COTTON RESPONSE TO SURFACE AND DEEP PLACEMENT OF POTASSIUM FERTILIZER

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Abstract

A series of field studies was conducted on Alabama soils to evaluate cotton response to surface broadcast and deep placement of K fertilizer. Experiments were initiated in 1989 on a Emory silt loam and a Norfolk sandy loam, and in 1990 on a Lucedale sandy clay loam. Potassium was applied at rates ranging from 0 to 90 lb K_2O A^{-1}. The K was either broadcast on the surface or deep placed. Surface broadcast applications were made with and without in-row subsoiling. Deep placement was achieved with a dry fertilizer applicator which applied the dry fertilizer at depths of 6 to 15 inches behind a subsoiler shank. The Emory and Lucedale soils also received 120 lb K_2O A^{-1} deep placed. Two additional treatments for all three soils received 1500 lb agricultural limestone with and without 90 lb K_2O A^{-1}. During the test the only site where there was a significant difference for surface versus deep placement treatments was on the Norfolk soil. On the Norfolk soil, deep placement of 30 lb K_2O A^{-1} produced higher yields as compared to the surface broadcast application of 30 lb K_2O A^{-1}. At higher rates the surface broadcast treatments consistently produced higher yields as compared to the deep placement treatments. For the Emory and Lucedale soils, there were no significant differences between the two methods of application. Results of these field studies suggest that for Alabama soils, the deep placement of K fertilizer for cotton is not superior to surface broadcast applications of K. The results also show that the deep placement of agricultural limestone with and without K fertilizer for cotton is not justified.

Introduction

Interest in the K nutrition of cotton has increased recently in the Southeast due to more frequent reports of late season K deficiency symptoms. The development of K deficiency late in the season may be due to modern cultivar differences and/or low available K in the subsoil. A survey of 108 cotton fields in Alabama during 1990 showed that 81% of the subsoil samples had a medium or lower soil test rating for K (3). For soils whose subsoil has been biologically depleted through several years of continuous cropping, K deficiency may not be totally corrected by higher rates of surface applied K. Previous work in California (2) has shown that the cotton root system fails to adequately exploit available K in the topsoil. Gulick et al. (2) suggested that K uptake by cotton will be optimized only if a large proportion of the root system is exposed to adequate available K.

Since many soils in the southeastern USA may not have a high level of available K throughout the root zone, cotton may respond to the deep placement of K in the subsoil. Research in the Mississippi Delta has shown increased lint yields on some soils as a result of the deep placement of K fertilizer and/or lime (6, 7). Fertilizer was applied with a dry fertilizer applicator (5) that placed the fertilizer behind a subsoil shank in a narrow vertical band extending from a depth of 6 to 15 inches in the soil. Soils producing the greatest response to deep placed K had subsoils with low to very low soil test ratings for K.

A series of field studies was conducted in North and Central Alabama to evaluate cotton response to surface and deep applications of fertilizer. The objectives were: 1) compare the efficiency of K fertilizer applied as a surface broadcast application to deep placement, and 2) determine if cotton yields can be increased by the deep placement of K fertilizer and/or agricultural limestone.

Materials and Methods

Field studies were initiated in 1989 on a Emory silt loam (Fluventic Umbric Dystrochrepts) in North Alabama and a Norfolk sandy loam (Typic Kandiudults) in central Alabama, and in 1990 on a Lucedale sandy clay loam (Rhodic Paleudults) in central Alabama. The soils had a 'medium' soil test rating for K in the surface layer (Table 1) and 'medium' or 'low' soil test ratings for K at greater depths.

Fertilizer treatments (Table 2) consisted of K applied as a surface broadcast application with and without in-row subsoiling or deep placed. On all sites, rates of K ranged from 0 to 90 lb K_2O A^{-1}. The Emory and Lucedale soils received an additional deep placement treatment of 120 lb K_2O A^{-1}. Two additional treatments received either 1500 lb A^{-1} agricultural limestone or 1500 lb agricultural limestone + 90 lb K_2O A^{-1}, deep placed. Deep placement and subsoiling treatments were established using the two-row dry fertilizer applicator described by Tupper and Pringle (5). All treatments were established in the spring just prior to planting. Treatments were arranged in a randomized block design with four replications.

Plots on the Emory soil consisted of 6 rows that were 30 feet long. On the Norfolk soil, plots had 4 rows that were 20 feet long, while on the Lucedale soil plots had 6 rows that were 50 feet long. Deltapine 50 was planted at each location.

In 1989, seed cotton was picked by hand on the Norfolk soil. For the remaining site years, seed cotton yields were determined by mechanically picking the two center rows from each plot. At early bloom, upper mature leaf samples were collected by plot for nutrient analysis.

Results

Throughout the test, seed cotton yields were near normal for the location on the Norfolk and Lucedale soils (Table 3). On the Emory soil, seed cotton yields were very high in 1989, near normal in 1990 and low in 1991. Low yields on the Emory soil in 1991 were due to drought conditions experienced in July and August.

The experiment was designed to separate yield responses due to deep placement of fertilizer from those due and to in-row subsoiling. A comparison of the subsoiled and nonsubsoiled check treatments shows that the Norfolk soil was the only site where a positive response to in-row subsoiling was obtained (Table 3). On the Norfolk soil, in-row subsoiling increased seed cotton yields by an average of 456 lb A^{-1} during the three years of the test. The Norfolk site has a well developed traffic pan at the base of the Ap horizon.

Although yield differences were not significant, the treatment receiving 1500 lb agricultural limestone A^{-1} deep placed on the Emory and Norfolk soils (Table 4) consistently produced lower seed cotton yields as compared to the subsoiled (in-row) check treatment. On the Lucedale soil the two year average yields were increased slightly by the deep placement of limestone compared to the subsoil check treatment. This response for the three soils was a little surprising since the subsoil pH on the Lucedale soils was approximately 6.5 while it was approximately 5.5 on the other two soils (Table 1). For most of the site years, the deep placement of 1500 lb limestone + 90 lb K_2O A^{-1} produced higher seed cotton yields as compared to the subsoil check treatment. On the Emory soil, the 3-year average yields from the deep placement of 1500 lb limestone + 90 lb K_2O A^{-1} were higher as compared to the deep placement of 90 lb K_2O A^{-1} alone. Similar results were observed on the Norfolk soil in 1991. For the Lucedale soil, the deep placement of limestone and K together gave the same yield as compared to the deep placement of 90 lb K_2O A^{-1} alone.

For the K treatments, seed cotton yields generally increased with the rate of surface, broadcast applications of K. On the Emory soil the greatest and most consistent response to surface applied K occurred without in-row subsoiling (Table 5). On the Norfolk soil cotton yields generally increased with K rate when the K

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was applied without in-row subsoiling whereas for the subsoiled treatments yields generally peaked at a rate of 60 lb K_2O A^{-1} (Table 6). On the Lucedale soil (Table 7) the most consistent response to surface applied K was obtained in combination with in-row subsoiling. The only site where there was a significant difference for the surface versus deep K treatments was on the Norfolk soil. On the Norfolk soil the deep placement of 30 lb K_2O A^{-1} produced higher yields as compared to the surface broadcast application of 30 lb K_2O A^{-1} (Table 6). When K was applied according to soil test (60 lb K_2O A^{-1}) or at higher rates, the surface applications consistently produced higher yields as compared to deep placement of K. For the Emory and Lucedale soils, there were no significant differences between the two methods of K application. In addition, in no instances did the deep placement of 1500 lb limestone and 90 lb K_2O A^{-1} together produce higher yields as compared to the surface broadcast application of 90 lbs K_2O A^{-1}. The concentration of K in cotton leaves sampled at early bloom also generally increased with K rate (Table 8). On average, the greatest increase was observed for the surface applied K.

Discussion

For this study there are four possible reasons for a lack of a consistent response of the deep placement of K fertilizer. First, the acid pH in the subsoil in the Emory and Norfolk soils (Table 1) could have inhibited cotton root growth, thus limiting the ability of the cotton plants to fully access the deep placed K. Secondly, cotton in these studies was not planted on beds. Since the cotton was planted flat, which is normal for Alabama, the seed may not have been centered over the subsoil channels. Thus, the cotton root system may not have grown directly into the subsoil channels. However, this does not appear to be the case, since soil water depletion measured on the Norfolk soil in 1990 and 1991 indicated that the cotton roots were in the subsoil channels (4). Thirdly, the volume of soil that is affected by the deep placement of K may be too small. Gulick et al. (2) has shown that K uptake is optimized only if a large proportion of the root system is exposed to adequate K. The proportion of the cotton root system that was affected by the deep placement of K may not have been large enough to significantly influence yields. Fourthly, the variety of cotton used in this study (Deltapine 50) may not be very responsive to the deep placement of K. Tupper et al. (8) showed that cotton varieties can differ in their response to the deep placement of K. They also reported that Deltapine 50 is not the most responsive variety to the deep placement of K. Results of this series of field studies suggests that for Alabama soils and a variety frequently grown, the deep placement of K fertilizer for cotton is not superior to surface broadcast applications of K. The results also show that the deep placement of agricultural limestone with and without K fertilizer for cotton is not justified.

Mention of a manufacturer does not indicate its approval by the USDA-ARS or by Auburn University at the exclusion of others.

Table 1. Initial chemical properties of the three soils.

Depth	CEC	pH	Mehlich I Extractable P	K	Mg	Ca
-inches-	meq/100 g		--------- lbs/acre			--------
		Emory sil				
0 to 10	10.94	6.5	62(VH)[1]	174(M)	73(H)	2450
10 to 20	10.56	5.5	35(H)	114(L)	54(H)	1690
20 to 30	9.84	5.0	32(H)	96(L)	49(L)	1280
		Lucedale scl				
0 to 6	6.77	6.3	86(H)	158(M)	236(H)	1180
6 to 12	6.30	6.5	39(M)	110(M)	285(H)	1050
12 to 18	5.85	6.3	16(L)	57(L)	235(H)	835
		Norfolk fsl				
0 to 6	4.77	7.0	92(H)	91(M)	168(H)	730
6 to 12	4.84	6.2	84(H)	68(L)	78(H)	580
12 to 18	4.96	5.6	17(L)	84(L)	91(H)	550

[1] Soil test ratings by Cope et al. (1). VH = 'Very High'; H = 'High'; M = 'Medium'; L = 'Low'.

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Table 2. Surface and deep fertilizer treatments applied at each location.

Treatment No.	(Rip) Subsoil	K Rate	Fertilizer Placement	Limestone
		-lbs K_2O/Acre-		lbs/acre
1-(Check)	No	0	---	0[1]
2-(SS-Ck)	Yes	0	---	0
3	No	30	Surface[2]	0
4	No	60	Surface	0
5	No	90	Surface	0
6	Yes	30	Surface	0
7	Yes	60	Surface	0
8	Yes	90	Surface	0
9	Yes	30	Deep[3]	0
10	Yes	60	Deep	0
11	Yes	90	Deep	0
12	Yes	0	Deep	1500
13	Yes	90	Deep	1500
14	Yes	120	Deep[4]	0

[1] Limestone application in selected treatments refers to placement of lime into the subsoil with a M. G. Dickey Inc. dry fertilizer applicator.
[2] Potassium fertilizer broadcast on soil surface prior (after in-row subsoiling) to secondary tillage.
[3] Deep placement - dry K fertilizer placed in a subsoil channel using a M. G. Dickey dry fertilizer applicator. Fertilizer was applied just prior to planting.
[4] On Emory and Lucedale soils only.

Table 3. Effect of subsoiling (0 lb K_2O A^{-1}) on seed cotton yields.

Subsoil	1989	1990	1991	Average
	lb/acre			
Emory				
No	3466	1778	1331	2205
Yes	3344	1980	1372	2218
LSD(0.10)	NS	NS	NS	NS
Norfolk				
No	1778	2140	2589	2169
Yes	2231	2785	2859	2625
LSD(0.10)	565	457	539	297
Lucedale				
No	--	2439	2638	2539
Yes	--	2374	2462	2418
LSD(0.10)		NS	NS	NS

Table 4. Effect of placement of K and agricultural limestone on seed cotton yields.

Treatment	1989	1990	1991	Average
	lb/acre			
Emory				
Subsoil-check	3344	1980	1372	2218
90 lb K20/ac, deep	3564	2068	1590	2407
1500 lb lime, deep	3398	1740	1329	2156
1500 lb lime + 90 lb K20, deep	3757	2220	1729	2569
LSD(0.10)	NS	220	226	158
Norfolk				
Subsoil-check	2231	2785	2859	2625
90 lb K20/ac, deep	2475	2736	2932	2714
1500 lb lime, deep	2067	2622	2687	2435
1500 lb lime + 90 lb K20, deep	2122	2948	3512	2861
LSD(0.10)	NS	457	539	297
Lucedale				
Subsoil-check	--	2374	2462	2418
90 lb K20/ac, deep	--	2691	2792	2741
1500 lb lime, deep	--	2589	2625	2607
1500 lb lime + 90 lb K20, deep	--	2550	2903	2727
LSD(0.10)	--	240	202	163

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Table 5. Effect of surface broadcast (with and without subsoiling) and deep placement of K fertilizer on seed cotton yields when grown on a Emory silt loam soil.

K Rate	1989 Surface -SS[1]	1989 Surface +SS	1989 Deep Placed	1990 Surface -SS	1990 Surface +SS	1990 Deep Placed	1991 Surface -SS	1991 Surface +SS	1991 Deep Placed	Average Surface -SS	Average Surface +SS	Average Deep Placed
	lb/acre											
30	3289	3480	3455	1900	2023	2053	1451	1612	1568	2213	2371	2359
60	3496	3689	3349	1950	1855	1843	1459	1541	1266	2302	2362	2152
90	3828	3678	3564	2105	1848	2068	1797	1614	1590	2577	2380	2407
120	--	--	3624	--	--	2218	--	--	1617	--	--	2486
LSD(0.10) [2]		NS			220			226			158	

[1] -SS = not subsoiled. +SS = subsoiled in-row prior to planting.
[2] LSD is for comparing means within a year.

Table 6. Effect of surface broadcast (with and without subsoiling) and deep placement of K fertilizer on seed cotton yields when grown on a Norfolk fine sandy loam soil.

K Rate	1989 Surface -SS[1]	1989 Surface +SS	1989 Deep Placed	1990 Surface -SS	1990 Surface +SS	1990 Deep Placed	1991 Surface -SS	1991 Surface +SS	1991 Deep Placed	Average Surface -SS	Average Surface +SS	Average Deep Placed
	lb/acre											
30	1566	2089	2490	1944	2205	3177	2181	2989	3087	1894	2428	2918
60	1738	2457	2134	2458	2728	2418	2638	3357	3406	2278	2847	2669
90	2021	2001	2475	2099	2834	2736	3079	3292	2932	2434	2675	2714
LSD(0.10) [2]		565			457			539			297	

[1] -SS = not subsoiled. +SS = subsoiled in-row prior to planting.
[2] LSD is for comparing means within a year.

Table 7. Effect of surface broadcast (with and without subsoiling) and deep placement of K fertilizer on seed cotton yields when grown on a Lucedale sandy clay loam soil.

K Rate	1989 Surface -SS[1]	1989 Surface +SS	1989 Deep Placed	1990 Surface -SS	1990 Surface +SS	1990 Deep Placed	1991 Surface -SS	1991 Surface +SS	1991 Deep Placed	Average Surface -SS	Average Surface +SS	Average Deep Placed
	lb/acre											
30	--	--	--	2573	2583	2364	2851	2671	2727	2712	2627	2545
60	--	--	--	2707	2700	2596	2753	2936	2844	2730	2818	2720
90	--	--	--	2423	2867	2691	2710	3027	2792	2567	2947	2741
120	--	--	--	--	--	2534	--	--	2991	--	--	2763
LSD(0.10) [2]					240			202			163	

[1] -SS = not subsoiled. +SS = subsoiled in-row prior to planting.
[2] LSD is for comparing means within a year.

Table 8. Effect of surface broadcast (with and without subsoiling) and deep placement of K fertilizer on the concentration of K in cotton leaves sampled at early bloom.

K Rate	Emory Surface -SS[1]	Emory Surface +SS	Emory Deep Placed	Norfolk Surface -SS	Norfolk Surface +SS	Norfolk Deep Placed	Lucedale Surface -SS	Lucedale Surface +SS	Lucedale Deep Placed
	%								
0	0.99	1.16	1.16	1.60	1.49	1.49	1.52	1.54	1.54
30	1.02	1.10	1.08	1.61	1.53	1.57	1.49	1.46	1.50
60	1.09	1.14	1.32	1.95	1.70	1.63	1.47	1.43	1.42
90	1.31	1.39	1.33	2.07	1.90	1.72	1.50	1.49	1.46
120	--	--	1.50	--	--	--	--	--	1.54
LSD(0.10) [2]		0.14			0.21			NS	

[1] -SS = not subsoiled. +SS = subsoiled prior to planting.
[2] LSD is for comparing means within a year.