Effectiveness of Seed-soaked Cu, Fall- Versus Spring-applied Cu, and Cu-coated P Fertilizer on Seed Yield of Wheat on a Cu-deficient Soil

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Background

- Deficiency of Cu is not wide spread in Saskatchewan, but it can cause a serious reduction in seed yield and quality of wheat when it occurs.
- Copper (Cu) deficiency is often associated with coarse-textured soils, and wheat is probably the most sensitive cereal to Cu deficiency.
- Yield responses of cereals to Cu fertilization have been investigated in western Canada, but for economic reasons producers have demanded information regarding low-rate application strategies in preventing/correcting Cu deficiency in wheat.

Objective

To determine the effect of seed-soaking of Cu fertilizer, fall- vs. spring-applied Cu, and Cu-coated P fertilizer on seed yield of wheat on a Cu-deficient soil in northeastern Saskatchewan.

Materials and Methods

- Location: Porcupine Plain; Soil: Dark Gray; Mean Precipitation: 450 mm;
- Growing Season: May to August; Crop: Hard Red Spring Wheat (AC Barrie)
- For this area, mean annual precipitation is 425 mm, and growing season (May to August) precipitation is 244 mm. Precipitation from May to August was 395 mm in 2005, 264 mm in 2006 and 301 mm in 2007.
- ***Experiment 1:*** Seed-soaked Cu @ 30, 60, 120 and 240 g Cu 100 kg-^{1} wheat seed; Foliar Cu @ 0.25, 0.50 and 1.00 kg Cu ha^{-1} applied at flag-leaf, 0.25 kg Cu at tillering + 0.25 kg Cu ha^{-1} at flag-leaf, 0.50 kg Cu at tillering + 0.50 kg Cu ha^{-1} at flag-leaf; Granular Cu @ 4.00 kg Cu ha^{-1} surface broadcast and incorporated into soil just prior to seeding; plus zero-Cu control.
- **Method for Soaking Seed:** For each Cu fertilizer application treatment separately, 190 g of wheat seed was thoroughly mixed with 30 mL solution of Cu fertilizer in distilled water in a small plastic container, and then left soaked overnight after covering it with a lid to prevent any water evaporation. For the zero-Cu control treatment, wheat seed was soaked in distilled water in the same way.
- ***Experiment 2:*** Granular Cu @ 2.0 and 4.0 kg Cu ha^{-1} applied by: surface broadcast in fall and incorporated into soil at seeding, broadcast and incorporated into soil at seeding, pre-emergence surface broadcast; Solution Cu @ 2.0 and 4.0 kg Cu ha^{-1} applied by: broadcast and incorporated into soil at seeding, pre-emergence surface broadcast; plus zero-Cu control.
- ***Experiment 3:*** Triple superphosphate (TSP) with zero-Cu control; TSP with 1% Cu in granules; TSP + granular Cu @ 4.0 kg Cu ha^{-1} broadcast and incorporated into soil at seeding.

- All plots received blanket application of N, P, K and S fertilizers every year in spring just prior to seeding to supply 105 kg N, 30 kg P, 42 kg K and 17 kg S ha^{-1} in Experiments 1 and 2, and 105 kg N, 20 kg P, 42 kg K and 17 kg S ha^{-1} in Experiment 3.
- Data Recorded: Seed Yield and Total Cu in Seed

Summary of Results

- Wheat showed severe Cu deficiency in all site-years for Experiment 1. For Experiments 2 and 3, Cu deficiency on wheat was severe in 2006, but moderate in 2007.
- There was a substantial increase in seed yield with proper application of Cu fertilizer.
- Seed yield response of wheat to applied Cu varied in different experiments due to variation in placement method, timing of application, formulation and rate of Cu, and severity of Cu deficiency.

Experiment 1 (Table 1)

- Seed-soaked Cu at very low rates increased seed yield of wheat, but the increases were lower than foliar applied Cu at low rates (0.50 to 1.00 kg Cu ha^{-1}) or soil incorporated Cu at high rates (4.0 kg Cu ha^{-1}).
- Seed yield was highest with two foliar Cu applications > soil incorporated Cu > one foliar Cu application > seed-soaked Cu.

Experiment 2 (Table 2)

- For granular Cu, seed yield increased only when Cu fertilizer at 4.0 kg ha^{-1} rate was applied in the previous fall.
- For spring application, seed yield increased only when solution Cu fertilizer at 4.0 kg ha^{-1} rate was spray-broadcast on soil surface and incorporated into soil prior to seeding.

Experiment 3 (Table 3)

- Seed yield increased considerably when Cu fertilizer at 4.0 kg ha^{-1} rate was broadcast and incorporated into soil at seeding.
- Application of Cu in TPS fertilizer granules had little effect on seed yield.

Conclusions

- The findings suggest that Cu deficiency in wheat can be corrected by soaking wheat seed in Cu solution, but potential for yield increase may not be as high as with foliar applied Cu or soil applied Cu.
- Deficiency of Cu in wheat can be corrected by surface-broadcast of Cu fertilizer at relatively high rates in fall, followed by incorporation into soil at seeding or by surface-broadcast of solution Cu fertilizer (most likely due to dispersion of Cu ions in the soil over the winter).

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Table 1. Effect of using Cu treated seed vs. other conventional methods of Cu application on seed yield at Porcupine Plain, Saskatchewan in 2005, 2006 and 2007 (Experiment 1)

Cu Application		Seed yield (kg ha^{-1})		
Rates	Methods	2005	2006	2007
0	n/a	684	373	764
30g Cu/100kg Wheat	Seed Soaked	2155	1446	1843
60g Cu/100kg Wheat	Seed Soaked	2062	1329	1836
120g Cu/100kg Wheat	Seed Soaked	2156	1993	2630
240g Cu/100kg Wheat	Seed Soaked	2160	1881	2213
0.25kg Cu/ha	Foliar	2918	2168	2524
0.50kg Cu/ha	Foliar	2747	2398	2569
1.00kg Cu/ha	Foliar	2777	2653	2610
[0.25 + 0.25] kg Cu/ha	Foliar	3454	3122	2811
[0.50 + 0.50] kg Cu/ha	Foliar	3167	3278	2653
4.0 kg Cu/ha	Surface	3086	2810	2653
	$LSD_{0.05}$	577	603	555
	SEM	199.5***	208.4***	191.8***

Table 2. Effect of fall vs. spring applied Cu on seed yield at Porcupine Plain, Saskatchewan in 2006 and 2007 (Experiment 2)

Cu Application			Seed yield (kg ha^{-1})	
Formulation	Rate kg Cu ha^{-1}	Timing	2006	2007
Granular ($CuSO_4$)	2.0	Fall	850	2427
Granular ($CuSO_4$)	4.0	Fall	1609	2302
Granular ($CuSO_4$)	2.0	Spring (Pre-tillage)	727	2086
Granular ($CuSO_4$)	4.0	Spring (Pre-tillage)	1011	2296
Granular ($CuSO_4$)	2.0	Spring (Pre-emergence)	737	2054
Granular ($CuSO_4$)	4.0	Spring (Pre-emergence)	865	2248
Solution (EDTA)	2.0	Spring (Pre-tillage)	1092	2111
Solution (EDTA)	4.0	Spring (Pre-tillage)	1677	2138
Solution (EDTA)	2.0	Spring (Pre-emergence)	1192	2217
Solution (EDTA)	4.0	Spring (Pre-emergence)	1096	2163
Control	0	n/a	597	1645
		$LSD_{0.05}$	465	420
		SEM	157.7**	$142.2^{0.08}$

Table 3. Effect of applying Cu-treated MAP, with the seed at seeding, on seed yield at Porcupine Plain, Saskatchewan in 2006 and 2007 (Experiment 3)

Cu Application		Seed yield (kg ha^{-1})	
50 kg MAP ha^{-1}	kg Cu ha^{-1}	2006	2007
11-52-0	0	809	1924
10-50-0 (1% Cu)	0.5	907	2016
11-40-0-11 (1% Cu)	0.5	1137	1962
11-52-0 + EDTA (pre-tillage)	4.0	2329	2447
	$LSD_{0.05}$	652	348
	SEM	188.3**	108.6*