SULFUR UPTAKE AND YIELD RESPONSE IN CORN AS AFFECTED BY FERTILIZER SOURCE AND RATE

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ABSTRACT

With sulfur deficiencies being found throughout Kansas, the evaluation of sulfur fertilization and plant uptake are vital to optimize corn production. The objective of this study was to evaluate the effect of application rates of sulfur on yield and uptake in corn. Nutrient concentrations in corn, biomass, and grain were evaluated at the Kansas River Valley Experiment Field at Rossville, Kansas in 2019. Five treatments were evaluated, including a control with no sulfur and no nitrogen, and four fertilizer treatments with 180 lbs of nitrogen and four rates of sulfur fertilizer (0, 30, 50, and 200 lbs. S acre^{-1}). The nitrogen source was urea and balanced for all treatments at 180 lbs. N acre^{-1}. The sulfur-containing fertilizers applications were at the time of planting corn. Whole corn plant biomass and grain samples were taken at physiological maturity and analyzed for nitrogen and sulfur concentrations. Results for the study show that sulfur application rates have a significant yield response in corn likely contributing to increased uptake of nitrogen. Moreover, high yielding environments increased whole plant sulfur uptake and removal.

INTRODUCTION

With the current lower commodity prices for corn, producers are looking to optimize nutrient inputs to enhance returns. Until recent years, sulfur is a nutrient that has often been overlooked. Increasing crop removal due to higher yields, decreased atmospheric deposition, and a greater amount of crop residues have increased the likelihood of sulfur deficiency (Camberato and Casteel, 2017). With decreasing soil test sulfur comes the need to replenish sulfur, however, the uptake and yield response of sulfur needs further research and is receiving increased interest from producers. Sulfur application is economically feasible in soils that have a severe sulfur deficiency, but not all fields respond to sulfur applications (Sawyer et al., 2011). Moreover, nitrogen application rates play a significant role in the response to sulfur application rates (Steinke et al., 2015). This study used Kansas State University's recommended rate for nitrogen for the Kansas River Valley Experiment Field and applied four different rates of sulfur.

MATERIALS AND METHODS

The Rossville field study was completed in September of 2019, initial soil samples were collected 0-6 in soil layer and analyzed for various soil parameters (Table 1). The experiment was in a randomized block design with four replications. Five treatments were evaluated, including a control (No N/ No S) and four rates of sulfur fertilizer (0, 30, 50, and 200 lbs. S acre^{-1}) which will be called control, low, medium, and high, respectively. The fifth treatment solely utilized urea served as the sulfur control treatment. (Table 2). Sulfur sources include Urea Calcium Sulfate (27%), Urea Calcium Sulfate (33%), and Ammonium Sulfate. The nitrogen source for the S control was urea following at Kansas State University's recommended nitrogen rate (180 lbs. N acre^{-1}). The Kansas River Valley Experiment Field used center pivot irrigation 6 times during the 2019 growing season. Whole plant biomass and grain samples were collected at physiological maturity in the corn crop. Whole plant biomass samples were gathered, weighed, and dried at 60°C and then reweighed to attain dry matter content. Corn was harvested, and yield was calculated and corrected to 15.5% moisture. After corn harvest, soil samples were collected from 0-24 in depth. All the soil samples were dried at 40°C, and nitrate and ammonium were measured utilizing a 1N KCl extraction, and sulfur was measured by a monocalcium phosphate extraction. All statistical analyses were completed in SAS using generalized linear mixed model (GLIMMIX) procedure was used for analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Preliminary results for this study showed significant differences in yield between sulfur fertilization rates for both nitrogen and sulfur plant total uptake. Whole plant sulfur uptake significantly increased when sulfur was applied. An increase in the uptake of sulfur with a high application rate more than likely resulted in higher lability of sulfur. Increasing the rate of sulfur showed no significant difference between sulfur rates (Figure 1), suggesting a rate of 30 lbs as sufficient for the corn crop. Increases in nitrogen uptake were seen when sulfur was applied (Figure 2). A substantial increase in nitrogen uptake is likely linked to keeping the balance of nitrogen to sulfur within the plant at approximately 16-25:1 (Steinke et al., 2015). Nitrogen uptake is indicative of increased yield and sulfur uptake suggesting that a higher yielding environments will also have elevated levels of sulfur removal (Figure 3). Soil sulfate levels in the 0-24" soil profile post-harvest was only significantly different at the high sulfur rate (Figure 4). This is likely due to excess S applied at the rate related to corn total need. Preliminary results show the highest sulfur application rate significantly increased yield compared to the urea-only application (Figure 5). This suggests sulfur applied at the lowest rate may have not been sufficient for maximum yield. An increase in nitrogen provided significantly more yield gain over the control when compared to sulfur. Further research is needed to see how sulfur and nitrogen interact to impact yield in corn.

REFERENCES

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Table 1. Soil test parameters for 0-6" pre-plant samples

P	K	Zn	Ca	Mg	Na	Fe	Mn
ppm							
31	148	1.7	1194	123	11	21	8
pH	Sikora	OM	Sand	Silt	Clay	CEC Sum.	EC
------pH------			------------%------------			Meq/100g	mS/cm
6.5	7.3	1.5	55	37	9	7	0.42

Table 2. Nitrogen and sulfur rates for each treatment

Treatment	Source	Nitrogen rate	Sulfur rate
		(lbs N ac^{-1})	(lbs S ac^{-1})
1	Ammonium sulfate	180	200
2	Urea + Calcium sulfate	180	50
3	Urea + Calcium sulfate	180	30
4	Urea	180	0
5	Control	0	0

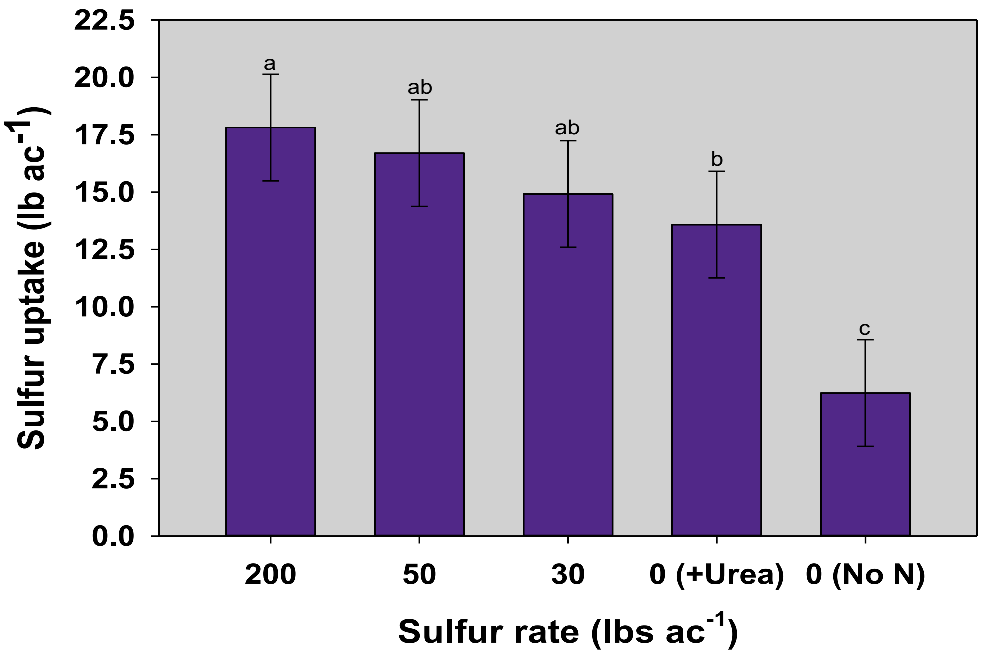

Figure 1. Whole plant sulfur uptake response at different levels of sulfur application in corn. Letters represent significant differences between treatments at $p<0.05$.

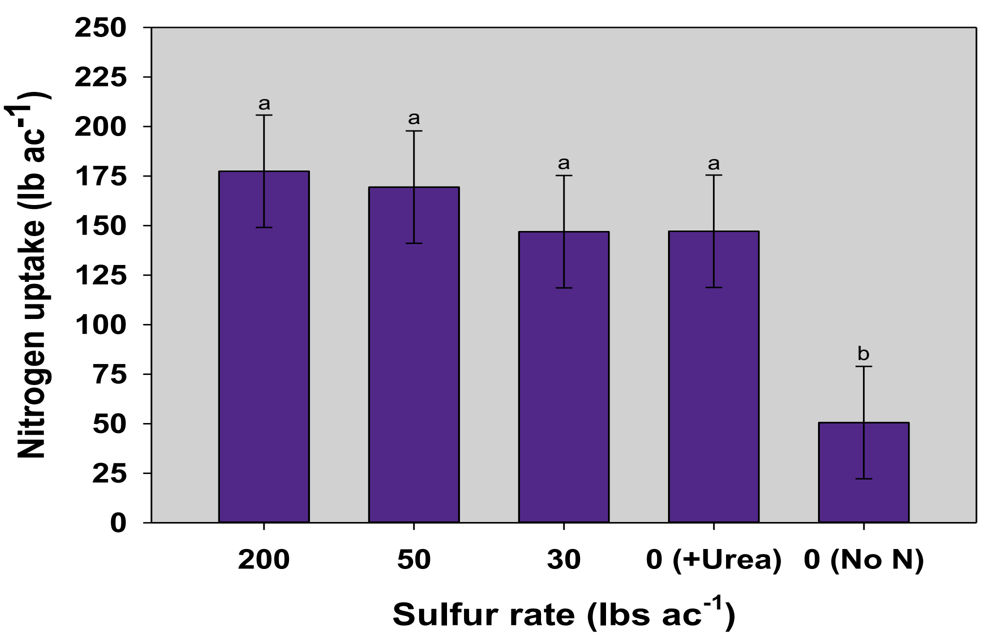

Figure 2. Whole plant nitrogen uptake response at different levels of sulfur application in corn. Letters represent significant differences between treatments at $p<0.05$.

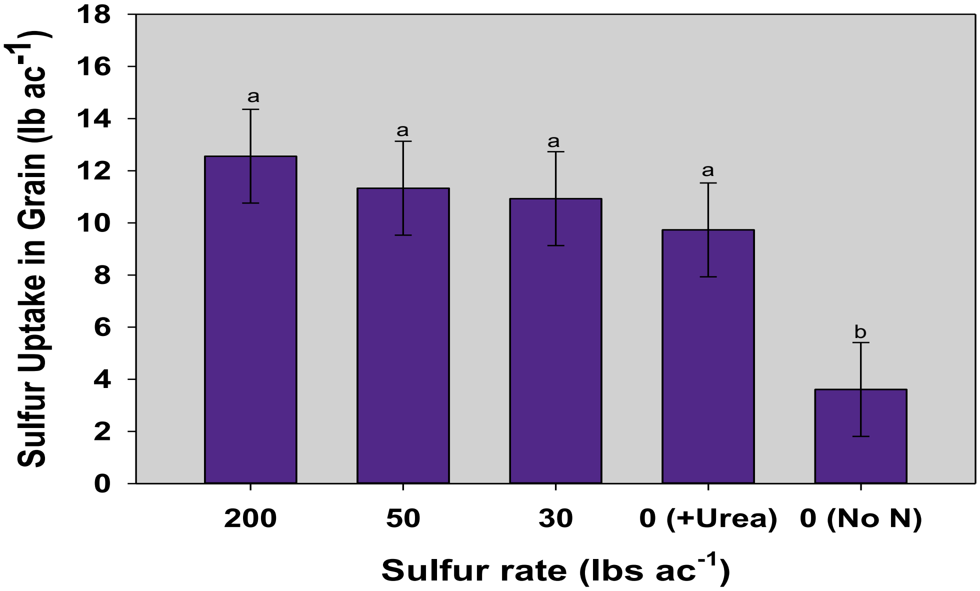

Figure 3. Sulfur removal in grain at physiological maturity in corn. Letters represent significant differences between treatments at $p<0.05$.

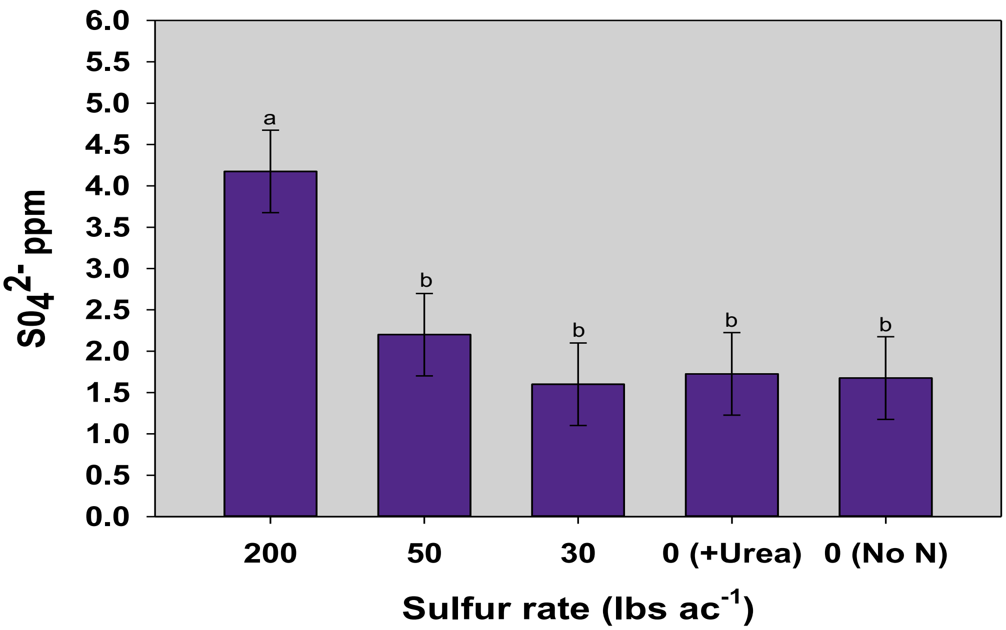

Figure 4. Corn post-harvest sulfate levels in the 0-24" soil profile samples. Letters represent significant differences between treatments at $p<0.05$.

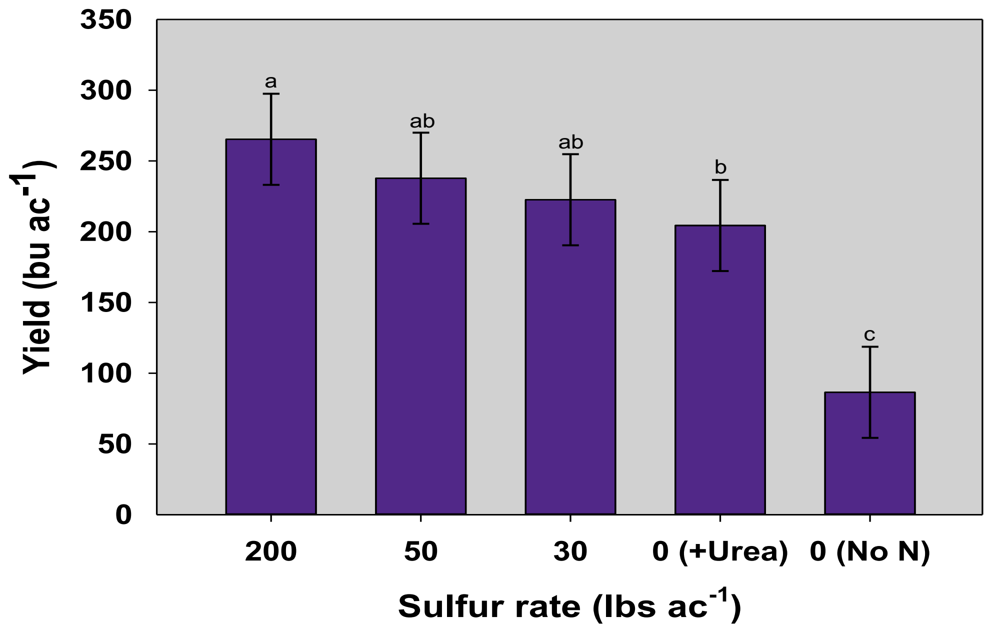

Figure 5. Corn yield response as affected by different rates of S application. Letters represent significant differences between treatments at $p<0.05$.