EVALUATION OF MACRO AND MICRONUTRIENTS FOR DOUBLE-CROP SOYBEAN AFTER WHEAT

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Abstract

With double crop soybean production, fertilizer is typically applied prior to planting wheat and intended for both crops; when wheat nutrient removal is higher than expected this may limit nutrient supply for the following soybean crop. The objective of this study was to evaluate the response of soybean grown after wheat to soil-applied and foliar fertilization, including changes in tissue nutrient concentration, and response in grain yield. Four sites were established in 2011 and 2012. All sites for this study were rain fed on no-till fields planted immediately after wheat harvest. Macronutrients (N, P, K) and micronutrients (Fe, Mn, Zn) and S were band-applied at planting. Foliar micronutrients were applied at flowering (R1). Tissue samples were collected prior to foliar fertilizer application at R1. Pre-plant and post-harvest soil sample were collected and analyzed. The tissue and soil samples were analyzed for the nutrients applied with the fertilizer treatments. During the two years of this study severe drought limited the potential yield response and possibly nutrient uptake, and this should be considered for data interpretation. Results across site-years indicated that tissue nutrient concentration for micronutrients was a poor indicator of potential yield response. Soybean seed yield sowed small response to soil-applied S, Mn, and Zn. However when micronutrients were foliar-applied, seed yield was significantly decrease, likely due to some leaf damage caused by foliar fertilizer application.

Introduction

Double cropping soybean after wheat can be a risky in much of Kansas due to the possibility of frost injury later in the season. Some years (like 2011 and 2012) the lack of water becomes a severe issue for double crop soybean grown after wheat that may leave very limited residual moisture in the soil. However, soybean can still be a very productive and a very profitable option most years. There are several advantages to double cropping soybean after wheat that can make it a plausible option. A successful double cropping system has the following advantages: increased gross returns per acre relative to small production cost increases, spreading of fixed costs such as land, taxes and machinery over two crops, reduced soil erosion because of continuous vegetative cover and enhanced use of land, labor and equipment (Massey, 2010). According to a 2010 cost-return study in central and eastern Kansas double-crop soybean can be very profitable. With average yields and grain prices in this region return to annual costs can range from 11-150% (Dumler and Shoup 2011). This coupled with limited inputs makes double-crop soybean a good option compared to letting the wheat field in follow during this period.
When it comes to fertilizing double crop soybean there are several different application methods that can be used. The fertilizer can be applied broadcast, sub-surface banded or by foliar application. Application timing is also another factor that should be considered. Typically when fertilizing double crop soybean the application is made pre-plant, pre-emergence, or even post emergence depending on what nutrients you are applying and what the soil test levels are. It is

also not uncommon to apply extra fertilizer when topdressing wheat to meet the fertilizer requirement for both the wheat and soybean (Minor and Wiebold 1998). By applying extra fertilizer when top-dressing the wheat crop will benefit from this application and likely provide residual nutrients for the following soybean crop.

Another factor for fertility management of both crops is the potential mobility and loss potential of each nutrient in the soil, this can be particularly important for areas with high rainfall. When dealing with mobile nutrients such as nitrogen and sulfur direct application before soybean planting may be particularly important. Nutrients such as phosphorous, manganese, iron, and zinc with limited mobility in the soil, may benefit from band application and near the roots for soybean (Minor, H. C. and W. Wiebold 1998).

Methods and Materials

Field experiments were conducted at 4 locations throughout central and eastern Kansas in 2011-2012. Sites were located at Belleville (North Central KS), Coffeyville (Southeast KS), Ottawa (East Central KS) and Rossville. Soil types were Crete silt loam in Belleville, Bates silt loam in Coffeyville, Wilson silt loam in Ottawa, and Eudora Silt loam in Rossville (table 2). Soybean was planted on 76 centimeter rows for Belleville, Ottawa, and Rossville. Coffeyville was drilled on 19 centimeter rows. At all locations fertilizer was applied surface band at planting. Nutrients applied included: Nitrogen as urea (22 kg N ha^{-1}) Phosphorus as mono-ammonium phosphate (MAP) (22 kg P_2O_5 ha^{-1}), Potassium as potassium chloride (22 kg K_2O ha^{-1}), Sulfur as elemental sulfur (22 kg S ha^{-1}), Iron as iron sulfate (11 kg Fe ha^{-1}), and Zinc as zinc sulfate (11 kg Zn ha^{-1}).

Foliar micronutrients Iron, Manganese, and Zinc were applied at a rate of 0.2 kg ha^{-1} at R1 growth stage. They were applied as HEDTA chelated Iron, and EDTA Manganese and Zinc. Soil samples were collected before planting and after harvest to evaluate the change in soil test values at 0-15 centimeter depth. The uppermost fully developed trifoliate (without petiole) was collected ta the R1and analyzed for Nitrogen, Phosphorus, Potassium, Sulfur, Iron, Manganese, and Zinc.

The experimental design was a randomized compete block design with 7 treatments. Treatments followed an omission plot approach, with one nutrient (or set of nutrients) omitted from the mix for each treatment (table 1). Statistical analysis was completed in SAS using the GLIMMIX procedure. Site and block within site were considered as random factors in the model. Statistical significance was set at the 0.10 probability level.

Table 1. Treatment numbers and nutrient(s) omitted from each treatment following an omission plot approach.

Treatment number	Nutrient(s) omitted
1	None
2	N, P, K
3	S
4	Fe
5	Mn
6	Zn
7	Foliar Fe, Mn, Zn

Results and Discussion

Soils at the study sites were all silt loam, with near optimum pH and nutrient levels as indicated by soil test (table 2). Potassium levels were very low at the Coffeyville location, suggesting a possible response to macronutrient application including K. Soil test for micronutrients (Zn, Fe, and Mn) are not calibrated for Kansas. However current guidelines indicate that soil test Zn would be in the optimum range (>1 ppm) for all sites and fertilizer Zn application would not be recommended.

Table 2. Soil information and average soil test results for 3 locations.

Site	Soil Series	CEC	pH	OM	P	K	Zn	Fe	Mn
		(meq/100g)		%	- - - - - - - - ppm- - - - - - - - - -				
Belleville	Crete Silt Loam	19.23	5.29	2.2	42	630	1.7	112.8	83.4
Coffeyville	Bates Silt Loam	17.52	6.41	1.6	24	74	1.8	44.9	35.3
Ottawa	Wilson Silt Loam	23.10	6.86	2.2	13	125	1.4	30.6	35.2

Zn, Fe, and Mn analyzed with the DTPA extraction.; P, Mehlich-3, colorimetric.
K, Ammonium-acetate.

Table 3. Increase in tissue nutrient concentration with the addition of fertilizer treatments.

Nutrient	Increase in concentration	Significance
	ppm	*P > F*
N	0.20	0.122
P	0.02	0.119
K	0.33	0.004
S	0.01	0.154
Fe	5.66	0.393
Mn	-0.81	0.893
Zn	-1.41	0.154

Increase in tissue nutrient concentration with the application of macro and micronutrients were inconsistent (table 3), with significant increase for tissue K across sites. Is increase in leaf K concentration may be due to the low soil test K found at some sites in the study. Is also possible that plant uptake from the band applied fertilizer was limited and therefore not evident by tissue analysis. Conditions during the growing season with limited rainfall may also influence these results. However, soybean seed yield showed small but significant yield increase to the application of sulfur as well as zinc and manganese (fig. 1). This may suggest that changes in tissue nutrient concentration were not a good indicator of potential yield response (Table 2 and fig. 1). However, is also possible that average yield increases are primarily contributed by sulfur from the Fe, Mn and Zn sulfate fertilizer sources and additional analysis is required. Foliar application of the combination of micronutrients (Fe, Mn and Zn) generated a decrease in seed yield (Fig 1). This was likely the result of visual leaf damage observed after foliar fertilizer application. Alternative foliar fertilizer sources may be required. Many studies have shown the benefit of foliar fertilizers, particularly for micronutrient management. However, similar to our results, some studies have shown different levels of leaf damage. This suggest that foliar application of some fertilizer sources may not be appropriate, and sources as well as application rates should be considered for attain the intended beneficial effect of foliar fertilizer application.

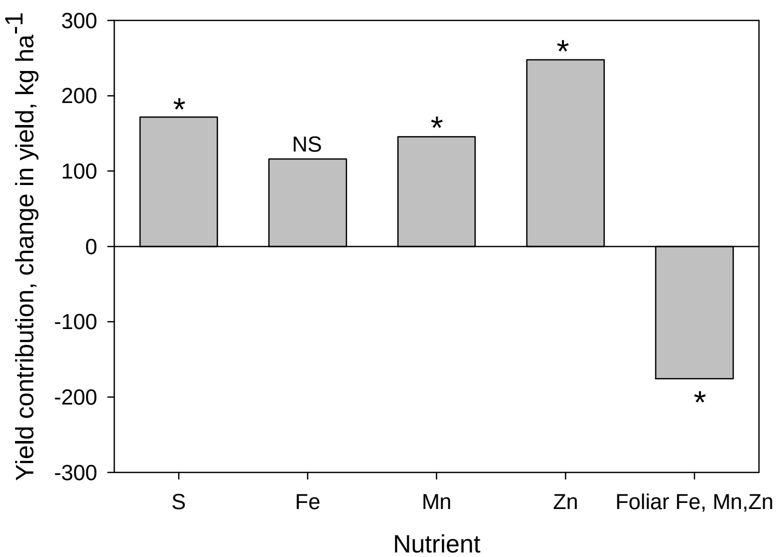

Figure 1. Yield response contributed by each of the nutrient(s). Yield values are expressed as the difference between treatment 1 minus each treatment (Table 1.) Asterisk indicates statistically significant differences from zero.

Summary

In all locations rainfall was significantly below yearly totals and expected yield was well below the county averages for all locations. Preliminary results from this study showed that band-applied fertilizer application increased yield. Soil-applied fertilizers sulfur, manganese, and zinc showed slight but significant yield responses across all locations. Similar yield tendencies were found for iron but they were not statistically significant. Foliar fertilizer significantly decreased yield across locations. This may have been caused by leaf damage from foliar fertilizer application. Although it was not statically significant, there was a numeric decrease in tissue Mn and Zn concentrations, however this did not affect yield.

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PROCEEDINGS OF THE

42^{nd}

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SOIL FERTILITY CONFERENCE

Volume 28

November 14-15, 2012
Holiday Inn Airport
Des Moines, IA

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Published by:
International Plant Nutrition Institute
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Brookings, SD 57006
(605) 692-6280
Web page: www.IPNI.net