COTTON LINT YIELD RESPONSE TO SULFUR FERTILIZATION

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Introduction

In recent years, reductions in sulfur emissions from coal-burning electric power facilities have reduced acid rain to streams and rivers. This has indirectly diminished a “free” supply of sulfur to agriculture. Sulfur is required for the formation of many proteins essential for plant growth. Leaf and petiole tissue testing in Missouri has shown sulfur deficiencies in wheat, rice, corn, and cotton fields with sandy soils. Sulfur deficiencies are more common in cold, wet growing seasons than hot, dry seasons. Soil sulfur is most available to plants in the sulfate form. Sulfate is negatively charged similar to nitrate and easy leaches from sandy soil. The primary supplier of sulfur to plants is soil organic matter mineralization. Since sandy soils often contain less organic matter than loamy soils, they usually have a lower potential for supplying crop S needs.

In 2003 and 2004, cotton fields were found on the Malden Ridge with light green and yellow leaves, which tested low in sulfur. Most soils on the Malden Ridge in Southeast Missouri are sandy. In 2004, supplies of ammonium sulfate fertilizer were scarce at mid-season when the S deficiencies were found. Fertilizer dealers had to transport ammonium sulfate by truck from West Virginia.

The objective of a three-year experiment, started in 2005, was to evaluate different forms of sulfur fertilizer and application rates on cotton in Southeast Missouri.

Methods and Materials

Field experiments were conducted on a Tiptonville silt loam soil (5.5 ppm SO_4-S, 1.5% organic matter, 15 meq/100g soil cation exchange capacity) at Portageville and a Malden fine sand soil (2.5 ppm SO_4-S 0.8% organic matter, 3.8 meq/100 g soil cation exchange capacity) at Clarkton, Missouri. Based on soil test results and University of Missouri recommendations a yield response to sulfur fertilization was expected at the fine sand site, but not the silt loam site.

A randomized block design with four replications was used. Dry fertilizer materials were broadcast and incorporated before planting. Ammonium sulfate, agricultural elemental sulfur, gypsum (calcium sulfate), and Epson Salt (magnesium sulfate) were evaluated at 0, 6, 12, and 18 lb S per acre. A 10% S foliar ammonium sulfate liquid formulation was evaluated at 0.13, 0.26, and 1.0 lb S per acre. Sulfur Plus™ (10% S) is derived from ammonium sulfate in a proprietary organic complex (Delta Formulation, Greenville, Mississippi). These treatments were tank mixed with glyphosate herbicide and sprayed 20 gallons per acre at 3 to 4 true cotton leaf stage.

Each year plant tissue samples (petioles) were collected from all plots at mid bloom. These samples were analyzed for nitrate and sulfur content. From this data a N/S ratio was calculated for each plot. SPAD 502 chlorophyll meter reading were also collected from each plot at this time.

Statistical analyses of the data were preformed with SAS (11) using General Linear Modeling procedures. Fisher’s Protected Least Significant Difference (LSD) was calculated at the 0.05 probability level for making treatment mean comparisons. The two sites were analyzed separately.

Results and Discussion

Analysis of variance for yield data showed a significant treatment effect at the Malden fine sand site but not at the Tiptonville silt loam site (Table 1). There were no two factor interactions at either site. The analysis of variance for SPAD 502 meter readings and plant tissue N, S, and N/S followed a similar pattern as the yield data. Averaged across years, sulfur fertilization increased yields more effectively on the sand site compared to the loam (Figure 1). Averaged across years, petiole S concentrations were lower on the Malden fine sand compared to the Tiptonville silt loam. This is due in part to the differences in organic matter between the two soils. On sandy soil, cotton lint yields were highest when fertilized with S at 18 lb S per acre.

Petiole S content was greatest at 12 lb S per acre (Table 2). In a low supplying soil S condition, sulfur fertilization helps cotton plants utilize N more effectively because both elements are required to make proteins in leaves. Sometimes petiole N will increase to high levels in cotton plants if S is deficient. We found that S fertilizer decreased the N/S ratio in cotton plants on the Malden fine sand. Although each rate of sulfur fertilization produced a lower N/S ratio than the check, there was no difference between the ratios of the three application rates. Generally, no cotton yield increases were found with N/S was less than 20. Epsom salt provided the highest petiole S content on the silt loam, although yields were not increased. On the Malden fine sand, Ammonium sulfate produced the highest lint yield, as well as the second highest petiole S content (Table 3).

Acknowledgement

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Table 1. Analysis of variance for cotton lint yields for sulfur treatments in 2005, 2006, and 2007 on a Tiptonville silt loam soil and a Malden fine sand soil.

Effect	Tiptonville silt loam (Pr>F)	Malden fine sand (Pr>F)
TRT	0.8494	0.0450
Year	0.0002	<0.0000
Year*TRT	0.6280	0.2392

Table 2. Leaf greenness and petiole nitrogen and sulfur and cotton lint yield from rates of soil-applied sulfur averaged across types of fertilizer [ammonium sulfate, elemental sulfur, calcium sulfate (gypsum), and magnesium sulfate (Epsom salt)] on a Tiptonville silt loam at Portageville, Missouri and a Malden fine sand at Clarkton, Missouri in 2005, 2006, and 2007.

Pre-plant fertilizer lb S/acre	Tiptonville silt loam					Malden fine sand				
	Leaf green[1]	Petiole N	Petiole S	Petiole N:S	Lint yield	Leaf green	Petiole N	Petiole S	Petiole N:S	Lint yield
		------ppm------			lb/acre		------ppm------			lb/acre
0	49	14138	1054	13	931	49	8780	405	22	548
6	48	13758	1256	11	889	50	8619	408	21	577
12	50	14258	1348	11	898	51	8286	487	17	606
18	50	14439	1353	11	919	50	7819	455	17	621

[1] Leaf greenness was read with a Minolta SPAD chlorophyll meter.

Table 3. Leaf greenness and petiole nitrogen and sulfur and cotton lint yield from sulfur fertilizers averaged across rates of sulfur on a Tiptonville silt loam at Portageville, Missouri and a Malden fine sand at Clarkton, Missouri in 2005, 2006, and 2007.

Fertilizer	Tiptonville silt loam					Malden fine sand				
	Leaf	Petiole			Lint	Leaf	Petiole			Lint
	green[2]	N	S	N:S	yield	green	N	S	N:S	yield
		------ppm------			lb/acre		------ppm------			lb/acre
Check	49	14138	1054	13	931	49	8780	405	22	548
Am sulfate	50	13142	1300	10	901	50	8285	489	17	638
Elemental S	50	13580	1261	11	929	50	9229	383	24	581
Gypsum	50	14240	1344	11	887	50	7726	445	17	565
Epsom salt	49	14644	1369	11	891	50	7733	482	16	621
S Plus™ [1]	50	14683	1313	11	904	50	8579	436	20	602

[1] Treatments were foliar-applied rates at 0.13, 0.26, and 1 lb S/acre in a tank-mix with glyposate herbicide.
[2] Leaf greenness was read with a Minolta SPAD chlorophyll meter.

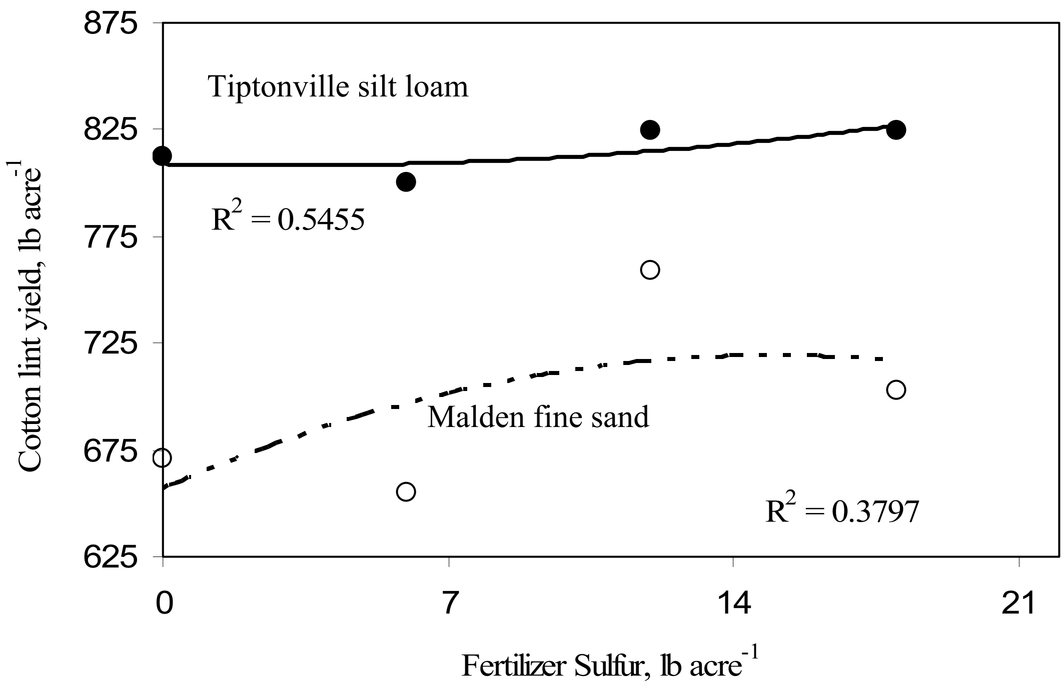

Figure 1. Effect of rate of soil applied sulfur averaged across years and types of fertilizer on cotton lint yield on silt loam and sandy loam soils.