Table 2. Vase life of selected cut foliages.

PLANT MATERIAL	AVERAGE DAYS VASE LIFE DEC. WATER	DEC. PRSV.	JUNE WATER	JUNE PRSV.
1. ADENANTHOS SERICEUS	30	28	32	28
2. COPROSMA REPENS cv MARBLE QUEEN	30	24	29	24
3. COPROSMA REPENS cv VARIEGATA	27	22	31	23
4. GREVILLEA DIMINUTA	30	30	19	28
5. GREVILLEA HY cv IVANHOE	29	29	22	20
6. GREVILLEA HY cv POORINDA PETER	28	30	16	30
7. GREVILLEA LONGIFOLIA	18	20	14	22
8. GREVILLEA OBTUSIFOLIA	28	21	0	0
9. LEUCADENDRON ARGENTEUM	21	24	10	13
10. LEUCADENDRON EUCALYPTIFOLIUM	14	18	9	11
11. LEUCADENDRON HY cv INCA GOLD	19	28	21	24
12. LEUCADENDRON HY cv PISA	30	30	28	22
13. LEUCADENDRON HY cv RED GEM	25	29	21	28
14. LEUCADENDRON HY cv SAFARI SUNSET	28	30	21	29
15. LEUCADENDRON HY cv SYLVAN RED	15	23	27	24
16. LEUCADENDRON MERIDIANUM	30	30	17	20
17. LEUCADENDRON NOBILE	29	29	0	0
18. LEUCADENDRON SALIGNUM	20	28	16	14
19. LEUCADENDRON SALIGNUM cv RED DEVIL	15	27	0	0
20. LEUCADENDRON SALIGNUM cv YELLOW BIRD	30	30	28	21
21. LEUCADENDRON STELLIGERUM	22	29	0	0
22. MELALEUCA BRACTEATA cv REVOLUTION GOLD	12	14	8	11
23. PITTOSPORUM CRASSIFOLIUM	29	24	26	27
24. PITTOSPORUM sp. cv TOM THUMB	26	27	20	25
25. PITTOSPORUM sp. cv WENDEL CHANNON	25	26	28	27

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THE POLY-POT-PACK: ANOTHER TOOL FOR CONSERVATION OF RESOURCES DURING PRODUCTION OF CONTAINER-GROWN PLANTS

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Additional index words. fertilizer, plastic, poly-pot-cap (PPC), water conservation.

Abstract. **Two modified nursery container systems [the poly-pot-cap (PPC) and the poly-pot-pack (PPP)], configured to a 15-cm diameter standard pot, were compared with a standard pot, with the potting medium surface exposed (OP) in the production of finished *Dieffenbachia maculata* (Lodd.) 'Compacta'. Each container in the series received 2.15 liters of a 200 ppm N solution, from a 24-8-18 fertilizer with micronutrients, intermittently during production with tap water supplying the balance of water required for plant growth. The PPC and PPP systems produced quality dieffenbachia plants comparable to OP-grown plants and utilized approximately 56% of the water required by plants in OPs.**

In a second experiment, 3 nutritional regimes (100, 200, and 300 ppm N) were evaluated and results indicate that use of a solution of 200 ppm N to provide 65% or more of the water required to finish dieffenbachia plants in PPPs confi-

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gured to a 15-cm diameter standard pot was close to optimal. Fertilizer use for production of dieffenbachia in PPC and PPP systems without leaching can be reduced to approximately 0.3-0.4 of amount currently recommended for OPs with a low level of leaching. Plastic can be conserved by shipping only the PPP-grown plant with its film envelope, which weighs approximately 7% of the rigid, 15-cm standard pot weight.

Horticulturists worldwide are increasingly aware of the limited natural resources available to them for production, packaging and shipping of products to appropriate markets. This is especially true of potted nursery plants under intensive culture. Any modification of a plant production system which increases the efficiency of production, conserves natural resources, protects the environment from undesirable discharges, is economically feasible, and still results in a high quality product is worthy of investigation.

The first example of floricultural cut crop production in small, prepackaged, peatlite medium units in the United States was described by Boodley and Sheldrake in 1966. Use of large, prepackaged, mat-like packages of peatlite medium to produce high quality cut chrysanthemums on raised pot plant benches was demonstrated in 1967 (Henley, 1967).

The prepackaged medium concept was extended to tailored, prepackaged units which configured to 15-cm standard floriculture pots in 1981 (Henley, 1981) with the production of dieffenbachia in packs of quality equal to or greater than those grown in open pots. It was shown that PPP-grown plants used 57-60% of the water utilized by OP-grown dieffenbachia during production.

The term poly-pot-pack was coined in 1982 (Henley, 1982), at which time the potential for closer packing of PPP-grown plants in shipping cartons was reported. Other potential advantages of the PPP were discussed in later papers (Henley, 1984a; Henley, 1984b). The challenge of conserving water, fertilizer and plastic during potted plant production with a self-mulched, prepackaged, potting medium pack was the primary reason for initiation of these studies.

Materials and Methods

Two experiments were designed to evaluate the irrigation and fertilization requirements of *Dieffenbachia maculata* (Lodd.) 'Compacta' grown in modified 15-cm container systems. The first experiment measured moisture use in conventional OPs; in prefilled pots covered with a plastic film, a treatment referred to as the poly-pot-cap (PPC); and in prefilled packages of potting medium tailored to the shape of a 15-cm standard pot - PPPs. Each of the 3 container systems were replicated 5 times. The potting medium used in both experiments was Vergro Potting Mix A (Verlite Company, Tampa, FL). Clysar® 100 ECL, a transparent shrink wrap film (DuPont Company, Wilmington, DE), was used for fabrication of PPCs and the PPPs which nested in conventional containers to assure the integrity of the root ball during production. The PPC and PPP films were perforated for insertion of tissue-cultured, 72-cell plug plants and drainage. The medium in both experiments was premoistened with a 0.1% solution of Aqua-Gro®-L (Aquatrols, Pennsauken, NJ) to container capacity. Peters® Professional Fertilizer 24-8-16 Tropical Foliage (Grace-Sierra, Fogelsville, PA) was the only fertilizer used in the 2 experiments. All fertilizer and water was applied to the upper medium surface through a drip tube. At time of harvest, a total of 2.15 liters of 200 ppm N nutrient solution from the 24-8-16 fertilizer had been applied to each container plus periodic application of water to supplement moisture required by plants in each treatment. Plants were grown in a shaded fiberglass greenhouse in Apopka which provided 1500-2000 ft-c and was maintained between 21 and 32°C. Both experiments were initiated 7 Nov 1990 and extended through 10 Apr 1991.

In the second experiment all plants were grown in 15-cm PPPs. At the time of harvest 2.15 liters of nutrient solution plus supplemental water had been applied to each container. Fertilizer was applied at 100, 200 and 300 ppm N from a 24-8-16, with 12 replicates per treatment.

Results and Discussion

Container design had a strong influence on the amount of water utilized during crop growth in the first experiment (Table 1). The PPC and PPP systems used 54.8% and 56.5%,respectively, of the water required for the OP system. The moisture saving feature of the modified containers is consistent with the water savings reported earlier for the PPP, which used 57.0% and 60.1%, for 2 different PPP designs compared to the OP (Henley, 1981). The slightly greater water use efficiency reported in the current experiment is probably due to the tighter fitting shrink wrap packaging compared with the looser fitting nonshrinking films used earlier. Water conserved by the PPC and PPP systems in the current experiment is attributed to the mulch function of the film stretched over most of the potting medium, which blocked most of the potential surface evaporation. Other than the amount of water needed initially to moisten the potting medium to container capacity, the amount of water used per 2-week period generally increased with crop age in all container treatments (Fig. 1).

Although there was a significantly higher top weight of dieffenbachia grown in OPs, it was not reflected in plant height and number of shoots per plant, which are primary components of plant quality (Table 1). Since the foliage plant industry grades its plants on the basis of size rather than weight, there were no significant differences in top quality among plants from the 3 container systems.

Fertilizer levels in the second experiment did not influence the number of shoots per plant (Table 2). The 200 and 300 ppm N treatments produced the tallest plants with the greatest fresh weight. The fertilizer treatments also influenced the potting medium extract pH and extract conductivity (Table 3). Increased fertilizer application rates resulted in decreased pH. This was expected since the Pet-

Table 1. Dieffenbachia growth and water use as influenced by container design.[z]

Container design[y]	Plant height (cm)	Shoots/plant (no.)	Fresh top weight (g)	Water used/ plant (l)
Open pot	32.8a[x]	8.4a	158a	6.2a
Poly-pot-cap	30.4a	7.4a	124b	3.4b
Poly-pot-pack	31.8a	8.0a	130b	3.5b

[z]Crop production period: 7 Nov 1990 - 10 Apr 1991.
[y]All containers had a 15-cm standard pot configuration.
[x]Means in same column followed by the same letter are not significantly different at the 5% level (Duncan's new multiple range test).

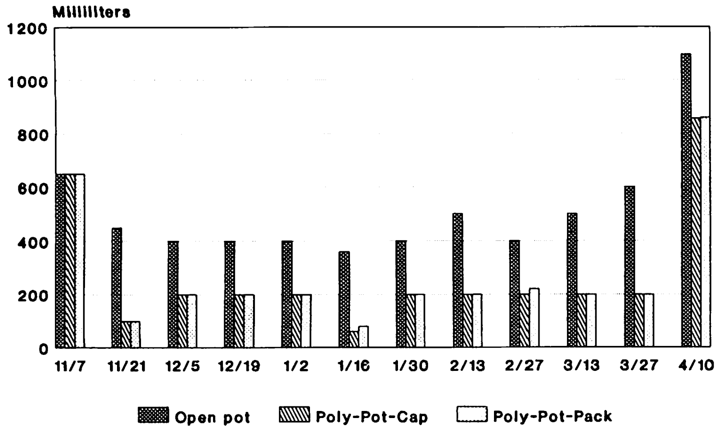

Fig. 1. Water added to potted *Dieffenbachia maculata* 'Compacta' as influenced by three container designs during production.

Table 3. Influence of fertilizer application concentration on pH and conductivity of the potting medium extract.[z]

Fertilizer application concentration (ppm-N)[y]	Extract pH	Extract conductivity (millimhos cm^{-1})
100	6.8a[x]	0.37b
200	6.7a	0.41b
300	5.9b	2.95a

[z]Soil extract was prepared by the pour-through method at the time of harvest (10 Apr 1991).
[y]Each container received 2.15 liters of fertilizer solution prepared from Peters 24-8-26 which supplied approximately 65% of the water used by the crop.
[x]Means in the same column followed by the same letter are not significantly different at the 5% level (Duncan's new multiple range test).

ers 24-8-16 has a potential acidity rating of 691 pounds of calcium carbonate equivalent per ton. Tap water used for the nutrient solutions and supplemental irrigation had a pH range of 7.0-7.2 and therefore did not strongly influence the potting medium extract pH.

Although the potting medium extract conductivity was low for the 100 and 200 ppm N treatments, the plants did grow well, especially at the 200 ppm rate. The mean extract conductivity of 2.95 millimhos cm^{-1} for the 300 ppm N application rate resulted in a more rapid accumulation of soluble salts than the 100 and 200 ppm N treatments. The extract conductivity means from each of the 3 fertilizer treatments fall within the range of 0.11 to 11.79 millimhos cm^{-1}, using the pour-through extraction procedure, which was reported to be satisfactory for production of good quality dieffenbachia (Poole and Conover, 1988). Since 2.15 liters of nutrient solution provided approximately 65% of the water utilized by the crop, it is estimated that good quality dieffenbachia can be grown with a constant fertilization level of 150-250 ppm N from a 24-8-16 applied to a high quality peatlite mix in either the PPC or PPP container system with zero leaching. The fertilizer savings is important because of reduced fertilizer cost and the reduced risk of environmental damage when the PPC or PPP are used. Based on the 2.15 liters from the 200 ppm N treatment, only 0.43 g N was used per 15-cm container (PPC and PPP) during the 5.5 month crop period compared to 1.43 g N, which is the amount recommended for commercial dieffenbachia production with moderate leaching of OPs during the same crop production time (Conover and Poole, 1990).

Table 2. Influence of applied fertilizer concentration on dieffenbachia growth.[z]

Applied fertilizer concentration (ppm-N)[y]	Plant height (cm)	Shoots/ plant (no.)	Fresh top weight (g)
100	30.5b[x]	8.6a	115.1b
200	32.2ab	9.2a	130.7a
300	33.8a	8.4a	120.3ab

[z]Crop production period 7 Nov 1990 - 10 Apr 1991.
[y]Each container received 2.15 liters of fertilizer solution prepared from Peters 24-8-16 which supplied approximately 65% of the water used by the crop.
[x]Means in same column followed by the same letter are not significantly different at the 5% level (Duncan's new multiple range test).

The amount of plastic used by the nursery industry in plant production containers is high and much waste of these containers occurs during production and, especially, at the consumer level. Although the water and fertilizer savings realized from the use of PPC and PPP are achieved through container design changes, the savings in plastic PPP use is very significant. Following through with the PPP concept, the finished plant is pulled from the supporting rigid pot, packed and shipped. The weight of one 15-cm standard pot (The Lerio Corp., Mobile, AL) is approximately 52 g, while the weight of film used to make a PPP of the same size is 3.6 g. On a weight basis, there is approximately 15 times as much plastic in the rigid pot than in the PPP of the same size and shape.

Since the average consumer disposes of used plastic pots which accumulate as declining plants are replaced indoors or container-grown landscape plants are installed, the savings in container plastic over a long term should exceed 90%. This projection does not include the plastic pots which would be reused for many years in the nursery to support successive crops using a PPP system nor does it consider the savings in plastic if a producer received potting medium in PPP units rather than in 3 ft^3 bags. Since the weight of plastic film used for fabricating potting media bags is approximately 116 g, an additional savings of approximately 2.4 g of plastic per PPP is realized, based on 48 units filled per bag. Although the PPC container system also conserves water and fertilizer similarly to the PPP, it is more wasteful of plastic than OPs because it requires a rigid pot plus a plastic film cover to function in the same manner.

The PPP system of plant production offers a viable alternative to conventional OP systems of plant production. Adoption of the system would require a commercial packaging step, possibly at the location where potting medium is blended.

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SYMPTOMS OF BORON TOXICITY INDUCED IN FOLIAGE PLANTS

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Abstract. **Since boron (B) can be present in water, potting ingredients and fertilizers, there is a possibility of plants accumulating toxic levels of B. Research was conducted to determine B tolerance levels and toxicity symptoms of 12 popular foliage plants. This study revealed differing tolerance levels for plants studied. *Aglaonema* exhibited foliage damage after one application, while weeping fig became chlorotic after 5 applications. Foliar damage and foliar B concentration caused by excess B is described. Boron toxicity symptoms developed on mature foliage, usually starting as chlorotic leaf tips or chlorotic patches at leaf margins near the apex of the leaf. These chlorotic areas advanced toward the leaf base and eventually turned necrotic and leaves sometimes dropped. On some species symptoms were scattered across foliage as dark lesions surrounded by chlorotic patches.**

Most foliage plants produced in artificial media require macro and microelement supplements for proper growth (Conover and Poole, 1973; Poole and Conover, 1976). The range between deficiency and toxicity is extremely narrow for the micronutrient boron, B (ben Jaacov et al., 1984; Kohl and Oertli, 1961; Marlatt, 1978; Poole and Conover, 1982, 1985a, 1985b). Since B may be present in irrigation water, potting medium ingredients, fertilizers and micronutrient supplements, there is a possibility of plants under commercial production regimes accumulating toxic levels of B. Tolerance levels and toxicity symptoms for most foliage plants are still unknown. The following research was conducted to determine B tolerance levels and B toxicity symptoms of 12 popular foliage plant genera.

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Materials and Methods

On 20 Nov. 1989 salable *Aglaonema* Schott. 'Silver Queen' (silver queen aglaonema), *Alpinia zerumbet* (Pers.) B.L. Burtt & R.M. Sm. 'Variegata' (variegated shell ginger), *Araucaria heterophylla* (Salisb.) Franco. (Norfolk Island pine), *Chamaedorea elegans* Mart. (parlor palm), *Codiaeum variegatum* (L.) Blume 'Petra' (Petra croton), *Dieffenbachia maculata* (Lodd.) G. Don 'Camille' (Camille dieffenbachia), *Dracaena fragrans* (L.) Ker-Gawl. 'Massangeana' (striped corn plant), *Epipremnum aureum* (Linden & Andre) Bunt. (golden pothos), *Ficus benjamina* L. (weeping fig), *Neoregelia carolinae* (Beer) L.B. Sm. 'Perfecta Tricolor' (Perfecta Tricolor blushing bromeliad), *Philodendron scandens oxycardium* (Schott) Bunt. (heart-leaf philodendron) and *Schefflera arboricola* H. Ayata (dwarf schefflera) were obtained from local commercial producers. All species with the exception of weeping fig were maintained in a glasshouse receiving 1200 ft-c maximum light with temperatures between 65° and 95°F. Weeping figs were placed in a shadehouse under 47% polypropylene shadecloth receiving 4600 ft-c maximum light intensity and temperatures between 45°

Table 1. Dates of boron application and foliage evaluation for twelve foliage plants.

Plant name	Boron applied (1989-1990)	Foliage graded (1990)
Aglaonema 'Silver Queen'	29 Dec.	8 Jan.
Alpinia zerumbet	29 Dec., 17 Jan., 5 Feb.	1 Mar.
Araucaria heterophylla	29 Dec., 17 Jan., 5 Feb.	1 Mar.
Chamaedorea elegans	29 Dec., 17 Jan., 5 Feb.	15 Feb.
Codiaeum variegatum 'Petra'	29 Dec., 17 Jan., 5 Feb.	1 Mar.
Dieffenbachia maculata 'Camille'	29 Dec., 17 Jan., 5 Feb.	7 Feb.
Dracaena fragrans 'Massangeana'	29 Dec., 17 Jan.	24 Jan.
Epipremnum aureum	29 Dec., 17 Jan.	24 Jan.
Ficus benjamina	29 Dec., 17 Jan., 5 Feb., 16 Mar., 6 Apr.	7 May
Neoregelia carolinae 'Perfecta Tricolor'	29 Dec., 17 Jan., 5 Feb., 16 Mar.	26 Mar.
Philodendron s. oxycardium	29 Dec., 17 Jan., 5 Feb., 16 Mar.	26 Mar.
Schefflera arboricola	29 Dec., 17 Jan., 5 Feb.	19 Feb.