Response of Lentil to Zinc Fertilization at Two Sites in Saskatchewan

S. Anderson, J. Schoenau, M. Maqsood, and A. Vandenberg
Zinc

• Essential trace element
  • Vital for enzyme function
  • Growth and development

• Human zinc deficiencies affect over 30% of the world population

Fig 1. Effect of foliar applied zinc on growth of barley plants in Central Anatolia (Cakmak, 2009)
Fig 2. Regions of crop zinc deficiency as reported in international literature (Alloway, 2008)
Lentil

• Canada is world leader in lentil exports
• Economically important crop for Saskatchewan
• Increasing global lentil consumption
• Inherently low source of bioavailable Zn
Research Objectives

• Investigate lentil cultivar response to zinc fertilization, particularly in terms of an increase in yield and grain zinc concentration
• Determine what zinc fertilization rates, lentil genotypes, soil characteristics, and forms of zinc will result in the greatest response
Rate

Form

Red

Small Green

Large Green

CDC Maxim

CDC Invincible

CDC Impower

March 11, 2014
Effects of soil applied zinc sulphate on lentil yield and grain zinc content under field conditions
Field Site Selection

Canadian Pulse Growing Regions

- **Brown Soil Zone**
- **Dark Brown Soil Zone**
- **Black Soil Zone**
- **Grey Soil Zone**

- **Bean**
- **Chickpea**
- **Lentil**
- **Pea**

Image credit: Encyclopedia of Saskatchewan, 2006

Image credit: Pulse Canada, 2014
## Soil Characteristics

Table 1. Summary of baseline soil properties from Central Butte and Saskatoon field site locations (May, 2013).

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>pH</th>
<th>EC (dSm⁻¹)</th>
<th>OC (%)</th>
<th>N (kg ha⁻¹)</th>
<th>P</th>
<th>K (kg ha⁻¹)</th>
<th>S</th>
<th>Zn (kg ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-15</td>
<td>8.0</td>
<td>0.23</td>
<td>1.4</td>
<td>8.4</td>
<td>17.7</td>
<td>535.0</td>
<td>14.8</td>
<td>0.93</td>
</tr>
<tr>
<td>15-30</td>
<td>8.1</td>
<td>0.26</td>
<td>-</td>
<td>8.5</td>
<td>-</td>
<td>-</td>
<td>16.9</td>
<td>0.54</td>
</tr>
<tr>
<td>30-60</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>10.4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>0-15</td>
<td>7.1</td>
<td>0.26</td>
<td>2.6</td>
<td>11.0</td>
<td>38.4</td>
<td>504.2</td>
<td>13.1</td>
<td>3.7</td>
</tr>
<tr>
<td>15-30</td>
<td>7.2</td>
<td>0.13</td>
<td>-</td>
<td>10.0</td>
<td>-</td>
<td>-</td>
<td>9.7</td>
<td>2.2</td>
</tr>
<tr>
<td>30-60</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>17.9</td>
<td>-</td>
<td>-</td>
<td>29.8</td>
<td>-</td>
</tr>
</tbody>
</table>
Experimental Set-Up

Main Plot: Fertilizer Rate
- 0 kg Zn ha\(^{-1}\)
- 2.5 kg Zn ha\(^{-1}\)
- 5 kg Zn ha\(^{-1}\)

Sub-Plot: Lentil Cultivar
- CDC Maxim
- CDC Imvincible
- CDC Impower
Results- Yield

Table 2. Effect of three rates of ZnSO$_4$ on grain and straw yield (kg ha$^{-1}$) of three lentil cultivars

<table>
<thead>
<tr>
<th>Site</th>
<th>Yield $^+$</th>
<th>Zn Rate</th>
<th>SEM$^\ddagger$</th>
<th>P values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(kg ha$^{-1}$)</td>
<td>Rate (R)</td>
<td>Cultivar (C)</td>
<td>R*C Interaction</td>
</tr>
<tr>
<td>Central Butte</td>
<td>Grain</td>
<td>2919a</td>
<td>2880a</td>
<td>2917a</td>
</tr>
<tr>
<td></td>
<td>Straw</td>
<td>2597a</td>
<td>2502a</td>
<td>2508a</td>
</tr>
</tbody>
</table>

$^+$ Means with the same letter in the same row are not significantly different (P>0.05) as determined by multi-treatment comparisons using the Tukey-Kramer method.

$^\ddagger$ SEM= standard error of mean

March 11, 2014
Effects of zinc fertilizer amendments on yield and grain zinc content under controlled conditions
Soil Preparation and Planting

• Base Macronutrient Application

• Control Treatment

• Soil Zinc Treatments
  • ZnSO₄
  • 9% Zn chelated with EDTA

• Foliar Zinc Treatments
  • 9% Zn chelated with EDTA
  • 7% Zn Lignosulphonate
Foliar Fertilization

- 8th-9th node stage
- 6 sprays = 1 ml pot⁻¹ = 500 L ha⁻¹
Fig. 4. Yield (g) of grain (left) and straw (right) of three lentil cultivars grown in a pot study under controlled conditions. For a given plant component (grain or straw), variety, and form, means with the same letters are not significantly different (P > 0.05) as determined by multi-treatment comparisons using Tukey-Kramer method.
Fig. 5. Zinc concentration (mg Zn kg⁻¹) of grain (solid bars) and straw (striped bars) of five fertilizer treatments. For a given plant component (grain or straw), means with the same letters are not significantly different (Tukey-Kramer, P > 0.05).
Fig. 6. Comparison of Zn fertilizer treatment effects on residual DTPA extractable soil Zn (mg Zn kg⁻¹) against total Zn removal (g Zn pot⁻¹) partitioned into uptake by grain (solid bars) and uptake by straw (striped bars). For a given measurement, means with the same letter are not significantly different (P>0.05). Error bars are standard error of the mean.
### Results- Zinc Removal

Table 2. Zn removal (µg Zn pot⁻¹) in three different lentil cultivars grown under controlled conditions and amended with five different Zn fertilizer treatments.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Zn Removal (µg Zn pot⁻¹) †</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Straw</td>
<td>Grain</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>CDC Maxim</td>
<td>58.7b</td>
<td>54.2a</td>
<td>112.9b</td>
<td></td>
</tr>
<tr>
<td>CDC Invincible</td>
<td>58.1b</td>
<td>50.1a</td>
<td>108.2b</td>
<td></td>
</tr>
<tr>
<td>CDC Impower</td>
<td>89.9a</td>
<td>49.6a</td>
<td>139.4a</td>
<td></td>
</tr>
<tr>
<td>SEM‡</td>
<td>2.92</td>
<td>3.00</td>
<td>4.54</td>
<td></td>
</tr>
<tr>
<td>P-value</td>
<td>&lt;.0001</td>
<td>0.494</td>
<td>&lt;.0001</td>
<td></td>
</tr>
</tbody>
</table>

† Means with the same letter in the same column are not significantly different (P>0.05) as determined by multi-treatment comparisons using the Tukey-Kramer method.
‡ SEM= standard error of mean
Conclusions

• Soil applied ZnSO₄ did not improve yield or grain zinc content
• Yield differences between cultivars, but not in response to zinc
• No significant differences between soil and foliar forms of zinc
• Total zinc removal does not differ significantly between zinc forms
  • Under controlled conditions, CDC Impower removes more zinc than CDC Maxim and CDC Imvincible
• Residual soil extractable zinc is significantly greater when ZnSO₄ is applied compared to other forms
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Questions?