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Corn and Soybean Yield Response to Micronutrients in Central Iowa

Antonio Mallarino
Iowa State University, apmallar@iastate.edu

Mazhar Haq
Iowa State University, mazhar@iastate.edu

Joshua Enderson
Iowa State University

Ryan Oltmans
Iowa State University, oltma028@iastate.edu

Mike Fiscus
Iowa State University

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Abstract
Plant nutrients referred to as micronutrients are essential for crops, but are needed in very small amounts. Prior research in Iowa and neighboring states showed inconsistent corn and soybean grain yield responses to micronutrient applications, except for Zn in corn. This report summarizes results of two studies with corn and soybean, one with application to the soil and the other with application to foliage, which were conducted from 2012 through 2014. The micronutrients evaluated were boron (B), copper (Cu), manganese (Mn), and zinc (Zn).

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Antonio Mallarino, professor
Mazhar Haq, assistant scientist
Joshua Enderson and Ryan Oltmans, graduate assistants
Department of Agronomy
Mike Fiscus, farm superintendent

Introduction

Plant nutrients referred to as micronutrients are essential for crops, but are needed in very small amounts. Prior research in Iowa and neighboring states showed inconsistent corn and soybean grain yield responses to micronutrient applications, except for Zn in corn. This report summarizes results of two studies with corn and soybean, one with application to the soil and the other with application to foliage, which were conducted from 2012 through 2014. The micronutrients evaluated were boron (B), copper (Cu), manganese (Mn), and zinc (Zn).

Materials and Methods

The two trials with corn-soybean rotations were established on fields that had received no manure or micronutrients in recent years. The soils at the sites were Webster silty clay loam and Clarion loam for the trials with fertilizer to the foliage and soil, respectively. The trial with fertilizer application to the foliage began with corn and the trial with application to the soil began with soybean. The row spacing was 30 in. in both trials. The cornstalks were chisel-plowed in the fall and residues from both crops were field cultivated in the spring. Uniform, non-limiting rates of phosphorus, potassium, and sulfur were applied across all plots. A rate of at least 180 lb N/acre was applied for corn.

For both trials, six treatments were applied each year to the same plots that were replicated four times. For the trial with application to the soil, treatments were a control; separate applications of B, Mn, or Zn banded with the planter; a mixture banded with the planter; and a mixture broadcast and incorporated into the soil. The granulated fertilizers and application rates (element basis) used were NuBor 10 with 10 percent B at 0.5 lb B/acre banded and 2 lb B/acre broadcast, Broadman20 with 20 percent Mn at 5 lb Mn/acre for both banded and broadcast, and EZ20 with 20 percent Zn at 5 lb Zn/acre for both banded and broadcast treatments. The banded fertilizers were mixed with mono-ammonium phosphate (MAP), which was applied 4 lb N/acre and 21 lb P_2O_5/acre. The same MAP rate was applied with the planter for both the control and broadcast mixture treatments.

For the foliar fertilization trial, six treatments were applied each year to the same plots and were replicated four times. The treatments were a control; separate applications of B, Cu, Mn, or Zn; and a mixture of all four nutrients. Fluid fertilizers were sprayed twice to the same plots at the V5/V6 stage of both crops, the V8/V10 stage of corn, and the R2/R3 stage of soybean. We used a hand-held CO_2 sprayer with a 5-ft spraying width and 15 gallon water/acre application rate. The fertilizers were Max-In Boron (8% B), Max-In Copper (5% Cu), MicroBolt Zinc (9% Zn), and MicroBolt Manganese (6% Mn). The total rates applied across both applications for B, Cu, Mn, and Zn (element basis) were 0.16, 0.08, 0.33, and 0.495 lb/acre, respectively.

Soil B was analyzed by the hot-water method, whereas soil Cu, Mn, and Zn were analyzed by both the DTPA and Mehlich-3 methods. Grain was harvested from a central area of each plot, and the yield was adjusted to 15.5 percent moisture for corn and 13 percent moisture for soybean. A grain sample was taken from each plot to be analyzed for the micronutrients concentration.

Results and Discussion

Table 1 shows the soil micronutrient levels for plots without fertilizer application for both trials. The hot-water test for B and the DTPA test for Cu, Mn, and Zn are the soil-test methods recommended by the north-central region soil-testing committee (NCERA-13). This committee recommends the Mehlich-3 test for P and K but not for Cu, Mn, and Zn because of non-existing calibrations with crop response in the region. Soils also were analyzed by this method, however, because it is being used by some private laboratories. The soil-test data for both trials show the common temporal variation observed in soil testing, which can be attributed to within-plot variability and crop removal interacting with undetermined year effects.

Iowa State University has micronutrients soil-test interpretations only for Zn in corn and sorghum. A soil Zn level less than 0.9 ppm by the DTPA test is considered deficient or marginal in Iowa (see Extension Publication PM 1688) and other states of the region. Other states consider sufficient levels of 0.5 to 2 ppm for B (hot-water method), and 0.2 ppm for Cu and 1 to 2 ppm for Mn (both by the DTPA method), but these interpretations may or may not apply to Iowa soils and crops varieties.

Grain yield data in Table 2 and 3 show that yield levels were moderate to high, except for soybean in 2013 and 2014 when yields were slightly lower than normal. There was no statistically significant yield increase from application of any micronutrient to the soil or foliage in any trial or year. In contrast to results for grain yield, fertilization often increased the micronutrients concentration in harvested grain (not shown).

A lack of grain yield increase from Zn agrees with interpretations used in Iowa for corn, because the Zn soil-test results by the DTPA method ranged from 0.9 to 3.0, which are classified adequate or higher. A lack of yield increases from Cu and Mn agrees with interpretations from other states because test results were much higher than levels considered sufficient. Concerning B, we could have seen a small soybean response in 2012 by using as a reference the lowest value considered sufficient by some states but the highest value incorrectly predicted increases in all years of both trials.

Conclusions

There was no corn or soybean grain yield increase from micronutrients applied to the soil or foliage in any trial or year of the study. Soil-test interpretations in the north-central region correctly predicted a lack of yield increases from Cu, Mn, and Zn. For B, however, results that only the lowest value of sufficiency ranges used by some states of the region could apply to Iowa conditions.

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Table 1. Soil micronutrient soil-test levels for two trials.†

	Soil fertilization trial			Foliar fertilization trial		
Soil test	**2012**	**2013**	**2014**	**2012**	**2013**	**2014**
	ppm					
B	0.4	0.6	0.7	0.7	0.9	0.9
Cu DTPA	1.3	1.3	2.1	1.1	1.1	1.3
Mn DTPA	12	13	12	21	20	15
Zn DTPA	3.0	2.6	6.0	0.9	1.7	2.6
Cu Mehlich-3	2.5	2.1	4.5	2.3	3.3	2.6
Mn Mehlich-3	33	27	30	96	111	82
Zn Mehlich-3	4.2	3.0	6.4	1.8	3.5	2.5

†6-in. soil samples taken before fertilization each year. Values are averages for each site in 2012 and for the control plots in 2013 and 2014.

Table 2. Effect of fertilization to the soil with boron, manganese, and zinc on corn and soybean grain yield.

		Fertilizer treatment						
Year	**Crop**	**Control**	**B**	**Mn**	**Zn**	**Mixture banded**	**Mixture broadcast**	**Statistics†**
		bu/acre						
2012	Soybean	51.4	53.8	54.6	51.9	54.9	53.5	ns
2013	Corn	178	176	186	170	184	162	ns
2014	Soybean	37.5	39.0	38.7	40.6	41.5	40.7	ns

†ns, not significant at statistical probabilities ≤ 0.05.

Table 3. Effect of foliar fertilization with boron, copper, manganese, and zinc on corn and soybean grain yield.

		Fertilizer treatment						
Year	**Crop**	**Control**	**B**	**Cu**	**Mn**	**Zn**	**Mixture**	**Statistics†**
		bu/acre						
2012	Corn	205	196	207	201	207	199	ns
2013	Soybean	34.7	38.5	37.6	36.0	37.7	38.2	ns
2014	Corn	212	215	209	209	205	197	ns

†ns, not significant treatment differences at statistical probabilities ≤ 0.05.