CHANGES IN SOIL TEST PHOSPHORUS IN CONTINUOUS RAIN-FED COTTON M.W. Ebelhar Mississippi State University Stoneville, MS

<u>Abstract</u>

Cotton yield response to fertilizer phosphorus (P) applications with and without AVAIL[®] Phosphorus Fertilizer Enhancer was evaluated has been evaluated from 2010 through 2013 on silty clay loam soil in the Mississippi Delta under rain-fed (dry-land) condition. Since then, no additional P has been applied but lint yields and soil test P are continuing to be assessed. Soil test P has been observed throughout the study with annual samples from each plot. The study area was located on Dundee and Forestdale silty clay loam (Typic Endoagualfs). The P rates were 0, 20, 40, and 60 lb P/acre (0, 100, 200, and 300 lb CSP/acre) with and without AVAIL® (0.5 gal/ton). The P applications were made in the fall after harvest (except the first year where P was spring-applied to start the study), but prior to any fall tillage. The fertilizer was pre-weighed, then applied with a hand-held spreader as a broadcast application to the entire plot. The eight treatments were arranged in a randomized complete block design with six replications and have been maintained throughout the study. All cultural practices (herbicides, insecticides, cultivation, etc.) were maintained uniformly throughout the growing season. After defoliation, the center two rows of each plot were harvested with a commercial spindle picker adapted for plot harvest. Random grab samples were taken during the harvest and used to determine lint percentage and lint yield. Soil samples were taken following harvest and prior to additional P fertilizer applications. To date, there has been no significant lint yield response to the applied P for any year. Soil test P increased with P applications as expected since the P additions were greater than crop removal. With time, after P additions stopped, soil test P has begun to decline and at the end of 2016 were still above levels that would warrant P fertilizer additions.

Introduction

Producers often are approached about trying products that are pitched to increase nutrient uptake or nutrient efficiency that would result in increased yields and profitability. In order to answer their questions, replicated field trials are used to accurately measure yields and natural field variability. Research was initiated to evaluate cotton response to P rates with and without AVAIL[®] P Fertilizer Enhancer (Specialty Fertilizer Products, later Verdesian Life Sciences) and four P rates. The study was established in a continuous cotton field under rain-fed conditions (no irrigation) beginning in 2010. The objectives of the research were to evaluate cotton lint yields as impacted by P additions with and without the enhancer and also monitor changes in soil test P over time. As P additions occur in excess of crop removal, one should expect P levels in the soil to increase. Once the additions cease, the soil test P levels should begin to decline. Information provided indicated that AVAIL was a unique formulation designed to minimize fixation and maximize fertilizer investment. It was a partial sodium salt of maleic-itaconic copolymer. The study was designed as a randomized complete block with six replications. Additional replications were used in an effort to more fully account for in-field variability and thus increase the sensitivity for evaluating treatments. Since soil test P was already above levels where a response to added P was expected, the treatments included a 0 lb P/acre application rate as a control.

Materials and Methods

A multi-year field study was initiated in the spring to 2010 to evaluate seedcotton and lint yield responses to increasing levels of P fertilizer (0-46-0) with and without a proposed uptake enhancer, AVAIL® P Uptake Enhancer. The treatments consisted of a factorial arrangement of four P rates (0, 20, 40, and 60 lb P/acre) with 0 or 0.5 gal AVAIL/fertilizer ton. Eight treatments were included in a randomized complete block design with six replications. Individual plots consisted of four rows (40-in centers) 75 ft in length. Plots have been maintained in the same location throughout the duration of the study. The P fertilizer was treated with AVAIL and then pre-weighed in the laboratory for each plot. The fertilizer was then broadcast applied in the fall after harvest and soil sampling with a hand-held spinner spreader. With the study initiated in 2010, the P applications were made in the spring and then again in the fall after harvest for the subsequent year. No special incorporation of material was used and all primary and secondary tillage served as the mechanism of incorporation. PhytoGen cotton seed was planted at 3.5 seed/ft and all cultural practices were held constant across the study. Nitrogen was applied as urea-ammonium nitrate solution (32% N) at a

rate of 150 lb N/acre. Application timing consisted of 60 or 90 lb N/acre applied at or near planting with the remaining N applied as a sidedress application at the pin-head to match-head square growth stage.

After defoliation, the two center rows of each plot were machine harvested with a commercial spindle picker adapted for plot harvest with grab samples taken during the harvest. These samples were ginned through a 10-saw micro-gin and used to determine lint percent and calculate lint yields. Following the harvest, 8 to 10 soil cores were randomly taken from 0-6 inches, composited, dried, ground, mixed, and analyzed by the Soil Testing and Plant Analysis Laboratory at Mississippi State University. All date was analyzed with an Analysis of Variance (SAS, Cary, NC) using Fisher's Protected Least Significant Difference at the 5% level of significance. Main effects were evaluated where interactions were not significant.

For the study, P fertilizer additions were made in 2010, 2011 and 2012 for the 2010-2013 cropping seasons. Following the cotton harvest of 2013, no additional P was applied. Each subsequent year, cotton yields have been determine and soil analyses completed and summarized.

Results and Discussion

Cotton lint yields can vary a great deal in the Mississippi Delta when grown under rain-fed conditions even though rainfall averages 53+ inches in a normal growing season. Rainfall distribution is the key to good yields but cannot be predicted nor anticipated. The research area for the current study has been in continuous cotton for many years for the same reason and offers the greatest potential for profitability. Grain crops such as corn and soybean are even more sensitive to rainfall and moisture compared to cotton. Thus, the basis for this study to be in continuous cotton production and rain-fed. Production may still be limited under rain-fed and continuous cotton production. Therefore it is important to limit inputs to help insure profitability. Fertilizer and seed are two of the highest input cost and knowing fertilizer needs can determine application. However, in the current study the objective was to evaluate P rates and the uptake enhancer, AVAIL without consideration of soil test P. Seedcotton and lint yields have been determined every year since the initiation of the study with mean separation by an Analysis of Variance (ANOVA) using Fisher's Protected Least Significant Difference. Treatment and interaction effects are shown in Table 1. The only significance detected was linter percent in 2011 and a significant lint percent interaction in 2014.

YEAR	SEED COTTON	LINT PERCENT	LINT YIELD	SEED COTTON	LINT PERCENT	LINT YIELD	
	TREA	TMENT EFF	ECTS	INTERACTIONS			
2010	0.4565	0.6545	0.2677	0.7212	0.9806	0.7610	
2011	0.6175	0.0104	0.5690	0.8469	0.0610	0.7823	
2012	0.6954	0.9317	0.5286	0.8849	0.9664	0.8961	
2013	0.4881	0.7660	0.5400	0.8522	0.3717	0.9081	
2014	0.9585	0.0906	0.9942	0.7223	0.0121	0.9618	
2015	0.9430	0.4734	0.9144	0.9963	0.2737	0.9874	
2016	0.7745	0.8336	0.8684	0.5063	0.5170	0.6568	

Table 1. Evaluation of phosphorus rates with and without AVAIL[®] P Fertilizer Enhancer. Analysis of variance for all treatments. Tribbett Satellite Farm, Tribbett, MS. 2010-2016.

Since there was no interaction effects in any of the years for seedcotton or lint cotton yields, the main effects were evaluated and shown in Table 2. There was no significant response to increasing P application rate and also no

significant effect of AVAIL[®] with respect to seedcotton or lint yield. Lint yields varied from year to year with good yields in all but 2011 where yields were less than half of the other four years (Table 3). Lint yields were especially good in 2010, 2012, 2013, 2014, and 2016 but no significant response to treatments. Even with six replications, the variability was high under the rain-fed condition (LSD ranged from 55 to 110 lb lint/acre, Table 3).

YEAR	SEED COTTON	LINT PERCENT	LINT YIELD	SEED COTTON	LINT PERCENT	LINT YIELD	
	PHOSPHORUS RATE			AVAIL			
2010	0.3397	0.3399	0.1881	0.1566	0.2445	0.0892	
2011	0.3207	0.0073	0.2997	0.3387	0.8907	0.3471	
2012	0.3064	0.6520	0.1851	0.5901	0.5095	0.4851	
2013	0.1425	0.9144	0.1580	0.9321	0.5719	0.8856	
2014	0.9259	0.9999	0.9370	0.7053	0.3177	0.5990	
2015	0.732	0.4540	0.6397	0.3888	0.9926	0.3949	
2016	0.8318	0.9198	0.8968	0.3935	0.4309	0.3556	

Table 2. Seedcotton, lint percent and lint yields from an evaluation of phosphorus rates with an without AVAIL Phosphorus Uptake Enhancer. Main Effects (No significant interaction). Tribbett Satellite Farm.

 Table 3. Summary of lint yields (lb/acre) from an evaluation of phosphorus rates averaged across AVAIL rates, under rain-fed condition, at the Tribbett Satellite Farm, Tribbett, MS

YEAR	PHOSPHORUS RATE (LB P/ACRE)							
	0	20	40	60	LSD0.05			
2010	1239	1311	1279	1274	65	NS		
2011	553	574	576	605	55	NS		
2012	1404	1493	1460	1444	82	NS		
2013	1506	1629	1578	1598	110	NS		
2014	1535	1534	1530	1506	106	NS		
2015	1049	1068	1035	1083	79	NS		
2016	1551	1576	1551	1549	84	NS		
AVERAGE	1262	1312	1287	1294				

(Lint yields averaged across AVAIL rates and replications for each year)

When lint yields were averaged across years and AVAIL rates, they were 1262, 1312, 1287, and 1294 for the 0, 20, 40, and 60 lb/acre phosphorus rates. Both 2013 and 2016 had cotton yields in excess of 1500 lb lint/acre with no fertilizer P applied.

Soil samples were taken (0-6" in depth) each year following harvest and analyzed for extractable P by the Soil Testing and Plant Analysis Laboratory at Mississippi State University using the Lancaster method. Soil test P levels tended to increase with increasing rate of P fertilizer while fertilizer P was applied. There was no difference between AVAIL[®] treatments so means are shown averaged across AVAIL[®] levels (Table 4). When looking at P removal, it has been estimated that 12 lb P/1000 lb lint can be removed. Therefore, even with 1600 lb/acre lint yields only about 20 lb P/acre is removed. Soil test levels at the initiation of the study showed soil P levels at greater than 100 lb P/acre with quite a bit of fluctuation from year to year even though no P was applied directly to the plots. Some movement has occur with primary and secondary tillage (fall and spring). With time there was a buildup of soil test P, especially at the higher P application rates. Following the 2013 crop season, no additional fertilizer P has been applied while cotton continues to be grown. Three crops have been removed since application ceased and soil test P levels are declining (Table 4). The measure of residual effects will continue for additional years to determine whether further decreases in soil test P will be observed.

Table 4. Extractable soil test phosphorus (lb P/acre) for continuous cotton under rain-fed conditions. Seven-year summary (2010-2016). Analysis completed by Soil Testing Plant Analysis Lab at Mississippi State University. Research conducted at Tribbett Satellite Farm. Tribbett. MS.

PHOS	Extractable Soil Test Phosphorus (lb P/Acre)								
(lb P/A)	2010	2011	2012	2013	2014	2015	2016		
0	111.5	103.2	122.3	134.0	108.1	96.3	63.4		
20	131.8	110.7	126.2	138.5	120.6	94.6	78.0		
40	146.7	130.3	128.0	152.7	133.8	104.2	78.5		
60	129.8	136.1	134.1	166.7	148.1	114.1	85.1		
LSD 0.05)	25.8 ns	11.0	16.3 ns	23.0	24.5	18.5 ns	9.5		

Two of the five basic questions to be answered when determining Best Management Practices (BMP's) for nutrients in agronomic production include: 1) Are the fertilizers necessary; and 2) How much fertilizer is economical. The first question is best answered by indicating that no fertilizer is necessary since soil test P levels are above recommended levels where an economical response is probably. The most obvious answer to the second question is, none.

To further examine the P effects, phosphorus removal was estimated for based on 1000 lb lint/acre removing 12 lb P/acre. Using this estimate P removal is shown in Table 5 for all P rates in a given year, averaged across AVAIL rates. Phosphorus removal ranged from around 7 lb/acre in 2011 (low cotton lint yields) up to 18-20 lb P/acre/yr when lint yields were 1500 lb/acre or more. Total P removal has been 106 to 110 lb P/acre (Table 5). With the unfertilized check (0 lb P/acre), soil test P has gone from 111 lb/acre, up to 134 lb/acre, and down to 63 lb/acre at present. At the higher P application rate, 60 lb/acre, a total of 240 lb P/acre (1200 lb 0-46-0/acre) while soil test has gone from at least 111 lb/acre, up to 167 lb/acre, down to 85 lb/acre at present.

YEAR	PHOSPHORUS RATE (LB P/ACRE)							
	0	20	40	60	LSD0.05			
2010	14.87	15.73	15.35	15.29	0.78	NS		
2011	6.64	6.89	6.91	7.26	0.66	NS		
2012	16.85	17.92	17.52	17.33	0.98	NS		
2013	18.07	19.55	18.94	19.18	1.32	NS		
2014	18.42	18.41	18.36	18.07	1.27	NS		
2015	12.59	12.82	12.42	13.00	0.95	NS		
2016	18.61	18.91	18.61	18.59	1.01	NS		
TOTAL P	106.05	110.22	108.11	108.71				

 Table 5. Phosphorus removal (lb P/acre) as estimated from lint yields under rain-fed conditions in an evaluation of P rates and AVAIL at the Tribbett Satellite Farm, Tribbett, MS

Summary

Results from the current study found no significant increase in either seedcotton or lint yields but an apparent increase in soil test P while fertilizer P was applied. Once P fertilizer was ceased, soil test P levels decreased as lint was removed from the field. The extent of the decrease appears to be large and could be related to plant uptake vs plant removal and the soil test P level could go up some as the residue is decomposed and P released back into the soil. The study did indicate no significant response to the AVAIL P Uptake Enhancer during any year. Plans are to continue monitoring yields and soil test P from the research area.