

electrolytes from root free space and causes a degree of physical injury, but media not removed would affect electrolyte leakage measurements.

When container media temperatures exceed 50°C for 20 min, substantial direct heat injury to roots of plants studied can be expected. Heat injury of roots from all 3 plants was minimal below 44 to 45° for 20 min. If maximum temperatures and corresponding exposure times can be maintained below these critical points, direct heat injury can be minimized or avoided. Long exposures to temperatures slightly less than the critical range may result in indirect heat injury (3, 8, 9). Responses of these plants to media temperatures below those inducing direct injury have not yet been characterized.

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Influence of N-P-K Factorial Fertilization on Growth Characteristics and Foliar Content of 4 Foliage Plants¹

R. T. Poole and C. A. Conover

IFAS, University of Florida, Agricultural Research Center, Rt. 3 Box 580, Apopka, FL 32703

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Abstract. Data indicated the N-P₂O₅-K₂O ratio of 1-1-1 is unnecessarily high in P₂O₅ and K₂O for *Dieffenbachia maculata* (Lodd.) G. Don 'Exotica', *Dracaena sanderana* Hort. Sander ex M. T. Mast, *Maranta leuconeura* var. *kerchoviana* E. Morr., and *Peperomia obtusifolia* (L.) A. Dietr. Plant growth and tissue nutrient levels were more sensitive to changes in N fertilization level than P and K. Tissue N was a more sensitive indicator of optimum growth and fertility practices than P or K.

Most foliage plants grow well with a 1-1-1 N-P₂O₅-K₂O ratio, such as an 8-8-8 or 20-20-20 fertilizer analysis, but they also grow satisfactorily with a 3-1-2 ratio, such as a 9-3-6 or 18-6-12 analysis (1).

Research on the N-P-K requirements of individual foliage plant species is still limited. Poole and Conover (5) found that 100-150 mg N, 25 mg P, and 100-120 mg K/10 cm pot at 4 week intervals in 50 ml of solution produced good quality *Aechmea fasciata* Baker. *Aglaonema commutatum* Schott cvs. Fransher and *Pseudobracteatum* (6) receiving 240 mg N, 80 mg P, and 240-360 mg K/15 cm pot monthly produced good quality plants. In a later study (7), Poole and Conover observed that weekly applications of 12.5-37.5 mg N, 5-50 mg P, and 25-50 mg K/10

cm pot produced high quality *Adiantum rad-dianum* K. Presl.

The 2 experiments reported here were conducted to determine the N-P-K requirements of *Dieffenbachia maculata* 'Exotica', *Dracaena sanderana*, *Maranta leuconeura* var. *kerchoviana*, and *Peperomia obtusifolia*.

Experiment 1.

Well-rooted dieffenbachia cuttings (15-20 cm) were potted May 14, 1979, into 13 cm diameter azalea pots containing 2 Florida sedge peat:1 pine bark:1 cypress shavings (v:v:v) amended with 4 kg/m³ dolomite and 1 kg/m³ Perk, a micronutrient blend, and placed in a glasshouse receiving 200 $\mu\text{Em}^{-2}\text{s}^{-1}$ maximum natural illumination. Plants were watered twice weekly and temperatures ranged from 20°C minimum to 35°C maximum. Treatments consisted of a 3 \times 2 \times 2 factorial combination in randomized block design of N, P, and K at 10, 30, or 50 mg N, 5 or 10 mg P, and 10 or 30 mg K/pot at weekly intervals in 100 ml of solution. N was obtained from NH₄NO₃, P from H₃PO₄, and K from KCl. Treatments were replicated 5 times

with 1 cutting/pot as an experimental unit.

Data collected at experiment termination, September 4, 1979, included height from pot rim to tip of leaves, foliar color (1 = light green to 5 = dark green color), and shoot fresh weight. The first mature leaves from the apex of the plant were collected and analyzed for elemental tissue content (4).

Data indicate good quality dieffenbachia can be grown with 50-5-30 mg N-P-K/13 cm pot weekly, a ratio of 10-1-6 (Table 1). Converting this ratio into a commercial formulation of N-P₂O₅-K₂O yields a ratio of 10-2.3-7 (about 4-1-3). Thus the popular and frequently used 1-1-1 ratio fertilizers appear unnecessary, waste energy, and can lead to ground water pollution because of excess fertilizer applied to pots.

Fifty mg N/13 cm pot per week produced slightly better plants than 30 mg N/pot, the suggested level (1) of N, but suggested levels of P and K were slightly higher or equal to levels used in this experiment. Since the levels of P used in this experiment did not affect plant growth, lower than suggested levels of P (1) might be acceptable (Table 1).

Best quality plants had tissue N content of 3.4% which is within the range suggested (3, 4) but 2.7% tissue N found in lower quality plants is also in the suggested range. Calcium level of the best plant was also within the suggested range, but P and Mg tissue content were slightly higher and K slightly lower than suggested levels (Table 1).

Experiment 2.

Well-rooted cuttings of dracaena (15-20 cm), maranta (6-8 cm), and peperomia (10-12 cm) were potted April 25, 1980, into 10 cm diameter square pots containing the same medium as in Experiment 1 and grown under the same conditions. Treatments consisted of a 2 \times 3 \times 3 factorial combination in randomized block design of N, P, and K. Rates for dracaena were 48 or 96 mg N; 16, 32, or 48 mg P; and 40, 60, or 80 mg K/pot; for maranta 48 or 72 mg N, 16, 24, or 32 mg P, and 24, 40, or 56 mg K/pot; and for

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Table 1. Influence of N, P, and K on height, fresh weight, foliar color, and elemental composition of *Dieffenbachia maculata* 'Exotica' (Expt. 1).

Element	Rate (mg/13 cm pot/wk)	Plant ht (cm)	Fresh wt (g)	Foliar color ¹	Elemental composition (% dry wt)				
					N	P	K	Ca	Mg
N	10	44	103	1.4	2.0	1.0	2.5	1.9	1.8
	30	53	148	4.0	2.7	0.6	2.2	1.8	1.6
	50	56	168	4.6	3.4	0.5	2.0	1.6	1.5
P	5	51	140	3.4	2.7	0.5	2.4	2.2	1.8
	10	52	140	3.3	2.7	1.0	2.1	1.4	1.5
K	10	51	135	3.5	2.7	0.8	1.9	1.9	1.8
	30	52	145	3.2	2.6	0.7	2.6	1.7	1.5
Significant effects:									
N linear		.01	.01	.01	.01	.01	.01	.01	.01
N quadratic		.01	.01	.01	NS	.01	NS	NS	NS
P linear		NS	NS	NS	NS	.01	.05	.01	.01
K linear		NS	.01	NS	NS	NS	.01	.01	.01

¹1 = light green, 3 = medium green, and 5 = dark green color.

peperomia 24 or 48 mg N, 8, 16, or 24 mg P, and 8, 24, or 40 mg K/pot at weekly intervals in 25 ml of solution.

Data collected at experiment termination, July 18, 1980, included height and foliar color of dracaena; height, width, and foliar color of maranta; and height and grade of peperomia. Several recently mature leaves were collected from the apex of the plant and analyzed for elemental tissue content (4).

Dracaena. Plants grew equally at all levels of N, P, and K. Using the lowest rate of each element, 48-16-40 mg/pot of N-P-K, a ratio of 6-2-5 or a commercial ratio of 6.0-4.5-6.0 (approximately 3-2-3) is obtained. Again, the wastefulness of a 1-1-1 ratio is indicated. Unfortunately, no element was limiting in this experiment so the best ratio cannot be determined.

Results indicate that suggested levels (1) are probably higher than necessary for production of high quality *Dracaena sanderana*. Tissue levels for N, 3.4%, P, 0.2%, and Mg, 0.5% are within the suggested ranges, but K, 1.8% and Ca, 0.6% levels were lower than suggested (4).

Maranta. Best foliar color was obtained with 72 mg N, 16 mg P, and 40 mg K/13 cm

pot/week, which is a ratio of 9-2-5 N-P-K or 9.0-4.5-6.0 when converting to the oxides, or about 2-1-1 (Table 2). Tissue levels of N, P, and Mg of good quality plants were within ranges previously suggested (4), while K and Ca were slightly lower. Tissue N level of 2.0% is in the suggested range, but plants with 2.0% tissue N did not have as good color as plants with 2.4% N content.

Peperomia. Plant grade and height were unaffected by varying levels of N, P, and K, indicating that limiting levels were not tested. Good quality plants were grown with a ratio of 3-1-1 N-P-K or 3.0-2.3-1.2 N-P₂O₅-K₂O (about 5-4-2). These results indicated that suggested levels (1) are higher than necessary when growing plants under our environmental conditions. Good quality peperomia grown in this experiment had tissue content of N, 3.3%; P, 0.2%; and K, 1.8%; similar to that of good quality peperomia grown in Hawaii, but plants in this test had less Ca, 0.6%, and Mg, 0.5%, in the plant tissue (2).

There were no significant interactions. The 4 test plants grew equally well or better when P and K levels were below the ratio of 1-1-1 (N-P₂O₅-K₂O) commonly used in the foliage industry. Because limiting quantities were

not reached for all the elements, optimum ratios cannot be determined. Ratios of 4-1-3, 3-2-3, 2-1-1, and 5-4-2 were shown to be optimum within the realm of levels tested and there is high probability that lower values of P and K will be proven acceptable in future experiments. A ratio of 4-1-2 or 3-1-2 (N-P₂O₅-K₂O) or about 8-1-3 (N-P-K) appears to be satisfactory for production of good quality plants of these species.

The N, P, and K fertilization levels suggested as guides (1) for optimum growth of foliage plants did not prove to be correct for all plants tested. However, most differences in growth measurements due to fertilizer variations were slight. Nitrogen was obviously the most critical element and was manifested in the tissue content levels. Levels of 3.4% N in tissue of dieffenbachia produced significantly better plants than 2.7% which was much better than 2.0% N. Maranta with 2.4% tissue N were better than plants with 2.0%. However, dracaena with 3.1% tissue N were as attractive as plants with 3.7% N and peperomia with 1.8% N were as good as plants with 2.6% N. A 3-fold increase in P applied did not improve quality of any plant and decreased color of maranta (Table 3). Dieffenbachia was the only plant that showed increased tissue P with increased P application. Increasing application level of K increased tissue levels, but only slightly increased fresh weight of dieffenbachia and foliar color of maranta.

These results show that the commonly used N-P₂O₅-K₂O ratio of 1-1-1 is unnecessarily high in P₂O₅ and K₂O for foliage plants tested. Suggested fertilizer levels should be used as guides only and optimum levels should be determined for individual cultural regimes. Plant growth and tissue nutrient levels were more sensitive to changes in N fertilization levels than P and K; thus, tissue N appeared to be the most sensitive indicator of optimum growth and fertility practices.

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Table 2. Influence of N, P, and K on height, width, foliar color, and elemental composition of *Maranta leuconeura* var. *kerchoviana* (Expt. 2).

Element	Rate (mg/13 cm pot/wk)	Plant ht (cm)	Plant width (cm)	Foliar color ¹	Elemental composition (% dry wt)				
					N	P	K	Ca	Mg
N	48	11	27	2.3	2.0	0.3	2.2	0.2	0.9
	72	12	28	4.6	2.4	0.2	1.9	0.2	0.9
P	16	11	29	3.8	2.3	0.2	1.9	0.2	0.9
	24	11	27	3.2	2.2	0.2	2.0	0.2	1.0
	32	11	28	3.3	2.2	0.2	2.2	0.2	0.8
K	24	10	23	3.2	2.2	0.3	1.8	0.2	1.0
	40	11	28	3.7	2.3	0.2	2.0	0.2	1.0
	56	13	32	3.3	2.1	0.1	2.3	0.2	0.8
Significant effects:									
N linear		NS	NS	.01	.01	.01	.05	NS	NS
P linear		NS	NS	.01	NS	NS	.05	NS	NS
P quadratic		NS	NS	.01	NS	NS	NS	NS	NS
K linear		NS	NS	NS	NS	.01	.01	NS	.01
K quadratic		NS	NS	.01	NS	NS	NS	NS	NS

¹1 = light green, 3 = medium green, and 5 = dark green color.