Trends Indicated by Nutrient Analysis of Cotton Tissue

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Cotton leaf tissue analyses at the North Carolina Department of Agriculture and Consumer Services (NCDA&CS) laboratory reflect improved cotton N management the last few years. Yet, there are many fields where farmers and crop advisers have opportunities to significantly improve K nutrition.

Use of plant tissue analysis as a monitoring tool is the best way to ensure optimal fertilization of upland cotton (*Gossypium hirsutum*). By detecting nutrient deficiencies before symptoms appear, growers have the opportunity to prevent irrecoverable losses in yield and quality. Growers who rely on visual symptoms forfeit this safeguard.

The Agronomic Division of NCDA&CS has provided its plant tissue analysis service to growers throughout the state since 1973 and recently has made it available to growers nationwide.

Plant tissue reports can be either predictive or diagnostic. Predictive reports are generated when samples are submitted to monitor nutrient status for the purpose of adjusting fertilization for optimum yield and quality. NCDA&CS encourages establishing a cotton monitoring program. It is best to manage a cotton fertilization program based on the results of tissue samples collected routinely over a period of several weeks to monitor trends and fine tune nutritional needs. "Predictive" samples are collected from fields that represent average conditions at approximately the same time each week, beginning one to two weeks prior to bloom and continuing through the third or fourth week of bloom. The sample contains at least 25 to 30 of the most recently mature and healthy-looking leaves from main stems (usually the leaf at the 4th node from the plant terminal). Petioles are detached from the leaf blade before leaving the field for analysis of leaf blade nutrient concentrations (N, P, K, S, Ca, Mg, Fe, Mn, Zn, Cu, and B) and petiole NO_3-N concentration.

"Diagnostic" reports are generated when samples are submitted to help understand an existing problem. When plants exhibit discoloration or abnormal growth, tissue testing can demonstrate whether the problem is nutrient related. The plant analysis report provides recommendations for corrective action as needed.

In the period from 1999 to 2006, North Carolina grew an average of 868,000 acres of cotton per year, and NCDA&CS analyzed nearly 21,000 cotton tissue samples. A summary of data from this 8-year period shows general trends in cotton nutrition.

Nitrogen Status

Leaf blade N provides information on N availability and uptake for the week or 2 weeks prior to sampling. NCDA&CS, through experience and research, has established that a concentration of 3.5 to 4.5% N in the leaf blade is associated with optimal growth and yield. Overall, during the period summarized, 9% of all cotton samples contained too little N; 27% contained sufficient N; and 64% contained too much N (**Table 1**). The percentage of cotton samples with insufficient N ranged from a low of 3% in 1999 and 2002 to a high of 19% in 2006. Samples with sufficient N ranged from a low of 17% in 1999 to a high of 39% in 2001. Samples with too much N decreased to 50% in 2006, from a high of 80% in 1999. A decrease in excess application of N is favorable since excess N is an environmental concern because of the danger for leaching and runoff.

Plant tissue nutrient analysis and monitoring can identify deficiencies and opportunities for corrective action.

The sample contains at least 20 of the most recently mature and healthy-looking leaves from main stems, usually the leaf at the 4th node from the plant terminal.

Table 1. Nitrogen sufficiency status (% of cotton leaf blade samples).

	1999	2000	2001	2002	2003	2004	2005	2006	All
Low	3	6	12	3	15	12	12	19	9
Sufficient	17	22	39	17	30	37	30	31	27
High	80	72	49	80	55	51	57	50	64

Abbreviations and notes for this article: N = nitrogen; NO_3 = nitrate; P = phosphorus; K = potassium; S = sulfur; Ca = calcium; Mg = magnesium; Fe = iron; Mn = manganese; Zn = zinc; Cu = copper; B = boron; ppm = parts per million.

Excessive N nutrition is also an economic concern because of the increasing price of most N fertilizers in recent years, and the challenges associated with cotton defoliation difficulty and regrowth. The average N concentration has fallen from 5.1% in 1999 to 4.4% in 2006 (**Table 2**). These data appear to indicate a trend toward improved N management.

In cotton, sufficiency ranges for K depend on growth stage. As the bolls develop and the crop matures, K concentration decreases in the leaf blade as it is allocated to the developing boll. From the early vegetative stage to early bloom (<5 weeks after full bloom), the desired K range within the tissue of most recently mature leaves is 1.5 to 3.0%. From late bloom (>5 weeks after full bloom) through maturity, the desired range is 0.75 to 1.5% K.

During early vegetative growth through early bloom, most samples (70 to 80%) contained sufficient levels of K (**Table 3**). The remaining samples were nearly always low in K. Samples testing high in K were very rare. From 1999 to 2006, the NCDA&CS documented a slight increase in the percentage of early cotton tissue samples with K deficiency. The yearly average K concentration ranged from 1.7 to 2.0% (**Table 2**). When plant tissue K is low, recommendations for remedial action are based upon soil K levels, environmental conditions and crop yield potential. Additional K is typically made as a soil application.

From late bloom to maturity, most samples (96 to 99%) had sufficient to high K levels (**Table 3**). K was rarely low. The yearly average K concentration ranged from 1.5 to 1.7%, generally above the established sufficiency range (**Table 2**).

The desired range for P within the tissue of the most recent mature leaves is 0.20 to 0.65%. P levels were rarely low. Typically, 98 to 99% of all samples fell within the desired range in most years (**Table 3**). The yearly average P concentration ranged from 0.31 to 0.37% (**Table 2**). The sufficiency range for S in cotton tissue is 0.25 to 1.0%. Samples with low or high S levels were not commonplace during the specified period (**Table 3**). In 2003 and 2006, 7% of the samples tested low for S. The yearly average S concentration ranged from 0.46 to 0.60% (**Table 2**).

NCDA&CS tissue analyses also measure concentrations of Ca, Mg, Fe, Mn, Zn, Cu, and B. The desired concentration ranges for these nutrients are: 1.25 to 3.0% Ca; 0.25 to 0.50% Mg; 50 to 250 ppm Fe; 20 to 350 ppm Mn; 20 to 40 ppm Zn; 5 to 25 ppm Cu; and 20 to 60 ppm B. As a rule, fewer than 10% of the samples analyzed tested low in these nutrients.

Table 2. Average and ranges in cotton leaf blade nutrient concentrations (%).

	1999	2000	2001	2002	2003	2004	2005	2006
N								
Average	5.1	4.9	4.5	5.0	4.6	4.5	4.6	4.4
Min	1.5	0.7	1.5	0.7	1.4	1.2	1.8	1.1
Max	9.0	8.2	7.6	7.5	7.9	8.1	7.0	7.8
K, early vegetative through early bloom growth stage								
Average	2.0	2.0	1.7	1.8	1.8	1.8	1.7	1.8
Min	0.6	0.6	0.5	0.7	0.6	0.8	0.5	0.8
Max	7.1	7.9	5.6	4.0	9.7	5.0	3.0	3.5
K, late bloom to maturity growth stage								
Average	1.7	1.7	1.5	1.7	1.5	1.5	1.5	1.5
Min	0.5	0.3	0.5	0.6	0.3	0.2	0.1	0.2
Max	3.9	4.1	3.6	4.9	3.0	3.1	2.6	6.4
P								
Average	0.35	0.34	0.31	0.33	0.37	0.36	0.34	0.34
Min	0.07	0.09	0.13	0.11	0.15	0.16	0.14	0.10
Max	1.0	0.86	0.87	0.17	0.89	0.88	0.72	0.8
S								
Average	0.60	0.51	0.47	0.55	0.46	0.56	0.50	0.48
Min	0.14	0.07	0.10	0.08	0.10	0.12	0.11	0.08
Max	2.08	1.48	1.33	1.51	1.39	1.57	1.43	1.20

Table 3. Cotton leaf blade K, P, and S sufficiency status (% of samples).

	1999	2000	2001	2002	2003	2004	2005	2006
K (early vegetative growth to early bloom)								
Low	17	13	31	19	25	23	24	25
Sufficient	81	85	69	80	74	76	76	74
K (late bloom to maturity)								
Sufficient	31	30	51	25	54	51	47	50
High	68	70	47	74	45	48	51	48
P								
Low	1	1	4	2	1	1	2	3
Sufficient	97	98	96	98	98	99	98	94
S								
Low	1	4	5	2	7	3	3	7
Sufficient	93	95	94	95	91	93	95	92

Conclusion

Even ideal fertilizer management, based on soil testing and research-based fertilizer recommendations, cannot overcome all factors that affect growth and yield. Plant tissue nutrient analysis and monitoring can identify deficiencies and opportunities for corrective nutrient addition, during the current season or before the next crop. A well-nourished plant has a greater ability to withstand stresses from various environmental pressures. Routine cotton tissue analysis provides nutritional information essential to efficiently manage fertilizer for optimum growth and yield, especially in times of increased fertilizer costs and environmental concerns. BC

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