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Sampling Plant Tissue for Nutrient Analysis

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Plant tissue analysis may be useful to diagnose plant nutritional problems or to monitor effectiveness of a soil fertility program. It is as simple as taking plant tissue samples from growing crops and sending them to a laboratory for nutrient analysis. However, if plants are sampled incorrectly, the outcome could be misleading and result in inappropriate fertilizer recommendations. This publication outlines sampling procedures and recommended nutrient content for Kentucky crops.

Tissue sampling should not substitute for a good soil testing program, but rather it is most effective when used in conjunction with soil testing. Many factors in addition to low soil fertility influence plant nutrient uptake (e.g., soil pH, soil compaction, herbicide damage, wetness, drought, cloudiness, insects, diseases, air temperatures, etc.). Simply adding more of the deficient element may not alleviate the symptoms. When tissue results are below optimal, you must determine the cause before attempting to correct the deficiency. Often plant tissue analysis is most useful when small areas of a field appear stunted or discolored.

The nutrient elements measured in plant tissue depend on the laboratory to which the samples are sent. Most laboratories analyze for nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), boron (B), copper (Cu), iron (Fe), manganese (Mn), and zinc (Zn). Testing for these 11 elements may be priced as a package.

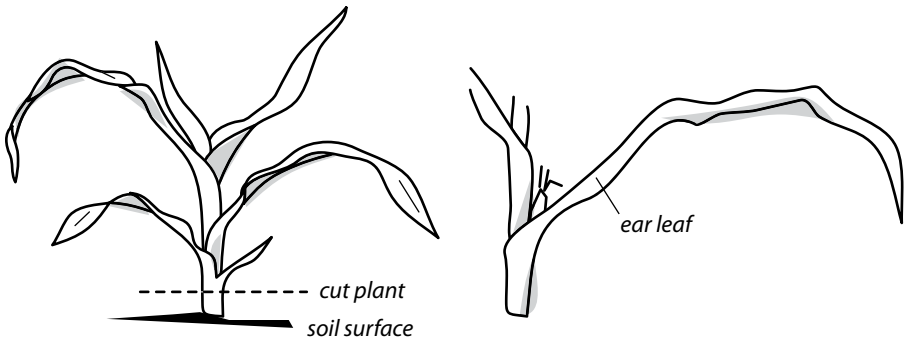

Figure 1—Corn. *Seedling* (plants less than 12 inches): Submit entire plant cutting 1 inch above the soil surface. *Vegetative:* Submit uppermost fully developed leaf (leaf collar visible). *Tasseling:* Submit the ear leaf.

Other elements such as arsenic (As), cadmium (Cd), chromium (Cr), lead (Pb), molybdenum (Mo), nickel (Ni), selenium (Se), and sodium (Na) may be analyzed on request for an additional fee. Although many of the latter elements are not essential for plant growth, the results may be important for identifying potentially toxic problems in plants and soil.

Mailing Kit and Other Materials

The University of Kentucky soil testing laboratory does not offer plant tissue analysis; however, most private soil testing laboratories also offer plant tissue analysis. Contact the laboratory for test availability, price, submission information, and supplies. Carefully follow instructions on the information forms, and fill out questionnaires completely. The questionnaire is an important communication between the producer and the laboratory. Lack of good or complete information may limit the interpretation of the results.

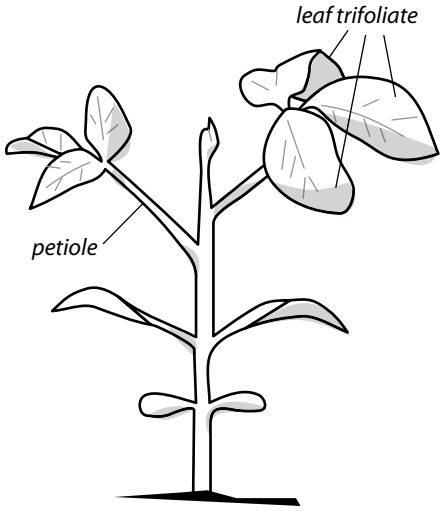

Figure 2—Soybean. *Seedling* (plants less than 12 inches tall): Submit entire plant cutting 1 inch above the soil surface. *Vegetative:* For plants between 12 inches and flowering, submit only the uppermost fully developed leaf blades (usually third or fourth leaf trifoliate from the top). Remove the trifoliate blades from the petiole, and sample at least 25 random plants.

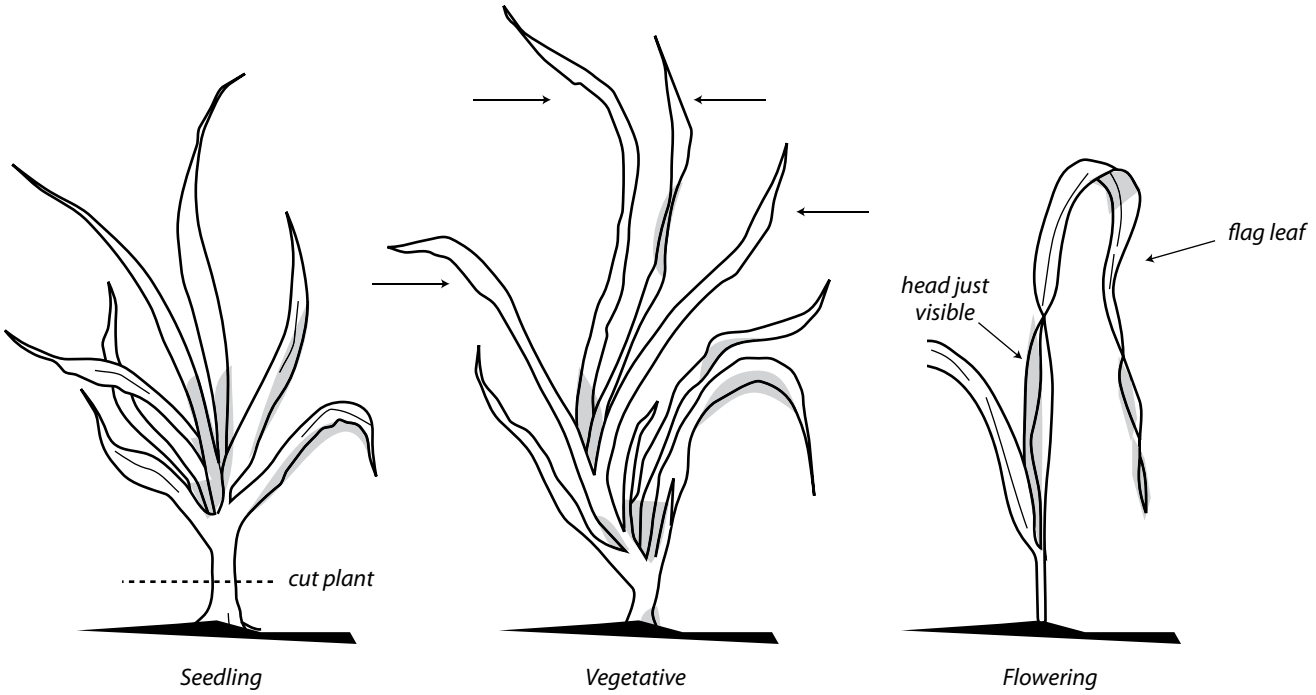

Figure 3—Wheat and Forage Grasses. *Seedling* (prior to jointing): Submit entire plant cutting 1 inch above the soil surface. *Vegetative* (between jointing and flowering): Break the top two or three leaves (growing point) from the plants. *Flowering:* Submit flag leaves only.

What and When to Sample

The difficult aspect of plant analysis is that nutrient levels within the tissue change as the plant or plant part ages. For example, corn leaves have a high concentration of nitrogen when they first emerge, but the N concentration can decrease rapidly as the plant grows. This happens because the plant has the ability to move nitrogen from older tissue to younger tissue. Therefore, the nitrogen analysis you receive from the lab will vary depending on which leaf was submitted. In addition, nutrient concentration tends to decrease as the plant grows because nutrients are being diluted with greater amounts of plant tissue. To account for this variability, sufficiency levels have been determined for specific plant parts at critical times in the crop's life cycle. That is why useful results require close attention to sampling a specific plant part at a particular growth stage. If tissue sampling is conducted at a time other than listed in this publication or if it is used as an aid for diagnosing problems in a field, samples from "good" and "bad" areas should be compared. Make sure you sample the same plant part in each area, and be sure that both areas have been treated the same (same variety, same planting date, etc.). As an aid to proper sampling, diagrams of alfalfa, clover, corn, grain sorghum, wheat and forage grasses, soybean, and tobacco are included in this publication.

For diagnostic purposes, plant tissue samples can be taken anytime after emergence until the beginning of flowering. At flowering, the plant changes from vegetative to reproductive stages. Nutrients then move into the seed, fruit, or grain from other parts. Therefore, a tissue sample taken after initial flowering is not accurate. Examples of being too late may include:

- corn silks that are starting to turn brown,
- flowers in soybean above the two or three lowest nodes
- seed head that is fully extended in small grains and forage grasses;
- greater than 10% of alfalfa and clover plants that are showing blooms, etc.

Sampling at the latest acceptable stage (initial flowering) gives the best picture of the general nutritional status of the plant because most of the nutrient uptake has occurred. Nutrient deficiencies could still develop when samples are collected at earlier growth stages.

Sample Collection and Handling

Randomly select the suggested number of plants throughout a field or desired sampling area, and remove the designated plant part. When a nutrient problem is suspected or there is abnormal growth in part of the area, collect two samples for comparison, one from the normal-appearing area and one from the abnormal area.

Collect the designated plant parts and place in a clean brown paper bag (No. 6 for grasses and small grains, No. 8 for legumes and soybean, or No. 12 for corn, grain sorghum, and tobacco). Dust- or soil-covered plant parts should be avoided. If sampled parts have a slight dust cover, brush gently with a

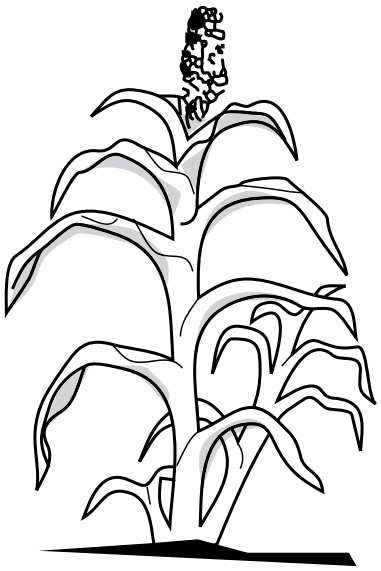

Figure 4—Grain Sorghum. *Seedling* (less than 12 inches tall): Submit entire plant cutting 1 inch above the soil surface. *Vegetative stages:* Sample the uppermost mature leaf (leaf collar visible). At flowering, sample the second leaf from the head.

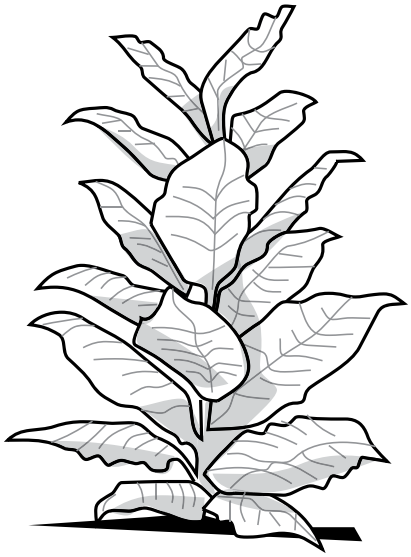

Figure 5—Tobacco. Select the most recently mature or fully expanded leaf. This is the first leaf from the growing point that is fully developed. Cell division is complete, but cell expansion will continue. Prior to topping, it is generally the fourth or fifth leaf from the bud.

soft brush. Do not rinse or wash with water as some elements may be leached from the sample. Sampling for diagnostic purposes usually means that some dead or diseased tissue is associated with abnormal plant growth that should be included.

For best results, either allow the samples to air dry or ship them to the lab using a next-day delivery service. If samples are to be air-dried, keep the bag open in a clean, dust-free area until the sample reaches a moisture content similar to that of dried hay. One day in a closed vehicle is usually enough to dry the samples. Never put the tissue into a plastic bag. When the tissue is dry, the bag can be folded and stapled shut. Write the sample number and the producer's name on the outside of the bag, and place into the shipping carton with the completed questionnaire.

Collecting Corn Stalk Samples

Corn stalk sampling is a special kind of plant tissue analysis because it is conducted at the end of the growing season. It is used to evaluate nitrogen management practices for future crop years.

Stalk samples should be collected within a three-week period beginning at or just prior to black layer formation. Nitrate levels in the stalk will remain consistent over this three-week period. Later sampling may result in unreliable readings because rain can leach nitrogen out of the stalk. If sampling is delayed, well-fertilized fields can appear deficient. More information about corn stalk analysis is available in AGR-180, "Corn Stalk Nitrate Test." See Table 3 for interpretation guidelines for the corn stalk nitrate test.

Stalk Nitrate Sampling Procedure

1. Select 15 stalks per sample.
2. Sample fields in a similar manner as with a soil sample. Take stalks that represent the area being sampled.
3. Avoid stalks affected by insects or diseases or with small ears or no ears.
4. Remove leaf sheaths.
5. Cut an 8-inch sample of stalk beginning 6 inches above the ground and terminating at 14 inches above the ground.
6. Place the samples in a paper sack, rather than plastic, to avoid mold growth.
7. Immediately send samples to the laboratory for nitrate analysis.

Table 1. Macronutrient sufficiency range for crops grown in Kentucky.

			Percent					
Crop	**Growth Stage**	**Plant Part**	**N**	**P**	**K**	**Ca**	**Mg**	**S**
Corn	Seedling (<4 inches)	Whole plant	4.0-5.0	0.4-0.6	3.0-4.0	0.30-0.8	0.2-0.6	0.18-0.50
	Vegetative	Uppermost mature leaf	3.0-4.0	0.3-0.5	2.0-3.0	0.25-0.8	0.15-0.6	0.15-0.4
	Tasseling	Ear leaf	2.8-4.0	0.25-0.5	1.8-3.0	0.25-0.8	0.15-0.6	0.15-0.6
Soybean	Early growth	Uppermost mature trifoliate	3.5-5.5	0.3-0.6	1.7-2.5	1.1-2.2	0.03-0.6	0.30-0.80
	Flowering	Uppermost mature trifoliate	3.25-5.0	0.3-0.6	1.5-2.25	0.8-1.4	0.25-0.7	0.25-0.60
Small Grain*	Seedling (before jointing)	Whole plant	4.0-5.0	0.2-0.5	2.5-5.0	0.2-1.0	0.14-1.0	0.15-0.65
	Flowering	Flag leaf	4.0-5.0	0.2-0.5	2.0-4.0	0.2-1.0	0.14-1.0	0.15-0.65
Grain Sorghum	Seedling (<12 inches)	Whole plant	3.9-5.0	0.2-0.5	2.0-4.0	0.3-0.6	0.25-0.6	0.24-0.5
	Vegetative	Uppermost mature leaf	3.0-4.0	0.2-0.4	2.0-4.0	0.3-0.6	0.2-0.5	ND
	Flowering	Flag leaf	2.5-4.0	0.2-0.35	1.4-4.0	0.3-0.6	0.2-0.5	ND
Burley Tobacco	Seedling	Whole plant	4.0-6.0	0.2-0.5	3.0-4.0	0.6-1.5	0.2-0.6	0.15-0.6
	Early growth	Uppermost mature leaf	4.0-5.0	0.2-0.5	2.5-3.5	0.75-1.5	0.2-0.6	0.15-0.6
	Flowering	Uppermost mature leaf	3.5-4.5	0.2-0.5	2.5-3.5	0.75-1.5	0.2-0.6	0.15-0.6
Alfalfa	At 1/10 bloom	Top 4-6 inches (leaves and stems)	3.0-5.0	0.25-0.70	2.0-3.5	0.8-3.0	0.25-1.0	0.25-0.50
Clover, Red	Prior to bloom	Top 4-6 inches (leaves and stems)	3.0-4.5	0.2-0.6	2.2-3.0	2.0-2.6	0.21-0.6	0.26-0.30
Clover, White	Prior to bloom	Top 4-6 inches (leaves only)	4.5-5.0	0.36-0.45	2.0-2.5	0.5-1.0	0.2-0.3	0.25-0.50
Orchard Grass	5 weeks after cutting or spring green-up	Whole plant	2.5-3.5	0.25-0.35	2.5-3.5	0.3-0.5	0.15-0.3	0.2-0.3
Tall Fescue	Actively growing	Whole plant	2.8-3.8	0.26-0.4	2.5-3.5	ND**	ND	ND

* Small grain includes wheat, oats, barley, and rye.
** A sufficiency range for these elements has not been determined.

Table 2. Micronutrient sufficiency range for crops grown in Kentucky.

			Parts per Million (ppm)					
Crop	**Growth Stage**	**Plant Part**	**Fe**	**Mn**	**Zn**	**Cu**	**B**	**Mo**
Corn	Seedling (<4 inches)	Whole plant	40-250	25-160	20-60	6-20	5-25	0.1-2.0
	Vegetative	Uppermost mature leaf	30-250	20-150	20-70	5-25	5-25	0.1-2.0
	Tasseling	Ear leaf	30-250	15-150	20-70	5-25	5-25	0.1-2.0
Soybean	Early growth	Uppermost mature trifoliate	ND**	ND	ND	ND	ND	ND
	Flowering	Uppermost mature trifoliate	25-300	17-100	21-80	4-30	20-60	0.1-2.0
Small Grain*	Seedling (before jointing)	Whole plant	30-200	20-150	18-70	4.5-15	1.5-4	0.1-2
	Flowering	Flag leaf	30-200	20-150	18-70	4.5-15	1.5-4.0	0.1-2.0
Grain Sorghum	Seedling (<12 inches)	Whole plant	75-400	13.200	12-150	4-20	3-30	ND
	Vegetative	Uppermost mature leaf	75-200	8-100	12-100	2-15	1-10	ND
	Flowering	Flag leaf	65-100	8-100	12-100	2-7	1-10	ND
Burley Tobacco	Seedling	Whole plant	50-300	20-250	20-60	5-10	18-75	0.2-1.0
	Early growth	Uppermost mature leaf	50-300	20-250	20-60	5-10	18-75	0.2-1.0
	Flowering	Uppermost mature leaf	50-300	20-250	20-60	5-10	18-75	0.2-1.0
Alfalfa	At 1/10 bloom	Top 4-6 inches	30-250	25-100	20-70	4-30	20-80	0.2-4.0
Clover, Red	Prior to bloom	Top 4-6 inches (leaves and stems)	30-250	30-120	18-80	8-15	30-80	0.5-1.0
Clover, White	Prior to bloom	Top 4-6 inches (leaves only)	25-100	25-100	15-25	5-8	25-50	0.15-0.25
Orchard Grass	5 weeks after cutting or spring green-up	Whole plant	50-250	50-200	20-50	3-10	5-20	ND
Tall Fescue	Actively growing	Whole plant	ND	ND	ND	ND	ND	ND

* Small grain includes wheat, oats, barley, and rye.
** A sufficiency range for these elements has not been determined.

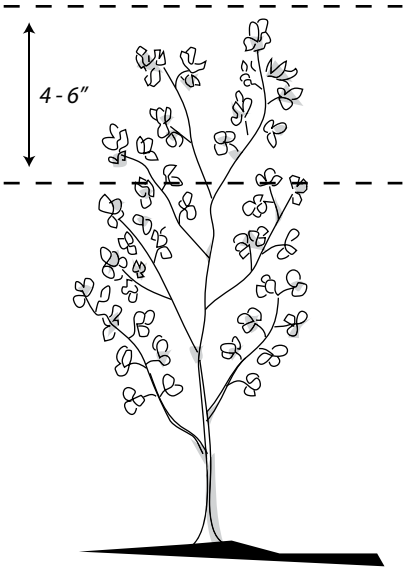

Figure 6—Alfalfa. Remove the upper 4 to 6 inches of plant at 10% bloom. Select at least 50 random plants for sampling.

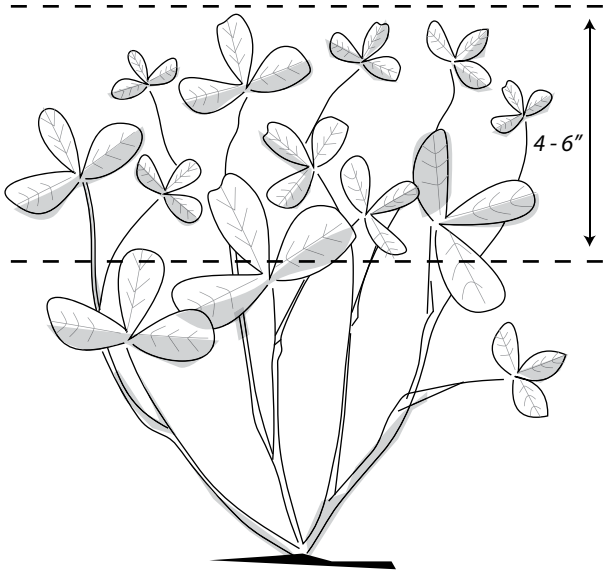

Figure 7—Red and White Clover. Remove the upper 4 to 6 inches prior to first bloom. For red clover, submit leaves, petioles, and stems. For white clover, submit only leaves.

Sampling Soil

For diagnostic use, a good representative soil sample should be collected. When abnormal growth areas exist, take one sample from the normal area and one sample from the problem area. Take individual soil cores adjacent to plants that are selected for tissue sampling. Soil should not get on the plant tissue as this will contaminate the sample and alter results for iron and manganese. Soils contain high amounts of these two elements. Follow instructions for submission of the soil sample to the soil testing laboratory.

Interpreting the Results

Tables 1 and 2 list the sufficiency ranges for crops commonly grown in Kentucky. If tissue results fall below the sufficiency range, then further evaluation is needed to determine if the deficiency is caused by a low level of soil nutrient or if it is caused by some other factor (e.g., soil pH, soil compaction, herbicide damage, wetness, drought, cloudiness, insects, diseases, air temperatures, etc.). If fertilizer is required to correct a deficiency, then macronutrients (N, P, K, Mg, Ca, and S) are generally applied to the soil, while in-season micronutrient (B, Zn, Cu, Fe, Mo, and Mn) applications are usually applied as a foliar spray. If foliar fertilizers are to be tank-mixed with herbicides, be sure they are compatible because some can reduce the efficacy of certain herbicides.

Nutrient levels above the sufficiency range can occur when another nutrient is deficient or if other growing conditions limit normal growth. Excessive nutrient levels are not concerning except in a few specific situations. When soil pH is low, manganese (Mn) toxicity can be a problem in corn, soybean, and tobacco. If the tissue Mn level is above the sufficiency range, a soil sample should be used to determine the appropriate amount of lime needed to raise the soil pH. Very rarely, nutrient levels can be high enough to affect grazing animals. If toxicity to animals is suspected, contact your local veterinarian.

Table 3. Interpretation of corn stalk nitrate analysis.

Plant Nitrogen Status	Stalk Nitrate (ppm as NO_3)	Interpretation
Low	0-250	High probability that nitrogen was deficient. Visual signs of N deficiency usually are apparent.
Marginal	250-700	N availability was close to "optimal," but it was too close to economic penalties for good N management.
Optimal	700-2000	High probability that yields were not limited by N availability. Visual signs of N deficiency on lower leaves are often observed in this range.
Excess	More than 2000	High probability that N was greater than needed for maximum yields.

References

The information contained in Tables 1 through 3 was derived from the following publications.

Campbell, C.R. (ed.). 2000. Reference Sufficiency Ranges for Plant Analysis in the Southern Region of the United States. Southern Cooperative Series Bulletin #394.

Murdock, L.W., and G.J. Schwab. 2006. Corn Stalk Nitrate Test. University of Kentucky Cooperative Extension Publication AGR-180.

Walworth, J.L. 2005. Plant Tissue Testing. University of Alaska Cooperative Extension Publication FGV-00244. (Red and white clover only).

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