COTTON SOIL FERTILITY ON ALABAMA BLACK BELT SOILS

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Abstract

Cotton producers on clayey soils of the West Alabama Black Belt Prairie region have often complained of leaf-spot diseases which cause early defoliation of cotton. Some of these problems seemed to have been associated with K deficiencies although the soils often test “high” or “very high” in extractable K. Because no soil fertility research has been conducted with cotton on these soils in several decades, an experiment was begun in 2005 to evaluate N, P, and K rates for cotton on these soils and to provide information for soil test calibration. The experiment contained 6 rates of N, 5 rates of P, and 6 rates if K. The experiment is non-irrigated so weather extremes have had a serious impact on yields. Reasonably good yields in 2007 and 2008 seem to verify that Auburn University’s current standard N recommendation of 90±30 lb. total N per acre is a good standard N recommendation for these soils. However, soil test interpretations suggests that current soil test P ratings may be much too low for these soils, e.g. what is considered “low” (16 mg P/kg using Mississippi/Lancaster extract) may actually be “high” extractable P levels for cotton. Therefore, P is often over recommended for these soils. On the other hand, significant cotton yield responses to added K suggest that the K rating should be “low” when it is currently rated “very high” (180 mg K/ kg using the Mississippi/Lancaster extract). This change would increase soil test K recommendations for cotton on these soils.

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.

Problems with early defoliation due to leaf spot diseases (*Cercospora sp., Alternaria sp*.) in 1999 and 2000 seemed to be exclusively associated with the fine-textured, soils of the Black Belt region (Table 1). Furthermore, any stress on the plant including soils low in K, seemed to be a factor in the incidences of leaf spot diseases (ACES, 2002).

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 as or higher than 120 pounds N per acre as a sidedress may be warranted.

Table 1. An informal grower survey of leaf drop problems with cotton in the Black Belt region of West Alabama in 1999 – 2001 (ACES, 2002).

	Probability of Problem Occurring				
Situation	Low	Moderate	High	VH	Not appli-cable
SOIL:					
Upland soil					X
Bottomland soil					X
Prairie-type, clayey soil (e.g. Houston clay)			X		
Red soil in prairie	X				
Coastal plain, sandy soil	X				
Tile drained soil		X			
TILLAGE PRACTICES:					
No till			X		
Para till		X			
Conventional	X				
PLANTING METHOD/TIME:					
Flat planted on stale seedbed			X		
Bedded, stale seedbed			X		
Flat planted with conventional tillage	X				
Flat planted into cover crop	X				
Planted on bed into cover crop	X				
Seed planted deeply (because of dry soil)				X	
Early planted			X		
Late planted	X				
RAINFALL/IRRIGATION:					
Excessive early-season rainfall				X	
Excessive late-season rainfall					?
Irrigated cotton	X				
COTTON VARIETY/CHARACTERISTICS					
Full-season variety	X				
Short-season variety				X	
Good early-season boll set		X			
CROPPING SYSTEMS:					
Following soybeans				X	
Following corn	X				
Cover crop	X				
SOIL FERTILITY:					
Low soil test K				X	
Low subsoil K					?
High N fertilization (>100 lb. N/acre)	X				
Low N fertilization (<100 lb. N/acre)		X			
Past high fertilization used	X				
Chicken litter used					X

Table 2. Initial, mean plow-layer soil test value (n=4) from site taken in 2004.					
		P	K	Mg	Ca
Extract used	Soil pH_w	----------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					

Table 3. Fertilizer treatments and cotton lint yields on a Vaiden clay in West Alabama, 2005-2008.										
Treatment number	Description	Rate of Nutrients applied			Cotton lint yields					
		N	P_2O_5	K_2O	2005	2006	2007*		2008*	
		----------pounds per acre ----------								
N rates										
1	No N	0	100	100	177	311	870	bcd	960	cde
2	Low N	30	100	100	214	380	1040	ab	1070	bcd
3	Intermediate N	60	100	100	265	403	990	abc	1220	abc
5	Control	90	100	100	388	393	1076	abc	1350	ab
4	High N	120	100	100	237	400	1037	ab	1340	ab
6	No S/VH N	150	100	100	320	387	1040	ab	1360	ab
P rates										
7	No P	90	0	100	280	378	910	abcd	1300	ab
8	Very low P	90	20	100	205	394	940	abcd	1350	ab
9	Low soil P	90	40	100	274	375	1091	a	1260	abc
10	Intermediate P	90	60	100	233	388	1027	ab	1460	a
5	Control	90	100	100	388	393	1076	abc	1340	ab
K rates										
11	No K	90	100	0	157	353	585	f	600	f
12	Very low K	90	100	20	170	324	784	de	770	edf
13	Low K	90	100	40	253	295	803	cde	1030	bcd
14	Intermediate K	90	100	60	341	335	922	abcd	1030	bcd
15	High K	90	100	80	319	349	806	cde	1150	abc
5	Control	90	100	100	388	393	1076	ab	1340	ab
Other treatments										
16	No lime	90	100	100	196	413	1027	ab	1350	ab
17	Nothing	0	0	0	160	300	649	ef	670	ef
	$L.S.D_{P<0.1}$				135	ns	--	--	--	--
*Values followed by the same letter are not significantly different at P<0.05.										

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. Another objective not covered in this paper is to develop soil test calibration for P and K for cotton on this soil.

Methods

Initial soil tests from the site indicated a very uniform site typical of unfertilized Black Belt area cropland (Table 2). 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 3). 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 beyond. 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.

Results

The 2008 growing season started out as the third drought year in a row for this area. It was extremely dry early in the season. Late summer rains and a tropical storm resulted in relatively good cotton lint yields (Fig. 2). However, stress due to dry weather did create some early defoliation due to leaf spot problems in August, especially on the low K treatments (Fig. 1). 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. 3). The drought severely limited yields in 2006, but critical rainfall in July resulted in somewhat higher yields in 2007 (Fig. 3, Table 3). 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.

Lint Quality

Cotton lint quality was measured in 2006, 2007 and 2008 on selected treatments by USDA AMS Cotton Program Birmingham Classing Office. There were no differences in mean fiber quality due to soil fertility treatment in 2006 and 2007 but there were differences in 2008 (Table 4).

Table 4. Fiber quality from selected treatments.

Treatment no. and description	Lint %	Micronaire	Length	Strength	Uniformity
Year = 2006					
Mean of all	47	4.60	97.0	26.9	81.9
Year = 2007					
Mean of all	43	3.97	1.02	26.4	81.9
Year = 2008*					
1. No N	49 a	4.05 a	1.04 a	27.5 ab	81.9 ab
4. 120 lb. N/acre	46 bc	4.22 a	1.07 a	28.8 a	83.0 a
7. No P	47 b	4.18 a	1.04 a	27.8 ab	81.0 b
11. No K	45 c	3.15 b	1.06 a	26.7 b	80.5 b
15. 80 lb. K_2O/acre	46 bc	3.78 ab	1.04 a	28.8 a	82.0 ab

* Values within the same column followed by the same letter are not significantly different at P<0.05.

N rates

Because of the higher yields and significant differences in treatment on yield in 2007 and 2008, these data are probably more relevant to producers (Table 3, Fig. 4). 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. In 2008, optimum yields were closer to the currently recommended 90 lb. total N per acre (Adams et al., 1994). There was a more dramatic response to N rates in 2005 but yields were low due to excessive rainfall and 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. 3). 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, 2007, and 2008, 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, 2007 and 2008. 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. In fact, without added K in 2005, 2007, and 2008, relative yields were at or below 50% of highest yields with K fertilization. According to Adams et al. (1994), a soil test rating of "very low" for a nutrient would be associated with a soil capable of producing only 50 percent of optimum yields without additional fertilization of that nutrient. This soil should be rated "very low" in K instead of "very high". At this rating, current recommendations for cotton would be up to 120 lb. K_2O per acre.

Leaf spot diseases

In early August of 2008, foliar leaf spot diseases (*Cercospora /Alternaria* complex) were apparent in the low K plots and by mid-August, many of these plots had defoliated due to the diseases. While this is the first time these diseases have been found in the 4 yr of this experiment, it did appear to be much more severe in the low K treatments.

Summary

This site has been plagued with extreme weather conditions and poor cotton yields in 2 out of 4 years. However, these conditions are not unlike that faced by most producers on these soils. Significant differences in 2007 and 2008 with reasonable, non-irrigated cotton lint yields 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. Currently recommended total N rates for cotton on these soils, 90 lb. N per acre, is certainly not too high. 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.

Fig. 1. Cotton in a "no K" treatment that was completely defoliated by 1 September due to leaf spot disease first noticed on 1 August (insert).

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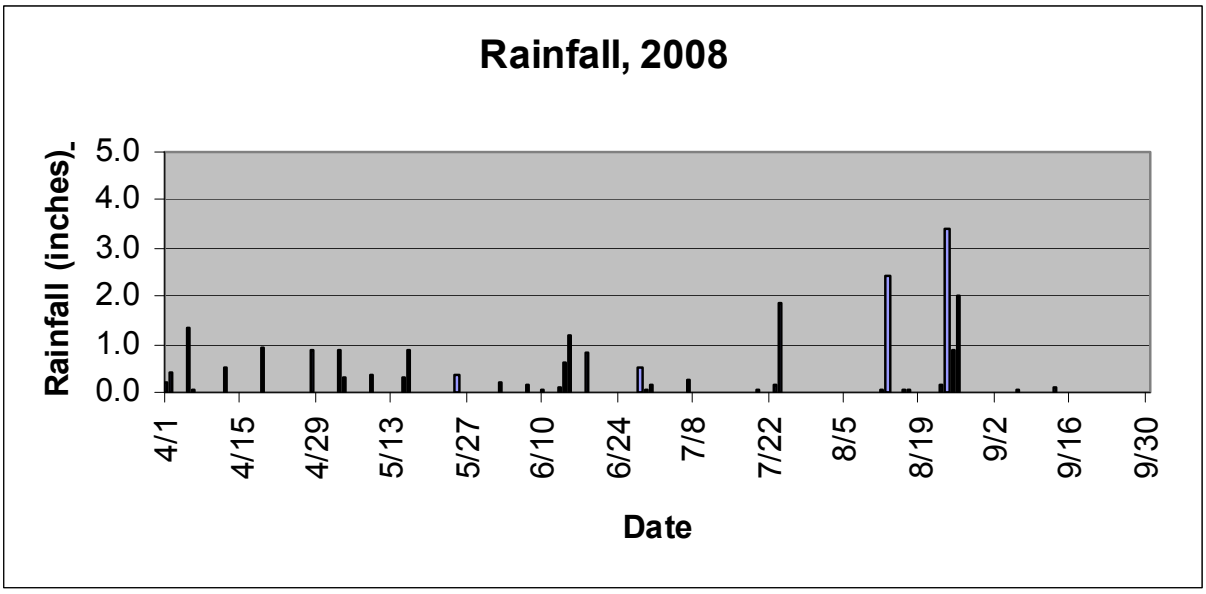


Fig. 2. Precipitation at Black Belt R&E Center in 2008. Note heavy rainfall on 24-26 August due to a tropical storm.

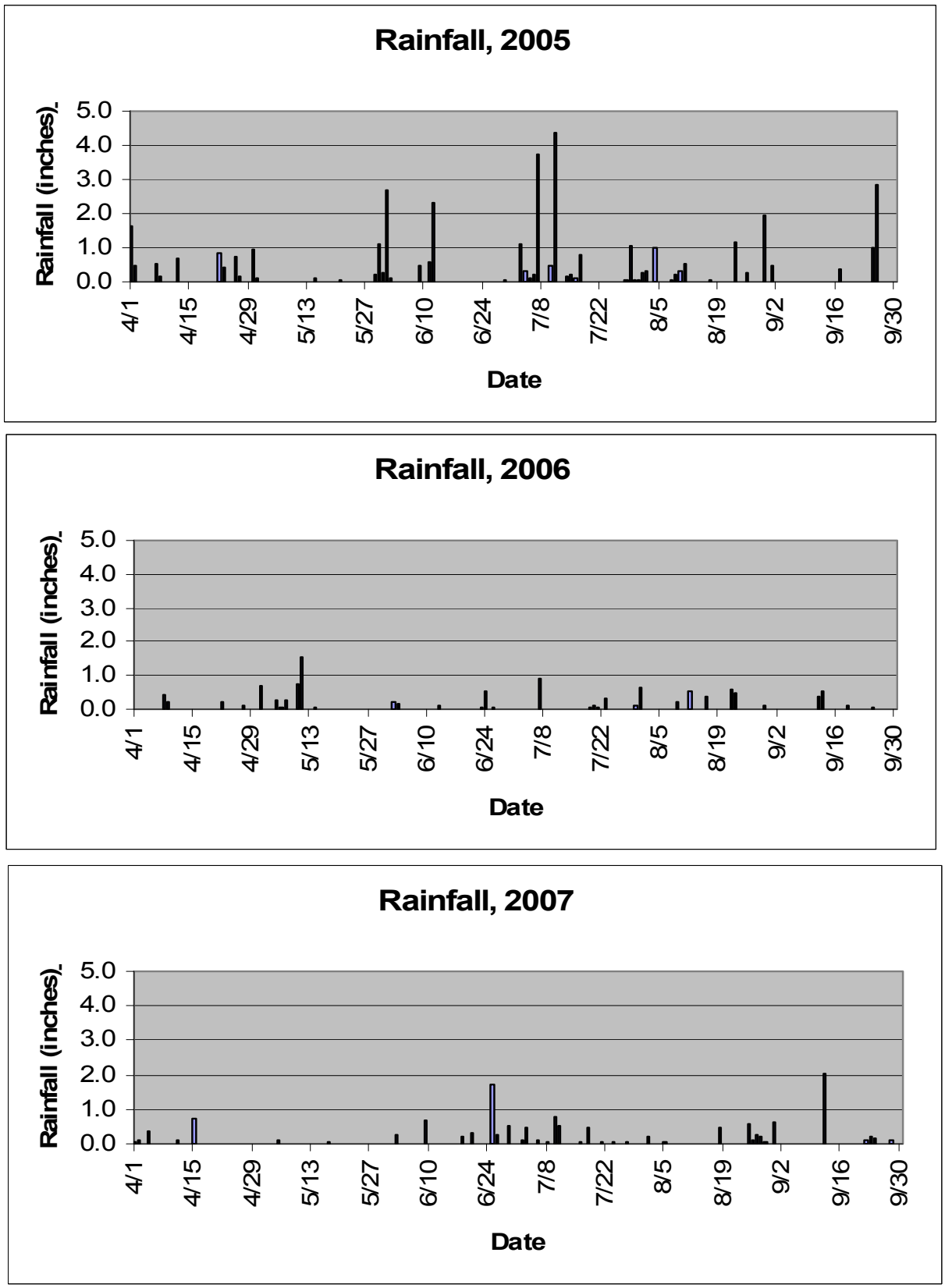
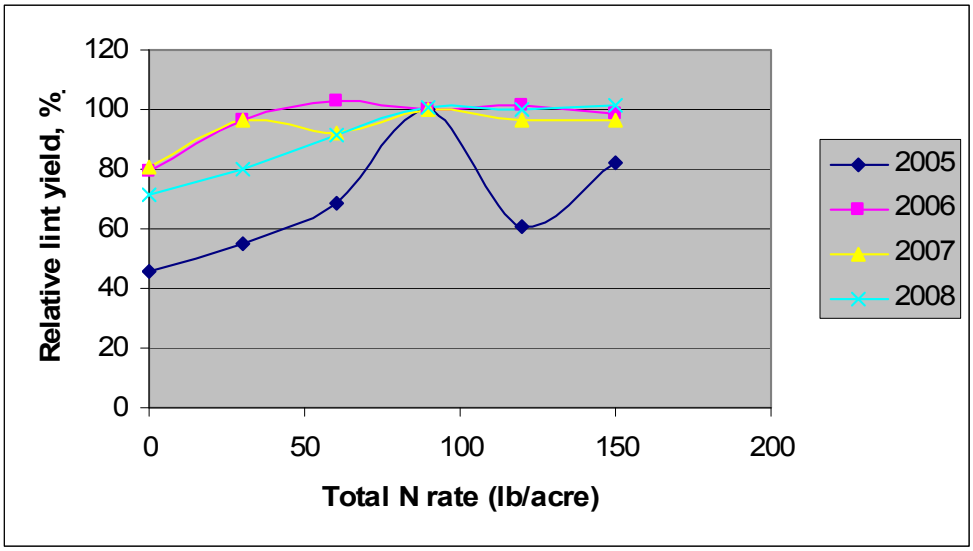
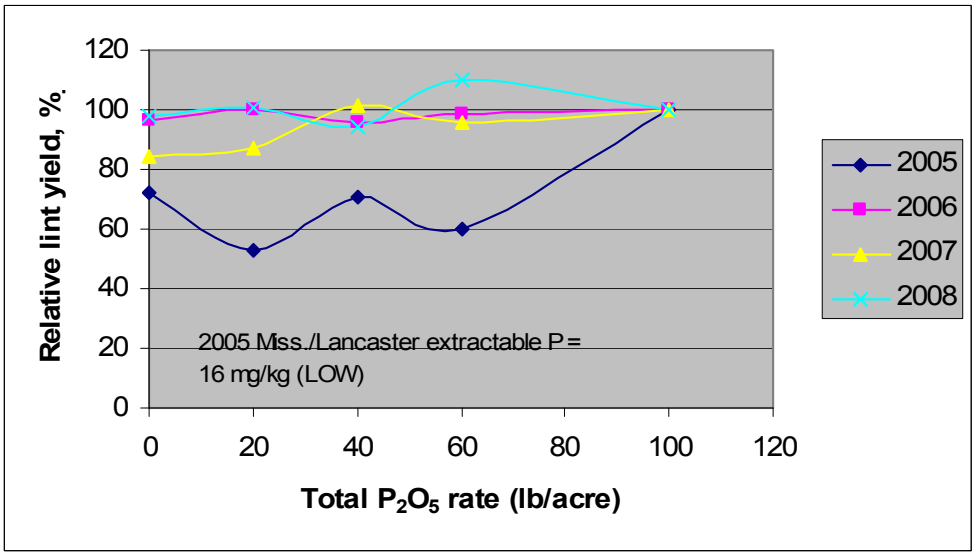


Fig. 3. Precipitation at Black Belt R&E Center, 2005-2007. Excessive rainfall in 2005 was following by an extreme drought in 2006 and a very dry spring in 2007.





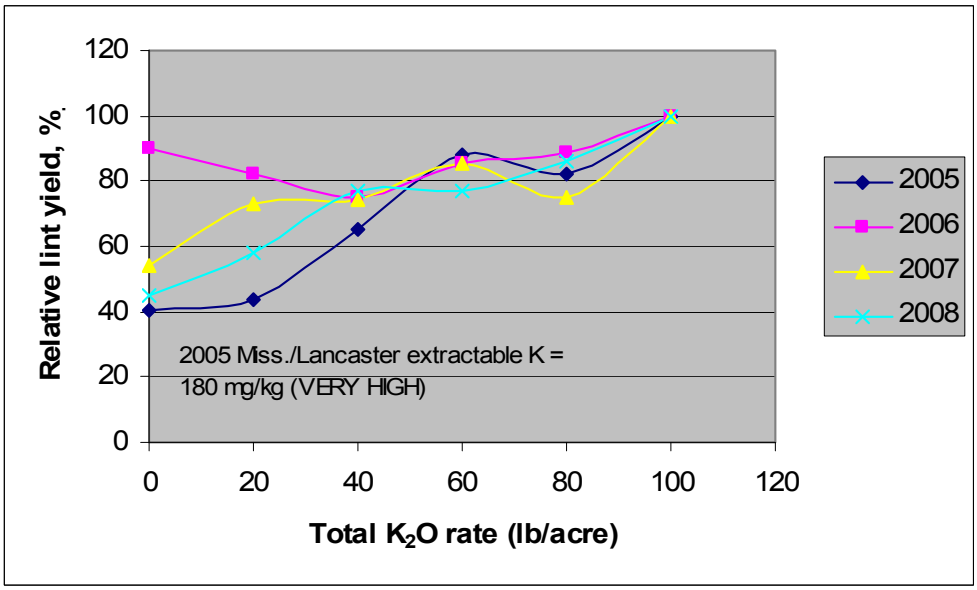


Fig. 4. Effect of rates of N, P_2O_5, and K_2O on relative cotton lint yields in 3 years on a Vaiden clay in West Alabama.