Spring Wheat Response to Copper Fertilization in North Dakota

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ABSTRACT

Traditionally, copper responses have been thought to be associated with organic soils. However, recent Canadian research has found that copper responses by wheat are possible on low organic matter, coarse textured soils. A yield response to copper in spring wheat was found in North Dakota on a coarse textured, low organic matter soil. Yield responses were not found in similar copper soil test levels of higher organic matter, heavier textured soils. A two-tiered recommendation strategy is suggested by the yield results. A soil copper survey of the state showed that generally levels of copper are lower on upland and sloping landscape positions than in depressional areas.

INTRODUCTION

Copper responses have been thought to be mostly associated with organic soils (Kubota and Alloway, 1972). Recent Canadian research on barley and spring wheat have shown yield responses with copper application on mineral soils, mostly low organic matter, coarse textured water-sorted glacial tills (Karamanos et al., 1986). Because many soils in North Dakota fit into this category, a study was begun in 1998 to investigate the response of spring wheat to copper fertilization.

METHODS

A simple experiment was conducted at six sites. Two of the sites were located three miles southeast of Valley City, ND in a field previously investigated for four years in a site-specific farming research study. Two sites were located in Wells Co., southwest of Devils Lake, ND. and two sites were located in Benson Co., west of Devils Lake. All sites had previously been affected by scab (*Fusarium graminearum*, Schwabe) in previous wheat and barley crops. Treatments were 5 lb/acre copper applied as copper sulfate (25%) and a control of no copper. Plots were 10 feet wide and 20 feet long, arranged in a randomized complete block design with 8 repetitions. Disease ratings were taken during the growing season near flowering.

A copper survey was conducted during the summer of 1998. Levels of copper in fields of the state by landscape position were previously unknown. Three sites were located and sampled in each of the 52 counties in North Dakota. Each site was georeferenced, and an upland, slope, and depressional sample obtained from each site. The sites were investigated when possible to indicate the presence of manure application during the past twenty years. Ten sites had a history of manure application and were deleted from the data set to prepare the mapping in this paper.

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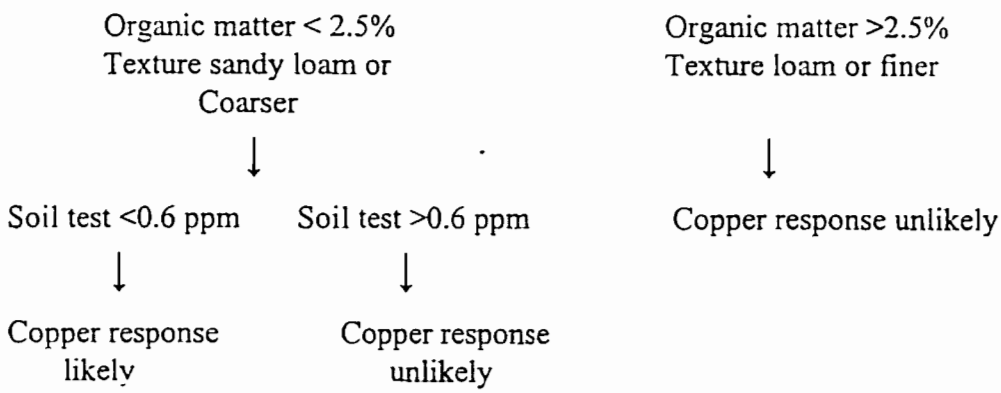
RESULTS AND DISCUSSION

The soil test data for each site shows that only the Valley City 1 site tested lower than 2 percent organic matter and had a sandy loam texture (Table 1). The other sites tested above 2 percent organic matter and were loam textures. The Valley City 1 site was also the only upland landscape position. The other sites were established on long gentle slopes or in depressions.

Yields were significantly increased at the Valley City 1 site by 15.8 bu/acre (Table 2). The treatments at the site were visually different from the four-leaf stage through harvest. Early in the season, treated plots were greener and had more tillers than the untreated plots. Height of the wheat at jointing and heading was higher in the treated plots than the untreated. The symptoms of copper deficiency at Valley City 1 could have been mistaken as drought injury.

Scab incidence is defined as the percent of heads showing scab. Scab head severity is the percent of the head with scab affected kernels. Field scab severity is calculated by multiplying scab incidence by scab head severity, and is a reasonable field measure of losses due to scab. Copper decreased scab incidence at the 10 percent probability level at the Valley City 1 site (Table 3). Copper also decreased head scab severity significantly at the 5 percent level at the Valley City 1 site (Table 4). Field scab severity was decreased with copper application at two sites, the Valley City 1 site and the Benson 1 site (Table 5). Copper may extend flower opening, increasing the incidence of ergot infection (Solberg et al., 1995). A similar mechanism may also be affecting scab results seen in this study. Leaf disease (Table 6) and black chaff incidence (Table 7) were not affected by copper.

Based on this first year of research, a two-tiered recommendation approach for growers interested in trying copper on wheat/barley is suggested.



A survey of North Dakota copper levels conducted during the summer of 1998 showed that copper levels tended to lowest on upland and sloping positions and highest in depressional areas within fields (Figures 1-3). Copper levels tended to be higher in the four corners of the state, with the exception of small areas in eastern Kidder, Stutsman and Barnes counties. Lowest copper levels were found in the south-central area along the Missouri River, areas in Slope and Billings counties in the west, the north-central area northwest of Devils Lake and the beach ridges west of the Red River Valley. Approximately two-thirds of the cultivated area of the state tested lower than 0.6 ppm copper, although the area falling into the category of less than 2.5 percent organic matter with sandy loam textures and coarser would be smaller in size.

Table 1. Soil properties of the six copper test sites.

Site	OM, %	Texture	Cu, ppm	pH
Valley City 1	1.8	Sandy loam	0.4	6.0
Valley City 2	3.5	Loam	0.4	6.4
Wells 1	2.6	Loam	0.4	7.1
Wells 2	2.3	Loam	0.5	7.6
Benson 1	3.2	Loam	0.4	6.8
Benson 2	4.2	Loam	0.4	7.4

Table 2. Yield of wheat with and without copper.

	---------- Yield, bu/acre ----------			
Site	With Copper	Without Copper	F	Significance
Valley City 1	39.7	24.1	16.3	P< 0.01
Valley City 2	60.5	55.5	0.9	NS
Benson 1	24.7	24.2	0.19	NS
Benson 2	37.6	39.1	0.50	NS
Wells 1	36.1	36.5	0.14	NS
Wells 2	36.3	41.0	1.70	NS

Table 3. Percent scab incidence.

	---------- % Incidence ----------			
Site	With Copper	Without Copper	F	Significance
Valley City 1	21.6	27.9	4.37	P<0.10
Valley City 2	5.4	6.3	0.21	NS
Benson 1	17.5	24.6	2.83	P<0.11
Benson 2	27.1	33.3	2.52	P<0.14

Table 4. Percent scab head severity.

	---------- Degree of Severity ----------			
Site	With Copper	Without Copper	F	Significance
Valley City 1	7.8	10.4	4.8	P<0.05
Valley City 2	7.3	6.4	0.3	NS
Benson 1	8.8	9.7	0.7	NS
Benson 2	13.8	15.1	0.5	NS

Table 5. Percent scab field severity.

	---------- Degree of Severity ----------			
Site	With Copper	Without Copper	F	Significance
Valley City 1	1.6	3.0	5.80	P<0.05
Valley City 2	0.44	0.40	0.06	NS
Benson 1	1.5	2.3	5.8	P<0.05
Benson 2	3.7	5.2	2.8	P<0.12

Table 6. Percent leaf disease incidence.

	---------- % Leaf Disease ----------			
Site	With Copper	Without Copper	F	Significance
Valley City 1	26.2	29.8	0.46	NS
Valley City 2	8.5	9.1	0.17	NS
Benson 1	4.7	6.7	2.22	P<0.16
Benson 2	20.0	25.5	1.25	NS

Table 7. Percent black chaff incidence.

	---------- % Incidence ----------			
Site	With Copper	Without Copper	F	Significance
Valley City 1	10.8	12.9	0.4	NS
Valley City 2	20.4	25.8	0.9	NS
Benson 1	2.1	0.4	2.9	P<0.11
Benson 2	20.0	17.9	0.9	NS

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Figure 1. North Dakota copper levels, non-manured sites, upland positions.

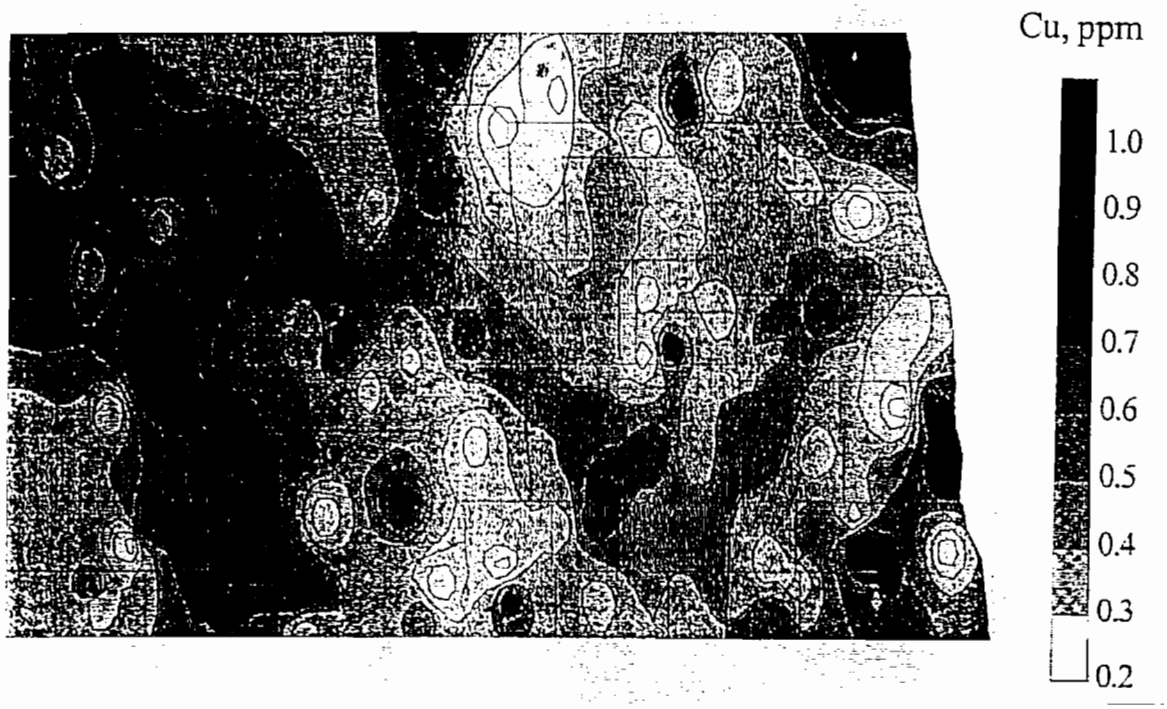

Figure 2. North Dakota copper levels, non-manured sites, sloping positions.

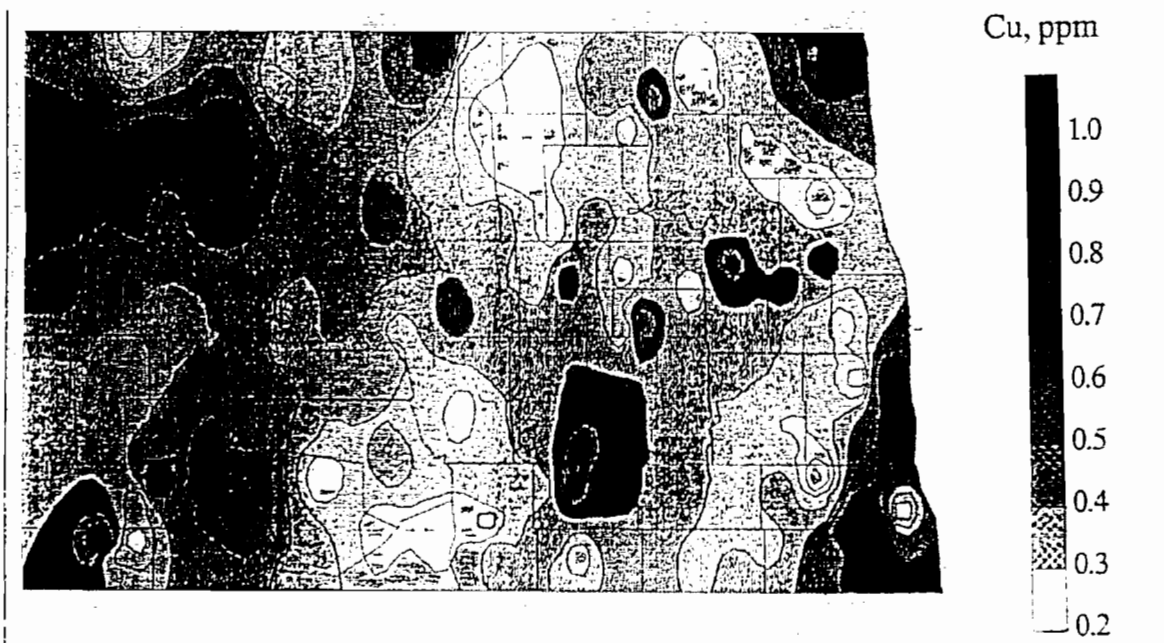

Figure 3. North Dakota copper levels, non-manured sites, depressional positions.

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