decisions would be delayed until the next sample was analyzed.

Petiole-P indicates that soil moisture conditions are adequate in part C (Figure 3). The increase in nitrate-N could have come from a fertilizer application. If no fertilizer was applied, then the increase in N could be the result of increased soil moisture, boll shed, or organic N becoming mineralized into available nitrate. If the field was being mapped on a regular basis, fruit loss could be easily checked.

The petiole monitoring program should be terminated when the majority of plants in the field reach cut-out (average nodes above white flower less than 4). At cut-out, development of new nodes slows considerably. Finding petioles from leaves that are physiologically the same age as in previous sampling periods is difficult, and the results are meaningless.

For more details on petiole analysis and laboratories offering these services, contact your county Extension agent. Remember, first samples should be collected one week prior to bloom, which is normally 50 to 55 days after emergence.

The petiole monitoring program is a tool that, in combination with other decision aids, can help a grower efficiently maximize the production potential as it is modified by the environment. Using petiole monitoring can improve the dollar return on a grower's fertilizer investment by targeting N fertilization strictly to fields that will show a yield benefit.

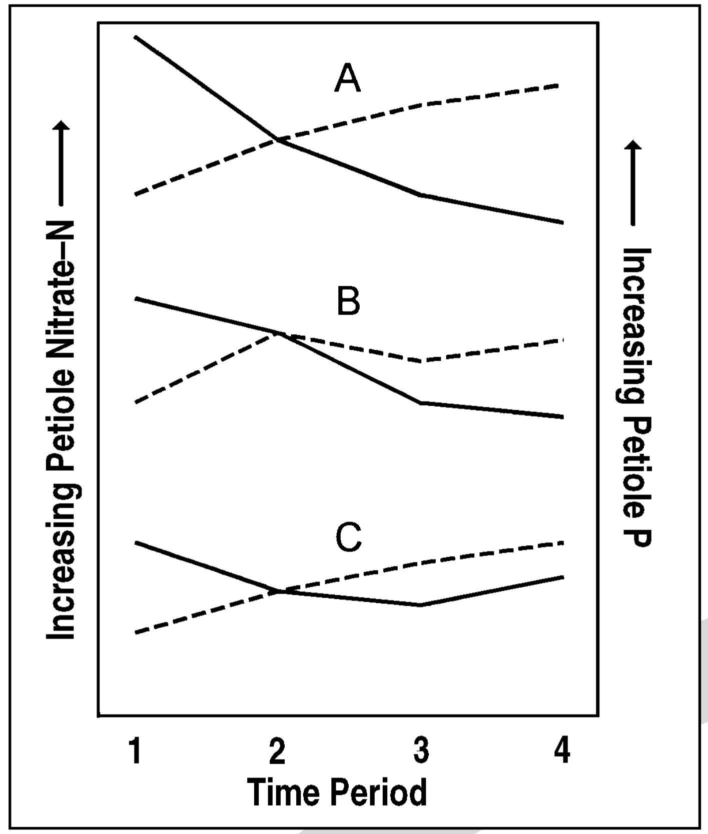

Figure 3. Interrelationships between petiole nitrate-N (solid lines) and petiole P (dashed lines).

The program is well suited for producers with center pivot irrigation systems that are plumbed for N injection. The systems should also be reasonably effective for flood irrigation systems in the Lower Rio Grande Valley. Care must be taken in interpreting petiole levels from fields with a potential for late-season N availability from organic sources.

Elizabeth Gregory, Editor
Rhonda R. Kappler, Graphic Designer

1.5M—1-96, New

AGR 2

L-5156

*Agri*LIFE EXTENSION
Texas A&M System

Using Petiole Analysis for Nitrogen Management in Cotton

M. G. Hickey, C. R. Stichler, and S. D. Livingston*

A major concern of cotton growers is maintaining sufficiency and balance in their nitrogen (N) fertilization program. Although the N content of lint is very low, N plays a major role in lint production. Nitrogen is important in overall plant growth rate, photosynthetic rate, bolls per plant, and seed production.

Most fields receive some type of preplant N application. Once preplant fertilizer is applied, field conditions may later alter both adequacy and availability of N for plant growth. The opportunity to correct an N deficiency through a side-dress soil application of N is the most practical, providing the cotton is small enough for ground equipment.

Urea-based foliar products can be used when cotton is large and will be damaged by soil application equipment or for late season applications when timing is critical. Foliar N products are more expensive than soil-applied products, and the amount that can be applied in a single application is limited, to prevent leaf burn. Without testing quantitatively how much actual N to apply, foliar applications can be expensive and largely a matter of guessing at the N shortages.

Causes of Nitrogen Shortages

Circumstances leading to N deficiencies may develop even though a producer has properly fertilized. Excessive rainfall or irrigation may have caused leaching of N from the rootzone or denitrification if the soil remains waterlogged. On the other hand, too-wet or too-dry field conditions may have delayed initial fertilization or side-dress applications.

Timely rains, particularly at peak bloom, may provide a producer the opportunity for greater lint yields. As the yield goal increases, the N requirement also increases. These and other diverse situations may cause a shortfall in N supply. If a grower could accurately predict the plant's N needs, application of additional N might provide increased yields on a cost-effective basis.

Nitrogen Balance Is Essential

Nitrogen management of cotton requires a balanced approach. Inadequate N leads to reduced yields and profits. Excessive levels of N can also reduce profits and may result in environmental problems. Excessive N fertilization can lead to rank growth that delays maturity, increases insect problems, and decreases the effectiveness of harvest-aid chemicals. Environmental problems can occur if N pollutes ground or surface waters.

Cotton is a perennial plant with an indeterminant growth habit. As such, it exhibits a dynamic response to the environment and to management. Cotton stores N in the leaves when N is easily available to the plant, for later use during the peak demand of boll setting. Cotton seed are very high in protein and represent a strong "sink" (place where N is stored) for N during boll development.

Most Nitrogen Deficiencies Occur Late in Season

Understanding cotton's seasonal demand for N is important in order to implement sound fertilizer N management strategies. The cotton plant's average N-requirement is 0.1 pounds N for every pound of lint produced. Uptake of soil N, primarily as nitrate, is excellent in the early and mid-season because of the healthy young root system. The variation in N demand through the season poses a burden to the plant's physiological systems. Competition for carbohydrates during boll filling results in decreased N uptake efficiency by the roots, which can cause problems. Nitrogen deficiency is more likely to

*Associate Professors and Professor, Soil Chemist and Agronomists, respectively, Texas A&M University.

occur later in the season as the N requirement is great and leaves may be stripped of stored proteins to meet boll feeding demands.

Reduced N supply to the plant results in a decline in the total leaf area, which in effect sets an upper limit on the number of bolls that can be filled. The plant sheds small bolls as a means of adjusting the fruit load to match its leaf area. Clearly, N must be readily available in the soil and sufficient levels must be stored in leaf tissue to meet the demands of the crop, or lint yields will be lower.

Fine-Tuning Nitrogen Fertilization

Adjusting the N supply to production potential is a strategy that leads to maximum yield and profit. Several techniques or predictive tools are useful for producers to successfully meet crop N needs. During the pre-season, producers need to:

1. make a realistic yield goal estimate.
2. determine residual nitrate-N levels through a soil test.

Pre-season fertilizer needs are best determined through soil test analysis for nitrate-N, with fertilizer recommendations coupled to yield goal. Choosing a realistic yield goal is important, because consistent fertilization for unattainable yields wastes capital. Producers who irrigate and have excellent water should base their yield goals on the amount of available water. Producers depending on limited irrigation or rainfall should average the yield for the top three out of the last six years. Over time, this will represent a running average that will include changes in management, varieties, and environment.

The petiole monitoring program offers producers a means of tracking in-season N needs of the crop. The program is best suited for irrigated producers with center-pivot or drip irrigation systems, but it also has practical application for growers in high rainfall areas where water supply is consistently adequate for high yields.

The magnitude of crop response to applied fertilizer N often changes with environmental conditions. Applications of supplemental N during fruiting and boll filling are often appropriate and profitable. Monitoring nitrate-N in the petiole provides a way to compensate for seasonal variation.

The aim of the monitoring program is to provide a tool that allows a grower to adjust N supply to the production potential dictated by the environment. Under normal conditions, petiole analysis will indicate N needs about 7 to 10 days before the onset of N stress.

When and How to Sample

The petiole analysis program starts one week prior to first bloom. To make successful interpretations using petiole analysis, consider previous fertilizer history, management practices, precipitation and/or irrigation amount, and plant monitoring data. Coupling petiole analysis with plant monitoring (height-to-node ratio, percent fruit retention, and nodes above white flower) provides producers with a set of complementary dynamic management tools.

About 20 petioles are adequate for analysis. The petiole is the leaf stalk, connecting the leaf blade to the mainstem (Figure 1). For producers using plant mapping, petiole samples should be gathered at the same time and should come from the same plants. Others should collect samples from randomly selected plants from uniform areas of the field.

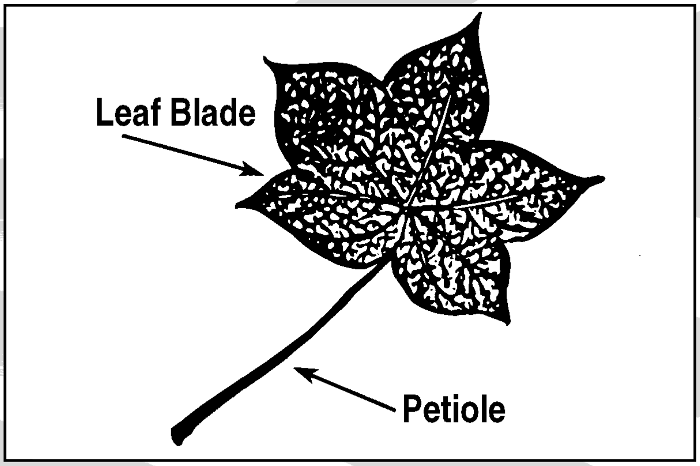

Figure 1. The petiole is the stem connecting the leaf to the mainstem.

Petiole analysis is based on analyzing petioles from leaves that are physiologically the same age through the season. This means that selecting the correct petiole is important. Take the petiole from the first fully expanded main stem leaf from the top of the plant. You can find the top leaf by identifying the quarter-sized main stem leaf in the terminal. Call this leaf number one; then count down two and three; and collect leaf number four. When in doubt, it is better to err by collecting a slightly older leaf than one too young.

Petioles should be placed into a paper envelope (not plastic) and sent to an appropriate laboratory. Include as much information as you can: soil moisture rating, insect control rating, fruiting rate, average internode length, nodes above white flower, fertilizer applied, and rain or irrigation received. Try to get the samples to the laboratory by Thursdays of each week. This will expedite getting your results back in a timely manner.

Using the Analyses

Nitrate-N in cotton petioles will be high (provided soil N is adequate) during the squaring stage. The shift to bloom starts a general decline in petiole nitrate-N that continues through boll maturation. In other words, as the plant shifts to developing and filling bolls, less nitrate-N is moved to the terminal for vegetative development.

Desirable levels of petiole nitrate-N during the cotton bloom period are shown in Figure 2. The area between the dotted lines in Figure 2 indicates the desirable range for petiole-N through the monitoring period. Nitrate-N values in the low range generally merit N fertilizer application unless the soil contains high levels of organic N. High or excessive levels of N are to be avoided, particularly late in the season, to avoid defoliation problems.

Three scenarios are plotted in Figure 2: N at optimum, N too low, and N too high. A crop with optimum N will often experience a substantial drop in petiole nitrate-N from the week prior to bloom to one week after bloom, but the nitrate-N levels should not fall below the desirable range.

Note that for the N-too-low scenario (Figure 2), petiole nitrate-N dropped below the optimum range at bloom plus one week and never recovered. An N fertilizer application should have been made just following one week after bloom (“+1” in Figure 2), and no yield loss would be expected.

For the N-too-high scenario (Figure 2), no additional fertilizer would be recommended. Any application of N would be a waste of money and would further enhance the potential for regrowth and delayed maturity. Cotton growing under those conditions would probably be rank, and the producer would be faced with a difficult harvest-aid situation.

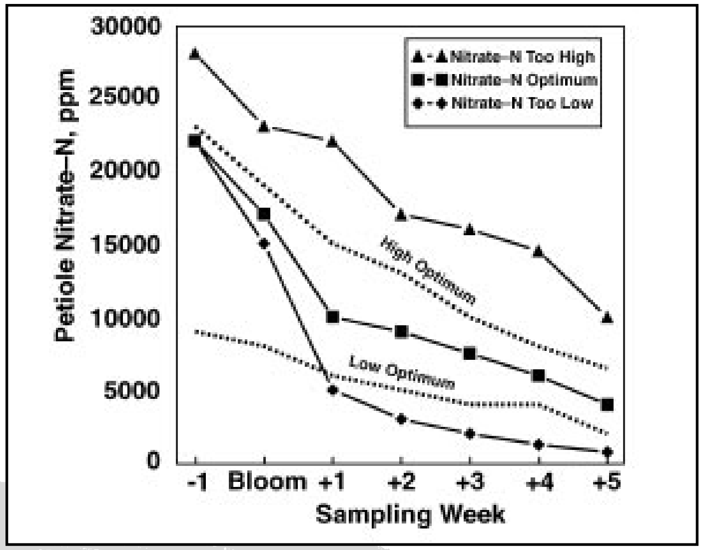

Figure 2. Optimum range for petiole nitrate-N, with three production scenarios where N is optimum, too high, and too low.

Excess soil-available-N during boll maturation can retard boll opening and leaf shed following harvest-aid applications. A special case of this can be seen where petiole nitrate-N has been low during weeks 1 through 3 after bloom and then increases dramatically as organic N from manures or residue from a high-yield corn crop becomes mineralized in the warm, wet soil.

Interpreting Results

Before a N fertilizer management decision is made, the change in petiole phosphorus (P) must also be considered. Environmental factors can influence petiole nitrate-N levels. These include: drought, excess moisture, and pest-related fruit loss. These effects are the reason it is so important to provide those making recommendations with as much weekly data as possible.

The interpretive relationships between petiole nitrate-N and petiole-P are shown in Figure 3 (page 4). In part A, nitrate-N is decreasing nicely and petiole-P is showing an increase over the four time periods. This situation (P increasing) indicates adequate soil moisture, fruiting is progressing nicely, and, if nitrate-N drops out of the optimum range, a deficiency condition will occur.

In part B (Figure 3), nitrates are dropping, but the decline in nitrate-N is steeper between time periods 2 and 3. Petiole-P, which is increasing, dropped between periods 2 and 3. This drop in P is generally indicative of a drought response, and management decisions would be delayed until the next sample was analyzed.

Petiole-P indicates that soil moisture conditions are adequate in part C (Figure 3). The increase in nitrate-N could have come from a fertilizer application. If no fertilizer was applied, then the increase in N could be the result of increased soil moisture, boll shed, or organic N becoming mineralized into available nitrate. If the field was being mapped on a regular basis, fruit loss could be easily checked.

The petiole monitoring program should be terminated when the majority of plants in the field reach cut-out (average nodes above white flower less than 4). At cut-out, development of new nodes slows considerably. Finding petioles from leaves that are physiologically the same age as in previous sampling periods is difficult, and the results are meaningless.

For more details on petiole analysis and laboratories offering these services, contact your county Extension agent. Remember, first samples should be collected one week prior to bloom, which is normally 50 to 55 days after emergence.

The petiole monitoring program is a tool that, in combination with other decision aids, can help a grower efficiently maximize the production potential as it is modified by the environment. Using petiole monitoring can improve the dollar return on a grower's fertilizer investment by targeting N fertilization strictly to fields that will show a yield benefit.

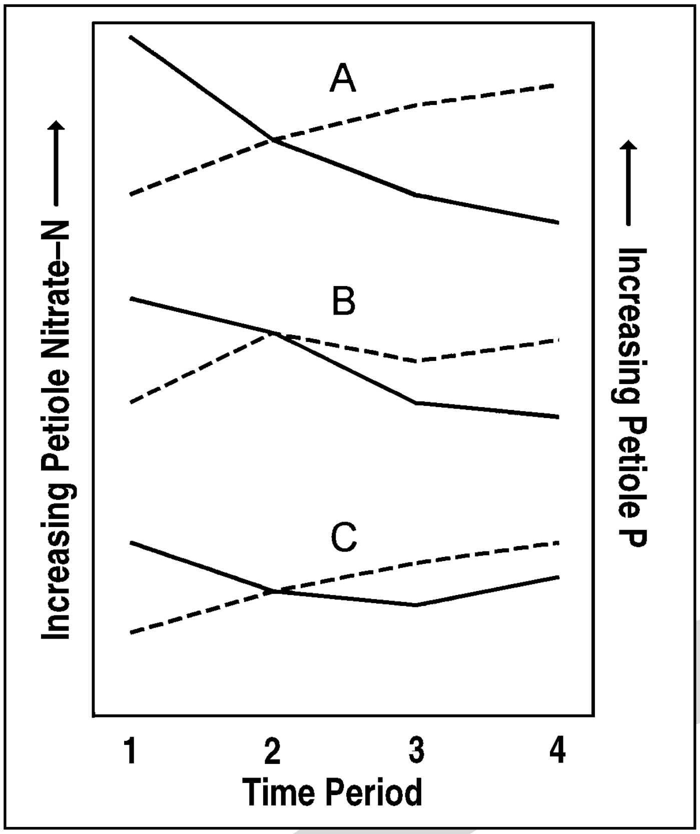

Figure 3. Interrelationships between petiole nitrate-N (solid lines) and petiole P (dashed lines).

The program is well suited for producers with center pivot irrigation systems that are plumbed for N injection. The systems should also be reasonably effective for flood irrigation systems in the Lower Rio Grande Valley. Care must be taken in interpreting petiole levels from fields with a potential for late-season N availability from organic sources.

Elizabeth Gregory, Editor
Rhonda R. Kappler, Graphic Designer

1.5M–1-96, New