FERTILIZATION OF COTTON ON A BLACK BELT SOIL IN ALABAMA

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Introduction

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. Most fine-textured, Black Belt soils test "low" in P and "high" or "very high" in K if recognized analytical techniques are used that are appropriate for these highly buffered, often calcareous soils (Adams et al., 1994). 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. These soils have a much higher cation exchange capacity compared to adjacent soils of the Coastal Plain or Tennessee Valley region. They generally have poor internal drainage, low saturated hydraulic conductivity, poor infiltration and may be calcareous with a soil pH above 7.0.

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).

On-farm tests were attempted in 2001-2003 on a Houston clay in West Alabama (Mitchell et al., 2004). 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. 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. 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.

Objectives

The purpose of this experiment is to identify optimum rates of N, P_2O_5, and K_2O for cotton on Black Belt soils by having a permanent site for soil fertility research at the Black Belt Research and Extension Center in Marion Junction, Alabama.

Methods

Initial soil tests from the site indicated a very uniform site typical of unfertilized Black Belt area cropland (Table 1). Phosphorus was rated low using the Mississippi/Lancaster extract which is the preferred method for these soils and is used by both the Auburn University and Mississippi State University soil testing laboratories. Potassium is rated "very high". Soil samples have been taken from each plot every year of this experiment but are not included in this paper.

This experiment was laid out in 2004 and was designed to complement the "Rates of NPK Experiment" (circa 1929) on other outlying units of the Alabama Agricultural Experiment Station (Cope, 1984). The site is on an acid, Vaiden clay (very fine, smetitic, thermic, Vertic Hapludalfs) and is the only soil fertility experiment in Alabama on Black Belt soils. The experiment consists of 6 N rates, 4 P rates, 5 K rates and a no-lime treatment and an unfertilized treatment replicated 4 times in a randomized block design (Table 2). Plot size is 15 x 25 feet (5, 36-inch rows wide). Because of disappointing yields in 2005 when cotton was planted no-till into a rye cover crop and excessive rainfall, the decision was made to switch to a ridge tillage system with no cover crop for 2006 and 2007. All the P and K and ½ of total N were applied within 1 week of planting in late April. Complement of N was applied in mid June. Lint yields were estimated by hand-picking 20 feet from the two middle rows in each plot. Relative yields are yields compared to the mean yield of treatment no. 5, the control treatment, which receives 90-100-100 pounds N-P_2O_5-K_2O per acre each year (Fig. 2).

Table 1. Initial, mean plow-layer soil test value (n=4) from site taken in 2004.

Extract used	Soil pH_w	P	K	Mg	Ca
		----------mg/kg and rating*----------			
Mehlich-1	6.0	4 Very Low	88 High	35 High	2330 (not rated)
Miss/Lancaster	6.0	16 Low	180 V. High	60 High	10,000+

*Adams et al., 1994

Results

Excessive rainfall from several tropical storms and anaerobic soil conditions dramatically limited cotton lint yields in 2005. The following two years have been described as the worst summer droughts and highest temperatures in over 50 years (Fig. 1). The drought severely limited yields in 2006, but critical rainfall in July resulted in somewhat higher yields in 2007. Yields were from hand-picked plots. If the 2006 and 2007 crops had been machine harvested, very little of the lint would have been saved because of hard locks and weak bolls. Cotton lint quality was measured in 2006 and 2007 on 4 different treatments by USDA AMS Cotton Program Birmingham Classing Office, No N (treat no. 1), No P (treat no. 7, No K (treat no. 11) and the complete fertilized control (treatment no. 5). There were no differences in mean fiber quality due to soil fertility treatment.

	2006	2007
Micronaire	4.6	3.97
Length	97	1.02
Strength	26.9	26.4
Uniformity	81.9	81.9

Because of the higher yields and significant differences in treatment on yield in 2007, 2007 data are probably more relevant to producers (Table 2, Fig. 2).

N rates. Optimum total N rates in the two dry years, 2006 and 2007, appear to be around 60 pounds N per acre, although rates above 30 pounds N per acre produced relative yields above 95% of maximum. Although there was a more dramatic response to N rates in 2005, yields were low because excessive rainfall resulted in severe denitrification losses on these poorly drained soils. On-farm tests in 2003 when excessive rainfall also limited yields, showed that delaying N application until sidedressing could almost double the yield potential of cotton (Mitchell et al., 2004). In these tests, optimum N rate when denitrification was a problem was 120 pounds N per acre as a sidedress.

P_2O_5 rates. One would have anticipated more dramatic responses to rates of P than we found in these tests because of the low soil test P rating (Fig. 2). Except for the low-yielding, wet year of 2005, there really was very little yield response to added P. This calls into question the current "low" rating for this soil test value for cotton.. The definition of a "low" soil test rating indicates that the soil will produce less than 75% of its potential without fertilization of that nutrient (Adams et al., 1994). Without P in 2006 and 2007, relative cotton lint yields were above 80%.

K_2O rates. In spite of the fact that this soil initially tested "very high" in K, there were significant increases in yield with higher rates of K_2O up to 100 pounds per acre in 2005 and 2007. These results provide credibility to grower's

claims that additional K seems to increase yields even though the soils are rated "very high" for K. There may be justification to change soil test K ratings for these soils and increase K recommendations for cotton. Additional studies are on-going related to this issue.

Summary

Three years of extreme weather conditions and very poor cotton yields at this site preclude any major conclusions regarding soil fertility. Significant differences in 2007 due to treatments suggest a need for modification of soil test ratings for both P and K on these soils. Phosphorus may be currently rated too low and potassium may be rated too high for cotton on these soils. Since these are the only established soil fertility variable plots on the Black Belt R&E Center, we hope that they will be maintained indefinitely as is the "Rates of NPK" experiment at 6 other Alabama locations to provide more conclusive evidence for changes in soil test calibration for similar Alabama soils.

Acknowledgement

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References

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Table 2. Fertilizer treatments and cotton lint yields on a Vaiden clay in West Alabama, 2005-2007.

Treatment number	Description	Rate of Nutrients applied			2005	2006	2007
		N	P_2O_5	K_2O	Lint yield	Lint yield	Lint yield
		----------pounds per acre----------					
N rates							
1	No N	0	100	100	177	311	870
2	Low N	30	100	100	214	380	1040
3	Intermediate N	60	100	100	265	403	990
5	Control	90	100	100	388	393	1076
4	High N	120	100	100	237	400	1037
6	No S/VH N	150	100	100	320	387	1040
P rates							
7	No P	90	0	100	280	378	910
8	Very low P	90	20	100	205	394	940
9	Low soil P	90	40	100	274	375	1091
10	Intermediate P	90	60	100	233	388	1027
5	Control	90	100	100	388	393	1076
K rates							
11	No K	90	100	0	157	353	585
12	Very low K	90	100	20	170	324	784
13	Low K	90	100	40	253	295	803
14	Intermediate K	90	100	60	341	335	922
15	High K	90	100	80	319	349	806
5	Control	90	100	100	388	393	1076
Other treatments							
16	No lime	90	100	100	196	413	1027
17	Nothing	0	0	0	160	300	649
	L.S.D $_{P<0.1}$				135	ns	220

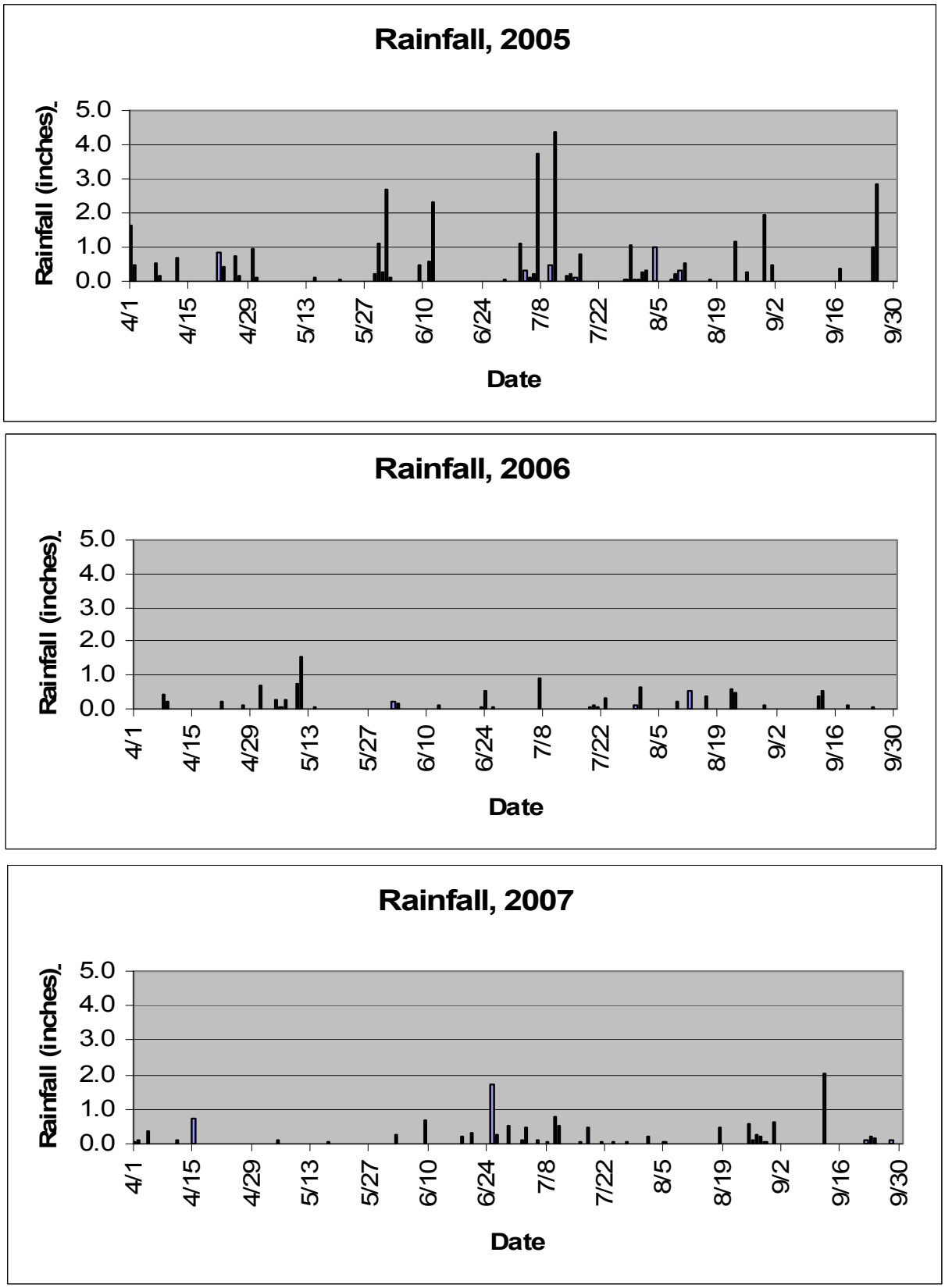
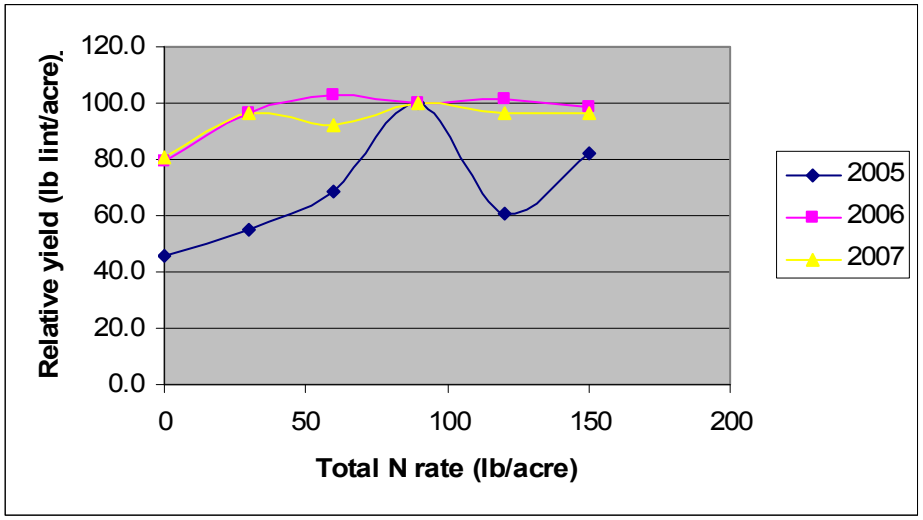
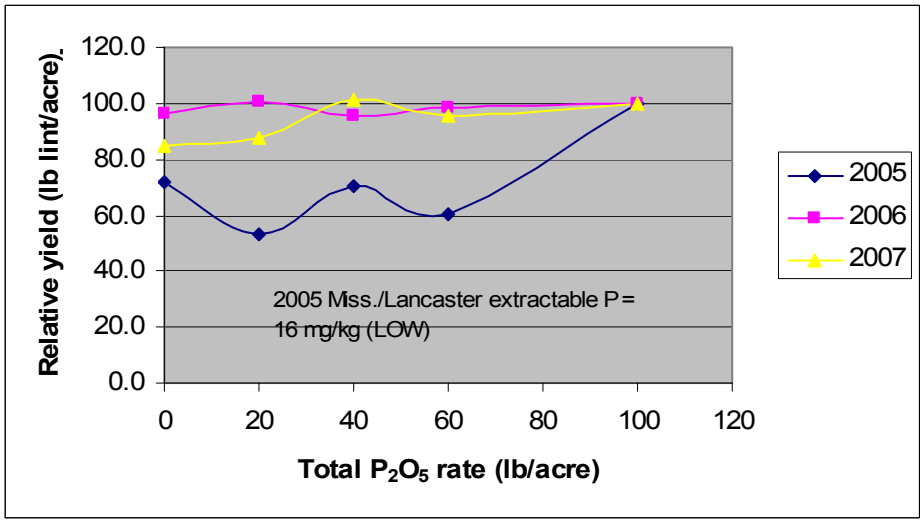


Fig. 1. Precipitation at Black Belt R&E Center, 2005-2007.





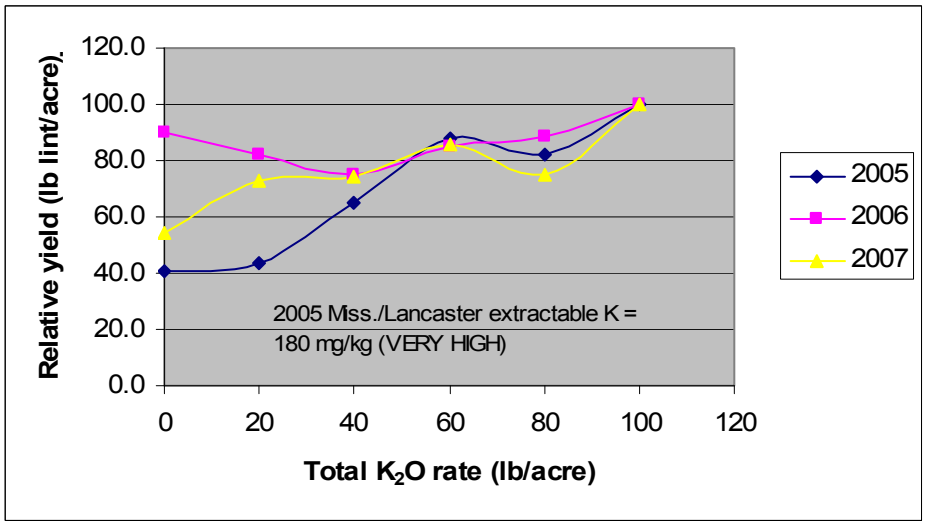


Fig. 2. Effect of rates of N, P_2O_5, and K_2O on relative cotton lint yields in 3 years on a Vaiden clay in West Alabama.