

Chapter 4

Recommended Plant Tissue Nutrient Levels for Some Vegetable, Fruit, and Ornamental Foliage and Flowering Plants in Hawaii

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Plant tissue analysis is used as a diagnostic tool to monitor the levels of nutrient elements necessary for plant growth. The table on the following pages gives generalized sufficiency ranges for N, P, K, Ca, Mg, S, B, Fe, and Mn for selected crops that are commonly grown in Hawaii. The information has been taken from the following sources:

Plant analysis handbook II. 1996. H.A. Mills and J. Benton Jones, Jr. MicroMacro Publishing, Athens, Georgia, USA. 422 p.

Plant analysis, an interpretation manual. 1986. D.J. Reuter and J.B. Robinson. Inkata Press, Melbourne-Sydney, Australia. 218 p.

Adequate nutrient levels in soils and plants in Hawaii. 1997. Y.N. Tamimi, J.A. Silva, R.S. Yost, and N.V. Hue. CTAHR publication AS-3. 2 p.

The sufficiency ranges are given for plant tissues of the crops at ages (or stages in the crop cycle) that research has found appropriate for sampling. The analysis data can be used as a guide for attaining improved crop quality and yield. For long-term orchard crops,

plant tissue nutrient levels can be logged over time and used as a diagnostic tool to assist in developing a fertilizer program. If a tissue level of a nutrient is below the lower end of the sufficiency range, the nutrient should be considered deficient, whereas if the level is above the upper end of the range, the nutrient can be considered as approaching a toxic level. The midpoint of the sufficiency range is the target to aim at. As the level approaches the lower limit, the nutrient should be added. As the level approaches the upper limit, additions of the nutrient should be withheld. It is important to be near the midpoint for most nutrients, because imbalances in the ratios of nutrients can affect crop growth.

Because environment plays a major role in nutrient uptake and crop development, the sufficiency ranges given here should be considered as general guides. In addition to variation due to environmental effects, different crop cultivars may have different critical levels.

The form reproduced on page 65 is used by the CTAHR Agricultural Diagnostic Center to obtain information on plant tissue samples submitted for nutrient analysis.

Recommended plant tissue nutrient levels: sufficiency values and ranges

Vegetables	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	B (ppm)	Fe (ppm)	Mn (ppm)
Beans, snap 10 most recently matured leaves	3.00–6.00	0.25–0.75	1.80–4.00	0.80–3.00	0.25–1.00	0.23	20–75	50–400	30–300
Bittermelon similar to cucumber									
Broccoli, heading most recently matured leaf	3.20–5.50	0.30–0.75	2.00–4.00	1.00–2.50	0.23–0.75	0.30–0.75	30–100	70–300	25–200
Cabbage, Chinese (won-bok) (mature plant) 1 st fully developed leaf	3.00–4.00	0.40–0.70	4.50–7.50	1.90–6.00	0.20–0.70	0.40–0.80	26–100	40–300	25–200
Cabbage, head (2–3 months) wrapper leaves	3.60–5.00	0.33–0.75	3.00–5.00	1.10–3.00	0.40–0.75	0.30–0.75	25–75	30–200	25–200
Cabbage, mustard (pak-choi) fully expanded leaf	2.39–5.51	0.36–0.80	2.86–5.74	1.29–3.21	0.19–0.35	0.41–0.77	19–39	85–363	35–52
Carrots (mid-grown) most recently matured leaf	2.10–3.50	0.20–0.50	2.50–4.30	1.40–3.00	0.30–3.00	0.20–0.40	30–100	50–300	60–300
Cauliflower, heading most recently matured leaf	3.30–4.50	0.33–0.80	2.60–4.20	2.00–3.50	0.24–0.50		30–100	30–200	25–250
Celery (6 wks) most recently matured petiole	1.60–2.00	0.30–0.60	8.60–10.00	2.20–3.50	0.25–0.50		25–50	30–100	10–100
Corn, sweet (5–6 wks) 5 th mature leaf from tip	3.50–4.50	0.30–0.50	2.80–3.80	0.50–0.90	0.20–0.50	0.21–0.70	8–25	50–300	31–300
Corn, sweet (early tassel) 5 th mature leaf from tip	2.70–3.50	0.30–0.50	2.50–3.50	0.70–1.00	0.20–0.50	0.21–0.70	8–25	50–350	31–300
Cucumber (bud to small fruit) 5 th mature leaf from tip	4.50–6.00	0.34–1.25	3.90–5.00	1.40–3.50	0.30–1.00	0.40–0.70	25–60	50–300	50–300
Daikon similar to radish									
Dasheen most recently matured leaf	2.69	0.44	2.92	2.29	0.45	0.43	34	47	50

	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	B (ppm)	Fe (ppm)	Mn (ppm)
Eggplant (bud to small fruit) most recently matured leaf	4.00–5.00	0.30–0.60	3.50–5.00	1.00–2.50	0.30–1.00		25–75	50–300	40–250
Ginger root (2–3 months) 3 rd leaf blade	3.00–3.50	0.24–0.33	3.90–5.70	1.10–1.30	0.50–0.80	0.35–0.40	80–112	110–160	125–250
Lettuce, head (mature) wrapper leaves	3.80–5.00	0.45–0.60	6.60–9.00	1.50–2.25	0.50–0.80		23–50	50–100	25–250
Lettuce, Romaine (mature) plant wrapper leaves	3.50–4.50	0.45–0.80	5.50–6.20	2.00–2.80	0.60–0.80		25–60	40–100	11–250
Onion, dry ($\frac{1}{2}$ – $\frac{1}{2}$ grown) top $\frac{1}{2}$ of leaf, no white portion	5.00–6.00	0.35–0.50	4.00–5.50	1.00–3.50	0.30–0.50	0.50–1.00	22–60	60–300	50–250
Peas, Chinese (1 st bloom) most recently developed leaflet	4.00–5.00	0.30–0.80	2.00–3.50	1.20–2.00	0.30–0.70		5–60	50–300	25–400
Pepper, bell (1 st fruit filled) most recently matured leaf	4.00–6.00	0.35–1.00	4.00–6.00	1.00–2.50	0.30–1.00		25–75	60–300	50–250
Potato, white (30 cm tall) most recently matured leaf	4.00–6.00	0.20–0.50	4.00–11.50	0.60–1.00	0.50–1.50	0.19–0.36	25–50	50–150	30–450
Potato, white (tubers $\frac{1}{2}$ grown) most recently matured leaf	3.00–4.00	0.25–0.40	6.00–8.00	1.50–2.50	0.70–1.00		40–70	40–100	30–250
Potato (sweetpotato) ($\frac{1}{2}$ grown) most recently matured leaf	3.30–4.50	0.23–0.50	3.10–4.50	0.70–1.20	0.35–1.00		25–75	40–100	40–250
Pumpkin most recently matured leaf	4.00–6.00	0.30–0.50	3.00–5.00	1.20–2.50	0.30–1.00		25–75	50–200	50–250
Radish (mid-season) most recently matured leaf	3.00–5.00	0.30–0.70	4.00–7.50	3.00–4.50	0.50–4.50		25–125	50–200	50–250
Squash, zucchini (mature, nonfruiting plant) most recently matured leaf	4.90	0.93	3.71	1.40	0.49	0.32	38	112	82
Taro, lowland most recently matured leaf	3.00–4.50	0.30–0.50	3.00–5.50	0.75–1.50	0.25–0.50	0.20–0.30	10–25	125–150	300–400
Taro, dryland most recently matured leaf	4.20–4.50	0.33–0.35	3.70–4.20	0.90–1.50	0.36–0.43		24–26	150–200	280–315

Recommended plant tissue nutrient levels: sufficiency values and ranges (continued)

	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	B (ppm)	Fe (ppm)	Mn (ppm)
Tomato (mid-bloom to 1 st cluster) leaves opposite or below top flower cluster	3.50–5.00	0.70–1.30	6.00–10.0	1.40–2.20	0.30–0.70		25–75	60–300	50–250
Watercress most recently matured compound leaf	4.20–6.00	0.70–1.30	4.00–8.00	1.00–2.00	0.25–0.50		25–50	50–100	50–250
Fruits									
Atemoya most recently matured leaf	2.50–3.00	0.16–0.20	1.00–1.50	0.60–1.00	0.35–0.50		15–40		
Avocado (5–7 months) most recently matured nonfruiting terminal leaf	1.60–2.00	0.08–0.25	0.75–2.00	1.00–3.00	0.25–0.80	0.20–0.60	50–100	50–200	30–500
Banana (production fields) mid-section leaf strips	3.50–4.50	0.20–0.40	3.80–5.00	0.80–1.50	0.25–0.80	0.20–0.80	10–50	75–300	100–1000
Cantaloupe (small fruit to harvest) 5 th leaf from tip	4.09–5.00	0.25–0.80	3.59–5.00	2.30–3.20	0.35–0.80	0.23–1.40	25–60	50–300	50–250
Cherimoya most recently matured leaf	2.25–3.10	0.15–0.25	1.00–2.00	0.55–1.25	0.30–0.50		15–60		
Coffee (maturity to flower set) 4 th leaf pair from tip	2.30–3.00	0.12–0.20	2.00–2.50	1.00–2.50	0.25–0.40	0.10–0.20	40–75	70–125	50–200
Grapefruit (nonfruiting) most recently matured leaf	2.40–3.00	0.15–0.50	0.80–2.20	1.50–5.50	0.25–0.75	0.15–0.50	30–100	60–200	25–200
Guava (production trees) 3 rd leaf pair from tip on fruiting shoots	1.25–1.70	0.15–0.20	1.25–1.75	0.80–1.75	0.25–0.50				
Honeydew melon (small fruit to harvest) 5 th leaf from tip	4.09–5.00	0.25–0.60	3.59–4.50	2.59–3.20	0.35–0.80	0.23–1.20	25–60	50–300	50–250
Lime (production fields, nonfruiting) most recently matured leaf	2.40–3.00	0.15–0.50	1.60–2.50	1.50–5.00	0.25–1.00	0.15–0.50	30–100	60–200	20–200
Lychee (fruit setting) most recently matured leaf behind spring flush	1.50–1.80	0.14–0.22	0.70–1.10	0.60–1.00	0.30–0.50	1.10–0.16	25–60	50–100	100–250

	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	B (ppm)	Fe (ppm)	Mn (ppm)
Macadamia (mature orchards) mature leaves from new growth	1.45–2.00	0.08–0.11	0.45–0.65	0.65–1.00	0.08–0.10	0.24	40–100	50	50–1500
Mango (after flowering) most recent fully matured leaf	1.00–1.50	0.13–0.18	0.30–1.20	2.00–3.50	0.20–0.40	0.06–0.22	30–100	70–100	60–200
Orange, navel (nonfruiting) most recently matured leaf	2.40–2.70	0.12–0.16	0.70–1.10	1.50–2.60	0.25–0.70	0.20–0.40	30–100	60–120	25–200
Papaya petiole under most recently set fruit	1.20–1.35	0.17–0.21	2.70–3.40	1.00–3.00	0.40–1.20		20–50	25–100	20–150
Persimmon (production trees) recently matured leaf from new growth	1.75–2.50	0.10–0.25	2.25–4.50	1.25–3.30	0.18–0.50	0.20–0.45	45–100	50–150	200–1000
Pineapple (inflorescence start) first fully expanded leaf, basal white section	1.50–2.50	0.10–0.30	3.00–6.50	0.40–1.20	0.30–0.60	0.10–0.30	30–75	75–200	50–400
Tangerine (production trees, nonfruiting) most recent fully matured leaf	3.00–3.40	0.15–0.25	0.90–1.10		0.17–0.44		31–100		
Watermelon (1 st flower to small fruit) 5 th leaf from tip, omit unfurled leaf	4.00–5.50	0.30–0.80	4.00–5.00	1.70–3.00	0.50–0.80		25–60	50–300	50–250
Ornamentals									
Aglaonema (production nursery) most recently matured leaf	2.50–3.80	0.20–0.75	1.50–6.50	0.50–2.00	0.30–1.00	0.18–0.40	20–75	50–300	50–300
Brassaia most recently matured leaf	2.00–4.50	0.15–0.50	2.00–4.75	0.75–3.65	0.25–0.75	0.20–0.80	20–60	50–300	40–300
Brassaia, dwarf most recently matured leaf	2.50–3.70	0.25–0.55	2.50–5.35	1.20–2.00	0.40–1.00	0.15–0.35	25–75	40–250	50–300
Croton most recent matured leaf	1.50–3.00	0.25–0.50	1.30–3.00	1.00–2.50	0.30–1.00	0.20–0.40	25–75	50–200	50–200
Dieffenbachia most recent matured leaf	2.50–3.95	0.25–0.85	2.75–6.50	1.00–2.40	0.30–1.30	0.20–0.55	15–45	50–300	50–300
Dracaena, Marginata most recent matured leaf	2.50–3.50	0.15–0.25	2.40–3.50	1.00–2.00	0.30–0.50	0.25–0.50	20–50	50–200	50–200

Recommended plant tissue nutrient levels: sufficiency values and ranges (continued)

	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	B (ppm)	Fe (ppm)	Mn (ppm)
Dracaena, Deremensis 'Janet Craig' most recently matured leaf	2.50-4.50	0.20-0.50	2.50-4.00	1.00-2.00	0.30-0.60	0.20-0.60	15-50	50-300	50-300
Dracaena, Fragrans 'Massangeana' most recently matured leaf	2.00-3.50	0.15-0.40	1.50-4.00	1.00-2.50	0.20-1.00	0.20-0.70	20-50	50-300	50-300
Ficus, benjamina (container production) most recently matured leaf	1.80-3.50	0.10-0.40	1.00-2.95	0.85-3.25	0.20-1.00	0.15-0.40	20-75	30-200	25-200
Ficus, elastica (container production) most recently matured leaf	1.30-2.50	0.10-0.50	0.60-2.10	0.30-1.20	0.20-0.50	0.15-0.50	20-50	30-200	20-200
Fern, Boston (greenhouse grown) most recently matured frond	2.10-3.00	0.25-0.70	1.60-3.80	0.40-2.50	0.25-1.00	0.20-0.50	20-70	28-300	27-200
Fern, leatherleaf (field production) most recently matured frond	2.00-3.00	0.25-0.50	2.00-4.00	0.50-1.00	0.20-0.80	0.20-0.50	20-50	20-200	30-300
Nepthytis most recently matured leaf	2.50-3.50	0.20-0.50	3.00-4.50	0.40-1.50	0.30-0.60	0.20-0.50	25-50	50-300	50-300
Palm, areca (container production) middle leaflets of most recently matured leaf	1.50-3.50	0.11-0.80	0.70-4.00	0.80-2.50	0.20-0.80	0.21-0.75	15-60	18-250	47-250
Palm, seifritzii (container production) middle leaflets of most recently matured leaf	2.50-3.50	0.15-0.30	1.60-2.80	1.00-2.50	0.25-0.80	0.21-0.40	25-60	50-300	50-250
Palm, rhapsis middle leaflets of most recently matured leaf	1.80-2.80	0.15-0.80	1.50-2.50	0.41-1.00	0.20-0.30	0.15-0.75	16-75	80-300	50-250
Palm, Manila mid-section of most recently matured leaf	1.95	0.24	0.81	0.55	0.34	0.34	15	26	48
Philodendron, hastatum most recently matured leaves	2.50-4.00	0.25-0.60	2.50-4.50	0.90-2.50	0.30-0.55	0.25-0.60	25-70	50-200	50-200
Poinsettia just pre-flowering, most recently matured leaf	4.00-6.00	0.30-0.70	1.50-3.50	0.70-2.00	0.40-1.00		30-100	100-500	100-200
Pothos, golden most recently matured leaf	2.50-3.50	0.20-0.50	3.00-5.50	1.00-2.00	0.30-1.00	0.20-0.40	20-60	50-300	50-300

	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	B (ppm)	Fe (ppm)	Mn (ppm)
Pothos, Marble Queen most recently matured leaf	2.70–4.00	0.20–0.50	3.00–7.00	1.00–2.00	0.30–1.00	0.20–0.40	20–60	50–300	50–300
Spathiphyllum (>4 mo) most recently matured leaf	3.30–5.00	0.20–1.00	2.30–6.00	0.80–2.00	0.20–1.00	0.20–0.50	20–70	50–300	40–300
Anthurium* leaves subtending ³ / ₄ -mature flower	1.87	0.15–0.19	2.00	1.50	0.34–1.00	0.16–0.75	25–135	50–400	50–1500
Azalea (mature plant with visible bud) most recently matured leaf	1.96–3.00	0.30–0.50	0.78–2.50	0.70–2.00	0.17–0.60	0.20–0.50	25–50	50–250	40–200
Bird of paradise most recently matured leaf	1.00–2.50	0.20–0.40	1.50–3.00	0.35–3.00	0.18–0.75	0.15–0.40	10–75	35–200	45–200
Bougainvillea (mature plant) most recently matured leaf	2.50–4.50	0.25–0.75	3.00–5.50	1.00–2.00	0.25–0.75	0.20–0.50	20–75	50–300	50–200
Carnation (field production) 5 th and 6 th leaf pair of nonflowering shoot	2.80–5.20	0.19–0.80	1.17–6.00	1.00–2.00	0.19–0.70	0.25–0.80	22–100	50–200	33–302
Chrysanthemum (nonflowering plant) 4 th leaf from tip, omit unfurled leaf	3.92–5.04	0.31–0.62	2.54–6.06	1.00–3.01	0.29–0.97		25–80	279	22–247
Gardenia (mature, flowering trees) most recently matured leaf	1.50–3.00	0.16–0.40	1.60–3.00	0.50–1.30	0.25–1.00	0.20–0.40	25–70	60–250	50–250
Ginger, Alpinia (red, pink) most recently matured leaf	2.19–2.70	0.30–0.37	2.46–3.34	0.75–1.35	0.35–0.47	0.29–0.48	10–17	31–50	214–529
Ginger, Hedychium (white) most recently matured leaf	1.87	0.2	3.13	1.06	0.41	0.23	14	138	944
Heliconia, parrot mid-section strips from recently matured leaf	1.67–1.79	0.27–0.38	1.72–2.13	0.75–0.81	0.33–0.38	0.36–0.39	10–15	30–40	26–93
Heliconia, pink lobster-claw mid-section strips from recently matured leaf	2.34	0.27	1.77	1.34	0.74	0.3	19	38	142
Hibiscus (matured) most recently matured leaf	2.50–4.50	0.25–1.00	1.50–3.00	1.00–3.00	0.25–0.80	0.20–0.50	25–100	50–200	40–200

*Anthurium data for N, P, K, and Ca from T. Higaki et al., 1994, CTAHR Res. Ext. Series 152; data for Mg, S, B, Fe, and Mn from H.A. Mills and J.B. Jones, Jr., 1996, Plant analysis handbook II.

Recommended plant tissue nutrient levels: sufficiency values and ranges (continued)

	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	B (ppm)	Fe (ppm)	Mn (ppm)
Hydrangea (mature, no flower) most recently matured leaf	2.24–5.60	0.25–0.70	2.20–7.80	0.60–2.00	0.22–0.61	0.20–0.70	20–50	50–300	38–300
Lily, Easter (up to bud expansion) most recently matured leaf	3.30–4.80	0.25–0.70	3.30–5.00	0.60–1.50	0.20–0.70	0.25–0.70	25–75	60–200	35–200
Pikake, <i>Jasminum sambac</i> 2–3" of terminal cutting	1.90	0.28	1.89	1.38	0.33	0.32	18	51	75
Protea (2–3 yrs) most recently matured leaf	1.20–1.30	0.04–0.06	0.34–0.73	0.52–1.00	0.10–0.12	0.18–0.24	14–24	38–51	145–165
Rose (production greenhouses) upper 3 leaflets from mature leaves	2.38–5.00	0.25–0.62	1.50–3.52	1.00–2.00	0.22–0.50	0.25–0.70	30–61	56–200	30–200
Orchids									
Cattleya (mature, nonflowering) most recently matured leaf	1.00–2.50	0.10–0.75	2.00–4.24	0.50–2.00	0.30–0.70	0.15–0.75	25–75	50–200	40–200
Cymbidium (young, nonflowering) most recently matured leaf	1.33–2.50	0.13–0.75	2.00–3.50	0.50–2.00	0.19–0.70	0.15–0.75	22–75	28–200	30–200
Cymbidium (mature, flowering size) most recently matured leaf	1.50–2.50	0.10–0.30	2.00–3.00	0.40–1.00	0.30–0.60		25–50	50–133	40–80
Dendrobium (Univ. Hawaii cutflower cultivars) 3 rd most recently matured leaf	1.45–1.90	0.15–0.22	1.75–2.40	0.65–1.00	0.40–0.80	0.15–0.50		50–100	30–100
Laeliocattleya (mature plant) recently matured leaf from new growth	1.68–1.85	0.06–0.08	1.94–2.77	1.05–1.63	0.99–1.43			90–300	200–700
Oncidium (mature, nonflowering) most recently matured leaf	1.54–2.04	0.26–0.58	2.23–3.95	0.71–1.09	0.28–0.48	0.15–0.39	11–21	16–61	243–772
Phalaenopsis (mature plant) most recently matured leaf	2.00–3.50	0.17–0.30	3.90–7.06	1.50–2.79	0.40–1.07		25–50	80–170	100–250
Phaphiopedilum (mature plant) most recently matured leaf	2.25–3.50	0.20–0.70	2.00–3.50	0.75–2.00	0.20–0.75	0.20–0.75	25–75	50–200	50–200



Plant Tissue Information Form

Name _____ Phone _____
first, middle initial, last

Mailing address _____ Fax _____

City _____ State _____ Zip code _____ E-mail _____

CES Extension Agent _____

Crop, variety _____	Plant condition	V. poor	Poor	Fair	Good	V. good
Plant age _____	General appearance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Plant part _____	Present yield	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Previous yield	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Sample site _____	Plant pests	Heavy	Moderate	Light	None
Date sampled _____	Disease	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Insect infestation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Specify types: _____				

Description of samples

(The sample identification label should be written on the sample container. This form may be used for up to nine samples. When information is given, be sure to clearly note by number [1-9] the sample(s) referred to. If this cannot be clearly done, use separate forms.)

Label	Description	Label	Description	Label	Description
1 _____	_____	4 _____	_____	7 _____	_____
2 _____	_____	5 _____	_____	8 _____	_____
3 _____	_____	6 _____	_____	9 _____	_____

Comments

(If more space is needed,
use the back of this form)

Soil management history type or formulation quantity applied how often applied date of last application

lime _____
manure _____
fertilizer _____
other _____

The samples are: accompanied by soil sample/s [provide soil sample ID label: _____]
 from a soil previously analyzed [provide ADSC job number from previous analysis report: _____]
 follow-up samples, related to tissue sample(s) previously analyzed
[provide ADSC job number from previous analysis report: _____]

Reason for plant tissue analysis

- Suspect nutrient disorder
- Periodic monitoring
- Survey
- Experiment
- Other (specify) _____

Crop is irrigated? Yes No

Soil data (past analysis; provide if ADSC job number is not known)

Analysis date _____
Soil series or planting medium: _____
Analysis values (lb/acre or ppm):
P _____ K _____ Ca _____ Mg _____
pH _____ Salinity (mmhos/cm) _____

ADSC use only:	Job Control no. _____	Date received _____ <small>month / day / year</small>
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Color code: white—Client, yellow—Agent, pink—ADSC