COTTON RESPONSE TO THE RATE AND SOURCE OF SULFUR ON A SANDY COASTAL PLAIN SOIL

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Abstract

A three- year (1993-1995) field test was conducted in south Alabama on a sandy coastal plain soil to evaluate the response of cotton (*Gossypium hirsutum* L.) to the source, rate and timing of sulfur fertilizer applications. Sulfur was applied as either ammonium sulfate, elemental sulfur, potassium sulfate, potassium thiosulfate, or K-Mg-sulfate at rates of 0, 10, 20 and 40 lb sulfur/acre. All sources were broadcast applied pre-plant and ammonium sulfate was also applied at first square. Seed cotton yields were increased by the application of sulfur during all three years of the test. Yields peaked at approximately 20 lb sulfur/acre. Averaged across sources, an application of 20 lb sulfur/acre increased seed cotton yields by an average of 26% as compared to the no sulfur check treatment. Applying sulfur pre-plant versus first square did not affect seed cotton yields in 1993 or 1995. In 1994, pre-plant applications of sulfur gave higher yields as compared to sulfur applied at first square. Seed cotton yields were not affected by the source of sulfur during 1993 or 1995. In 1994, ammonium sulfate and K-Mg-sulfate produced slightly higher yields as compared to the other sources. Lint quality in 1993 and 1994 was not affected by any of the sulfur treatments.

Introduction

Cotton acreage in South Alabama has steadily increased in recent years (Alabama Agricultural Statistics, 1992). The soils typically found in the Southern Coastal Plain are sandy textured and have low levels of extractable sulfate-sulfur (Neller, 1959; Reneau and Hawkins, 1980; Rhue and Kamprath, 1973). Many of these soils also have low sulfur adsorption capacities (Chao et al., 1962; Ensminger, 1954; Neller, 1959; Martini and Mutters, 1984). A limited adsorption capacity for sulfate-sulfur will result in a limited residual effect of applied sulfur if leaching is occurring (Rhue and Kamprath, 1973).

It is on these deep sandy soils that a response to sulfur would be most expected. Yield responses to sulfur fertilization have been reported for cotton on some sandy soils in the Southeast. For Alabama in the 1950ies, sulfur fertilization was reported to increase seed cotton yields by 205 lb/ acre (Ensminger, 1958). In the mid 1950ies Wilcox and Sedberry (1954-55) reported a significant increase in cotton yield due to sulfur fertilization on a sandy loam Typic Paleudult in Louisiana. Jordan (1964) also reported significant responses to sulfur fertilization in Georgia. There is no data in the literature which describes the effect of sulfur fertilization on cotton fiber quality.

The Auburn University Soil Testing Laboratory currently recommends that all crops receive 10 lb of sulfur/acre/year (Adams et al., 1994). This requirement was easily met when most fertilizer P was applied as normal superphosphate which contains approximately 12% sulfur (Platou and Irish, 1982). Currently most of our high analysis P fertilizers contain <3% sulfur.

Cotton response to sulfur fertilization has not been evaluated on the sandy coastal plain soils in Alabama during the past 20-30 years. The primary objective of this study was to evaluate cotton response to the rate, source and timing of sulfur application on a sandy coastal plain soil.

Materials and Methods

A field study was conducted at the Wiregrass Substation in Headland Alabama on a Dothan sandy loam (fine-loamy, siliceous, thermic, Plinthic Paleudults; Table 1). Sulfur was applied pre-plant as a surface broadcast application at rates of 0, 10, 20 and 40 lb/acre. Sulfur was applied as ammonium sulfate (24.2% sulfur), elemental sulfur (90% sulfur), potassium sulfate (18% sulfur), K-Mg-sulfate (20% sulfur, 11% magnesium) and potassium thiosulfate (2.1 lb sulfur/gallon; Table 2). Ammonium sulfate was also applied at first square to evaluate cotton response to the time of sulfur application. In 1995, two additional treatments were added to determine cotton response to magnesium. These additional treatments received 20 lb magnesium/acre as magnesium chloride, hexahydrate (11% magnesium) in combination with 0 or 20 lb sulfur/acre as ammonium sulfate.

All treatments received 90 lb N/acre, 60 lb P_2O_5/acre and 140 lb K_2O/ acre. Experimental plots consisted of eight rows that were 30 feet long. Treatments were arranged as a randomized complete block design with 4 replications. The variety was 'Deltapine 90'.

Upper most mature cotton leaves (blades plus petioles) were collected at early bloom for sulfur analysis. Seed cotton and lint yields were determined at maturity by harvesting the two center rows from each plot. Lint quality was determined by HVI. Sulfur concentration in the leaf tissue was determined using a Leco SC 432 (Leco Corp., St. Joseph, MI).

Results and Discussion

In 1993, severe drought conditions were experienced during the growing season (Table 3) especially during May, June and August. Total rainfall received from May-September was only 63% of the long term average. These

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drought conditions resulted in very low seed cotton yields (Table 4). Statistical analysis of the data showed that yields were increased by the rate of sulfur (Table 4), but were not affected by the source of sulfur (Table 5), the time of sulfur application (Table 6), or the interaction between source and rate. Seed cotton yields increased with the rate of sulfur up to 20 lb sulfur/acre. The application of 20 lb sulfur/acre increased seed cotton yields by an average of 135 lb/acre (21% increase) as compared to the no sulfur check treatment.

The 1994 growing season was extremely wet (Table 3). July was a particularly wet month with a total of 19.4 inches of rain. Approximately 15 inches of rain were received during the first seven days of July. In spite of the wet growing conditions, near average (for Alabama) seed cotton yields were obtained in 1994 (Table 4). Statistical analysis of the data showed that yields were affected by the rate of sulfur (Table 4), the source of sulfur (Table 5) and the time of application (Table 6; $P < 0.10$). Seed cotton yields were not affected by the interaction between source and rate of application. Yields increased with the rate of sulfur up to 40 lb sulfur/acre (Table 4). The application of 20 lb sulfur/acre (averaged across sources) increased seed cotton yields by an average of 431 lb/acre (31% increase) as compared to the no sulfur check treatment. Ammonium sulfate and K-Mg-sulfate produced slightly higher yields (Table 5) as compared to elemental sulfur, potassium sulfate and K-thiosulfate ($P < 0.10$). The pre-plant application of sulfur resulted in higher seed cotton yields as compared to sulfur applied at first square (Table 6).

In 1995, seed cotton yields were affected by the rate of sulfur (Table 4), but not by the source of sulfur (Table 5), time of application (Table 6) or the interaction between source and rate of application. Yields increased with the application of sulfur up to a rate of 20 lb/acre. The application of 20 lb sulfur/acre increased seed cotton yields by an average of 388 lb/acre (24% increase) as compared to the no sulfur check treatment.

In 1993 and 1994 lint quality parameters were not affected by any of the sulfur treatments. In 1995, length was increased slightly by the application of sulfur. Length was also affected by the interaction between source and rate.

Concentration of sulfur in cotton leaves collected at mid-bloom increased with the rate of applied sulfur during all three years of the study (Table 7). There were no effects of sulfur source or the time of application on the concentration of sulfur in the cotton leaf tissue collected in 1993. In 1994 and 1995 the first square sulfur treatments resulted in slightly higher sulfur concentrations as compared to the pre-plant treatments (data not shown). During both 1994 and 1995 there was a significant interaction between the source and rate of sulfur (Table 8). A comparison of the data from 1994 and 1995 showed that between years there was a great deal of inconsistency among the sources.

Due to the favorable performance of K-Mg-sulfate in 1994 (Table 5), a couple of additional treatments were added in 1995 to evaluate the effects of magnesium on cotton yields (Table 2). These first year results suggest that cotton may be responding to the applications of magnesium on this deep sandy soil (Table 9). Additional research needs to be conducted to verify this response.

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Table 1. Initial chemical properties of the Dothan fine sandy loam soil that was used to evaluate cotton response to the rate and source of sulfur.

Soil Depth (inches)	pH	Extractable SO_4-Sulfur (lb/acre)
0-11	6.1	3.0
11-18	6.1	4.30
18-24	5.6	17.0
24-30	5.2	38.0
30-36	5.1	70.0

Table 2. Sulfur treatments. Magnesium treatments (Trt. No. 20 and 21) were applied during 1995 only.

Trt. No.	Sulfur Source	Sulfur Rate	Time of Application	Mg Rate
		lb/acre		lb/acre
1	Check	0.	Pre-plant	0
2	Ammonium Sulfate	10	Pre-plant	0
3	Ammonium Sulfate	20	Pre-plant	0
4	Ammonium Sulfate	40	Pre-plant	0
5	Ammonium Sulfate	10	First Square	0
6	Ammonium Sulfate	20	First Square	0
7	Ammonium Sulfate	40	First Square	0
8	Potassium Sulfate	10	Pre-plant	0
9	Potassium Sulfate	20	Pre-plant	0
10	Potassium Sulfate	40	Pre-plant	0
11	Elemental Sulfur	10	Pre-plant	0
12	Elemental Sulfur	20	Pre-plant	0
13	Elemental Sulfur	40	Pre-plant	0
14	Potassium Thiosulfate	10	Pre-plant	0
15	Potassium Thiosulfate	20	Pre-plant	0
16	Potassium Thiosulfate	40	Pre-plant	0
17	K-Mg-Sulfate	10	Pre-plant	0
18	K-Mg-Sulfate	20	Pre-plant	0
19	K-Mg-Sulfate	40	Pre-plant	0
20	None	0	Pre-plant	20
21	Ammonium Sulfate	20	Pre-plant	20

Table 3. Rainfall received during the 1993,1994 and 1995 growing seasons as compared to the long term average.

Month	1993	1994	1995.00	Long Term Average
	---------------------------- inches	------------------------		
April	8.50	1.6	4.50	4.60
May	1.25	0.6	2.80	4.40
June	1.72	9.4	3.80	4.60
July	5.34	19.40	5.30	6.0
August	1.57	3.6	5.20	5.0
September	4.82	3.5	1.70	4.10
Total	23.20	38.10	23.30	28.70

Table 4. Seed cotton yields as affected by the rate of sulfur applied to a Dothan sandy loam soil.

Sulfur Rate	1993	1994	1995
	------------------------ lb/acre	---------------------------------------	
0	653	1373	1621
10	733	1567	1905
20	788	1781	2009
40	731	1804	1907
$LSD_{(0.10)}$	68	257	211

Table 5. Seed cotton yields as affected by the source of sulfur.

Sulfur Source	1993	1994	1995
		------------------ lb/acre	-------------
Ammonium Sulfate	702	1807	1860
Elemental Sulfur	744	1461	1872
K-Mg-Sulfate	732	1821	1972
Potassium Sulfate	711	1467	1767
Potassium Thiosulfate	744	1600	1830
$LSD_{(0.10)}$	NS	287	NS

Table 6. Effect of time of sulfur application as ammonium sulfate on seed cotton yields.

Time of Applic.	1993	1994	1995
	--------------------	lb/acre	--------------------
Pre-Plant	702	1952	1860
First Square	705	1359	1779
LSD(0.10)	NS	311	NS

Table 7. Sulfur concentrations in upper most mature cotton leaves at mid-bloom as affected by the rate of sulfur applied to a Dothan sandy loam soil.

Sulfur Rate	1993	1994	1995
	------------------------	%	------------------------
0	0.27	0.22	0.24
10	0.38	0.25	0.28
20	0.41	0.27	0.32
40	0.47	0.28	0.36
$LSD_{(0.10)}$	0.03	0.01	0.02

Table 8 . Effect of sulfur rate and source on sulfur concentrations in cotton leaves collected at mid-bloom in 1995.

Sulfur Rate	Ammonium Sulfate	Elemental Sulfur	K-Mg-Sulfate	Potassium Sulfate	Potassium Thio-sulfate
lb/acre	------------------------------		% Sulfur		----------------------------
0.0	0.24	0.24	0.24	0.24	0.24
10.0	0.26	0.26	0.30	0.28	0.32
20.0	0.34	0.29	0.34	0.37	0.29
40.0	0.39	0.29	0.37	0.40	0.35
LSD (0.10)			0.04		

Table 9. Effect of magnesium, with and without sulfur, on seed cotton yields in 1995. Except for K-Mg-sulfate treatment, magnesium was applied as magnesium chloride, hexahydrate and sulfur was applied ammonium sulfate (AS).

Treatments	Seed Cotton Yield
	------------- lb/acre ----------------
Check	1621
20 lb/acre Mg	1924
20 lb/acre Mg + 20 lb/acre S as AS	2347
20 lb sulfur/acre as K-Mg-Sulfate	2311