

Upland and Pima Cotton Response To Banded Phosphate Fertilization

J. C. Silvertooth, J. E. Malcuit, T. A. Doerge, G. W. Thacker and S. W. Stedman

ABSTRACT

Four field experiments were established in Arizona in 1988 and six in 1989 to evaluate the effects of banded phosphorus (P) fertilizer on cotton. Experiments each year involved both Upland (*Gossypium hirsutum* L.) and American Pima (*G. barbadense* L.). Banded applications of P fertilizer were made with placement of the concentrated band of fertilizer 6 in. below and 3 in. to the side of the zone of seed placement. Fertilizer sources of P_2O_5 were with 10-34-0 or 16-20-0. At all locations, a series of rates of applied P_2O_5 were established as the treatment variables, including a check (0 lb P_2O_5 /acre). Rates of applied P ranged from 0 to 90 lb P_2O_5 /acre, at increments of approximately 30 lb P_2O_5 /acre. In all cases, treatments in the field were arranged in a randomized complete block design with four replications. Plant measurements for plant height, flower numbers per unit area, number of mainstem nodes, and nodes to the first fruiting branch were initiated by the fifth true leaf stage to evaluate plant response in terms of growth and development. Plant tissue samples were also taken at several stages of growth from each experiment throughout the growing season. Tissue samples consisted of petioles and leaf blades from the uppermost fully developed leaves. Petioles were analyzed for extractable PO_4 -P and leaf blades for total P. Lint yield measurements also were taken. With the exception of one of the experimental locations in each year, no statistically significant differences ($P < 0.05$) were found among any treatments for any of the plant growth parameters. The same was true with regard to petiole PO_4 -P and leaf blade total P levels measured. No significant differences among treatments were found for either Upland or Pima cotton with regard to lint yield in 1988 or 1989.

INTRODUCTION

Most soils that support cotton (*Gossypium* spp.) production in Arizona are high in pH (>7.5), calcareous, and provide low levels of extractable phosphorous ($NaHCO_3$ extractable). Such soil conditions are known to be quite conducive to fixation of broadcast applications of phosphorus (P) fertilizer, rendering the fertilizer P largely unavailable to the crop.

The availability of soil P to cotton plants has also been a question of concern based upon standard soil test evaluation ($NaHCO_3$ extraction). For example, $NaHCO_3$ extractable levels of P > 10 ppm are usually considered sufficient for cotton production, and levels below 4 ppm are indicative of possible deficient levels of P. However, many agricultural soils produce $NaHCO_3$ extractable levels of P between 5 and 10 ppm, which is a questionable zone in terms of possible response to P fertilization.

Many Arizona cotton farmers have expressed considerable interest in the potential merits of banded P fertilization. Banded applications of P reduce fixation due to minimal mixing with soil constituents, and they are often attributed to strong early season vigor and improved yield potential. Common assertions also state that extractable levels of PO_4 -P from cotton petioles provide a reliable indication of the P fertility status in cotton, which can be used accordingly as a management test.

Currently, very little information is available concerning the use of banded P fertilizers with Upland (*G. hirsutum* L.) or American Pima (*G. barbadense* L.) cotton grown in soil and climatic conditions similar to Arizona.

Therefore, the objectives of these experiments were to study the effectiveness of different rates of fertilizer P applied as ammonium polyphosphate (APP, 10-34-0) or ammonium phosphate sulfate (16-20-0) in a concentrated band pre-plant on both Upland and Pima cotton, with and without additional applications of foliar applied P fertilizer.

METHODS

To study the effects of banded P fertilization on both Upland and Pima cotton, six field experiments were conducted in 1989 and four in 1988 at the locations specified in Table 1. The initial soil test analyses are presented in Table 2 and the treatments imposed are described in Tables 3 and 4. For all experiments, treatments were arranged in the field in a randomized complete block design with four replications. The soil-applied treatments were made by use of a knife-shank applicator placing the fertilizer in a concentrated band approximately 6 inches below and 3 inches to the side of the zone of seed placement. The experiments at Marana in 1988 included a treatment consisting of a preplant soil application of 10-34-0, plus a foliar application of 10-34-0 at early bloom (Table 3). Foliar applications were made with a ground rig applicator providing 23 gal./acre total output. Heat unit accumulation from planting to date of foliar treatment application in Marana in 1988 was 1964 H. U. (86/55 thresholds).

Plant measurements were initiated at all sites early in the season to monitor crop growth and development. Multiple, 1-meter samples were taken within each plot at approximately 14-day intervals. Measurements included number of plants m^{-1} , plant heights, mainstem nodes $plant^{-1}$, flowers m^{-1} and total bolls m^{-1} . The purpose for these measurements was to detect any possible differences in plant growth and development that may have resulted from fertilizer treatments (particularly early season responses).

Plant tissue samples also were collected at several dates from each experiment. Samples of both the leaf blade and petiole of the uppermost fully developed leaf on a plant were taken from 40-50 plants within each plot. Petioles and leaf blades were separated, dried and ground to pass a 2mm sieve. Petioles were subjected to an acetic acid extraction, an aliquot of which was then used for PO_4 determination by a colorimetric procedure. Leaf blades were analyzed for total P, and also determined colorimetrically from a nitric-perchloric acid digest.

All plots were harvested by use of a two-row mechanical picker in the center four rows of each plot.

All experimental data were subjected to analysis of variance procedures and an LSD multiple comparison test, as outlined by the SAS Institute (1985).

RESULTS

No differences among treatments were detected for any of the plant growth measurements taken at any of the experiments, except for Harquahala, 1989. Differences among banded P treatments were detected at two dates of sampling at Harquahala in 1989 (Table 6). Similar differences were detected for tissue analyses (Table 12), but not in terms of lint yield at this location (Table 15).

Mean values for extractable PO_4 -P from petioles and total P from leaf blades are shown in Tables 7 to 12. Changes in these nutrient concentrations with stage of growth are also shown across the dates of sampling.

No differences have been expressed among banded P treatments in terms of harvested cotton lint from the 1988 experiments or from the six 1989 experiments harvested (Tables 13 through 15).

Further work and development of this project is intended for 1990.

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Table 1. Locations for banded phosphate experiments in Arizona, 1988 and 1989.

<u>Location</u>	<u>Crop</u>	<u>Variety</u>	<u>Soil Type</u>	<u>Planting Date</u>
<u>1988</u>				
Coolidge	Upland	DPL-90	Mohall Sandy Loam	5 April
	Pima	S-6		5 April
Marana	Upland	DPL-20	Vinton-Anthony Sandy Loam	26 April
	Pima	S-6		26 April
<u>1989</u>				
Marana	Upland	STV-506	Gila Loam	15 April
Coolidge #1	Upland	DPL-90	Mohall Loam	4 April
Coolidge #2	Upland	DPL-77	Mohall Sandy Loam	3 April
Coolidge #3	Pima	S-6	Mohall Sandy Loam	7 April
Coolidge #4	Pima	S-6	Mohall Loam	6 April
Harquahala	Upland	DPL-90	Laveen Loam	12 April

Table 2. Initial soil test analyses from each phosphate experimental area used.

<u>Location</u>	<u>Crop</u>	<u>Ca#</u>	<u>Mg</u>	<u>Na</u>	<u>K</u>	<u>NO₃-N*</u>	<u>P**</u>	<u>pH</u>	<u>EC</u>	<u>ESP***</u>
		-----		ppm	-----			(1:1 H ₂ O)	ds m ⁻¹	-%-
<u>1988</u>										
Coolidge	Upland	4600	360	295	270	12	5	8.5	1.8	4.6
Coolidge	Pima	4530	360	290	400	13	6	8.5	1.5	4.5
Marana	Upland	4560	240	175	290	15	7	8.1	1.5	2.8
Marana	Pima	4570	225	162	292	16	9	8.2	1.5	2.7
<u>1989</u>										
Marana	Upland	5700	270	170	130	22	36	8.3	1.8	2.3
Coolidge #1	Upland	5400	370	310	280	16	8	8.3	2.5	4.2
Coolidge #2	Upland	4300	320	225	310	19	7	8.4	2.3	4.3
Coolidge #3	Pima	5000	400	290	370	13	6	8.4	1.8	4.1
Coolidge #4	Pima	5300	430	410	460	11	7	8.3	2.3	5.4
Harquahala	Upland	5500	385	215	410	20	6	8.2	3.4	2.9

Exchangeable cations using neutral molar ammonium acetate.

* NO₃-N using specific ion electrode.

** NaHCO₃ extractable P.

*** Computed - exchangeable sodium percentage.

Table 3. Treatments and rates used in phosphate experiments conducted in Arizona, 1988.*

<u>Treatment</u>	<u>Soil Treatment</u>	<u>Foliar Treatment**</u>
	----- lb. P ₂ O ₅ /acre -----	
1	0	--
2	30	--
3	30	5 ***
4	65	--

* P source was 10-34-0.

** Marana location only.

*** Applied at early bloom, 23 gal./acre total output.

Table 4. Banded phosphorus treatments for each cotton experiment, 1989.*

<u>Location</u>	<u>Crop</u>	<u>P Rate</u>			
		----- lb. P ₂ O ₅ /acre -----			
Marana	Upland	0	30	60	90
Coolidge #1	Upland	0	30	68	90
Coolidge #2	Upland	0	30	68	90
Coolidge #3	Pima	0	30	68	90
Coolidge #4	Pima	0	68	90	---
Harquahala	Upland	0	30	54	---

* Treatments arranged in a randomized complete block design with four replications in each case.

Table 5. Mean values for extractable $PO_4\text{-P}$ and total P from cotton petioles and leaf blades respectively, for 1988 experiments.

<u>Location</u>	<u>Experiment</u>	<u>Sample Date</u>	<u>$PO_4\text{-P}^{**}$</u>	<u>P_T^{***}</u>
Coolidge	Pima	6/30/88	2571	0.47
	Upland	6/30/88	1646	0.47
Coolidge	Pima	8/16/88	1992	0.42
	Upland	8/16/88	784	0.31
Marana	Pima	7/29/88	3730	0.56
	Upland	7/29/88	2321	0.43
Marana	Pima	8/16/88	2664	0.49
	Upland	8/16/88	1285	0.36

**Extractable $PO_4\text{-P}$, from acetic acid extraction of cotton petioles.

***Total P, determined from leaf blades following nitric-perchloric acid digestion.

Table 6. Plant height means from Harquahala banded P experiment, 1989.

<u>Sample Date</u>	<u>Plant Height</u>			<u>$LSD_{0.05}$</u>
	<u>lb. P_2O_5/acre</u>			
	<u>0</u>	<u>30</u>	<u>54</u>	
	<u>cm</u>			
7 June	15 B*	18 AB	20 A	5
15 June	21 B	23 AB	25 A	4
19 July	40	42	42	NS

* Means followed by the same letter within a row are not significantly different ($P \leq 0.05$) according to pairwise comparisons using a Fisher's LSD.

Table 7. Mean values for PO_4P extracted from cotton petioles and total P from leaf blades, Coolidge #1 experiment, 1989 (Upland cotton).

P Rate - lb. P_2O_5 /acre -	Sample Date		
	13 June	13 July	8 August
	----- Petiole PO_4P (ppm) -----		
0	2371	2221	1436
30	2577	2166	1301
68	2445	2574	1336
90	2180	2438	1260
LSD _{0.05}	NS	NS	NS
	----- Leaf Blade Total P (%) -----		
0	.54	.41	.39
30	.52	.47	.32
68	.49	.47	.29
90	.45	.40	.50
LSD _{0.05}	NS	NS	NS

Table 8. Mean values for PO_4P extracted from cotton petioles and total P from leaf blades, Coolidge #2 experiment, 1989 (Upland cotton).

P Rate - lb. P_2O_5 /acre -	Sample Date			
	13 June	13 July	26 July	8 August
	----- Petiole PO_4P (ppm) -----			
0	2284	1854	1115	1172
30	2891	1824	1216	1130
68	1979	1803	1091	1172
90	2142	1599	1066	1160
LSD _{0.05}	NS	NS	NS	NS
	----- Leaf Blade Total P (%) -----			
0	.41	.36	.29	.25
30	.41	.36	.38	.24
68	.41	.35	.36	.24
90	.39	.35	.33	.24
LSD _{0.05}	NS	NS	NS	NS

Table 9. Mean values for PO_rP extracted from cotton petioles and total P from leaf blades, Coolidge #3 experiment, 1989 (Pima cotton).

P Rate - lb. P ₂ O ₅ /acre -	Sample Date			
	13 June	13 July	26 July	8 August
	----- Petiole PO _r P (ppm) -----			
0	2533	1860	2168	1824
30	2540	1696	1964	2008
68	2376	1764	1785	1759
90	2531	1907	1752	2078
LSD _{0.05}	NS	NS	NS	NS
	----- Leaf Blade Total P (%) -----			
0	.51	.32	.57	.39
30	.50	.33	.54	.38
68	.41	.37	.48	.48
90	.47	.39	.50	.38
LSD _{0.05}	NS	NS	NS	NS

Table 10. Mean values for PO_rP extracted from cotton petioles and total P from leaf blades, Coolidge #4 experiment, 1989 (Pima cotton).

P Rate - lb. P ₂ O ₅ /acre -	Sample Date			
	13 June	13 July	26 July	8 August
	----- Petiole PO _r P (ppm) -----			
0	3200	1895 B*	1907	1302 B
68	2923	2431 A	1923	1436 AB
90	2977	2346 A	2175	1826 A
LSD _{0.05}	NS	439	NS	408
	----- Leaf Blade Total P (%) -----			
0	.51	.39	.38 B	.32
68	.50	.41	.40 B	.35
90	.54	.45	.49 A	.41
LSD _{0.05}	NS	NS	.07	NS

* Means followed by the same letter within a column are not significantly different (P<0.05) according to pairwise comparisons using a Fisher LSD.

Table 11. Mean values for PO_4P extracted from cotton petioles and total P from leaf blades, Marana experiment, 1989 (Upland cotton).

<u>P Rate</u> - lb. P_2O_5 /acre -	<u>Sample Date</u>	
	<u>13 July</u>	<u>3 August</u>
	----- Petiole PO_4P (ppm) -----	
0	1915	1505
30	1925	1439
60	1910	1455
90	2243	1302
LSD _{0.05}	NS	NS
	----- Leaf Blade Total P (%) -----	
0	.48	.28
30	.47	.27
60	.49	.25
90	.50	.27
LSD _{0.05}	NS	NS

Table 12. Mean values for PO_4P extracted from cotton petioles and total P from leaf blades, Harquahala experiment, 1989 (Upland cotton).

<u>P Rate</u> - lb. P_2O_5 /acre -	<u>Sample Date</u>		
	<u>19 July</u>	<u>3 August</u>	<u>16 August</u>
	----- Petiole PO_4P (ppm) -----		
0	1379 A*	1149	1172 B
30	1374 A	1062	1505 A
54	1206 B	1278	1465 A
LSD _{0.05}	153	NS	265
	----- Leaf Blade Total P (%) -----		
0	.31 A	.26	.28
30	.33 A	.26	.31
54	.27 B	.25	.44
LSD _{0.05}	.03	NS	NS

* Means followed by the same letter within a column are not significantly different ($P \leq 0.05$) according to pairwise comparisons using a Fisher's LSD.

Table 13. Mean lint yield results from the Marana banded phosphate experiment, 1989.

<u>P Rate</u> -- lbs. P ₂ O ₅ acre ⁻¹ --	<u>Yield</u> -- lbs. lint acre ⁻¹ --
0	1372
30	1398
60	1403
90	1421
LSD _{0.05}	NS*
CV (%)	3.2

*Treatment means are not significantly different ($P \leq 0.05$).

Table 14. Mean lint yield results from the banded phosphate experiments, Coolidge, AZ, 1989.

<u>Experiment</u>	<u>Crop</u>	<u>Yield</u>				<u>LSD</u>	<u>CV %</u>
		<u>P Rates (lbs. P₂O₅ acre⁻¹)</u>					
		<u>0</u>	<u>30</u>	<u>68</u>	<u>90</u>		
		----- lbs. lint acre ⁻¹ -----					
1	Upland	1637	1611	1617	1622	NS*	3.4
2	Upland	1550	1619	1565	1583	NS	7.5
3	Pima	700	660	726	685	NS	4.7
4	Pima	841	---	822	850	NS	9.6

*Treatment means are not significantly different ($P \leq 0.05$).

Table 15. Mean lint yield results from the Harquahala banded phosphate experiment, 1989.

<u>P Rate</u> -- lbs. P_2O_5 acre ⁻¹ --	<u>Yield</u> -- lbs. lint acre ⁻¹ --
0	1549
30	1604
54	1635
LSD _{0.05}	NS*
CV (%)	5.3

*Treatment means are not significantly different ($P < 0.05$).