Corn and Soybean Response to the Micronutrients Boron, Manganese, and Zinc Applied to the Soil

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Introduction

Prior research on micronutrients fertilization for corn and soybean has been scarce in Iowa and has shown inconsistent yield responses. Therefore, the objective of a study conducted during 2012 and 2013 was to assess effects of boron (B), manganese (Mn), zinc (Zn), and their mixture on corn and soybean grain yield. Iowa State University has no interpretations of soil or tissue tests for micronutrients, other than for Zn in corn and sorghum.

Materials and Methods

The site had no recent history of manure or micronutrient application. Soil type was Grundy silt clay loam with pH 5.8 and 4.8 percent organic matter. Soybean was planted in 2012 and corn was planted in 2013. Tillage was chisel-plowing of cornstalks in the fall and disking of both cornstalks and soybean residue in the spring. Corn (Pioneer 0993HR) and soybean (Pioneer 93M11) were planted using a 30-in. row spacing. Six treatments replicated four times were applied each spring to the same plots. These were a control, single applications of B, Mn, or Zn banded with the planter, a mixture banded with the planter, and a similar mixture broadcast and incorporated into the soil by disking. Each plot had six crop rows measuring 50 ft in length.

Granulated fertilizers were used, and the nutrient sources and application rates were the following:

- Boron: NuBor 10, with 10 percent B at 0.5 lb B/acre for planter-band and at 2 lb B/acre for broadcast.
- Manganese: Broadman20, with 20 percent Mn at 5 lb Mn/acre both for planter-banded and broadcast.
- Zinc: EZ20, with 20 percent Zn at 5 lb Zn/acre both for planter-banded and broadcast

All micronutrients banded with the planter were mixed with MAP at 4 lb N/acre and 21 lb P_2O_5/acre. The same MAP rate was applied with the planter for the control and broadcast treatments. Uniform, non-limiting rates of nitrogen, phosphorus, potassium, and sulfur were applied across all plots.

The initial soil-test levels (6-in. sampling depth) were 0.34 ppm for B, 20 ppm for Mn, and 2.3 ppm for Zn. Soil B was analyzed by the hot-water extraction method, and both Mn and Zn by the DTPA method. At the V5 to V6 crop growth stage, the above-ground portions of plants were sampled from each plot. Ear leaves of corn (leaf blades) were sampled at the R1 (silking) stage, and the uppermost mature trifoliate soybean leaves were sampled at the R2 to R3 growth stage. All samples were analyzed for their total micronutrient concentrations. Grain was harvested with a plot combine, and the yield was adjusted to 15.5 percent moisture for corn and 13 percent moisture for soybean.

Results and Discussion

Table 1 shows results of plant tissue analyses and effects of fertilization on the tissue concentrations. Fertilization with B, Mn, and

Zn alone or in mixture seldom had consistent effects on the concentrations of these nutrients in small plants or leaves. Consistent concentration increases with all application methods were observed only for B in small corn and soybean plants at the V5-V6 growth stage, and also for Zn in corn plants at the V5-V6 stage. There were no increases for Zn in soybean small plants or for Mn in corn or soybean small plants.

No fertilization treatment consistently increased the micronutrient concentrations in corn ear leaves at the R1 stage or in soybean plants at R2-R3 growth stage. Inconsistent or no effect of micronutrient fertilization on plant tissue concentrations have been observed before, which can be explained by dilution of the very small amounts applied in the plant dry matter.

Table 2 shows the grain yield results. Soybean yield levels were very low in 2012 because of insufficient rainfall. Corn yield levels were moderate to high in 2013, and were affected by excess moisture in early spring and insufficient rainfall later in the season. There were no statistically significant grain yield increases due to application of any micronutrient by any method in any year. For soybean, there were no clear trends. For corn, apparent increases ranging from 5 to 17 bushels/acre were not reliable or statistically significant because of high variability due to weather effects.

Iowa State University has micronutrients soil-test interpretations only for Zn in corn, for which DTPA soil-test values less than 0.9 ppm are considered deficient or marginal (Extension Publication PM 1688). Other states of the north-central region have similar interpretations. Therefore, no yield increase was expected because the initial Zn soil-test level was 2.3 ppm. Other states consider sufficient soil-test levels of 0.5 to 2 ppm for B and 1 to 2 ppm for Mn, but these may or may not apply to Iowa soils. A yield increase could have been expected from B since the initial level was 0.34 ppm but not from Mn because it was 20 ppm.

No state of the north-central region has micronutrient sufficiency levels established for corn or soybean at the V5-V6 growth stage, but a few have them for leaf tissue test results at mid-season. Guidelines in Illinois, for example, suggest possible deficiency if concentrations in corn ear leaves are less than 10, 15, and 15 ppm for B, Mn, and Zn, respectively. Guidelines for soybean indicate a deficiency may occur if concentrations of leaves at the early podding stage are less than 25, 20, and 15 ppm for B, Mn, and Zn, respectively. According to these recommendations and the observed leaf concentrations in the study (Table 1), we could have seen a grain yield increase only from B in corn because the concentration of B in the ear leaves in the control plots were the only ones lower (2.8 ppm) than the sufficiency levels indicated.

Conclusions

There was no crop yield increase from application of B, Mn, or Zn. A lack of yield response from Zn agreed with Iowa soil-test interpretations, and a lack of response from Mn agrees with interpretations in other states of the north-central region. However, a lack of yield increase from B indicated soil and tissue interpretations from other states do not apply to Iowa.

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Table 1. Effect of micronutrients fertilization on the concentration of boron, manganese, and zinc in plant tissue at two growth stages.

Crop	Year	Stage	Nutrient	Control	Nutrient alone	Mixture banded	Mixture broadcast
				------------------------ ppm ------------------------			
Soybean	2012	V5-V6	B	33	36	47	38
			Mn	49	44	58	55
			Zn	34	35	41	34
		R2-R3	B	45	45	45	56
			Mn	33	31	35	34
			Zn	48	46	46	50
Corn	2013	V5-V6	B	9.3	11	9.5	15
			Mn	115	72	65	74
			Zn	36	43	42	42
		R1	B	2.8	2.8	3.0	3.8
			Mn	47	40	47	41
			Zn	22	20	20	26

Table 2. Effects of fertilization with the micronutrients boron, manganese, and zinc on corn and soybean grain yield.

Crop	Year	Control	B	Mn	Zn	Mixture banded	Mixture broadcast	Statistics*
		-------------------------------- bu/acre --------------------------------						
Soybean	2012	37.9	39.1	38.2	38.2	38.3	37.4	ns
Corn	2013	160	165	169	177	171	167	ns

*ns, not significant at P≤0.10 or P≤0.05.