ZINC SULFATE AND UREA AMMONIUM NITRATE INTERACTION EFFECTS ON CORN-COTTON PRODUCTION SYSTEM

G. Singh
G. Kaur
M. W. Ebelhar
Delta Research and Extension Center
Mississippi State University
Stoneville, MS

Abstract

Zinc (Zn) deficiency has been observed in corn and cotton in certain parts of the Mississippi Delta region, where soils are low in organic matter content generally less than 1%. The application of Zn fertilizer in these low organic matter soils might increase corn and cotton yields. Therefore, a field experiment was conducted at the Delta Research and Extension Center, Stoneville, MS in 2020 to evaluate the interactive effects of Zn sulfate and urea ammonium nitrate fertilizer application rates on crop yields, soil properties, and Zn uptake in a corn-cotton cropping system. The experimental design was a randomized complete block with five replications. Corn-cotton rotation was maintained with each phase of crop appearing every year. Urea ammonium nitrate was applied at four rates (Corn: 160, 200, 240, and 280 lb N/acre; Cotton: 30, 60, 90, and 120 lb N/acre). Zinc sulfate was applied at the rate of 0, 5, 10, and 15 lb Zn/acre. Averaged over all Zn application rates, the highest corn yield (207 bu/ac) and N uptake (205 lb/ac) by corn were obtained with an N application rate of 280 lb N/ac. Corn grain oil and protein content decreased with increased application of Zn fertilizer. Cotton lint yield was significant for N and Zn rate treatments. The highest lint yield of 1514 lb/ac was obtained by 120 lb N/ac with 5 lb Zn/ac treatment.

Introduction

Zinc deficiency symptoms have continued to surface over the last several years and have been evident in both corn and cotton. The problem has been most evident on the sandier soils where organic matter levels are generally less than 1%. Efforts have been underway in the Mississippi Delta to increase organic matter levels by utilizing crop rotations. Crop rotations date back hundreds of years, but the practice was abandoned in favor of mono-crop cotton when cotton was king in the Mid-South. In the last ten years, cotton acreage has decreased from 1.2 million to less than 300,000 acres while corn acreage has increased, especially when corn prices were high. In the last few years, corn acreage has declined and fluctuates from year to year but still exceeds cotton acreage. Soil test zinc has been observed in the deficient range and could be increased with zinc fertilizer applications. Both soil-applied and foliar products are available but the range in application cost can be quite expensive. A small amount of applied zinc could be beneficial when zinc deficiency is evident or measured. The deficiency could occur even when visual symptoms are not evident. Research at the Delta Research and Extension Center has shown significant yield increases when cotton follows corn compared to cotton following cotton. The advantage has averaged from 10-17% in most studies to over 20% in the long-term Centennial Rotations established in 2004 at Stoneville, MS. The advantages of crop rotation vary from soil type to soil type and can even be negative when rainfall levels are high in the summer months. The objective of this study was to evaluate the interactive effects of Zn sulfate and urea ammonium nitrate fertilizer application rates on crop yields, Zn uptake, grain, and fiber quality in a corn-cotton cropping system.

Methods

The study was located at the Delta Research and Extension Center with four N rates (Corn: 160, 200, 240, and 280 lb N/acre; Cotton: 30, 60, 90, and 120 lb N/acre) and 4 zinc rates (0, 5, 10, and 15 lb Zn/acre). The experiment was setup in a randomized complete block design with five replications. Zinc sulfate was used by dissolving in water and applied as a sidedressed band with a coulter rig, similar to urea-ammonium nitrate solution, to each side of the planted row.

Due to extreme wet conditions and high precipitation, no tillage operations were completed for seedbed preparation in fall 2019. In spring 2020, seedbed preparation was completed in April which was followed by the planting of corn hybrid Pioneer 2089 VYHR @ 32,000 seeds/acre. Cotton hybrid PhytoGen 330 W3FE was planted in May @ 41,000 seeds/acre. Preplant nitrogen was applied at 120 lbs N/ac to corn and 30 or 60 lbs N/acre to cotton. The remaining N was applied as a split application to all the treatments. During preplant sidedressed application of N, Zinc sulfate was also applied to the treatments. Corn biomass samples were collected from all treatments to determine silage yield.

Corn biomass samples were oven-dried, weighed, grounded, and analyzed for nitrogen and zinc concentration to determine N and Zn uptake by corn. Corn was harvested on Sept. 15, 2020, using a Kincaid 8xp plot combine, and grain samples were collected to determine grain harvest moisture, bushel test weight, seed index (100-seed weight), and grain quality (protein, starch, and oil). Cotton boll samples were collected before picking cotton and were processed for lint yield and fiber quality. Cotton was picked using a two-row cotton picker on Oct. 2, 2020. After harvesting, soil samples from each plot (0-6" depth) were collected for determining available nutrients in soils. All collected data were statistically analyzed using the Glimmix procedure in SAS statistical software (Tables 1 & 2).

Results

The highest nitrogen uptake in corn biomass was 227 lb N/ac for treatment that received 280 lb N/ac with 5 lb Zn/ac (Table 3). There were no differences in corn yield based on N and Zn interactions (Table 3). Averaged over all Zn application rates, the highest corn yield (207 bu/ac) and N uptake (205 lb/ac) by corn were obtained with an N application rate of 280 lb N/ac. Statistically, the increase in N rate from 200 to 280 lb N/ac did not increase corn grain yield in the year 2020. Corn yield was increased by 17 bu/ac (9%) when the N application rate was increased from 160 lb N/ac to 240 lb N/ac. Similarly, N uptake by corn was increased by 20 lb/ac (11%) when the N application rate was increased from 160 lb N/ac to 240 lb N/ac. Corn silage Zn uptake was similar among all Zn treatment except the control when averaged over the N application rates (Table 3). Corn grain oil and protein content decreased with increased application of Zn fertilizer. Soil samples collected after harvesting corn in 2020 revealed significant differences in soil Zn and N concentrations. Soil Zn concentrations were highest for 15 lb Zn/ac treatment and decreased with lower Zn application rates.

Seed cotton yield was affected by the main effects of N rate treatments with the highest seed cotton yield of 3177 lb/ac for 120 lb N/ac followed by 3073 lb/ac for 90 lb N/ac (Table 4). Cotton lint yield was significant for N and Zn rate treatments. The highest lint yield of 1514 lb/ac was obtained by 120 lb N/ac with 5 lb Zn/ac treatment. A regression analysis was performed between N rates and lint yields for different Zn rate treatments (Figure 1). Results indicated that for 15 lb Zn/ac application agronomic optimum yields were obtained with 90 lb N/ac. Similarly, for 5 and 10 lb Zn/ac application agronomic optimum yields were obtained with 120 lb N/ac and showed an increasing trend (Figure 1). Cotton lint samples were analyzed for fiber quality and fiber elongation increased with higher rates of Zn treatments when average over the N rate treatments (Table 4).

Summary

Zinc deficiency has been observed in corn and cotton grown on soils having low organic matter content, which can result in lower crop yields. Reduction in crop yields can be prevented by the application of Zn fertilizer in these low organic matter soils. This study was conducted to evaluate the impact of Zn fertilizer application on corn and cotton production under different N application management systems. The application of Zn in our study did not impact corn grain yield, but it reduced the corn grain oil and protein content. In contrast, a significant interaction of Zn application rates was obtained with N application rates for the cotton lint yields. The highest lint yield of 1514 lb/ac was obtained by 120 lb N/ac with 5 lb Zn/ac treatment. This study will be continued for more years to determine the best Zn application under different N application rates for obtaining higher corn and cotton yields in the Mississippi Delta region.

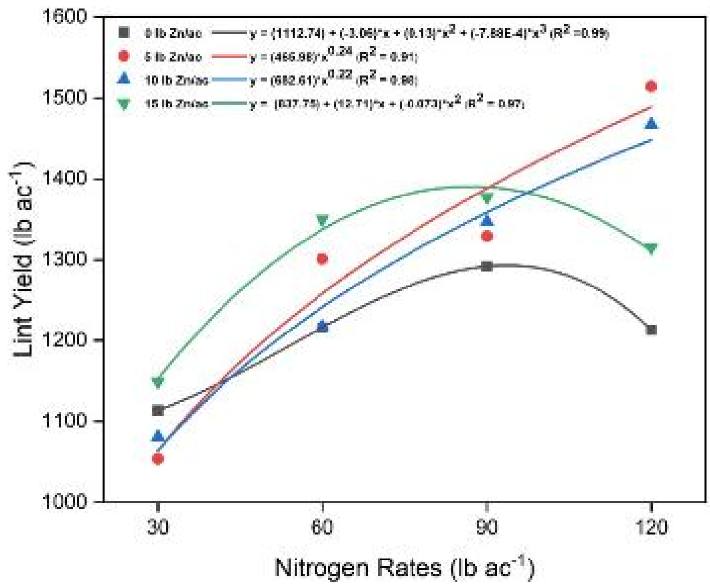

Figure 1. Regression analysis between N rates and lint yields for different Zn rate treatments.

Table 1. Probability value table for parameters collected from N x Zn rate corn study in year 2020. Statistical analysis was performed at p<0.05. Model significance is indicated in bold values.

Source of Variation	df	Corn Silage	Silage N Uptake	Silage Zn Uptake	Plant Population	Grain Moisture	Test Weight	Grain Yield	Grain Oil	Grain Protein	Grain Starch	Seed Index	Soil Zn	Soil NO_3-N	Soil NH_4-N
		ton/ac	lb/ac		plant/ac	%	lb/bu	bu/ac		%		g/100 seeds		mg/kg	
								p-values							
Nitrogen Rates	3	0.0629	**0.0178**	0.1359	0.5764	**0.0002**	**<0.0001**	**0.0034**	0.0815	**<0.0001**	0.5257	**<0.0001**	0.3278	**0.0395**	0.7430
Zinc Rates	3	**0.0014**	0.5214	**0.0004**	0.8782	0.6576	0.1070	0.2407	**0.0020**	**<0.0001**	0.1394	0.5785	**<0.0001**	0.9180	0.6459
Nitrogen x Zinc	9	0.1909	**0.0291**	0.3578	0.2810	0.7984	0.4907	0.6895	0.1570	0.7191	0.3737	0.1627	0.9143	0.9064	0.1908

Table 2. Probability value table for parameters collected from N x Zn rate cotton study in year 2020. Statistical analysis was performed at p<0.05. Model significance is indicated in bold values.

Source of Variation	df	Seed Cotton Yield	Lint Yield	Fiber fineness	Fiber length	Fiber Uniformity Index	Fiber Strength	Fiber Elongation	RD	Hunter's +b	Level of non-lint particles	Soil Zn	Soil NO3-N	Soil NH4-N
		lb/ac		millitex	inches	%	g/tex	%	% reflectance	Yellowness			mg/kg	
			p-values											
Nitrogen Rates	3	**<0.0001**	**<0.0001**	**0.0241**	0.4557	0.6223	0.3707	0.1461	0.1174	0.3490	**0.0381**	0.7115	0.2829	0.1781
Zinc Rates	3	0.1624	0.0933	0.2197	0.1906	0.6415	0.3795	**0.0054**	0.4494	0.4027	**0.0381**	**<0.0001**	0.2826	0.9638
Nitrogen x Zinc	9	0.3214	**0.0369**	**0.0376**	0.4881	0.1249	0.8808	0.3160	0.1116	0.6611	**0.0174**	0.7468	0.4652	0.9531

Table 3. Means represent nitrogen (N) and zinc (Zn) rate treatments' main effects and their interactions for corn silage N and Zn uptake, corn grain yield, grain oil, and protein content. Means followed by the same letter within a column or a row do not differ significantly at P<0.05.

N Rate (lb N/ac)	Silage N Uptake (lb/ac)					Silage Zn Uptake (lb/ac)					Corn Yield at 15.5% (bu/ac)					Grain Oil (%)					Grain Protein (%)				
	Zinc Rate (lb Zn/ac)				Main Effects	Zinc Rate (lb Zn/ac)				Main Effects	Zinc Rate (lb Zn/ac)				Main Effects	Zinc Rate (lb Zn/ac)				Main Effects	Zinc Rate (lb Zn/ac)				Main Effects
	0	**5**	**10**	**15**		**0**	**5**	**10**	**15**		**0**	**5**	**10**	**15**		**0**	**5**	**10**	**15**		**0**	**5**	**10**	**15**	
160	163c	186bc	192bc	185bc	181b	5.7	6.7	7.1	6.6	6.5	181	184	177	197	185b	3.62	3.68	3.62	3.62	3.64	7.14	6.98	6.76	6.84	6.93c
200	184bc	210ab	192bc	188bc	194ab	5.2	7.7	7.3	7.0	6.8	200	198	196	191	196ab	3.66	3.54	3.62	3.52	3.59	7.98	7.54	7.42	7.34	7.57b
240	225a	186bc	184bc	209ab	201a	6.3	6.1	6.9	7.5	6.7	201	202	190	218	202a	3.64	3.64	3.54	3.52	3.59	8.42	8.2	7.88	7.86	8.09a
280	193bc	227a	209ab	193bc	205a	6.4	7.3	7.4	8.0	7.3	200	204	211	214	207a	3.76	3.62	3.66	3.54	3.65	8.66	8.26	8.26	7.74	8.23a
Main Effects	191	202	194	194		5.9b	6.9a	7.2a	7.3a		195	197	194	205		3.67a	3.62ab	3.61b	3.55c		8.05a	7.75b	7.58bc	7.45c	

Table 4. Means represent nitrogen (N) and zinc (Zn) rate treatments' main effects and their interactions for seed cotton yield, lint yield, and cotton fiber quality (fineness and elongation). Means followed by the same letter within a column or a row do not differ significantly at P<0.05.

N Rate (lb N/ac)	Seed Cotton Yield (lb/ac) Zinc Rate (lb Zn/ac)				Main Effects	Lint Yield (lb/ac) Zinc Rate (lb Zn/ac)				Main Effects	Fiber Fineness (millitex) Zinc Rate (lb Zn/ac)				Main Effects	Fiber Elongation (%) Zinc Rate (lb Zn/ac)				Main Effects
	0	**5**	**10**	**15**		**0**	**5**	**10**	**15**		**0**	**5**	**10**	**15**		**0**	**5**	**10**	**15**	
30	2562	2412	2455	2586	2504c	1114ef	1054f	1081f	1149ef	1100c	4.81bcde	5.01a	4.94ab	4.86abcd	4.90a	6.00	5.95	6.00	5.93	5.97
60	2828	3022	2800	3108	2939b	1216de	1301cd	1217de	1350bcd	1271b	4.63e	4.82bcd	4.91abc	4.91abc	4.82ab	5.78	5.95	6.15	6.10	5.99
90	2915	3020	3138	3219	3073ab	1292cd	1329bcd	1347bcd	1377abc	1336ab	4.71de	4.79bcde	4.75cde	4.81bcde	4.76b	5.83	5.88	6.08	6.00	5.94
120	2989	3304	3295	3121	3177a	1213de	1514a	1467ab	1315cd	1377a	4.91abc	4.75cde	4.75cde	4.76cde	4.79b	5.78	5.83	5.88	6.00	5.87
Main Effects	2823	2940	2922	3009		1209	1299	1278	1298		4.76	4.84	4.84	4.83		5.84c	5.90bc	6.03a	6.01ab	