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FERTILIZATION OF COTTON ON BLACK BELT PRAIRIE SOILS IN ALABAMA

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Abstract

Soil fertility research with cotton has not been conducted on the fine-textured, often calcareous soils of the Alabama Black Belt Prairie region in several decades although as much as 30,000 acres are being planted on these soils. Cotton producers on these soils regularly express concern about N rates and potential K deficiencies. An on-farm experiment in 2002 and 2003 on a Houston clay in Dallas County included N, P, K, S, and B variables. Very high soil K levels at this site precluded any expected response to added K. Leaf blade K levels suggested the need for growers to pay very close attention to the time of sampling when using leaf analyses to diagnose K sufficiency levels in cotton. Excessive K application appeared to suppress leaf-blade Mg concentrations and yields in 2002. Although soil test P was near the critical value used for Lancaster extractable P on Black Belt soils, there was no yield response to added P. This suggests that the current critical value is certainly not too high. There was no yield response to B or S. Leaf blade B and S were within the established sufficiency ranges for mid bloom. Most of the total N application should be applied as a sidedress even if it is applied as late as early bloom. This is to avoid denitrification losses from extremely wet springs such as 2003. In moderately dry years as in 2002, the A.U. standard recommendation of 90 pounds N per acre appeared sufficient for maximum yields. However, in extremely wet years as in 2003, rates as high or higher than 120 pounds N per acre as a sidedress may be warranted.

Introduction

Most fine-textured, Black Belt soils test "high" or "very high" in potassium if recognized analytical techniques are used that are appropriate for these highly buffered, often calcareous soils. Nevertheless, cotton growers in this area sometime suspect K deficiency in spite of ". . . following the soil test recommendation." Very little research has been conducted to verify soil test calibration or recommendations for cotton on these soils.

Nitrogen management is also a concern for cotton on these slowly permeable soils where N denitrification may be more of a concern than nitrate leaching. On-farm research has suggested higher N rates are needed for corn on these soils (Mitchell et al., 1991). Very little research has been conducted with cotton on these soils in Alabama. Standard N recommendations are based on research conducted on sandier, Coastal Plain soils or finer textured soils of the Tennessee Valley in northern Alabama (Adams et al., 1994).

Objectives

1. Determine the need for additional K fertilization for high-yielding cotton on Black Belt soils.
2. Determine if cotton will respond to other fertility treatments on Black Belt soils.
3. Determine optimum N rate for cotton on Black Belt soils
4. Evaluate existing soil test methodologies for evaluating K for cotton on Black Belts soils.

Methods

Ideally, soil fertility research should be conducted under very controlled conditions. Unfortunately, the Black Belt Research and Extension Center at Marion Junction is not equipped to conduct cotton research. Therefore, this project was conducted on a cotton field managed by Octacot Farms near Browns, Alabama, using their equipment (Fig. 1). This test began in 2001 on a Vaiden clay. This site did not work out and was abandoned with no data collected. In 2002 and 2003, a much better location was found on a Houston clay, 1-5% slope (very-fine, smectitic, thermic Oxyaquic Hapluderts). The experimental site was not irrigated.

Treatments

Fertility treatments were similar to those found on existing, long-term fertility experiments around Alabama where cotton and other crops have been produced (Cope, 1984) (Table 1). Soil at the site initially tested "high" in P and "very high" in K with a pH of 6.1. No response to P or K would be anticipated at these soil test levels (Table 2). Plot size was 6 rows wide (38-inch rows) and 25 feet deep. Eleven treatments were replicated 4 times in a RCB design. All P, K, and S were applied as close to planting as possible. In 2002, the fertilizer N was applied 1/2 at planting and 1/2 as a sidedress during squaring. Fertilizer N at the rate of 50 pounds N per acre was mistakenly applied to the entire test area after planting in 2002. Therefore, sidedress N rates were adjusted such that total N treatments in 2002 were actually 50, 80, 95, 120, and 180 pounds N per acre. Boron was applied at sidedressing. In 2003, all the fertilizer treatments were applied at planting. Excessive rainfall during the entire 2003 growing season resulted in severe N denitrification and low yields.

The grower planted on raised beds formed several weeks prior to fertilizer application. All field operations other than fertilization were performed by the grower (Table 2).

Late Sidedress N Test in 2003
With the excessive rainfall in 2003, loss of N from denitrification was apparent by mid June. Therefore a late sidedress N test was established in an unfertilized area adjacent to the existing experiment. Purpose of this additional experiment was to determine the effect of a late sidedress application of N to cotton stressed from excessive rainfall and saturated soils. Rates of sidedress N (0, 30, 60, 90, and 120 pounds N per acre) were applied on 24 June to plots of identical size and design as the original experiment (4 replications in a RCB design). In addition to the N variables, 60 pounds P_2O_5 and 120 pounds K_2O per acre were applied to all treatments on 24 June 2002 when the cotton was at first bloom.

Results

N Rates
Non-irrigated cotton on this site produced more than twice the yield in 2002 compared to 2003 (Table 2; Fig. 2). Since all of the N in the main experiment was applied at planting in 2003, most of the yield loss was assumed to be due to denitrification. This is supported by the late sidedress test that was established on 24 June adjacent to the main experiment (Fig. 3). Yields increased with sidedress N rates as high as 120 pounds per acre. Most growers can get by applying all N to cotton at or near planting in most years because typically, May and June are dry months in Central Alabama. Fig. 4 clearly shows this wasn't the situation in 2003. In 2002, there was no significant difference in 50 pounds total N and 180 pounds total N applied in split applications. Both produced at or above 1000 pounds lint per acre. In 2003, a standard recommended rate of 90 pounds N per acre (Adams, et al., 1994) applied at planting was not significantly different from no-N application with lint yields less than 500 pounds per acre. When the same rates were applied as a late sidedress in 2003, cotton lint yields almost doubled to over 900 pounds lint per acre. Weather conditions in 2003 demonstrate the reason behind split or multiple N applications to cotton. Leaf N analyses also support yields results (Table 3). In 2002, increasing N rates resulted in increasing N concentrations in the leaf blade during mid bloom. In 2003, there were no differences in N concentration (mean of 2.53% N) at mid-bloom due to N applied at planting. However, in the "late sidedress N test", N in leaf blades at mid-bloom ranged from 2.56% (no N) to 3.46% (120 lb. sidedress N/acre). The grower applied a late sidedress N application to the rest of the crop in this field and averaged over 800 pounds lint per acre.

K Application
Typical of many Black Belt soils, this site soil tested "very high" in K. Yields in 2002 and 2003 show no response to additional K application at this level. In 2002, a relatively drier year than 2003, there appeared to be a slight depression in yield from a very high K application of 240 pounds K_2O per acre as muriate of potash. This has been seen in other tests and is probably due to salt damage to cotton with such a high K rate. Excessive K application also appeared to suppress leaf Mg concentration (Table 3) but had little effect on K concentration in the leaves.

Phosphorus, Sulfur, and Boron (Fig. 2)
Although growers often are concerned about these nutrients in Black Belt soils, this test showed no significant yield increase to their application. Many unfertilized Black Belt soils test "low" in P but this site was marginally "high". A Lancaster extract of 72 pp2m (parts per two million or pounds per acre) is currently considered the critical value between "medium" where P would be recommended and "high" where none is recommended. This site had an initial extractable P level of 76 pp2m (mean of 4 samples) which is marginal. The lack of a response to added P confirms Auburn University's recommendation under these growing conditions. There have been no documented yield responses to direct application of S or B to cotton on Black Belt soils in Alabama. Responses to these elements are more likely on well drained, low organic matter sandy soils where leaching is a consideration. This soil has slow permeability.

Leaf Analyses (Table 3)
Leaf samples were collected during mid bloom from selected treatments in 2002 and in 2003. Only the 2002 data are presented in Table 3 because of similar results both years. The results of these analyses may indicate why some growers are confused by leaf analyses. All treatments, even those receiving very high K applications, indicate low K concentrations when compared to the standard sufficiency ranges reported for early bloom (1.50-3.00%K). Clearly, there was no K deficiency in any of these treatments. Since these samples were taken during mid-bloom rather than early bloom, lower K concentrations are to be expected. Mitchell and Baker (2000) suggest using 0.75-2.5% for cotton leaf blade during late bloom to early maturity. If these values are used as in Table 3, then none of the treatments had leaf K below sufficiency. Also, reported sufficiency levels used for Mg, B, and Zn may suggest to some growers that this crop was marginally low in these nutrients if the inappropriate sufficiency range is used for the age of the crop. Clearly, B was not low because there was no yield response to

this nutrient. Other research has failed to show a response by cotton to Mg and Zn under these conditions. Low leaf Mg levels seem to have been induced by the excessive rate of K applied in some treatments.

Summary

1) Potassium. Very high soil K levels at this site precluded any expected response to added K. Leaf blade K levels suggest the need for growers to pay very close attention to the time of sampling when using leaf analyses to diagnose K sufficiency levels in cotton. Excessive K application appeared to suppress leaf-blade Mg concentrations and yields in 2002.
2) Phosphorus. Although soil test P was near the critical value used for Lancaster extractable P on Black Belt soils, there was no yield response to added P. This suggests that the current critical value is certainly not too high.
3) Boron and sulfur. There was no yield response to B or S. Leaf blade B and S was well within the established sufficiency ranges for mid bloom.
4) Nitrogen. Most of the total N application should be applied as a sidedress even if it is applied as late as early bloom. This is to avoid denitrification losses from extremely wet springs such as 2003. In moderately dry years as in 2002, the A.U. standard recommendation of 90 pounds N per acre appeared sufficient for maximum yields. However, in extremely wet years as in 2003, rates as high or higher than 120 pounds N per acre as a sidedress may be warranted.

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Table 1. Fertilizer treatments used in 2002 and 2003.

Treatment	N*	P_2O_5	K_2O	Other
	pounds/acre			
1. No K	95/90	60	0	
2. Moderate K	95/90	60	60	
3. High K	95/90	60	120	
4. Very High K	95/90	60	240	
5. High Sulfur	95/90	60	120	51 lb. S/acre as ammonium sulfate
6. High Boron	95/90	60	120	1.0 lb. B/acre as Solubor™
7. No P	95/90	0	120	
8. No N	50/0	60	120	
9. Moderate N	80/60	60	120	
10. High N	120	60	120	
11. Very high N	180	60	120	

*The first value is the total N rate applied in 2002; the second value is the rate applied in 2003.

Table 2. Information about the crop in 2002 and 2003

	2002	2003
Cultivar	'DPL 5415 RR'	'DPL 5415 RR'
Tillage	Raised beds/cultivation	Raised beds/cultivation
Plant date	4/18	4/24
Date fertilizer applied	4/18	4/29
Date sidedressed N	6/13	No sidedress N applied
Date of harvest	10/5	10/25
Rainfall (May-September)	24.85 inches	38.24 inches
Mean lint yield on test	1015 pounds/acre	448 pounds per acre
Yield C.V.	13.5%	12.5%
Soil test at site:		
pH	6.1	
Extractable P (Lancaster)	76 pp2m (High)	
Extractable K (Lancaster)	519 pp2m (Very High)	
Extractable Mg (Lancaster)	496 pp2m (High)	
CEC	> 15.0 cmol/kg	

Table 3. Leaf blade analyses taken in 2002 from selected treatments.

Treatment	N	P	K	Ca	Mg	S	B	Zn	Mn	Cu	Na
	%						mg/kg				
1. No K	--	0.38	0.92	2.42	0.32	--	18	17	43	5	712
2. Moderate K	--	0.34	0.86	2.36	0.30	--	18	16	41	5	691
3. High K/control	3.58	0.36	0.89	2.43	0.29	0.35	17	17	41	4	679
4. Very High K	--	0.35	0.94	2.54	0.28	--	16	18	44	6	667
5. High Sulfur	3.44	--	--	--	--	0.34	--	--	--	--	--
6. High Boron	--	0.36	0.92	2.38	0.30	--	18	18	37	5	690
7. No P	--	0.36	0.93	2.37	0.29	--	16	16	37	5	562
8. No N	3.24	--	--	--	--	--	--	--	--	--	--
9. Moderate N	3.43	--	--	--	--	--	--	--	--	--	--
10. High N	3.68	--	--	--	--	--	--	--	--	--	--
11. Very high N	4.16	--	--	--	--	--	--	--	--	--	--
L.S.D. (P<0.05)	0.49	ns	ns	ns	0.04	ns	2	ns	7	ns	219
A.U. sufficiency range at early bloom	3.50 to 4.50	0.30 to 0.50	1.50 to 3.00	2.00 to 3.00	0.30 to 0.90	0.25 to 0.80	20 to 80	20 to 200	25 to 300	5 to 25	na
Recommended range at mid to late bloom	3.0 -4.5	0.15 -0.6	0.75 -2.5	2.0 -4.0	0.3 -0.9	0.3 -0.9	15- 200	50- 300	10- 400	--	--

Figure 1. Experiment was conducted on a Houston clay (very-fine, smectitic, thermic Oxyaquic Hapluderts) in western Dallas County in the Black Belt Prairie region of Central Alabama.

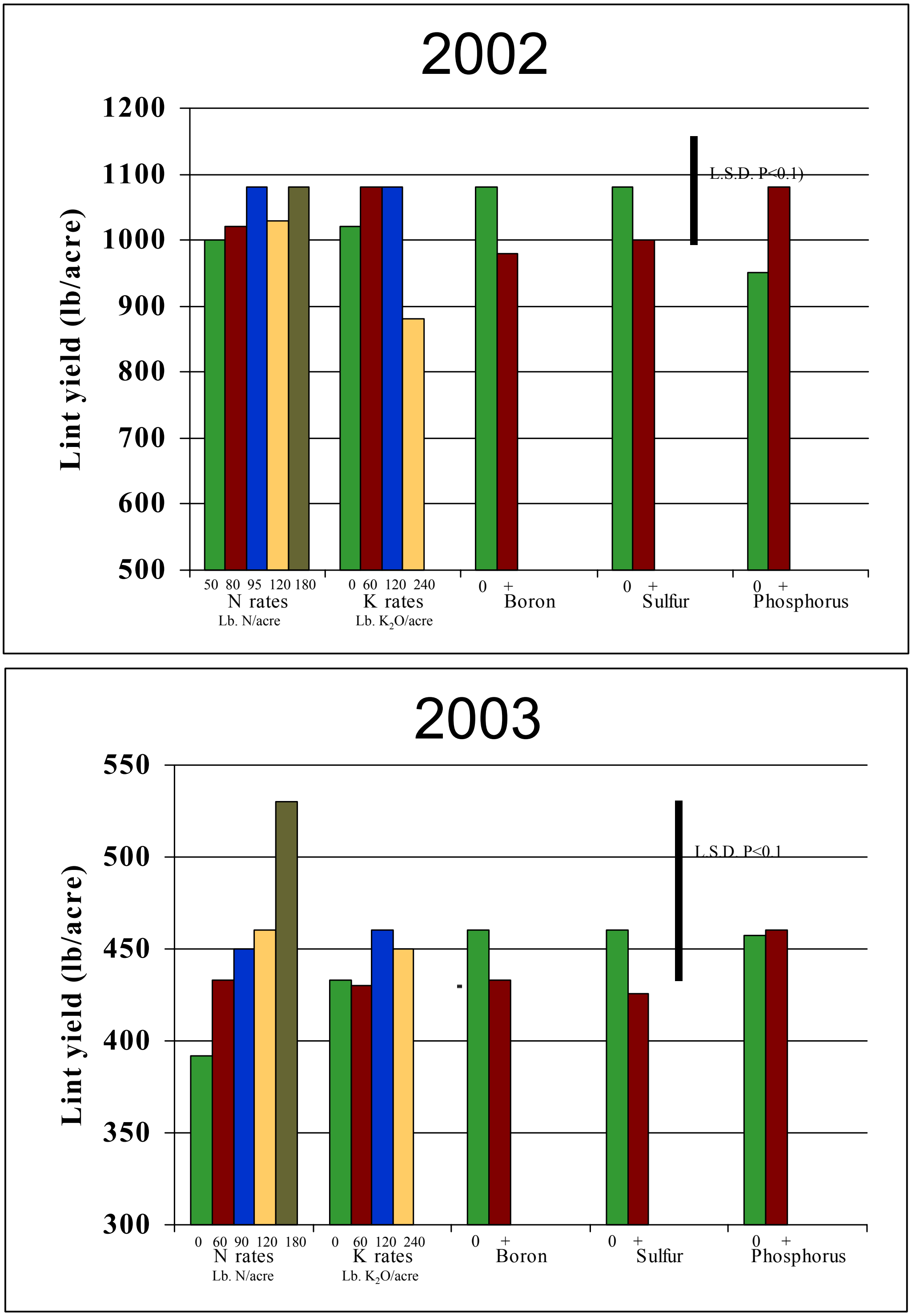

Figure 2. Cotton lint yields from selected treatments in 2002 and 2003. Note that 2002 yields were more than doubled those in 2003 due to excessive and persistent rain during much of the 2003 growing season which resulted in severe denitrification losses.

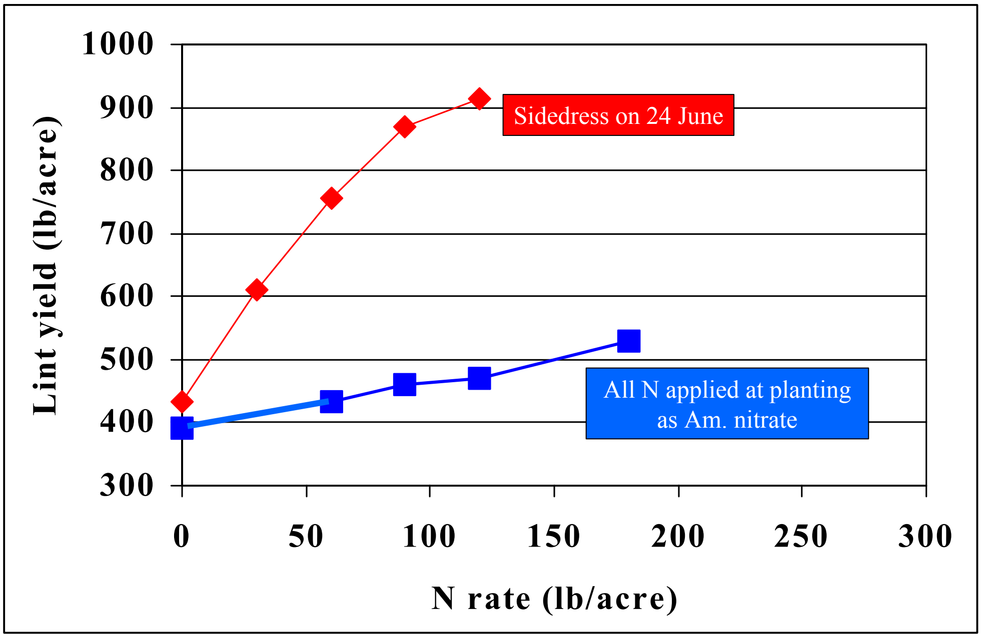

Figure 3. Effect of N on cotton lint yields on a Houston clay in Dallas Co. in 2003. Excessive rainfall resulted in loss of almost all N applied at planting regardless of source.

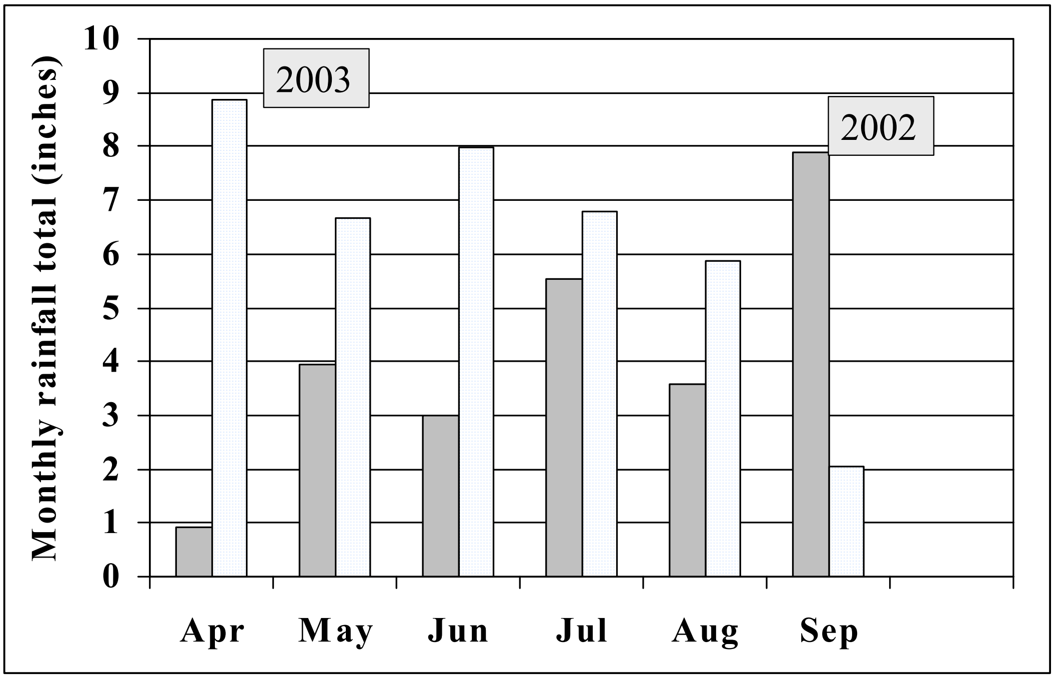

Figure 4. Monthly rainfall totals in 2002 and 2003 at Marion Junction, AL, about 5 miles from site of experiment.