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Evaluation of Secondary and Micronutrients for Soybean Production in Kansas

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Abstract

Study of secondary and micronutrients is growing because of their potential contribution to yield increases. The objective of this study was to evaluate soybean response to secondary and micronutrient fertilizer application to maximize yields. A randomized complete block design was employed with four replications at five locations during 2013 and five locations in 2014. Treatments consisted of an unfertilized control; micronutrient fertilizer as individual nutrients for boron, copper, manganese, sulfur, and zinc; and a mix of these nutrients using two different placements (dry broadcast and liquid band). Soil samples were collected prior to planting and after harvest. Soybean trifoliates were collected at R2–R3 growth stage and analyzed for the micronutrients evaluated in this study. At harvest, nutrient concentration was analyzed in the seed, and yield was calculated at 13% moisture. No significant difference was found in yields between treatments by location or across locations. Results from tissue and grain analysis showed significant treatment effects on zinc concentrations across locations.

Keywords

micronutrient, soybean, tissue analysis

Evaluation of Secondary and Micronutrients for Soybean Production in Kansas

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Summary
Study of secondary and micronutrients is growing because of their potential contribution to yield increases. The objective of this study was to evaluate soybean response to secondary and micronutrient fertilizer application to maximize yields. A randomized complete block design was employed with four replications at five locations during 2013 and five locations in 2014. Treatments consisted of an unfertilized control; micronutrient fertilizer as individual nutrients for boron, copper, manganese, sulfur, and zinc; and a mix of these nutrients using two different placements (dry broadcast and liquid band). Soil samples were collected prior to planting and after harvest. Soybean trifoliates were collected at R2–R3 growth stage and analyzed for the micronutrients evaluated in this study. At harvest, nutrient concentration was analyzed in the seed, and yield was calculated at 13% moisture. No significant difference was found in yields between treatments by location or across locations. Results from tissue and grain analysis showed significant treatment effects on zinc concentrations across locations.

Introduction
Obtaining maximum yield production of a particular crop requires adequate supply of all essential nutrients, including micronutrients that can limit plant growth and yield. One way to avoid yield reduction is through a complete and adequate supply of nutrients with fertilizer application. Essential plant micronutrients are zinc (Zn), iron (Fe), manganese (Mn), boron (B), chloride (Cl), and copper (Cu). Although there has been more emphasis on macronutrient (nitrogen, phosphorus, and potassium) deficiencies, micronutrient deficiencies can cause the same significant effects by reducing productivity (Havlin et al., 2005). Research with B, Cu and Mn, and S has not shown consistent responses for optimum yields. Most Kansas soils are considered adequate in micronutrients, and fertilization is not usually recommended; however, some soils may be low in some micronutrients. In Kansas, Fe and Mn are the most common deficiencies (Mueller, 2012). Past studies conducted on soybean suggest potential trends of plant nutrient uptake in response to secondary and micronutrient fertilizer application. This study emphasizes soybean production under optimum conditions, where micronutrients can potentially help maximize yields.

Procedures

This project was completed at university experiment fields and producer farms using conventional small-plot methodology. The small plots were established on a total of 10 sites in 2013 and 2014. The size of individual plots was 10 ft × 27 ft. A randomized complete block design was employed with four replications at all locations. Treatments consisted of micronutrient fertilizer applied as individual nutrient for B, Cu, Mn, S, and Zn, in addition to a mix of these nutrients using two different placements (broadcast and band application). All of the micronutrients were dry fertilizer sulfate–based and gypsum for the S treatment. The rates for Cu, Mn, S, and Zn were broadcast-applied at 10 lb/a and 2.5 lb/a for B. Including a control, 8 treatments were replicated 4 times.

Soil samples at a depth of 0–6 in. were collected from each individual plot prior to treatment application and postharvest (Table 1). A composite of 10 cores was collected from the two middle rows of each plot. The analysis included soil test phosphorus (P), soil test potassium (K), and soil pH, in addition to micronutrients B, Cu, Mn, and Zn. Soil pH was determined on a 1:1 (soil:water) basis. Soil P was determined by Mehlich-3 extraction (Frank et al., 1988). The soil organic matter test was collected per block and analyzed by the Walkley-Black method (Combs and Nathan, 1998). Copper, Mn, and Zn were analyzed by DTPA extraction (Whitney, 1998), and B by the hot water method.

Tissue samples provided evidence to support the outcome of the micronutrient fertilizer treatments. Tissue samples were collected at R2–R3 stage, taking 30 uppermost trifoliates of the two middle rows (15 trifoliates per row). The analysis of tissue sample was for total P, K, S, B, Cu, Mn, and Zn.

The harvested area of each plot was 5 ft × 27 ft (the two middle rows). Grain samples were weighed to calculate yield. Grain yield was adjusted to 13% moisture, and test weight was determined by using a grain analysis computer (GAC 2100, Dickey-john). Grain samples were analyzed for P, K, S, Cu, B, Mn, and Zn concentration.

Data were analyzed by location and across locations. Soybean parameters were analyzed using PROC GLIMMIX (SAS 9.3; SAS Institute Inc., Cary, NC) to determine if a significant response to treatments occurred. Separation of means at a significance level of $P = 0.10$ was done using the LINES option in PROC GLIMMIX.

Results

Yield response showed no effect of fertilizer application between treatments across locations (Table 2). The application of micronutrients tended to increase yields compared with the control, but no significant difference was observed by any individual nutrient or blend of nutrients. These results are similar to those obtained by Widmar (2013) on double-crop soybean after wheat.

A clear trend can't be seen for the element concentration in tissue samples, except for Zn (Table 3). The same trend for Zn was found for grain samples. For soil test changes comparing individual elements and blend of the same, no evidential trend was detected for any of the treatments applied (Figures 1, 2, 3 and 4).

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Table 1. Site description, soil test data, and soybean variety for small plots 2013–2014

Site	County	Sand	Clay	Organic matter	P	K	B	Cu	Fe	Mn	Zn	Soybean variety
		%			ppm							
2013												
1	Reno	80.5	7.0	1.1	27.3	134	0.6	0.2	14.1	10.9	1.1	P94Y23
2	Franklin	11.5	22.5	2.7	9.4	141	1.8	1.3	64.4	40.7	1.2	Prod. 3801
3	Republic	22.0	17.5	2.1	38.2	534	0.9	1.0	57.5	43.7	0.8	---
4	Shawnee	37.0	10.0	1.5	33.1	206	0.9	0.8	21.7	19.8	1.3	Prod. 3801
5	Jefferson	10.5	33.0	3.2	59.0	258	1.5	1.2	36.9	24.6	5.0	---
2014												
6	Clay	13.0	27.5	2.4	28.1	263	0.5	1.2	63.3	25.5	0.7	P39T67R
7	Brown	11.5	21.0	2.0	57.1	211	0.4	2.1	85.8	45.3	1.7	383-2R
8	Franklin	14.0	24.0	2.3	5.6	116	0.4	1.4	81.6	40.5	1.3	P48T53R
9	Shawnee	37.5	17.0	2.0	5.2	211	0.4	0.7	14.9	14.8	0.3	NK 39U2
10	Republic	19.5	22.5	2.6	11.5	502	0.6	1.1	55.2	30.8	1.4	---

Table 2. Soybean yield (adjusted to 130 g/kg moisture) in response to secondary and micronutrient fertilizer at 10 sites in 2013 and 2014 ($\alpha < 0.10$)

	Treatments							
Site	Control	B	Cu	Mn	S	Zn	Broadcast mix	P < F
	------ Yield (bu/a) ------							
1	29	25	33	35	33	33	35	0.277
2	39	38	37	39	37	38	37	0.761
3	65	71	68	65	66	62	61	0.407
4	56	62	57	57	57	60	62	0.281
5	62	66	61	62	62	61	68	0.597
6	50	49	50	51	50	49	46	0.603
7	79	80	83	79	81	80	77	0.891
8	39	41	39	41	37	37	38	0.553
9	29	26	24	30	27	28	29	0.681
10	61	64	60	59	62	62	60	0.480
Average	51	52	51	52	51	51	51	0.9522

Table 3. Significance test for soybean parameters (tissue and grain analysis) across locations in 2013 and 2014 ($\alpha < 0.10$)

	Variables			
Sample	S	Cu	Mn	Zn
	------ $P < F$ ------			
Trifoliates	0.633	0.021	0.044	<.0001
Grain	0.975	0.199	0.630	<.0001

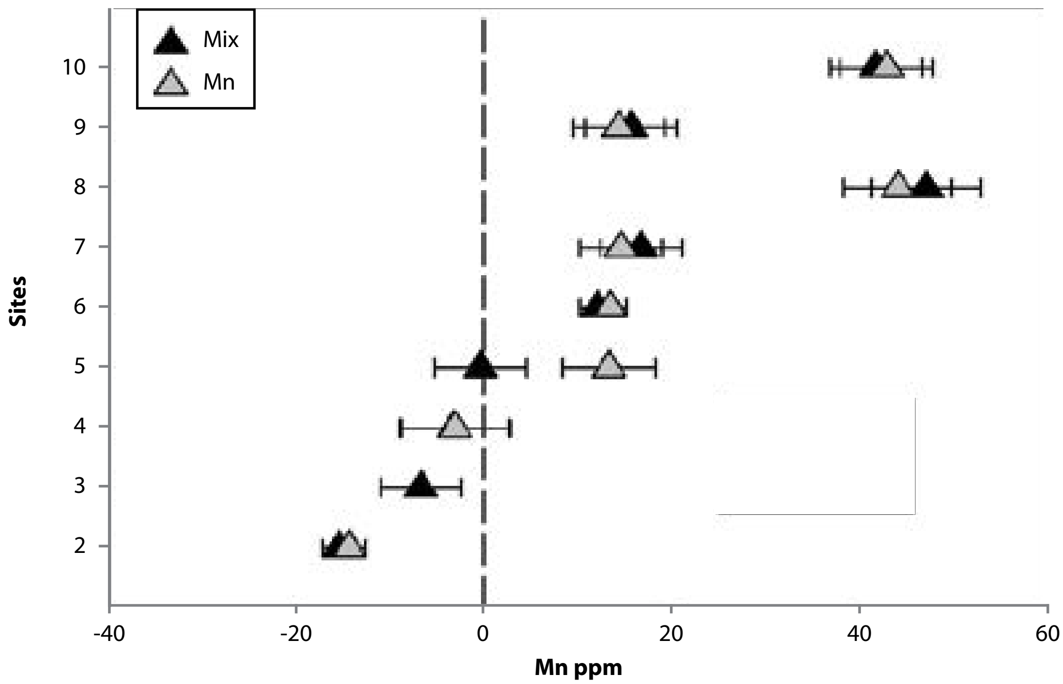

Figure 1. Changes in soil test levels after manganese (Mn) fertilizer application at 10 sites in 2013 and 2014.

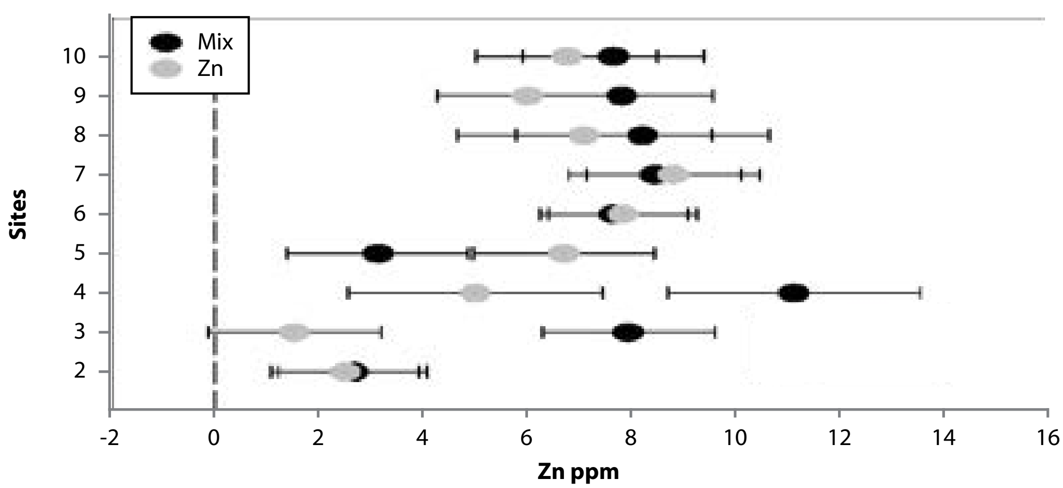

Figure 2. Changes in soil test levels after zinc (Zn) fertilizer application at 10 sites in 2013 and 2014.

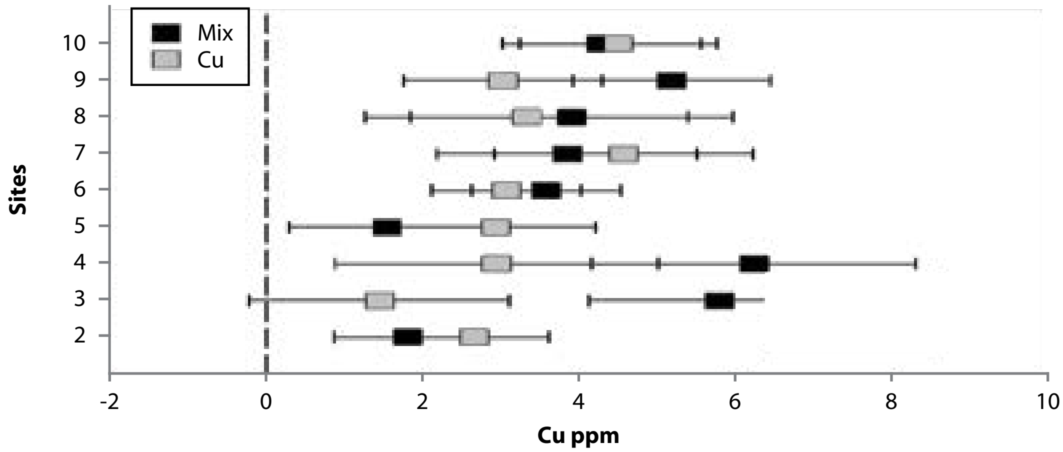

Figure 3. Changes in soil test levels after copper (Cu) fertilizer application at 10 sites in 2013 and 2014.

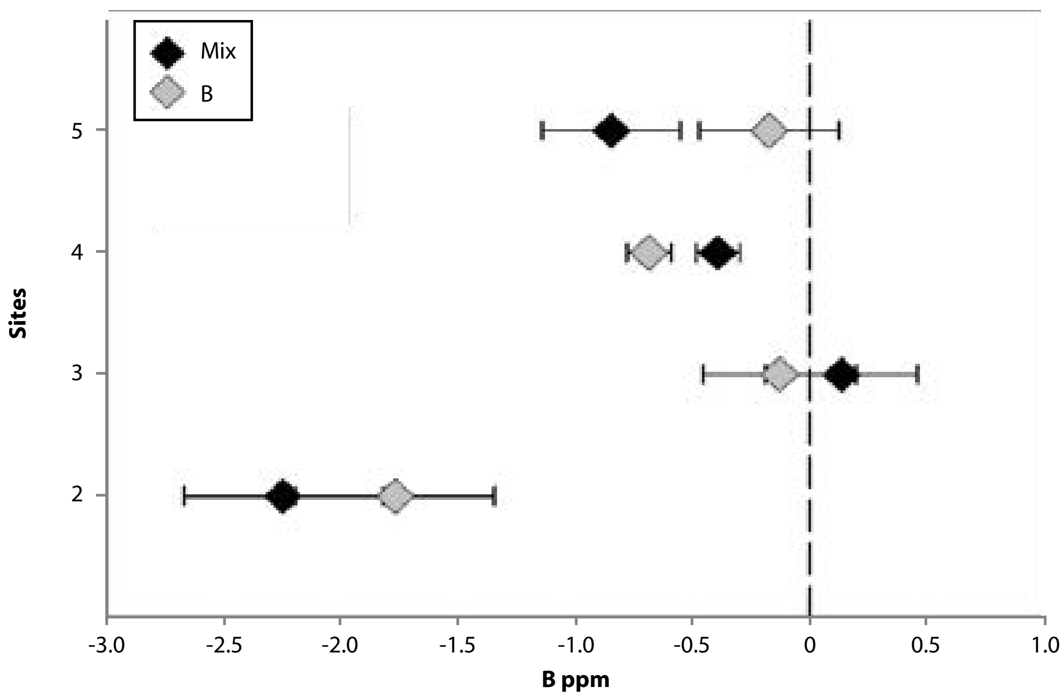

Figure 4. Changes in soil test levels after boron (B) fertilizer application at four sites in 2013.