Table 2. Mean fresh weight, number of new leaves and number of tillers pot pot[z] of pampas grass 10 weeks after potting.

Treatment	Fresh weight tops (g)	Number of new leaves	Number of tillers per pot
Control (no fertilizer)	2.12 c[y]	12.0 c	2.9 c
Osmocote—2 kg/m^3 (oz/ft^3)	6.36 a	23.4 b	4.9 a
Osmocote—3 kg/m^3 (oz/ft^3)	4.62 b	22.4 b	4.3 ab
Osmocote—4 kg/m^3 (oz/ft^3)	5.14 b	22.6 b	4.6 ab
Liquid—100 mg/l N (ppm)	4.58 b	22.4 b	4.1 b
Liquid—200 mg/l N (ppm)	6.62 a	23.8 b	4.6 ab
Liquid—400 mg/l N (ppm)	6.88 a	28.3 a	4.8 a

[z]Initial number of plants (tillers) per pot was one.

[y]Mean separation within columns by the LSD; P = 0.05; n = 20. Analysis of leaf number and tillers per pot on square-root transformed data; nontransformed data are presented.

Literature Cited

1. Dunstan, D.I. and K.E. Turner. 1984. The acclimatization of micropropagated plants. pp. 123–129. *In*: I.K. Vasil (ed.). Cell Culture and Somatic Cell Genetics of Plants. Vol. 1. Academic Press, Inc. Orlando, FL.

2. Lewandowski, V.T. 1991. Rooting and acclimatization of micropropagated *Vitis labrusca* 'Delaware'. HortScience 26:586–589.

3. McCown, D.D. 1986. Plug systems for micropropagules. pp. 53–60. *In*: R.H. Zimmerman, R.J. Griesbach, F.A. Hammerschlag, and R.H. Lawson (eds.). Tissue Culture as a Plant Production System for Horticultural Crops. Martinus Nijhoff Publ. The Netherlands.

4. Meyer, M.H. 1975. Ornamental Grasses. Charles Scribner's Sons, New York, NY.

5. Minotta, G. 1985. Comparison of different substrates for the acclimatization of micropropagated plantlets of white poplar (*Populus alba*). Colture-Protette 14:73–76.

6. Murashige, T. and F. Skoog. 1962. A revised medium for rapid growth and bioassays with tobacco tissue cultures. Physiol. Plant. 15:473–497.

7. Preece, J.E. and E.G. Sutter. 1991. Acclimatization of micropropagated plants to the greenhouse and field. pp. 71–93. *In*: P.C. Debergh and R.H. Zimmerman (eds.). Micropropagation. Technology and Application. Kluwer Academic Publ., The Netherlands.

8. Rahman, M.A. 1988. Effects of nutrients on the growth and survival of *in vitro Artocarpus heterophyllus* Lam. plantlets after transfer to *ex vitro* conditions in the glasshouse. J. Hort. Sci. 63:329–335.

9. Robacker, C.D. and W.L. Corley. 1992. Plant regeneration of pampas grass from immature inflorescences cultured in vitro. HortScience 27:841–843.

10. SAS Institute, Inc. 1985. SAS user's guide: Statistics, version 5 edition. SAS Institute, Inc., Cary, NC.

Determination of Constant-Feed Liquid Fertilization Rates for *Spathiphyllum* 'Petite' and *Dieffenbachia* 'Camille'[1]

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Abstract

Spathiphyllum 'Petite' and *Dieffenbachia* 'Camille', two popular foliage plants sensitive to excess salts, were grown using 9 levels of water-soluble fertilizer in a 3-1-2 ratio of N-P_2O_5-K_2O. The range for maximum growth occurred at 100–200 ppm (mg/l) N for *Spathiphyllum* and 200–400 ppm (mg/l) N for *Dieffenbachia* on a constant-feed basis. *Spathiphyllum* showed more noticeable leaf burn symptoms compared to *Dieffenbachia* when the concentration of fertilizer in the irrigation water increased above the range that yielded maximum growth.

Index words: tropical foliage plants, salinity, fertilizer, peace lily, dumbcane

Species used in this study: peace lily (*Spathiphyllum* Schott. 'Petite'); dumbcane (*Dieffenbachia* Schott. 'Camille').

Significance in the Nursery Industry

Spathiphyllum and *Dieffenbachia* are two of the most popular tropical foliage plant species. Accumulation of soluble salts in the growing medium from water-soluble fertilizers and dissolved soluble salts in the irrigation water are limiting factors in plant growth and survival. The range for maximum growth was 100–400 ppm N from a 3-1-2 N-P_2O_5-K_2O fertilizer on a constant-feed basis. *Spathiphyllum* performed best at the lower end of this range, while *Dieffenbachia* performed best at the upper end. Our results show

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that growth reduction and poor appearance of plants were associated with high concentrations of fertilizers in the irrigation water, even when leaching was employed.

Introduction

Fertilizer is the most frequent source of salinity in the growing medium (5). Fertilizer requirements for tropical foliage plants vary depending on the species. For example, Poole and Chase (4) recommended 333 and 389 ppm N for *Brassaia* and *Peperomia*, respectively. Conover and Poole (2) recommended 467 ppm N for *Ctenanthe* 'Dragon Tracks'. Some of the tropical foliage plants extensively produced in the U.S. are sensitive to high soluble salts. Therefore, determining the optimum fertilization of these crops is necessary to yield optimum growth and quality while minimizing soluble salt accumulation and plant injury. This experiment was performed to determine the constant liquid feed rate of N-P_2O_5-K_2O fertilizer required for maximum growth of two salt-sensitive tropical foliage plants (1).

Materials and Methods

Two cultivars of tropical foliage plants sensitive to salt injury were selected: *Spathiphyllum* Schott. 'Petite' (peace lily) and *Dieffenbachia* Schott. 'Camille' (dumbcane).

Twelve-week-old tissue culture liners of both species were obtained from Plant Reproduction International, Houston, Texas. The experiment with *Spathiphyllum* started on April 9, 1988 and terminated on June 29 (12 weeks). The average high and low temperature in the greenhouse was 34°C (93°F) and 17°C (63°F), respectively. The experiment with *Dieffenbachia* started on June 11, 1988 and terminated on August 27 (11 weeks). The average high and low temperature in the greenhouse was 35°C (95°F) and 21°C (70°F), respectively. Light intensity was reduced to 350 $\mu mol\ m^{-2}\ s^{-1}$ at noon (clear sky) using neutral shade cheese cloth (2).

Plugs containing an average of three plantlets were transplanted into 10 cm (4 in) plastic pots containing a pH adjusted spaghnum peat moss based medium, Sunshine Mix #2 (Fison Hort. Inc., Vancouver, BC), which contained no added nutrients. The following were incorporated into the medium: 1059 g/m^3 (1.06 oz/ft^3) of micronutrients from Micromax (Grace Sierra Horticultural Products Co.), 2970 g/m^3 (2.96 oz/ft^3) $CaSO_4$, and 2970 g/m^3 (2.96 oz/ft^3) $MgSO_4$. The fertilizer used was Peter's water-soluble Tropical Foliage Special 24N-8P_2O_5-16K_2O (Grace Sierra Horticultural Products Co.). The nitrogen concentrations were 0, 25, 50, 100, 200, 400, 800, 1600, and 3200 ppm N; P_2O_5 and K_2O were present in a 3:1:2 ratio. The fertilizer treatments will be referred to by nitrogen concentration. The experimental design was a completely randomized design with 5 replications per treatment. All fertilizer solutions were prepared with reverse-osmosis water. Plants were hand-watered, as needed, with 250 ml (8.45 oz) of the treatment solution; this was enough to saturate the medium and cause a small amount of leaching. At harvest, height, total and individual leaf area, and leaf dry weight were recorded. Height was determined by measuring from the base of the plant to the tip of the longest leaf. Leaf area was measured with a portable area meter Li-Cor 3000 (Li-Cor, Inc., Lincoln, NE). To obtain leaf dry weight, plant tissue was placed in paper bags, dried for 48 hours at 80°C (176°F), then weighed.

Results and Discussion

Several trends were similar for both species (Fig. 1). The 0 ppm N treatments showed deficiency symptoms of leaf chlorosis, leaf necrosis, stunting, and small leaves that prematurely defoliated. Only a small increase in nutrient concentration (25 or 50 ppm) was needed to greatly enhance growth. Nitrogen levels of 800 ppm and 1600 ppm severely injured both species. The 3200 ppm N treatment killed all plants.

In both species, total leaf area increased dramatically with increasing concentration of nutrients up to 200 ppm N, after which leaf area steadily decreased (Fig. 2, A and B). In *Spathiphyllum*, and to a lesser extent in *Dieffenbachia*, total leaf area of plants in the 100 ppm N treatment was almost as great as that of the 200 ppm N treatment. This is of importance because one of the goals of foliage plant production is to maximize leaf production. If similar total leaf area is produced with half the fertilizer input, production costs are minimized. The 400 ppm N treatment showed a decrease in total leaf area compared to the 200 ppm N treatment for *Spathiphyllum*, but not for *Dieffenbachia*. Therefore, the range for producing the greatest total leaf area is 100–200 ppm for *Spathiphyllum* and 200–400 ppm N for *Dieffenbachia*. This range is very broad, but normal for foliage plants (2).

The average leaf size of *Spathiphyllum* (Fig. 2, C) increased with increasing fertilizer up to 100 ppm N and then decreased as fertilizer concentration increased. Since this is the same basic trend as total leaf area (Fig. 2, A), this indicates that *Spathiphyllum* was producing fewer and smaller leaves at the higher fertilizer rates. For *Dieffenbachia*, average leaf size (Fig. 2, D) responded differently from total leaf area (Fig. 2, B). Leaf size remained relatively constant throughout the range of 100–800 ppm N. This indicates that *Dieffenbachia* produced the same size, but fewer leaves as fertilizer rate increased above 100 ppm.

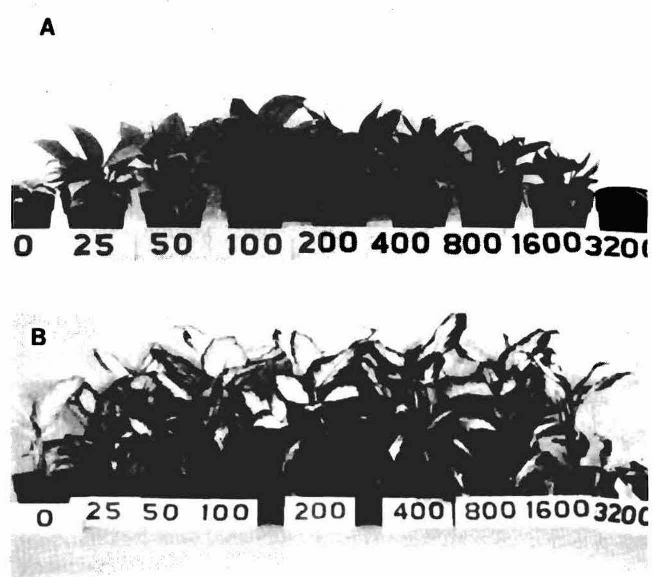

Fig. 1. Overall appearance of *Spathiphyllum* 'Petite' (A) and *Dieffenbachia* 'Camille' (B) grown with fertilizer levels from 0 to 3200 ppm N from a 3-1-2 soluble fertilizer.

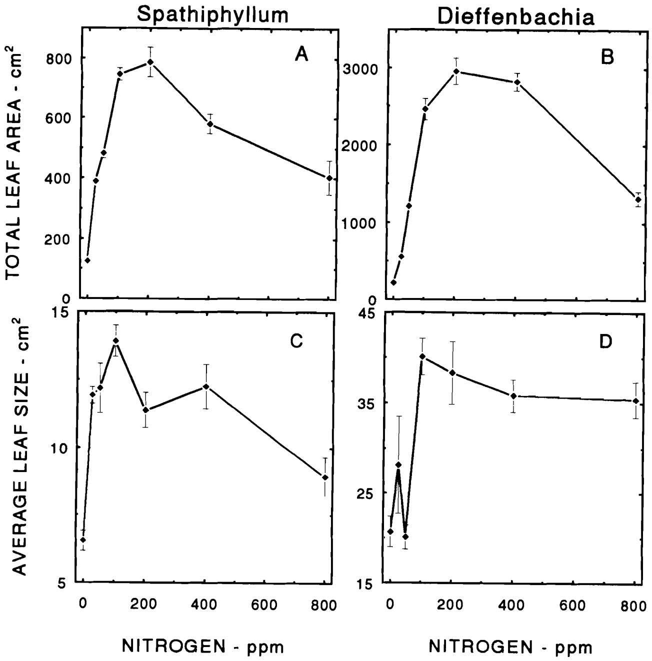

Fig. 2. **Total leaf area (cm²) (A and B), and average leaf size (cm²) (C and D) of *Spathiphyllum* 'Petite' (A and C) and *Dieffenbachia* 'Camille' (B and D) grown with nine fertilizer levels of a 3-1-2 soluble fertilizer. The 1600 and 3200 ppm N levels are not shown because of severe leaf damage or death. Bars indicated standard error of the mean.**

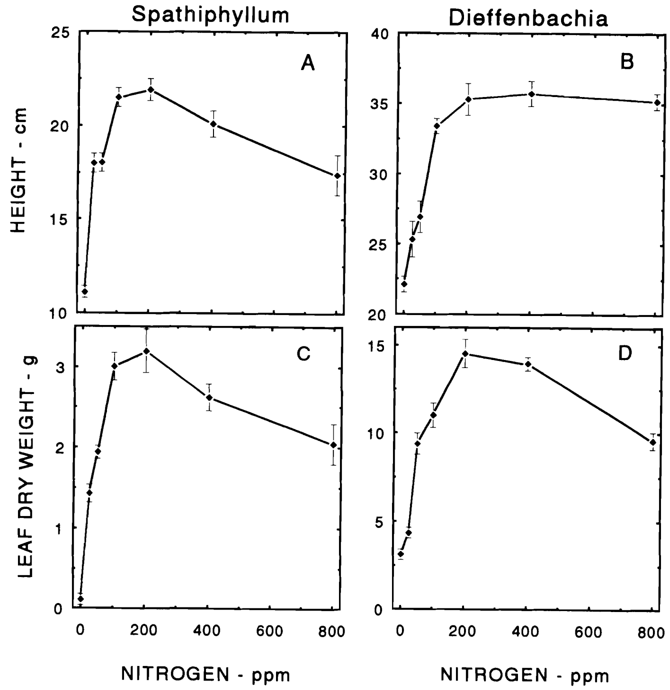

Fig. 3. **Plant height (cm) (A and B) and leaf dry weight (g) (C and D) of *Spathiphyllum* 'Petite' (A and C) and *Dieffenbachia* 'Camille' (B and D) grown with nine fertilizer levels of a 3-1-2 soluble fertilizer. The 1600 and 3200 ppm N levels are not shown because of severe leaf damage or death. Bars indicate standard error of the mean.**

For *Spathiphyllum*, the range for maximum height was 100–200 ppm N, with decreased height above and below this range (Fig. 3, A). The height of *Dieffenbachia* increased up to 200 ppm, after which it remained constant (Fig. 3, B). For *Spathiphyllum*, maximum leaf dry weight occurred at 100–200 ppm N (Fig. 3, C). For *Dieffenbachia*, maximum leaf dry weight occurred at 200–400 ppm N (Fig. 3, D).

Overall, *Spathiphyllum* presented a range of maximum growth from 100–200 ppm N. Increasing amounts of fertilizer in the irrigation water caused a more noticeable reduction in growth and leaf burn in *Spathiphyllum* when compared to *Dieffenbachia*. These results suggest that *Spathiphyllum* is more sensitive to soluble salts in irrigation water than *Dieffenbachia*.

Poole and Chase (4) studied the effects of increasing concentrations of fertilizer applied to foliage plants and the relationships between growth and conductivity of leachate of growing media. For *Spathiphyllum* 'Mauna Loa', they found that the best plant quality was obtained when plants were grown with 111 ppm N for the first 10 days and with 390 ppm N afterwards. This is a higher N requirement than demonstrated in our studies. They also observed that the best root growth was obtained with the lowest N level tested (78 ppm N), and the worst root growth was obtained with the highest N level tested (700 ppm). This shows the sensitivity of *Spathiphyllum* roots to soluble salts in the media and/or the phenomenon of N favoring shoot growth over root growth (3).

For the growth parameters measured, *Dieffenbachia* presented a range of maximum growth from 200–400 ppm N. The decrease in growth and plant appearance when higher fertilizer concentrations were used was not as severe as in *Spathiphyllum*. This suggests that *Dieffenbachia* may be more tolerant to a wider range of soluble salts in irrigation water than *Spathiphyllum*.

In summary, these results showed that for salt-sensitive tropical foliage plants, fertilizers in the irrigation water may need to be less concentrated than that recommended for more salt-tolerant tropical foliage species (2, 4).

Literature Cited

1. Campos Núñez, Ricardo. 1990. The influence of irrigation water salinity on optimal nitrogen, phosphorus, and potassium liquid fertilizer rates. M.S. Thesis, Texas A&M University.

2. Conover, C.A. and R.T. Poole. 1978. Influence of cultural factors on growth of *Ctenanthe* 'Dragon Tracks'. Proc. Fla. State Hort. Soc. 91:227–229.

3. Joiner, J.N. 1981. Foliage Plant Production. Prentice Hall, Inc., Englewood Cliffs, NJ.

4. Poole, R.T. and A.R. Chase. 1987. Response of foliage plants to fertilizer application rates and associated leachate conductivity. HortScience 22:317–318.

5. Rohsler, H.M. and R.D. Wright. 1984. What nurserymen should know about soluble salts. Amer. Nurserymen 160:73–77.