

# Nitrogen, Potassium and Magnesium Nutrition of Three Orchid Genera<sup>1</sup>

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**This is the detailed study on nutrition by Dr Poole and Professor Seeley from which Mr Bill Johnson evolved a simple and successful way of applying its findings.**

**A further study titled *Mineral nutrition of orchids* can be found in *Orchid Biology - Reviews and Perspectives II*, edited by Professor J. Arditti. It has been written by Dr Hugh A. Poole, now of A and L Southern Agricultural Laboratories, Florida, and Professor Thomas J. Sheehan of the University of Florida. This study is highly recommended. The book is in some orchid society libraries.**

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**Abstract:** In nutrient culture, growth of hybrid plants of *Cymbidium* and *Phalaenopsis* was optimal with 100 ppm N, 50-100 ppm K and 25 ppm Mg and optimal for *Cattleya* with 50 ppm each of N, K and Mg. *Cymbidium* plants developed N deficiency symptoms when supplied with 50 ppm N. K levels tested had little effect on growth responses. Mg at 100 ppm decreased growth of all three genera in comparison to 50 ppm.

Recommended orchid fertilization programs have been quite varied and often confusing. Evers and Laurie (9), in nutritional studies on mature plants in gravel culture, concluded that orchids could be successfully grown in inert media as Haydite and silica gravel with periodic applications of chemical nutrient solutions. Scully (20) stated that orchid plants required little fertilizer because of their slow growth, but, Adams (1) recommended five different fertilizers monthly for best growth and flowering. Davidson (7) and Beaumont and Bowers (2) found that growth was more affected by fertilizers than by the potting medium. Fennell (10) observed best orchid growth in fir bark when plants were given liquid fertilization weekly. Poole and Sheehan (16) found that antagonisms among nutrients increased when *Cattleya* plants were fertilized more frequently.

Cibes et al. (4) in a gravel culture experiment observed that an increase in either N or K levels resulted in an increase in *Vanilla* vine growth, with the high-N, high-K level producing the best growth. Plants receiving low N were chlorotic and plants receiving high N had dark green colour. There was no apparent effect of K on foliage colour. Davidson (7) observed that deficiencies of N and P limited growth of *Cattleya* more drastically than did K, Ca or Mg in gravel culture and they were more likely to respond to applications of N and/or P. He reasoned that plants lacking an external supply of K are capable of translocating this nutrient from old tissues and re-utilising it to meet most of the growth requirements for K by new tissues. Likewise, Ca and Mg present in old tissues are re-utilised, but to a lesser extent than K. Small amounts of K, Ca and Mg often present in rooting media or water supplies appeared to satisfy the requirement of these elements for *Cattleya*.

Sheehan (21) reported that increased N fertilization levels resulted in an increased number of flowers on *Cattleya* 'Trimos' grown in hardwood bark media. In similar studies

with *Phalaenopsis* hybrid seedlings, there was a significant interaction between types of barks and N levels. However, best growth generally occurred at the higher N levels. Davidson (6) suggested fertilizing every second watering with a 3-1-1 (N-P<sub>2</sub>O<sub>5</sub>-K<sub>2</sub>O) ratio for fir bark since this medium was deficient in N due to a high C:N ratio. Lunt and Kofranek (12) stated that high rates of liquid N fertilizer applied weekly promoted vegetative growth at the expense of flowering in *Cymbidium* grown in two grades of fir bark.

Curtis and Spoerl (5) evaluated NO<sub>3</sub> vs. NH<sub>4</sub> sources of N at constant pH levels and reported that both ions were usable by orchid embryos. NH<sub>4</sub> was superior to NO<sub>3</sub> for *Cymbidium*, slightly better for *Cattleya* and inferior for *Vanda*. Lunt and Kofranek (12) found more N in mature leaves, but no growth differences, of *Cymbidium* plants fertilized with (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> compared to those receiving Ca (NO<sub>3</sub>)<sub>2</sub>. Poole (14) found that *Cattleya* plants receiving NH<sub>4</sub> fertilization weekly had greater dry wt of roots and greater fresh wt and leaf area of new vegetative growth than those receiving NO<sub>3</sub>. Plants similarly fertilized at two and three-week intervals showed no differences in growth between the two N sources. However, plants receiving NH<sub>4</sub> at three-week intervals showed greater chlorosis of the leaves after 10 months of growth than did plants receiving NO<sub>3</sub>. This chlorosis was probably due to an NH<sub>4</sub>-induced K deficiency, resulting from greater antagonisms between the NH<sub>4</sub> and K ions at less frequent fertilization.

Sheehan (21) was unable to affect flowering of 'Trimos' *Cattleya* or growth of *Phalaenopsis* seedlings in three hardwood barks by varying levels of P or K. Poole and Sheehan (16) increased growth of mericloned *Cattleya* plants by increasing levels of K fertilization at low P levels. They also induced Ca deficiency and leaf-tip die-back symptoms of new leaves by increasing P fertilization and noted Ca deficiency among several orchid genera in the absence of Ca in the regular fertilizer program (16, 17).

Recently, Poole and Sheehan reported complete tissue analyses of various plant parts of *Cattleya* (18) and *Phalaenopsis* (19). These studies provide a reference point for further nutritional work with these orchid genera. In *Cattleya*, N and K decreased and P, Ca and, to some extent, Mg increased with leaf age in *Phalaenopsis*, N and K content of leaves

decreased dramatically with age while Ca and Mg increased slightly with age. Tissue analysis of new *Cattleya* leads showed that N, K and Mg were present in higher quantities than the six other elements tested. For short term experiments, these three elements appeared to show the greatest promise for initial studies of elemental interactions and nutritional requirements of orchids.

The object of the present study was to study the effects of N, K and Mg on growth and chemical composition of orchids.

**Methods and Materials:** Three 3 x 3 x 3 fractional experiments in randomised block design with four replications were initiated to study effects of three levels each of N, K and Mg on growth and chemical composition of representative hybrid plants of three orchid genera: *Cattleya*, *Cymbidium* and *Phalaenopsis*. Plants were grown in 7.5-litre ceramic crocks under nutrient culture conditions in a glass greenhouse, with 50 per cent shade from March 15 to October 15. Minimum greenhouse temperatures were maintained at 18°C (night) and 24°C (day). Plants were given supplemental lighting of 6.4-10.8 klx at plant height from 7.00 am to 7.00 pm, using General Electric Power Groove VHO-WW fluorescent tubes to provide a minimal amount of light for active growth during the winter and dark weather. Each crock contained about 2000, 16 mm-diameter quartz glass spheres (Vitro Agate Co, Parkersburg, WVa). Eighteen-litre glass carboys containing nutrient solutions were connected to crocks and a compressed air source by neoprene tubing. Compressed air regulated by a manual valve was utilized to pump solutions to plants at 8:00 am, 11:30 am and 3:00 pm daily and about 15 minutes were required for complete drainage. Solutions made with distilled water were changed monthly in the *Phalaenopsis* study and bi-weekly in the *Cattleya* and *Cymbidium* studies.

Nutrient solutions were prepared with reagent grade chemicals, except technical monosodium ferric diethylenetriamine pentaacetate (Sequestrene 330 Fe), the Fe source. N was supplied at 50, 100 and 200 ppm; K at 100, 200 and 300 ppm for *Phalaenopsis* and 50, 100 and 200 ppm for *Cattleya* and *Cymbidium*; and Mg at 25, 50 and 100 ppm. The ratio of NH<sub>4</sub> to NO<sub>3</sub> was maintained at 1:3. Other essential nutrients were provided in the following ppm concn: P, 20; Ca, 200; Cl, 10; Fe, 3; Mn, 1; B, 0.25; Zn, 0.20; Cu, 0.025; Mo, 0.001.

Seedlings of a *Phalaenopsis* hybrid P. 'Linda Mia' x P. 'Bruce Shaffer' (donated by Rod McLellan Co, South San Francisco, CA), averaging 3.0 g fresh wt were planted on March 25, 1972, with one plant per crock. The experiment was initiated the following day and terminated January 1, 1973. The *Cattleya* and *Cymbidium* studies were initiated February 1, 1973, with one plant each per crock using mericloned plants of unknown hybrids (obtained from the Department of Ornamental Horticulture, University of Florida, Gainesville and Dos Pueblos Orchid Co, Goleta, California, respectively). The *Cymbidium* experiment was terminated October 30, 1973, and the following responses were measured: dry wt of leaves and roots, plant ht, number of leaves and cumulative length of necrotic leaf tips for each plant. For the *Cattleya* study, three-pseudobulb divisions were used and treatments were terminated January 23, 1974. Original leaves, pseudobulbs and rhizomes were discarded.

All plant tissues measured were analysed by standard laboratory procedures for N, P, K, Ca, Fe, Mn, Zn, Cu, B, Na and Al but only the macroelements for leaves are reported in this paper (15).

## Results and Discussion

**Growth.** N concn was the most important factor determining growth of all three orchid genera (Table 1) for *Phalaenopsis* and *Cymbidium*, 100 ppm N appears to be adequate or near optimal for best plant growth. *Cymbidium* grown with 50 ppm N had a greater incidence of leaf-tip dieback of the older leaves, probably due to deficiency of N. Plants with 200 ppm N were shorter, had fewer leaves and lower root dry wt than those receiving 100 ppm N. N levels between 50 and 150 ppm should deserve more attention for these plants. Sheehan (21) reported that best growth of *Phalaenopsis* seedlings occurred at the higher N levels when grown in different bark media. Lunt and Kofranek (12) also found that high rates of liquid N fertilizer applied weekly promoted vegetative growth of *Cymbidium* plants grown in fir bark media.

The *Cattleya* response to N levels was drastically different. Plants grown at 50 ppm N had greater dry wt of leaves and roots and larger leaves than plants grown at 100 or 200 ppm N and greater dry wt of pseudobulbs and flowers and number of growths than plants receiving 200 ppm N. Under the conditions of this experiment, 50 ppm N is near optimal for

best growth of this hybrid. However, Sheehan (21) found that increased N fertilization levels resulted in an increased number of flowers on 'Trimos' *Cattleya* grown in bark media. These two studies would appear to be in conflict unless the 50 ppm N treatment in marbles supplied to the plant an amount of N comparable to that supplied by Sheehan's high N treatment after a large percentage of applied N was used for microbial decomposition of the medium, suggests Davidson (6).

The K levels tested had virtually no effect on orchid growth. The only significant effect of K levels on the three plants tested was the *Cymbidium* with 200 ppm K having fewer leaves than plants receiving 50 or 100 ppm K. Sheehan (21) was unable to affect either flowering of *C. 'Trimos'* or growth of *Phalaenopsis* seedlings by varying K levels. However, Poole and Sheehan (16) were able to increase growth of *Cattleya* grown in tree-fern medium by increasing K levels at low P concn. Even at the low K level, K concn of all orchid tissues analysed appeared adequate and well above levels determined by Poole and Sheehan for adequate growth of *Cattleya* (18) and *Phalaenopsis* (19). An increase in plant growth would not be expected unless K had been deficient. Under these conditions, the 50 ppm K level appears to be adequate for good vegetative growth of orchids, although substantially higher amounts may not adversely affect plant performance.

Dry wt of *Phalaenopsis* roots and number of leaves of *Cymbidium* plants were adversely affected by 100 ppm Mg as compared to 25 and 50 ppm levels. In working with chrysanthemum cuttings rooted in peat having different levels of exchangeable Mg and Ca, Paul and Thornhill (13) observed that rooting decreased when exchangeable Mg was greater than 80 per cent. They also found that mist containing increased portions of Mg caused rooting failure in both sand and peat when the percentage of total cations was 70 per cent Mg. High Mg in the presence of high Ca, therefore, may have a direct effect on root growth of *Phalaenopsis* and an indirect effect on leaf metabolism in the *Cymbidium* plants. In *Cattleya* plants high Mg decreased leaf size and number of growths as compared to 50 ppm Mg. Thus, 25 ppm Mg appears to be near optimal for growth of *Phalaenopsis* and *Cymbidium* and levels of 100 ppm or more may be harmful.

Root dry wt of *Cattleya* receiving 50 ppm Mg was greater than those receiving 25 ppm Mg, and leaf dry wt was greater than with either 25 or 100 ppm. Mg at 100 ppm was antagonistic also to number of growths and leaf length. There are few reports on the effects of Mg levels on orchid growth. Chin (3) reported that omission of Mg severely reduced dry wt of *Dendrobium phalaenopsis* hybrid seedlings and Davidson (7) reported that a deficiency of Mg did not limit growth of *Cattleya* as much as deficiencies of N or P. The optimum Mg level for *Cattleya* appears to be 50 ppm rather than the 25 ppm as found for the other genera tested. This may be due to the greater biomass of the *Cattleya* plants, thus requiring more Mg for good growth. *Cattleya* plants of comparable size to the *Cymbidium* and *Phalaenopsis* plants may grow adequately at 25 ppm Mg. Regardless of size, however, 100 ppm Mg appeared to be detrimental to good root and/or vegetative growth of all three genera.

**Foliar analyses.** Increasing substrate levels of N, K and Mg significantly increased plant tissue concn of these nutrients. With only a few exceptions, increasing N levels resulted in decreased concn of K, Ca and Mg in foliage (Table 2). In *Cymbidium* leaves, significant increases of P and Mg occurred when N was increased in the nutrient solution.

The  $\text{NH}_4$  form of N has been shown to adversely affect cation accumulation (7, 11). The slight increase in Mg concn of *Cymbidium* leaves may be due to lesser antagonism of  $\text{NH}_4$  and Mg or a greater antagonism of  $\text{NH}_4$  and K, permitting Mg to be absorbed concurrently with increasing  $\text{NO}_3$  anions available in the substrate with increasing N levels.

Increasing K levels generally decreased concn of Ca and Mg in orchid leaves except for Mg content of *Cattleya* (Table 3). Increasing Mg levels increased Mg and restricted Ca concn of orchid leaves. The depressing effect of increasing supply and accumulation of one or more of the major cations, K, Ca and Mg, on the accumulation of one another has been demonstrated with many plants (8, 11). Ammonium appears to be more effective in depressing K than the reverse in orchids. The only major exception to this relationship is where increments of N were associated with increased Mg concn of *Cymbidium* leaves. However, this may be explained by the lessening of the  $\text{NH}_4$  antagonism to other cations in solution due to greater utilisation of

the  $\text{NH}_4$  form of N by *Cymbidium* plants, as was reported by Curtis and Spoerl (5) for germinating seeds and by Lunt and Kofranek (12) for mature *Cymbidium* plants.

#### ***Cattleya* growth as affected by N levels.**

The dramatic reduction in growth of *Cattleya* due to increasing N levels was unexpected. For most crops, increments of N result in increased growth up to a point when N concn in tissues become toxic or other factors necessary for good growth become limiting. Since N increments drastically reduced growth of *Cattleya* with only a slight increase in N concn of leaves and a decrease in total absorbed N by the plant, the possibility that a limiting factor(s) is responsible appears likely.

With *Cattleya*, increasing N levels decreased growth of roots more severely than leaves or pseudobulbs. This could result from a decrease in synthesis of necessary carbohydrates by the leaves, translocation and/or utilisation of these carbohydrates by the roots. High production of organic acids, especially oxalic, would reduce the available pool of carbohydrates necessary for growth and would affect the roots severely.

Increments of N decreased the concn and total accumulation of K, Ca and Mg in leaves with the greatest reduction in Mg. Obviously, increments of N were detrimental to the accumulation of many of the essential elements as well as their total content in the plant tissues. If the concn of these elements are adequate or in the lower range of adequacy for the best-growing plants in the low N treatments, then such decreases could induce deficiencies of any or all of these elements. Oxalates may actually increase the requirements for Ca and Mg in the plant thus placing greater demands on an already diminished supply of these nutrients.

Further evidence of a deficiency or deficiencies causing the growth reduction or a portion of it is present in the Mg data for growth responses in this study (Table 1). When Mg levels were reduced from 50 to 25 ppm for *Cattleya* plants, a 42 per cent reduction in Mg concn of leaves and a 16 per cent decrease in plant growth occurred. This reduction in Mg concn is comparable to adding high N and it could account for approximately half of the growth reduction of leaves and roots caused by the high N treatment. K levels tested in this study did not result in a similar decrease in growth as Mg. However, impairment of carbohydrate synthesis, enzyme activities and changes in cytoplasmic pH due to increases in

organic acids resulting from nutritional disorders could increase the demand for K and

thus provide a growth response for K due to inter-relationships with other nutrients.

**TABLE 1.**  
Main effects of N, K and Mg on growth responses of *Phalaenopsis*, *Cattleya* and *Cymbidium* orchids.

Genus	Response	Nutrient Level			
		25 ppm	50 ppm	100 ppm	200 ppm
N levels					
Phalaenopsis	Dry wt leaves (g)		1.34a <sup>+</sup>	1.80b	1.60ab
	Dry wt roots (g)		1.26a	1.62b	1.37ab
	Leaf area (cm <sup>2</sup> )		117a	153b	1.40ab
	Leaf span (cm <sup>2</sup> )		18.1a	22.5b	20.8b
Cymbidium	Dry wt leaves (g)		6.06ab	6.68b	5.36a
	Dry wt roots (g)		2.73ab	2.79b	2.03a
	No. of leaves		11.6b	11.6b	10.6a
	Plant ht (cm)		51.4ab	53.4b	48.3a
	Leaf-tip die-back (cm)		5.4b	2.7a	1.2a
Cattleya	Dry wt leaves(g)		9.84b	8.15a	6.98a
	Dry wt pseudobulbs (g)		7.31b	6.46ab	5.73a
	Dry wt roots (g)		10.55b	7.83a	5.87a
	Dry wt flowers (g)		1.28b	0.95ab	0.56a
	No. of growths		6.4b	5.6ab	5.3a
	Leaf length (cm)		20.2b	18.7a	17.7a
K levels					
Cymbidium	No. of leaves		11.5b	11.5b	10.8a
Mg levels					
Phalaenopsis	Dry wt of roots (g)	1.54b	1.51b	1.19a	
Cymbidium	No. of leaves	11.7b	11.3ab	10.8a	
Cattleya	Dry wt leaves (g)	7.89a	9.34b	7.74a	
	Dry wt roots (g)	7.45a	8.78b	8.02ab	
	No. of growths	5.8ab	6.4b	5.3a	
	Leaf length (cm)	18.09ab	19.6b	18.1a	

+ Mean separation in rows by Duncan's multiple range test, 5% level.

**TABLE 2.**  
Main effects of N on elemental composition of *Phalaenopsis*, *Cattleya* and *Cymbidium* leaves.

Genus	N level (ppm)	Leaf concn (%) dry wt				
		N	P	K	Ca	Mg
<i>Phalaenopsis</i>	50	1.79a <sup>+</sup>	0.29b	7.19b	3.27c	0.61b
	100	1.92a	0.24a	7.30b	2.71b	0.51a
	200	2.26b	0.24a	6.68a	2.41a	0.48a
<i>Cattleya</i>	50	1.68a	0.21a	4.58b	1.47c	0.56b
	100	1.84b	0.20a	4.31b	1.30b	0.47ab
	200	1.97c	0.19a	3.85a	1.12a	0.37a
<i>Cymbidium</i>	50	2.06a	0.25a	3.06b	0.98a	0.30a
	100	2.25b	0.26a	3.02b	0.97a	0.33ab
	200	2.67c	0.28b	2.71a	0.97a	0.36b

+ Mean separation in columns within genera by Duncan's multiple range test 1% level.



**TABLE 3.**  
Main effects of K and Mg on elemental composition of  
*Phalaenopsis*, *Cattleya* and *Cymbidium* leaves.

Genus	Nutrient (ppm)	Leaf concn (% dry wt)		
		K	Ca	Mg
	<i>K levels</i>			
<i>Phalaenopsis</i>	100	5.77a <sup>+</sup>	3.16c	0.59b
	200	7.49b	2.79b	0.54b
	300	7.92c	2.43a	0.46a
<i>Cattleya</i>	50	3.66a	1.44c	0.49a
	100	4.34b	1.29b	0.46a
	200	4.73c	1.15a	0.46a
<i>Cymbidium</i>	50	2.48a	1.05c	0.38a
	100	3.00b	0.91b	0.32a
	200	3.31c	0.88a	0.30a
	<i>Mg levels</i>			
<i>Phalaenopsis</i>	25	7.15a	3.20c	0.31a
	50	7.05a	2.86b	0.49b
	100	6.97a	2.32a	0.80c
<i>Cattleya</i>	25	4.26a	1.49b	0.29a
	50	4.32a	1.38b	0.50b
	100	4.16a	1.01a	0.61c
<i>Cymbidium</i>	25	2.88a	1.11c	0.21a
	50	2.96a	0.97b	0.31b
	100	2.95a	0.83a	0.47c

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