Interpreting Soil Tests and Micronutrient Management

Richland County

March 28, 2014

by Clain Jones, Extension Soil Fertility Specialist
clainj@montana.edu; 994-6076

MONTANA STATE UNIVERSITY EXTENSION

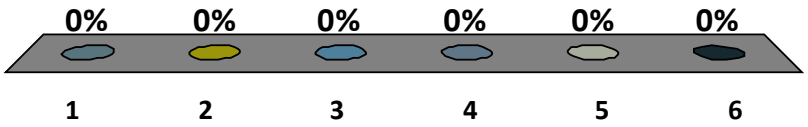
Objectives

- Discuss value of soil sampling
- Interpret soil test results
- Determine fertilizer recommendations
- Present considerations and options for micronutrient fertilization

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?

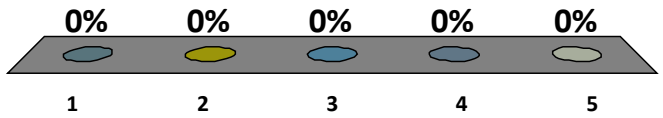
1. 0 to 10%
2. 10 to 20%
3. 20 to 30%
4. 30 to 40%
5. > 40%
6. I didn't come prepared to take a quiz



Based on 20+ studies: ~18%

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

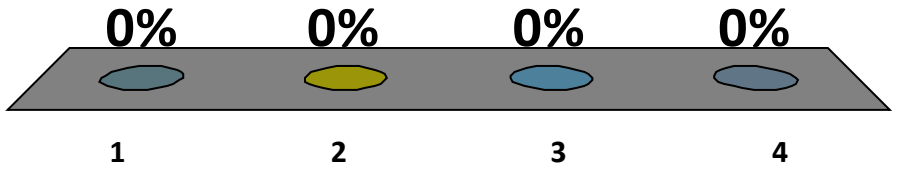
1. Warm and moist soil surface with only sprinkles for 2 weeks
2. Cold and moist soil surface with only sprinkles for 2 weeks
3. Warm and dry soil surface followed quickly by > 0.5 inches of rain or irrigation
4. Cold and dry soil surface followed quickly by > 0.5 inches of rain or irrigation
5. I don’t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



1 is correct based on ours and others research

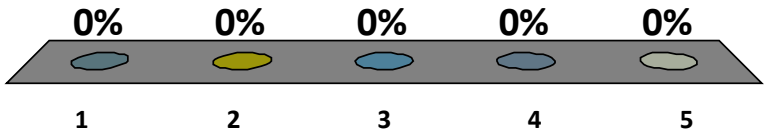
Have you made any management changes based on MSU's urea volatilization research?

1. No, I didn't know about the research.
2. No, but I plan to.
3. Yes, but don't think they decreased volatilization.
4. Yes, and think they decreased volatilization.



If you have made management changes, what was your ***biggest*** change?

1. I now try to apply urea immediately before rain or irrigation.
2. I now use a fertilizer designed to decrease volatilization (like Agrotain).
3. I now subsurface band or incorporate more of my urea.
4. I now try to apply only to dry soil surfaces.
5. Other



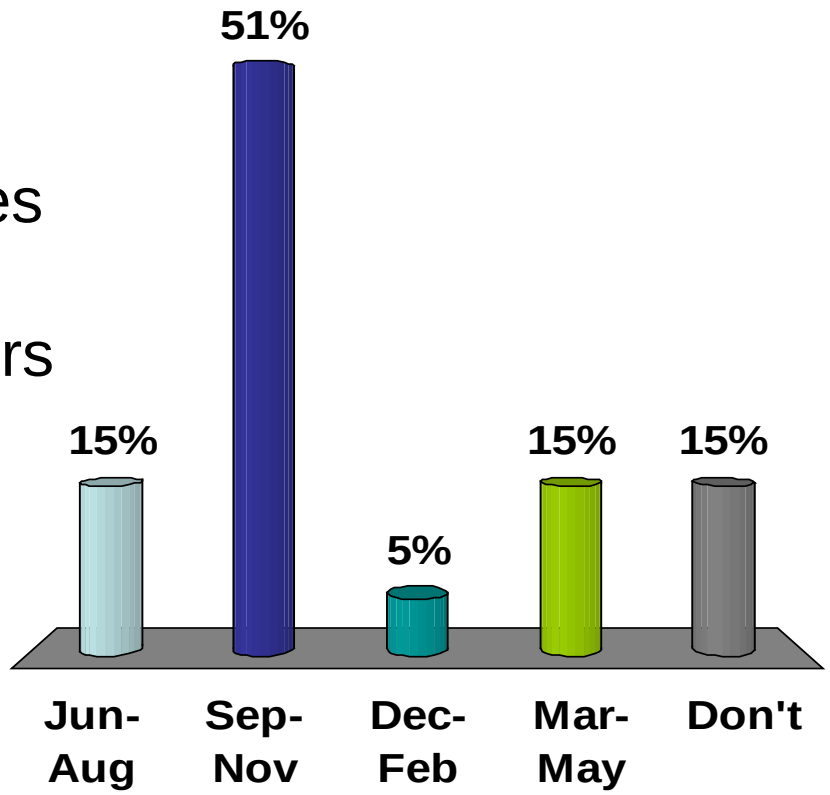
Soil Testing

1. Proper sampling location, depth and timing. See: *Soil Sampling and Laboratory Selection* (MT4449-1) *Soil Sampling Strategies* (MT200803AG).
2. Interpretation of test results: *Soil Test Interpretation* (MT200702)
3. Develop fertilizer rates specific to your soil and crop. *Developing Fertilizer Recommendations for Agriculture* (MT200703).
4. 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). There is not a good soil test for S.

Timing of soil sampling

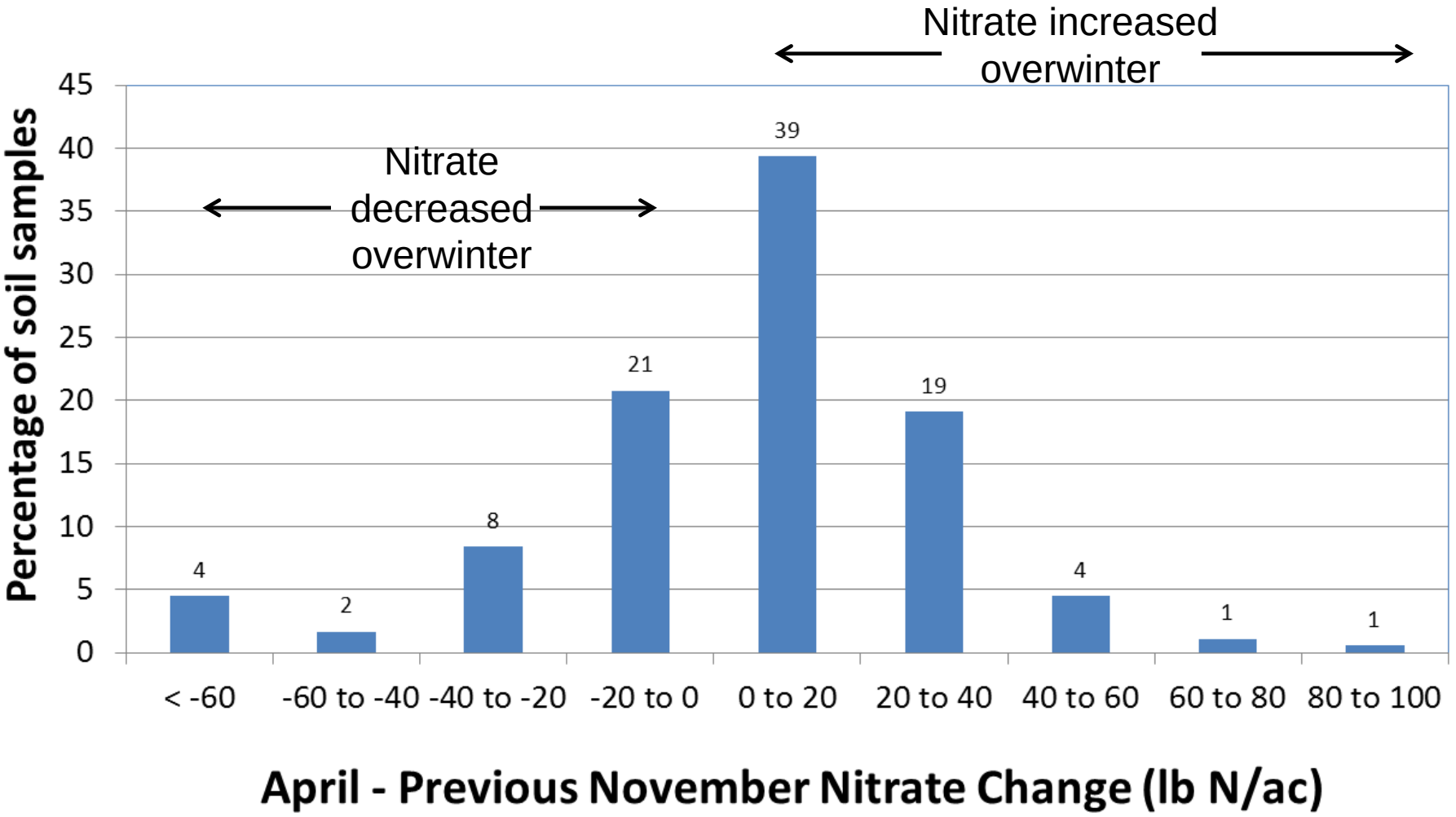
- Nitrogen fertilizer guidelines are based on spring soil samples for nitrate in Montana
- BUT, most sampling in MT occurs from late summer to late fall

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

Advantages of soil testing (even if only occasionally)

- To identify factors limiting crop production
- 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

Figure 3. Sample Soil Test Report and Fertilizer Recommendations

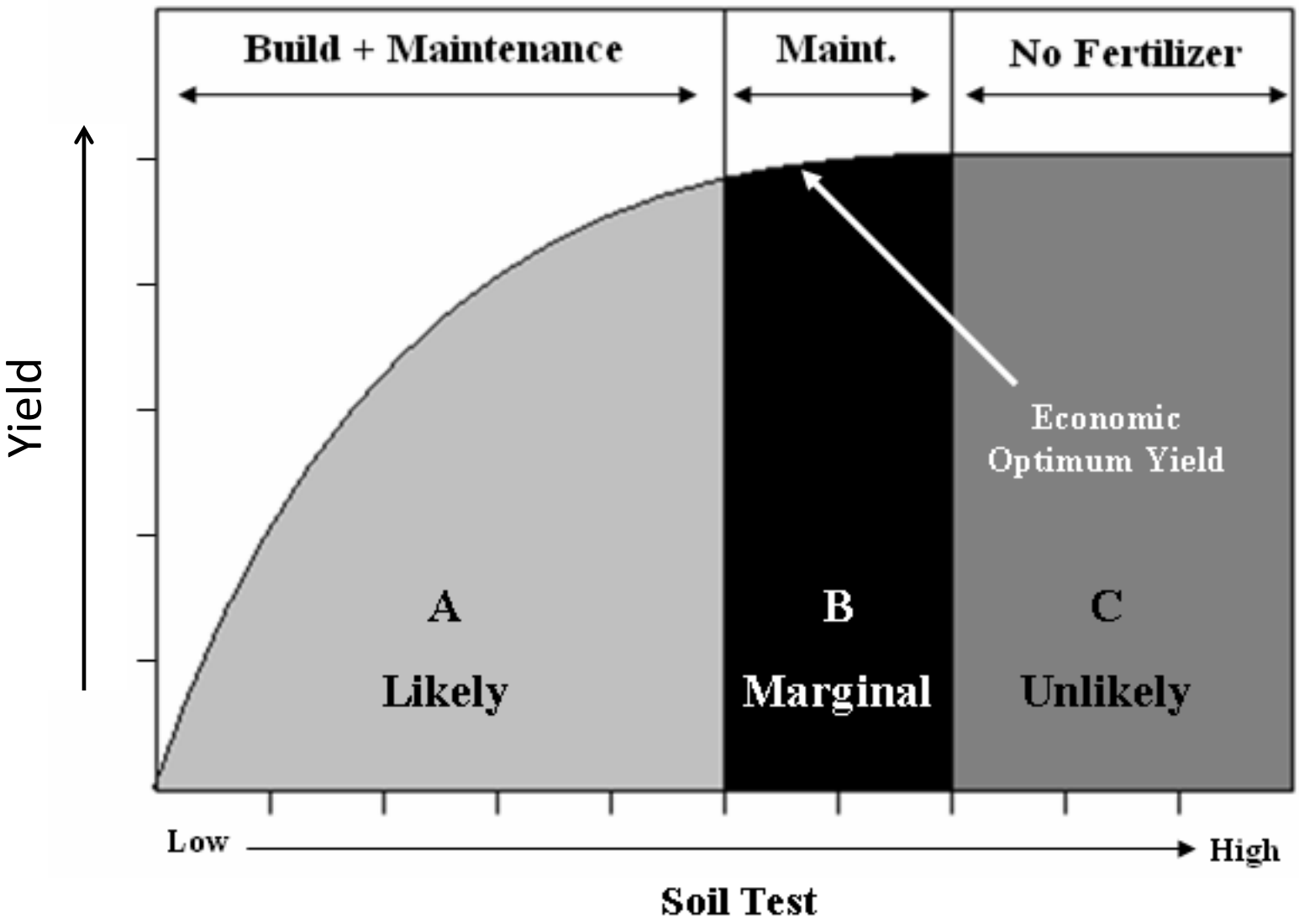
Name: Producer		**Sample Date:** April 1, 2007		
Lab Number: 12345		**Your Sample Number:** 1		
Crop to be Grown: Spring Wheat		**Previous Crop:** Fallow		
Sampling Depth: 0 to 24 inches		**Yield Goal:** 50 bu/acre		
Soil Test Results			**Interpretation**	**Recommendation**
Nitrate-N	0-6 in	37 lb/acre		
	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

Soil test indicates probability of response



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

MONTANA STATE UNIVERSITY EXTENSION

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

Authors:

Clain Jones
Montana State University Extension
406-994-6076
clainj@montana.edu

Duane Griffith
Montana State University Extension
406-994-2580
griffith@montana.edu

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

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)

Fertilizer Guidelines for Montana Crops (EB0161)

There are 8 mineral micronutrients that have been found to be essential for growth of most plants:

Deficiency observed in MT	No known deficiency in MT
Boron (B)	Molybdenum (Mo)
Chloride (Cl)	Nickel (Ni)
Copper (Cu)	
Iron (Fe)	
Manganese (Mn)	
Zinc (Zn)	

Why might we be seeing, or eventually see, more micronutrient deficiencies?

There is a finite amount of micronutrients in the soil. Micronutrient deficiencies will likely increase as:

- Yields and amount removed from field increases
- No micronutrients are added (individually, in manure, or in P fertilizers*)

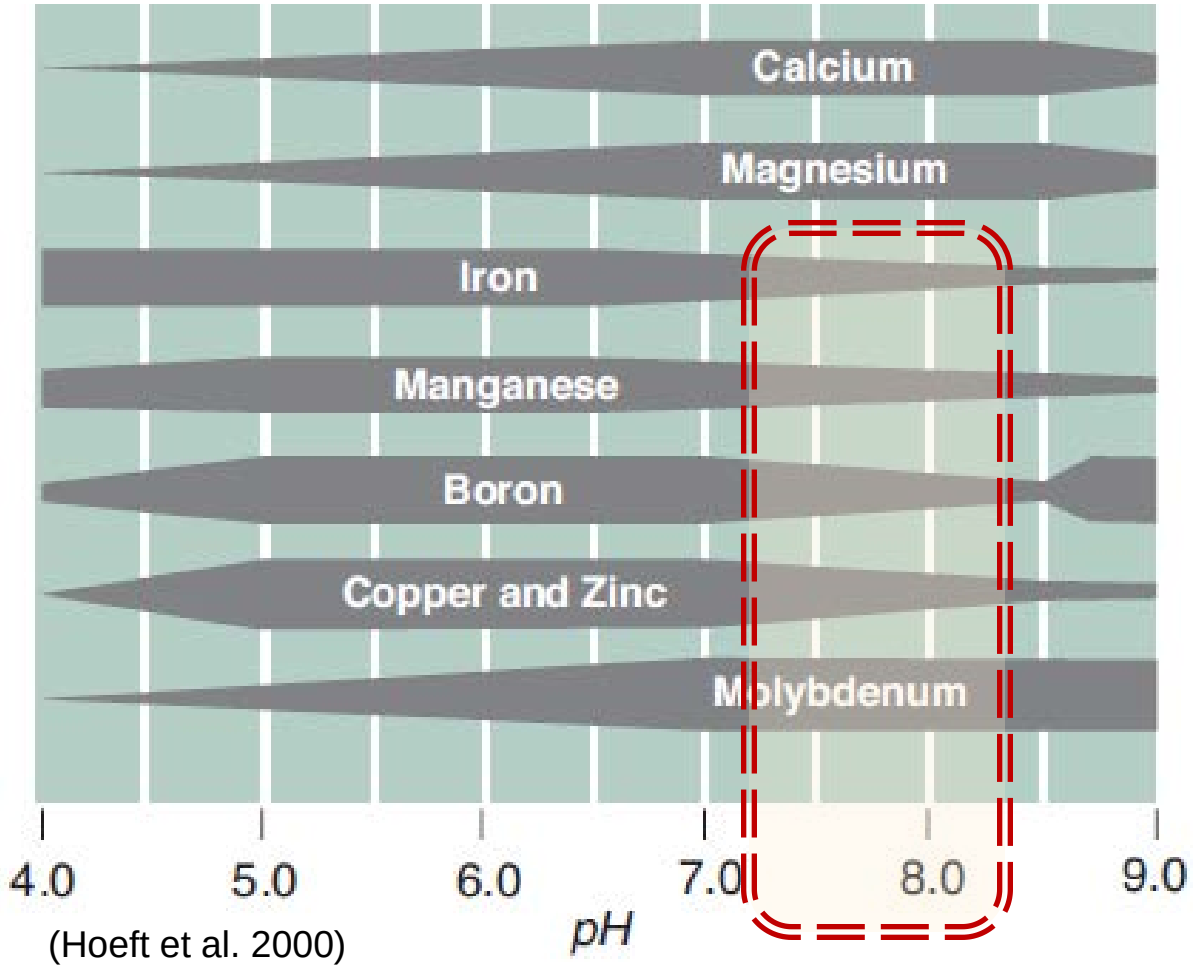
*example: 18-46-0 has 5.5 mg Cu/kg, 386 mg Zn/kg (Raven and Loeppert, 1997)

Conditions that affect availability

Nutrient	Limiting conditions
Boron Chloride	Low Cl in rain (MT) Very wet or very dry Coarse, sandy <2% SOM (B) pH >7.5 (B)
Copper Iron Manganese Zinc	Cool and wet <2% SOM Poorly drained (Fe) Coarse and dry (Cu) pH >7.5

Soil pH affects micronutrient availability

Chloride is not affected by pH



(Hoeft et al. 2000)

Mobility and processes that affect availability

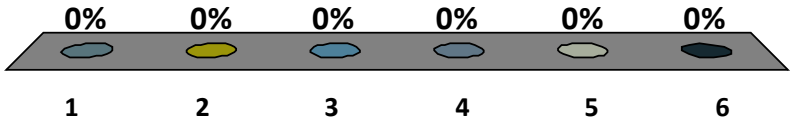
Nutrient	Mobility	Limiting processes
Boron Chloride	Mobile Soluble	Leaching Harvest
Copper Iron Manganese Zinc	Immobile Insoluble	Harvest Binding to soil or forming minerals

Why is mobility important?

Affects fertilizer placement

Your experience with micro deficiencies (read all answers before answering)

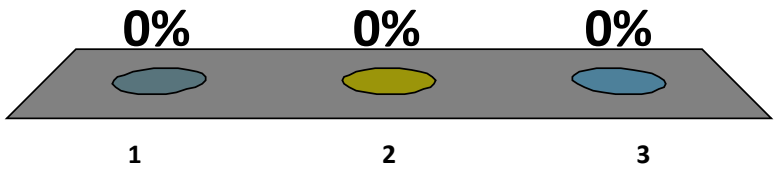
1. I don't think I've seen any
2. I've suspected micro deficiencies based on symptoms, but didn't verify with tissue testing
3. I've verified micro deficiencies through tissue testing
4. I've verified micro deficiencies through fertilizer trials
5. Both 3 and 4
6. Other



0 of 30

Have you started soil testing in the last five years, when your farm historically has not?

1. Yes
2. No
3. Are you kidding? I'm still not allowed to drive the new tractor.



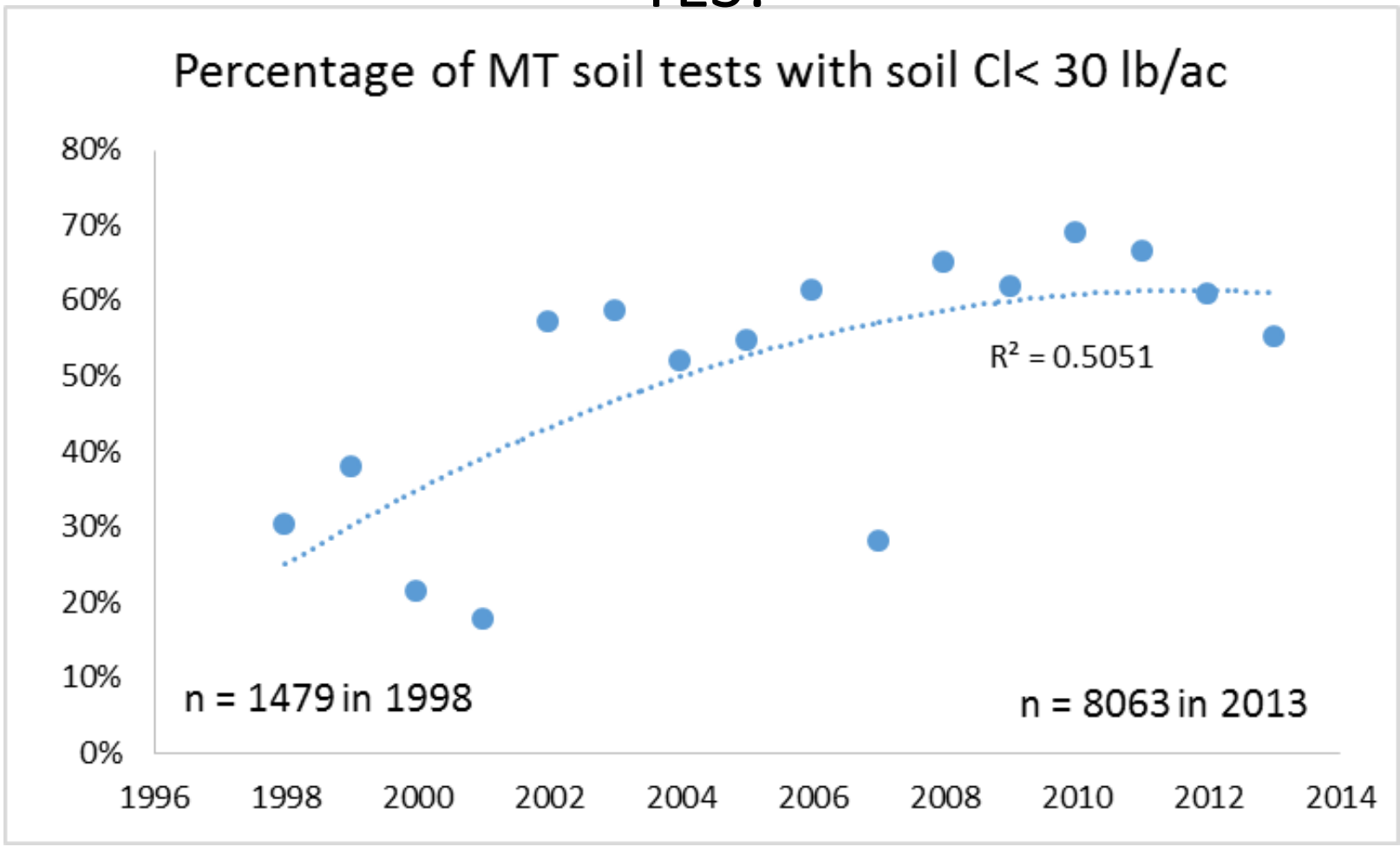
Selected total and available micronutrients in MT surface soils in past 34 years

	1979* (n=301)		2013 (n>5300) Agvise Labs
	Total	Available	Available
Nutrient	(ppm in top 0-6")		
Copper	30	2.0	1.1 (0.5 crit lev)
Iron	38,000	15.8	20.1 (5 crit lev)
Manganese	600	12.4	3.7 (1 crit lev)
Zinc	50	1.2	0.9 (0.5 crit lev)

The majority of metals are bound in minerals or soil organic matter, not immediately available to plants. *Haby and Sims 1979

Have % of soil chloride levels below 'critical level' increased in last 15 years in Montana?

YES!



Source: Agvise, unpub. data

Micronutrient fertilizer guidelines based on soil analysis (EB0161)

	Soil test (ppm)					
	< 0.25	0.25 – 0.5	0.5 – 1.0	1.0 – 2.5	2.5 – 5.0	> 5.0
Nutrient	**Fertilizer rate (lb/acre)**					
Boron	2	2	1	0	0	0
Copper	2	2	0	0	0	0
Iron	4	4	4	4	2	0
Manganese	20	20	10	0	0	0
Zinc	10	5	0	0	0	0
Chloride	30 lb /acre is generally considered critical level					

See *Micronutrients: Cycling, Testing and Fertilizer Recommendations*
http://landresources.montana.edu/soilfertility

Under “Extension Publications” then “Nutrient Management Modules”

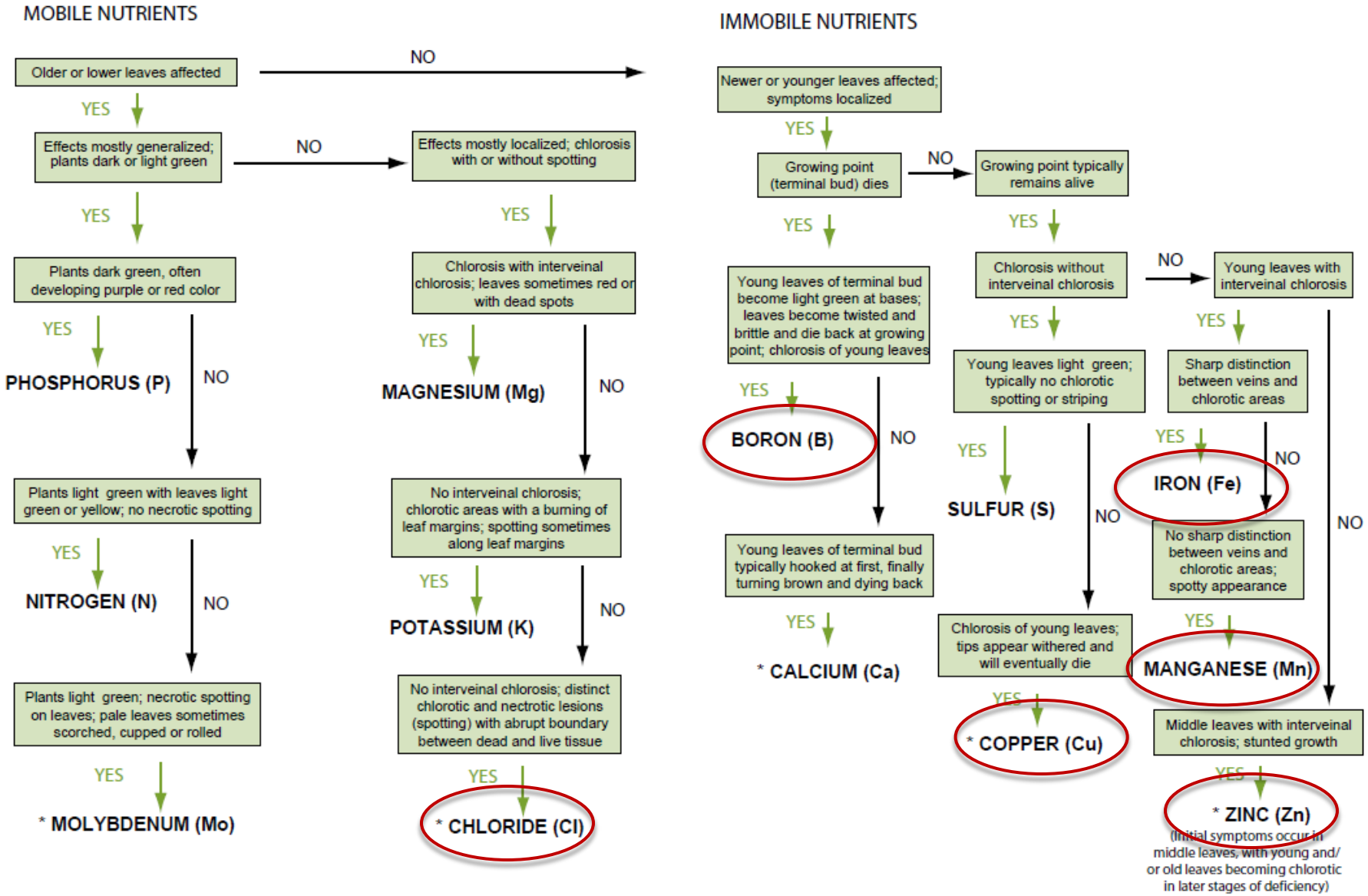
Questions so far?

In-season micronutrient adjustments

- Use visual tissue assessment for potential deficiency See *Plant Nutrient Functions and Deficiency and Toxicity Symptoms (NMM 9):* http://landresources.montana.edu/nm
- Use tissue concentrations – other than for chloride there are no MT guidelines for micros based on tissue tests
- Once plant shows deficiency, potential yield may already be reduced

Visual tissue assessment

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

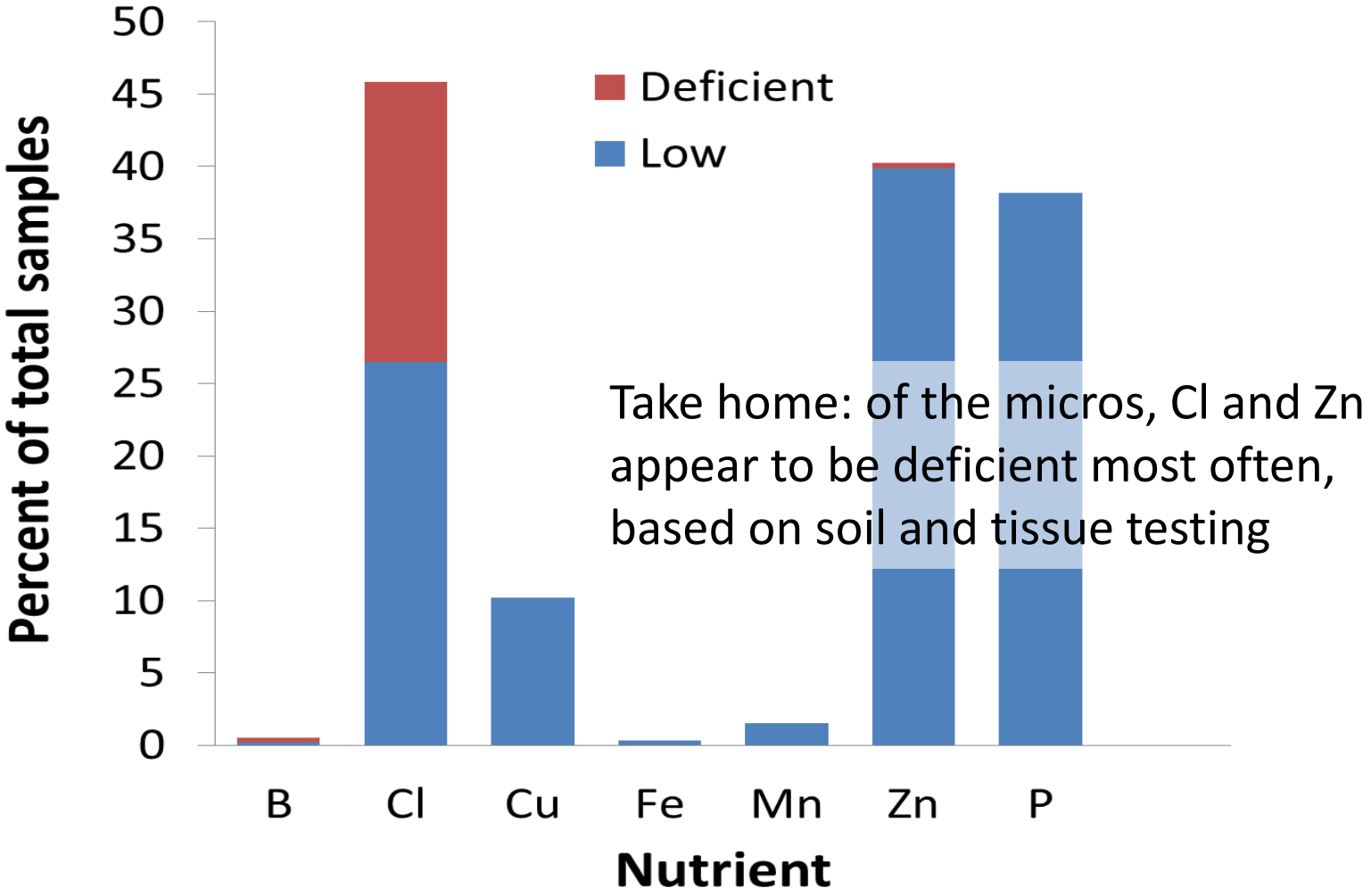


What do Cl and Zn deficiency look like?

Cl deficiency (wheat)

Zn deficiency

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



Take home: of the micros, Cl and Zn appear to be deficient most often, based on soil and 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

Typical minimum sufficient micronutrient levels in plant tissue

Crop	Sample	B	Cu	Fe	Mn	Zn
		(ppm)				
Alfalfa	Upper 6” of leaves at bloom	30	8	30	25	20
Small grains	Whole plant prior to grain filling	5	3.7 (barley) 4.5 (oat) 2.5 (wheat)	20	15	15
Canola	Leaves at flowering	30	2.7	20	15	15

McKenzie 2001

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 visual or tissue testing?

Relative response to micronutrients

	Response to micronutrient				
Crop	Boron	Copper	Iron	Manganese	Zinc
Wheat	Low	High	Low	High	Low
Barley	Low	Medium	Medium	Medium	Low
Sugar beet	Medium	Medium	High	High	Medium
Alfalfa	High	High	N/A	Low	Low
Grass	Low	Low	High	Medium	Low

Voss 1998

Common micronutrient forms

Form	Availability	Nutrients	Application surface	Residual > 1 year
Sulfate (salts)	Water soluble, plant available	Cu, Fe, Mn, Zn B (borate)	Soil or Foliage	Yes
Oxysulfate	Oxide portion not very available, sulfide portion is, should be > 50% water soluble	Cu, Fe, Mn, Zn	Soil	Yes
Oxide	Bound with O_2, not soluble, needs to be converted	Cu, Fe, Mn, Zn	Soil	Yes, but is not plant available
Chelate	Plant available form	Cu, Fe, Mn, Zn	Soil or Foliage	No
Manure	Bound in OM	Cu, Zn	Soil	Yes

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

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 Sulfate and oxysulfate are not recommended			

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

Conclusions

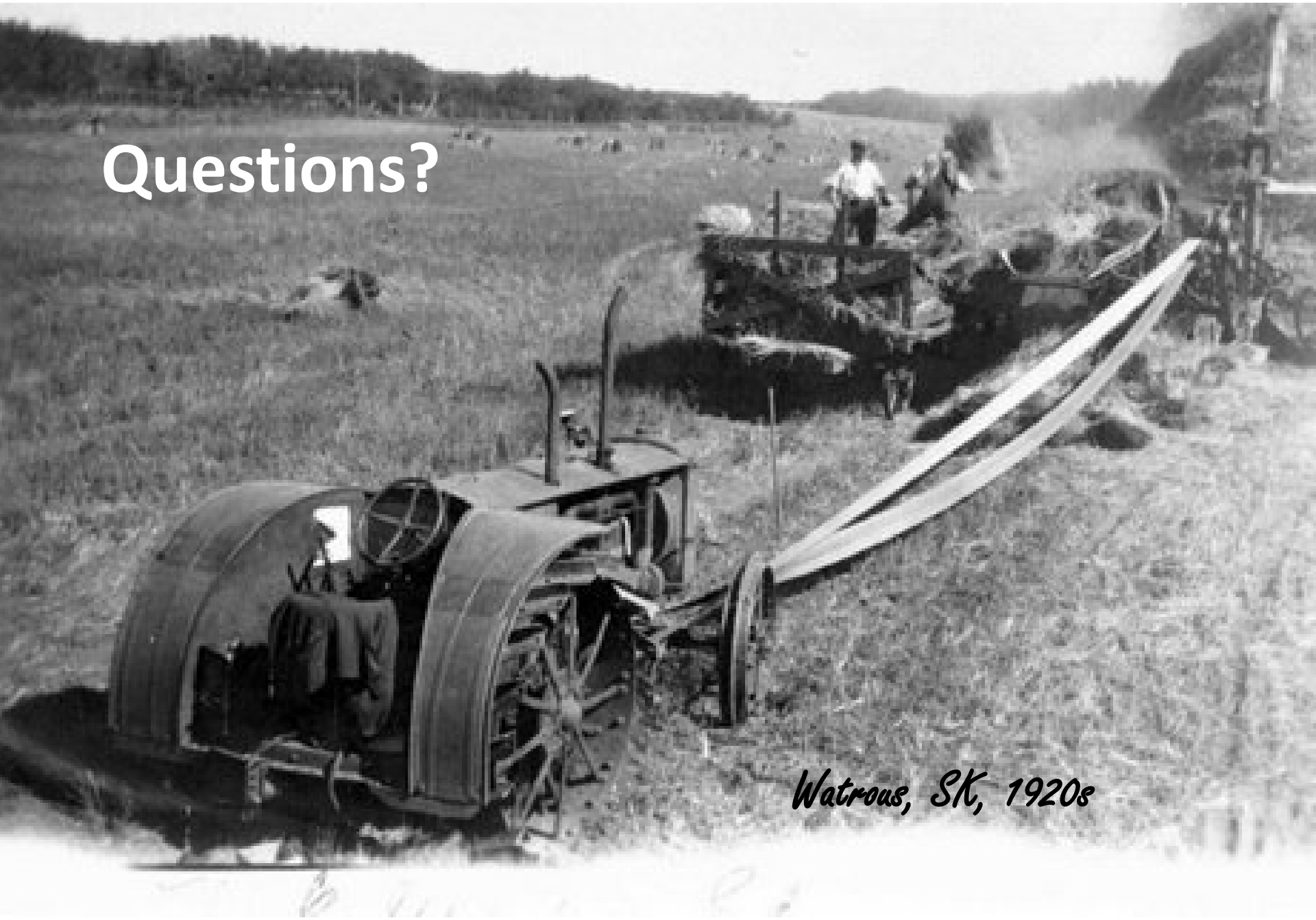
- Soil tests can identify limiting factors, increase yield and/or save on fertilizer costs, and decrease environmental risks.
- Soil tests for N are best done in the spring, can be done in fall for P and K, and not worthwhile for S
- Micronutrients can be evaluated by soil or tissue sampling, or visual assessment
- There are tools available to help determine fertilizer needs and rates

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”

This presentation: Go to “Presentations”


Questions?
Watrous, SK, 1920s