Forage Seed Response to Copper Fertilization

2013-2015 Combined Report

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SUMMARY:

In June 2013, we applied foliar EDTA chelated copper to established timothy (3 locations) and hybrid bromegrass (1 location) on replicated mini-plots. This was repeated in June of 2014 and June 2015, but we added 2 other liquid Cu foliar treatments; dropped one unresponsive site and added another potentially responsive hybrid bromegrass site. At harvest we evaluated treatment effects on seed yield in all three years and on straw yield in 2014 and 2015. At Site 1 in 2013 (a field with a history of copper fertilizer application) seed yield of timothy did not increase when copper was applied, and showed a weak tendency to decline slightly. At two other sites in 2013, copper fertilization increased seed yield of timothy by 20 and 29% (Site 3 and Site 2 respectively). At Site 4, copper fertilizer increased seed yield of hybrid bromegrass by 30%. The three sites where copper did increase yield all had no known history of copper application.

Statistical analyses of individual sites did not reveal any significant differences. A combined analysis of the three sites that had no known history of copper fertilization indicated that the copper response was statistically significant at the 5% probability level. During 2014, foliar copper had minimal impact on straw yield at 3 of 4 locations, and tended to increase straw yield at one location. Seed yield was unaffected at one location, showed a weak tendency to increase at a second location and was dramatically increased at the remaining two locations. There was no clear indication that any foliar Cu product was superior to another. Seed yield averaged across the 3 Cu treatments and 4 locations were 126% of the untreated check. This ranged from a low of 97% at the least responsive site to 155% of the check at the most responsive site. During 2015, forage seed yields were generally lower than for the previous 2 years, likely because early season precipitation was much lower than normal in the region. Seed yield of the check treatment averaged across sites was 343 kg/ha while that of the 3 copper treatments average 320 kg/ha or 93% of the check. Straw yield for the three coper treatments was also only 94% of the check. These results do suggest that low seed yield with forages may reflect copper deficiencies, but could also be related to climatic conditions as was the case in 2015. Forage seed growers in these regions who suspect copper deficiencies should consider applying copper to test strips in their fields to verify both the presence and magnitude of responses. This information could then be used to decide whether copper application is economic. Our results suggest that when seed yield potential is high, responses to copper fertilization are more likely to occur. Results also confirm that application of foliar copper at relatively low rates can be effective at correcting deficiencies. Results also confirm that applying foliar copper to mini-plots and comparing yield to adjacent untreated areas is an effective way of identifying where copper applications may be economic. For additional information about Cu fertilization and effectiveness of different forms of Cu, see the Research Results page '*Some Useful Information about Copper (Cu) and Copper Fertilizers*' on the Northeast Agriculture Research Foundation website at neag.ca.

INTRODUCTION:

Copper is an essential micronutrient needed for proper fertilization and seed formation. Copper deficiencies are not widespread in Northeastern Saskatchewan, but where they occur they can result in very substantial yield losses to susceptible grain crops. Deficiencies are most common on organic (peat) and coarse textured (sandy) soils. Deficiency symptoms can include yellowing and curling of young leaves, pigtailing (curling) of leaf tips, delayed heading, aborted heads or spikelets, stem or head bending or browning of stems and heads. A recent review of copper studies in Alberta indicated that copper deficiencies don't generally affect hay yields enough to warrant treatment. However, little is known about effects of copper deficiencies on forage seed yield. Forage seed yields in Northeastern Saskatchewan can be highly variable from year to year and between fields within a year. Numerous environmental, soil and pest factors could play a role in such variability. Copper deficiencies are often implicated on soils that are low in available copper. Soil and tissue tests can be useful in identifying where copper deficiencies might occur, but have not proven highly effective at identifying expected responses to fertilizer copper. As a result growers could experience losses because copper is not applied where it is deficient or where relatively expensive copper fertilizers are used where the soil supply is adequate. One of the most cost effective ways to identify where deficiencies occur is to apply copper to small areas in a field and compare yield with adjacent untreated areas. Results can then be used to decide whether copper application on a field scale is warranted.

OBJECTIVE:

The objective of this trial was to determine if established seed forage fields, where yields were lower than expected last year, would respond to copper fertilizer.

MATERIALS AND METHODS:

In June 2013, we selected 4 sites in the Choiceland, Nipawin, White Fox regions where we thought there was some evidence of copper deficiency. Sites were those on soils where copper deficiencies could typically occur, and where previous yields were below expectations. None of the sites showed typical symptoms of severe copper deficiency like pig-tailing of leaves, late tillering or very poor growth. All sites were on sandy soils with moderate organic matter. Three sites were established timothy, and one was established hybrid bromegrass. At each site we located 5 pairs of 0.18 m^2 mini-plots. At the late flag leaf stage, we applied foliar EDTA chelated copper solution at a rate of 0.22 lb/ac in 40 gallons per acre (gpa) of water to one of each pair of mini-plots. The remaining plots were left untreated. At maturity, all mini-plots were harvested by stripping all seed from stalks from each mini-plot, followed by cleaning of the seed to remove foreign material.

Site 1 has had copper fertilizer applied at a rate of 1pound per acre on 4 or 5 occasions in the past, and soil tests indicated that copper was not needed on this field. Site 2 appeared to have had copper sulfate fertilizer applied before we set up miniplots because we could see the blue granules of copper sulfate on the soil surface. At Sites 3 and 4 copper had not been applied recently and it is unknown if copper has ever been applied to these fields.

In 2014 and 2015, we used three of the same sites as in 2013, but dropped site 1 from 2013 and added a site at Carrot River. The 2014 and 2015 protocol was the same as for 2013, but we added 2 more foliar copper treatments; one with a Nexus Liquid Copper 5% product applied to supply 0.22 lb/ac Cu in 40 gpa of water and the second with a YARA product called Coptrac 500 also applied at a rate that supplied 0.22 lb/ac of Cu.

At maturity, all mini-plots were harvested by cutting forage near the soil surface and bagging each. After drying, the seed was stripped from the straw and cleaned to remove non-seed material. The clean seed and straw were weighed separately.

RESULTS AND DISCUSSION:
2013:

Yields that we observed were considerably higher than growers might expect, in part because seed was hand harvested with zero loss. In selecting uniform areas for treatment we may also have inadvertently selected higher yielding areas of the fields. Regardless the responses to copper application should remain valid on a percentage basis. At Site 1 where copper had been applied previously there was no response to copper, and the site showed a weak and statistically non-significant trend for yield to decline (Table 1). At the other sites application of copper tended to increase yield, but statistical analyses of individual sites did not reveal significant responses. Because Sites 2-4 did not have a known history of copper application we did a combined analysis on these 3 sites. When combined the copper response was statistically significant at the 5% probability level. At these three responsive sites copper fertilization increased yield by 25% (range 20-30%).

Table 1. Seed yield (kg/ha) at four sites on established fields of Timothy or Hybrid Bromegrass grown for seed in 2013.

SITE	Seed Yield kg/ha		Cu Response (%)
	No Cu	Cu	
Site 1 (Timothy)	1186	1070	90
Site 2 (Timothy)	969	1247	129
Site 3 (Timothy)	780	933	120
Site 4 (Hybrid brome)	540	700	130
Sites 2-4 Average	100	126	126

2014:

Straw yield was largely unaffected by foliar Cu application at sites 1-3, but at site 5 straw yield showed a tendency to be increased with each of the Cu treatments, although the response was not statistically significant (Table 2).

Table 2. Straw yield (kg/ha) at four sites on established fields of Timothy or Hybrid Bromegrass grown for seed in 2014.

SITE	Straw Yield kg/ha				Avg. Cu Response (%)
	No Cu	EDTA Cu	Liquid Cu 5%	Coptrac 500	
Site 2 (Timothy)	2921	3089	3054	3082	105
Site 3 (Timothy)	3918	3897	3381	3974	95
Site 4 (Hybrid Brome)	5703	5086	5691	6221	99
Site 5 (Hybrid brome)	4217	5720	5621	4809	128
4 Site Average	4190	4448	4437	4522	107

At site 2, seed yield was unaffected by foliar Cu regardless of formulation used (Table 3). At site 3 there was a trend for foliar Cu to increase seed yield, and at sites 4 and 5 there was a very strong (statistically significant) trend for foliar Cu to increase seed yield. Overall, the average response to foliar Cu was to produce seed yield that was 126% of the untreated check. However this ranged from 97% of untreated to 155% of untreated.

Table 3. Seed yield (kg/ha) at four sites on established fields of Timothy or Hybrid Bromegrass grown for seed in 2014.

SITE	Seed Yield kg/ha				Avg. Cu Response (%)
	No Cu	EDTA Cu	Liquid Cu 5%	Coptrac 500	
Site 2 (Timothy)	624	684	523	609	97
Site 3 (Timothy)	580	673	620	670	113
Site 4 (Hybrid brome)	523	645	844	946	155
Site 5 (Hybrid brome)	635	834	1116	803	145
4 Site Average	591	709	776	757	126
Timothy Average	602	679	572	640	105
Hybrid brome Average	579	740	980	875	150

2015:

During 2015, neither straw nor seed yield was affected by Cu fertilization at any site (Tables 4 and 5). Straw yield in 2015 was more than 25% lower than for 2014, while seed yield was more than 50% lower than in 2014, likely because early season precipitation was much lower than normal. Perennial grasses begin growth earlier in the growing season than spring seeded annual grain crops. For this reason they require ample moisture early in spring to promote high straw or seed yield. It was not unexpected that straw yield was unaffected by Cu fertilizer, since we did not see a strong straw yield response in 2014. However there was a reasonable expectation that seed yield would respond to Cu fertilizer based on past responses on these fields. Yields averaged across the three Cu fertilizer treatments were 90 to 106% of the untreated check at these 4 locations. Lower yield potential in 2015 most probably explains why we did not observe any seed yield response to fertilizer copper. It appears that there was adequate copper available to support seed yields in the 225 to 625 kg/ha range (the yield range for the check treatments). It also appears that moisture was the seed yield limiting factor rather than the mount of Cu available to the crops. Seed yield also tended to be more variable across replicates in 2015 than in 2014. This is typical of what occurs with other crops when the supply of water is limited.

Table 4. Straw yield (kg/ha) at four sites on established fields of Timothy or Hybrid Bromegrass grown for seed in 2015.

SITE	Straw Yield kg/ha				Avg. Cu Response (%)
	No Cu	EDTA Cu	Liquid Cu 5%	Coptrac 500	
Site 2 (Timothy)	2880	2654	2505	2552	89.2
Site 3 (Timothy)	2690	2784	2455	1888	88.3
Site 4 (Hybrid Brome)	4269	3842	3837	4258	93.2
Site 5 (Hybrid brome)	2997	3117	2841	3435	104.5
4 Site Average	3209	3099	2910	3033	93.8

Table 5. Seed yield (kg/ha) at four sites on established fields of Timothy or Hybrid Bromegrass grown for seed in 2015.

SITE	Seed Yield kg/ha				Avg. Cu Response (%)
	No Cu	EDTA Cu	Liquid Cu 5%	Coptrac 500	
Site 2 (Timothy)	257	283	224	233	96.0
Site 3 (Timothy)	270	273	270	207	92.6
Site 4 (Hybrid brome)	621	491	633	556	90.2
Site 5 (Hybrid brome)	224	251	203	257	105.8
4 Site Average	343	325	333	313	96.2

Overall, the sites where Timothy were grown showed a good response (20% or greater seed yield increase) to foliar Cu fertilization at 2 site years, a weak response (10% or greater seed yield increase) at 1 site year and no or a negative response at 4 site years. Where Hybrid bromegrass was grown there was a very good response (40% or greater seed yield increase) to foliar Cu fertilizer at 2 sites, a good response (20% or greater seed yield increase) at 1 site year, and no response at 2 site years. This result would suggest that the supply of Cu from the soil can vary from year to year. It also suggests that when conditions favor high seed yield (ample early spring moisture) Cu fertilization on soils that test low for this micronutrient may be needed to realize full yield potential.

Although there was some variability between sites, there was no clear trend for one Cu product to be better or worse than any other. Where responses occurred, they generally occurred with all products tested.

The fact that foliar Cu impacted seed yield more consistently than straw yield suggests that Cu deficiencies may not be readily apparent as poor vegetative growth. Conversely it may reflect that application of foliar Cu at the flag leaf stage may be too late to impact straw production while still providing a good seed yield response.

Economic Implications:

The cost of foliar Cu at the rates we used is in the range of $5.20 to $11.40/ac plus application costs. With typical seed yields of 250 lb/ac for Hybrid bromegrass and 300 lb/ac for timothy, a 25% yield increase would amount to 62 lb/ac of Hybrid bromegrass and 75 lb/ac of timothy. Yield increases of this magnitude at current seed prices would readily offset the cost of the fertilizer material as well as application costs.

These results point out the difficulty in evaluating the need for a micronutrient like copper. Copper levels in the soil can vary widely over short distances and as a consequence responses to copper fertilizer can be quite variable. Within sites we observed large differences in Cu responses. This could reflect spatial variability in soil Cu levels as well as other sources of error. As a result it is important to have adequate replication to provide an accurate estimate of responses where microplots are used.

We did not note any ergot bodies in any of the hybrid bromegrass seed samples so it is unclear if copper application has any impact in controlling this disease.

Considering that 6 of 12 sites responded to copper, it may be that copper deficiencies for forage seed production are more widespread than previously thought. These results suggest that low seed yield with forages may reflect copper deficiencies, particularly when early moisture supplies and other factors favor high seed yields. Forage seed growers in these regions who suspect copper deficiencies should consider applying copper to test strips in their fields to verify both the presence and magnitude of responses. Larger test strips would provide a more accurate indication of responses while not risking the full cost of treating whole fields that may not need copper fertilizer. This information could then be used to decide whether copper application is economical.

CONCLUSIONS:

Results from 2013 to 2015 suggest that copper can be a factor in low yields of established timothy and hybrid bromegrass grown for seed. Results also confirm that application of foliar copper at relatively low rates (0.22 lb/ac) can be effective at correcting deficiencies. Results also confirm that applying foliar copper to mini-plots and comparing yield to adjacent untreated areas is an effective way of identifying where copper applications may be economical. What is troubling is that responses on the same fields vary from year to year, making it difficult to predict when Cu responses can be anticipated. Considering the low cost of foliar Cu fertilization and the relatively large responses to foliar Cu, it may be a useful practice to apply foliar Cu to all forage grass seed fields where the crop is grown on light textured soils with limited capacity to supply

Cu. The question that remains is whether we can develop a reliable predictor or threshold for soil or tissue Cu to be used to assess the need for foliar Cu.

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