Micronutrient Demonstrations at Agri-ARM Sites

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Irrigation Crop Diversification Corporation

Government of Saskatchewan

AgriARM Sites

- Five Agriculture Canada Research Stations
  - Indian Head – Indian Head Agricultural Research Foundation
  - Swift Current – Wheatland Conservation Area
  - Scott – Western Applied Research Corporation
  - Melfort – Northeast Applied Research Foundation
  - Outlook – Irrigation Crop Diversification Corporation at Canada-Saskatchewan Irrigation Development Center
- Conservation Learning Center – Prince Albert
- South East Research Farm – Redvers
- East Central Research Foundation - Canora

Outline

1) Copper fertility for irrigated and dryland fields
2) Copper and zinc fertilization of irrigated alfalfa
3) Importance of pH for micronutrient fertility
4) Zinc fertility for irrigated beans
5) Boron fertility on dryland and irrigated canola
6) Liebig's Law of the Minimum
7) IHARF work with nutritional seed treatments
8) Conclusion

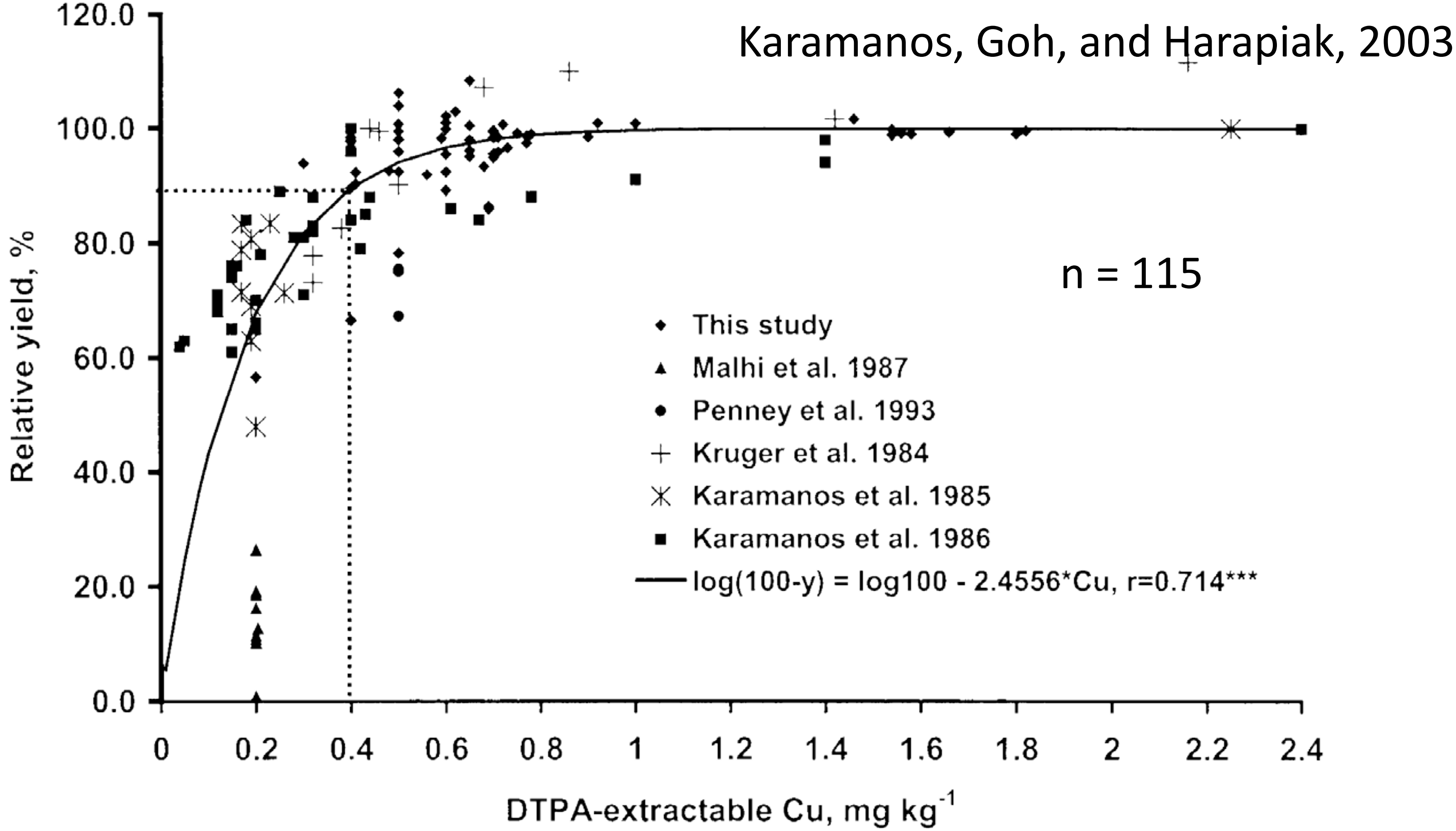
Micronutrient Testing Under Irrigation

- Does irrigation change soil fertility?
  - Increase in nitrogen mineralization
    - Trish Meyer (1995)
  - Land leveling impacts – movement of topsoil
    - Zn, K effects - mimic of erosion
      - Minimized by continuous cropping, high fertility, forages, fungicide application to beans and potatoes (supplies copper and zinc)
    - Soil pH – calcium and carbonates
    - Crop – alfalfa excellent at finding nutrients and bringing them to surface soil due to association with mycorrhiza
  - Tillage associated with beans and potatoes

Cu Deficiency in Light Textured Soils

- Light textured soils have less supply
- Continuous cropping builds soil organic matter
- Good moisture supplies promote deeper rooting
- Roots find more available copper and bring to surface in residues
- Wheat grown on sandy soils most likely

Relationship of DTPA Cu to Yield Response of Spring Wheat

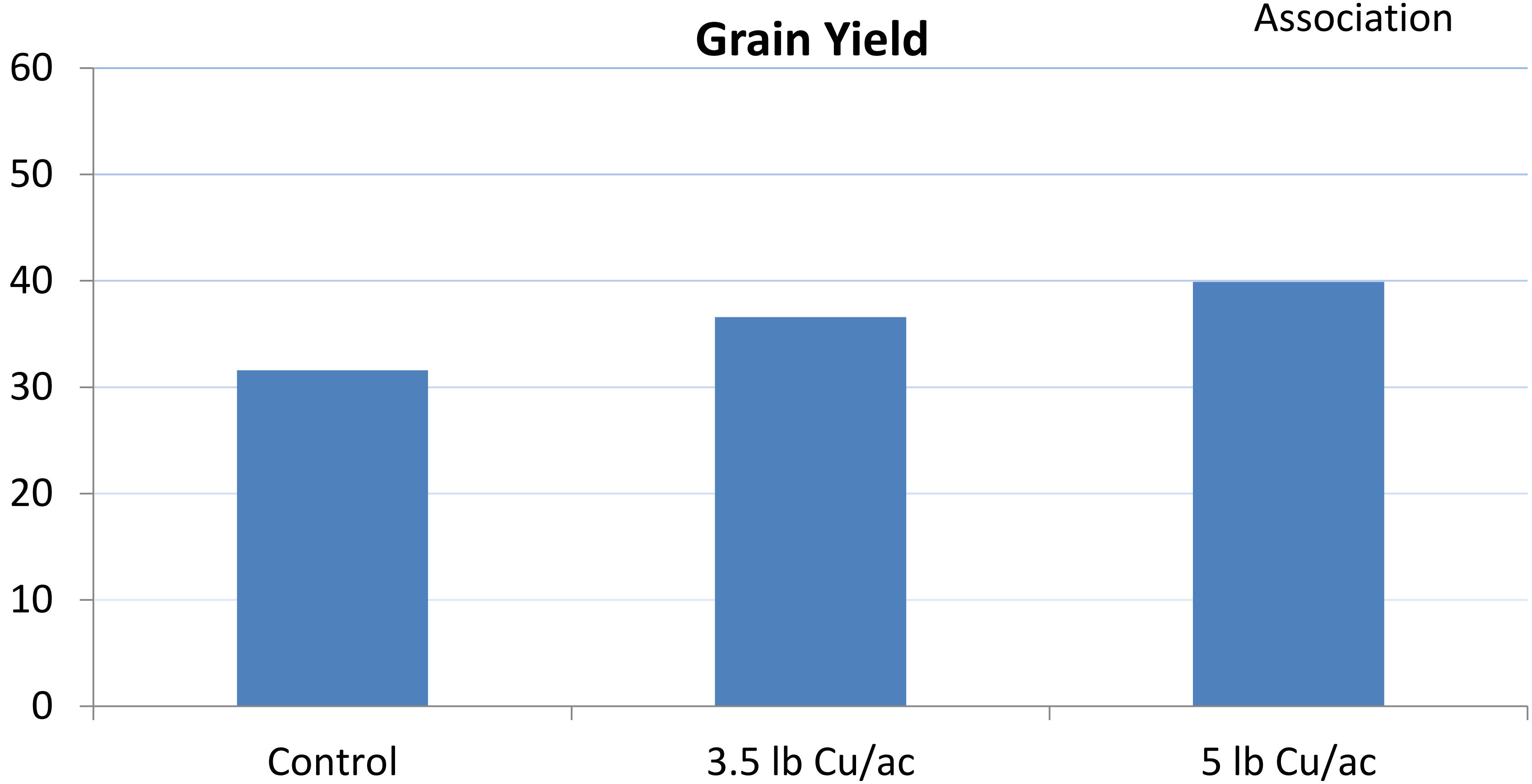


Low DTPA copper soil test more likely on sandy soil associations

- Regosolic Soils
  - Dunesand
- Brown Soils
  - Chaplin, Hatton
- Dark Brown Soils
  - Alert, Asquith, Biggar

Spring Wheat Riverhurst 2014

Chaplin Soil Association



DTPA soil test level
0.3 ug Cu/g soil

Dryland site

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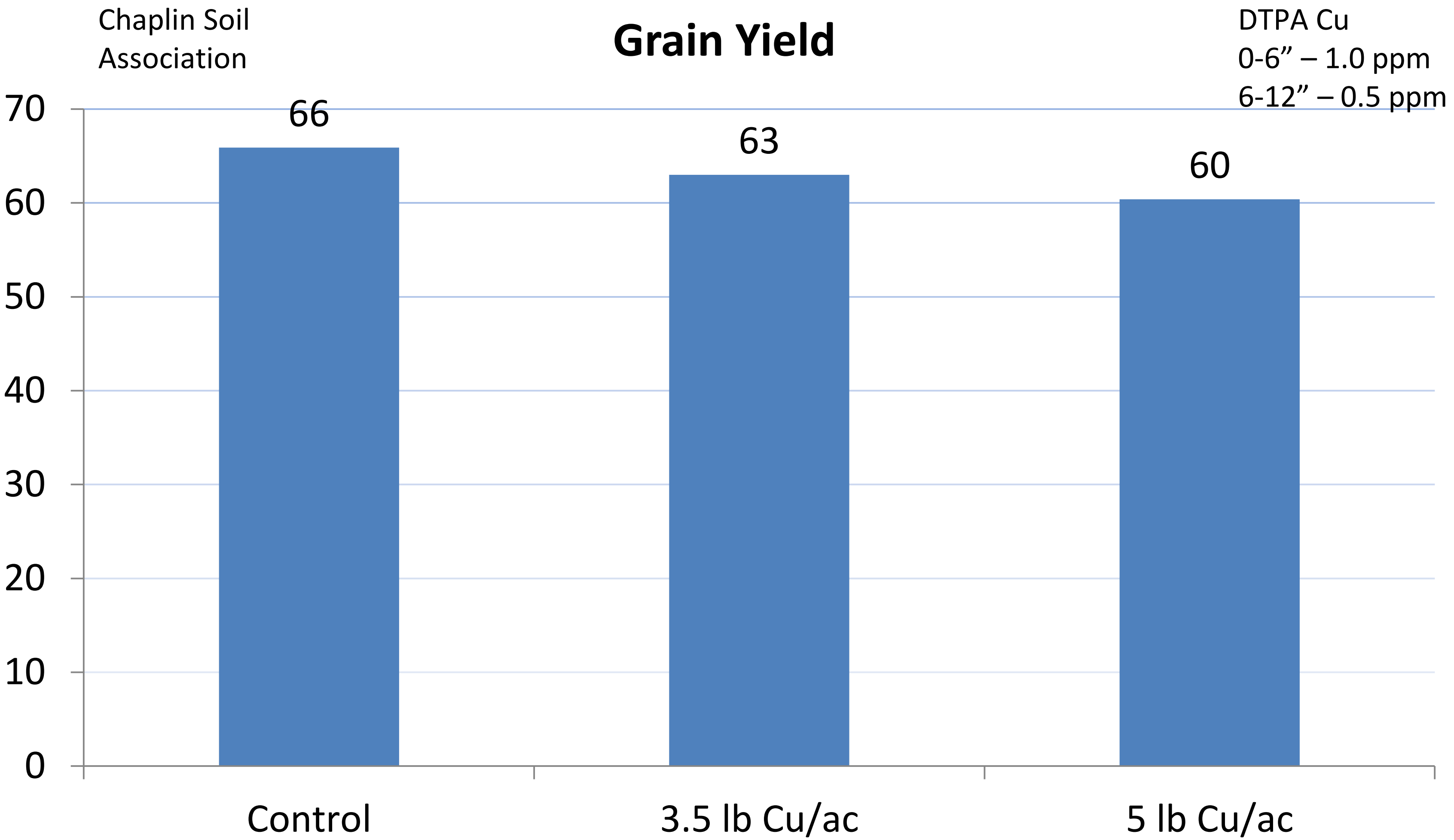
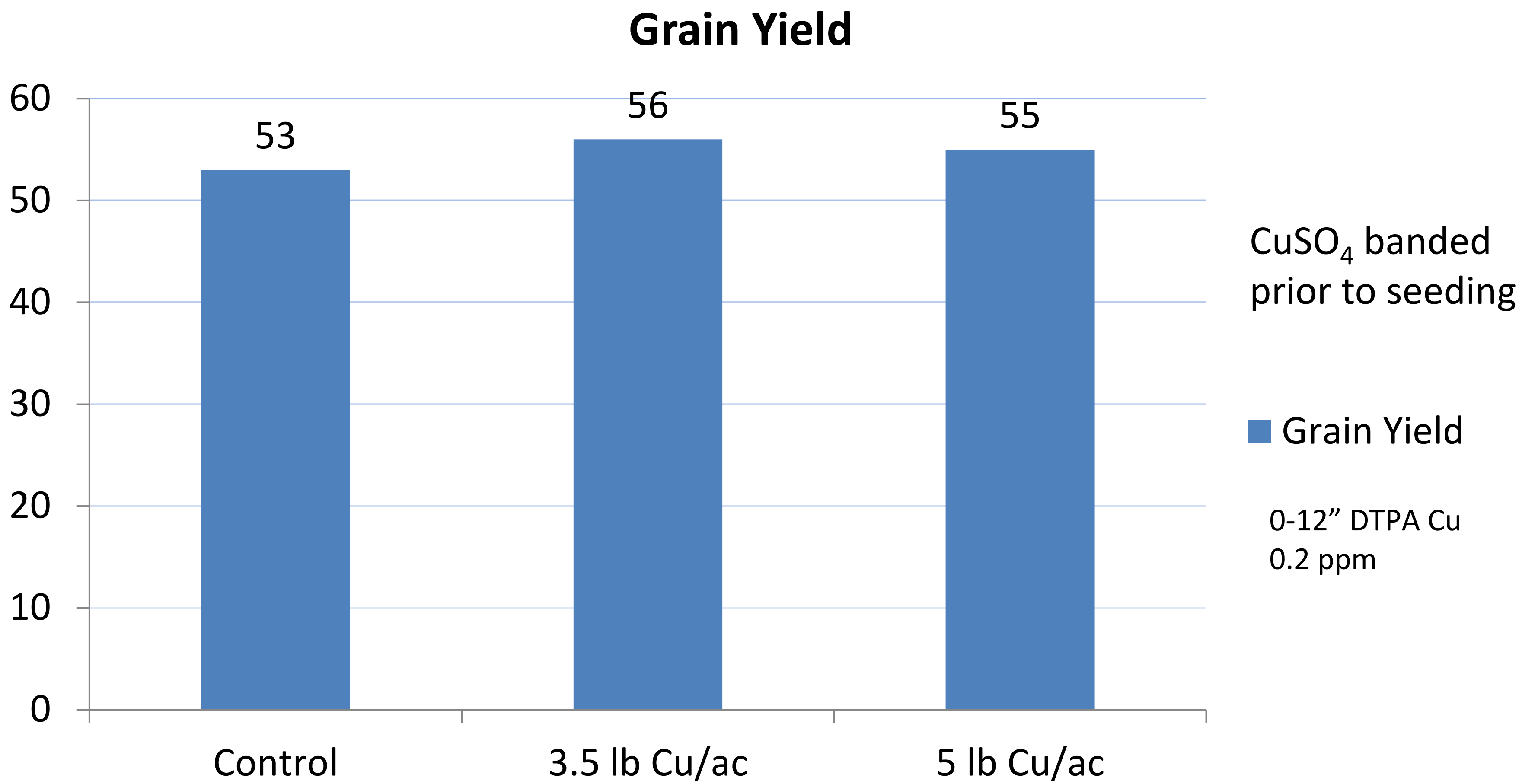
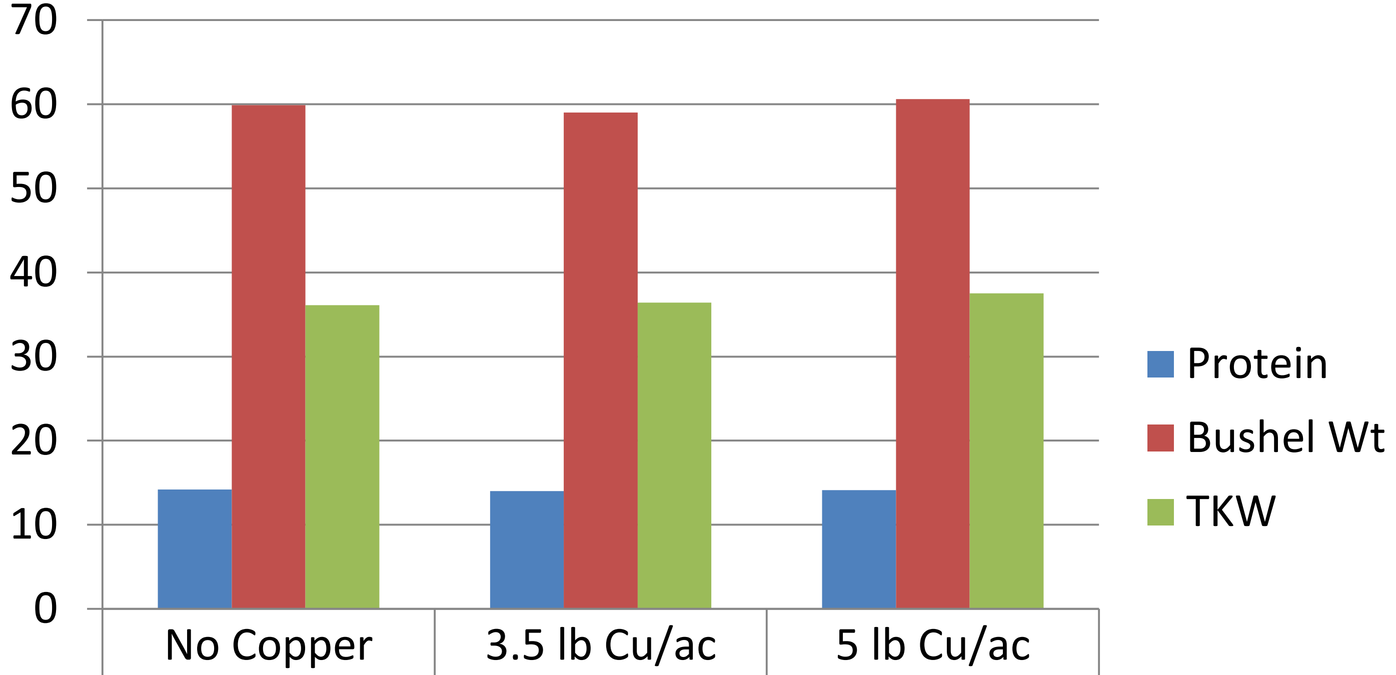
Spring Wheat Riverhurst 2014



Riverhurst 2015
CPS Wheat Yield



CPS Wheat
SW27-24-5-W3 2015



	No Copper	3.5 lb Cu/ac	5 lb Cu/ac
Protein	14.2	14	14.1
Bushel Wt	59.9	59	60.6
TKW	36.1	36.4	37.5

Application of 3.5 lb Cu/ac

Other Supplies of Copper

- Beans – bacterial blight
  - Parasol 50% Cu – 2 applications@ 1.3 kg/ac = 2.86 lb Cu/ac
- Potatoes – early and late blight
  - Two foliar applications of CuEDTA = 0.4 lb Cu plus

  Two lb Cu on soil to control late blight = 2.4 lb Cu/ac
- Copper fertilizer for wheat – 3.5 lb Cu/ac
- Grow dry bean or potato on suspect Cu deficient land and spray for disease

Copper and Zinc Fertilization of Alfalfa

- Granular $CuSO_4$ at 5 lb Cu and $ZnSO_4$ at 4 lb Zn broadcast on soil surface in mid April, 2015
- NH_4SO_4 broadcast at 20 lb S/ac in mid April, 2015
- Soil test level – DTPA Cu = 0.1 ppm Cu

Applying Micronutrients

Copper and Zinc Fertilization of Alfalfa

Treatment	1st cut (ton/ac)	2nd cut (ton/ac)	3rd cut (ton/ac)	2015 Forage Yield (ton/ac)
Check	3.17	1.90	0.61	5.68
Cu	3.03	1.80	0.60	5.43
Zn	2.92	1.96	0.60	5.48
CuZn	2.91	1.84	0.62	5.36

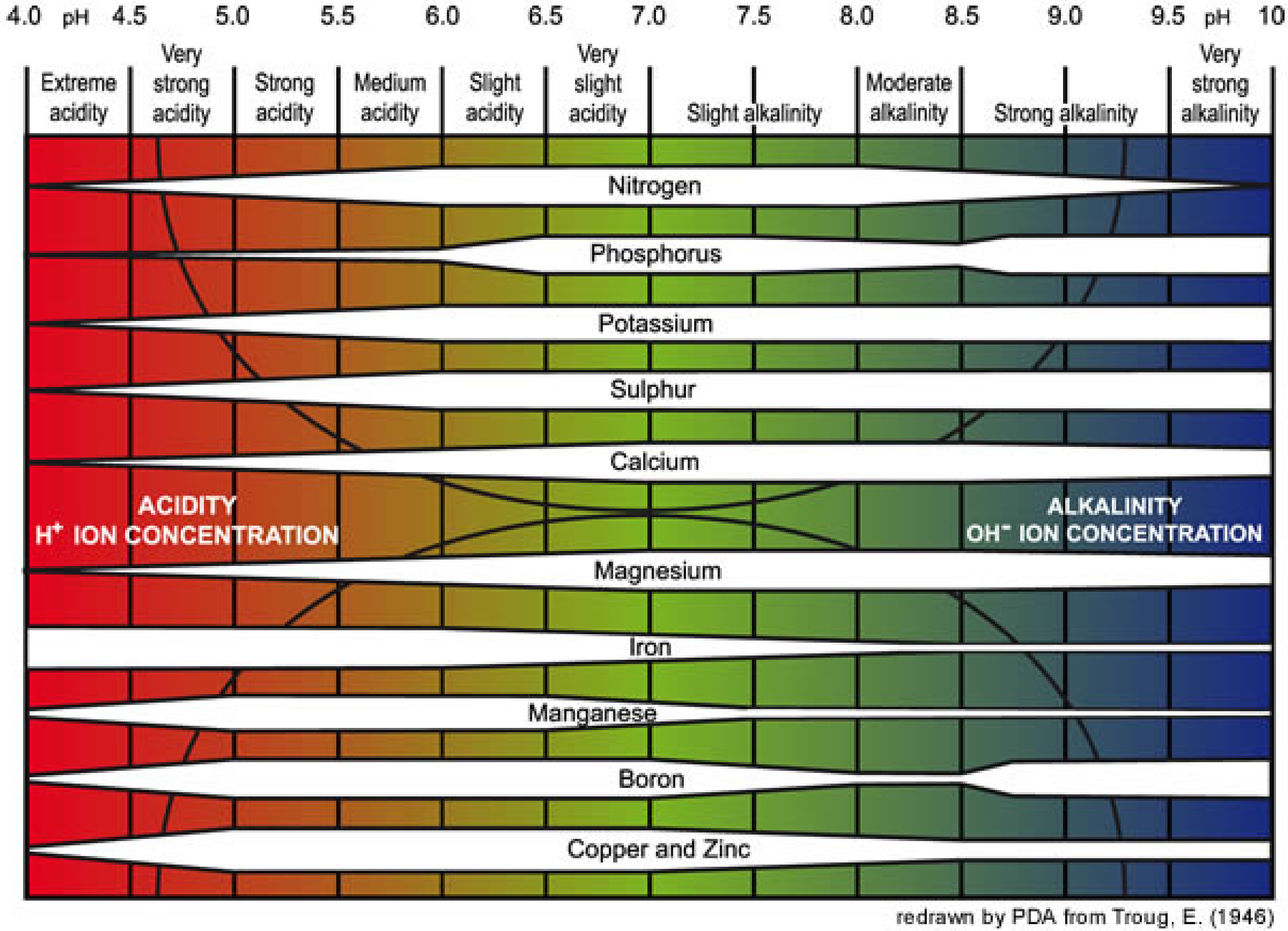
Conclusions of Forage Project

- Yield impact in 1st year negative at best
- Minimal improvement in Cu and Zn concentrations in alfalfa forage in first year
- Trend for improved crude protein, and lower ADF and NDF.
- MILK 2006 model predicted increased milk production of 1500 lb raw milk/dairy cow/year
- Predicted value of milk - $500/dairy cow/year
- Minimal benefit for beef cow producer – increased nourishment for calf ?

Cropping Effects on Soil Properties

- Reduced tillage – leads to improved O.M.
- N fertilizer promotes lower pH in surface soil
- Greatest impact of soil pH effects on micronutrient supply
- Tillage/erosion/land leveling brings carbonates to surface layer

pH Effect on Micronutrient Availability



Micronutrients Supplied by Irrigation

- Very low level of dissolved micronutrients in LDDA irrigation water
  - Exceptions – S – 4-5 lb S /ac inch

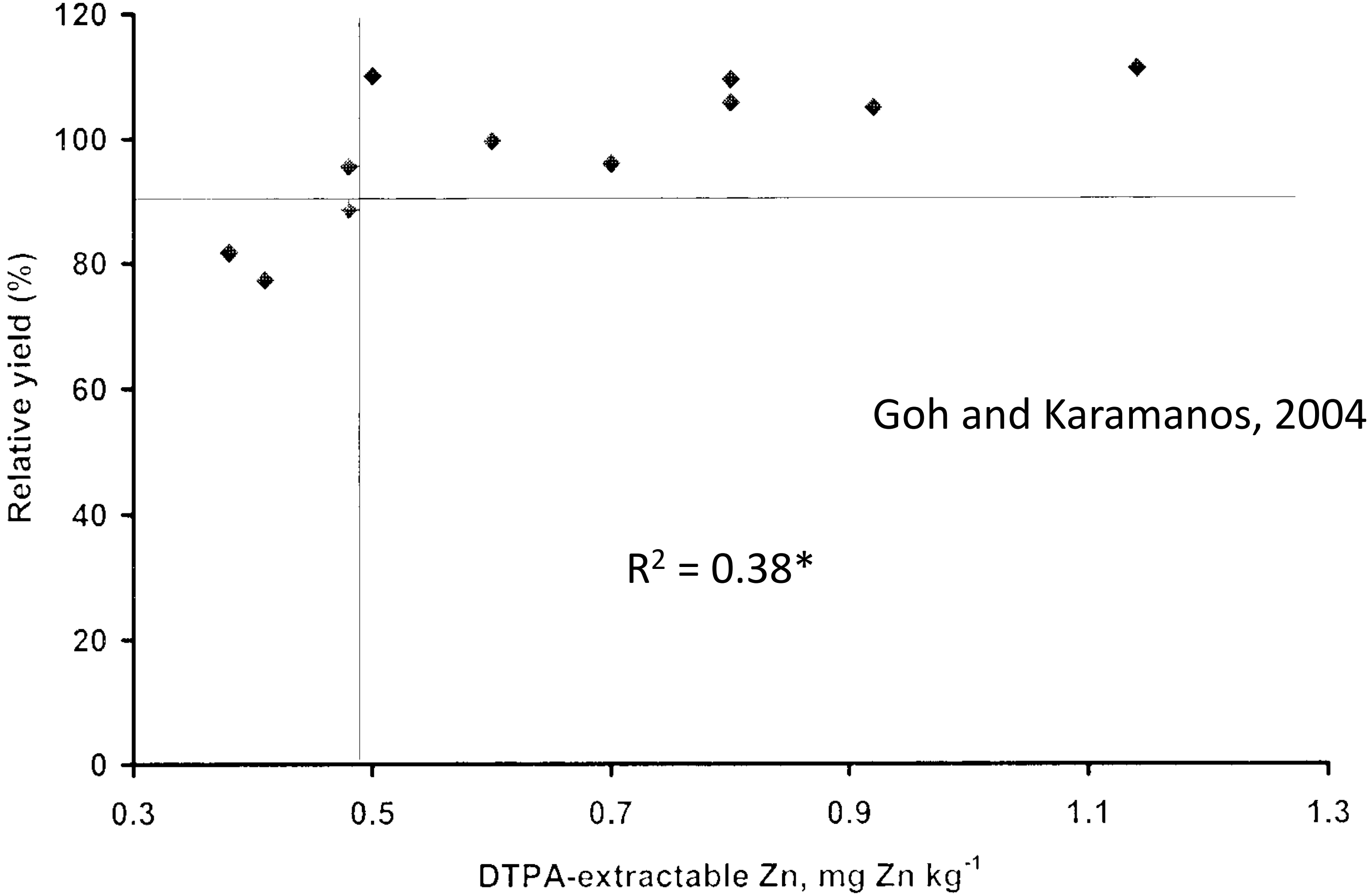
    B – 0.005 lb B /ac inch

    N – 0.03 lb NO_3/ac inch

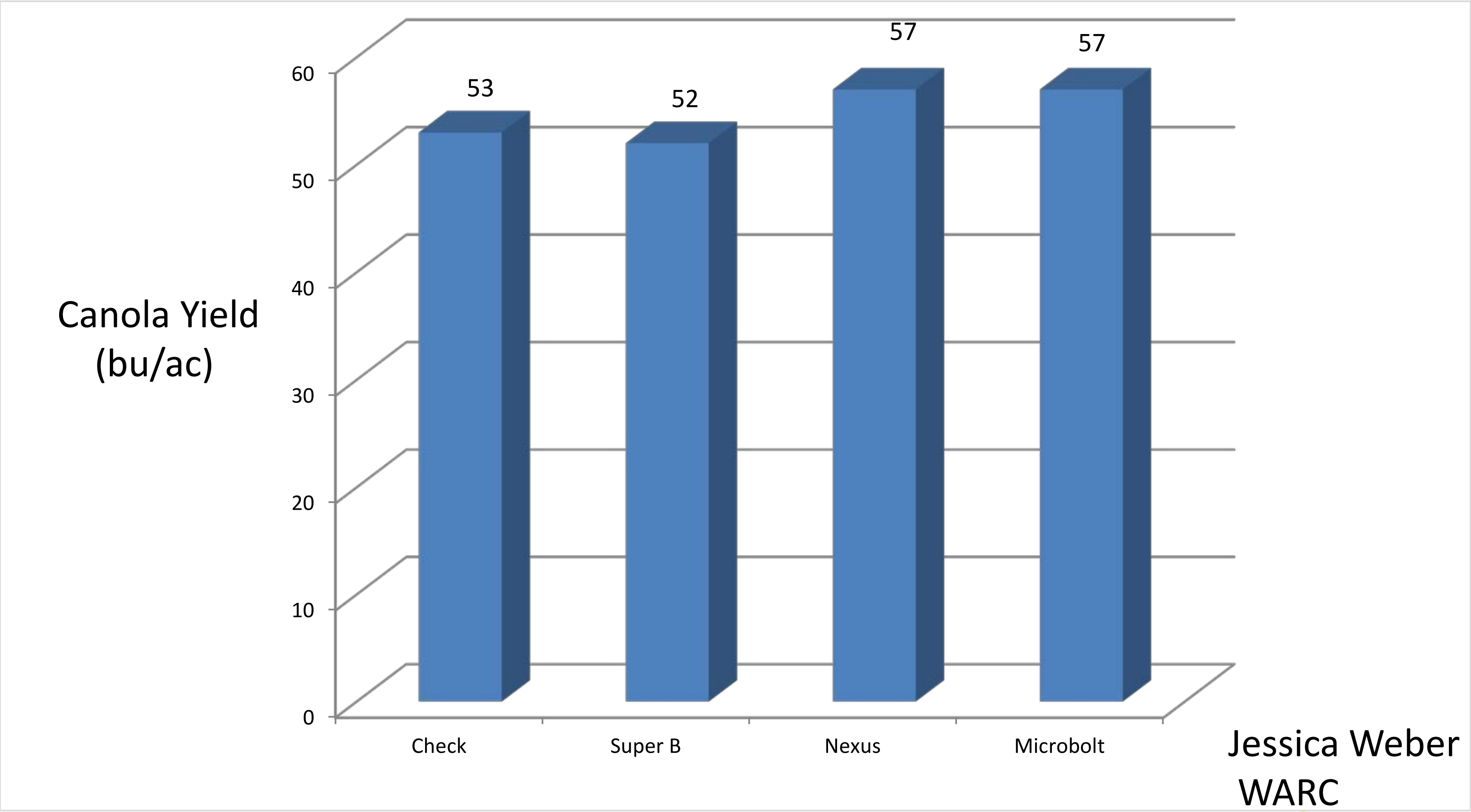
Response of Dry Bean to Fertilizer Application in Southern Alberta (McKenzie et al., 2001)

- No significant yield response to $ZnSO_4$
  - Only one of 9 sites showed a trend towards yield response had DTPA-Zn below 1.0 ppm Zn (P=0.11)
- Zn recommended to reduce risk of early frost crop losses

Response of Beans to Zinc Application



Application of Foliar B to Canola at Early Flowering at WARC (2015)



Jessica Weber
WARC

Foliar Boron on Canola At Early Flowering (Irrigated Sites)

Joel Peru, ICDC, 2015

Hiebert, Riverhurst, SK   LDDA

Treatment	Yield (bu/acre)
Control	65.3
0.11 lb B/ac	66.5
0.23 lb B/acre	64.5

Ellert, Lisieux, SK Fife Lake

Treatment	Yield (bu/acre)
Control	62.6
0.11 lb B/ac	57.5
0.23 lb B/acre	64.9

Staging of canola for B application

http://www.canolawatch.org/2014/06/11/nutrient-essentials-boron/

Micronutrient Testing

- Soil analysis – Karamanos – no yield response among 40 dryland sites testing less than 0.15 ppm hot water soluble B
- B soil test not very helpful
- Boron in irrigation water – 0.005 lb dissolved B per ac-in South Sask. River water

Response of Canola to Foliar B (Karamanos et al., 2002)

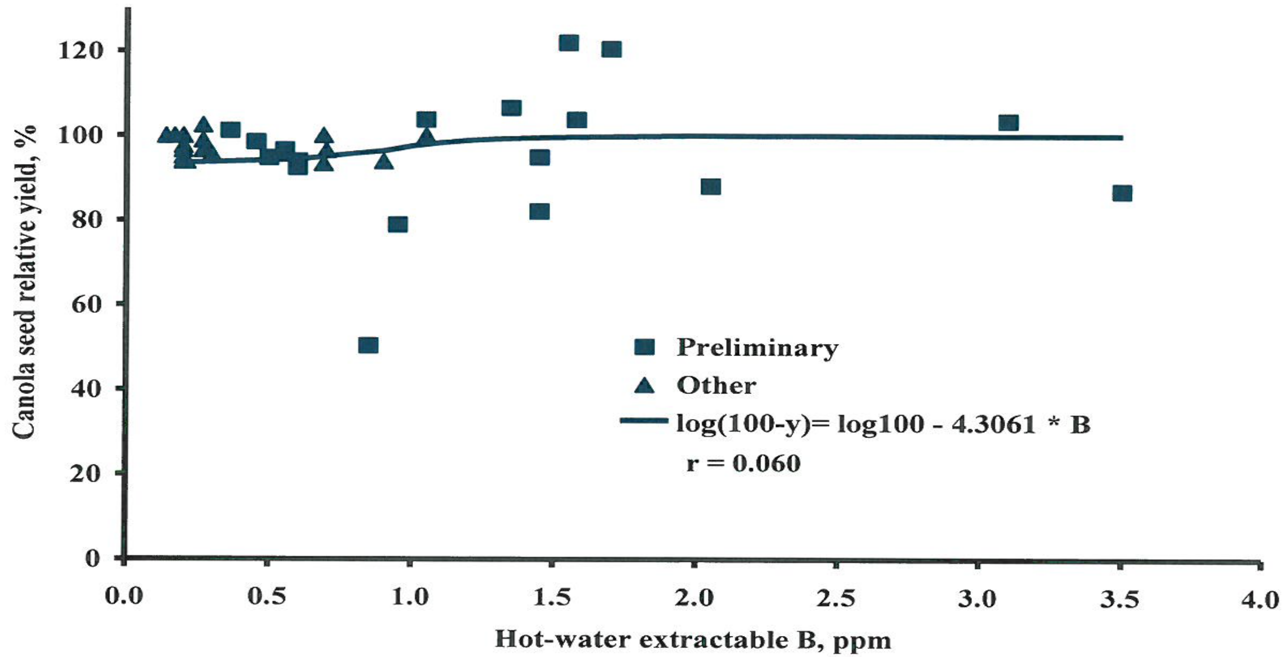


Figure 3. Relative yield of canola (*Brassica napus*) in relation to hot water extractable B levels in the 0-6 inch depth of eighteen sites from the preliminary survey-type research and nineteen research sites carried out across western Canada.

Conclusions on Foliar B for Canola

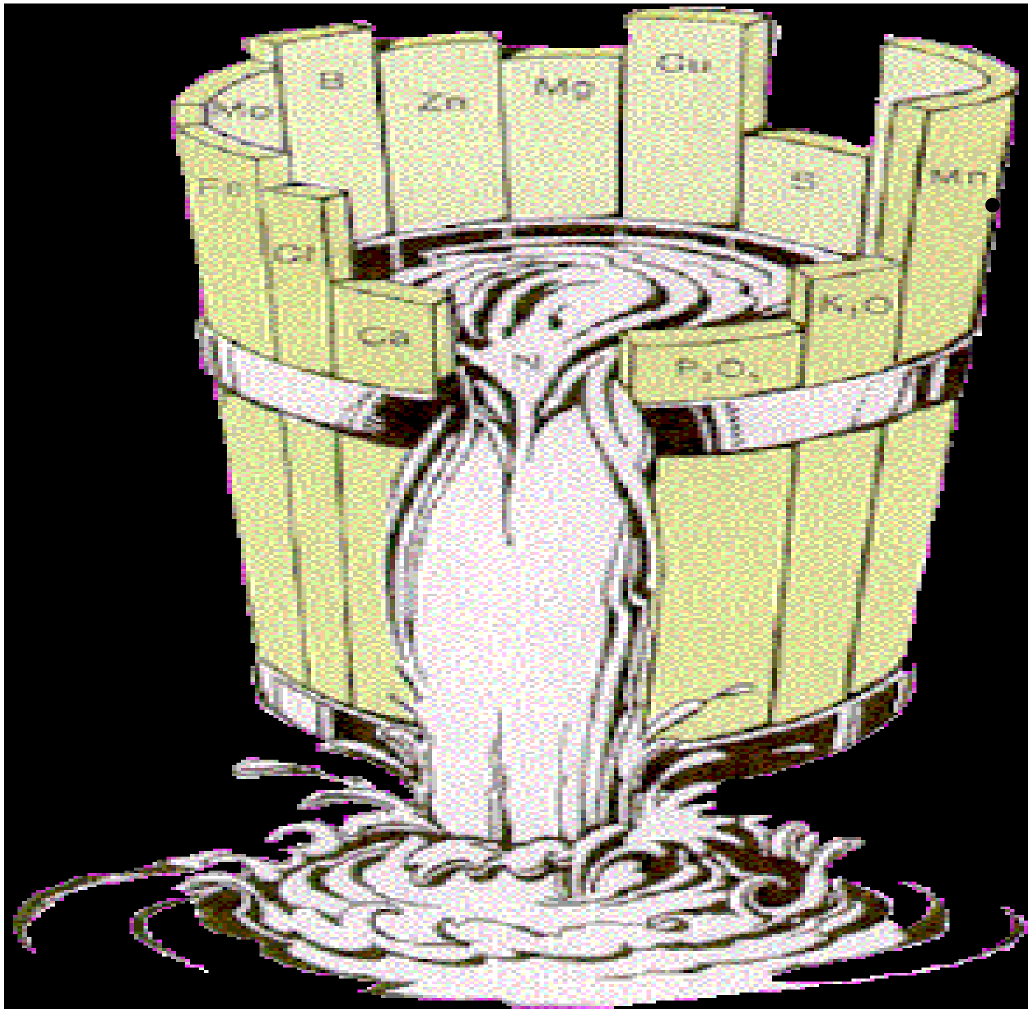
- Best chance for improved yield when canola is under stress from heat
- Heat causes blasting of flowers but boron promotes canola's tolerance to stress
- B supply from mineralization of organic matter - dry spring limited B mineralization in spring 2015
- Tissue B – 30 ppm adequate
- Canola grown under irrigation less likely to experience stress than dryland canola
- Irrigated canola receives B from irrigation water
- Canola Council suggests only 3% average yield response for dryland canola

Manganese Deficiency in Alfalfa near Leader

Highly leached high pH light textured soil on flood plain of South SK River

Potassium deficiency ?

Liebig's Law of the Minimum



- The yield potential of a crop is like a barrel with staves (nutrients) of unequal length. The capacity of the barrel is limited by the length of the shortest stave and can only be increased by lengthening that stave. When that stave is lengthened, another stave becomes the limiting factor.

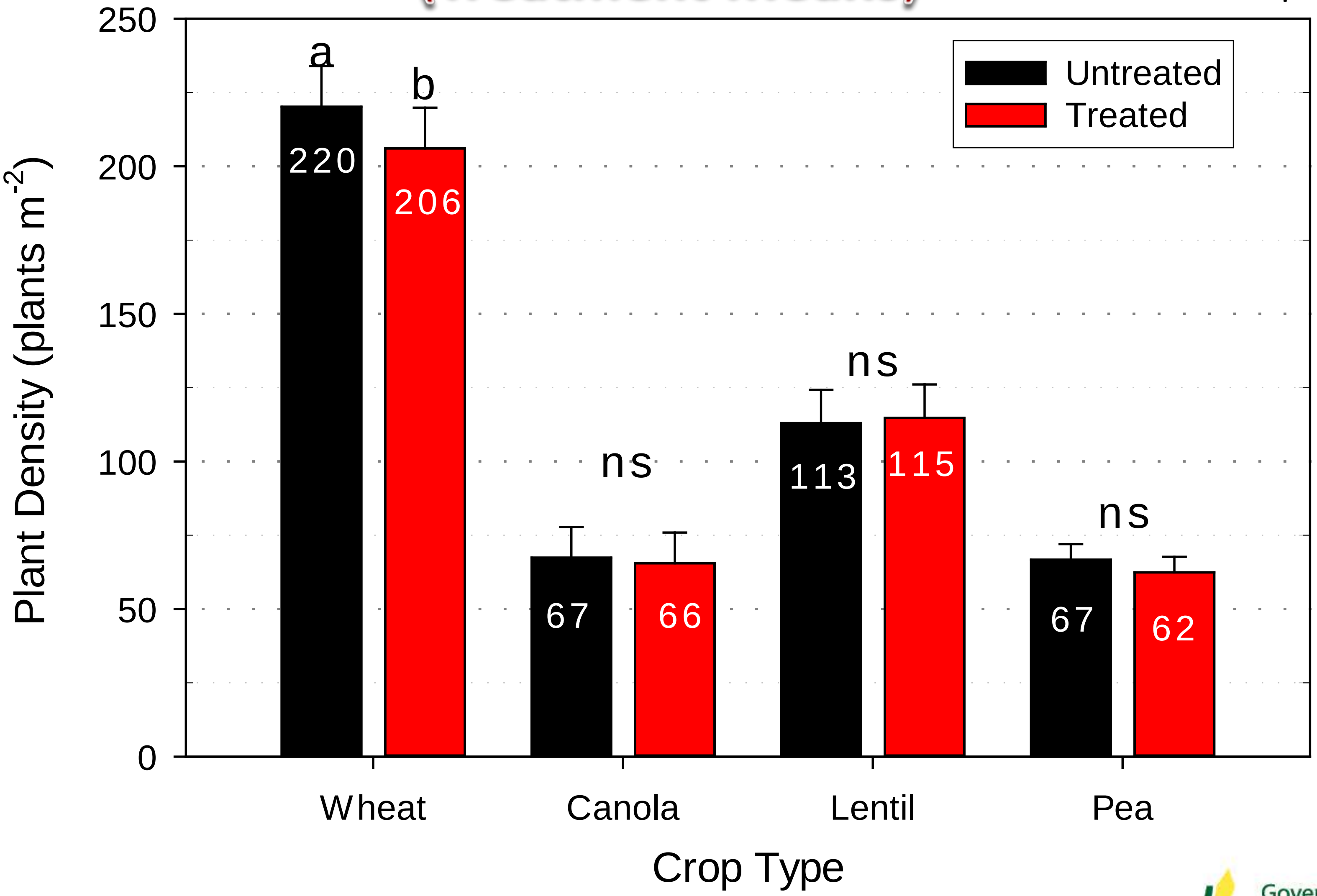
2012 IHARF Yield Buster

- Objective – To demonstrate effects of commercially available seed-applied micronutrient fertilizer products and granular $ZnSO_4$ application on spring wheat emergence, development, growth and grain yield.

Plant Density: All locations and Years

(Treatment Means)

Source: Chris Holtzapel, IHARF



Yield: All locations and Years

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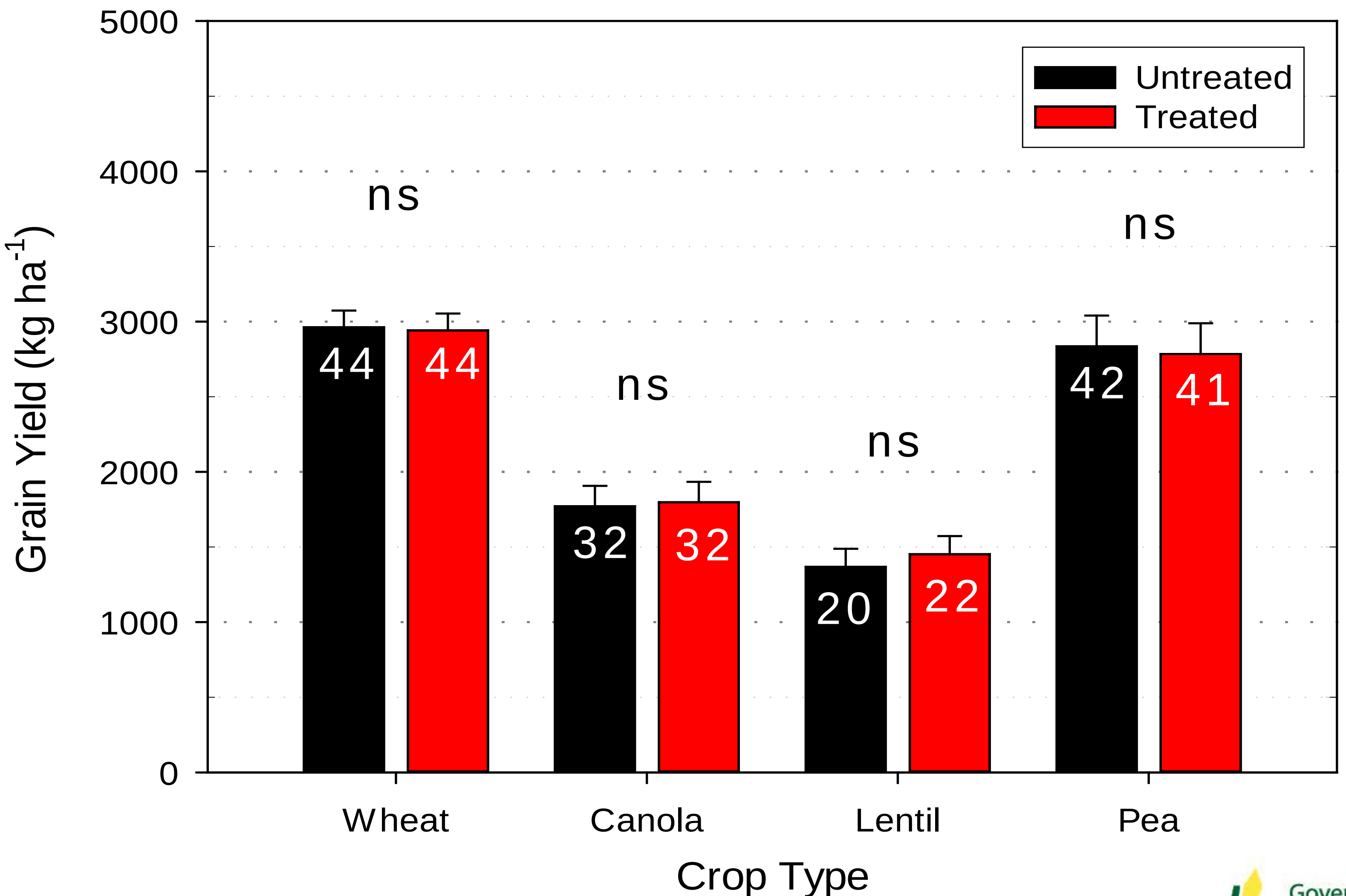
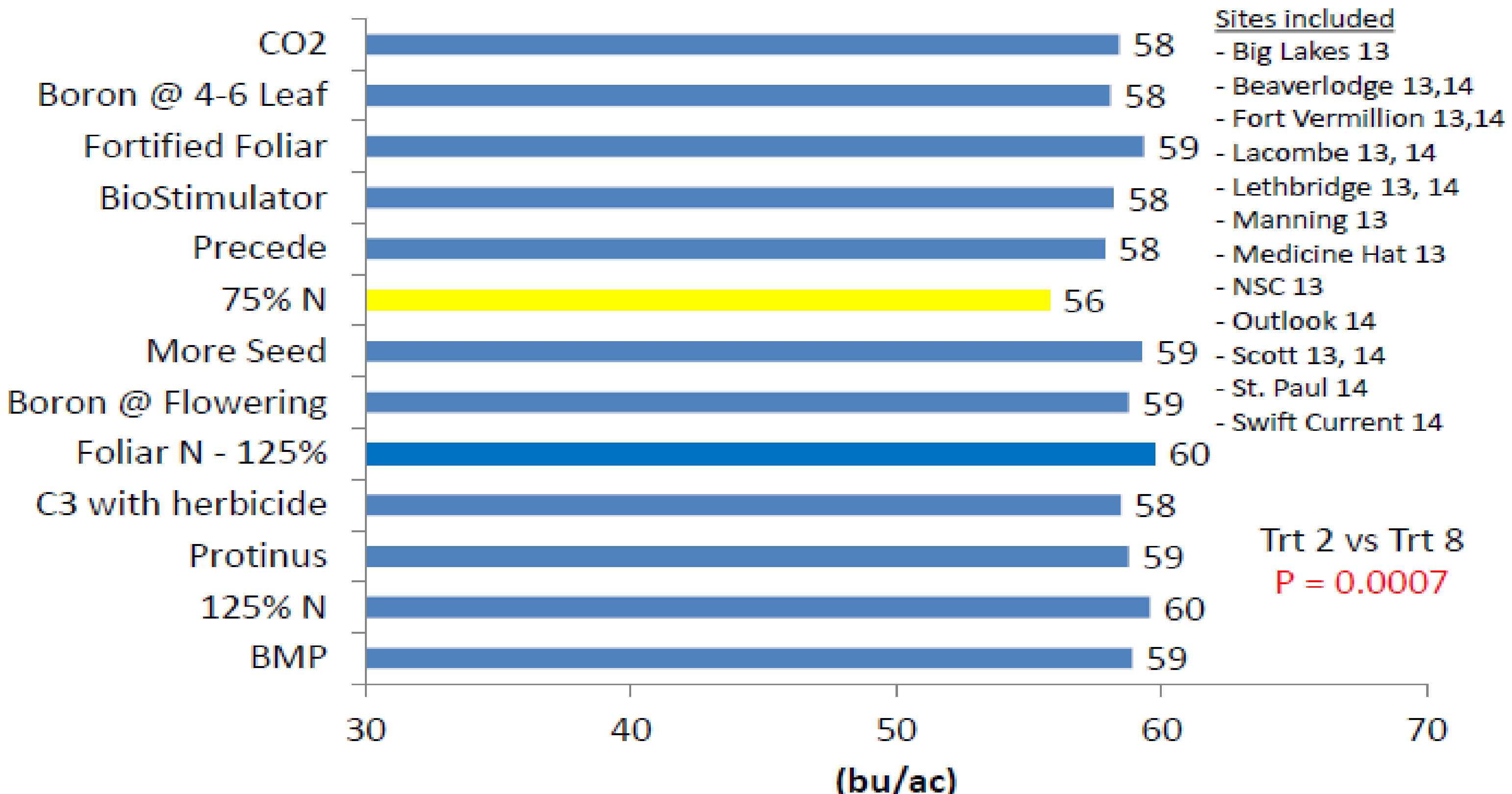


Canola Council Ultimate Canola Challenge

All Sites -2013 + 14 (17 locs) - Yield (bu/ac)



http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/crop15187/$FILE/keith-gabert-ultimate-canola-challenge-2015.pdf

Conclusion

- Potential for responses to copper, zinc, and boron on deficient soils
- Use soil and plant tissue analysis as well knowledge of potentially deficient soils
- Recognize importance of pH in micronutrient fertility

Acknowledgements

- ADOPT, Irrigation Crop Diversification Corp
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- Crop Production Services
- Agrium
- The Rak
- Dave Christensen
- Doug Waterer


Photo credit: Jeff Ewen
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Geochemistry of Boron

- Only non-metal among micronutrients
- Present in rocks and minerals formed at late stages of magmatic crystallization
- Insignificant in terrestrial and freshwater clays
- Boron present in higher amounts in marine sediments

Geochemistry of Copper

- Due to high electronegativity, copper is found mainly in sulphide minerals
- Strongly adsorbed to mineral surfaces
- Adsorption increases at higher pH

Geochemistry of Iron

- Iron content of upper lithosphere about 5%
- Present as a) free metallic iron
  - b) primary oxides and sulphide minerals
  - c) primary silicate minerals
  - During weathering, Fe released retained as free oxides or in clay minerals substituting for Al
  - Oxidizing (alkaline) environment – precipitation of Fe^{+3}
  - Reducing (acid) environment – solution as Fe^{+2}

Geochemistry of Zinc

- Zn^{+2} substitutes for Mg^{+2} and Fe^{+2}in silicate minerals
- Zn more abundant in basic and intermediate rocks than acidic rocks
- Great tendency to associate with sulphides
- Among sedimentary rocks, highest concentration found in shales
- Common in hydrothermal deposits
- Weathering yields soluble Zn^{+2} which is stable and dominant to pH 9
- In soil, adsorption to clay minerals, hydrous oxides and organic matter control Zn in solution

Geochemistry of Manganese

- Many oxidation states … BUT
  - Mn^{+2} common for igneous rocks and Mn^{+4} common for sedimentary rocks
  - In natural environs, lower oxidation state has greatest mobility, while higher oxidation state connected with fixation
  - Mn^{+2} has much larger ionic radius

Geochemistry of Molybdenum

- Concentration of Mo in soil water greater in alkaline than in acid environments