NCDA&CS
Plant Tissue Analysis Guide

Plant/Waste/Solution/Media Analysis Section
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Figure credits:
All figures were developed by the NCDA&CS Agronomic Division, with the exception of

a) the corn diagram in Figure 1, which was adapted, with permission, from the University of Illinois Cooperative Extension and
b) the cabbage/lettuce diagram in Figure 1, which was adapted from CorelDRAW® clipart.

1. INTRODUCTION TO PLANT TISSUE ANALYSIS

Plant tissue analysis is a quantitative measurement of essential plant nutrients within a sample of plant tissue. It can be used to identify nutrient-related problems (deficiencies, toxicities or imbalances), rule out nutrition as the source of a problem, monitor nutrient status as a basis for managing a crop fertility program and/or evaluate the effectiveness of a fertility program. Additionally, plant analysis can help determine the optimal time for harvest of flue-cured tobacco.

The following 16 nutrients are essential for a plant to complete its life cycle: carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), boron (B), molybdenum (Mo) and chloride (Cl^-). Carbon, hydrogen and oxygen are obtained from air and water and are not generally limiting factors. The other nutrients are provided by soil minerals, soil organic matter, limestone, amendments (such as crop residue, animal manure, compost, agricultural waste and industrial waste) and/or fertilizer.

The NCDA&CS Agronomic Division lab provides interpretive guidelines for 11 of the essential nutrients (N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, B) as part of its standard plant tissue analysis. Standard analysis also includes a measurement of sodium (Na) concentration. Although Na is not a nutrient, it can affect plant growth and may be phytotoxic to plants at concentrations as low as 0.25%. In addition to the standard analysis, tests for nitrate-nitrogen (NO_3-N), Mo and Cl^- are available, by request, for an extra fee per sample.

For ***strawberry and cotton*** samples, criteria have been developed for the nitrate-nitrogen (NO_3-N) concentrations in the petioles attached to the leaf samples. Petiole analysis provides a snapshot of NO_3-N uptake from the soil to the leaves at the time of sampling and is an important tool for in-season nitrogen management. Petiole NO_3-N is a required test for strawberry and cotton and is automatically assigned to these crops regardless of whether petiole samples are submitted or NO_3-N is requested.

For ***Brassica*** **crops (e.g., broccoli, cabbage, canola, kale, mustard, turnip), poinsettia, spinach, and alfalfa**, Mo is essential to yield quality. Mo is automatically included in the standard analysis for these crops even where the test is not requested.

2. COLLECTING A GOOD SAMPLE

Advisors and growers use tissue analysis to measure concentrations of nutrients in an "indicator" plant part collected at a specific stage of crop development. Then, they compare those measurements to established standard values known as sufficiency ranges. Therefore, you must submit the correct plant part at the correct growth stage to receive valid interpretations and recommendations. Sampling incorrectly can result in misleading findings and inappropriate nutrient management decisions.

Plant part. The correct plant parts to sample for specific crops are listed in Appendix A, as well as the corresponding plant part codes to enter on the Plant Sample Submission Form.

For most crops, interpretations are based on sampling the most recent mature leaf (MRML). The MRML is the most fully expanded or mature leaf and is generally the third to fifth leaf below the growing point (Figure 1). It is neither dull from age nor shiny green from immaturity.

Other possible indicator plant parts include the whole plant, top of the plant, ear leaf, petiole, outermost undamaged leaf and harvest leaf (Table 1). When the sampling protocol for a specific crop is unknown, selection of the MRML will generally provide the best indication of nutritional status.

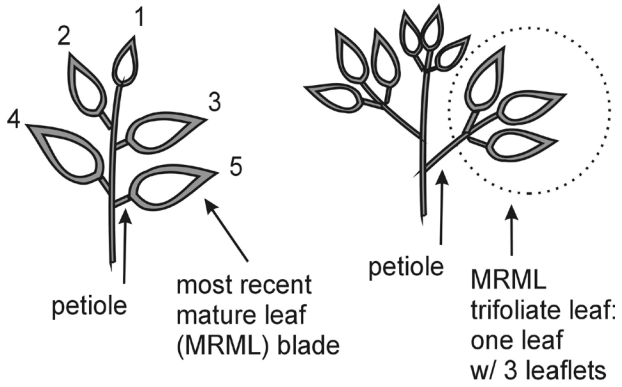

Figure 1. Identification of the most recent mature leaf (MRML) in simple and trifoliate leaved plants.

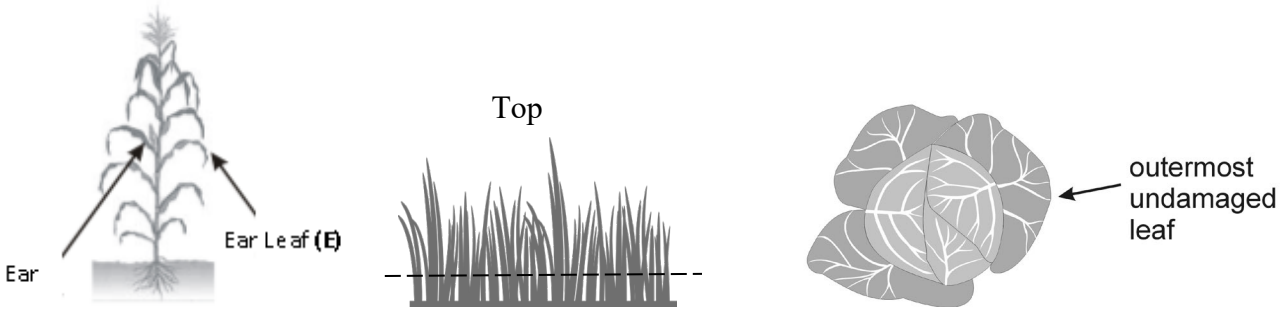

Figure 2. Some examples of appropriate plant parts for tissue sampling.

Table 1. Indicator plant-part codes, descriptions and example crops.

Indicator plant part		Example crops
Code[1]	**Description**	
M	Most recent mature leaf (MRML)	Most plants, including cotton & strawberry[2]
W	Whole plant (cut ½–1" above soil surface)	Seedling or young plants
T	Top 3–6 inches or top 2–4 leaves	Turf; forage grass and small grains prior to reproductive growth stages
E	Ear leaf (opposite and below ear)	Corn (from tasseling through silking)
P	Petiole[3] only	Vinifera grape
O	Outermost undamaged leaf	Lettuce and other leaf vegetables
H	Harvest leaf	Tobacco

[1] This is the code from Appendix A that must be written on the *Plant Sample Submission Form.*
[2] Even though cotton and strawberry tissue samples include both leaf blades and petioles (separated), the appropriate plant-part code is M.
[3] Petiole is the leaf stem.

Growth stage. For several crops (small grains, corn, forage grasses), the appropriate plant part varies with the growth stage. The correct plant part to sample at differing growth stages for these crops are listed in Appendix A, as well as the corresponding growth stage codes to enter on the Plant Sample Submission Form.

In addition, some sufficiency ranges may vary at differing growth stages. When samples are collected at other growth stages, the advisor and/or grower must consider principles of plant nutrition when reviewing results and interpretations. For example, potassium (K) levels in leaves of a plant will decrease as the plant moves into reproductive growth, so K sufficiency levels of a MRML during the early or blooming growth stage will be higher than levels during the fruiting growth stage.

Representative sampling. A good *representative sample* is comprised of tissue obtained randomly from multiple plants within the area of interest. Although only a very small amount of plant material is required for the test (< 1 gram), each sample must include material to adequately represent the area of interest. For crops with small leaves (e.g., azalea), 75–100 leaves make a good sample. For larger-leaved crops (e.g., corn or tobacco), significantly fewer leaves are needed. See Appendix A for the recommended number of leaves to sample for a specific crop.

Sample storage. The way that plant tissue samples are handled between time of collection and arrival at the laboratory greatly affects the quality of analytical results. If delivery time to the laboratory (or to a drying oven) is expected to exceed 12 hours, then it is best to refrigerate or air-dry the samples. Samples should be collected, stored and submitted in paper bags or envelopes. Leaf samples stored in plastic bags are highly prone to decay, which significantly affects the analytical results.

3. UNDERSTANDING THE PLANT ANALYSIS REPORT

Laboratory results are interpreted by comparing nutrient concentrations within a sample to known nutrient sufficiency ranges for a specific indicator plant part and/or growth stage. The sufficiency ranges have been developed from research, survey data, field observations and/or experience. Reliability varies depending on the extent of research conducted on each crop.

For each nutrient measured, the NCDA&CS Plant Analysis Report provides an index value ranging from 0 to 124 and an interpretation category of deficient (D), low (L), sufficient (S), high (H) or excess (E) in addition to the actual concentrations. The critical value (Figure 2) is the point at which a nutrient shortage causes a 5 to 10% loss in yield or growth; the point of mild toxicity indicates the same degree of loss due to nutrient excess.

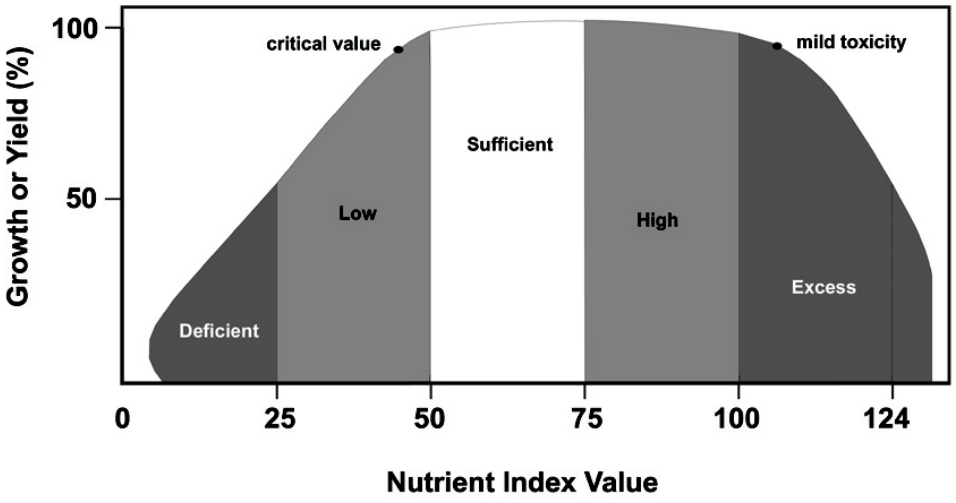

Figure 2. Expectation of yield or growth (%) in response to increasing nutrient concentration and interpretation index

- *Deficient* (0–24) and l*ow* (25–49) index values indicate that the nutrient concentration is below the desired level and may be contributing to reduced growth, yield and/or quality. When nutrient indexes are low or deficient, it is important to determine the cause before making a corrective action. Causes for low nutrient levels in the indicator plant part can include low soil nutrient levels or nutrient imbalances in the growing substrate; low or high soil pH; very wet or dry soils; very low or high soil and air temperatures; soil compaction; heavy fruit load; insect, disease and/or nematode pressure; and chemical damage from herbicides or air pollutants.

- A *sufficient* (50–74) index indicates that the nutrient concentration is optimum for growth and yield.

- *High* (75–99) and *excess* (100–124) index values indicate the nutrient concentrations are above the desired level. *High* concentrations are not normally detrimental to growth or yield, but the potential to impact crop quality increases as the index approaches 100. *Excess* concentrations may cause problems due to plant toxicity or nutrient imbalances. Nutrient concentrations can be very high due to high levels in the growing substrate; contamination from a foliar spray of a pesticide or nutrient; soil contamination; very high or low soil pH; or as a side effect of limited plant growth caused by another problem.

Nutrient ratios. Plant reports provide values for ratios of nitrogen to sulfur (N:S), nitrogen to potassium (N:K) and iron to manganese (Fe:Mn) because of the effects these nutrients have on each other. As a general guideline, the ratio value should be 1.2–2.2 for N:K and >1 for Fe:Mn.

The most important ratio is N:S, which has an acceptable value of 10–18 for most crops. Values approaching and exceeding 18 indicate that there is not enough sulfur present for the plant to use nitrogen efficiently. This situation can occur even when sufficient plant tissue concentrations of both nitrogen and sulfur are present. Small grains and corn are particularly sensitive to elevated N:S ratios.

4. SUMMARY

Plant tissue analysis is a tool used to identify problems and manage nutrients in an economically and environmentally responsible manner. Other factors to be considered in conjunction with plant analysis include recent soil pH and fertility levels, fertilization history, soil texture, environmental conditions (such as soil moisture, soil temperature and recent rainfall events), cropping history, crop age or growth stage, distribution of problem in the field or greenhouse, disease, insect and nematode pressure, visual appearance of the crop and pesticide use injury.

Appendix A. Sampling procedures for plant tissue analysis

Crop	Growth Stage [1]		Plant Part [2]		Leaves: # to collect	Extra test
	When to collect samples	Code	Plant part to collect (Indicator plant part)	Code		
African violet	Mature plants of flowering size	B, M	Most recent mature leaf	M	25	—
Alfalfa	Prior to or early bloom	E, B	Most recent mature trifoliate leaves from the top 1/3 (6″) of plants	T	30	Mo
Apple	5 to 10 weeks after full bloom (mid-June to mid-July)	M	Most recent mature leaf from mid shoot, leaves near base of current year's growth, or leaves from spurs; 4–8 leaves per plant from 20–30 plants	M	50	—
Asparagus	Mid-summer	E	Top 4–6″ of most recent mature fronds	M	20–30	—
	Late-summer	M	Top 18″ of most recent mature fronds	M		
Azalea	Prior to flowering	E	Most recent mature leaf	M	75–100	—
Bahiagrass	*see* Grass (Forage & Pasture)					
Barley	*see* Small Grain					
Bean	Seedlings (less than 12″)	S	All the above-ground portion	W	20–30	—
	Prior to, or during initial bloom	E, B	Most recent mature leaf	M		
Beet	Early to mid-growth	E, B	Most recent mature leaf	M	20–30	—
Begonia (*Rieger elatior*)	Prior to heavy flower formation	E, B	Most recent mature leaf (1st leaf from top that is 2″ wide or greater)	M	20	—
Bentgrass	*see* Grass (Turf)					

Appendix A. Sampling procedures for plant tissue analysis (Continued)

Crop	Growth Stage [1]		Plant Part [2]		Leaves: # to collect	Extra test
	When to collect samples	Code	Plant part to collect (Indicator plant part)	Code		
Bermuda, coastal (hybrid)	*see* Grass (Forage & Pasture)					
Bermudagrass (turf)	*see* Grass (Turf)					
Blackberry	Postharvest (10 to 14 days after final harvest)	M	Most recent mature leaf on primocane (nonfruiting laterals)	M	20–40	—
Blueberry	Early or during bloom	E, B	Most recent mature leaf from mid-portion of current season's growth	M	50–60	—
Bluegrass	*see* Grass (Forage & Pasture)					
Bluestem, big	*see* Grass (Forage & Pasture)					
Boxwood	Summer	M	2–3″ cuttings from terminal growth	M	20 cuttings	—
Broccoli	Early or prior to head formation	E, B	Most recent mature leaf	M	25–30	Mo
Bromegrass	*see* Grass (Forage & Pasture)					
Cabbage	Early to midgrowth	E	First mature leaf from center of whorl; should be oldest undamaged leaf	M	25–30	Mo
Cabbage, Chinese (heading types)	8-leaf stage	E	Oldest undamaged leaf	M	25–30	Mo
Camellia	Summer	M	Most recent mature leaf	M	25–30	—
Caneberries	*see* Blackberry or Raspberry					

Appendix A. Sampling procedures for plant tissue analysis (Continued)

Crop	Growth Stage [1]		Plant Part [2]		Leaves: # to collect	Extra test
	When to collect samples	Code	Plant part to collect (Indicator plant part)	Code		
Canola	Prior to bloom	E	Most recent mature leaf	M		—
Cantaloupe	*see* Melons					
Carnation	Unpinched plants	E	4th or 5th leaf pair from base of plant	M	20–30	—
	Pinched plants	B, F, M	5th or 6th leaf pair from top of primary laterals	M		
Carrot	Early growth (60 days after seeding)	E	Most recent mature leaf	M	20–30	—
Cauliflower	Early or prior to head formation	E	Most recent mature leaf	M	25–30	Mo
Centipede	*see* Grass (Turf)					
Cherry	5 to 10 weeks after full bloom	M	Leaves near base of current year's growth ***or*** from spurs; 4–8 leaves per plant from 20–30 plants	M	50–100	—
Chinese cabbage (heading types)	8-leaf stage	E	Oldest undamaged leaf	M	25–30	Mo
Chrysanthemum	Prior to or at flowering	E, B, F	Most recent mature leaf from top of plant ***or*** upper leaves on flowering stem	M	20–30	—
Clover	Prior to bloom	E	Top 4–6 inches of the plant	T	40–50	—
Collards	Early	E	Oldest undamaged leaf	M	25–30	Mo

Appendix A. Sampling procedures for plant tissue analysis (Continued)

Crop	Growth Stage [1]		Plant Part [2]		Leaves: # to collect	Extra test
	When to collect samples	Code	Plant part to collect (Indicator plant part)	Code		
Corn, field	Seedling (<4″)	S	Entire top of plant cut 1″ above soil	W	15–20 plants	—
	Early (4–12″)	E	Entire top of plant cut 1″ above soil	W		
	Prior to tasselling (>12″)	E	First fully developed leaf below the whorl; This leaf should be totally unrolled and have developed a sheath (collar) on the stalk.	M	10–15	
	Tasselling & shooting to silking	B, F	Leaf opposite and below the uppermost developing ear (earleaf)	E		
	Maturity	M	Leaf opposite and below the uppermost developing ear	M		
	Sampling after silking is not recommended	—	—	—	—	
Corn stalk (end of season)	1–3 weeks after black layer has formed on 80% of the kernels of most ears	M	8″ segment collected at 6–14″ above the soil line	H	15	Only test: NO_3-N
Corn, sweet	Prior to tasselling	E	First fully developed leaf below the whorl; This leaf should be totally unrolled and have developed a sheath (collar) on the stalk.	M	15–20	—
	At tasselling	B, F	Leaf opposite and below the uppermost developing ear (earleaf)	E		

Appendix A. Sampling procedures for plant tissue analysis (Continued)

Crop	Growth Stage [1]		Plant Part [2]		Leaves: # to collect	Extra test
	When to collect samples	Code	Plant part to collect (Indicator plant part)	Code		
Cotton	Seedling: Four weeks following emergence of 2–3 true leaves	S Weeks 1, 2, 3, 4	Most recent mature leaf and petioles. Separate petioles in the field.	M	25–30	Petiole NO_3-N
	Early: Four weeks following seedling (S) stage, includes pinhead square formation	E Weeks 1, 2, 3, 4				
	Bloom: Begins when plants have at least 5 open blooms per 25 row feet	B Weeks 1, 2, 3, 4				
	Fruit: Begins 5th week after beginning of bloom	F Weeks 1, 2, 3, 4				
	Mature	M				
Cucumber	Early to early bloom	E, B	Most recent mature leaf (generally 4th to 5th leaf from a growing point)	M	15–20	—
Cucumber, greenhouse	Early to early bloom	E, B	Most recent mature leaf (generally 4th to 5th leaf from a growing point)	M	8–10	—
Fescue	*see* Grass (Turf or Forage & Pasture)					
Fir	During dormancy (~Sept–Dec)	M	Two or three shoots from the upper 1/3 or ½ of 8–12 trees. DO NOT sample from leader or top whorl.	M	15–30 shoots	—
Daisy, gerber	All growth stages	E,B,F,M	Most recent mature leaf	M	25–50	—
Gammagrass	*see* Grass (Forage & Pasture)					

Appendix A. Sampling procedures for plant tissue analysis (Continued)

Crop	Growth Stage [1]		Plant Part [2]		Leaves: # to collect	Extra test
	When to collect samples	Code	Plant part to collect (Indicator plant part)	Code		
Gardenia	Summer	B	Most recent mature leaf	M	25	—
Garlic	Early growth prior to root/bulb enlargement	E	Center mature leaves	M	20–30	—
Geranium	All growth stages	E,B,F,M	Most recent mature leaf	M	25–50	—
Grape, muscadine	Mid to late summer but prior to final swelling of fruit (end of bloom through Aug); Best Time – June to early July	B, F	Most recent mature leaf opposite fruit clusters from well-exposed shoots (generally the 1st or 2nd fruit cluster from the base of the shoot)	M	25-60	—
Grape, vinifera	Full bloom through veraison (ripening of fruit)	B, F	PETIOLES ONLY from Most recent mature leaf opposite fruit clusters from well-exposed shoots (generally the 1st or 2nd fruit cluster from the base of the shoot)	P	25-60	—

Appendix A. Sampling procedures for plant tissue analysis (Continued)

Crop	Growth Stage [1]		Plant Part [2]		Leaves: # to collect	Extra test
	When to collect samples	Code	Plant part to collect (Indicator plant part)	Code		
Grass (Forage & Pasture)	Tillering (Less than 6″ tall)	S	Entire top of plant cut ½″ above soil	T	2 handfuls	—
	Greater than 6″ tall and prior to seed head formation (after tillering to before boot stage)	E	Top 6 inches of plant or the upper half of the plant (top 4 leaves)	T	20 tops	
	After seed head formation (recommended only when troubleshooting)	F	Most recent mature leaf (leaf below seed head)	M	20–30 leaves	
Grass (Turf)	During normal growing season; at least two days regrowth	M	Two handfuls of freshly mowed grass (with trash removed)	T	2 handfuls	—
Holly	Summer	M	Most recent mature leaf	M	30–50	—
Hydrangea	Early summer	M	Most recent mature leaf	M	30–50	—
Impatiens	All growth stages	E,B,F,M	Most recent mature leaf	M	25–50	—
Kale	Early or during bloom	E, B	Most recent mature leaf	M	25–30	Mo
Lettuce	Anytime during growing season	E	Outermost undamaged leaf	M	10–20	—
Lettuce (leaf), greenhouse	Anytime during growing season	E	Outermost undamaged leaf	M	10–20	—
Lima bean	*see* Bean					
Marigold	All growth stages	E,B,F,M	Most recent mature leaf	M	25–50	—
Melons	Prior to or during bloom; prior to fruit	E, B	Most recent mature leaves (generally the	M	12–30	—

Appendix A. Sampling procedures for plant tissue analysis (Continued)

Crop	Growth Stage [1]		Plant Part [2]		Leaves: # to collect	Extra test
	When to collect samples	Code	Plant part to collect (Indicator plant part)	Code		
(watermelon, muskmelon)	set		5th leaf from the growing tip)			
Millet	*see* Grass (Forage & Pasture)					
Milo	*see* Sorghum					
Mung bean	*see* Bean					
Muskmelon	*see* Melons					
Mustard greens	Early or during bloom	E, B	Most recent mature leaf	M	25–30	Mo
Oats	*see* Small Grain					
Onion	Early growth prior to root/bulb enlargement	E	Center mature leaves	M	20–30	—
Orchardgrass	*see* Grass (Forage & Pasture)					
Ornamental shrubs & trees	During active growth	M	Most recent mature leaf on current year's growth	M	30–100	—
Pansy	All growth stages	E,B,F,M	Most recent mature leaf	M	25–50	—
Peach	Mid-season; 12 to 14 weeks after bloom	F, M	Leaves near base of current year's growth; 4–8 leaves per plant / 20–30 plants	M	50–100	—
Peanut	Prior to, or at bloom.	E or B	Most recent mature tetrafoliate leaves (about 3rd to 5th leaf from growing point)	M	25–30	—

Appendix A. Sampling procedures for plant tissue analysis (Continued)

Crop	Growth Stage [1]		Plant Part [2]		Leaves: # to collect	Extra test
	When to collect samples	Code	Plant part to collect (Indicator plant part)	Code		
Pear	5 to 10 weeks after full bloom	M	Leaves near base of current year's growth or leaves from spurs; 4–8 leaves per plant from 20–30 plants	M	50–100	—
Peas (English, southern)	Prior to or during initial flowering	E, B	Most recent mature leaf (about the 3rd set of leaf from the growing point).	M	30–60	—
Pecan	6–8 weeks after bloom; 8–12 weeks after catkin fall (July 7 to August 7)	M	Middle pairs of leaflets from a compound leaf on a terminal shoot	M	30–45	—
Pepper (bell, hot, banana)	Prior to bloom	E	Most recent mature leaf	M	20–30	—
Petunia	All growth stages	E,B,F,M	Most recent mature leaf	M	25–50	—
Pine	Summer	M	Needles from upper 1/3 crown; select dominant trees with good form and crown; primary lateral branches from first flush of past season's growth; strip needles (include sheaths and fascicles)	M	200 needles	—
Poinsettia	Prior to or at bloom	E, B	Most recent mature leaf	M	15–20	Mo
Potato, Irish	Prior to or during early bloom	E, B	Most recent mature leaf (3rd to 6th leaf from the growing tip)	M	20–30	—
	Early flowering to half-grown tubers	M	Most recent mature leaf (3rd to 6th leaf from the growing tip)	M		
Raspberry	Postharvest (10 to 14 days after final harvest)	M	Youngest mature leaves on primocane (nonfruiting laterals)	M	20–40	—
Rhododendron	Summer	M	Most recent mature leaf	M	20–30	—

Appendix A. Sampling procedures for plant tissue analysis (Continued)

Crop	Growth Stage [1]		Plant Part [2]		Leaves: # to collect	Extra test
	When to collect samples	Code	Plant part to collect (Indicator plant part)	Code		
Rose	During flower production	F	Upper leaves on the flowering stem ***or*** 5-leaflet leaf below bud	M	20–30	—
Rye	*see* Small Grain					
Ryegrass	*see* Grass (Forage & Pasture)					
Small Grain	Seedling stage to early jointing; GS 3–6 (Feekes) or GS 26–31 (Zadoks)	S	Entire top of plant cut ½″ above soil	W	2 handfuls	—
	Early jointing to just prior to heading (ie just prior to boot); GS 7–9 (Feekes) or GS 32–39 (Zadoks)	E	The 2–4 uppermost leaves (Top 4–6″)	T	25–40	
	Just prior to heading (boot stage); GS 10–11 (Feekes) GS 45–100 (Zadoks) [sampling after heading is not recommended]	B	Flag leaf	M	30–40	
Snap Bean	*see* Bean					
Sorghum (Milo, Grain sorghum)	Early or Bloom	E, B	If E, first leaf out of the whorl; if B, second leaf from the top	M	20	—
Sorghum-Sudan	Early or Bloom	E, B	Top 4″ to 6″ of plant	T	15–20 plants	—
Soybean	Seedlings (less than 12″)	S	Entire top of plant cut 1″ above soil	W	20–30	—

Appendix A. Sampling procedures for plant tissue analysis (Continued)

Crop	Growth Stage [1]		Plant Part [2]		Leaves: # to collect	Extra test
	When to collect samples	Code	Plant part to collect (Indicator plant part)	Code		
	Prior to, or during initial bloom; before pod set [sampling after pods begin to set is not recommended]	E, B, F	Most recent mature leaf	M		
Spinach	Mid-growth	M	Most recent mature leaf	M	20	Mo
Spinach, greenhouse	All growth stages	M	Most recent mature leaf	M	20	Mo
Spruce	Mid-season to late summer	M	2–3″ terminal cuttings	M	25 cuttings	—
Squash	Summer	B, F, M	Most recent mature leaf (about 5th leaf from the growing point)	M	15–20	—
Strawberry, field	Early	E Weeks 1–8	Most recent mature leaf and petioles. Separate petiole in the field	M	20–25	Petiole NO_3-N
	Bloom/Fruit: Initiated when there are 5–10 blooms on >75% of the plants or 2–3 blooms on most plants; Harvest usually begins at B/F week 5 or 6	B/F Weeks 1–12	Most recent mature leaf and petioles. Separate petiole in the field	M	20–25	Petiole NO_3-N
	Mature	M Weeks 1–4	Most recent mature leaf and petioles. Separate petiole in the field	M	20–25	Petiole NO_3-N
Strawberry, high tunnel	All growth stages	E,B,F,M	Most recent mature leaf and petioles. Separate petiole in the field	M	20–25	Petiole NO_3-N
Strawberry, greenhouse	All growth stages	E,B,F,M	Most recent mature leaf and petioles. Separate petiole in the field	M	20–25	Petiole NO_3-N
Sweetpotato	Midgrowth; prior to root enlargement	E	Most recent mature leaf (generally the 4^{th} to 5^{th} leaf)	M	20–30	—

Appendix A. Sampling procedures for plant tissue analysis (Continued)

Crop	Growth Stage [1]		Plant Part [2]		Leaves: # to collect	Extra test
	When to collect samples	Code	Plant part to collect (Indicator plant part)	Code		
Tobacco, burley	Seedling	S	Entire top of plant cut 1″ above soil	W	8–12	—
	Prior to bloom	E	Most recent mature leaf (about 4th leaf from growing point)	M		
	During bloom	B, F		M		
	Maturity	M		M		
Tobacco, flue-cured	Seedling (greenhouse transplants)	S	Entire top of plant cut 1″ above soil	M	1 tray	—
	Before bloom	E	Most recent mature leaf (about 4th leaf from growing point)	M	8–12	
	During early bloom	B		M		
	During late bloom	F		M		
	Mature	M		M		
	Harvest leaf	M	Upper leaves (tips) (Position U) (~21st to 30th nodes from the bottom)	H		
	Harvest leaf	M	Middle leaves (smoking) (Position M) (~11th to 20th nodes from the bottom)	H		
	Harvest leaf	M	Lower leaves (lugs & cutters) (Position L) (~1st to 10th node from the bottom)	H		

Appendix A. Sampling procedures for plant tissue analysis (Continued)

Crop	Growth Stage [1]		Plant Part [2]		Leaves: # to collect	Extra test
	When to collect samples	Code	Plant part to collect (Indicator plant part)	Code		
Tomato, field	Early growth (5-leaf stage through first flower)	S, E	Most recent mature leaf (4^{rd} to 5^{th} compound leaf back from the growing point)	M	8–10	—
	Early flower through first fruit set (golf-ball-sized fruit)	B		M		
	First fruit set through harvest	F, M		M		
Tomato, greenhouse	Early growth through first fruit set	S, E, B	Most recent mature leaf (4^{rd} to 5^{th} compound leaf back from the growing point)	M	8–10	—
	First fruit set through harvest	F, M				
Triticale	*see* Small grains					
Turnip greens	Early or during bloom	E, B	Most recent mature leaf	M	25–30	Mo
Walnut	6 to 8 weeks after bloom	M	Middle pairs of leaflets from a compound leaf on a mature shoot	M	30–35	—
Watermelon	*see* Melons					
Wheat	*see* Small grains					
Zucchini	*see* Squash					

[1]Growth-stage codes: S = Seedling, E = Early, B = Bloom (prior to first fruit), F = Fruiting, M = Mature. To receive meaningful recommendations on a plant analysis report, you must collect and submit tissue samples from the growth stage indicated in this table and write the associated code on the Plant Sample Submission Form. Analysis of tissue collected at other growth stages may still provide useful information even though there are insufficient data for the lab to issue recommendations.

[2]Plant -part codes: W = Whole plant, T = Top, E = Ear leaf, M = Most recent mature leaf (MRML), O = Outermost undamaged leaf, P = Petiole, H = Harvest leaf. To receive meaningful recommendations on a plant analysis report, you must collect and submit the plant tissue part indicated in this table for the crop you are sampling and write the associated code on the Plant Sample Submission Form. Samples of other tissue may still provide useful information even though there are insufficient data for the lab to issue recommendations based on it.