Phosphorus Nutrition of Cotton

The cotton plant has five main growth stages: 1) germination and emergence, 2) seedling establishment, 3) leaf area and canopy development, 4) flowering and boll development, and 5) maturation. An effective way of assessing the development, or progression of physiological events, of a cotton plant is with heat units or growing degree days. A heat unit is expressed in degrees Fahrenheit and is defined by the following equation:

Heat Unit = \[\frac{(\text{daily maximum temperature} + \text{daily minimum temperature})}{2} - 60\].

Figure 1 shows an example of a timeline that generally describes the relationships among time, heat unit accumulation, and cotton development. Proper nutrition helps assure that a cotton crop remains healthy throughout the season, and that it progresses through each stage of development with minimal stress.

Phosphorus (P) is an important nutrient in cotton production for several reasons. It is essential for vigorous root and shoot growth, promotes early boll development, hastens maturity, helps overcome the effects of compaction, increases water use efficiency, and is necessary for energy storage and transfer in plants. Approximately 30 lb P\textsubscript{2}O\textsubscript{5}/A is taken up for every bale of cotton produced. Of the total uptake, slightly less than 50% (14 lb P\textsubscript{2}O\textsubscript{5}) is removed per harvested bale. Phosphorus uptake by cotton closely follows the pattern of dry matter accumulation (Figure 2). By first flower, the crop has accumulated about 20% of the total seasonal uptake. After this time, the rate of uptake increases dramatically. By peak bloom, about half of the crop’s P has been taken-up, and by first open boll the crop has taken up over 70% of its needs. Peak daily uptake of P occurs 60 to 100 days after planting and can exceed 1.4 lb P\textsubscript{2}O\textsubscript{5}/A/day. Failure to maintain the uptake demand during the peak period will result in plant stress, yield loss, and a decline in lint quality. Phosphorus uptake is completed by the time the crop reaches the 50% open boll stage.

Figure 1. A production timeline for irrigated cotton in the Texas High Plains (Source: R. Boman).

<table>
<thead>
<tr>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>November</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10</td>
<td>30</td>
<td>60</td>
<td>90</td>
<td>120</td>
<td>150</td>
</tr>
<tr>
<td>0</td>
<td>10</td>
<td>525</td>
<td>1060</td>
<td>1470</td>
<td>1640</td>
<td>2280</td>
</tr>
</tbody>
</table>

Approximate days after planting

Approximate heat units after planting

Figure 2. Accumulation of N, P, and dry matter by cotton. Phosphorus accumulation is directly proportional to dry matter accumulation, while N is slightly higher through most of the season (Source: D. Krieg).
To ensure proper seed and lint development, adequate soil P levels must be built and maintained. There are other important reasons to build soil test P levels into the high or medium to high range: to increase root growth for efficient uptake of other nutrients, capitalize on “good weather” years and minimize risk associated with “bad weather” years, raise soil productivity, increase yield potential of all crops in the rotation, and improve grower profit potential. A rule of thumb for raising soil test P is that it takes 6 to 14 lb P₂O₅/A above crop removal to build soil test P by 1 lb/A on sandy loam to silt loam soils.

Figure 3 illustrates the results of research in North Carolina on a sandy loam Coastal Plain soil. The economic Mehlich 3 P critical level was 33 parts per million (ppm), or 80 lb/A using an 8 in. sampling depth. The authors reported that once the optimum soil test P was achieved, about 33 lb P₂O₅/A/year would be needed just to maintain the soil test P in a cotton, corn, and peanut rotation.

Figure 3. Relative yield response by conventional-tillage cotton to soil test P in North Carolina.

An example of response to fertilizer P is shown in Figure 4. The study was conducted from 1994 through 1999 on Loring silt loam (loess) at Milan, Tennessee. Yields were increased with P fertilization in both tillage systems, but the response to P fertilization was greater in the no-till system.

Figure 4. Six-year average cotton response to P rate and tillage in Tennessee.

The critical fertilizer P rate to achieve 95% of the maximum cotton yield on this low P soil was determined to be 96 lb P₂O₅/A for the disk-till system and 80 lb P₂O₅/A for no-till. Placement of P fertilizer can be an important consideration in some circumstances. Banded application of P may be beneficial, especially where soil test levels are low or in reduced tillage systems. Rates of fertilizer in-furrow with the seed are limited due to possible seedling damage and toxicity. For example, research has shown that rates of 11-37-0 fluid fertilizer greater than 2.5 to 2.8 gal/A can reduce cotton stands and yield, and rates greater than 1.5 gal/A are generally not recommended.

Insufficient P results in dwarfed plants, delayed fruiting and maturity, and reduced yield. While placement of P fertilizer is not as important as in the production of many other crops, banding P can increase yields in some situations (e.g., reduced or no-till, compacted soil conditions). Use soil tests to help determine the optimum P application rate. Soil test levels should be maintained in the medium to high range to assure consistent production, and that P does not limit cotton yield and quality.

For more about Phosphorus Nutrition of Cotton, a PowerPoint slide presentation is available free at www.ppi-ppic.org/presentations/cotton