COTTON RESPONSE TO SURFACE APPLICATIONS OF POTASSIUM FERTILIZER: A TEN YEAR SUMMARY

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Abstract

Field studies were conducted in North Alabama to evaluate cotton (*Gossypium hirsutum*) response to long-term applications of K fertilizer, and to evaluate K movement and status within the soil profile resulting from these applications. The test was initiated in the fall of 1986. Potassium was applied to a Dewey silt loam (Typic Paleudult) at rates of 0, 60, 120 and 180 lb K_2O acre^{-1} for the first three years of the study. No K fertilizer was applied during the fourth year of the study (1990). After the fourth year of the test, half of the plots were left in residual. The experiment had a split plot design with four replications. During 1987-1989, two varieties were compared (Stoneville 825 and Deltapine 50) and these served as whole plots. During 1991-1997, only one variety was evaluated and annual versus residual K fertilization served as whole plots. Potassium treatments have been used as subplots throughout the test. During the first three years of the test there were no consistent differences between Stoneville 825 and Deltapine 50. Lint yields were increased significantly by K fertilization in one out of every two years during this 10-year test. In non-responsive years, a lack of a response to K fertilization was attributed to poor rainfall amount and/or distribution. In good production years, K fertilization on this soil increased lint yields by as much as one bale per acre. During 1991-1996, residual K fertility treatments consistently produced lower yields as compared to annual K treatments. In this test there were no significant differences between split (fall-spring), fall or spring applied K with respect to lint yields. The yield response data from this test gives strong support to the calibration data currently used by the Auburn University Soil Testing Laboratory. For the duration of this test, applying K according to the recommendations of the Auburn University soil testing laboratory resulted in an average increased yield of 2.8 lb lint for every lb of applied K_2O. Micronaire increased with increasing K rates and was the only lint quality parameter that was consistently affected by K fertilization. Soil analysis data showed increased levels of Mehlich 1, ammonium acetate and boiling nitric acid (nonexchangeable) extractable K in the plow layer of this soil. Data collected in 1989, 1993 and 1997 indicate that there was no detectable downward movement of K in this soil.

Introduction

Late season K deficiency in cotton across the cotton belt has led to renewed interest in soil test calibration for K in many states. In recent years cotton response to K fertilizer rates and placement as well as foliar feeding has been evaluated. Responses of cotton to K fertilization in many of these relatively short-term studies have been inconsistent.

Previous work in Alabama has shown that cotton yields are more affected by inadequate K as compared to soybeans (*Glycine max* (L) Merr.) and grain crops (Cope, 1981). Potassium deficiency is often more dramatic when cotton is planted on soils that previously had been in hay production (Rouse, 1960) which is related to the depletion of soil K levels.

This field study was initiated in the fall of 1986 on a Tennessee Valley soil in North Alabama that had been in alfalfa (*Medicago sativa* L.) production for five years. The objectives of the study were: 1) Evaluate cotton response to long-term applications of K fertilizer; 2) Evaluate cotton response to annual and residual K fertilization; and 3) Evaluate K movement and status within the soil profile resulting from these applications.

Materials and Methods

The study was initiated in the fall of 1986 on a Dewey silt loam (clayey, kaolinitic, thermic Typic Paleudult) in North Alabama. Alfalfa had been produced in the test site for five years prior to the initiation of this test. Initially, the site had a "low" soil test rating for K according to the Auburn University Soil testing Laboratory. Potassium was applied at rates of 0, 60, 120 and 180 lb K_2O acre^{-1}. Fertilizer was broadcast in the spring or split applied in the fall and spring. Fall applied fertilizer was broadcast and the experimental area was turned with a moldboard plow to a depth of 8 to 10 inches. Spring applied K was broadcast prior to the final tillage operation in the spring. Initial treatments also included two cotton varieties: 1) Deltapine 50 and 2) Stoneville 825. Stoneville 825 is a longer season wilt susceptible variety while Deltapine 50 is a short season variety with some resistance to wilt. Plots were 25 feet long with six rows.

The experiment had a split-plot design with four replications. Varieties (1987-1989) were the whole plots. Potassium treatments were the subplots. The experiment was conducted using this treatment combination during the growing seasons of 1987, 1988 and 1989. In the fall of 1989 and spring of 1990, no K fertilizer was applied and

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soybeans (*Glycine max* (L) Merr.), variety "centennial" were grown in the entire experimental area. Potassium fertilization was resumed in the fall of 1990 with two major changes in the experiment: 1) only one variety was grown in the test and 2) half of the experimental plots received annual K fertilization treatments while the remaining plots were left in residual. Thus, during 1991-1997, annual and residual K fertilization where the whole plots and the initial K treatments served as subplot. Deltapine 50 was planted in 1991 and 1992 while Deltapine 51 was planted in 1993-1997.

Yields were determined each year by mechanically picking the two center rows from each plot. Lint quality was evaluated beginning in 1989 (HVI since 1991). Since 1989, surface soil samples have been collected in the fall of most years for routine soil test analysis by the Auburn University Soil Testing Laboratory.

In the fall of 1989, 1993 and 1997 intensive soil sampling was conducted in the residual (1989, 1993) and annual (1989, 1993, 1997) treatments to evaluate the profile distribution of K. Six, 1.25 inch diameter soil cores were collected from the center of each plot following harvest in the fall. Each core was subdivided into depth increments of 0-9, 9-15, 15-20, 20-25, and 25-30 inches. Samples from the same plot and depth were composited, air dried, and ground to pass a 10 mesh sieve. The samples were analyzed for Mehlich 1 (1989, 1993, 1997), 1 N ammonium acetate (1993) and boiling nitric acid (1993; nonexchangeable) extractable K. Surface samples collected from selected annual treatments in 1993 were also subjected to evaluation of K quantity/intensity relationships.

Results and Discussion

During the first three years of the test (1987-1989) short (Deltapine 50) and long (Stoneville 825) season varieties were compared. Yield data showed that there were no treatment effects on seed cotton or lint yields in 1987. In 1988 and 1989, differences in yield among the two varieties were inconsistent (data not shown) and there were no interactions between variety and K treatments. Thus, from this three-year data set we concluded that there were no differences among the two varieties in terms of their response to K fertilization. In 1990, soybeans did not respond to residual fertility levels (no K fertilizer applied in 1990) and averaged 31 bushels/acre.

In this test, annual K treatments were applied during the growing seasons of 1987-1989, no K was applied for the growing season of 1990 and beginning in 1991 (fall of 1990) half of the plot have been kept residual while the remaining plots have received the annual treatments as outlined in Table 1. For the duration of this test, significant yield responses to K treatments by cotton were obtained in 1988, 1989, 1992, 1994 and 1996 (i.e. one out of every two years of the test!) (Table 2). Yield data are not presented for 1997, since adverse early season growing conditions resulted in a loss of the test. During those years where no significant responses to K fertilization were obtained, a lack of response was attributed to the amount and/or distribution of rainfall. In some years, K fertilization increased lint yields by as much as one bale per acre.

Annual treatments consistently produced higher lint yields as compared to residual treatments during 1991-1996 (Table 3). Differences were significant ($P \leq 0.10$) only for those growing seasons where a significant response to K rate was observed. A somewhat surprising result was that there were no interactions between the K treatments (K rate) and the residual vs. annual treatments. For the growing seasons having a significant response to K treatments (Table 2), there was excellent correlation between mean lint yields (annual and residual treatments) and the corresponding soil test K levels (data not shown). Plotting (data not shown) lint yields vs. soil test K levels showed that lint yields peaked at approximately 240-250 lb/acre of Mehlich 1 extractable K, which is in direct agreement with the calibration that is currently used by the Auburn University Soil Testing Laboratory.

In addition to K rates, the experiment also included treatments to evaluate split (fall and spring), fall and spring applications of K (Table 1). For the duration of this test (1987-1996) applying K fertilizer in the fall or split applications (i.e. half applied in the fall and half applied in the spring) of K did not improve lint yields as compared to applying the same total K rate preplant in the spring (Table 2). The results of this test suggest that it does not really matter when fertilizer K is applied to the cotton crop.

Micronaire (Table 4) was the only lint quality parameter that was consistently affected by K treatments. With few exceptions, significant differences in Micronaire were observed only during those growing seasons where lint yields were affected by K treatments. As illustrated in Table 3, lint micornaire increased with increasing K rate. Annual treatments (1991-1996; data not shown) resulted in higher micronaire as compared to the residual treatments. As with the lint yield data, there was excellent correlation between micronaire and the level of Mehlich 1 extractable soil K (data not shown).

Increase in Lint Yield Due To K Fertilization

For a producer that is applying K fertilizer on a regular basis, it would be beneficial to know how much extra lint production is being obtained for every unit of K fertilizer applied. We addressed this question using two approaches. In the first approach, we looked at the total lint production and total K fertilizer applied since the initiation of the test for the annual K treatments (Table 5). Yield data from all cropping seasons (i.e. even those years where yields were not affected by K treatments) were included. Total lint yields for 1987-1996 were calculated and these were used to calculate the total lint yield increase by subtracting the total lint yields obtained from the “0” K check treatment (Table 5). The average lint yield increase per lb of applied K_20 was calculated by dividing the lint yield increase by the total K fertilizer applied during 1987-1996. These calculations show that an average increase of 3.38 lb lint was obtained per lb of K_20 for the treatment receiving 60 lb K_20 acre^{-1} year^{-1}. For increasing K rates, there was a linear decrease in the average increase in lint yield due to K fertilization. The check treatment on this soil had a “low” soil test rating for K, based on the recommendations of the Auburn University Soil Testing Laboratory, and the corresponding K fertilizer recommendation would be 90 lb K_20 acre^{-1}. If the recommendations of the Auburn University Soil Testing Laboratory are followed, a producer could expect an average increase of 2.8 lb lint acre^{-1} for every lb of applied K_20 if K is applied to this soil with a “low” soil test rating.

For our second approach (Table 6), it was assumed that most producers would not allow a soil to become as depleted in K as this site was depleted at the initiation of our test and it was assumed that most cotton soils would have a “medium” soil test rating for K. Beginning in 1991 half of the experimental plots were put in residual, and at that time all of the treatments that had been fertilized with K during 1987 and 1989 had “medium” soil test ratings for K which would be more typical of actual cotton soils. Thus, in our second approach we looked at the increase in lint yields due to annual K fertilization while accounting for the increase in yield due to the residual K fertilizer applied during 1987-1989. Total lint yields for 1991-1996 were determined and average lint yield increases were calculated by subtracting the total lint yields from the “0” K check treatment and the total lint yield from the corresponding residual treatment (Table 6). These calculations showed that the expected increase in lint yield per lb of applied K_20 was lower if the residual K fertility is accounted for during 1991-1996 (Table 6) as compared to basing the calculation on the total K applied from 1987-1996 (Table 5). The residual fertility treatments on this soil had a “medium” soil test rating for K, based on the recommendations of the Auburn University Soil Testing Laboratory and the corresponding K fertilizer recommendation would be 60 lb K_20 acre^{-1}. If the recommendations of the Auburn University Soil Testing Laboratory are followed, a producer could expect an average increase of 2.0 lb lint for every lb K_20 applied to this soil with a “medium” soil test rating.

Soil Profile K

In the fall of 1989 and 1993 intensive soil sampling was conducted in all treatments. Analysis of these samples (data not shown) revealed that K fertilization had increased ($P \leq 0.1$) Mehlich 1 (1989, 1993), ammonium acetate (1993) and boiling nitric acid (1993; nonexchangeable) extractable K in the plow layer of this soil. However, there were no significant differences for these forms of soil K at any depth below the plow layer (up to 30 inches deep). An additional set of soil samples was collected from the annual treatments in the fall of 1997, To date, these samples have been analyzed for Mehlich 1 extractable K and the data show that after 10 annual applications of K fertilizer there is no detectable downward movement of K beneath the plow layer (Table 7) of this soil.

References

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Table 1. Annual K fertilizer treatments. No K fertilizer was applied in the fall of 1989 and spring of 1990. Beginning in the fall of 1990, half of the experimental plots continued to receive annual K treatments.

Annual K Rates			Total Fertilizer K Applied	
Fall	Spring	Total	1987-1989	1991-1997
		lb K_2O/acre		
0	0	0	0	0
0	60	60	180	420
0	120	120	360	840
0	180	180	540	1260
60	60	120	360	840
90	90	180	540	1260
120	0	120	360	84

Table 2. Effect of K fertilizer treatments on mean lint yields. For 1988 and 1989, means are averaged across varieties and for 1992-1996, yields are averaged across annual and residual K treatments. Yields are presented for those years where a significant response to K fertilization was observed.

Annual K Rates			Lint Yields				
Fall	Spring	Total	1988	1989	1992	1994	1996
---- lb K_2O/acre ----					lb/acre		
0	0	0	573	856	961	1237	888
0	60	60	653	1102	1262	1418	1035
0	120	120	637	1172	1258	1524	1082
0	180	180	624	1227	1465	1560	1145
60	60	120	649	1182	1439	1479	1104
90	90	180	718	1186	1438	1556	1085
120	0	120	618	1129	1389	1478	976
	$LSD_{(0.10)}$		58	140	109	127	95

Table 3. Mean lint yields as affected by annual and residual K fertility treatments for 1991-1996.

K Trt.	1991	1992	1993	1994	1995	1996
			-------- lint yields, lb/acre			
Annual	705	1396	1011	1575	817	1133
Residual	645	1235	906	1337	705	957
Probability	NS	0.01	NS	0.01	NS	0.03

NS = non significant

Table 4. Effects of K fertilization (means averaged across annual and residual treatments) on lint Micronaire. Data are presented only for those years (1991-1996) where a significant ($P \leq 0.10$) response to K treatments was observed.

Annual K Rates			Micronaire		
Fall	Spring	Total	1992	1994	1996
--------- lb K_2O/acre -------					
0	0	0	2.98	3.41	3.38
0	60	60	3.39	3.60	3.67
0	120	120	3.56	3.70	3.73
0	180	180	3.59	3.81	3.75
60	60	120	3.65	3.68	3.61
90	90	180	3.69	3.71	3.85
120	0	120	3.54	3.68	3.80
$LSD_{(0.10)}$			0.17	0.15	0.20

Table 5. Total fertilizer K applied to annual treatments from 1987-1996 as compared to the total lint yields, the total lint yield increase due to K fertilization and the average increase in lint yield per lb of applied fertilizer K_2O.

		1987-1996			
Annual Rates		Total	Total	Lint Yield	Lint Increase
Fall	Spring	Fert. K	Lint Yield	Increase	per lb K_2O
-------- K_2O --------		-------------- lb/acre --------------			
0	0	0	7460	---	---
0	60	540	9285	1825	3.38
0	120	1080	9663	2203	2.04
0	180	1620	10114	2654	1.64
60	60	1080	9978	2518	2.33
90	90	1620	10083	2623	1.62
120	0	1080	9374	1080	1.77

Lint Yield Increase = total lint yield minus total yield from "0" K check
Increase per lb K_2O = (Yield increase)/(total K applied during 1987-1996)

Table 6. Total fertilizer K applied to annual treatments from 1991-1996 as compared to total lint yields for the annual treatments, the total lint yield increase due to annual K fertilization (corrected for yield increase due to residual K fertility) and the average increase in lint yield per lb of applied fertilizer K_2O.

		Lint Yield Increase 1991-1996			
Annual Rates		Total	Total	Lint Yield	Lint Increase
Fall	Spring	Fert. K	Lint Yield	Increase	per lb K_2O
--- lb K_2O/acre ---		-------------- lb/acre --------------			
0	0	0	---	---	---
0	60	360	1307	707	1.96
0	120	720	1633	1051	1.46
0	180	1080	1973	1019	0.94
60	60	720	1870	977	1.36
90	90	1080	1902	861	0.8
120	0	720	1378	800	1.11

Total lint yield = total lint yield (1991-1996) for annual K treatments minus total lint yield from corresponding residual K treatment.
Lint Yield Increase = total lint yield minus total lint yield from the "0" K check treatment
Increase per lb K_2O = (Lint Yield Increase)/(total K applied during 91-96)

Table 7. Soil test K (Mehlich 1 extractable) in the fall of 1997 as affected by annual applications of K fertilizer (1987-1997)

Annual	Soil Depth (Inches)				
K Rate	0-9	9-15	15-20	20-25	25-30
lb K_2O/acre	---------------- soil test K, lb /acre ----------------				
0	127	69	69	70	73
60	162	68	65	61	61
120	197	74	58	59	59
180	261	85	64	64	59
$LSD_{(0.10)}$	24	NS	NS	NS	NS