EVALUATION OF SECONDARY AND MICRONUTRIENT FOR SOYBEAN PRODUCTION IN KANSAS

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Abstract

Secondary and micronutrients are being increasingly studied for their potential to contribute to yield increase. 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 micronutrient fertilizer as individual nutrient for B, Cu, Mn, S and Zn, in addition to 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 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 and across locations. Results from tissue and grain analysis showed significant treatment effect on Zn concentration across locations.

Introduction

Obtaining maximum yield production of a particular crop would require adequate supply of all essential nutrients, including micronutrients that can limit plant growth during the growing season and yield. One of the ways to avoid yield reduction is through a complete and adequate supply of nutrients with fertilizer application. The essential plant micronutrients are zinc (Zn), iron (Fe), manganese (Mn), boron (B), chloride (Cl), and copper (Cu). Although there has been more emphasis on macronutrients (nitrogen, phosphorus and potassium), deficiency; both can cause the same significant effect by reducing productivity (Havlin et al., 2005). Research with boron, copper manganese and sulfur has not shown consistent responses for optimum yields. Most Kansas soils are considered adequate in micronutrient levels and fertilization are usually not recommended. However, some soils may be low on some micronutrients. In Kansas, iron and zinc 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 contribute to maximize yields.

Materials and methods

This project was completed at university experiment fields and producer farms using conventional small plot methodology. The small plots were established in a total of 10 sites through 2013 and 2014. The size of individual plots was 10 ft. wide and 27 ft. long. 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 lbs acre^{-1} and 2.5 lbs acre^{-1} for B. These were applied as individual nutrients and one treatment as mix of all these individual nutrients. One additional treatment included band-applied liquid source of 1 lb/acre of Zn, Mn and Cu EDTA and 0.5 lbs acre^{-1} of boric acid. Including a control, there was a total of 8 treatments and replicated 4 times.

Soil samples at a depth of 0-6 inches were collected from each individual plot prior to treatment application and at post-harvest. A composite of ten cores was collected from the 2 middle rows of each plot. The analysis included soil test phosphorus, soil test potassium and soil pH, in addition to the micronutrients B, Cu, Mn, and Zn. Soil pH was determined on 1:1 (soil: water). Soil phosphorus was determined by Mehlich3-extraction (Frank et al., 1988). Soil organic matter test was collected per block and was analyzed by the method of Walkley-Black (Combs and Nathan, 1998). Copper, Mn and Zn were analyzed by DTPA extraction (Whitney, 1998) and B by method of hot water.

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. wide and 27 ft. long (the two middle rows). Grain samples were weighed to calculate yield. Grain yield was adjusted to a 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.

The data was analyzed by location and across locations. Soybean parameters were analyzed using PROC GLIMMIX (SAS 9.3) to determine if a significant response to treatments occurred. Separation of means at a significant level of $P=0.10$ using the LINES option in PROC GLIMMIX.

Summary

Yield response showed no effect of fertilizer application. The application of micronutrients tended to increase yields in comparison to the control but no significant difference was observed by any individual nutrient or blend of nutrients (Table 1). These results are similar to the ones obtained by Widmar (2013) on double crop soybean after wheat.

For tissue samples there was no significant difference in P, K, and S. On the Hutchinson site significant differences were found for Cu, Mn and Zn. Four out of five locations showed a response to Zn concentration in tissue and two sites showed response for the Mn application. A clear trend can't be seen for the element concentration in tissue sample except for Zn. The same trend for Zn was found for grain samples (Table 2).

Manganese levels in post-harvest soil samples tended to be not significant at most locations. For Ottawa and Topeka broadcast mix showed the highest levels for all the nutrients applied, except for Mn in one of this sites (Fig. 1-4). In general, the broadcast mix and the nutrient applied individually generated higher levels than those of the control.

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Table 1. Soybean yield (adjusted to 130 g kg^{-1} moisture) response to secondary and micronutrient fertilizer at 5 sites in 2013.

Treatments	Sites					
	Hutchinson	Ottawa	Scandia	Topeka	Winchester	Average
	- - - - - - - - - - - - - - - - - - Yield (bushels $acre^{-1}$) - - - - - - - - - - - - - - - - - -					
Control	29	39	65	56	62	50
B	25	38	71	62	66	52
Cu	33	37	68	57	61	51
Mn	35	39	65	57	62	52
S	33	37	66	57	62	51
Zn	33	38	62	60	61	51
Broadcast Mix	35	37	61	62	68	53
Banded Mix	27	38	65	62	64	51
P < F	0.277	0.577	0.197	0.281	0.597	0.848

Table 2. Significance test for soybean parameters (tissue and grain analysis) (α<.10).

Sample	Variables	Sites					
		Hutchinson	Ottawa	Scandia	Topeka	Winchester	Across Sites
					P < F		
Tissue	P	0.257	0.771	0.320	0.167	0.757	0.7528
	K	0.394	0.295	0.320	0.589	0.655	0.4027
	S	0.163	0.481	0.185	0.461	0.174	0.6331
	Cu	0.009	0.415	0.545	0.599	0.185	0.0208
	Mn	0.076	0.289	0.234	0.018	0.154	0.0436
	Zn	0.002	0.548	0.002	<0.001	0.001	<.0001
Grain	P	0.730	0.960	0.403	0.462	0.417	0.3036
	K	0.743	0.493	0.349	0.708	0.455	0.9793
	S	0.165	0.209	0.711	0.206	0.595	0.9913
	Cu	0.039	0.302	0.579	0.074	0.298	0.3028
	Mn	0.946	0.923	0.510	0.583	0.744	0.6075
	Zn	0.436	<0.001	0.025	<0.001	0.639	<.0001

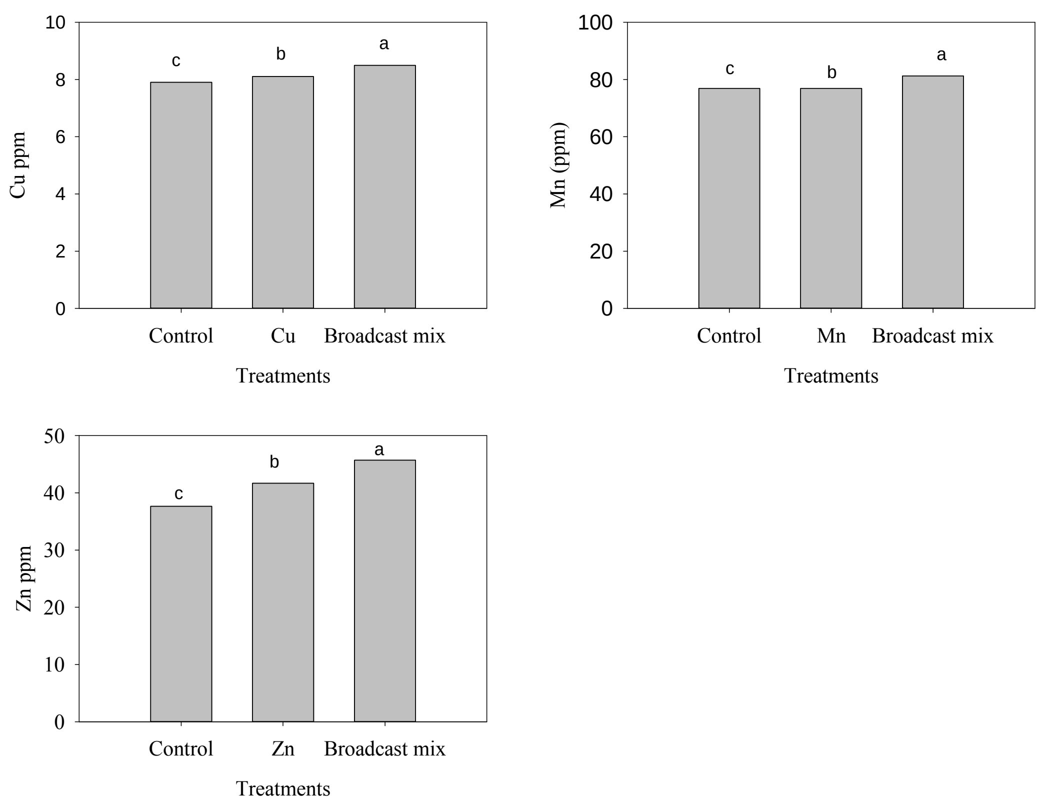

Figure 1. Tissue test levels in the trifoliate leaves collected at the R2-R3 stage across sites.

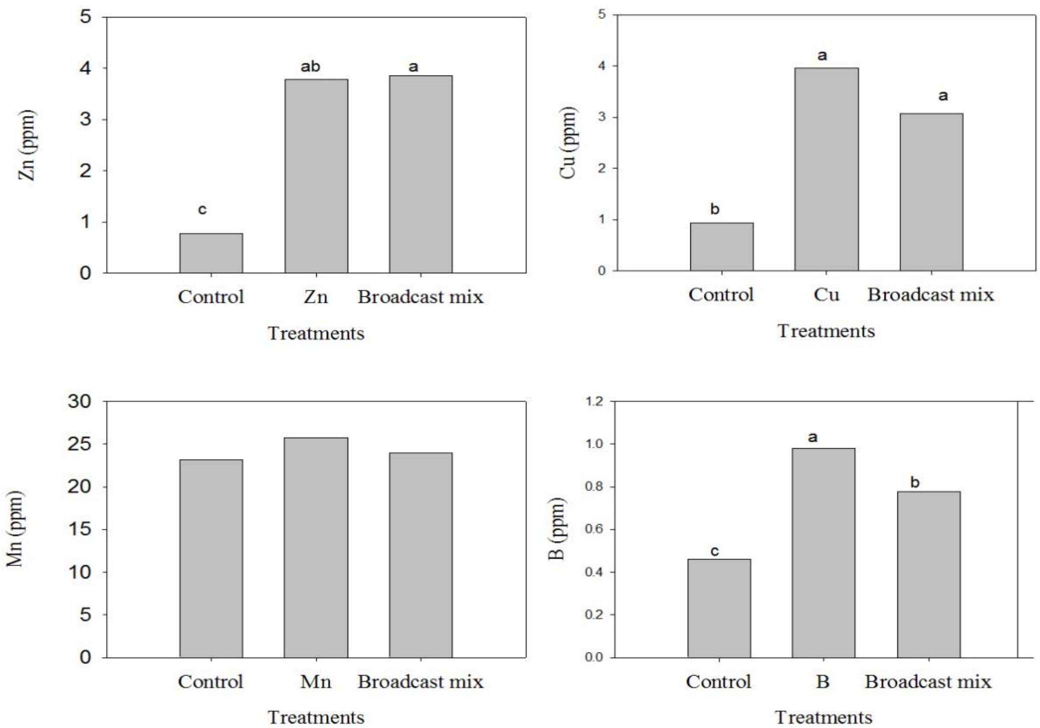

Figure 2. Post-harvest soil test levels of nutrients applied with fertilizer at the Ottawa location.

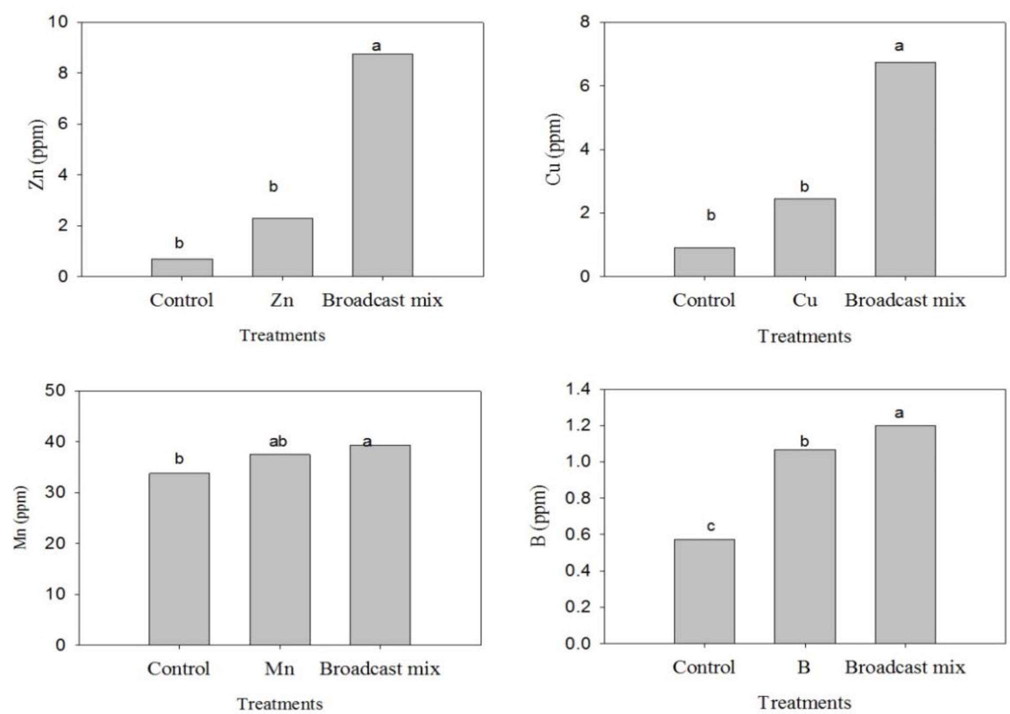

Figure 3. Post-harvest soil test levels of nutrients applied with fertilizer at the Scandia location.

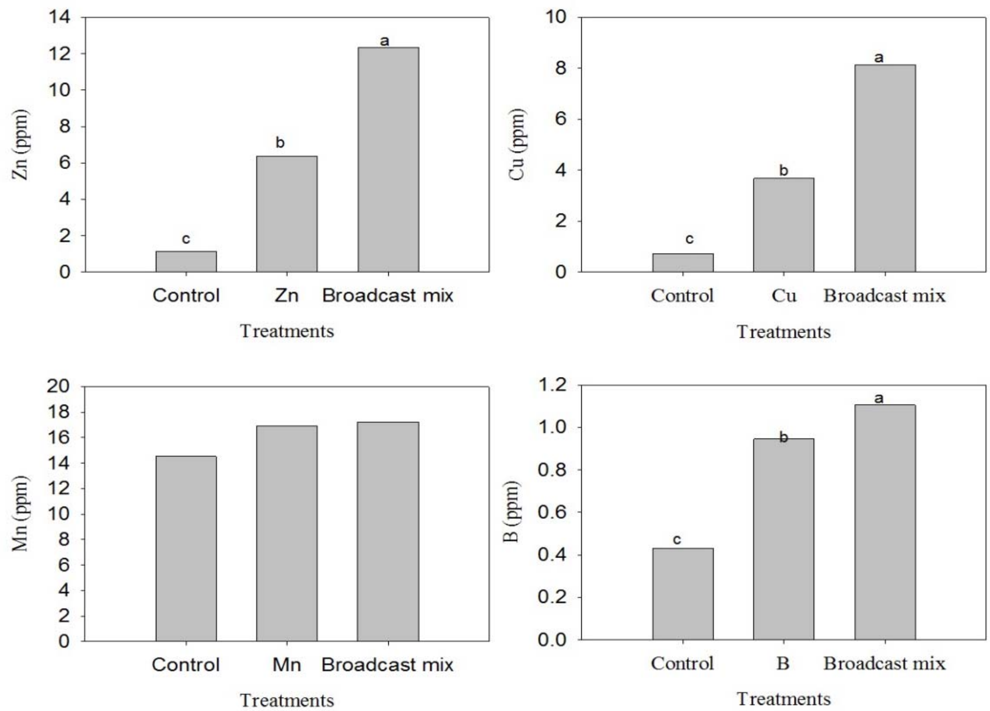

Figure 4. Post-harvest soil test levels of nutrients applied with fertilizer at the Topeka location.

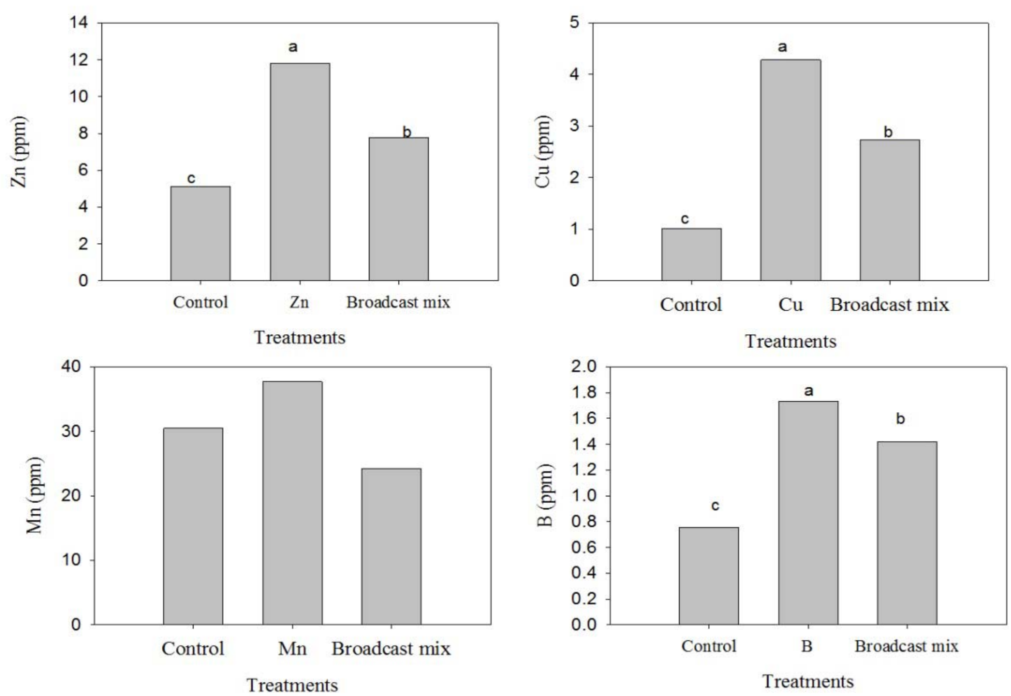

Figure 5. Post-harvest soil test levels of nutrients applied with fertilizer at the Winchester location.

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