MICRONUTRIENT NUTRITION FOR CORN AND SOYBEAN: EMERGING ISSUES IN KENTUCKY

J.H. Grove and G.J. Schwab
University of Kentucky, Lexington, Kentucky

Abstract

In certain Kentucky regions, corn-Zn and soybean-Mn are well known crop-micronutrient problems. In response to grower observations/concerns in another region, soil and leaf tissue sampling indicated that pH P, K, B, Cu and Zn nutrition problems were co-mingled. A series of corn and soybean field studies were conducted between 2008 and 2010 to sort out/among possible problems/solutions, relative to similar soils in other areas of the state. The results indicate that when P and K nutrition are sufficient, B, Cu and Zn nutritional problems, especially for corn, can remain. Soils in these fields lack adequate B, Cu and Zn; and the availability of these micronutrients can be complicated by producer management of organic matter, pH and P levels in these poorly buffered soils.

Introduction

Well documented micronutrient nutrition problems in Kentucky include Zn for corn and Mn for soybean, observed on modest to small production areas in two different regions of the state. Work done in the early 1980's suggested that B deficiency in corn was 'out there', but there was little evidence that the problem was so significant as to justify further research effort.

In 2007, the Russell County agricultural extension agent asked for assistance for local grain producers, who were not achieving their yield expectations. Earlier work with these growers, in the late 1980's, had focused on improving corn N nutrition management, but gains from that work had run their course. Greg Schwab surveyed a number of corn and soybean fields, taking both soil and plant tissue samples. Depending upon the field, soil sampling found low organic matter levels and generally high soil pH values (greater than 7.0); identified potential P and K deficiencies; while plant analysis found suboptimal concentrations of B, Cu and Zn. In an initial 2008 field experiment, corn and soybean leaf tissue composition was positively impacted by micronutrient application but yield information was inconclusive because of severe drought.

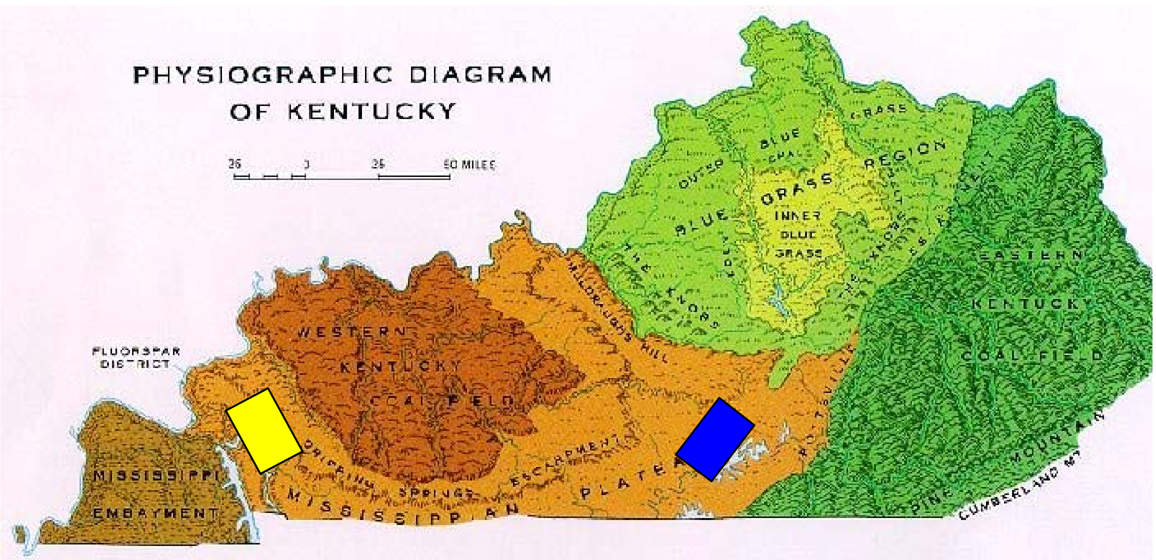
Approach

In 2009, micronutrient studies were conducted in grower fields in Russell County and at the West Kentucky Research and Education Center in Caldwell County. Caldwell and Russell counties are located in the western and eastern portions, respectively, of the Mississippian Plateaus physiographic region (Figure 1). Soils in Caldwell County were Zanesville silt loams (fine-silty, mixed, active, mesic Oxyaquic Fragiudalfs), formed in loess and residuum of sandstone, shale and siltstone. Those in Russell County were Lonewood (fine-loamy, siliceous, semi-active, mesic Typic Hapludults) and Sango (coarse-silty, siliceous, semi-active, thermic Glossic Fragiudults) silt loams, formed in thin loess and residuum of sandstone and siltstone. The

Russell County soils are coarser; more weathered; and exhibit less buffer capacity.

The Caldwell County studies were focused on Zn and P nutrition, while those in Russell County emphasized B, Cu, Zn and P treatments. In Caldwell County, several P sources, including diammonium phosphate (DAP), monoammonium phosphate (MAP), and the new MAP plus S (or S plus Zn) materials from Mosaic (MES materials) were used. All trials were performed with no-tillage soil management, and all materials were dry granules broadcast over the soil surface just after plant emergence. Soil samples were taken, by block, prior to fertilizer application. Leaf samples were collected just after silk emergence in corn and during early flowering in soybean. Plots were harvested with a small-plot combine and grain yields corrected to 15.5 (corn) and 13.5 (soybean) % moisture.

Figure 1. Kentucky's physiographic regions, with Caldwell (in western Kentucky, yellow) and Russell (in south-central Kentucky, blue) counties indicated.



In 2010, greater focus was given to micronutrient studies on grower fields in Russell County, again emphasizing B, Cu and Zn. Though both corn and soybean trials were conducted, only corn yield information is available at this writing. As in 2009, all materials were dry granules broadcast on the surface of no-till soils soon after plant emergence. Soil and leaf tissue samples were collected as in 2009. Corn plots were harvested with a small-plot combine and grain yields corrected to 15.5 % moisture.

Summary

In 2009, Caldwell County soybean yield responded positively to applied P nutrition (Table 1), as would be expected given the low initial soil test P level (Mehlich III extractable P = 10 pp2m). All materials were equally effective as P nutrition sources. No response to S was observed. The Zn-containing product (MESZ) improved soybean Zn nutrition (as measured by leaf Zn, Table 1), despite coincident P addition and the known antagonism between Zn and P in plant nutrition. Unfertilized soybean was visibly stunted, which accounts for the dry matter dilution in leaf Zn concentration that occurred with the addition of other P sources.

Table 1. 2009 soybean leaf tissue composition and grain yield response to greater Zn and P nutrition (Caldwell County; Zanesville silt loam: pH = 6.0; organic matter = 2.7%; Mehlich III-K, P and Zn = 310, 10 and 2.4 pp2m, respectively).

P Source	**P Rate** lb P_2O_5/acre	**Zn Rate** lb Zn/acre	**Leaf P** %	**Leaf Zn** ppm	**Yield** bu/acre
-	0	0	0.29 b*	45 ab*	47.6 b*
DAP	70	0	0.34 a	40 b	62.3 a
DAP+S	70	0	0.34 a	41 b	58.9 a
MAP	70	0	0.35 a	41 b	66.9 a
MAP+S	70	0	0.35 a	41 b	62.1 a
MES10	70	0	0.36 a	43 b	67.7 a
MES15	70	0	0.34 a	43 b	63.6 a
MESZ	70	1.75	0.35 a	47 a	60.4 a

*Mean values within a column followed by the same letter are not significantly different at the 90% level of confidence.

The 2009 Caldwell County corn exhibited no leaf composition or yield response to the P, S or Zn treatments (Table 2), though both Mehlich III extractable P and Zn were marginal, indicating that fertilizer P and Zn might be needed. Soil pH and organic matter levels were adequate for corn production. Leaf P and Zn concentrations (Table 2) indicated adequate P and Zn nutrition. Yields were generally good (Table 2). There were no differences among the different sources of P, S or Zn (Table 2). The MESZ source did not influence the crop's Zn nutrition (Table 2). Addition of S did not impact S nutrition (data not shown).

Table 2. 2009 corn leaf tissue composition and grain yield response to greater Zn and P nutrition (Caldwell County; Zanesville silt loam: pH = 5.9; organic matter = 2.7%; Mehlich III-K, P and Zn = 260, 31 and 2.7 pp2m, respectively). Also applied 60 lb K_2O/acre.

P Source	**P Rate** lb P_2O_5/acre	**Zn Rate** lb Zn/acre	**Leaf P** %	**Leaf Zn** ppm	**Yield** bu/acre
-	0	0	0.25 a*	30 a*	213 a*
DAP	70	0	0.26 a	26 a	205 a
DAP+S	70	0	0.29 a	27 a	228 a
MAP	70	0	0.27 a	27 a	223 a
MAP+S	70	0	0.30 a	27 a	208 a
MES10	70	0	0.27 a	27 a	215 a
MES15	70	0	0.28 a	27 a	218 a
MESZ	70	1.75	0.26 a	27 a	212 a

*Mean values within a column followed by the same letter are not significantly different at the 90% level of confidence.

Russell County experienced good rainfall and cooler than average summer temperatures in 2009. Soybean yields were high (Table 3). The borate and sulfate micronutrient sources generally raised leaf tissue micronutrient concentrations (Table 3), though the highest rate of Zn sulfate was needed to accomplish this. However, there was no yield response to any of the micronutrient treatments (Table 3). This soybean crop “saw“ little need for additional micronutrient nutrition.

Table 3. 2009 soybean leaf tissue composition and grain yield response to greater B, Cu, and Zn nutrition (Russell County; Sango silt loam: pH = 7.2; organic matter = 1.8%; Mehlich III-P, K, B, Cu and Zn = 100, 310, 0.5, 0.6 and 7.6 pp2m, respectively).

micro-nutrient	**Rate** lb B, Cu, Zn/acre	**Leaf B** ppm	**Leaf Cu** ppm	**Leaf Zn** ppm	**Yield** bu/acre
-	0	24.0 b*	4.8 b*	49.5 b*	64.6 a*
B	1	41.9 a	3.9 b	48.1 b	64.8 a
Cu	5	24.5 b	6.8 a	49.1 b	66.9 a
Zn	2	27.0 b	4.4 b	50.1 ab	64.7 a
Zn	5	24.9 b	4.0 b	52.9 ab	60.8 a
Zn	20	31.8 b	5.0 b	55.0 a	60.8 a

*Mean values within a column followed by the same letter are not significantly different at the 90% level of confidence.

The two Russell County corn trials (Tables 4 and 5), both on Lonewood soils, exhibited different patterns of response to the micronutrient treatments. In these trials, the Cu treatment was unintentionally confounded with Zn due to the chosen product. At Field 1 (Table 4), B fertilization raised both leaf B concentration and yield, but not enough for statistical significance. Fertilization with the Cu/Zn mixture did significantly increase leaf Cu and Zn levels and also increased yield, but a yield benefit to Cu was not found as the yield response to the Cu/Zn mixture was not different from that to Zn alone (Table 4). There was a large yield response to Zn, especially at the highest rate of Zn applied. This was not expected, given the soil test Zn level at this location.

Compared to Field 1, the second Russell County corn field exhibited similar leaf B concentrations, but greater leaf Cu and Zn concentrations (Table 5). Boron addition again raised both leaf B and yield, but only leaf B was increased significantly (Table 5). Both Zn and Cu/Zn mixed fertilizers raised leaf Zn, significantly so at the highest Zn rate (Table 5). Grain yield was generally improved by Zn addition, but was significantly increased only by the lowest rate of the Zn-only material. Greater rates on Zn appeared to have suppressed grain yield, and leaf Zn reached an excessive concentration at the highest Zn application rate.

The different patterns in corn response exhibited by the two fields were most likely due to differences in their P nutritional status. Field 1 was high in available P, while Field 2 was medium. The impact of additional P nutrition, in combination with additional Zn, on yields and corn leaf P and Zn concentrations in these two fields is shown in Table 6.

Table 4. 2009 corn leaf tissue composition and grain yield response to greater B, Cu, and Zn nutrition (Russell County, Field 1; Lonewood silt loam: pH = 7.3; organic matter = 2.3%; Mehlich III-P, K, B, Cu and Zn = 110, 320, 0.8, 1.1 and 4.1 pp2m, respectively).

micro- **nutrient**	**Rate** lb B, Cu, Zn/acre	**Leaf B** ppm	**Leaf Cu** ppm	**Leaf Zn** ppm	**Yield** bu/acre
-	0	3.8 a*	7.5 b*	11.5 c*	144 c
B	1	5.3 a	8.3 b	11.5 c	162 c
Zn	2	4.5 a	8.3 b	13.3 c	189 b
Zn	5	4.8 a	7.8 b	13.8 bc	192 ab
Zn	20	4.0 a	7.3 b	19.3 a	212 a
Cu & Zn	5 & 2.5	4.0 a	11.8 a	16.8 ab	187 b

*Mean values within a column followed by the same letter are not significantly different at the 90% level of confidence.

Table 5. 2009 corn leaf tissue composition and grain yield response to greater B, Cu, and Zn nutrition (Russell County, Field 2; Lonewood silt loam: pH =5.7; organic matter = 1.5%; Mehlich III-P, K, B, Cu and Zn = 43, 180, 0.5, 0.8 and 3.1 pp2m, respectively). Also applied 60 lb K_2O/acre.

micro- **nutrient**	**Rate** lb B, Cu, Zn/acre	**Leaf B** ppm	**Leaf Cu** ppm	**Leaf Zn** ppm	**Yield** bu/acre
-	0	4.3 b*	10.8 a*	15.0 d	147 cd
B	1	6.3 a	11.0 a	15.0 d	160 bc
Zn	2	4.5 b	11.3 a	17.3 cd	186 a
Zn	5	4.3 b	10.5 a	21.3 bc	152 cd
Zn	20	4.8 b	11.5 a	40.8 a	152 cd
Cu & Zn	5 & 2.5	4.3 b	11.8 a	18.0 cd	136 d

*Mean values within a column followed by the same letter are not significantly different at the 90% level of confidence.

Table 6, below, illustrates the classic Zn versus P antagonism in corn nutrition. In Field 1, a low rate of added Zn decreases leaf P, but increases leaf Zn and yield (Table 6), and more Zn does more of the same, resulting in the highest yield, leaf Zn, and lowest leaf P at the highest Zn application rate (20 lb Zn/acre). However, adding more P (and additional Zn), raises leaf P, maintains leaf Zn, but reduces yield (Table 6).

In Field 2, a low rate of added Zn increases leaf P, leaf Zn and yield (Table 6), but more Zn reduces leaf P, continues to raise leaf Zn and gives less yield. Adding additional P (and additional Zn), raised soil test levels for both nutrients, leaf concentrations of both nutrients, and increased yield (Table 6). Field 1 needed Zn, and possibly B, while Field 2 needed both P and

Zn, and also possibly needed B. Due to confounding, the benefit of increased Cu availability was not well tested.

Table 6. 2009 soil test, corn leaf tissue composition, and grain yield responses to greater Zn and P nutrition at the two Russell County locations.

Fertilizer P Rate lb P_2O_5/acre	**Fertilizer Zn Rate** lb Zn/acre	**Soil Test P** pp2m	**Soil Test Zn** pp2m	**Leaf P** %	**Leaf Zn** ppm	**Yield** bu/acre
			Field 1 (Mehlich III – P = 110 pp2m)			
0	0	113 c	4.3 c	0.41 a	11.5 c	144 d
0	2	107 c	6.5 b	0.39 a	13.3 b	189 bc
0	5	102 c	7.6 b	0.39 a	13.8 b	192 ab
0	20	118 c	24.5 a	0.33 b	19.3 a	211 a
80	2	130 b	4.8 c	0.40 a	13.8 b	174 bc
200	5	197 a	6.8 b	0.42 a	13.5 b	174 bc
			Field 2 (Mehlich III – P = 43 pp2m)			
0	0	41de	1.8	0.18 cd	15.0 d	147 d
0	2	52 c	3.1	0.21 c	17.3 c	186 c
0	5	32 e	7.6	0.16 d	21.3 b	152 d
0	20	48 cd	24.0	0.18 cd	40.8 a	152 d
80	2	71 b	4.4	0.26 b	15.3 d	226 b
200	5	114 a	9.1	0.34 a	19.3 bc	254 a

*Mean values within a column followed by the same letter, for a given Field, are not significantly different at the 90% level of confidence.

In 2010, the same unconfounded factorial design for B, Cu and Zn was used in two corn fields. Miconutrient rates averaged 1.6, 1.7 and 3.0 lb/acre of B, Cu and Zn, respectively. The P, K and S nutrition in each field was maintained by application of 115, 133 and 29 lb/acre of P_2O_5, K_2O and S, respectively. The two fields evidenced the same pattern of response to the factorial combination of micronutrient treatments, so their statistical analyses were combined (Table 7).

The 2010 season turned dry at silking, and drought impacted the results. Field 2 exhibited 18 % greater yield than Field 1 (Table 7). On average, there was a 21 % greater yield where B was applied, but the difference was much larger in Field 1 (+ 48 %) than in Field 2 (Table 7), despite the fact that there was no difference in leaf B response to B addition between the two fields.

On average, there was a 10 % yield response to Cu addition (Table 7), a first for Kentucky, that is complicated by the fact that both leaf B and leaf Cu were positively influenced by Cu addition (Table 7). The statistical analysis for yield revealed a location by B by Cu interaction, where the greatest response to Cu addition occurred when no B was applied in Field 1, but in Field 2 was greatest when B was applied (Table 7). The yield interaction was not mirrored in the statistical analyses for leaf B and leaf Cu.

There was an average 10 % yield response to Zn fertilization (Table 7), that was also complicated by the positive impact of Zn addition on both leaf B and leaf Zn levels (Table 7). The statistical analysis for yield found a B by Zn interaction in all three of these variates. The addition of Zn was much less effective at improving corn Zn nutrition and yield when B was not added (Table 7), though the addition of Zn improved B nutrition in both fields.

Table 7. 2010 Russell County corn leaf tissue composition and grain yield response to greater B, Cu, and Zn nutrition (Sango and Lonewood silt loams).

Field	**B ?** no/yes	**Cu ?** no/yes	**Zn ?** no/yes	**Leaf B** ppm	**Leaf Cu** ppm	**Leaf Zn** ppm	**Yield** bu/acre
1	-	-	-	8.6 a	3.6 a	16.1 a	138 b
2	-	-	-	8.2 a	3.1 a	15.0 a	163 a
-	no	-	-	3.4 b	3.4 a	15.0 a	136 b
-	yes	-	-	13.4 a	3.3 a	16.2 a	165 a
1	no	-	-	3.6 b	-	-	111 b
1	yes	-	-	13.5a	-	-	164 a
2	no	-	-	3.1 b	-	-	161 a
2	yes	-	-	13.3 a	-	-	165 a
-	-	no	-	6.5 b	2.8 b	15.6 a	143 b
-	-	yes	-	10.3 a	3.9 a	15.6 a	158 a
1	no	no	-	3.4 c	3.1 b	-	90 d
1	no	yes	-	3.9 c	4.4 a	-	131 c
1	yes	no	-	10.0 b	2.9 b	-	163 b
1	yes	yes	-	17.0 a	4.0 a	-	165 b
2	no	no	-	3.0c	2.3 b	-	159 b
2	no	yes	-	3.3 c	3.9 a	-	163 b
2	yes	no	-	9.5 b	2.8 b	-	160 b
2	yes	yes	-	17.1 a	3.5 a	-	171 a
-	-	-	no	7.1 b	3.4 a	14.5 b	143 b
-	-	-	yes	9.7 a	3.3 a	16.6 a	158 a
-	no	-	no	3.4 c	-	14.9 b	133 c
-	no	-	yes	3.3 c	-	15.1 b	139 c
-	yes	-	no	10.8 b	-	14.2 b	153 b
-	yes	-	yes	16.0 a	-	18.2 a	177 a

*Mean values within a column, for a given ‘effect’, followed by the same letter are not significantly different at the 90% level of confidence.

These data indicate that these Russell County soils, especially under corn, do not provide sufficient micronutrient nutrition. The reasons for this vary with field and season, but are generally associated with seasonal climate, parent material and soil organic matter levels. Soils at the research center in Caldwell County are not so similar as to allow this work to be done there.

PROCEEDINGS OF THE

40th

NORTH CENTRAL

EXTENSION-INDUSTRY

SOIL FERTILITY CONFERENCE

Volume 26

November 17-18, 2010
Holiday Inn Airport
Des Moines, IA

Program Chair:

Richard Ferguson
University of Nebraska - Lincoln
Lincoln, NE 68583
(402) 472-1144
rferguson@unl.edu

Published by:

International Plant Nutrition Institute
2301 Research Park Way, Suite 126
Brookings, SD 57006
(605) 692-6280
Web page: www.IPNI.net