EFFECT OF LONG TERM POTASSIUM RATE AND PLACEMENT ON COTTON

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Abstract

This paper presents the second four years of an eight-year study on the effect of potassium rates and placement systems on lint yield with four cotton varieties. The study was conducted on a Beulah and Bosket very fine sandy loam potassium deficient soil with 5.9 pH values or higher. Three potassium fertilizer rates (80, 120, and 160 lb K_2O/A) in their 5th, 6th, 7th, and 8th years of application and three placement systems (surface broadcast, deep banded, and split – 50% surface broadcast and 50% deep banded) were applied to four cotton varieties ('DES 119', 'DP 5415', 'LA 887', and 'SG 501') to study the effect on lint yield. Results were variable for potassium treatment and varieties over years. However, potassium applications significantly increased lint yield. The most consistent yield increases came from deep banding potassium in the drill from 6 to 15 inches deep. The most consistent rate for deep banding was 120 lb K_2O/A. The surface broadcast method was the least consistent method for increasing lint yields. The no potassium (check) treatment produced the lowest lint yield in 15 of 16 possibilities. The Stoneville deep banding dry materials applicator was very effective in deep banding potassium fertilizer and can be used to correct low potassium subsoils and increase lint yields.

Introduction

Typically, soils are sampled and amended in the first six inches. Roots explore this volume, but also explore deeper depths. Sampling soils at deeper depths has shown that there are a lot of soils with potassium deficiencies in the subsoil (Hamil et al., 1987).

In an effort to develop a more economical and efficient means of correcting subsoil potassium deficiencies, a deep banding dry materials applicator was developed at Stoneville in 1985 (Tupper and Pringle, 1986). The applicator utilized a chain-conveyor system to meter dry material into each row. The material flowed down a 2x4-inch hollow steel tube and was released in a continuous vertical band. The band ran from 6 to 15 inches deep and was approximately 2 inches wide in the soil profile directly below the drill. The tube was attached to the rear of a 28x1-inch parabolic super chisel shank.

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The dry materials applicator was tested with both lime and/or fertilizer to correct subsoil acidity and/or nutrient deficiencies (Tupper and Pringle, 1986; Tupper and Ebelhar, 1990; Tupper et al., 1991). Deep banding 160 lb K_2O/A on DES 119 dry-land cotton significantly increased yield, micronaire, and taproot length over ripping the drill without potassium (Tupper and Ebelhar, 1990). Under subsoiled conditions, the applicator shank, operated 15 inches deep in the drill without K_2O, accounted for 10.8% of the yield response. Whereas, 160 lb K_2O/A applied in the deep band accounted for the remaining 89.2% of the yield response in a three-year study (Tupper and Ebelhar, 1990).

Low soil test potassium (K) values in the subsoil can be corrected by deep banding muriate of potash directly under the drill row (Tupper, 1992; Tupper et al., 1992a; Tupper et al., 1992b; Tupper and Ebelhar, 1992; Tupper and Ebelhar, 1993). Soil test potassium levels were significantly correlated with lint yields at all three soil sample depths (0"-6", 6"-12", and 12"-18") in non-irrigated solid planting, in irrigated solid and skip-row plantings (Tupper, 1992). The objectives of this study were: (1) to test a dry materials applicator by placing potassium in the subsoil, and (2) to determine the effects of potassium placement systems and rates on four commercial varieties.

Materials and Methods

An experiment was initiated in 1989 on a Buelah and Bosket very fine sandy loam soil at Stoneville, MS. The field was subsoiled in the fall at a 45° angle to the row each year. Three rates of potassium: 80, 120, and 160 lb K_2O/A were each applied in the spring in three potassium placement systems: surface broadcast incorporated, deep banded 6 to 15 inches deep in the drill, and split – 50% surface broadcast incorporated and 50% deep banded 6 to 15 inches deep in the drill. These nine fertilizer treatments and a no potassium (check) made up the 10 main plots of a split-plot experiment. The sub-plots consisted of four varieties: DES 119, Deltapine 50 (DP 50), Stoneville 453 (ST 453), and Coker 130 (C-130) during 1989 to 1992. The first three years results were reported at this conference in 1992 (Tupper et al., 1992). Three of the four varieties were changed in 1992. The four varieties used in the second four year period were: DES 119, Deltapine 5415 (DP 5415), Stoneville LA 887 (LA 887), and Suregrow 501 (SG 501). This paper will report the results of the study through the second four-year period (1993-1996).

Eight-row plots (40-inch rows, solid planted cotton) were used in this experiment for fertilizer treatments (main plots) and two-row plots for varieties (sub-plots). The fertilizer treatments were applied and maintained on the same rows each year (8 years) with the varieties randomized annually. Plots were 100 ft long and replicated six times.

Soil samples were taken from each (main plot) fertilizer treatment prior to the study at three depths: 0"-5", 5"-10", and 10"-15" deep. Soil samples were analyzed by the Mississippi Cooperative Extension Service (MCES) Soil Testing and Plant Analysis Laboratory at Mississippi State University. A summary of soil test values prior to the initial treatment is presented in Table 1. High (H) mean levels of available phosphorus (P), and low (L) mean levels of exchangeable potassium (K^+) were present at all three soil sample depths.

After defoliation, the two-row sub-plots were harvested twice each year with a spindle picker for yield determinations. Representative samples of seed cotton were taken from each of 40 treatments at first and second harvest. Replications of each treatment combined, and ginned to determine lint percent and lint yield of each treatment was calculated. A small scale ginning system (20 saw gin stand) was provided by the USDA Ginning Laboratory at Stoneville. Data were subjected to analysis of variance and means were separated by Fisher Protected Least Significant Difference procedure at the 5% level of significance.

Results and Discussion

All potassium rates are expressed in lb K_2O/A and in this paper will be referred to as 80, 120, and 160 in the discussion of results. The effects of long-term potassium placement, rates, and no potassium (check) treatments on lint yields of the four varieties from applications number 5, 6, 7, and 8 are reported in the eight-year study.

In 1993, DES 119 and SG 501 had potassium treatments that produced significantly higher lint yields than the check (Table 2). Deep banded 80 and 160 rates and the split 160 rates increased lint yield of DES 119. The deep banded 120 rate increased lint yield of SG 501.

The cotton varieties were very responsive to potassium fertilizer in 1994 (Table 3). All nine potassium treatments increased lint yield of DES 119 and DP 5415. Seven of the nine treatments increased lint yields of LA 887 and SG 501. The surface broadcast 80 and split applied 80 treatments failed to produce a significant lint yield increase for LA 887. Also, the surface broadcast 80 and 120 treatments failed to increase lint yield for SG 501.

Results for 1995 are given in Table 4. Lint yields were significantly increased for DES 119 by surface broadcast 120, and for DP 5415 by split applied 160. Three potassium treatments increased lint yield of LA 887, surface broadcast 120 and 160 and deep banded 120. Only deep banded 120 increased lint yield of SG 501. Seven of the nine potassium treatments increased lint yield when averaged over varieties. Yields were not increased by the deep banded 80 and surface broadcast 80 treatments.

In 1996, only the surface broadcast 80 treatment increased lint yield of DES 119 (Table 5). No potassium treatment increased the lint yield of DP 5415, but six treatments significantly increased lint yield of LA 887. Only surface broadcast 120 and 160 and split applied 160 failed to increase lint yield of LA 887. Five treatments increased lint yield of SG 501. They were surface broadcast 80, deep-banded 80, 120 and 160, and split applied 120. Six of the nine potassium treatments increased lint yield when averaged over varieties. The surface broadcast 120 and 160 and the split applied 160 did not increase lint yields.

Due to a variety by treatment interaction in 1993 and 1994, a ranking for lint yield from 1 (best) to 10 (worst) was used to evaluate the most consistent treatments and a ranking range within varieties over all four years (Table 6). Although some variation was recorded between variety, potassium treatment, and years, the most consistent potassium placement system across variables was obtained with the deep banding treatments. Comparing the four varieties over four years (16 possible number 1 rankings), deep banding recorded 12 out of 16, surface broadcast 3 out of 16, and split applications 1 out of 16. In the deep banded potassium treatments, 120 had 8 of the 12 number 1 rankings, 160 had 3, and 80 had 1. The check was clearly the worst yield treatment recording 15 out of a possible 16 number 10 rankings. Surface broadcast potassium treatments recorded 12 out of 16 possible number 9 rankings plus 1 number 10 ranking. Split applied and deep banded treatments each recorded 2 number 9 rankings.

Additional deep tillage and fertilizer equipment has now been developed. A low-till parabolic subsoiler with reduced surface disturbance and power requirement was developed and built at Stoneville in 1993. The deep banding dry materials applicator was adapted to the low-till parabolic subsoiler in 1997. New studies are planned to determine if these developments continue to improve tillage and placement of fertilizer and lime.

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Table 1. Mean soil test values for soil pH, phosphorus, potassium, and cation exchange capacity (CEC) prior to initiation of experiment, Stoneville, MS, 1989.[1/]

Soil Sample Depth	Soil pH	Available P level	Exchangeable K^+ Level	CEC
(in.)		--------------------(lb/A)--------------------		meq/100 g
0-5	7.3[2/]	125 H	158 L	7.8
5-10	6.6	117 H	117 L	8.4
10-15	6.6	116 H	113 L	9.8

[1/]Soil samples were analyzed by MCES Soil Testing and Plant Analysis Laboratory at Mississippi State University.
[2/]Each value represents an average of 40 plots

Table 2. Effect of potassium rates and placement on lint yield of 4 cotton varieties grown solid planted in 40-inch rows. Stoneville, MS, 1993.

Potassium		Cotton Variety[1/]				Trt.
Place	Rate	DES119	DP5415	LA887	SG501	Average[3/]
	(lbK_2O/A)	---------------------lint (lb/A)	---------------------			
Surface	80	905[2/]	632[2/]	874[2/]	951[2/]	
	120	821	581	889	924	
	160	814	618	920	927	
Deep	80	954	745	952	987	
	120	905	746	958	998	
	160	957	724	964	948	
Split	80	887	711	949	949	
	120	888	708	954	971	
	160	935	686	938	980	
Check	---	778	673	851	861	

[1/]LSD 5%=66 for comparing between varieties within a deep placement treatment.
[2/]LSD 5%=133 for comparing between two placement and rate treatments with a variety or between varieties.
[3/]Treatment average omitted because of treatment x variety interaction.

Table 3. Effect of potassium rates and placement on lint yield of 4 cotton varieties grown solid planted in 40-inch rows. Stoneville, MS, 1994.

Potassium		Cotton Variety[1/]				Trt.
Place	Rate	DES119	DP5415	LA887	SG501	Average[3/]
	(lbK_2O/A)	---------------------lint (lb/A)	---------------------			
Surface	80	953[2/]	1006[2/]	1107[2/]	1008[2/]	
	120	1070	1020	1202	970	
	160	1030	1005	1205	1015	
Deep	80	1143	1086	1210	1146	
	120	1160	1187	1283	1168	
	160	1107	1122	1254	1261	
Split	80	1016	1088	1086	1102	
	120	1017	1026	1256	1152	
	160	1082	1066	1223	1069	
Check	---	785	848	963	856	

[1/]LSD 5%=82 for comparing between varieties within a deep placement treatment.
[2/]LSD 5%=156 for comparing between two placement and rate treatments with a variety or between varieties.
[3/]Treatment average omitted because of treatment x variety interaction.

Table 4. Effect of potassium rates and placement on lint yield of 4 cotton varieties grown solid planted in 40-inch rows. Stoneville, MS, 1995.

Potassium		Cotton Variety[1/]				Trt.
Place	Rate	DES119	DP5415	LA887	SG501	Average
	(lbK_2O/A)	---------------------lint (lb/A)	---------------------			
Surface	80	763[2/]	774[2/]	914[2/]	858[2/]	827[3/]
	120	894	817	935	947	898
	160	756	789	963	948	864
Deep	80	764	739	918	873	823
	120	854	844	1001	982	920
	160	844	805	891	929	867
Split	80	824	805	910	955	873
	120	817	765	895	941	854
	160	812	873	919	920	881
Check	---	723	707	768	815	753

[1/]LSD 5%=79 for comparing between varieties within a deep placement treatment.
[2/]LSD 5%=156 for comparing between two placement and rate treatments with a variety or between varieties.
[3/]LSD 5%=78 for comparing between potassium treatments averaged over varieties.

Table 5. Effect of potassium rates and placement on lint yield of 4 cotton varieties grown solid planted in 40-inch rows. Stoneville, MS, 1996.

Potassium		Cotton Variety[1/]				Trt.
Place	Rate	DES119	DP5415	LA887	SG501	Average
	(lbK_2O/A)	----------------------lint (lb/A) ----------------------				
Surface	80	902[2/]	966[2/]	1012[2/]	1007[2/]	972[3/]
	120	753	853	974	979	890
	160	814	844	968	955	895
Deep	80	887	912	1062	1041	976
	120	865	928	1007	1061	965
	160	868	945	1033	994	960
Split	80	878	955	1022	963	955
	120	888	933	1019	1005	961
	160	791	910	948	977	907
Check	---	788	903	893	878	866

[1/]LSD 5%=82 for comparing between varieties within a deep placement treatment.
[2/]LSD 5%=112 for comparing between two placement and rate treatments with a variety or between varieties.
[3/]LSD 5%=56 for comparing between potassium treatments averaged over varieties.

Table 6. Treatments ranked by lint yield and range over the four years for each variety. Stoneville, MS.

		Cotton Variety			
Potassium		DES 119		DP 5415	
Place	Rate	Rank[1/]	Range[2/]	Rank	Range
	(lbK_2O/A)				
Surface	80	6	1-9	6.5[4/]	1-8
	120	7.5	1-9	8	3-10
	160	9	6-9	9	6-9
Deep	80	3	2-7	5	2-9
	120	2	1-6	1	1-5
	160	1	1-5	2	2-4.5
Split	80	7.5	4-8	3	2-4.5
	120	4	2-7	6.5	4-8
	160	5	3-8	4	1-7
Check	---	10	10-10	10	7-10

		Cotton Variety				
Potassium		LA 887		SG 501		Average
Place	Rate	Rank[1/]	Range[2/]	Rank	Range	Rank[3/]
	(lbK_2O/A)					
Surface	80	9	5-9	7	3-9	7
	120	8	3-8	9	4-9	8
	160	5.5	2-8	8	3-9	9
Deep	80	2.5	1-5	2.5	2-8	3
	120	1	1-6	1	1-2	1
	160	2.5	1-9	4	1-7	2
Split	80	7	3-9	5	2-8	5
	120	4	2-8	2.5	3-5	4
	160	5.5	4-9	6	3-7	6
Check	---	10	10-10	10	10-10	10

[1/]Mean rank over the four years.
[2/]Range or ranking during the four years.
[3/]Average rank over the four years for the four varieties.
[4/]Mean ranking used for a tie.