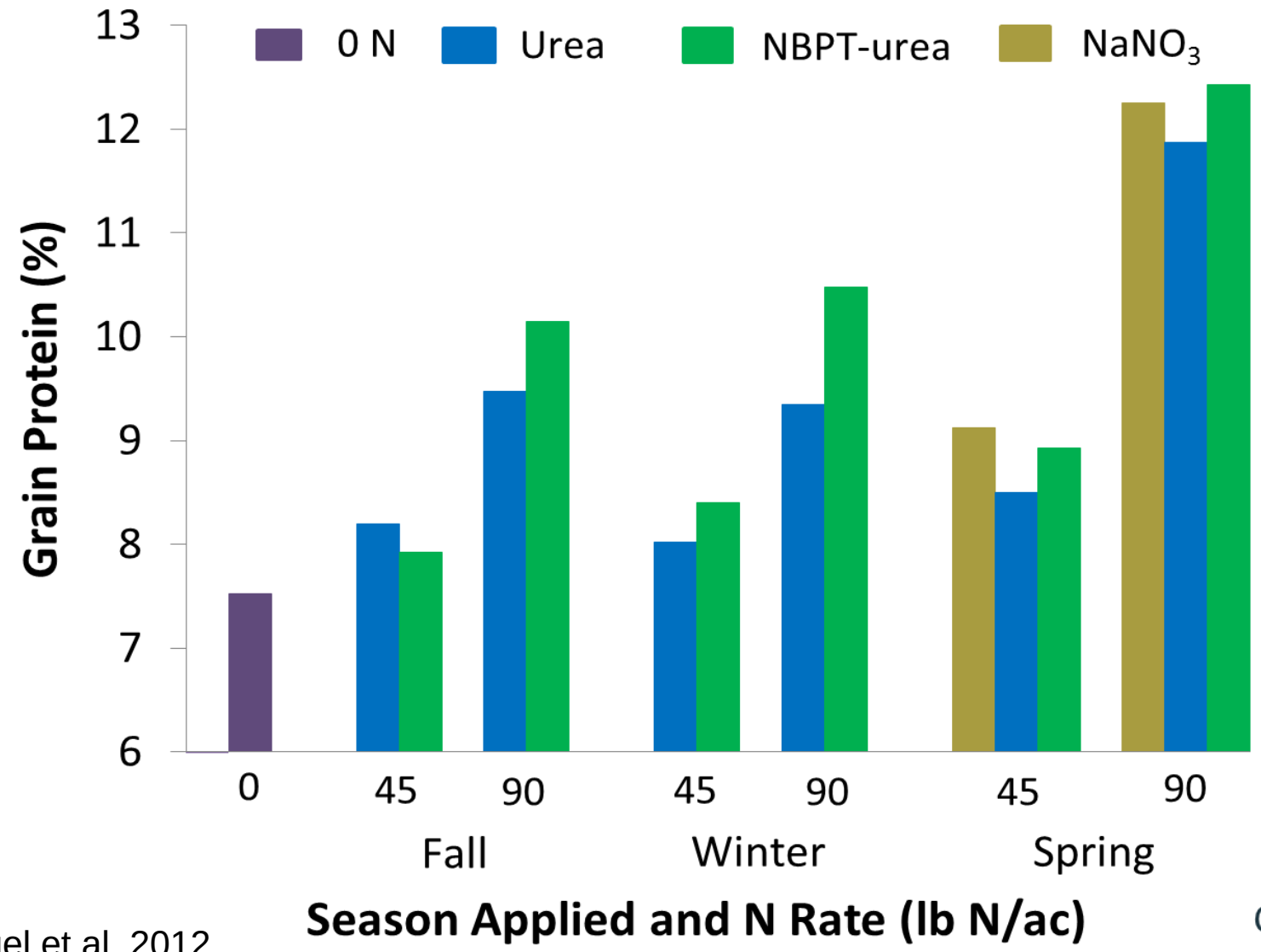
Are yield and protein affected by application timing, source, or volatilization loss?

- 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

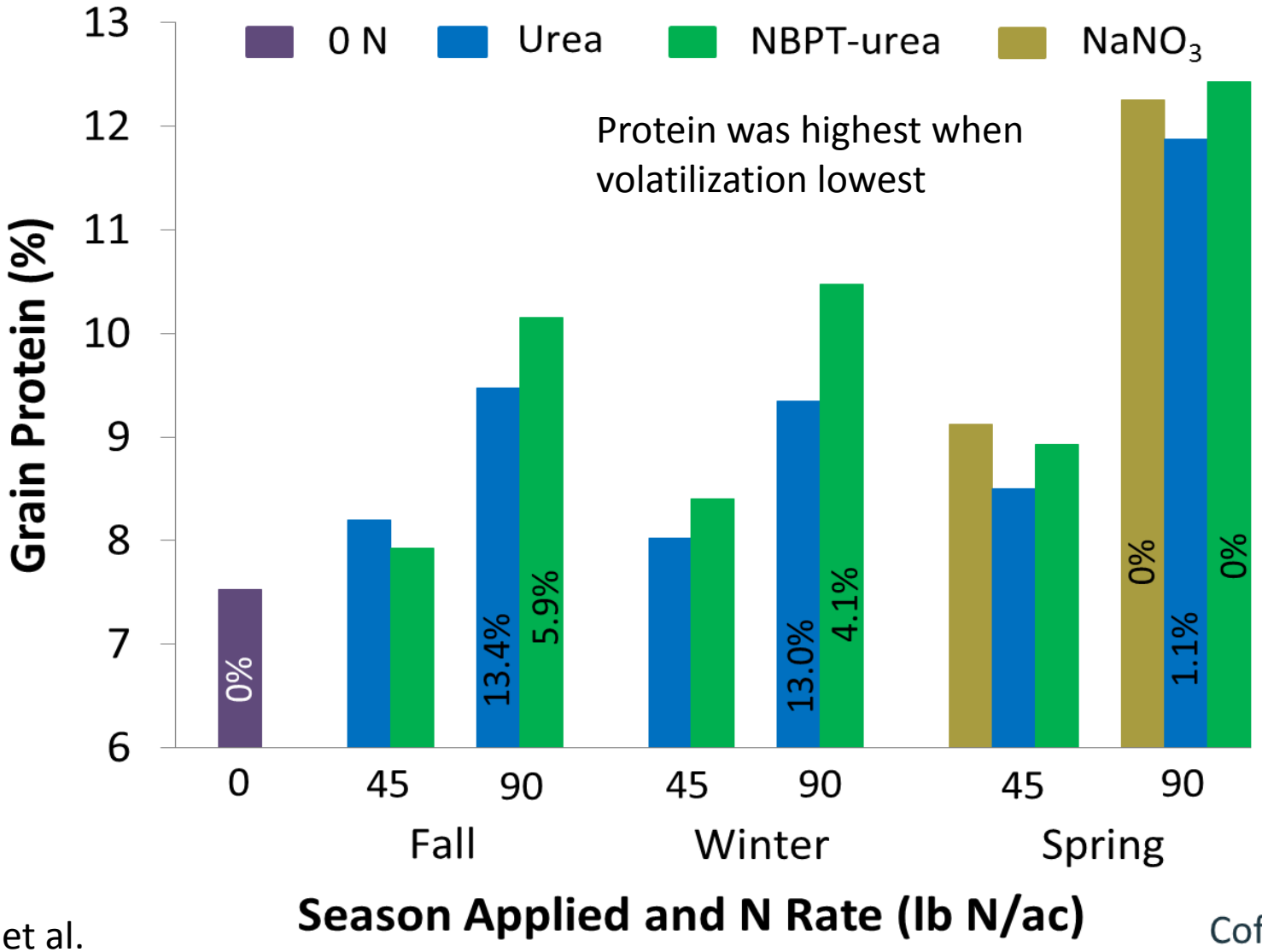
Source, application rate and timing affect protein



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 (Engel unpub.)

Based on 2012 results, it appears:

- Reducing volatilization of fall applied urea may increase yields, less so with winter and spring broadcast urea
- NBPT tends to increase yield when used with 90 lb N/acre, but not with 45 lb N/acre rate
- Protein tends to be higher with spring than fall or winter urea application, especially at higher N rate
- Reduced volatilization by using NBPT appears to increase protein at the 90 lb N/acre rate, especially when used on fall and winter broadcast urea

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):

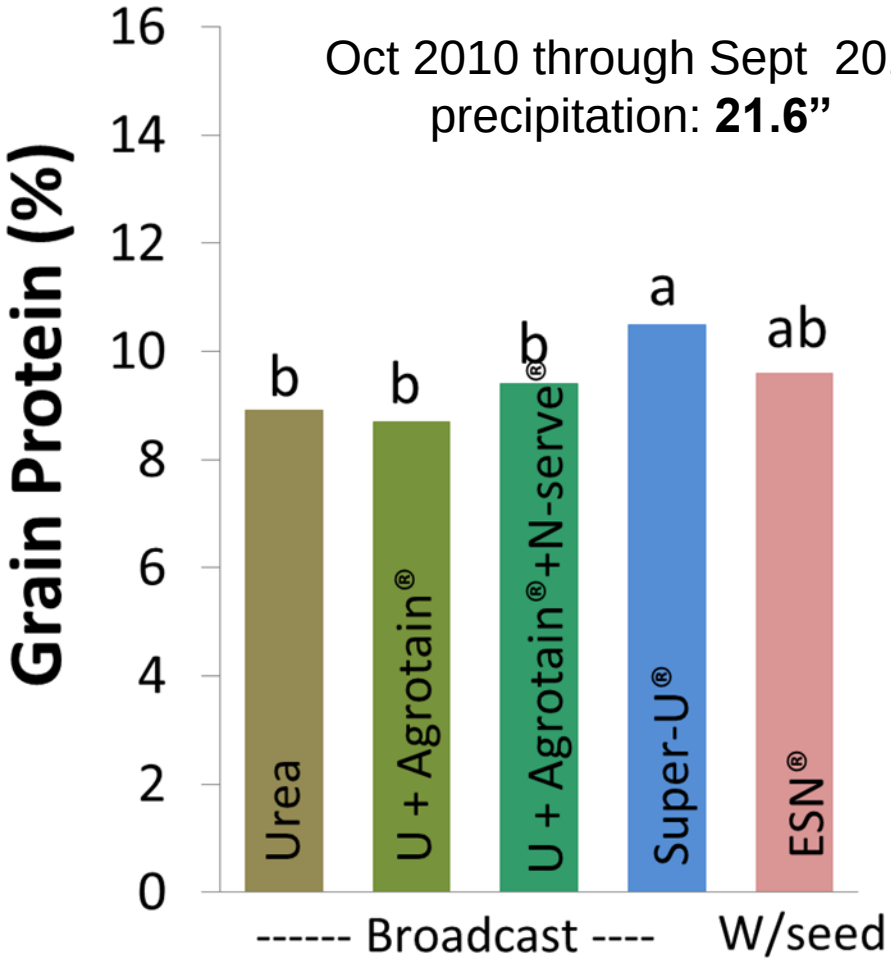
  Regular urea

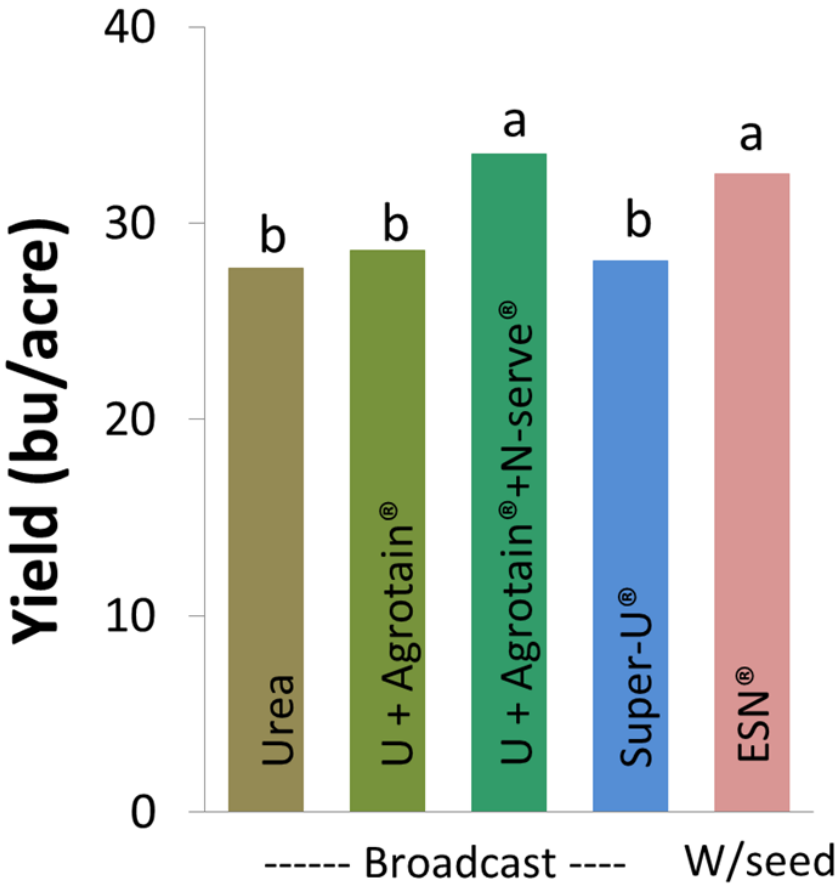
  Super U (w/ urease and nitrification inhibitors)

  Urea mixed with Agrotain and N-serve (nit inhib)

  ESN with seed (only in fall)

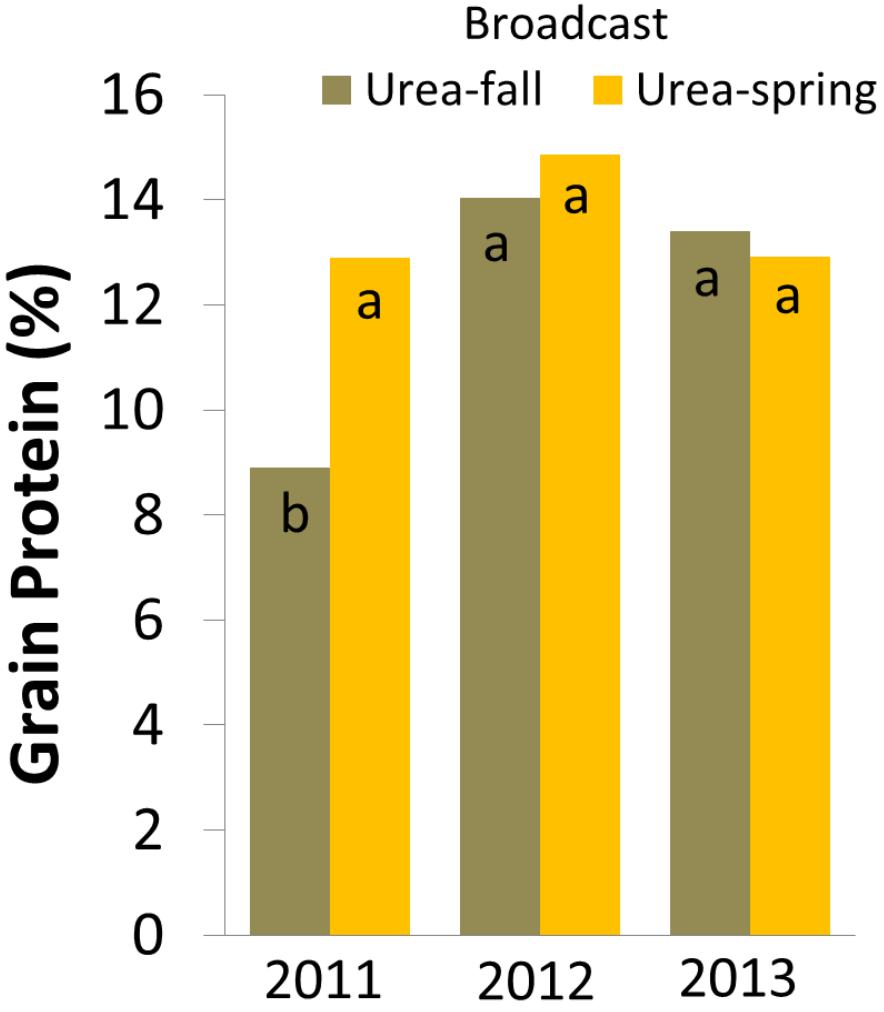
Effect of source and placement (fall applied) on grain yield under high risk leaching conditions

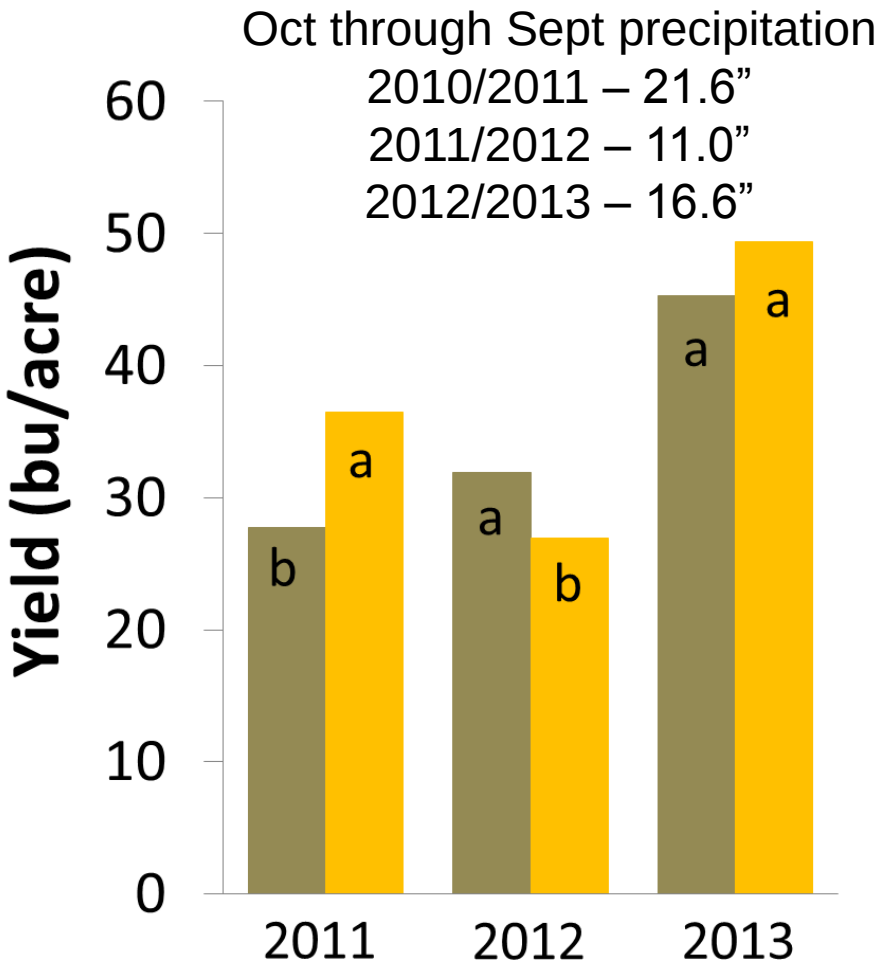




Fertilizer Fact 62, Moccasin, MT

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





Fertilizer Fact 62, Moccasin, MT

Take home messages of Moccasin study

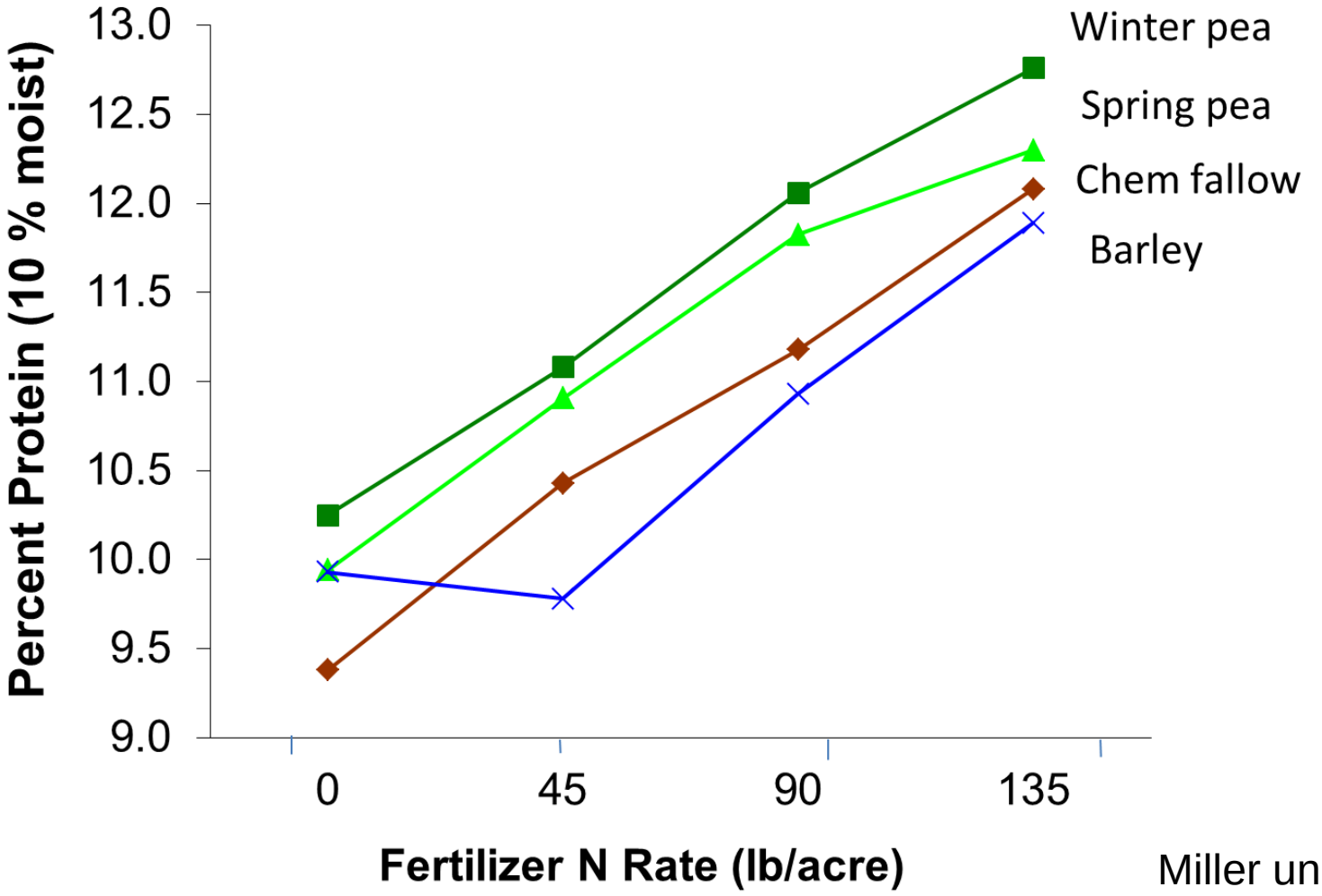
- In wet year, enhanced efficiency fertilizers produced similar or higher yields and protein as conventional urea
- In dry year, yields and protein were similar for EEFs and conventional urea (data not shown), so EEF net revenue would be worse.
- In wet year, spring application increased yield and protein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

Questions on rate and timing?

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 at wide row spacing)

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



Miller unpub data

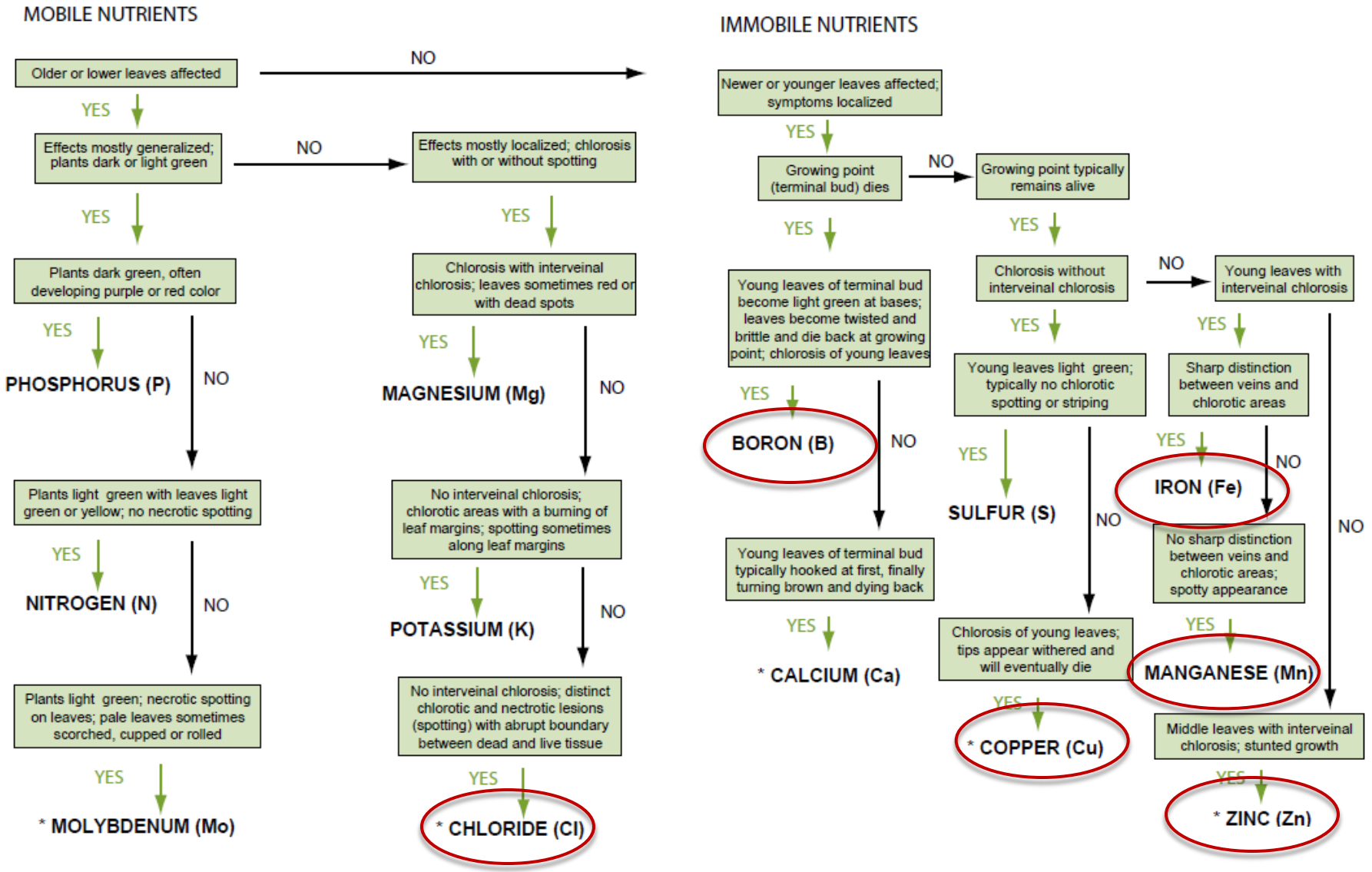
Questions on N?

Rates for P, K, S and micronutrients

- Base fertilizer rates on soil tests (MT200702AG, MT200703AG, EB0161): EXCEPT – Can't use soil test for S
- Tissue tests: There are tissue concentration sufficiency ranges, but other than for Cl there are no MT fertilizer guidelines for micronutrients based on tissue tests
- Visual deficiency symptoms (MT4449-7); however, once symptoms appear yield may already be reduced

Visual tissue assessment

In Nutrient Management Module 9
http://landresources.montana.edu/nm



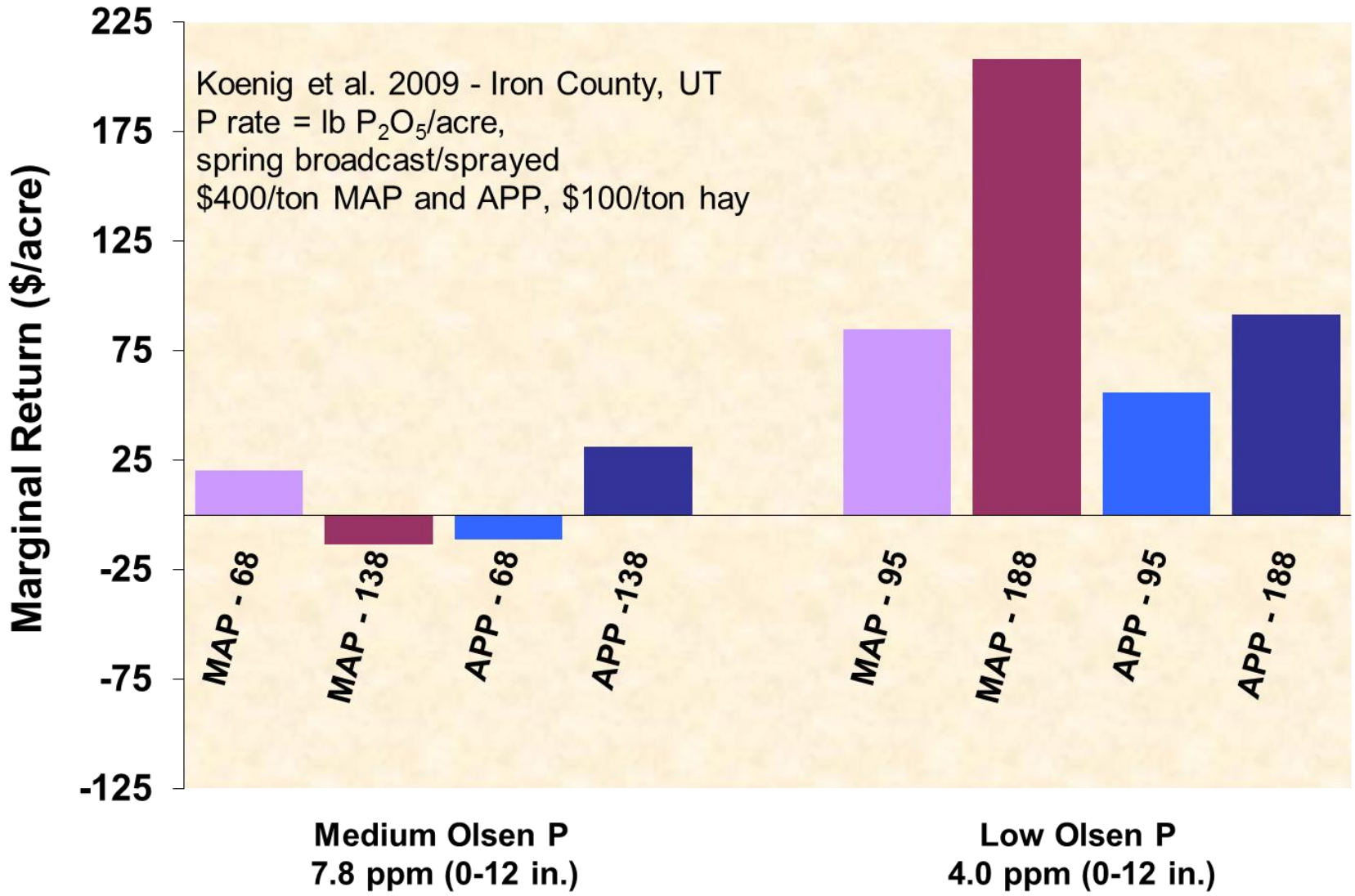
Timing depends on source

- Slowly available (Phosphate rock, Ca-phosphate, elemental sulfate, Ca-sulfate, oxysulfate forms of microminerals)
  - take time to become available
  - apply well before needed – e.g. fall
  - can build soil levels
  - less expensive per unit
- Readily available (chelated or sulfate forms, phosphate)
  - Apply when needed – e.g. spring
  - foliar/liquid options
  - more expensive per unit

Phosphorus

- Phosphate P is equally ‘available’ to the plant, whether in dry granular or liquid form
- Soil chemistry determines how much gets taken up by plant
  - Alkaline soils with high Ca bind P to create mineral form unavailable to plants
  - Soil organic matter decreases availability
  - Cold dry soils decrease availability

P source on alfalfa – net return

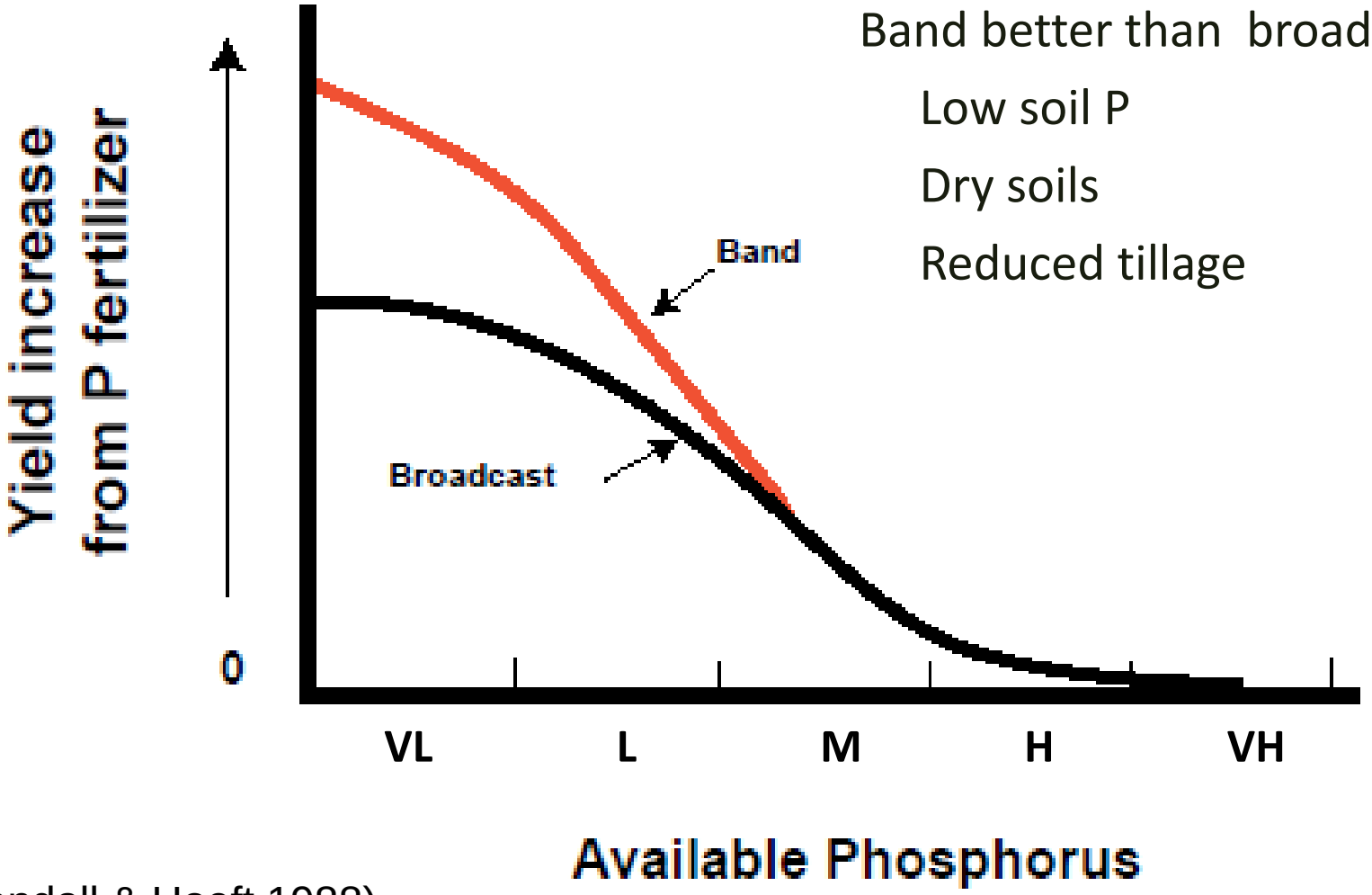


Alfalfa is able to take up P through crown

Placement of phosphate and KCl

- Incorporate prior to seeding
- Place in rooting zone at seeding – avoid seedling burn
  - <20 lb P_2O_5/acre MAP, 0 DAP with seed
  - <10-15 lb N plus K20 with seed
- In-season foliar application of P can increase yield, no information on foliar K

P band vs. broadcast

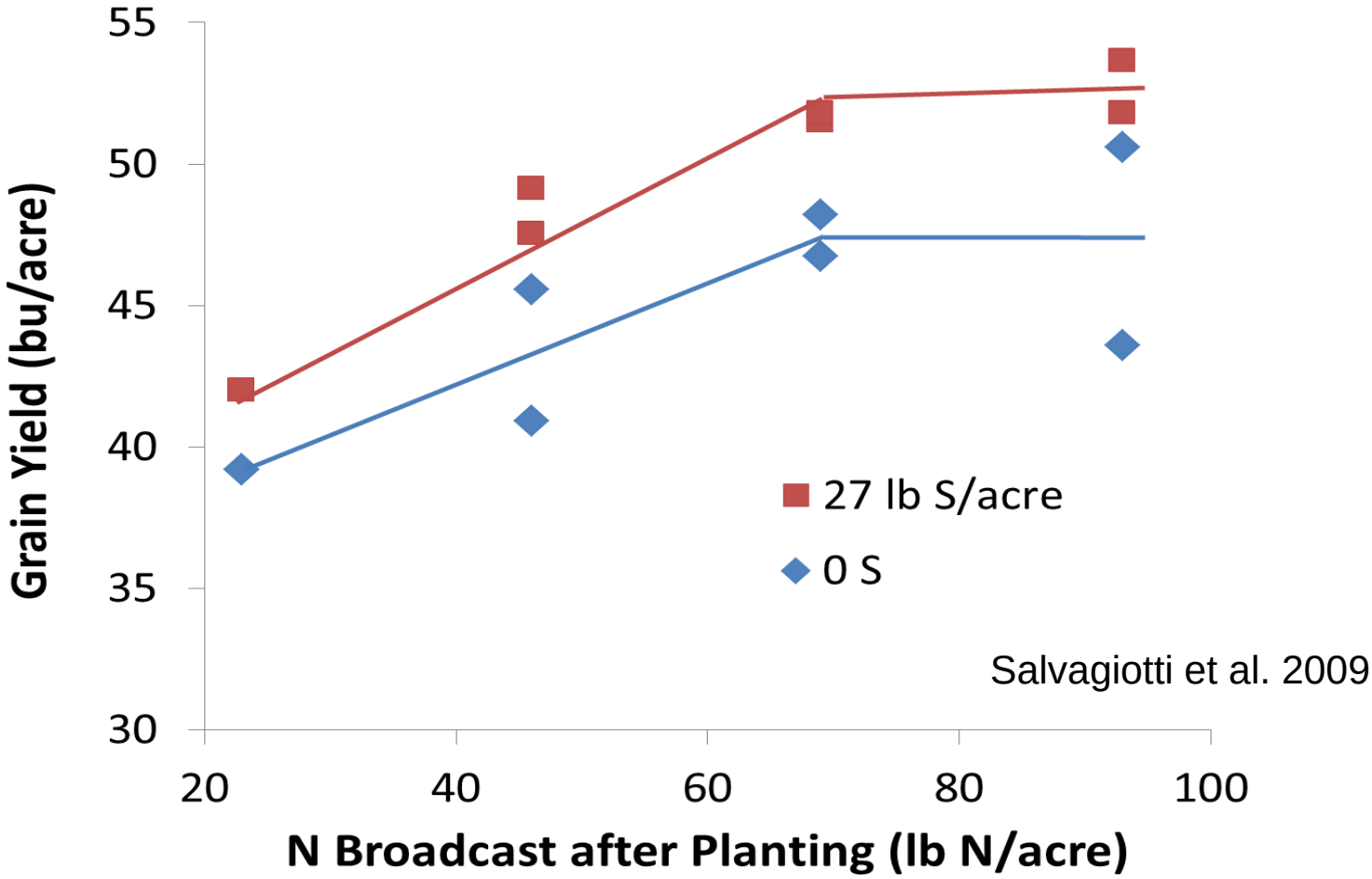


Band better than broadcast:

- Low soil P
- Dry soils
- Reduced tillage

(Randall & Hoeft 1988)

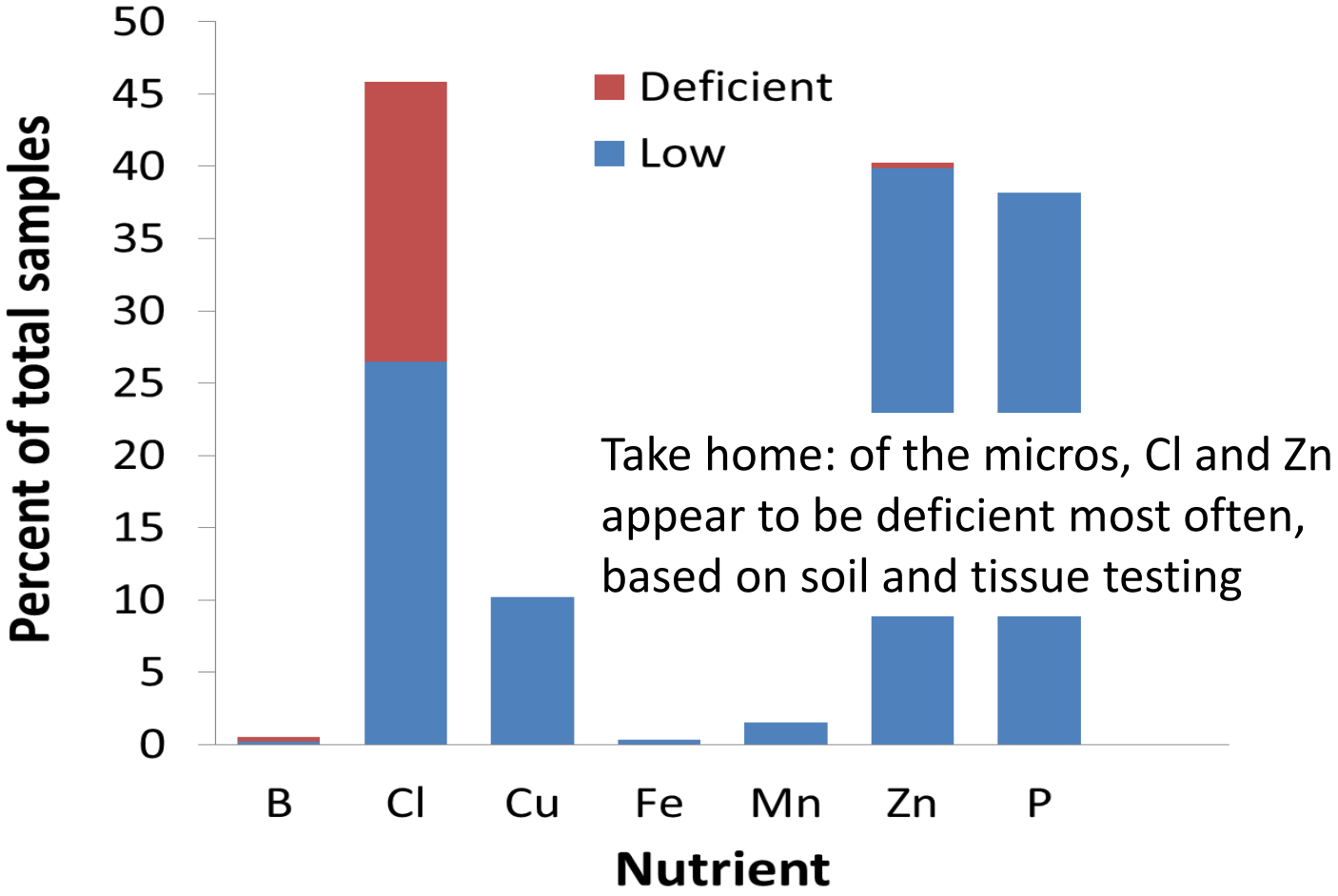
Sulfur increases N uptake and yield



S increased total N uptake, but not protein concentration

Questions on P, K or S?

Small grain tissue nutrient concentrations from Montana in 2013 (source: Agvise, n=589)



There may be error b/c many samples are not the correct plant part and there may be bias because more samples with deficiency symptoms are submitted than w/o symptoms

Micronutrient fertilizer application timing and method

Timing

- Borate, chelated or sulfate forms: Spring
- Oxysulfate forms: Fall

Method

- Preferred method is broadcast and incorporated – except iron is best as chelated foliar
- Seed-placed and subsurface band is generally not recommended (due to toxicity)
- Foliar applications use less than ½ the suggested rate. Can be done with borate, and chelated copper, iron, manganese and zinc

Karamanos 2000, Gerwing and Gelderman 2005

Chloride

- Cl is very mobile so may need to add more if leaching or yield potential are high. 20 lb KCl/acre annually may provide enough.
- Yield increase from Cl may be due to disease suppression
- Over 210 trials in KS, MN, MT, ND, SD, MB and SK have evaluated Cl-response in wheat and barley, average increase of 5 bu/acre (Cindy Grant, Agriculture and Agri-Food Canada)

Conclusions

- Incorporation is the best way to minimize N volatilization loss
- Sufficient pre-plant N followed with spring top-dress helps reduce loss to nitrate leaching
- Enhanced efficiency products may or may not increase yields and grain protein. They do better in wet years or with irrigation than in dry conditions. Use cautiously given additional expense.
- Place immobile nutrients in the root zone, esp. in reduced till and dry conditions

Conclusions continued

- Place immobile nutrients in the root zone, esp. in reduced till and dry conditions
- Apply plant available sources shortly before needed by plant
- Apply slowly available sources in the fall
- Micronutrients likely best broadcast and incorporated or as chelated foliar
- Tools are available to evaluate and calculate fertilizer needs

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

Practices to Increase Wheat Grain Protein (bulletin)
Ammonia Volatilization (2 bulletins)
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?