TECHNICAL NOTE

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Boise, Idaho

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Plant Nutrient Deficiency for Idaho Crops

R. D. Johnson, State Nutrient Management Specialist, NRCS Boise, Idaho

Plant Nutrient Deficiency

Symptoms

Visual symptoms of plant nutrient deficiencies are an important diagnostic tool for evaluating the nutritional health of crops in the field. The experienced observer can recognize nutritional disorders because the symptoms are characteristic for each element.

Insect and plant disease problems may obscure nutrient deficiencies, but when pests and diseases are minimal the deficiency symptom may be conclusive evidence of plant nutrient disorders.

Soil fertility and plant nutrient deficiencies in Idaho field crops have been limited to nitrogen, phosphorus, potassium, iron, zinc and boron. Deficiency symptoms of these elements in selected crops are described in the following paragraphs. A good reference for photos showing nutrient deficiency symptoms can be found in Chapter 4 (Essential Plant Nutrients), Western Fertilizer Handbook [5].

Primary Nutrients:

Nitrogen, Phosphorus and Potassium are designated as primary nutrient based on their importance in crop production.

Nitrogen (N): N deficiency in corn and small grains appears as light green or yellowish color. Older leaves are affected first. As the severity increases the lighter color appears in the younger plant parts. With very severe N deficiency the older leaves die and may fall off the plant. N deficiency has not been observed in legume crops in Idaho.

Phosphorus (P): P deficiency symptoms are less well characterized because changes in plant color or shape do not occur. In general, P-deficient plants are stunted or have reduced growth vigor. Visual detection of P deficiency is aided if a well nourished crop is nearby for comparison. Years ago it was said that purple coloration of plant tissue, especially in corn, was an indication of P deficiency. However, purple color is associated with genetic and environmental factors and has little, if any, relation to P nutrition.

Potassium (K): K fertilizer responses have been observed in Idaho in alfalfa and corn grown on low-K soils. In alfalfa K deficiency appears as small white spots in older leaves. The spots are localized near the leaf margin. As the severity increases the number of spots increases and they develop closer to the midrib of the leaflet. In severe cases a general yellowing of the leaf may be superimposed over the spotting effect.

A second K deficiency symptom in alfalfa may be seen in the same area as the more common spotted symptom described above. The second symptom appears as uniform marginal chlorosis of the leaflet. The boundary between chlorotic and normal leaf cells is sharp and somewhat irregular. As the severity increases the proportion of chlorotic tissue increases, and in the extreme, may occupy more than half of the leaf area. Both K deficiency symptoms may be seen on different plants in the same field.

K deficiency in corn has apparently been marginal because the characteristic symptoms have not been seen in field trials where K fertilizer responses have been measured. It is expected that symptoms will become visible when the stress is more severe. K deficiency in corn is expected to appear as a marginal chlorosis or necrosis beginning first on the older leaves. Where it occurs, the symptom will be most prominent toward the leaf tip.

Secondary Nutrients:

Sulfur, Calcium and Magnesium are designated as secondary nutrients. Sulfur and Calcium besides being important in development of essential amino acids and cell walls, play an important role in maintaining pH and salt balance in Idaho soils.

Sulfur (S): S deficiency in Idaho crops is frequently seen in non-irrigated soils of Northern and Eastern Idaho. Symptoms of S deficiency in plants are often confused with N deficiency. The difference is that with S deficiency the young leaves are light green to yellowish in color, where with N deficiency the older tissue is affected first.

Calcium (Ca): Ca imbalances, due to over cropping or wet soil conditions, can result in cork spot and bitter pit. This is not as common in Southern Idaho as Northern Idaho or other parts of the country. The exception would be vegetable crops grown under intensive management on granitic sandy soils.

Micronutrients:

Nutrients are designated as micronutrients, not on the importance in crop production, but on the amount that a plant utilizes through out its life cycle. Generally micronutrient deficiencies in crop production systems are addressed by utilizing foliar applications. Micronutrient elements are very reactive in soils and the rates of application of micronutrients or soil amendments to correct the soil condition leading to the micronutrient deficiency are often uneconomical. Each micronutrient discussed is important to Idaho crops.

Iron (Fe): Fe deficiency in Idaho crops is frequently seen in corn and alfalfa. This deficiency is referred to as lime-induced chlorosis because it occurs in plants growing on calcareous soils. However, all calcareous soils do not react alike in terms of iron deficiency. Fe deficiency appears as interveinal chlorosis; the veins and adjacent tissue have the normal green color and the interveinal areas are light green to yellow. In severe cases the entire leaf will be chlorotic with often the leaf margins showing necrosis (full death). Lime-induced chlorosis is aggravated by too much soil moisture, soil salinity and, in some cases, excessive soil phosphorus.

Zinc (Zn): Zn deficiency in field corn occurs sporadically in Idaho. It is associated to some extent with land leveling and subsoil exposure. Zinc deficiency, when it occurs, may appear early in the season when corn is less than 10 inches high. In mild deficiency situations, the symptom may disappear as the season progresses. As the deficiency becomes more severe the chlorotic strips coalesce toward the leaf base, and in the extreme the lower part of the leaf will appear white and translucent and the plant overall will be stunted. Sometimes the stalk will take on a red or purple coloration. Zn deficiency is easily controlled with the application of Zn-containing fertilizers.

Boron (B): B in Idaho soils has been toxic as often as it has been deficient. The toxicities occur most often in inland desert areas associated with high-boron waters. Deficiencies are generally related to high rainfall areas frequently seen in non-irrigated areas of Northern and Eastern Idaho or in irrigated areas utilizing low-boron surface waters in the production of tree crops and legumes. B deficiency in Idaho crops when found has been limited to vegetable fruit crops, tree crops and legumes. This deficiency is often referred to as “witches-broom”, which is due to the death of terminal growth, causing lateral buds to develop and producing a thickened, curled, wilted and chlorotic leaves. In fruit and tuber crops B deficiency can result in soft or necrotic spots in fruit or tubers. Often this disorder develops during storage and is due to poor carbohydrate and starch distribution and storage within the plant.

Boron can be very toxic to some field crops grown in Idaho. Potatoes and beans can develop toxicity symptoms following an over application of B in Alfalfa rotations.

Manganese (Mn): Mn deficiency in fruit trees appears as the fading of green color from the margin toward the mid-rib of the leaf between the veins. The faded area becomes brownish-yellow in color as the season progresses. The leaves are usually normal in size, although fruit yields are reduced. Symptoms are first evident on older leaves. Manganese deficiency is more common with peaches and apricots than the other tree fruits.

Plant Tissue Testing

Plant tissue analysis may serve two general purposes:

(1) To determine whether current soil fertility management practices are satisfying crop nutritional needs in relation to the soil type, climatic conditions and the irrigation, and other crop production management practices.

(2) To help establish the cause of visual growth disorders—whether they are the result of insects, diseases, or plant nutrient deficiencies. Plant nutrient deficiency symptoms, as a diagnostic tool, are discussed in detail in the next section.

The interpretation of plant tissue analyses depends on time of season and plant part sampled. Studies focusing on plant tissue analysis as a diagnostic tool have emphasized economy and ease of plant sampling.

Among the agronomic crops, plant or tissue analysis has been most intensely studied in Idaho are potatoes, sugarbeets and field corn. Lesser amounts of information are available on other crops. This Tech Note summarizes tissue sampling location, timing of sampling and critical nutrient ranges for crops grown in Idaho.

Plant tissue analysis is primarily used to detect nutrient deficiencies and to evaluate responses to fertilizer additions and other cultural practices. Both soil testing and plant analysis are useful diagnostic tools and one should not be used in lieu of the other. Similar to soil testing, an important aspect of plant analysis is sample collection and handling. Plant composition varies with age, plant part, plant condition, variety, and environmental factors. Therefore, it is essential that proper sampling protocols be followed.

These guidelines should be consulted prior to sampling any crop to ensure proper interpretation and meaningful results. Separate sampling and analyses should be conducted in those areas that appear to differ greatly from the rest of the field. This same approach should also be used when conducting diagnostic or troubleshooting procedures.

It is also important to identify what not to include in a tissue sample. Plants that are under stress, or mechanically or insect damaged, or disease infested should not be sampled. Finally, it is desirable to withhold sampling during, or immediately following (i.e., a few days), an irrigation event.

Use a clean container such as a paper bag or a plastic pail when collecting a tissue sample. Never use a metal container due to the risk of sample contamination. Avoid placing tissue samples in a plastic bag unless the bag is vented or the sample is refrigerated.

Once a tissue sample has been collected, it should be delivered to the laboratory as soon as possible. Do not store plant tissue samples in air-tight bags or at room temperature. Keep plant tissue samples cool (refrigerator temperature) but do not freeze.

Accurate plant sampling requires experience and knowledge, therefore, the use of trained and experienced samplers is strongly recommended.

Desired sample locations for common crops and a table presenting an outline the appropriate sample times, plant parts, and sample sizes pertaining to plant tissue collection for various crops follow.

Corn [2]

Plant less than 12 inches tall - Collect all of the above ground portion.

Before tasseling - Collect the first fully developed leaves from the top.

From Tasseling to silking - Collect the leaves below and opposite from the ear.

Collect from 12 to 20 plants selected at random.

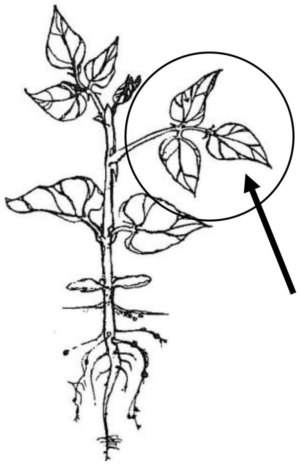
Critical nutrient ranges [1, 2]

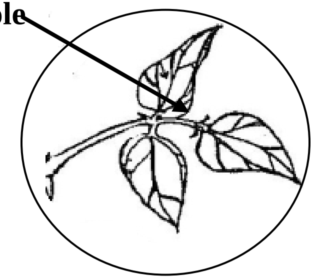
Plant Part Sampled		Sampling Time	Plants to Sample
1st mature leaf or leaf opposite/below ear		Tasseling-Silking	12 – 20
Nutrient	**Time or Growth Stage**	**Plant Part**	**Adequate Range**
Corn (field)			
N	Silking	Ear leaf	2.4-3.7%
P	Silking	Ear leaf	0.23-0.26%
K	Silking	Whole leaf opposite and below ear	1.7-2.0%
Zn	pollination	6^{th} leaf from bottom	15-20 ppm

* Nitrogen (N), Phosphorus (P), Potassium (K), Zinc (Zn)

Field Beans and Peas [1]

Prior to or during initial flowering





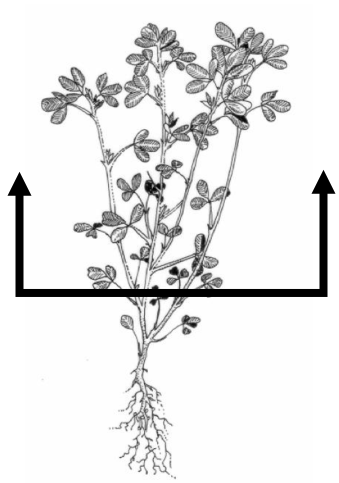
Critical nutrient ranges [1, 2]

Plant Part Sampled		**Sampling Time**	**Plants to Sample**
First fully developed trifoliate leaf and petiole - 4th leaf from tip		Midgrowth to early bloom (June-July)	20 – 30
Nutrient	**Time or Growth Stage**	**Plant Part**	**Adequate Range**
Beans (field)			
N	1st trifoliate leaf	Whole tops	3.4%
P	1st trifoliate leaf	Whole tops	0.2-0.3%
K	Full bloom	Whole tops	2.6-3.2%
Zn	Mid season	Youngest mature leaf	20-25 ppm

* Nitrogen (N), Phosphorus (P), Potassium (K), Zinc (Zn)

Alfalfa, Clovers, Trefoil and Legumes [1]

6" to early bloom

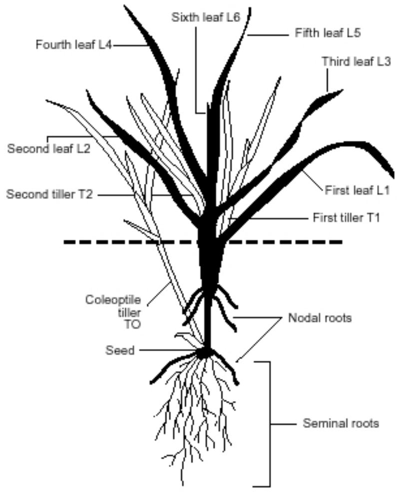


Critical nutrient ranges [1, 2, 6]

Plant Part Sampled		Sampling Time	Plants to Sample
Sample to 6" or Upper 1/2 and/or 2/3 of plant		10% Bloom	10 – 30
Nutrient	**Time or Growth Stage**	**Plant Part**	**Adequate Range**
Alfalfa			
N	1/10 bloom	Whole Tops	3-4%[6]
P	1/10 bloom	Whole Tops	0.2-0.25%[6]
K	1/10 bloom	Whole Tops	1.8-2.0%[6]
S	1/10 bloom	Whole Tops	0.20-0.25%[6]
Zn	1/10 bloom	Top 1/2	10-14 ppm
B	1-10 bloom	Top 2/3	10-20 ppm
Mo	1-10 bloom	Top 1/2	0.3-0.5 ppm

* Phosphorus (P), Potassium (K), Sulfur (S), Zinc (Zn), Boron (B), Molybdenum (Mo)

Small Grains & Grasses Seedling [1]



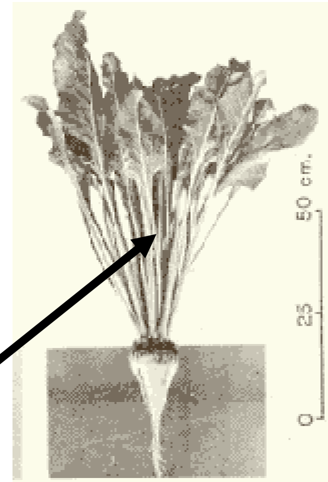
Critical nutrient ranges [1, 2]

Crop	Plant Part Sampled	Sampling Time	Plants to Sample
Turf	Leaf - blades only, no soil	Active growth	2 cups
Wheat/Barley/Oats	Leaf - top leaves down to 4th or 5th leaf	Before heading	25 - 50
Nutrient	**Time or Growth Stage**	**Plant Part**	**Adequate Range**
Barley			
NO_3-N	Early tillering	Crown tissue	6000-8000 ppm
Zn	Heading	Leaves of 2nd node	20-25 ppm
Grass (orchard)			
N	12" height	Tops	3.5-4%
P	6" height	Tops	0.35-0.40%
K	6" height	Tops	1.8-2.2%
S	Early bloom	tops	0.10-0.15%
Wheat			
N	Boot	Top two leaves	2.3-2.7%
N	Jointing	Total tops	2.5-3.0%
NO_3-N	Jointing	1st 2" above ground	0.08-0.15%
P	Heading/early boot	Total tops	0.15-0.20%
K	Early boot	Total tops	1.5-2.0%
K	heading	Total tops	1.25-1.75%

* Nitrogen (N), Nitrate-N (NO_3-N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Manganese (Mn), Iron (Fe), Boron (B), Zinc (Zn)

Sugar Beets [1]

Anytime during growing season



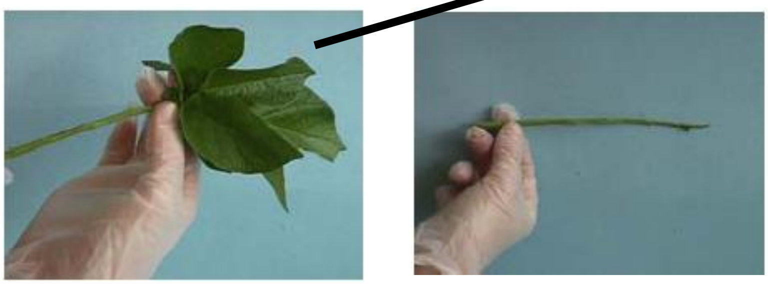
Critical nutrient ranges [1, 2]

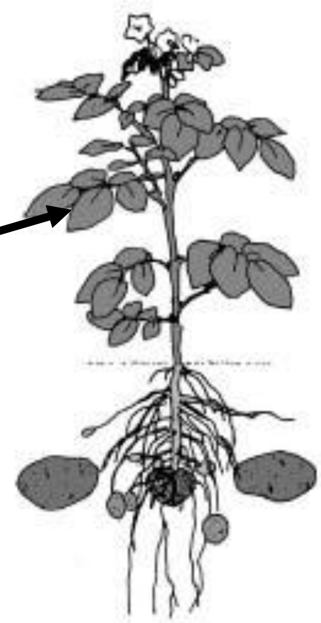
Plant Part Sampled		Sampling Time	Plants to Sample
Petiole and/or blade - of the most recent leaf		Thinning to harvest	15 - 20
Nutrient	**Time or Growth Stage**	**Plant Part**	**Adequate Range**
Sugarbeets			
NO_3-N	June 15	Petiole youngest fully mature leaf	7,000-10,000 ppm
	July 1		5,000-9,000 ppm
	July 15		2,000-5,000 ppm
	August 1		1,000-2,000 ppm
P	Aug 30	Petiole youngest fully mature leaf	0.25-0.30%
PO_4-P	July 1		0.10-0.12%
	July 1		
S		Recently mature blade	0.25-0.30%
Zn	Aug 1		8-12 ppm
B	July 1	Recently mature blade	20-40 ppm
	July 1		
		Recently mature blade	

* Nitrate-Nitrogen (NO_3-N), Phosphorus (P), Phosphate-P (PO_4-P), Sulfur (S), Zinc (Zn), Boron (B)

Potatoes [1]

Prior to and during early flowering





Stripping leaflets from the petiole

Critical nutrient ranges [1, 2]

Plant Part Sampled		Sampling Time	Plants to Sample
Petiole - of 4th leaf from tip		Early through late season	40 – 50
Nutrient	**Time or Growth Stage**	**Plant Part**	**Adequate Range**
Potatoes			
NO_3-N	Vegetative, tuberization, tuber growth	4th petiole	15,000-25,000 ppm
NO_3-N	Maturation	4th petiole	5,000-10,000 ppm
P	Vegetative, tuberization, tuber growth	4th petiole	0.22-0.30%
K		4th petiole	7.0-13.0%
Zn		4th petiole	10-20 ppm

* Nitrate-Nitrogen (NO_3-N), Phosphorus (P), Potassium (K), Zinc (Zn)

Onion [3]

Prior to and during early bulb growth

Sample washed root mass of 20 to 30 plants

Time or Growth stage[4] - 3 to 4 leaf thru 1.5 to 3 inch dia. Bulbs

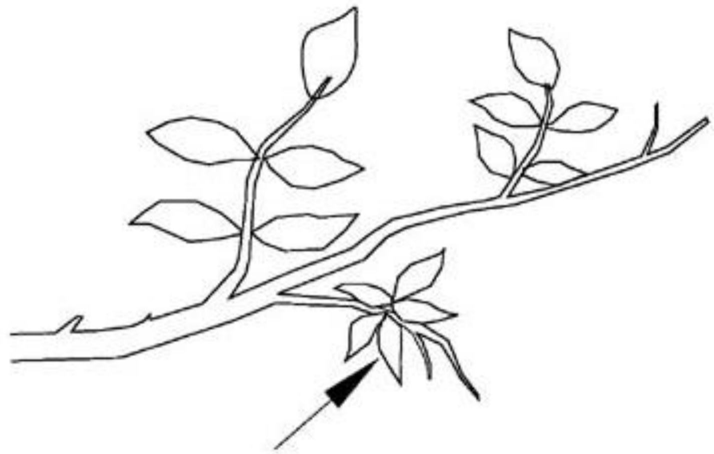
Critical nutrient ranges [1, 2]

Plant Part Sampled		**Sampling Time**	**Plants to Sample**
Washed roots		3 leaf to 3" bulb	20 – 30
Nutrient	**Time or Growth Stage**	**Plant Part**	**Adequate Range**
Onions			
N	3-to5-leaf stage	Most recently matured leaf	3.5 to 4%
NO_3-N	3- to 5-leaf stage	Roots at the base of the plant	6,000-10,000 ppm
NO_3-N	8- to 10-leaf stage		4,000-6,000 ppm
NO_3-N	1.5”- to 3”-bulbs		2,000-4,000 ppm
PO_4-P	3- to 4-leaf stage	Most recently matured leaf	3,000-3,300 ppm
PO_4-P	3- to 4-leaf stage	Roots at the base of the plant	2,000-2,500 ppm
PO_4-P	8- to 10-leaf stage	Roots at the base of the plant	1,600-2,000 ppm
K	3- to 8-leaf stage	Most recently matured leaf	2.5-3.5%
K	Growing season	Roots at the base of the plant	3-5%
S	3- to 8-leaf stage	Leaves or Roots	0.5-0.8%

* Nitrogen (N), Nitrate-N (NO_3-N), Phosphorus (P), Phosphate –P (PO_4-P), Potassium (K), Sulfur (S)

Tree

Apples, Pears, Almonds, Apricots, Cherries, Prunes, Plums



Collect the leaves from non-fruiting, non-expanding, spurs at mid season.

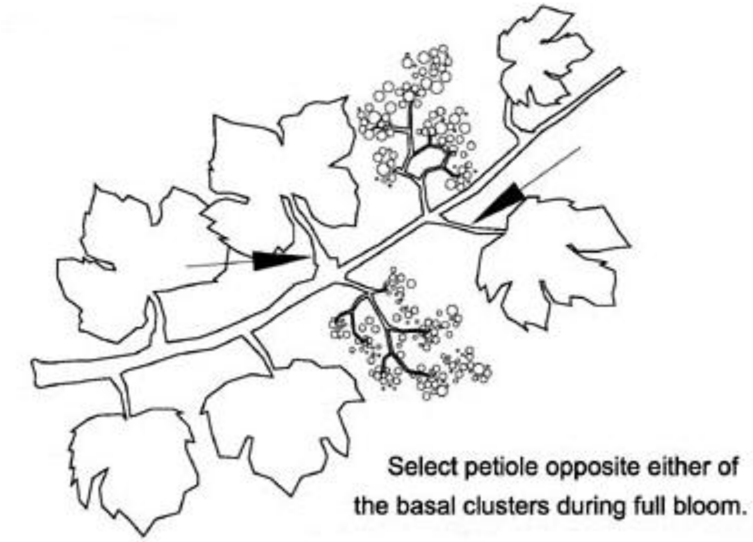
Critical nutrient ranges [1, 2]

Crop	Plant Part Sampled	Sampling Time	Plants to Sample
Apple	Leaf-2-5 month non-fruiting, non-expanding	Late July	50 – 100
Cherry	Leaf - 2-5 month old fully expanded spurs	Late July	25 – 60
Peach	Leaf - most recently mature from basal to mid-shoot	Late July	25 – 60

	Apples			Peach			Cherry		
Nutrient*	**Deficient**	**Normal**	**Excess**	**Deficient**	**Normal**	**Excess**	**Deficient**	**Normal**	**Excess**
		(Percent)			(Percent)			(Percent)	
N	1.6	2.0-2.2	3.0	2.0	3.0-3.6	4.0	1.7	2.3-2.6	3.5
P	0.10	0.14-	0.65	0.10	0.14-	0.65	0.10	0.14-	0.65
K	0.90	0.20	4.0	1.0	0.20	3.0	0.10	0.20	3.0
Ca	0.50	1.2-3.0	3.0	0.50	1.5-2.8	3.0	0.50	1.3-2.8	3.0
Mg	0.18	0.8-2.4	2.0	0.18	1.0-2.4	2.0	0.18	0.8-2.4	2.0
		0.23-			0.23-			0.25-	
		0.33			0.80			0.80	
		(ppm)			(ppm)			(ppm)	
Mn	20	40-200	220	20	35-200	220	20	35-200	220
Fe	40	50-200	220	40	50-200	220	40	50-200	220
B	25	30-60	100	25	30-60	100	25	30-60	100
Zn	15	18-80	200	15	18-80	200	15	18-80	200

* Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Manganese (Mn), Iron (Fe), Boron (B), Zinc (Zn)

Vine – Grape [2]



Plant Part Sampled	Sampling Time	Plants to Sample	
Leaf - recently mature opposite basal clusters	Full Bloom	25 – 60	
Nutrient	**Time or Growth Stage**	**Plant Part**	**Adequate Range**
Grapes			
NO_3-N	August	Recent mature petiole	0.015-0.045%
P	August	Recent mature petiole	0.1-0.2%
K	August	Recent mature petiole	0.6-1.2%
Mg	August	Recent mature petiole	0.1-0.15%
B	August	Recent mature petiole	25-40 ppm
Zn	August	Recent mature petiole	25-50 ppm
Mn	August	Recent mature petiole	50-75 ppm
Fe	August	Recent mature petiole	15-25 ppm

Nitrate-Nitrogen (NO_3-N), Phosphorus (P), Potassium (K), Magnesium (Mg), Boron (B), Zinc (Zn), Manganese (Mn), Iron (Fe), North American Proficiency Testing (NAPT) participating western laboratories

A&L WESTERN AGRICULTURAL LABS
1311 WOODLAND AVE, SUITE #1
MODESTO CA 95351
209-529-4080
http://www.al-labs-west.com

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