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Corn and Soybean Yield Response to Micronutrients in an Iowa Sandy Soil

Antonio Mallarino
Iowa State University, apmallar@iastate.edu

Pablo Barbieri
Iowa State University, pablob@iastate.edu

Ryan Oltmans
Iowa State University, oltma028@iastate.edu

Joshua Enderson
Iowa State University

Vine Lawson
Iowa State University, vlawson@iastate.edu

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Abstract
Micronutrients are essential for crop growth, but prior research in Iowa and neighboring states has shown inconsistent grain yield responses to fertilization except for Zn in corn. In 2013, we summarized two years of research at this farm that evaluated effects of boron (B), manganese (Mn), and zinc (Zn) application on corn and soybean yields. In this report, we combine those results with additional research conducted in 2014.

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Antonio Mallarino, professor
Pablo Barbieri, postdoctoral research associate
Ryan Oltmans and Joshua Enderson, graduate assistants
Department of Agronomy
Vince Lawson, farm superintendent

Introduction

Micronutrients are essential for crop growth, but prior research in Iowa and neighboring states has shown inconsistent grain yield responses to fertilization except for Zn in corn. In 2013, we summarized two years of research at this farm that evaluated effects of boron (B), manganese (Mn), and zinc (Zn) application on corn and soybean yields. In this report, we combine those results with additional research conducted in 2014.

Materials and Methods

The experiment was conducted on a Toolesboro sandy loam soil with no history of manure or micronutrients application. Soil pH, organic matter, and clay were 6.2, 3.6, and 8.7 percent, respectively. Crops were corn in 2012, soybean in 2013, and corn in 2014. The cornstalks were chisel-plowed in the fall and residues from both crops were disked in the spring. Corn (Pioneer P1395AM in 2012 and 1023AM in 2014) and soybean (Pioneer 92Y75) were planted in rows spaced 30 in. apart. Soil B was analyzed by the hot-water method, and soil Mn and Zn were analyzed by both the DTPA and Mehlich-3 methods.

Six treatments, which included a control, were replicated four times and applied each year to the same plots. Each micronutrient was banded with the planter, a mixture was banded with the planter, and a mixture broadcast and incorporated into the soil. Each plot was 20 ft wide × 55 ft long. The granulated fertilizers and the application rates used were the following:
- Boron: NuBor 10, with 10 percent B at 0.5 lb B/acre banded and 2 lb B/acre broadcast.
- Manganese: Broadman20, with 20 percent Mn at 5 lb Mn/acre for both banded and broadcast.
- Zinc: EZ20, with 20 percent Zn at 5 lb Zn/acre for both banded and broadcast.

The fertilizers banded with the planter 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. Uniform, non-limiting rates of phosphorus (P), potassium (K), and sulfur (S) were applied across all plots. A rate of at least 200 lb N/acre was applied for corn. The plots were irrigated. Amounts of micronutrients applied with the water each year were insignificant in relation to the fertilizer rates applied (less than 0.034, 0.051, and 0.034 lb/acre of B, Mn, and Zn, respectively).

At the V5 to V6 crop growth stage, the above ground portions of plants were sampled from each plot. Corn ear leaves (blades) were sampled at the R1 stage (silking), and the uppermost soybean mature trifoliate leaves were sampled at the R2 to R3 stage. All tissue samples were analyzed for the concentrations of B, Mn, and Zn. At plant maturity, grain was harvested from a central area of each plot and yield was adjusted to 15.5 percent moisture for corn and 13 percent moisture for soybean.

Results and Discussion

Table 1 shows the initial soil micronutrient levels and the fertilization effects on post harvest levels in 2012 and 2013 (data from fall 2014 are not available at this time). The hot-water test for B and the DTPA tests for Mn and Zn are the soil-test methods recommended by the north-central region soil-testing committee (NCERA-13). The Mehlich-3 tests for Mn and Zn are not recommended because of non-existing calibrations with crop response, but are used by some private laboratories. Data for the control plots showed the usual observed variation over time. Fertilization increased most levels, but mainly after the second application. Iowa State University (ISU) has micronutrients soil-test interpretations only for Zn in corn and sorghum. Soil Zn levels less than 0.9 ppm by the DTPA method are considered deficient (ISU Extension Publication PM 1688). Other states consider soil-test levels of 0.5 to 2 ppm for B and 1 to 2 ppm for Mn (DTPA) sufficient, but these may or may not apply to Iowa conditions.

Table 2 shows plant-tissue test results from 2012 and 2013 (data from 2014 are not available at this time). Fertilization increased the B and Zn concentration in corn at the V5-V6 stage, but Mn fertilization seldom did. No treatment consistently increased any micronutrient concentration in corn leaves at the R1 stage or in soybean plants at any stage. Little or no fertilization effect on plant tissue concentration has been observed before. This lack of effect is explained by dilution of the small amounts applied in the dry matter produced. No state of the north-central region has any recommendations for the V5-V6 growth stage, but some have recommendations for samples taken later in the season. Deficiencies in corn are deemed likely if concentrations in the ear leaves at silking are less than 10, 15, and 15 ppm for B, Mn, and Zn, respectively. Deficiencies in soybean are deemed likely if concentrations in the leaves at early podding are less than 25, 20, and 15 ppm for B, Mn, and Zn, respectively.

Table 3 shows that crop grain yield levels were moderate to high, but there were no statistically significant yield increases from application of any micronutrient in any year. In 2014, there was an apparent yield decrease from the broadcast mixture, which was not statistically significant. Fertilization sometimes increased the micronutrients concentration in grain in 2012 and 2013 (not shown). Analyses of corn grain samples taken in 2014 have not been completed.

According to soil-test results in Table 1 and interpretations in Iowa or some other states, a yield increase could have been expected from B but not from Mn or Zn. ISU has no interpretations for tissue tests, but according to results in Table 2, use of interpretations for leaves in some states would have suggested corn yield increases for the three nutrients and soybean yield increases for B and Mn but not for Zn.

Conclusions

There was no grain yield response to any micronutrient. ISU soil Zn interpretations for corn (the only ones available) correctly predicted a lack of response. Use of soil or tissue test interpretations from other states often would have erroneously predicted corn or soybean responses from B, Mn, or Zn.

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Table 1. Initial and post-harvest micronutrient soil-test levels.

Soil Test	Spring 2012	Fall 2012		Fall 2013	
	Initial	Control	Treated†	Control	Treated†
	ppm				
B	0.18	0.28	0.21	0.32	0.41
Mn DTPA	2.1	2.0	2.0	1.9	2.3
Zn DTPA	1.2	1.3	1.7	2.3	6.8
Mn Mehlich-3	6.6	8.0	13.5	9.1	10.9
Zn Mehlich-3	1.7	0.9	3.2	1.9	8.1

†Average for the planter-band treatments (results from 2014 are not available at this time).

Table 2. Effect of fertilization with boron, manganese, and zinc on the concentration of these micronutrients in corn and soybean plant tissue at two growth stages.†

Crop	Year	Stage	Nutrient	Control	Nutrient alone	Mixture banded	Mixture broadcast
				ppm			
Corn	2012	V5-V6	B	6	8	10	14
			Mn	18	19	14	15
			Zn	26	29	29	30
		R1	B	4	4	5	6
			Mn	13	12	9	11
			Zn	11	11	11	11
Soybean	2013	V5-V6	B	24	27	25	26
			Mn	21	19	20	21
			Zn	37	29	31	27
		R2-R3	B	23	28	31	44
			Mn	24	25	22	24
			Zn	34	29	26	65

†Results from 2014 are not available at this time.

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

Crop	Year	Control	B	Mn	Zn	Mixture banded	Mixture broadcast	Statistics†
		bu/acre						
Corn	2012	199	196	193	193	185	185	ns
Soybean	2013	55.5	54.9	57.5	58.0	54.1	56.0	ns
Corn	2014	234	232	229	219	233	209	ns

†ns, not significant at statistical probabilities ≤ 0.05