MICRONUTRIENT TESTING & MANAGEMENT IN BARLEY, CORN & PULSES

Barley and Sugarbeet Symposium
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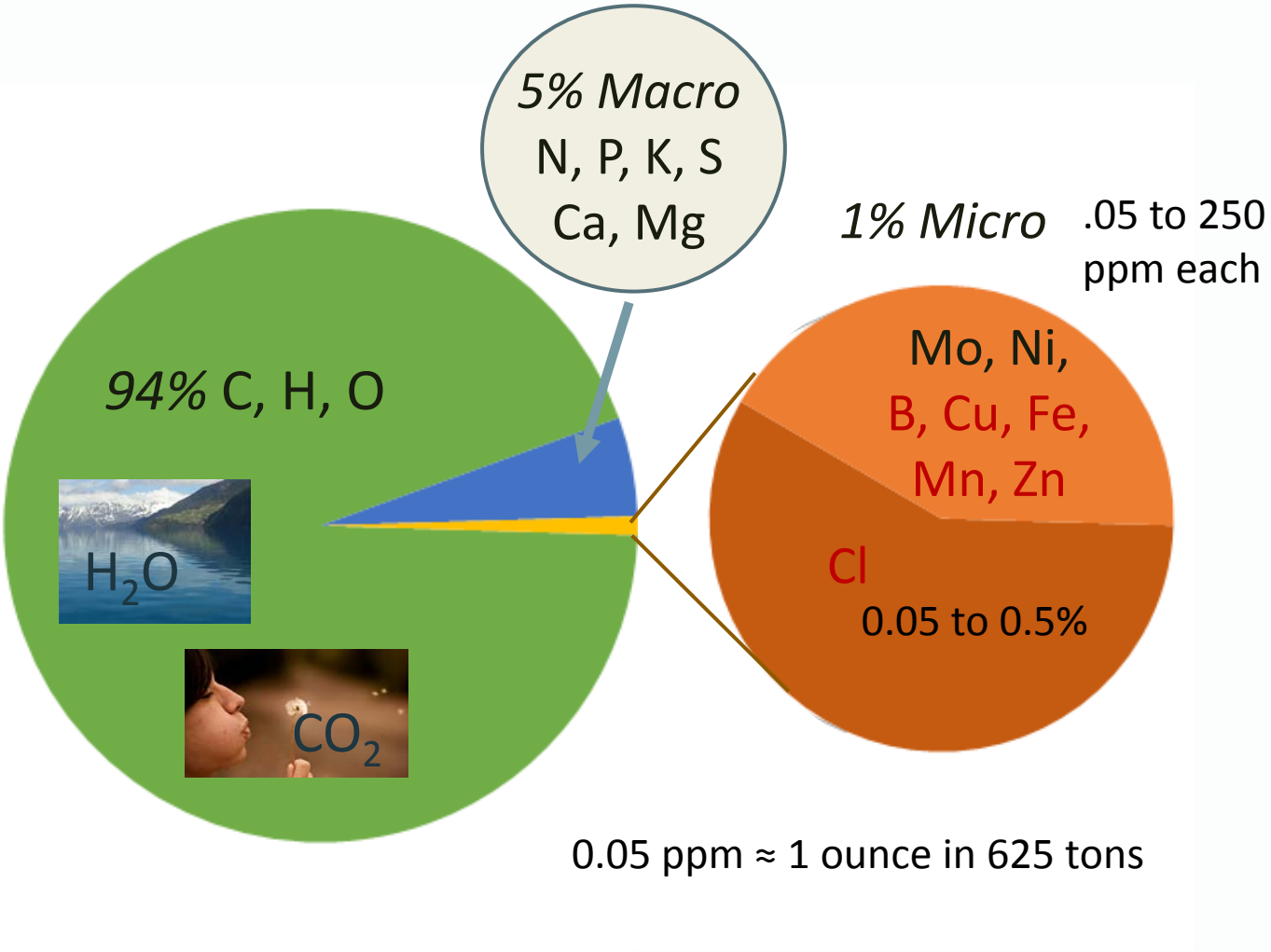
MONTANA STATE UNIVERSITY

MSU Soil Fertility Extension

Goals Today

- Discuss soil and tissue testing for micronutrients
- Illustrate deficiency symptoms
- Provide general guidelines for micronutrients
  - sources
  - rates
  - application methods
  - timing

Nutrient amounts in dried plant material



Deficiency observed in MT
Boron (B)
Chloride (Cl)
Copper (Cu)
Iron (Fe)
Manganese (Mn)
Zinc (Zn)

The micronutrients are simply needed in smaller amounts by the plant than the macronutrients.

Conditions that affect availability to plant

Nutrient	Limiting conditions
Boron Chloride	Low Cl in rain 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

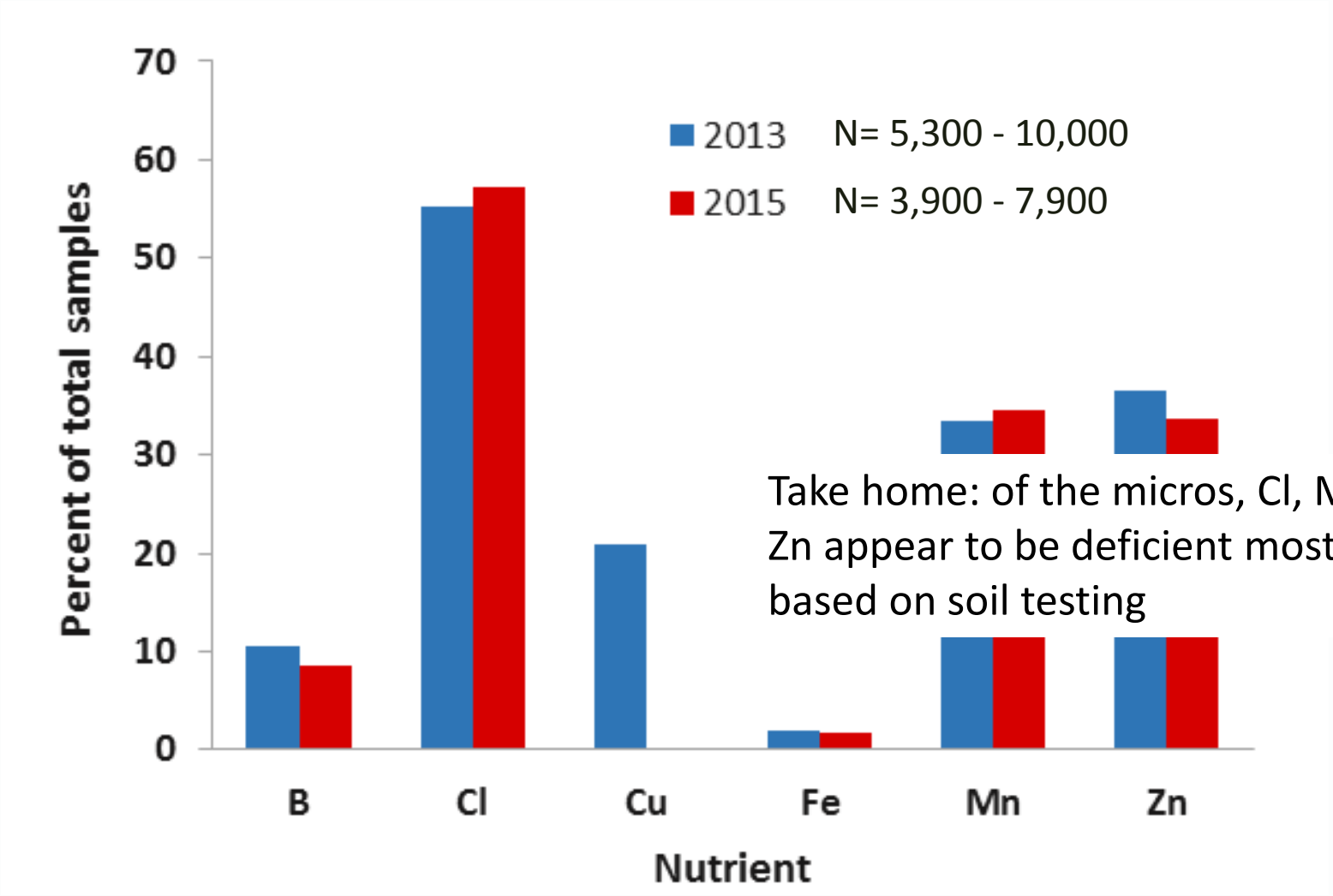
Most Montana soils are generally alkaline (pH > 7.0)

Early growing season often cold soils and either dry or very wet

Soil testing

- Use in combination with other tools
- Tests are not highly accurate, precise, or consistent among labs
- Although published
  - Critical soil levels are not well established. In 87 corn fields, B and Zn soil levels were correlated to yield, not Cu, Fe, Mn (Stewart 2016)
  - Correlations between soil (& tissue test) levels and fertilizer rate guidelines are not well established

MT soils with deficient micronutrient concentrations (source: Agvise)



There may be bias because more samples may be submitted when deficiency symptoms are suspected than when not

Reliability of soil test results from a single soil

	Zn (DTPA, ppm)	Cu (DTPA, ppm)	B (hot water, ppm)
Range of concentration reported by the labs	0.5 – 1.0	0.2 – 1.0	0.2 – 1.8
Uncertainty around each reported value	± 0.12	± 0.08	± 0.12
Possible 'true, actual' value	0.38 – 1.12	0.12 – 1.08	0.08 – 3.0

Based on 95% confidence, from a soil sample evaluated 95 times in the ALP Program 2006-2012. Miller, 2013.

Variability among labs. If comfortable, use the same lab over time.

Ask if a member of a proficiency program (e.g., ALP, NAPT);
if so, ask if can see results

Nutrient In The Soil			Interpretation			
			VLow	Low	Med	High
Cl	0-24''	20 lb/ac	********			
S	0-6"	14 lb/ac	**********			
	6-24"	36 lb/ac	**********	**********	**********	**
B						
Zn						
Fe						
Mn						
Cu		0.5 ppm	**********	**********		
Mg						
Ca						

1st Crop Choice		
Wheat-High Pro.		
YIELD GOAL		
50 Bu		
SUGGESTED GUIDELINES		
Band		
LB/ACRE		APPLICATION
N	111	50
P_2O_5	36	Band *
K_2O	10	Band (Starter)*
Cl	20	Broadcast
S	9	Band (Trial)
B		
Zn		
Fe		
Mn		
Cu	2	Band
Mg		
Lime		

Look for notes provided by laboratory, e.g.,

- Crop 1: 44 lb of 0-0-60 = 20 lb of Cl
- Caution: Seed placed fertilizer can cause injury

Micronutrient soil critical levels and fertilizer guidelines

Nutrient	Critical soil level (ppm)	Fertilizer form	Timing Spring (S) Fall (F)	Rate (lb/acre)	
				Broadcast & incorporate[1]	Seed-placed
Boron	< 0.2 - 1.0	Sodium borate	S	0.5 – 3	NR[2]
Copper	< 0.1 - 0.5	Sulfate	S or F	2 - 8	NR
		Oxysulfate	F	2 - 8	NR
		Chelate	S	0.5	0.25 – 0.5
Iron	< 2 - 5	?	?	2 - 5	
		Chelate	S	NR	NV
Manganese	< 1.0	Sulfate	S	50 – 80	4 – 20
		Chelate	S	NR	NR
Zinc	< 0.5	Sulfate	S or F	3.5 – 5	NR
		Oxysulfate	F	5 – 10	NR
		Chelate	S	1	NV

[1]Subsurface band is not recommended for any of these fertilizers. [2] NR not redommended, NV not verified

Sources: Karamanos 2000, Gerwing and Gelderman 2005, EB0161, McKenzie 2016

Cl on small grains

- Cl is very mobile so may need to add more if leaching or yield potential is high. 20 lb KCl/acre annually may provide enough.
- Over 210 trials in KS, MN, MT, ND, SD, MB and SK have evaluated Cl-response in wheat and barley*
- Significant yield response in 48% of trials*
- Average response of 5 bu/acre*

*Source: Cindy Grant, Agriculture and Agri-Food Canada

Questions?

Tissue analysis for in-season micronutrient adjustments

- Visual tissue assessment for potential deficiency See *Plant Nutrient Functions and Deficiency and Toxicity Symptoms (NMM 9):* http://landresources.montana.edu/nm
- Tissue concentrations – other than for chloride there are no MT guidelines for micros based on tissue tests. In 87 corn fields, there was a positive correlation between tissue test concentrations and yield only for Cu (Stewart 2016), not for B, Fe, Mn, Mg or Zn.
- Once deficiency observed, potential yield may already be reduced

Visual tissue assessment

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

MOBILE NUTRIENTS

Older/lower leaves affected — NO → Next page

YES ↓

Effects mostly generalized; plants dark or light green — NO → Effects mostly localized; chlorosis with or w/out spotting

YES ↓

Plants dark green, often becoming purple or red

YES ↓ PHOSPHORUS (P)

NO ↓

Plants light green with leaves light green or yellow; no necrotic spotting

YES ↓ NITROGEN (N)

NO ↓

Plants light green; necrotic spotting on leaves; pale leaves sometimes scorched, cupped or rolled

YES ↓ MOLYBDENUM (Mo)

Effects mostly localized; chlorosis with or w/out spotting

YES ↓

Interveinal chlorosis; leaves sometimes red or with dead spots

YES ↓ MAGNESIUM(Mg)

NO ↓

No interveinal chlorosis; chlorotic areas with a burning or spotting along leaf margins

YES ↓ POTASSIUM (K)

NO ↓

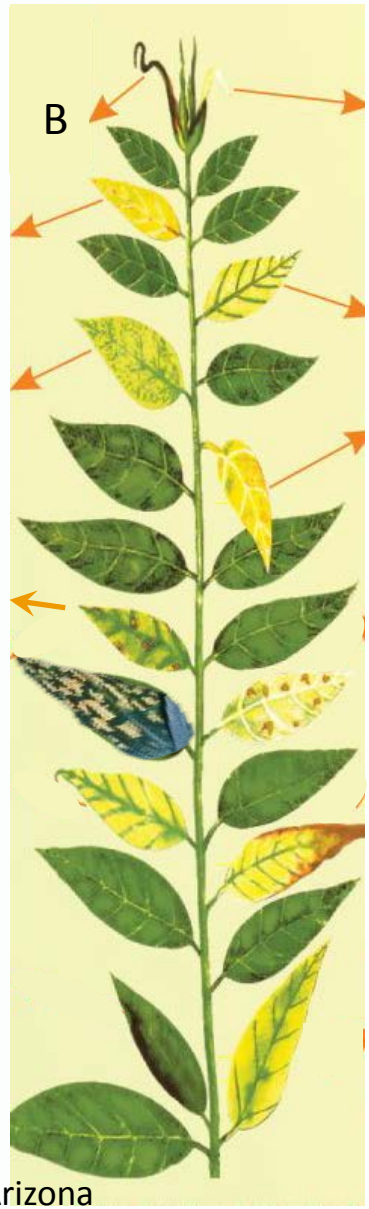
No interveinal chlorosis; distinct chlorotic and necrotic lesions (spotting) with abrupt boundary between dead and alive tissue

YES ↓ CHLORIDE (Cl)

U of Arizona

IMMOBILE NUTRIENTS

Newer or younger leaves



U of Arizona

Growing point (terminal bud) dies — NO → Growing point typically stays alive

YES

Leaves of terminal bud become light green at bases; leaves become twisted and brittle and die back at growing point; chlorosis of young leaves

YES → BORON (B)

NO

Young leaves of terminal bud hooked at first, finally turning brown and dying

YES → CALCIUM (Ca)

NO

Dark green zone next to blunted necrotic leaf tip, thickened curling leaves

YES → NICKEL (Ni)

Growing point typically stays alive

YES

Chlorosis w/out interveinal chlorosis — NO → Young leaves with interveinal chlorosis

YES

Leaves light green; typically no chlorotic spotting or striping

YES → SULFUR (S)

NO

Chlorosis of young leaves; tips appear withered and will eventually die

YES → COPPER (Cu)

Young leaves with interveinal chlorosis

YES

Sharp distinction between veins and chlorotic areas

YES → IRON (Fe)

NO

No sharp distinction between veins and chlorotic areas; spotty appearance

YES → MANGANESE (Mn)

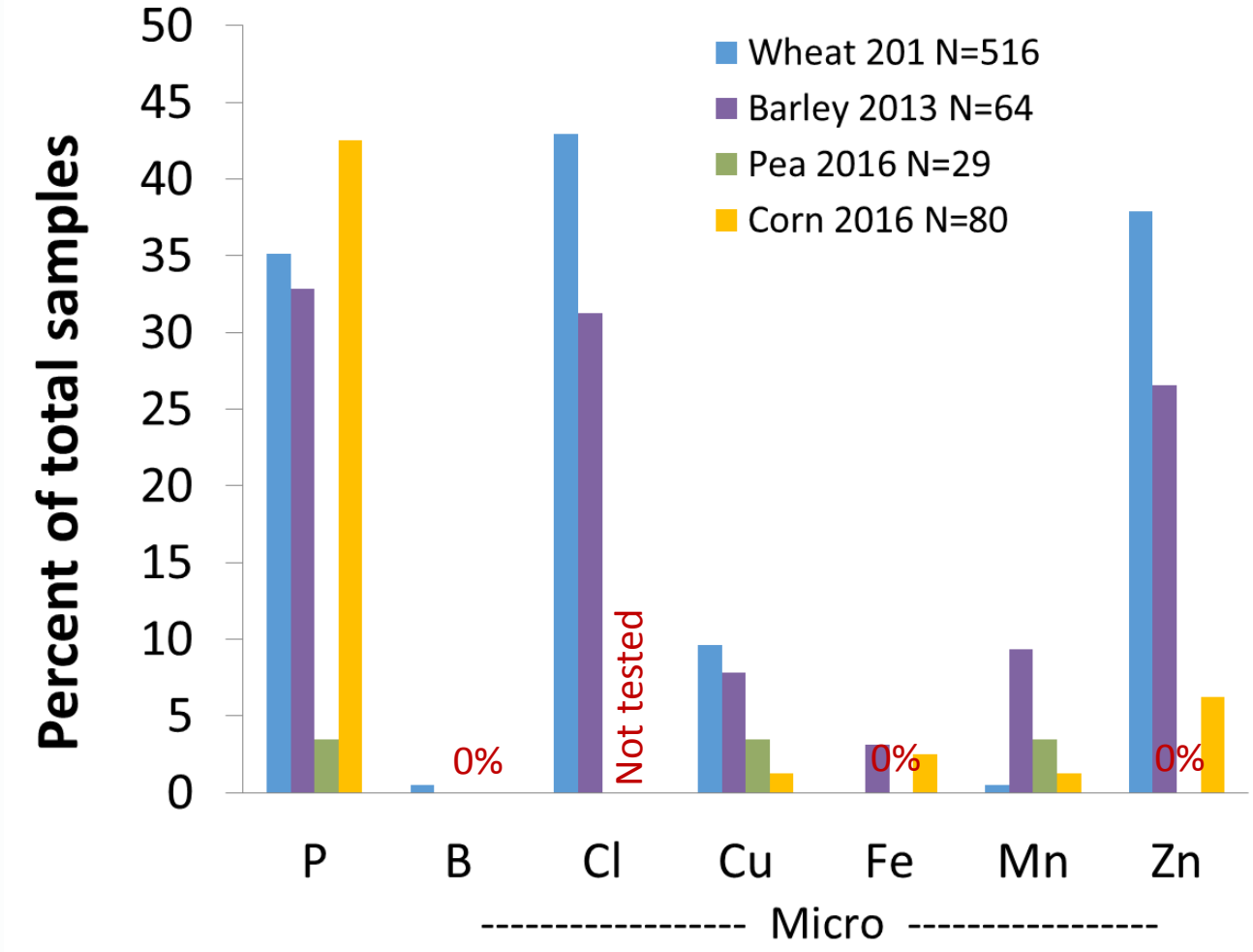
NO

Middle leaves with interveinal chlorosis; stunted growth

YES → ZINC (Zn)

(Initially in middle leaves, young and/or old leaves become chlorotic in later stages of deficiency)

Wheat, barley, pea, and corn with low or deficient tissue micronutrient concentrations in MT (source: Agvise)



Based on tissue testing, of the micros, Zn and Cl appear deficient most often in barley and wheat.

Deficiencies are not common in pea.

P is a greater concern in corn.

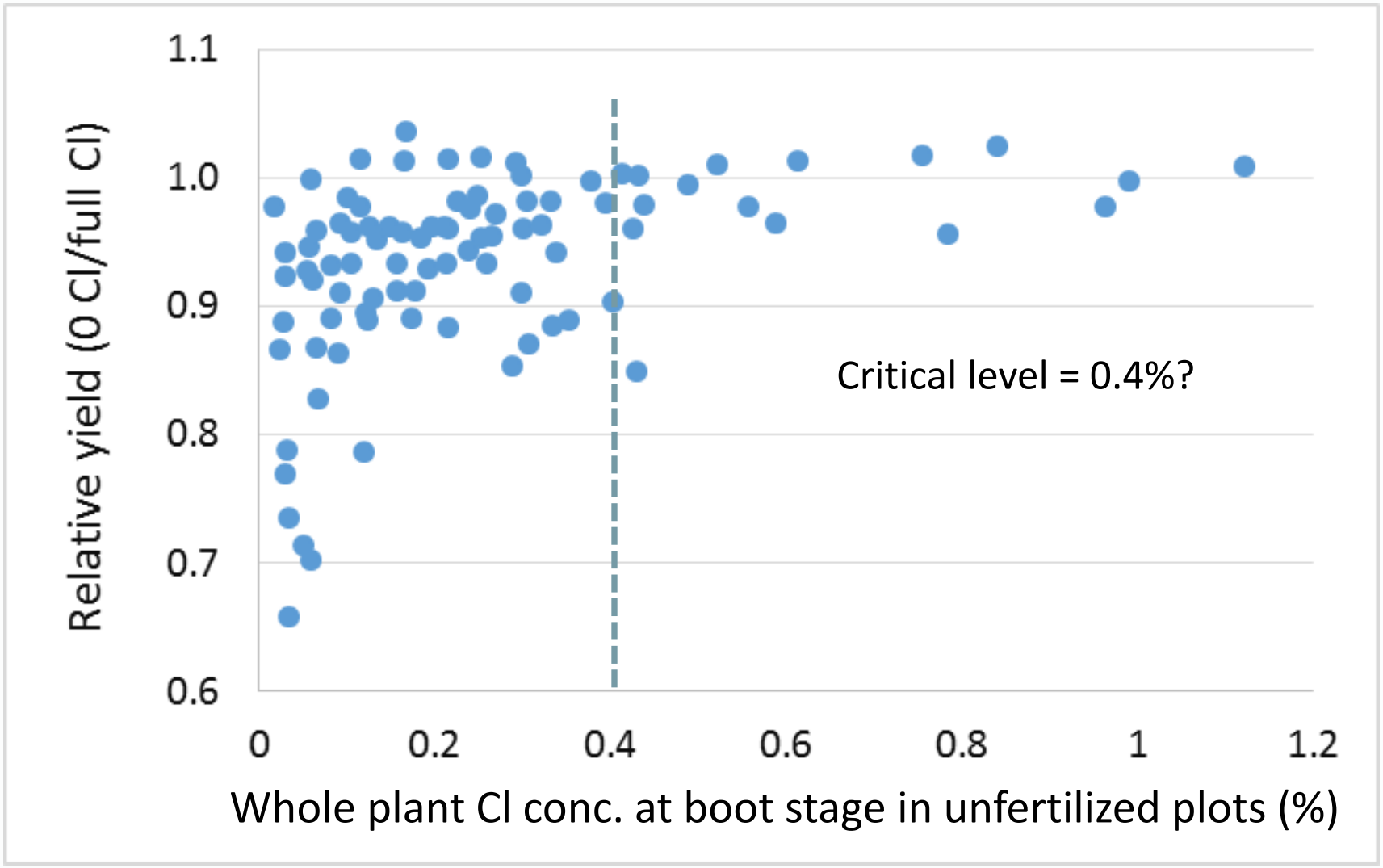
There may be error b/c many samples are not the correct plant part and there may be bias because more samples with deficiency symptoms are submitted than w/o symptoms

Published minimum sufficient micronutrient levels in plant tissue

Crop	Sample	B	Cu	Fe	Mn	Zn
		(ppm)				
Barley[1]	Whole plant prior to grain filling	5	3.7	20	15	15
Corn[2,3]	Ear-leaf at R1-R2	4-25	3-20	21-250	20-250	20-70

1. McKenzie 2001, 2. Daniel Kaiser U of M, Twin Cities, 3. Voss 1998

Wheat tissue Cl concentration



Fertilizer Fact No.3
96 variety x site trials over 4 Great Plains states

Foliar fertilizer sources and rates

Element	Fertilizer source[1]	Rate (lb/ac) [1]
Boron	sodium borate	0.3-0.5
Copper	chelated	0.2-0.25
Iron	chelated	0.15
Manganese	chelated	0.5-1.0
Zinc	chelated	0.3-0.4
Best applied in spring Sulfate and oxysulfate are not recommended		

1. Karamanos 2000

Questions?

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

Apply these foliar or in root zone

Common micronutrient forms (Source: Gov. of SK)

Form	Availability	Nutrients	Apply to:	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 considerations

- Micronutrient availability in a fertilizer source is not guaranteed
- Some fertilizers contain heavy metals in excess of safe levels (Westfall et al., 2005)

Micronutrient fertilizer application timing and method

Timing

- Borate, chelated, sulfate, or high solubility (>40%) oxysulfate forms: Spring
- Oxide and low solubility (<40%) oxysulfate forms: Fall

Method

- Broadcast and incorporated is ideal, but challenging to get even distribution of a very small quantity
- 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 Cu, Fe, Mn, Zn

Karamanos 2000, Gerwing and Gelderman 2005

Relative response to micronutrients

	Response to micronutrient				
Crop	Boron	Copper	Iron	Manganese	Zinc
Barley	Low	Medium	Medium	Medium	Low
Corn	Low	Medium	Medium	Medium	High
Pea	Low	Low	N/A	High	Low
Sugarbeet	Medium	Medium	High	High	Medium

Voss 1998

Conclusions

- “Micronutrients should be used when there is an economic benefit to the farmer, ….” – R. Karamanos
- A combination of deficiency symptoms, soil testing, and tissue testing may be best approach at identifying deficiencies. This is NOT an exact science.
- Micronutrient deficiencies are the exception, not the rule
- Cool wet conditions cause deficiency – will generally disappear when weather warms
- Too much micronutrient can hurt yield more than not enough
- The main challenge is even distribution of a very small quantity – consider foliar options
- *Most conclusive test is growth responses from field strip trials*

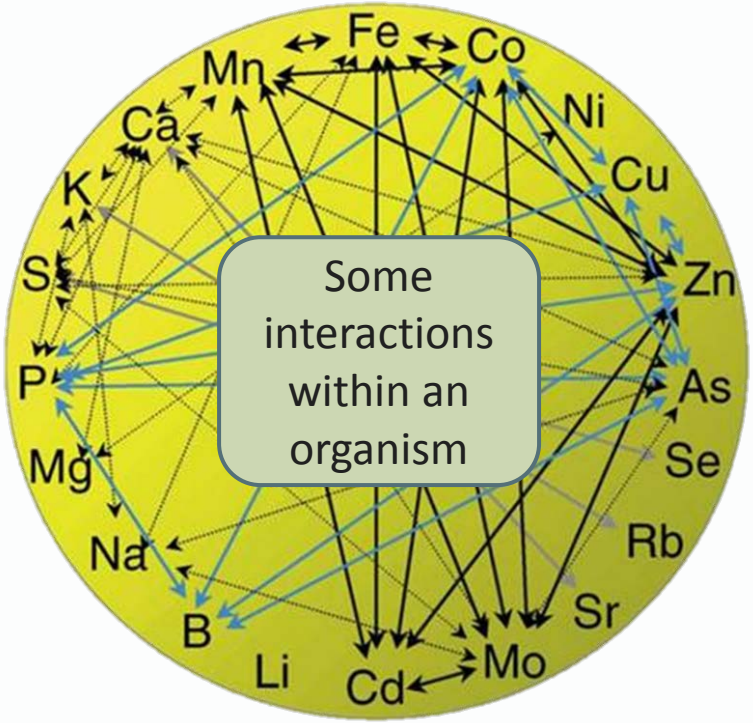
For more information

Additional soil fertility information and this presentation are available at

http://landresources.montana.edu/soilfertility

- For more information on micronutrients, see Nutrient Management Module 7 (NMM 7)
- For plant nutrient functions and deficiency symptoms, see NMM 9
- For fertilizer placement, look at NMM 11 http://landresources.montana.edu/nm

Questions?



Baxter 2009

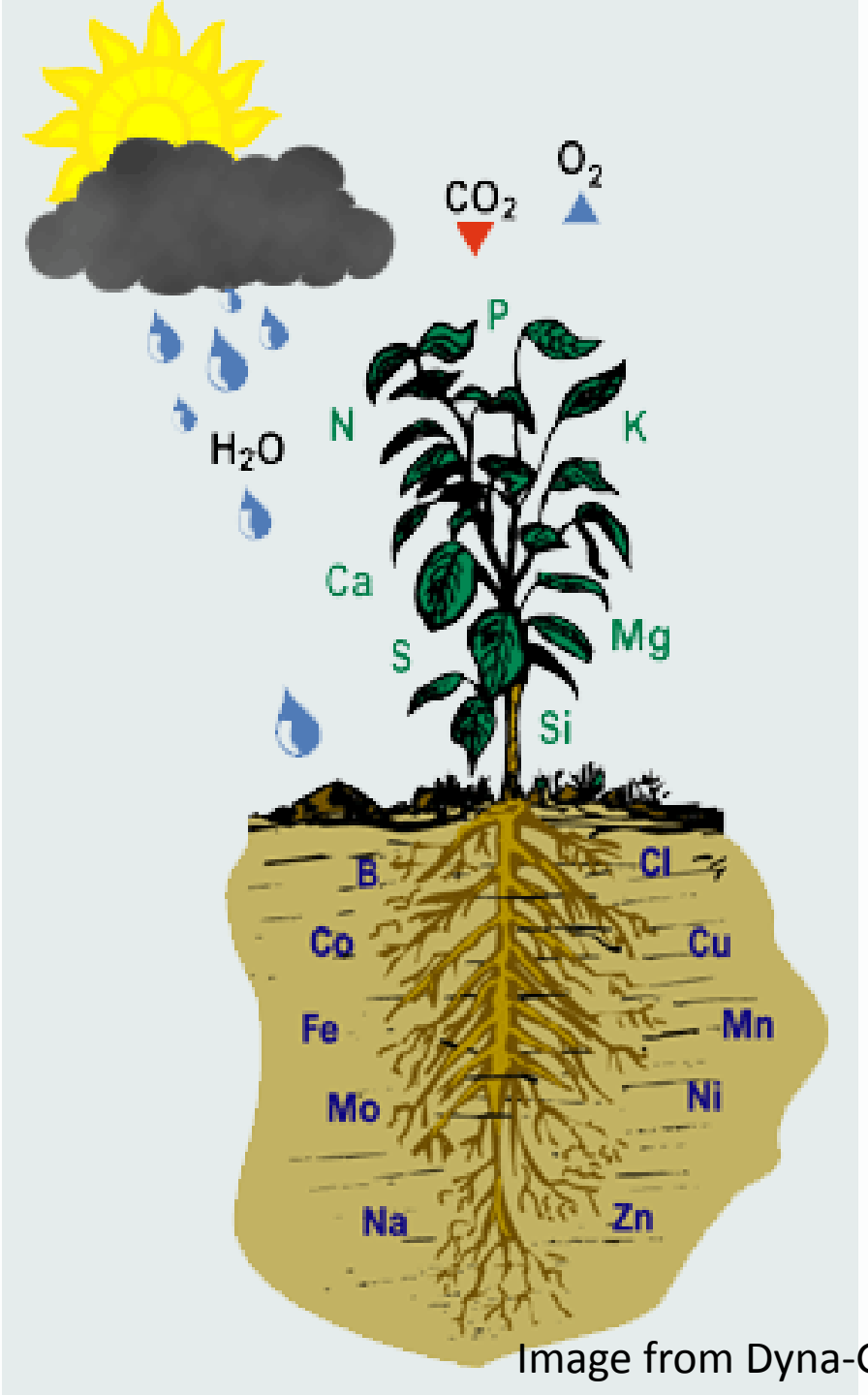


Image from Dyna-Gro