Seedcotton Yield and Petiole Phosphorus as Affected by Phosphorus Fertilizer Application


BACKGROUND INFORMATION AND STATEMENT OF RESEARCH PROBLEM

Phosphorus (P) is a major component of molecules involved in energy transfer in the cotton (*Gossypium hirsutum* L.) plant, and P deficiency will limit plant growth and lint production. While P toxicity is very rare in most agricultural soils, excessive buildup of P in agricultural soils and its potential transport into surfacewaters are environmental concerns. To maintain healthy plants and protect the environment, accurate P-fertilizer recommendations are required. In Arkansas, P-fertilizer recommendations are currently based on soil-P extracted with a modified Mehlich-3 (M3) solution (1:7 soil:solution). Additionally, most of the correlation and calibration research supporting Arkansas’ cotton P fertilization practices was conducted with cultivars that are no longer in use. This database is currently the best available scientific information for P fertilization of cotton in Arkansas. The University of Arkansas Soil Testing and Research Laboratory will change the extraction procedure from the modified Mehlich-3 to the standard Mehlich-3 (1:10 soil:solution) procedure, which extracts more P from soil. Research on improving techniques for monitoring plant nutrient status is another area that can lead to improved P management. In recent years researchers have evaluated the potential for using spectral radiometry to assess the nutritional status of crops. Spectral radiometry is a rapid non-destructive technique, which if proven suitable can significantly improve our ability to monitor crop nutritional status in-season. One such method is the use of a chlorophyll meter. One of the commonly used instruments is a Minolta SPAD (soil plant analysis development) meter. The SPAD meter measures the...
difference in light absorption at 430 and 750 nm (Wood et al., 1992). The former is the transmittance peak for chlorophyll a and b, and the latter is in the near infrared region. The instrument converts the difference in light absorption at these two wavelength into a numerical SPAD value ranging from 0 to 80 as an index of plant chlorophyll content. The objectives of the replicated field experiment reported here were to evaluate the effect of P fertilization and cotton cultivar on seedcotton yield and evaluate the effect of P fertilization on plant stress as indicated by leaf fluorescence and chlorophyll content.

**RESEARCH DESCRIPTION**

A replicated field experiment was conducted at the University of Arkansas Cotton Branch Experiment Station (CBES) in Marianna, Ark., during the 2004 growing season on a Zachary silt loam. The experimental design was a randomized complete block with a split-plot treatment structure where cotton cultivar (‘Stoneville 4892’ and ‘Paymaster1218’ ) was the main plot factor and P rate (0, 30, 60, and 90 lb P₂O₅/acre) was the subplot factor. Each experimental treatment was replicated four times. Individual plots were 43 ft long and 12.5 ft wide allowing for four rows of cotton with 38-in. row spacings. Prior to application of any soil amendments composite soil samples were collected from 0- to 6-in. soil depth of each replication. Soil samples were extracted with Mehlich-3 solution (1:10 ratio). Nitrogen and potassium (K) were applied as recommended by soil test results. Seedbeds were prepared using conventional tillage and cotton management practices closely followed University of Arkansas Cooperative Extension Service production guidelines. Cotton was planted on 12 May, emerged on 25 May, first bloom occurred on 21 July, and was harvested with a mechanical picker on 16 October. Cotton petiole samples were collected from the fifth node from the top of 20 plants selected randomly the week before first bloom and the first two weeks of bloom and analyzed for P. Leaf fluorescence and chlorophyll content were measured three weeks after first flower on 11 August on the 10 uppermost, fully expanded main-stem leaves (fourth node from the top) in each plot on Paymaster 1218 cotton cultivar. Fluorescence was measured using a modulated fluorometer Osi-FL and chlorophyll content was measured using a Minolta Spad meter. Analysis of variance was performed to evaluate the effect of cotton cultivar, P application rate, and their interaction on seedcotton yield and petiole P using the PROC GLM procedure of SAS.

**RESULTS AND DISCUSSION**

Prior to application of P fertilizer, Mehlich-3-extractable P in the top 6 in. was 52 lb P/acre (Table 1). Current University of Arkansas fertilizer guidelines recommend application of 30 lb P₂O₅/acre at this level of soil-test P. Seedcotton yield was not significantly affected (P >0.05) by the main effects of cultivar or P rate or by the cultivar × P rate interaction. Although not statistically significant, the lowest yields were produced by the unfertilized control and the greatest yields were produced by the highest P fertilizer rate (Table 2). The data suggest that P was not a cotton yield-limiting factor and both cultivars have similar P requirements. Updated University of Arkansas P-fertilizer...
recommendations for cotton and the standard Mehlich-3 extractant will interpret the soil-test P for this soil as ‘Medium’, which means that a small positive yield response may occur from P fertilization. We observed similar results in 2003, which suggest that additional research with a wider range of soils is needed to develop new P fertilizer recommendations for cotton.

Petiole P concentrations were affected by P fertilizer rate only on 15 July and generally decreased as cotton development progressed (Table 2). Leaf fluorescence of the Paymaster 1218 cultivar ranged from 0.53 to 0.59 [(Fms-Fs)/Fms] with a trend for leaf fluorescence to increase as P rate increased, which may indicate less physiological stress (Fig. 1). Additional work will be conducted in future years to investigate the potential utility of this technique for monitoring the P-nutritional status of cotton. No consistent trend was observed for the effect of P-fertilizer rates on cotton leaf chlorophyll, however chlorophyll content of plants fertilized with 60 lb P O₅/acre were significantly higher than those fertilized with 90 lb P O₅/acre (Fig 2). As P plays an important role in membranes and energy transfer it was hypothesized that increasing P would be reflected in higher chlorophyll levels for improved photosynthesis.

**PRACTICAL APPLICATIONS**

Cotton planted in a silt loam with initial Mehlich-3-extractable (1:10 soil:solution) P of 52 lb P/acre did not respond to P fertilization suggesting that P was not a cotton yield-limiting factor on this soil. Cotton cultivar and cultivar-by-P rate did not have a significant effect on seedcotton yields. Data will be used to build a database of cotton yield response to P fertilization so that soil-test P can be interpreted and used to develop agronomically and environmentally sound P-fertilizer recommendations for cotton production in Arkansas.

**LITERATURE CITED**


**ACKNOWLEDGMENTS**

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Table 1. Selected chemical properties of soil samples collected from the 0- to 6-in. depth of experimental sites.

<table>
<thead>
<tr>
<th>Rep</th>
<th>pH</th>
<th>OM (%)</th>
<th>CEC (meq/100 g)</th>
<th>NO_3-N</th>
<th>P (lb/acre)</th>
<th>K (lb/acre)</th>
<th>Ca (lb/acre)</th>
<th>Mg (lb/acre)</th>
<th>Cu (lb/acre)</th>
<th>Zn (lb/acre)</th>
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</thead>
<tbody>
<tr>
<td>I</td>
<td>6.2</td>
<td>1.6</td>
<td>13</td>
<td>3.7</td>
<td>52</td>
<td>168</td>
<td>2279</td>
<td>423</td>
<td>2.2</td>
<td>3.9</td>
</tr>
</tbody>
</table>

* Soil pH was measured in a 1:2 (weight:volume) soil-water mixture.
* OM, soil organic matter determined by weight loss on ignition.
* NO_3-N measured by ion-specific electrode.
* Mehlich-3 extractable soil nutrients (1:10 extraction ratio).

Table 2. Effect of soil-applied P fertilizer on seedcotton yield and petiole-P concentration in a Zachary MeB silt loam at CBES in 2004. The means are averaged for each treatments across both cultivars.

<table>
<thead>
<tr>
<th>P_2O_5 rate (lb/acre)</th>
<th>Seedcotton yield (lb/acre)</th>
<th>15 July wk before bloom (mg/kg)</th>
<th>23 July 1st wk of bloom (mg/kg)</th>
<th>28 July 2nd wk of bloom (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2007</td>
<td>3638</td>
<td>2070</td>
<td>1174</td>
</tr>
<tr>
<td>30</td>
<td>2071</td>
<td>3478</td>
<td>2129</td>
<td>1157</td>
</tr>
<tr>
<td>60</td>
<td>2167</td>
<td>4530</td>
<td>2255</td>
<td>1250</td>
</tr>
<tr>
<td>90</td>
<td>2171</td>
<td>4207</td>
<td>2356</td>
<td>1160</td>
</tr>
<tr>
<td>MSD at 0.05&lt;sup&gt;z&lt;/sup&gt;</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

* Minimum Significant Difference as determined by Waller-Duncan Test (NS, not significant at P=0.05).
Fig. 1. Effect of soil phosphorus level on leaf fluorescence \( [(F_{ms}-F_{s})/F_{ms}] \) measured three weeks after first flower on cotton cultivar Paymaster 1218. Columns with the same letter are not significantly different \((P=0.05)\).

Fig. 2. Effect of soil phosphorus level on leaf chlorophyll content (SPAD units) measured three weeks after first flower on cultivar Paymaster 1218. Columns with the same letter are not significantly different \((P=0.05)\).