Soil Nutrient Management:

Testing, Sources, and Foliar Application

Soils Workshops for Hill, Blaine and Phillips Counties

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MONTANA STATE UNIVERSITY EXTENSION

AGRICULTURE

MAKING A DIFFERENCE IN MONTANA COMMUNITIES

Objectives

- Discuss value of soil and tissue sampling
- Interpret soil test results
- Determine fertilizer recommendations
- Present nutrient source options, including foliar applications
- Discuss effects of timing for different sources
- Present results of different sources on grain yield and protein

But first, some questions to help us assess impact of Rick Engel’s and my work on urea volatilization

What percentage of urea would you estimate is lost to the air from volatilization if urea is broadcast (no-till) between mid-fall and early spring and not incorporated into the soil, ON AVERAGE?

1. 0 to 10%
2. 10 to 20%
3. 20 to 30%
4. 30 to 40%
5. > 40%
6. I didn't come prepared to take a quiz

Based on 20+ studies: ~18%

What do you think are worst case conditions for urea volatilization?

1. Warm and moist soil surface with only sprinkles for 2 weeks
2. Cold and moist soil surface with only sprinkles for 2 weeks
3. Warm and dry soil surface followed quickly by > 0.5 inches of rain or irrigation
4. Cold and dry soil surface followed quickly by > 0.5 inches of rain or irrigation
5. I don’t know

1 is correct based on ours and others research

Have you made any management changes based on MSU's urea volatilization research? If 'yes', what was your ***biggest*** change?

1. No
2. Yes. I now try to apply urea immediately before rain or irrigation.
3. Yes. I now subsurface band or incorporate more of my urea.
4. Yes. I now try to apply only to dry soil surfaces.
5. Yes. Other

Thank you!

Fertilizer guidelines

- Guidelines for N, P, K and 5 micro-nutrients for winter wheat and spring wheat production are provided in *Fertilizer Guidelines for Montana Crops* (EB0161).
- They are based on soil analysis. *Soil Sampling and Laboratory Selection* (MT4449-1) *Soil Sampling Strategies* (MT200803AG). There is not a good soil test for S.

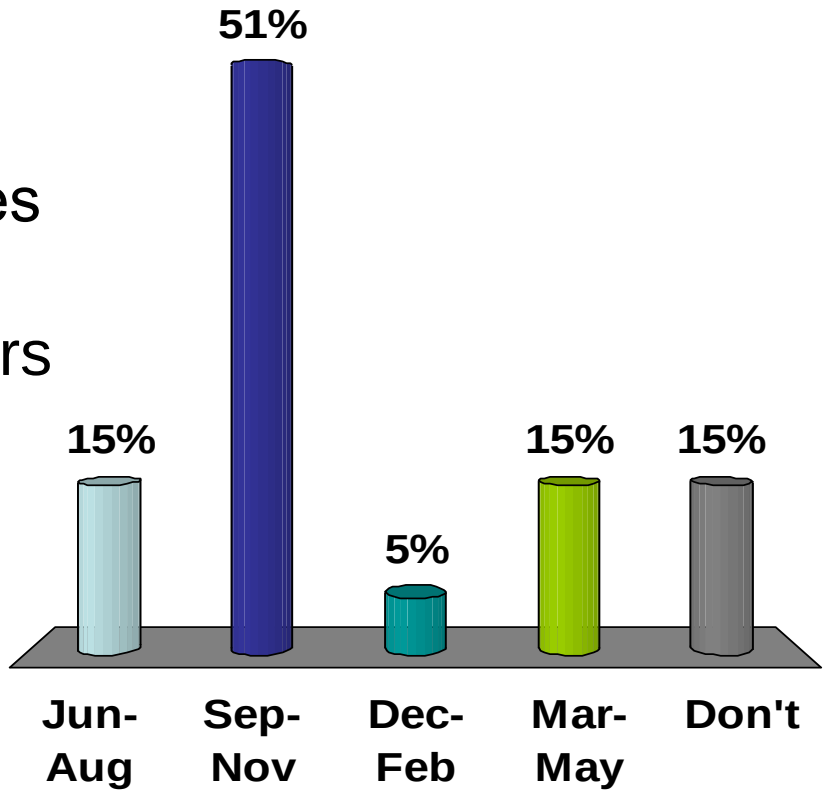
Advantages of soil testing (even if only occasionally)

- To identify nutrient deficiency or imbalance
- To help calculate optimal fertilizer rates
- Especially important in case where soil nutrient availability has been depleted or is in excess
- Can increase yield and/or save on fertilizer costs, and decrease environmental risks

Timing of soil sampling

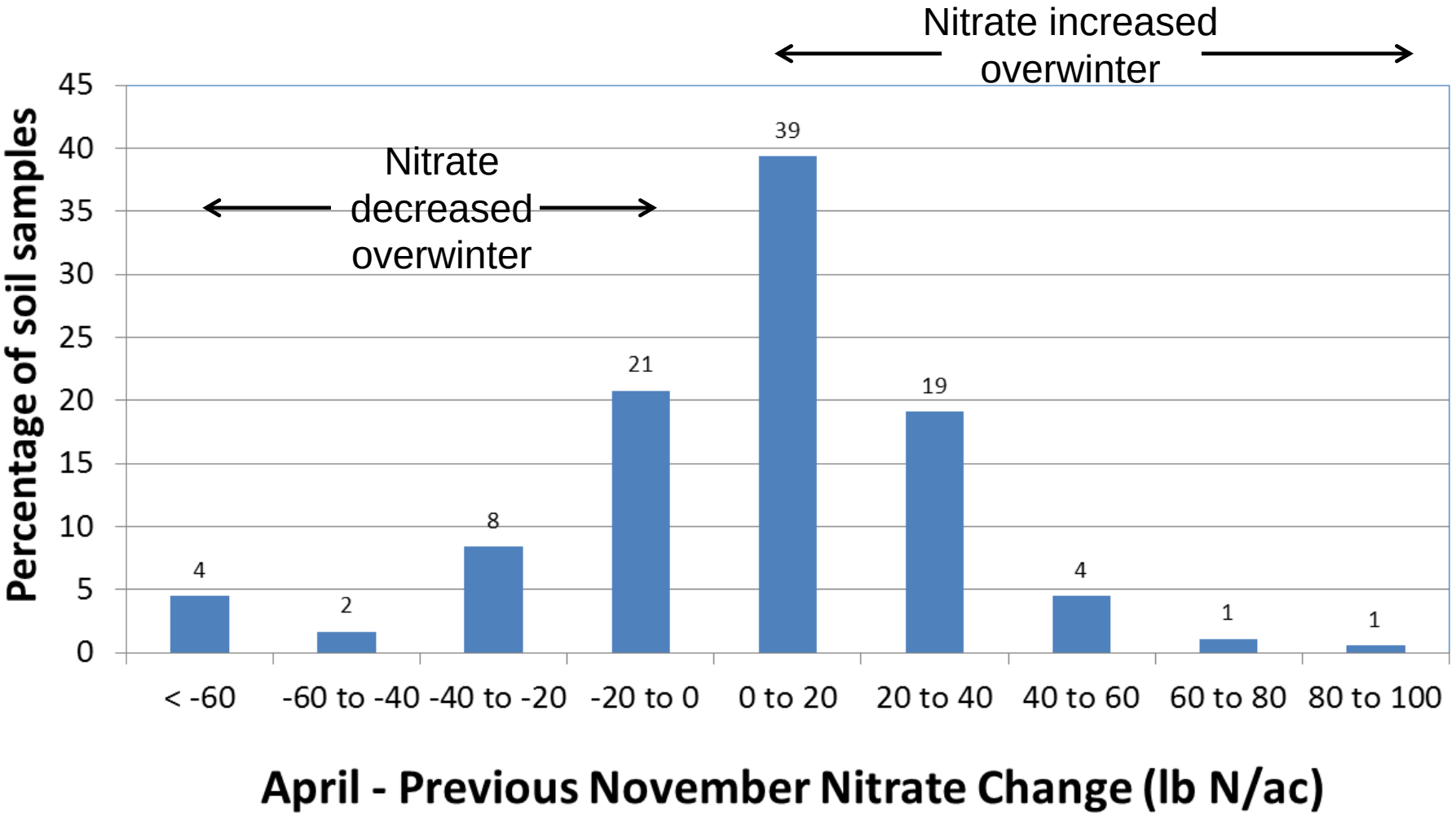
- Nitrogen fertilizer guidelines are based on spring soil samples for nitrate in Montana
- BUT, most sampling in MT occurs from late summer to late fall

Based on 35 'clicker' responses at MABA 2010 Convention, when asked when crop advisers do most of their soil sampling:



Why is this a potential problem?

November to April nitrate changes, Montana data based on 180 samples (Jones et al. 2011)



Soil sampling timing summary

- Changes in nitrate levels change from late summer/fall to spring can be large and highly variable
- High nitrate levels on shallow coarse soils can be lost overwinter, resulting in under-fertilization
- Nitrate levels can increase overwinter, resulting in over-fertilization
- Sampling later will better represent growing season nitrate levels

Soil test indicates probability of response

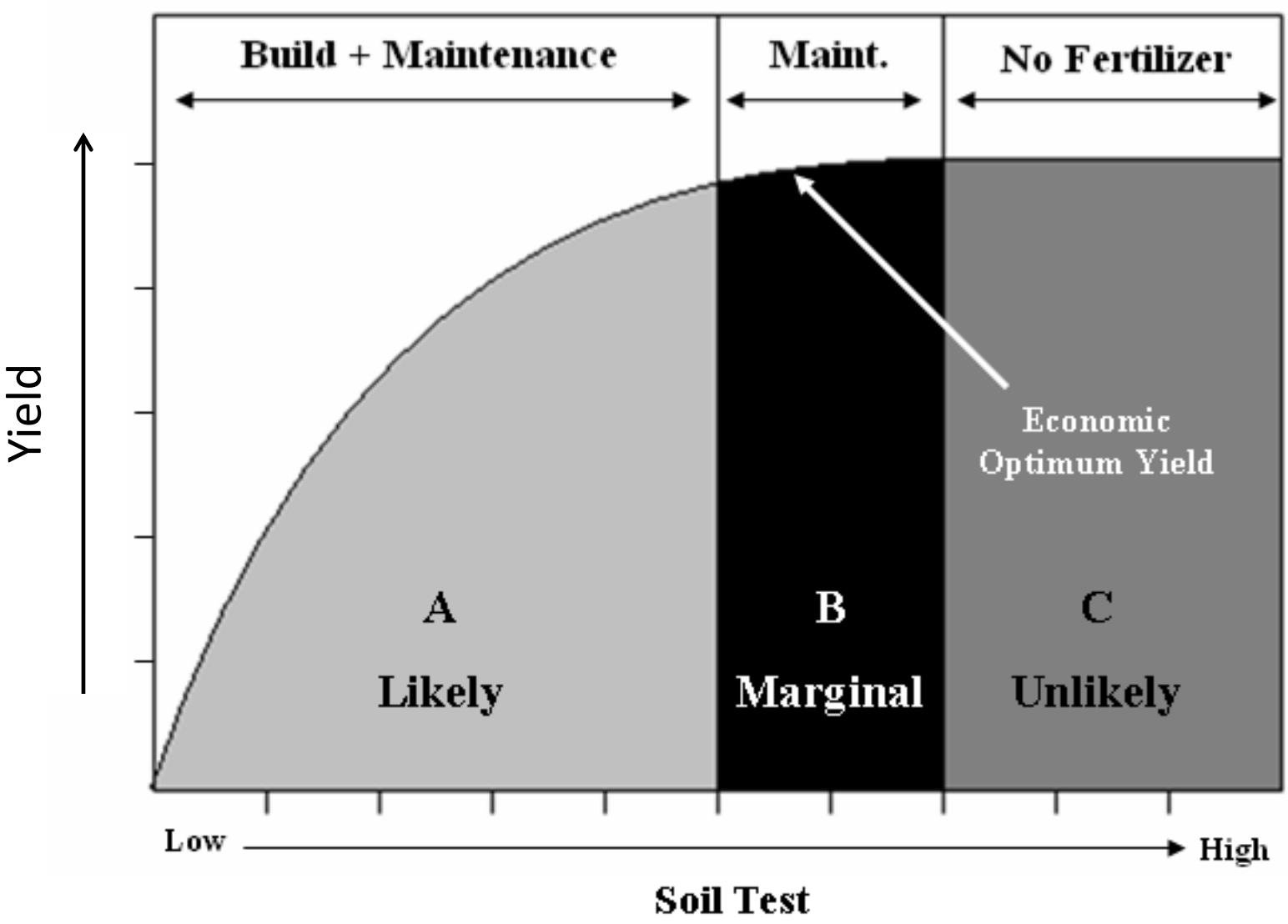


Figure 3. Sample Soil Test Report and Fertilizer Recommendations

Name: Producer		**Sample Date:** April 1, 2007		
Lab Number: 12345		**Your Sample Number:** 1		
Crop to be Grown: Spring Wheat		**Previous Crop:** Fallow		
Sampling Depth: 0 to 24 inches		**Yield Goal:** 50 bu/acre		
Soil Test Results			**Interpretation**	**Recommendation**
Nitrate-N	0-6 in	37 lb/acre		
	6-24 in	36 lb/acre		
	0-24 in	73 lb/acre	Medium	90 lb N/acre
Olsen Phosphorus	0-6 in	15 ppm	Medium	20 lb P_2O_5/acre
Potassium	0-6 in	192 ppm	Medium	40 lb K_2O/acre
Sulfate-S	0-6 in	6 lb/acre		
	6-24 in	54 lb/acre		
	0-24 in	60 lb/acre	High	———
Boron	0-6 in	0.5 ppm	Medium	1 lb B/acre
Copper	0-6 in	1.7 ppm	Very High	———
Iron	0-6 in	47 ppm	Very High	———
Manganese	0-6 in	10 ppm	Very High	———
Zinc	0-6 in	1.3 ppm	High	———
Soluble Salts	0-6 in	0.3	Low	———
Organic Matter	0-6 in	3.4%	Medium	———
Soil pH	0-6 in	7.7	Medium/High	———
CEC	0-6 in	17.8	Medium	
Soil Texture	0-6 in	Sandy Loam		

What are the first things to look for on a soil test report?

Factors affecting crop production

Factor	Value	Impact/consider
Soil organic matter	≤ 1 (%)	Minimize fallow, add a perennial, increase N
	> 3 (%)	N credit (~15 lb N/ac)
Soil pH	< 6	Poor legume nodulation
	> 8.3	Sodic soil, nutrients tied up
Soluble salts (EC)	> 4 (mmhos/cm)	Too saline, water stress, nutrient imbalance

Limiting soil nutrient levels

Nutrient	Limiting level in top 6 inches (ppm)
N	Crop and yield goal dependent
P	16
K	250
S	Not available
B	1.0
Cl	30 lb/ac in top 2 feet
Cu	0.5
Fe	5.0
Mn	1.0
Zn	0.5

Table 1. *Interpretation of Soil Test Reports for Agriculture* (MT200702AG)

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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P fertilizer guidelines

Table 18. P fertilizer guidelines based on soil analysis (EB0161)

crop	Olsen P soil test level (ppm)				
	0	4	8	12	16*
	P fertilizer rate (lbs P_2O_5 /acre)				
Spring wheat	50	45	35	30	20
Winter wheat	55	50	45	40	35

* With P>16 ppm consider using crop removal rates as P fertilization guideline

Example

Winter wheat, Olsen P = 10 ppm

P_2O_5 needed = **42.5 lb/ac**

Questions on soil sampling, test interpretation and rate calculations?

For more information:

Interpretation of Soil Test Reports for Agriculture (MT200702AG)

Developing Fertilizer Recommendations for Agriculture (MT200703AG)

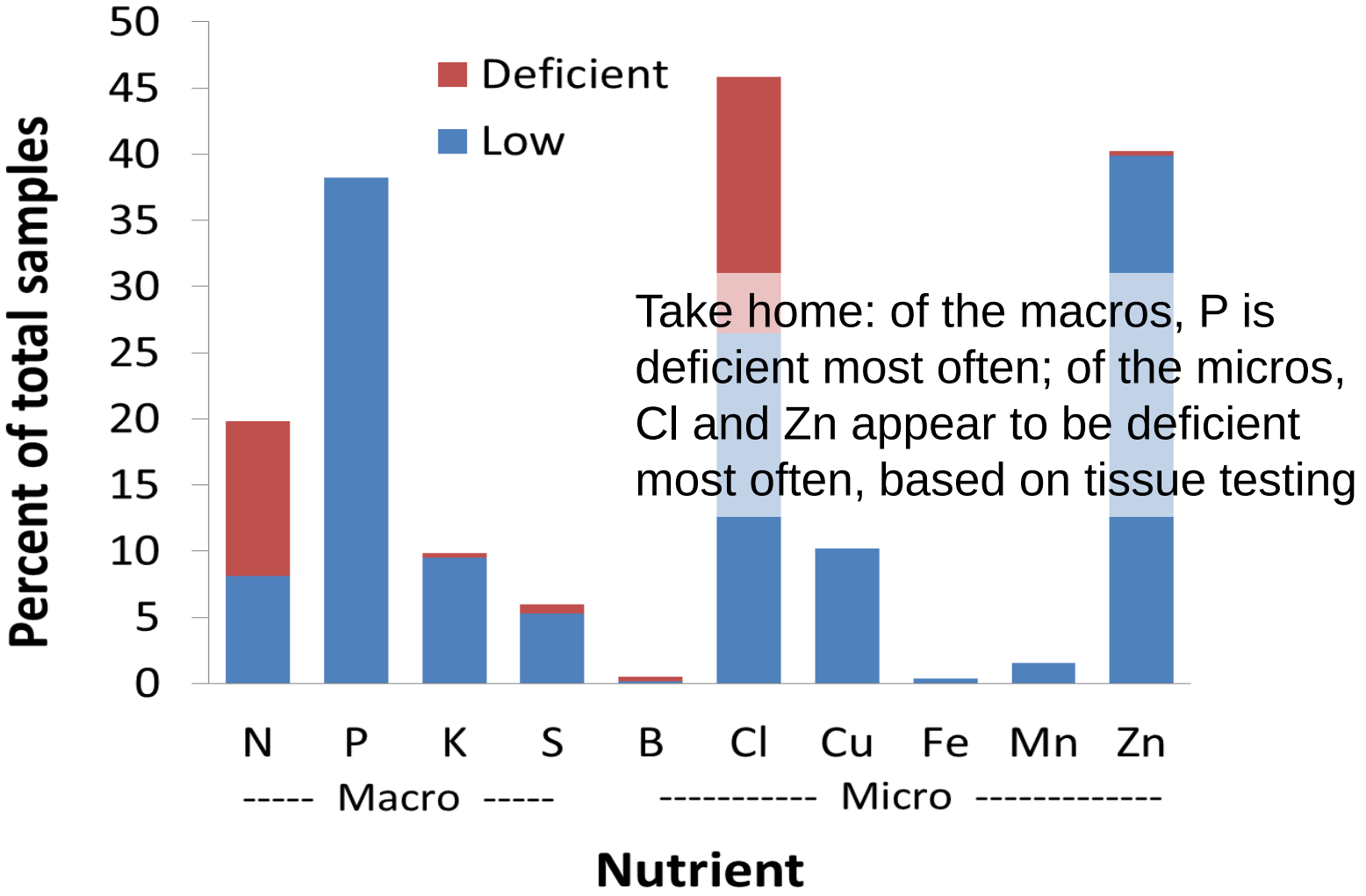
Tissue testing

- Vegetation index sensors (NDVI) have potential for adjusting N by early tillering in SW for yield (Walsh unpub. data)
- Tissue sampling:
  - Crop dependent sufficiency ranges
  - Correct time and tissue sampled
  - Correct handling of sample
  - Sufficiency ranges and fertilization recommendations not well established in MT, best to compare with healthy plants from same area
- Soil test better for P and K

Tissue testing for S and micronutrients

- Tissue sampling for S is useful if deficiency is suspected. N:S ratio is important, but can be misleading if both N and S are lacking.
- See *Secondary Macronutrients: cycling, testing and fertilizer recommendations* (MT4449-6) for sufficiency ranges
- There are tissue concentration sufficiency ranges, but other than for Cl there are no MT fertilizer guidelines for micronutrients based on tissue tests

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



Take home: of the macros, P is deficient most often; of the micros, Cl and Zn appear to be deficient most often, based on tissue testing

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

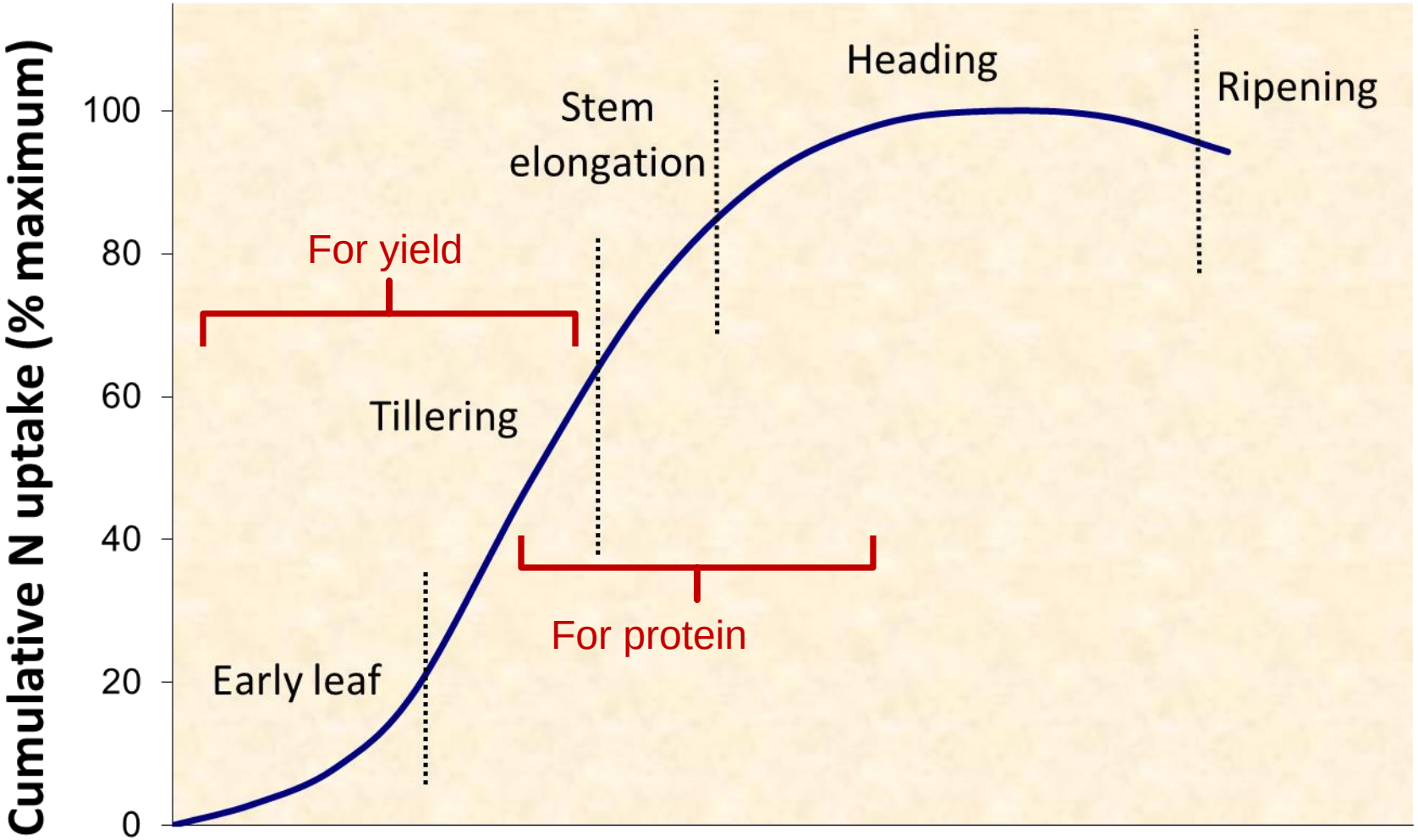
How know if Cl is deficient in your wheat?

Based on plant Cl level at boot stage:

- Cl < 0.12 ppm: large chance for a response
- 0.12 < Cl < 0.4 ppm: some chance for a response
- See *Winter Wheat Response to Chloride Fertilizers* (Fertilizer Fact #3) for more details.

Questions on tissue testing?

Source affects timing – N must be *available* to benefit yield and protein



More info in Nutrient Uptake Timing (EB0191)

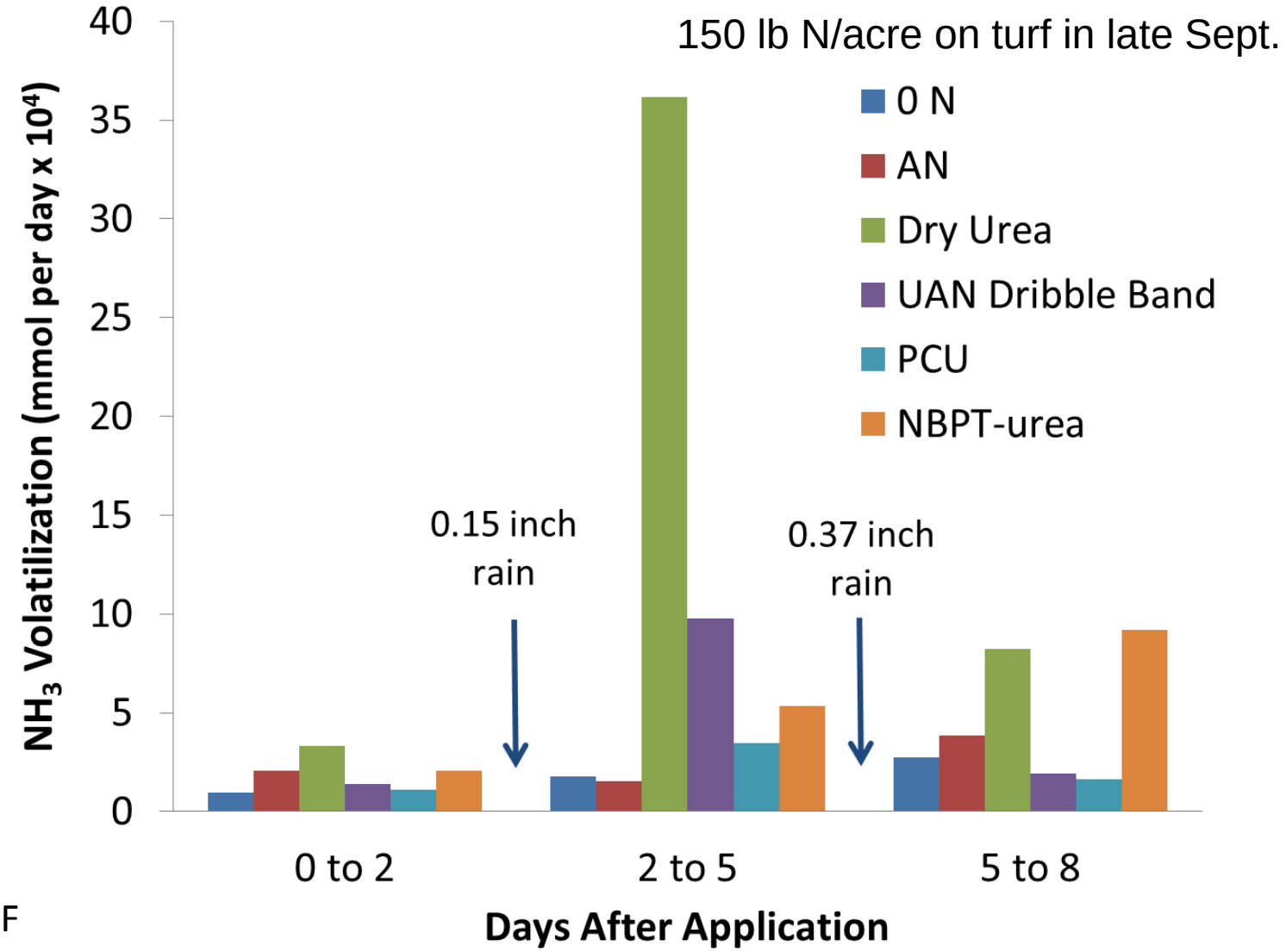
Nutrient sources

- Enhanced efficiency fertilizers generally designed to increase availability and reduce losses to environment
- Foliar fertilizers used for in-season adjustments

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 (NBPT=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?

Effect of N source on volatilization



Washington
Soil Temp = 50°F
Koenig unpub. data

UAN volatilization with and without Agrotain®

% of surface applied N volatilized over 7 days

	Check	UAN	UAN+Agrotain
May (74°F)	0	7	1
July (86°F)	0.6	50	16

Grant et al. 1996, Manitoba

Does NBPT decrease volatilization losses in Montana (Engel et al)?

- Based on 17 studies:

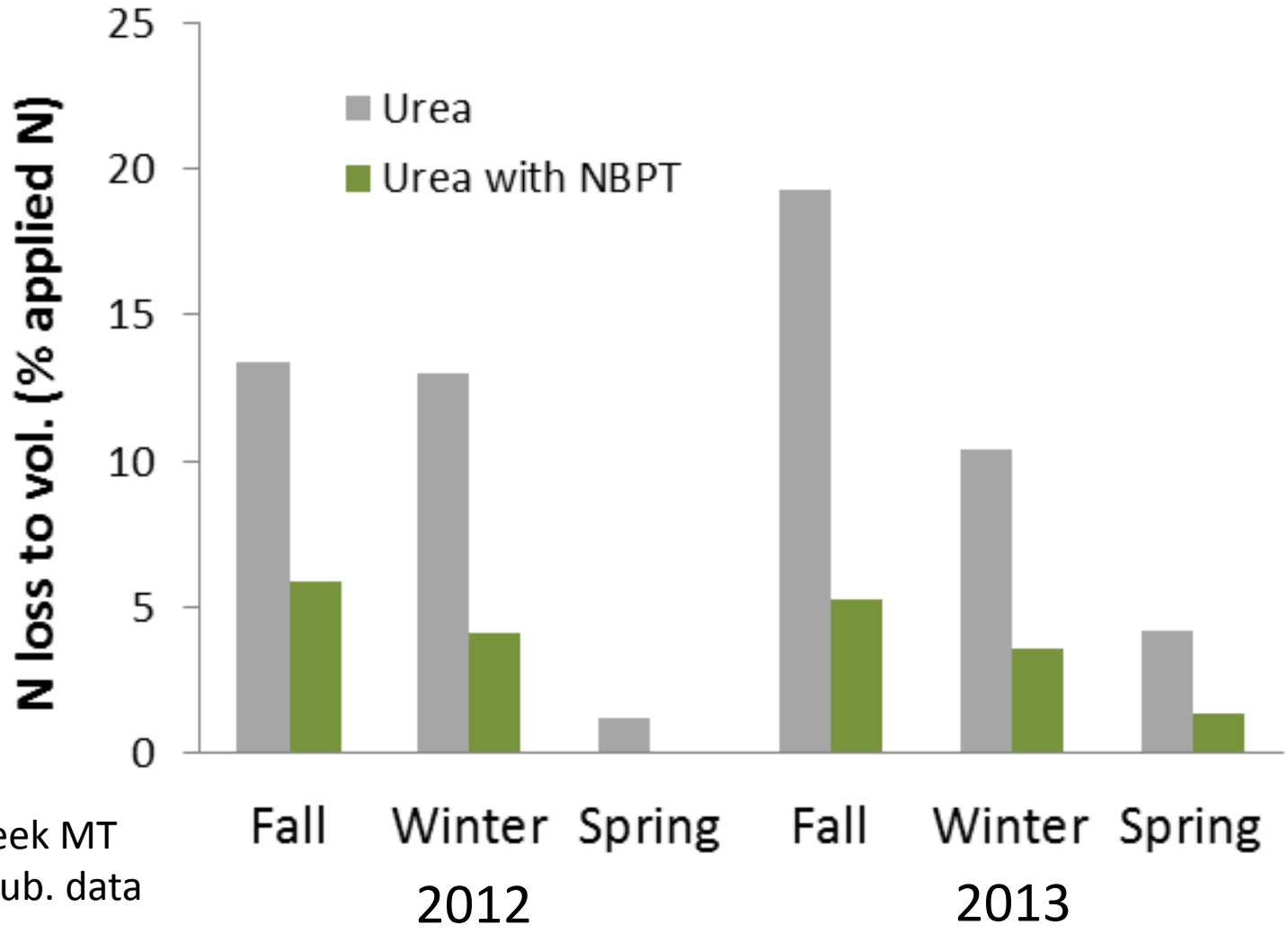
  Average N lost from urea: 18.1%

  Average N lost from NBPT-urea: 6.5%

- Worst case-conditions for loss:

  moist surface with only sprinkles for weeks (Fertilizer Fact #59)

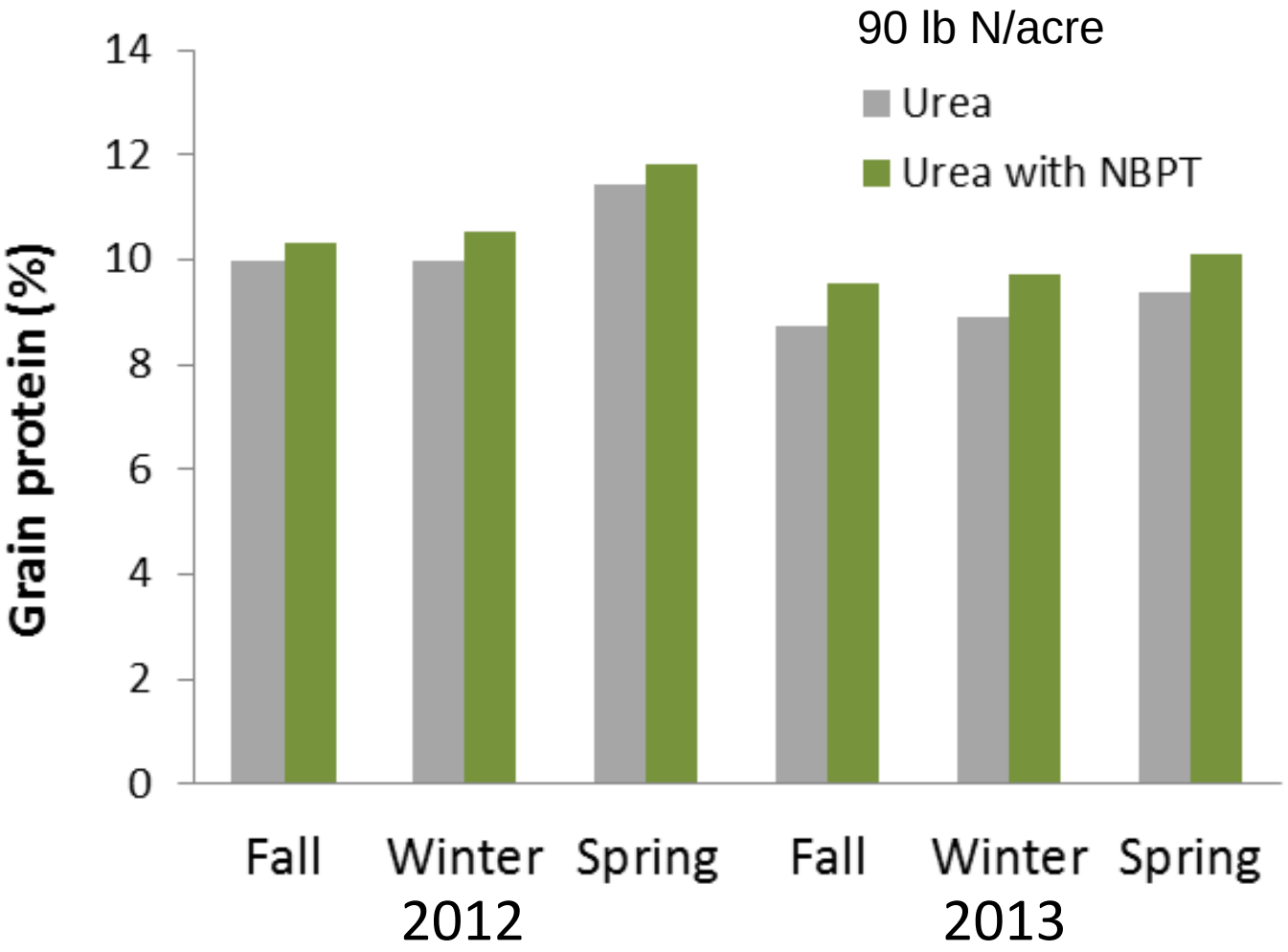
NBPT (Agrotain ®) reduces N loss



Coffee Creek MT
Engel unpub. data

NH_3 losses observed for late-fall and winter app > than spring, even though temperatures were colder; mitigation by NBPT ≈ 65%

NBPT with broadcast urea can increase WW grain protein



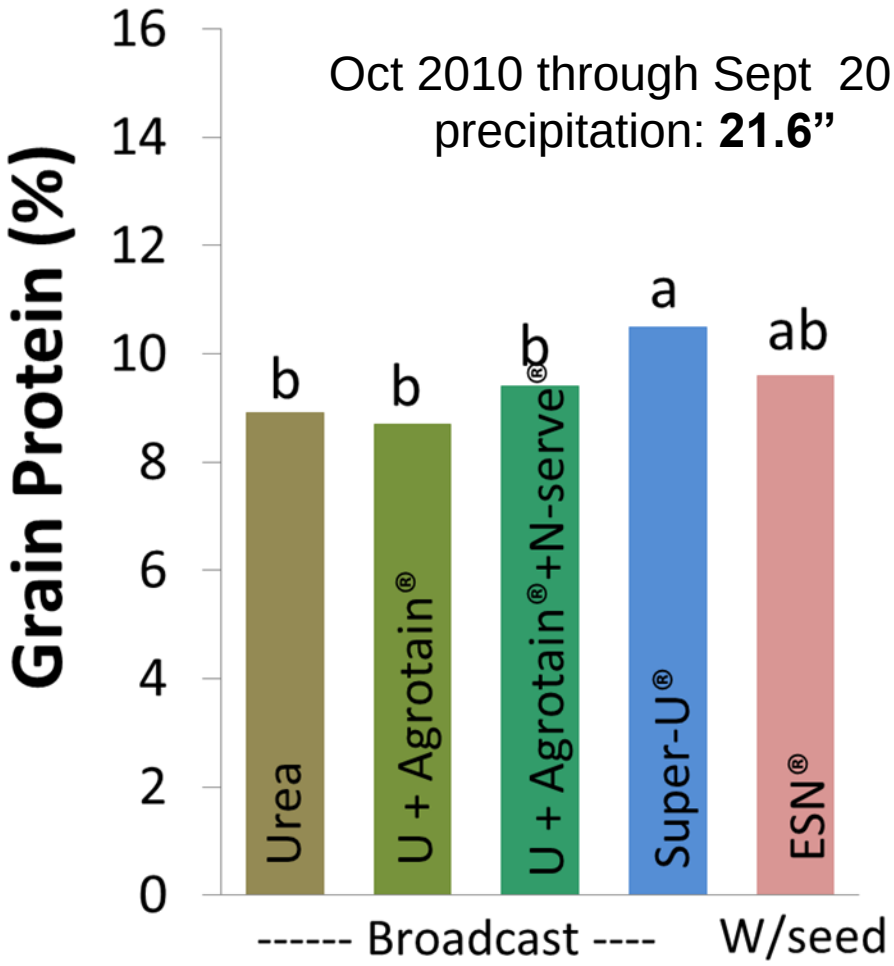
NBPT sig increased protein by about 0.4 to 0.8 % points for both years. NBPT only increased yield in Fall 2012.

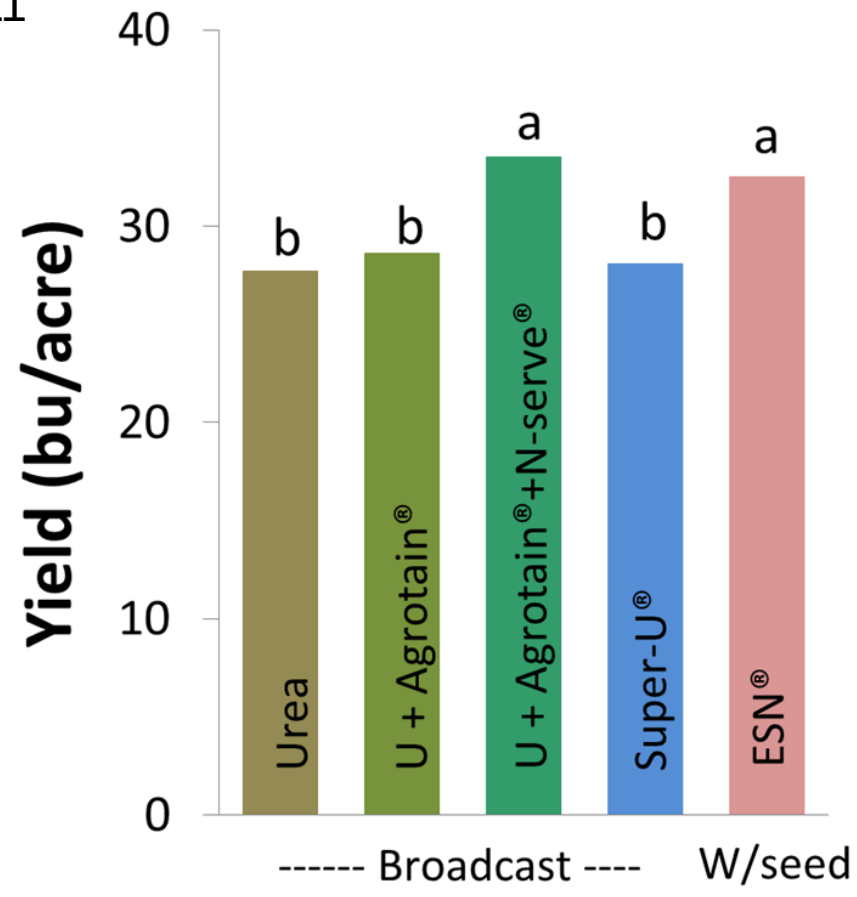
Coffee Creek, MT
Engel unpub data

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 protein and yield under high risk leaching conditions





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 lower.

Questions on EEFs?

Foliar N facts and considerations

- Only 8-11% of foliar applied liquid urea was taken up by leaves, whereas 37-67% of soil applied N was taken up by plant in same study (Rawluk et al. 2000)
- ½ inch rain (have you been living right?) or irrigation to soak into soil
- If scab risk, do not irrigate within 5 days of flower, so time foliar accordingly.

Source and rate of N affect leaf burn

- 32% UAN applied at heading caused more flag leaf burn and reduced grain yield more than an equal amount of N from foliar urea
- Flag leaf burn increased with N rate regardless of source, max suggested rate is 30 lb N/ac

Brown & Long 1988, Parma, ID, irrigated winter wheat

Fertilizer leaf burn

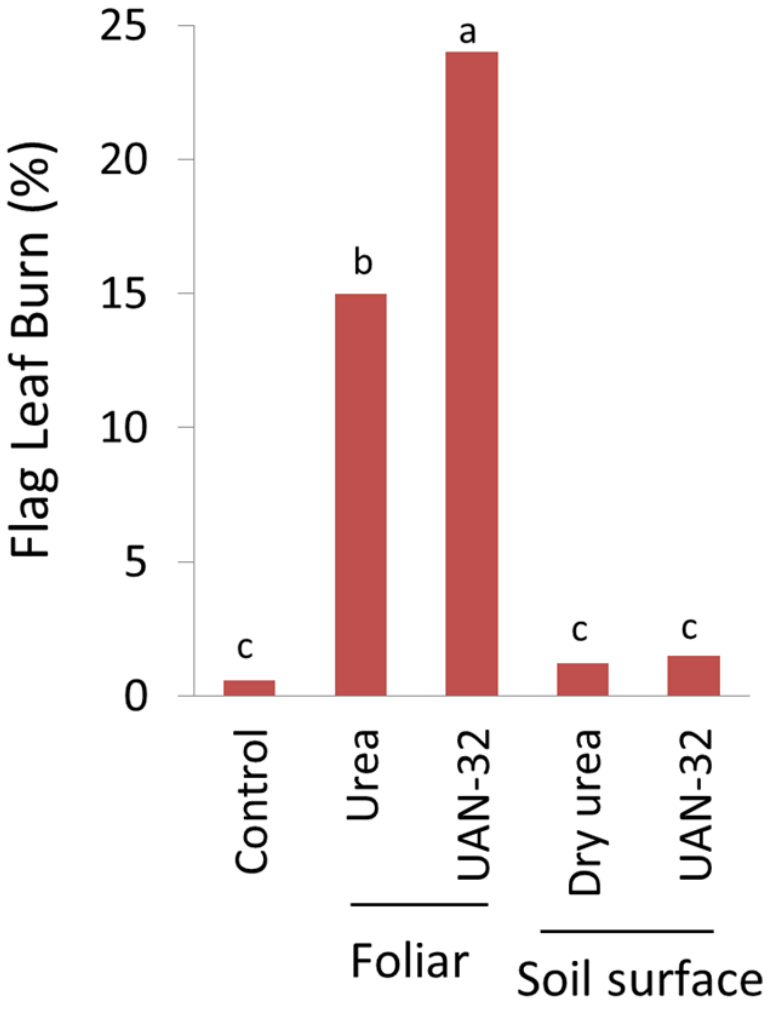
- Reduce to 20 lb N/ac max if combined with herbicide
- Leaf damage increased with:
  - Surfactant + more than 20 lb N/ac of 28-0-0 UAN
  - Urea + Agrotain®
  - Sulfur

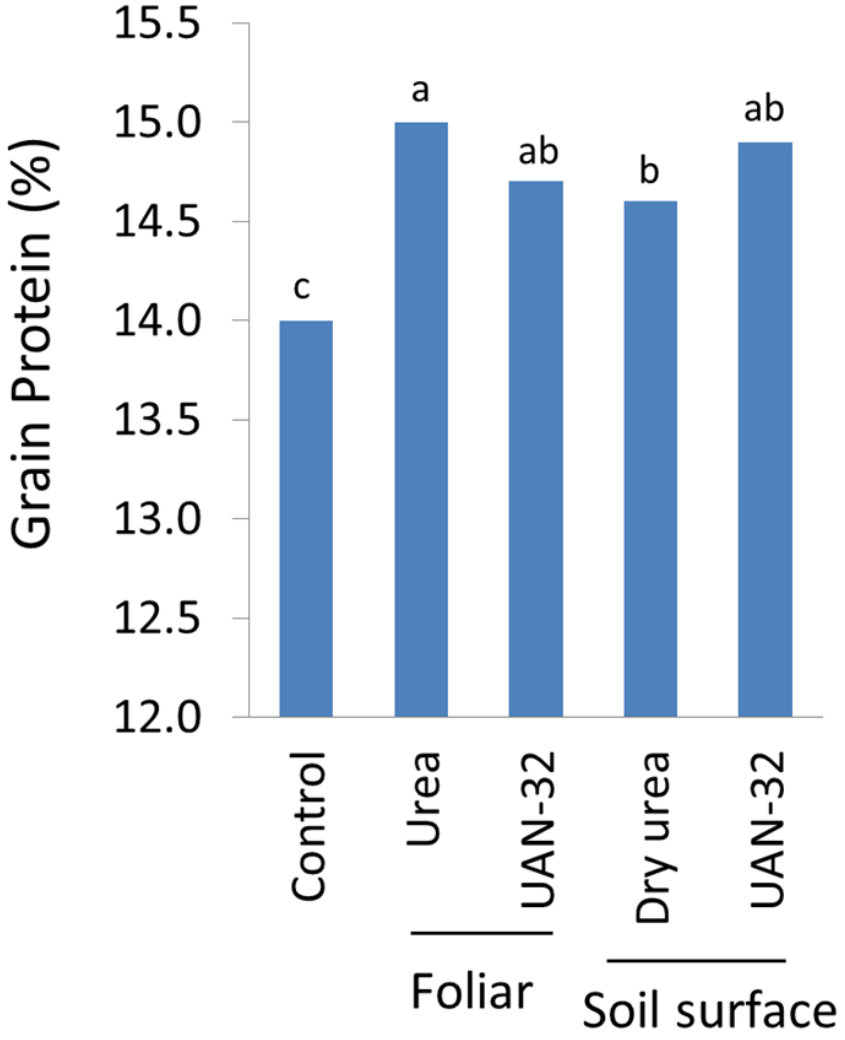
http://fieldcrop.msu.edu/sites/fieldcrop/files/E2602.pdf

http://www.msuweeds.com/assets/Annual-Results/2010-Results/Wheat/2010ResultsWT02-10.pdf

- 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 source and placement effect on irrigated spring wheat leaf burn and grain protein



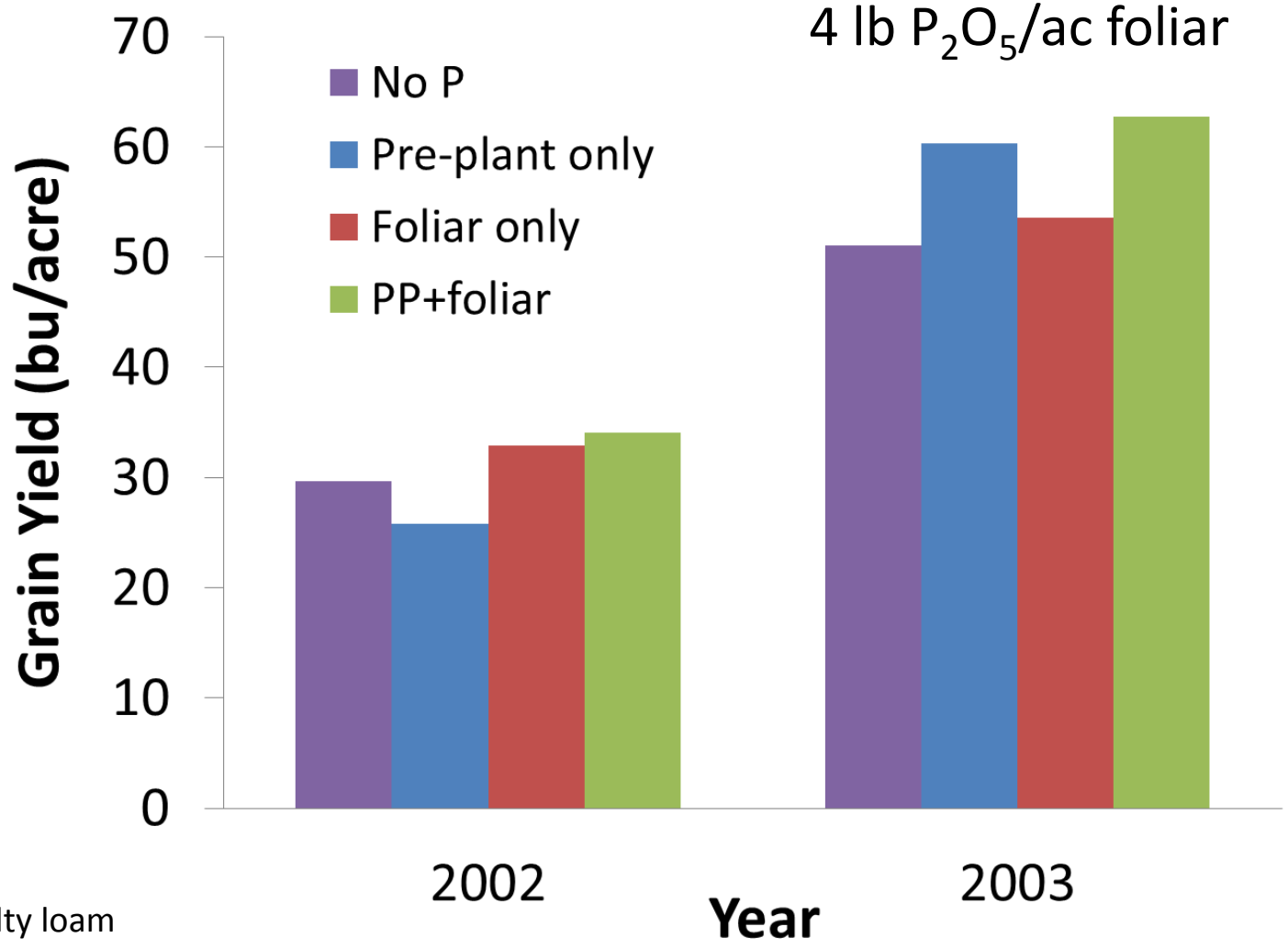


Brown 1995, Idaho, Irrigated SW

All received top-dress at tillering to produce 120 bu/ac, **Yield was not sig different among treatments.**

Pre-plant plus foliar P offers most consistent yield benefit

60 lb P_2O_5/ac preplant
4 lb P_2O_5/ac foliar



Oklahoma, fine silty loam
Olsen P 6 ppm, TSP incorporated preplant
Mosali 2006

Foliar application of micronutrients

Micronutrients should not be applied unless deficiency is identified through:

- soil analysis (see EB0161 for soil applied fertilizer guidelines)
- tissue sampling
- visual deficiency symptoms (MT4449-9)

Micronutrient tissue concentrations, foliar fertilizer sources and rates

Element	Limiting tissue concentration (ppm)[1.]	Fertilizer source[2.]	Rate (lb/ac) [2.]
Boron	3	sodium borate	0.3-0.5
Copper	5	chelated	0.2-0.25
Iron	50	chelated	0.15
Manganese	25	chelated	0.5-1.0
Zinc	20	chelated	0.3-0.4
Best applied in spring Sulphate and oxysulphate are not recommended			

1. Small grains at tillering, source: AgVise 2. Karamanos 2000

Questions on Foliar?

Conclusions

- Soil tests can increase yield and/or save on fertilizer costs, and decrease environmental risks.
- Soil tests for N are best done in the spring, can be done in fall for P and K, and not worthwhile for S
- Tissue sampling can help with in-season adjustments
- There are tools available to help determine fertilizer needs and rates

Conclusions continued

- NBPT (Agrotain®) helps reduce urea loss to volatilization and can increase grain protein
- Slow and controlled release fertilizers tend to be more beneficial in wet than dry conditions
- Foliar applications are useful for in-season adjustments
- Foliar N is best followed by rain or irrigation

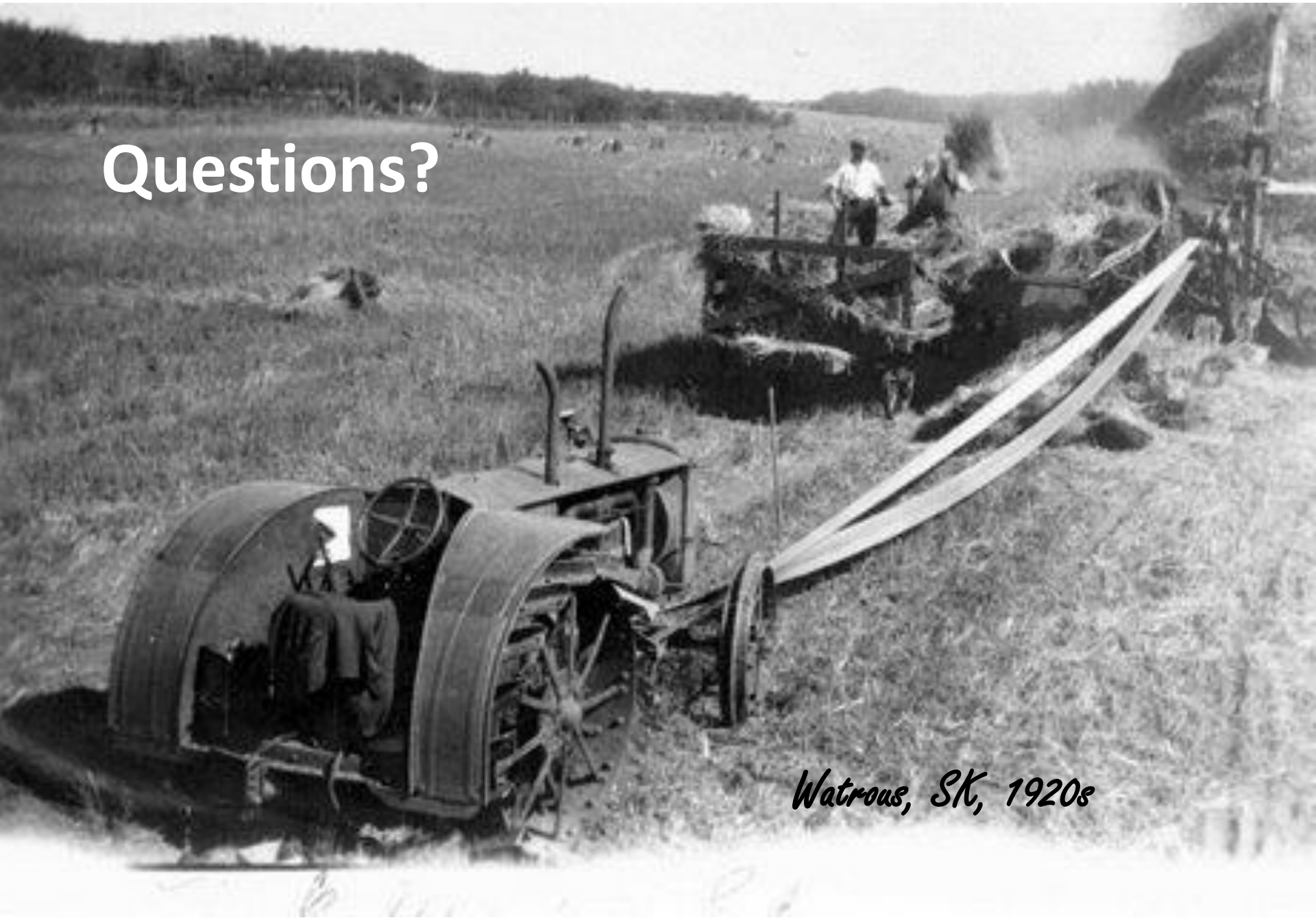
Additional info at:
http://landresources.montana.edu/soilfertility

Soil fertility publications:
Go to “Extension Publications”
NEW! *Nutrient Management for Forages*
a) Nitrogen and b) PKS and Micronutrients

Fertilizer Facts and economic model:
Go to “Fertilizer Information”

MT research data on volatilization: Fertilizer Facts 59 & 60, and http://landresources.montana.edu/ureavolatilization

This presentation: Go to “Presentations”


Questions?
Watrous, SK, 1920s