Micronutrients and Crop Health

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Micronutrients

- Elements required in very small amounts, but still essential. No less important in plant nutrition than N, P, K or S. !

- Micro's of interest for Sask include:

Copper (Cu), Zinc (Zn), Manganese (Mn), Iron (Fe) Boron (B), Chlorine (Cl)

Micronutrients are a bit "mysterious" by nature!

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- Deficiency may appear, then disappear. Symptoms easily confused with other forms of stress.
- Unique combinations of soil, environmental and crop conditions often needed for deficiency to show up.
- Difficult to diagnose, responses often small, fleeting, variable.
- Misjudgement can be expensive.

Plant absorption of micronutrients

- **Micro metals: copper, zinc, manganese, iron**

Taken up as cations (positively charged ions)

And as **chelates**: metal complexed with organic matter.

Micro cations tend to strongly react with soil and become fixed, especially at high pH. Chelation prevents this, keeps them soluble.

- **Boron** taken up as borate, **chlorine** as chloride anion.

  B and Cl are quite mobile in the soil.

- Uptake through roots, also foliage.

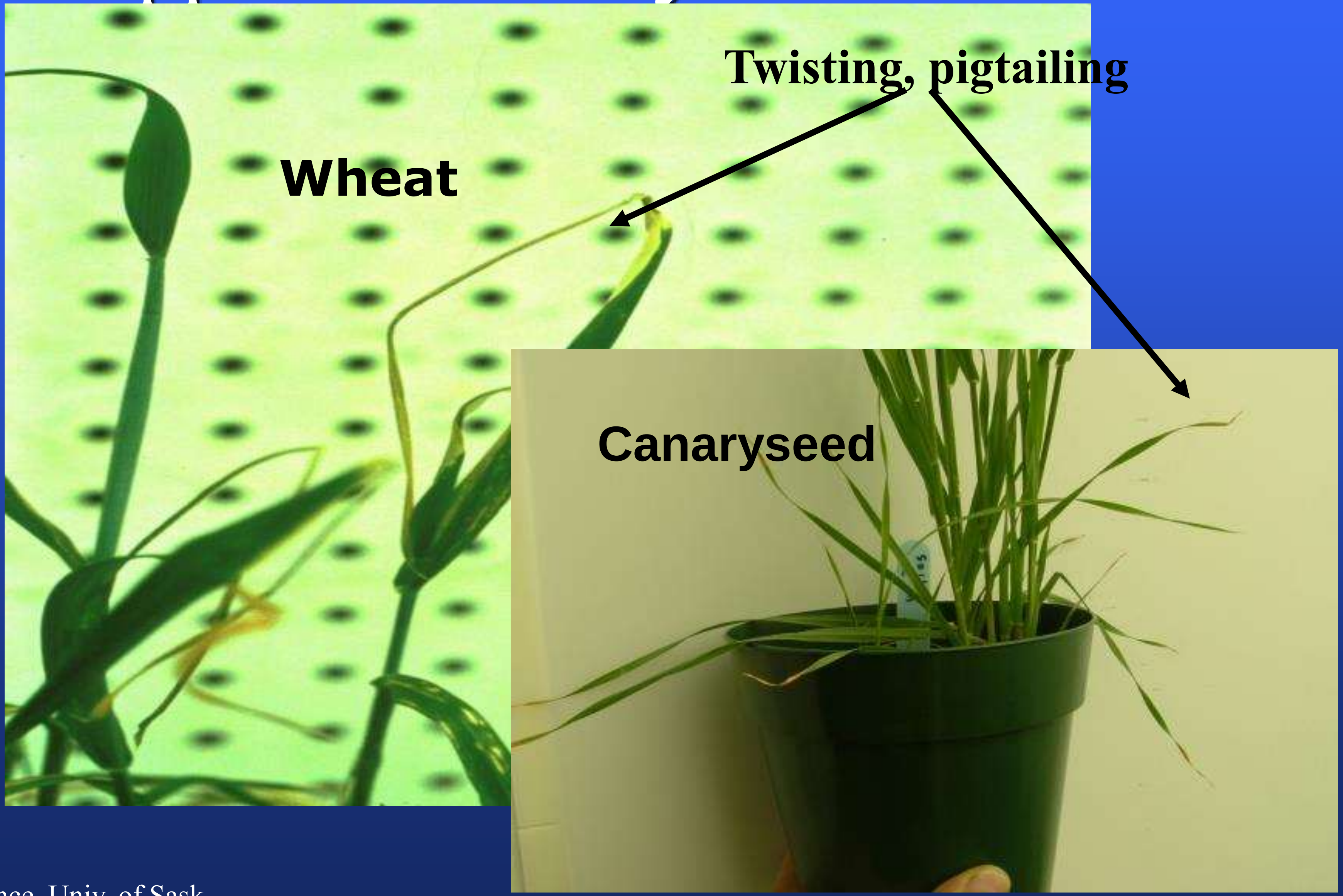
Role of Micronutrients in Crop Nutrition

COPPER, ZINC, MANGANESE

- Metals involved in electron transport, enzyme activation, hormone regulation
- Can also play roles in disease resistance.

Example: Copper deficiency may aggravate ergot infections.

Copper deficiency in cereals



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BORON: Cell wall extension, division at growing points, especially affects reproduction ie pollination.

CHLORIDE: Charge balancing, osmotic relationships, cell turgor, resistance to root and leaf diseases

Effect of Chloride on Leaf Spot in Winter Wheat

Diagnosing Micronutrient Deficiencies

- Using visual inspection alone is risky, inconclusive.
- Symptoms sometimes fairly specific: For Cu deficiency, get pig-tailing, melanosis in cereals. However other symptoms less specific: wilted leaves, poor grain fill.

- Must recognize that micronutrient availability can vary greatly across farm fields.

- Deficiencies tend to occur in patches, localized areas within a field: eroded knolls, sand or gravel lens.
- Sampling strategy must account for this.

Know Where to Look

Soil Conditions Contributing to Micronutrient Deficiencies

- **Sandy:**
  - low content of minerals capable of releasing micronutrients by weathering.

- **Calcareous (high lime content), high pH:**
  - will fix micros like Cu and Zn into insoluble forms.
- **Very low or very high O.M. content.**
  - low O.M. can contribute to low B availability. Peat soils can suffer from deficiency in Cu and Mn.
- **Nutrient imbalances.**
  - high soil P can interfere with Zn and Cu uptake.

Sandy Gray Soils have greatest frequency of micronutrient deficiencies

- Generalizations about where and when a micronutrient deficiency will occur can be dangerous.
- Soil and tissue testing are tools that can add some resolution. Some debates about critical levels.
- When responses are isolated and not clear cut, difficult to establish recommendation criteria.

- A combo of soil and tissue testing, plus some test strips most conclusive.

Responses to Micronutrient Fertilization

COPPER

Of the micronutrients, Cu is the element most likely to arise as a limitation in SK.

Cereals, especially wheat, are crops most susceptible.

Response of HRS Wheat (var. Barrie) to Copper Fertilization in a Gray Luvisol near Porcupine Plain, SK. (Malhi et al., 2003)

Control	1566 kg/ha (a)
2 kg Cu/ha Soil incorp at seeding	1591 kg/ha (a)
0.25 kg Cu/ha Foliar at flagleaf	2555 kg/ha (b)

Flaten et al., 2003 also found foliar application most effective for correction of Cu deficiency in year of application.

BORON

- Canola, alfalfa are crops believed to be most susceptible to deficiency.
- Large yield responses to B fertilization in W. Canada reported in literature are rare.
- Even on soils with very low extractable B content, no significant yield response of canola to B application observed in field (Karamanos et al. 2002; Malhi et al., 2003).

Response of canola to boron fertilization grown on two Gray Luvisols in the growth chamber (Malhi et al., 2003)

Rate of B mg/kg	Canola seed yield g/pot
0	18.5
1	19.8
2	20.8
3	20.9

NS at p<0.05

Significant at p<0.10

Note: Over-application of boron can lead to toxicity issues!

SMA Fact Sheet: Boron in Crop Production

Can boron addition reduce incidence of club root in canola?

Source: Canola Council of Canada

A study conducted in AB, ON and QC (Deora et al. 2014 Can.J. Plant Sci 94) in soil infested with *Plasmodium brassicae* showed no reduction in clubroot incidence with B fertilization and no yield response except on one organic soil in ON.

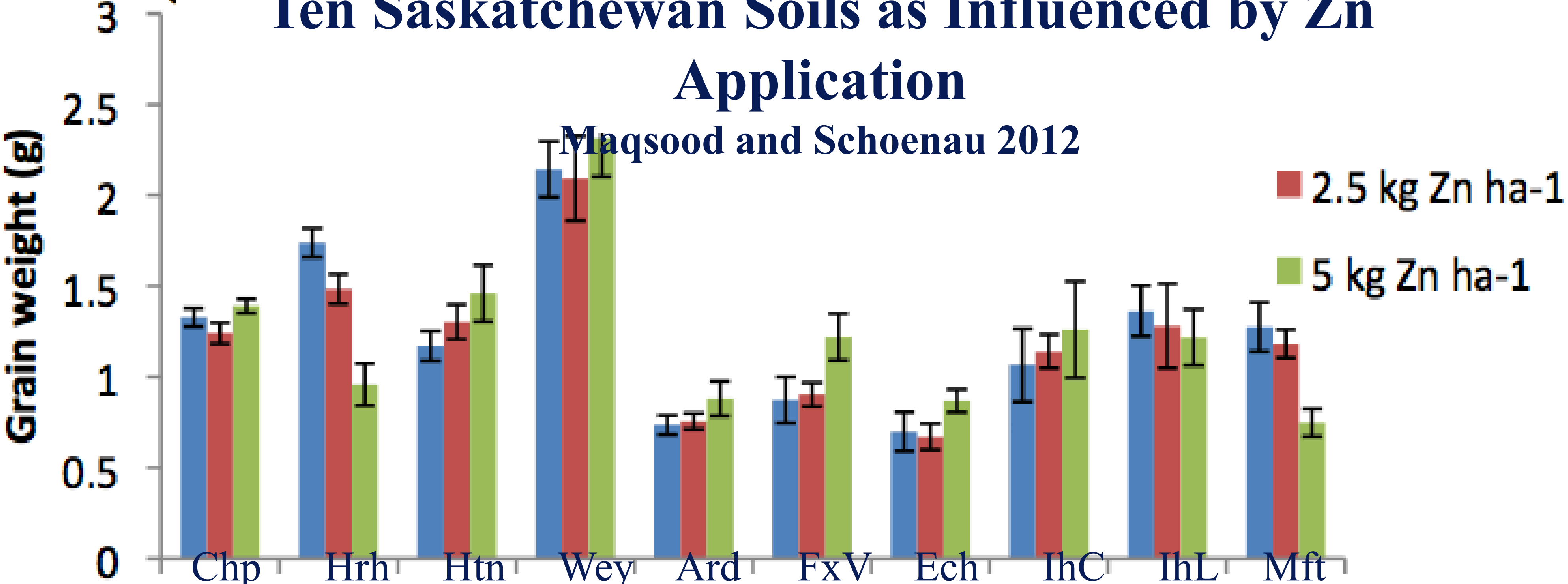
ZINC

Significant responses of cereals to zinc application observed on soils from eroded knolls under growth chamber conditions (Greer et al. 2002; Cowell and Schoenau 1993).

Lentils, beans can be responsive to zinc fertilization.

Grain Yield of Lentil Grown in the Polyhouse on Ten Saskatchewan Soils as Influenced by Zn Application

Maqsood and Schoenau 2012

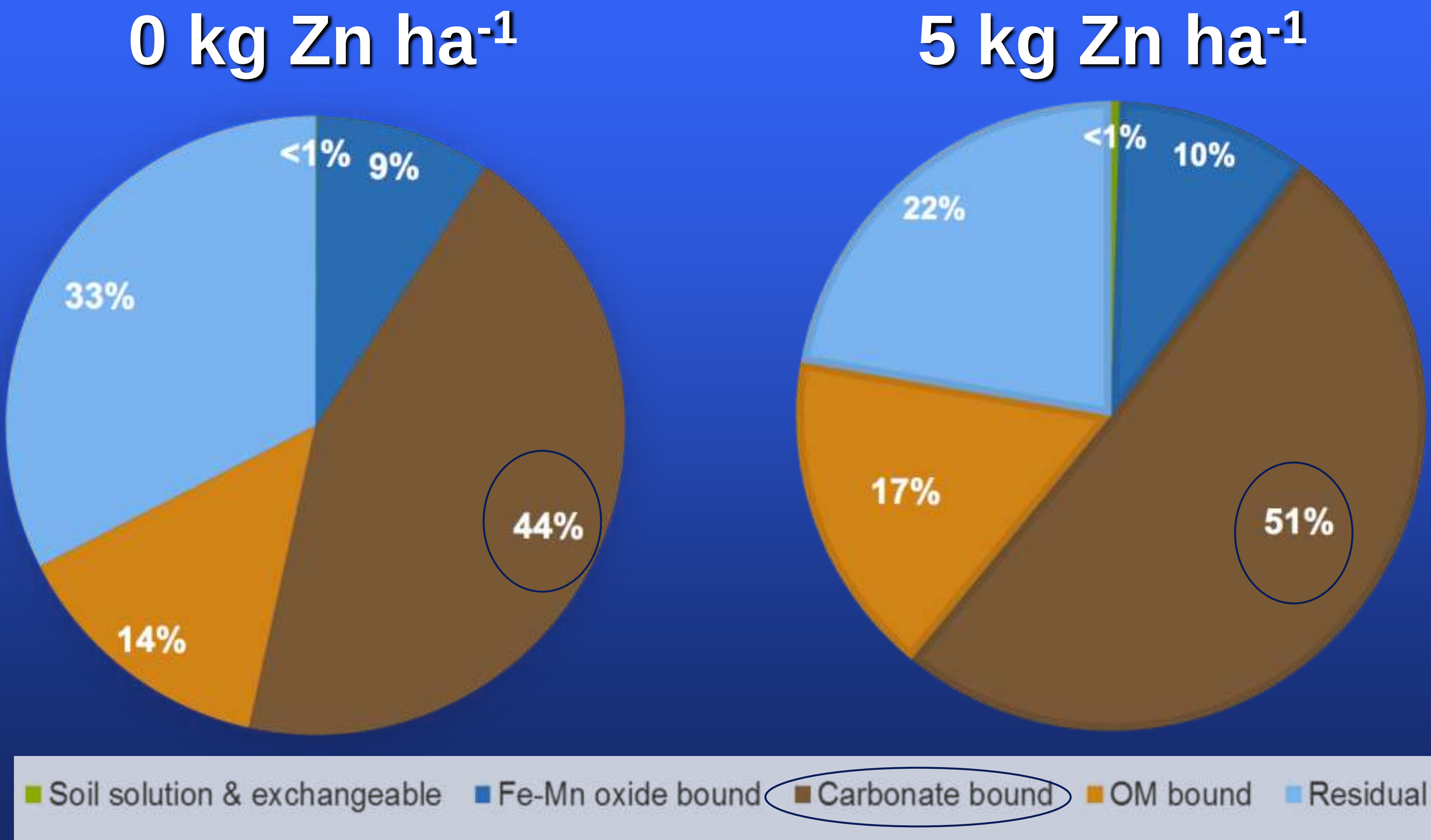


Lentil Response to Zn Fertilization in Field

Anderson et al. 2013

Site	Yield[†]	Zn Rate (kg ha^{-1}) 0	2.5	5	SEM[‡]	P values Rate (R)	Cultivar (C)	R*C Interaction
Central Butte	Grain	2919	2880	2913	359	0.9944	0.5542	0.9250
	Straw	2597	2502	2508	194	0.9285	0.1982	0.5882
Saskatoon	Grain	4104	4355	4172	183	0.6089	0.8774	0.7352
	Straw	3743	3946	3872	168	0.6907	0.6904	0.7619

Effect of Zinc Fertilization Rate on Soil Zinc Fractions



MANGANESE

Cereals, especially oats, grown on peaty soils at northern agricultural fringe could respond to manganese.

Deficiencies of Mn not an issue in mineral soils.

IRON

Iron (Fe) deficiencies produce rather marked symptoms: interveinal chlorosis.

Source: Fe deficiency chorosis in soybean. North Dakota State University Crop and Pest Report 6/23/11 Kandel and Goos http://www.ag.ndsu.edu/cpr/plant-science/iron-deficiency-chlorosis-in-soybean-6-23-11

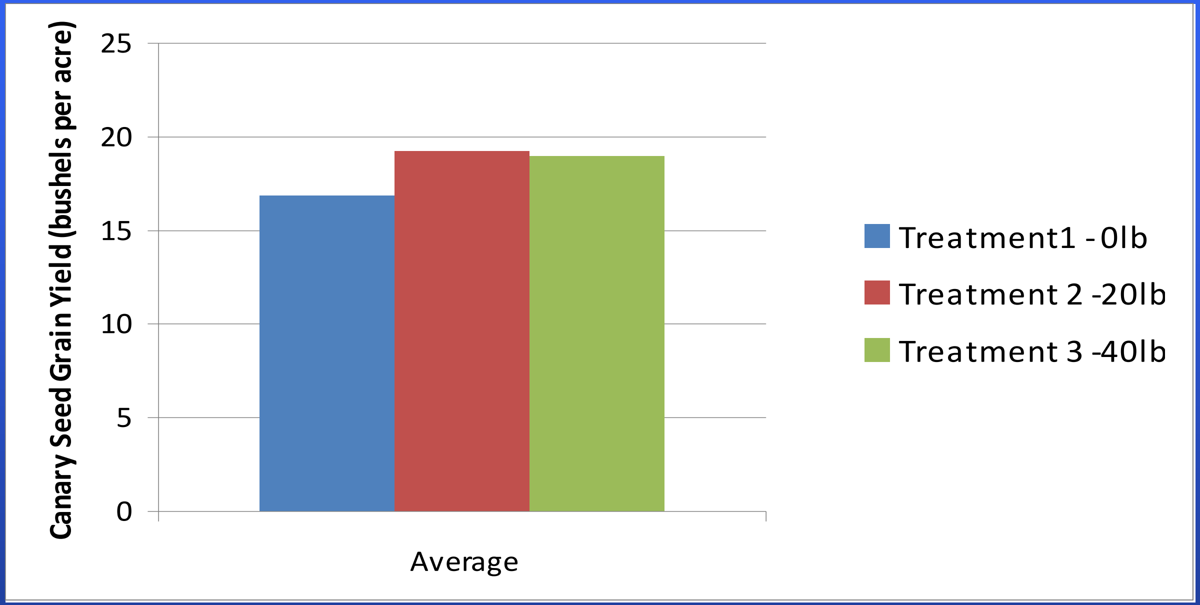
- Deficiencies not reported in field crops in SK
- High pH, poor drainage, salinity aggravate Fe deficiency
- Soybeans rather inefficient users of Fe. Some varieties more sensitive to Fe deficiency than others.

CHLORIDE

Potential for response of cereals in highly leached soils with low extractable Cl. Response may be associated with disease pressure.

- Application of 40 lb/ac of KCl increased wheat yield in foot slope positions of a landscape in southern Saskatchewan with less than 30 lb/ac of Cl 0-60cm (Schoenau et al., 1997).
- More widespread use of KCl has likely reduced the incidence of Cl as a limitation.

Response of Canary Seed to KCl Addition (Theaker 494.6 2011)



Also, May et al. 2012 showed seed yield increase of ~ 24% from chloride added to canaryseed in Dk Brown soil zone of SK.

Micronutrient Fertilizers

Inorganic: most common are sulfates e.g. zinc sulfate, copper sulfate, borate

Organic: natural and synthetic chelates. More effective than inorganic salts, but also more expensive.

Typical rates: inorganic 1-5 lbs /acre; organic < 1 lb/acre

Low application rates pose distribution challenge.

Application: broadcast, band, seed-placed, foliar spray, seed coat, fertilizer coating

Broadcast inferior when soil fixation is high. Watch out for toxicity to seedlings when seed placing, especially for B and Cu.

Foliar applications work well for in-season remediation, but not likely to be much residual effect beyond season of application.

Final Thoughts

- Limitations in macro-nutrients more likely the major factor holding back yield than a micro-nutrient deficiency in most SK soils.
- Micronutrients should be considered as **part of the overall balance** of nutrients required to optimize yield and economic return.
- Because of variable nature, special care and consideration is needed to be conclusive in diagnosis of limitations.

- **“Patchy”** nature of micronutrient deficiencies makes them obvious target for site-specific fertilization.
- Multiple evidence approach best for identifying and verifying deficiency.


Thanks for your attention!