Using Tissue Analysis to Monitor Cotton Nutrition

Kristin Hicks, Plant/Waste/Solution/Media Section Chief
N.C. Dept. of Agriculture & Consumer Services Agronomic Division
Mailing Address: 1040 Mail Service Center, Raleigh, NC 27699-1040
Location: 4300 Reedy Creek Rd, Raleigh, NC 27607-6465
Phone: (919) 664-1600
Website: www.ncagr.gov.divisions/agronomic-services

For cotton, tissue analysis can be used to fine-tune fertilizer application rates, detect hidden hunger and diagnose abnormal color or growth. A good tissue sampling program helps ensure that cotton nutrition does not limit yield. A typical tissue report includes concentrations of NO_3-N in the petiole and total P, K, Ca, Mg, S, Fe, Mn, Zn, Cu and B in the leaf blade. ***The fee for each sample is $7, whether the sample contains leaves and petioles or only petioles.***

Timing of Cotton Tissue Samples

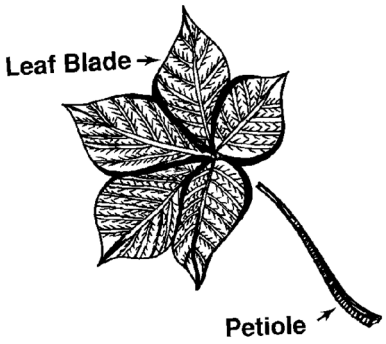
By mid-bloom, root expansion and nutrient uptake slow significantly. Therefore, it is important to collect tissue samples early enough in the season so the crop will respond well to corrective action if it is needed. A good monitoring protocol might involve collecting samples at three different stages of growth: 1) match-head square, 2) first week of bloom and 3) third week of bloom. However, if you suspect a nutritional problem, don't wait. Submit a tissue sample for problem diagnosis as soon as possible.

Being able to recognize cotton growth stages is essential when collecting tissue samples. Pinhead square is the stage when the flower bud can first be distinguished. It typically occurs about 35 days after emergence; match-head square follows in about one week. The first week of bloom typically begins 21 days after pinhead square formation; it is further defined as the presence of five open flowers per 25 row feet. Third week of bloom is self-explanatory.

The purpose of the first sample is to detect hidden hunger or nutrient problems before the crop begins its most rapid period of nutrient uptake. The second sample will indicate whether the crop is responding as desired to nitrogen that was applied 1–3 weeks before bloom. The third sample is the last opportunity to make soil fertilizer applications before root activity really slows.

Collecting Predictive Tissue Samples

Once the timing of tissue samples has been decided, it is important to know which plant part to collect. As a rule, cotton tissue samples should include at least 25–30 most recent mature leaves. These leaves are about three to five nodes from the terminal bud and include the blades and petioles. Separate petioles from the blades in the field to stop movement of nutrients from one to the other.



NCDA&CS offers an alternate testing option for growers who want measurements of petiole phosphorus and potassium in addition to NO_3-N. To receive petiole analysis for P and K, submit a sample containing only petioles and specify **P** (petiole) as the **PLANT PART** code on the *Plant Sample Information* form (see next section). If both leaf blade and petiole P and K are desired then the leaf blade and petiole samples must be listed twice on the form. At the present time, the lab provides interpretations for petiole P and K based on sufficiency ranges used in Georgia and Arkansas.

Completing the *Plant Sample Information* Form

To receive the most accurate recommendations, you must fill out the *Plant Sample Information* form completely and accurately. Two especially important pieces of information that must be correct are crop **GROWTH STAGE** and the **WEEK** the sample was collected (Table 1). For example, the correct codes for a sample collected at match-head square would be **E** for **GROWTH STAGE** and **3** for **WEEK**. Table 2 shows how to code samples on a *Plant Sample Information* form.

Table 1. Consecutive GROWTH STAGE and WEEK designations for cotton tissue samples

S = seedling, 4 wks 1–4				**E** = early vegetative growth, 4 wks 1–4				**B** = bloom, 4 wks 1–4				**F** = fruit, 4 wks 1–4			
S1	**S2**	**S3**	**S4**	**E1**	**E2**	**E3**	**E4**	**B1**	**B2**	**B3**	**B4**	**F1**	**F2**	**F3**	**F4**

Table 2. Specifying growth stage and position codes for cotton on a *Plant Sample Information* form: a) sample at first week of bloom for leaf blade and petiole analysis, and b) sample at first week of bloom for petiole analysis only.

2a

LAB NUMBER (leave blank)	SAMPLE ID	CROP NAME	GROWTH STAGE	WEEK	PLANT PART	PLANT POSITION
1	F,I,E,L,D,2	Cotton	B	1	M	U
2						
3						
4						
5						

2b

LAB NUMBER (leave blank)	SAMPLE ID	CROP NAME	GROWTH STAGE	WEEK	PLANT PART	PLANT POSITION
1	F,I,E,L,D,1	Cotton	B	1	P	U
2						
3						
4						
5						

Correct coding is critical because the adequate ranges for petiole NO_3-N change as the week of each growth stage progresses. Erroneous coding could lead to an incorrect interpretation and recommendation for NO_3-N; a grower might miss a needed N application or make one in excess. The potassium sufficiency range is similar, in that it changes by growth stage although not by week (Table 3).

Dry conditions and limited soil moisture are important factors to consider when collecting a cotton tissue sample. Research conducted at NCSU indicates that when soil moisture is limiting, concentrations of nitrogen (as NO_3-N) and potassium decrease in cotton petiole tissue (Holt JS, personal communication). The implication for cotton tissue analysis is that it may not always be a reliable indicator of fertilizer needs under dry conditions. Therefore, rather than sampling on a precise schedule, it may be preferable to wait for a rain event and collect tissue samples 48–72 hours afterwards, if possible.

Interpreting Plant Analysis Results for Cotton

Each NCDA&CS *Plant Analysis Report* indicates the sufficiency ranges for leaf blade nutrients (Table 3) and the target ranges for petiole NO_3-N (Table 4) that have been established for our state's conditions. Optimal concentrations of petiole P and K for our soils and production practices are in the process of being determined based on research at N.C. State University. Table 5 provides sets of petiole-K critical values based on values used in Georgia and Arkansas. At early bloom, petiole P should be about 800 ppm (0.08%).

Well-organized records (environmental conditions, fertilizer application rates, tissue and soil reports, yields) are of invaluable help in planning the fertilization of upcoming crops. Regional agronomists can also be of assistance: www.ncagr.gov/agronomi/rahome.htm.

Table 3. Leaf blade sufficiency ranges *

Nitrogen (N)%	3.5–4.5
Phosphorus (P)%	0.2–0.65
Potassium (K)% **	
seedling (**S**) – early bloom (**E**)	1.5–3.0
bloom (**B**)	1.2–2.5
fruit (**F**) – maturity (**M**)	0.75–2.5
Calcium (Ca)%	1.25–3.0
Magnesium (Mg)%	0.25–0.5
Sulfur (S)%	0.25–1.0
Manganese (Mn), ppm	20–350
Iron (Fe), ppm	50–250
Boron (B), ppm	20–60
Copper (Cu), ppm	5–25
Zinc (Zn), ppm	20–40

* Ranges correspond to NCDA&CS indexes of 50–75.
** K sufficiency range depends on growth stage.

Table 4. Desired range of petiole nitrate-nitrogen (ppm) by growth stage and week

Week	Seedling (S)	Early (E)	Bloom (B)	Fruit (F)	Mature (M)
1	11,000–21,000	8,500–12,500	4,000–8,500	200–4,000	200–2,500
2	10,000–17,500	7,000–11,500	3,200–8,000	<3,200	150–2,000
3	9,500–15,500	5,500–9,500	2,000–7,000	<2,500	100–1,500
4	9,000–14,000	5,000–9,000	900–5,500	<1,700	50–1,000

Table 5. Petiole K (%) critical values and/or sufficiency ranges used in the Southeast

Growth Stage	Week	Georgia	Arkansas
E	4		4.00
B	1	3.0–5.0	3.55
B	2	2.5–4.5	3.10
B	3	2.0–4.0	2.65
B	4	> 1.5	2.65
F	1	> 1.5	1.75
F	2	> 1.5	1.30
F	3	> 1.5	