Options for Application of Copper Products on Wheat in Manitoba

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Introduction

Yield responses to Cu are very much influenced by both product and method of placement. Earlier work (Karamanos et al. 1985; Penney et al. 1993) had established broadcast and incorporation as the most efficient and in most cases the only effective method of applying Cu to soils. Broadcast and incorporated recommended rates of Cu primarily as CuSO4.5H2O or Cu-oxysulphate ranged between 3 and 5 lb Cu/acre. The high cost of Cu products, however, has been prohibiting to broadcasting them at the minimum recommended rate of 3 lb Cu/acre, especially on soils that are perceived to be marginal in micronutrient levels. Application of copper at lower rates that those recommended would only lead to inefficient physical distribution of the product, minimization of the chances for a response and waste of money. Consequently, the practice of placing smaller and more economic amounts with the seed was adopted as an alternative. However, very little research has been carried out in support of this practice. The need for granular products, so that blending of small amounts can be effective, further complicated the practice.

A thorough examination of the choice and availability of micronutrient products in western Canada in general and in Manitoba in particular has been provided by Nutting (2000). Mineral soils in Manitoba are generally considered as containing sufficient levels of Cu except possibly the Almassippi loamy fine sands and Gilbert sandy loams.

The objectives of this project were to assess:

1. Method of placement and rate of application of granular copper products;
2. Effectiveness of side-banded liquid (EDTA) Cu;
3. Effectiveness and best time of application of two types of foliar products.

Materials and Methods

Four experiments, each containing two trials, were carried out in 2001 at Elm Creek and Miami, Manitoba and were repeated on the same plots in 2002. The soil characteristics of the experimental sites are shown in Table 1. Available Cu levels in the 0-15 cm depth ranged between 0.09 and 0.14 and 0.21 and 0.31 and averaged 0.12 and 0.24 mg DTPA-Cu kg⁻¹ (ppm) at Elm Creek and Miami, respectively (Table 2).

Effect of Side-Banded Liquid (Cu-ETDA) Copper on the Wheat Yield. A split-plot design with six replicates was employed both at the Elm Creek and Miami sites. The main plots consisted of two rates of broadcast and incorporated (Pestell) CuSO4.5H2O (0 and 5 lb Cu/acre). Four rates (0, 0.25, 0.5 and 1 lb Cu/acre) of Tiger 7.5% Cu-EDTA that were side-banded approximately 1 inch away from the seed were superimposed on the broadcast and incorporated rates. The trials were established in 2001 and all the side-banded treatments were repeated in 2002, thus comparing annual applications of side-banded Cu-EDTA to a one-time application of CuSO4.5H2O.

Assessment of Granular Products for Broadcast & Incorporation of Copper. A randomized complete block design with six replicates that included a control treatment and four products (CuSO4.5H2O, Ruff’n
Tuff Cu-EDTA, Nexus frits with measured Cu solubility of 12% and Agrium 65 oxysulphate with measure Cu solubility of 80%) applied at 5 lb Cu/acre were established in 2001 both at Elm Creek and Miami. Only residual effects were assessed in 2002.

Table 1. Soil characteristics of the experimental sites.

<table>
<thead>
<tr>
<th>Location</th>
<th>Experiment</th>
<th>pH</th>
<th>OM (%)</th>
<th>N</th>
<th>P (mg kg(^{-1}) or ppm)</th>
<th>K</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elm Creek</td>
<td>Liquid (SB)</td>
<td>6.8</td>
<td>2.0</td>
<td>5.2</td>
<td>21.2</td>
<td>108.8</td>
<td>18.3</td>
</tr>
<tr>
<td></td>
<td>Placement &amp; rates</td>
<td>7.8</td>
<td>1.8</td>
<td>2.5</td>
<td>27.8</td>
<td>101.8</td>
<td>9.7</td>
</tr>
<tr>
<td></td>
<td>Products (BI)</td>
<td>7.3</td>
<td>1.8</td>
<td>2.9</td>
<td>23.2</td>
<td>107.8</td>
<td>8.5</td>
</tr>
<tr>
<td></td>
<td>Products (SR)</td>
<td>6.4</td>
<td>1.8</td>
<td>2.8</td>
<td>22.8</td>
<td>107.8</td>
<td>9.7</td>
</tr>
<tr>
<td></td>
<td>Foliar</td>
<td>7.2</td>
<td>1.4</td>
<td>5.3</td>
<td>23.8</td>
<td>118.8</td>
<td>26.0</td>
</tr>
<tr>
<td>Miami</td>
<td>Liquid (SB)</td>
<td>7.0</td>
<td>2.0</td>
<td>5.8</td>
<td>22.8</td>
<td>179.2</td>
<td>6.8</td>
</tr>
<tr>
<td></td>
<td>Placement &amp; rates</td>
<td>7.8</td>
<td>2.4</td>
<td>6.1</td>
<td>13.3</td>
<td>178.0</td>
<td>12.0</td>
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<tr>
<td></td>
<td>Products (BI)</td>
<td>7.9</td>
<td>2.3</td>
<td>6.5</td>
<td>12.3</td>
<td>132.2</td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td>Products (SR)</td>
<td>7.6</td>
<td>2.3</td>
<td>6.9</td>
<td>14.7</td>
<td>129.3</td>
<td>10.8</td>
</tr>
<tr>
<td></td>
<td>Foliar</td>
<td>7.6</td>
<td>2.3</td>
<td>7.3</td>
<td>14.8</td>
<td>143.8</td>
<td>7.2</td>
</tr>
</tbody>
</table>

Table 2. DTPA-extractable Cu levels at the two sites for the original site sample and subsequent detailed sampling of each site.

<table>
<thead>
<tr>
<th>Location</th>
<th>Sampling</th>
<th>Foliar Cu Mean (mg kg(^{-1}) or ppm)</th>
<th>Seed-placed granular Cu Mean (mg kg(^{-1}) or ppm)</th>
<th>B &amp; I Cu Mean (mg kg(^{-1}) or ppm)</th>
<th>Seed-placed liquid Cu Mean (mg kg(^{-1}) or ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miami</td>
<td>Original Site</td>
<td>0.15±0.02</td>
<td>0.16±0.02</td>
<td>0.15±0.01</td>
<td>0.17±0.02</td>
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<tr>
<td></td>
<td>Detailed 0-6&quot;</td>
<td>0.24±0.05</td>
<td>0.21±0.04</td>
<td>0.21±0.02</td>
<td>0.31±0.13</td>
</tr>
<tr>
<td></td>
<td>Detailed 6-12&quot;</td>
<td>0.27±0.04</td>
<td>0.21±0.02</td>
<td>0.25±0.03</td>
<td>0.39±0.38</td>
</tr>
<tr>
<td>Elm Creek</td>
<td>Original Site</td>
<td>0.11±0.02</td>
<td>0.11±0.04</td>
<td>0.15±0.03</td>
<td>0.10±0.03</td>
</tr>
<tr>
<td></td>
<td>Detailed 0-6&quot;</td>
<td>0.12±0.02</td>
<td>0.09±0.01</td>
<td>0.12±0.05</td>
<td>0.12±0.06</td>
</tr>
<tr>
<td></td>
<td>Detailed 6-12&quot;</td>
<td>0.12±0.02</td>
<td>0.11±0.02</td>
<td>0.12±0.06</td>
<td>0.12±0.06</td>
</tr>
</tbody>
</table>

Assessment of Granular Products for Seed-Placement of Copper. A trial with a split-plot design with six replicates was established in 2001 both at the Elm Creek and Miami sites. The main plots consisted of two rates of broadcast and incorporated (Pestell) CuSO\(_4\).5H\(_2\)O (0 and 5 lb Cu/acre). Four products (identical to the ones used for broadcast and incorporation experiments) were seed-placed at a rate of 2 lb Cu/acre. Seed-row applications of Cu were repeated in 2002, thus comparing annual application of seed-placed Cu to a one-time broadcast and incorporation of CuSO\(_4\).5H\(_2\)O.

Effectiveness of Two Foliar Copper Products Applied at Various Growth Stages on Wheat Yield. Two products with different chemical composition (one sulphonic acid and one oxychloride based) were utilized in this experiment. A split-plot design with the two products (Tiger Tech 5% and Coptrel 500) as main plots and various growth stages (Feekes 2, 6 2&6 and 10 – tillering, first node visible, both at tillering and first node visible and early booting) as sub-plots were replicated six times. One experiment was established in 2001 at Miami and two in 2002 at both Miami and Elm Creek.

All plots received blanket application of N, P, K S and other micronutrients as required based on soil tests and were harvested using a Wintersteiger Nurserymaster Elite experimental combine and the grain samples were dried at 60 °C by forced air and weighed to determine grain yield.
The results from all tests were subject to ANOVA and regression analysis using SYSTAT 8.0 (SPSS Inc. 1998).

**Results and Discussion**

Responses were much stronger at Elm Creek than Miami and wheat yields were much higher in 2001 compared to 2002.

**Effect of Side-Banded Liquid (Cu-ETDA) Copper on the Wheat Yield.** At Elm Creek application of 5 lb Cu/acre as CuSO$_4$.5H$_2$O in 2001 led to a 20-bu/acre-yield increase from 6.5 bu/acre for the control to 24.6 bu/acre for the 5 lb Cu/acre treatment. However, maximum yield (33.9 bu/acre) resulted from the side-band application of 1 lb Cu-EDTA. Similarly in 2002, residual Cu from the 5 lb Cu/acre treatment provided a yield increase of 11 bu/acre from 0.5 bu/acre for the control to 11.5 bu/acre, but side banding of 1 lb Cu/acre as Cu-EDTA increased the yield to 17.0 bu/acre. Maximum yield of 22.3 bu/acre was obtained with the application of 1 lb Cu/acre as Cu-EDTA on the treatment that had received 5 lb Cu/acre as CuSO$_4$.5H$_2$O. Similar trends were observed at Miami; however, the yields were considerably higher than those at Elm Creek. Hence, in 2001 the control yielded 46.1 bu/acre and the 5 lb CuSO$_4$.5H$_2$O-Cu/acre and 1 lb Cu-EDTA-Cu/acre treatments 52.3 and 58.2, respectively. In 2002, the corresponding yields were, 21, 26.8 and 31.2 bu/acre, respectively. All treatments for both years at both sites were combined in Figure 1.

**Grain yield without CuSO4-Cu = 10.958 + 36.506Cu - 24.539Cu$^2$, r$^2$ = 1**

**Grain yield with 5 lb CuSO4-Cu/ac = 19.44 + 23.069Cu - 16.196Cu$^2$, r$^2$ = 0.9711**

**Grain yield without CuSO4-Cu = 26.41 + 52.639Cu - 33.036Cu$^2$, r$^2$ = 0.9994**

**Grain yield with 5 lb CuSO4-Cu/ac = 38.397 + 21.666Cu - 11.545Cu$^2$, r$^2$ = 0.9994**

![Figure 1. The effect of side banding Cu as liquid Cu-EDTA and broadcast and incorporating 5 lb of granular Cu as CuSO$_4$.5H$_2$O on the yield of wheat.](image)

**Assessment of Granular Products for Broadcast & Incorporation of Copper.** Broadcast and incorporation of 5 lb Cu in different forms resulted in an overall yield increase over the control with three of the four products used. Thus, CuSO$_4$.5H$_2$O, Cu-EDTA and high solubility oxysulphate yielded equally well in both years and at both sites (Figure 2).

**Assessment of Granular Products for Seed-Placement of Copper.** There was a significant (P<0.05) yield increase to the application of 5 lb of CuSO$_4$.5H$_2$O-Cu at Elm Creek in 2001 and at both Elm Creek and Miami in 2002. Only at Elm Creek in 2002 was there a significant (P<0.10) increase in the yield of
wheat with the application of the second dose of 2 lb Cu/acre of CuSO₄·5H₂O, Cu-EDTA and high solubility Cu-oxysulphate. Overall yield and yield increases are shown in Figure 3.

Figure 2. Effect of form of Cu fertilizer broadcast and incorporated at 5 lb Cu/acre on the average yield of wheat grown over the two years of the experiments at both Elm Creek and Miami.

Figure 3. Effect of form of Cu fertilizer seed-placed at 2 lb Cu/acre per year compared to one time application of 5 lb CuSO₄·5H₂O-Cu on the average yield of wheat grown over the two years of the experiments at both Elm Creek and Miami.

Effectiveness of Two Foliar Copper Products Applied at Various Growth Stages on Wheat Yield. There was a significant (P<0.05) yield response to foliar Cu application in both years of the experiment. The overall results (Figure 4) reflected individual trial results for both 2001 and 2002. Thus, foliar application of a sulphonic acid based Cu product provided maximum yield when applied at Feekes 6 stage (first node visible); an oxychloride product did not consistently provide maximum yield. Application of foliar
products either at early or late growth stages of wheat did not provide maximum yield in both of the experiments.

![Graph showing grain yield and growth stage of application of foliar Cu fertilizers](image)

Figure 4. Effect of form and growth stage of application of foliar Cu fertilizers on the average yield of wheat grown over the two years of the experiments at both Elm Creek and Miami (percentages denote relative increase over the control).

**Conclusions**

1. Copper as CuSO₄·5H₂O, high solubility (>65%) oxysulphate, or chelated forms broadcast and incorporated at 4 lb Cu/acre will correct Cu deficiency of wheat;

2. Same forms as above seed-placed at 2 lb Cu/acre will correct Cu deficiency after two years of application, but will not provide maximum yield;

3. Seed-placement of Cu-EDTA at 0.5 lb Cu/acre will correct Cu deficiency;

4. Application of 0.2 lb Cu/acre of sulphonic acid based Cu at Feekes 6 will correct Cu deficiency.

**References:**


SPSS Inc. 1998. SYSTAT 8.0. Chicago, IL.