weight (Tables 1 and 2). This effect is reduced in crops treated with a growth retardant which suggests a beneficial use for these chemicals on cultivars which do not require them for height control.

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A DIFFERENT CONCEPT OF PLANT PRODUCTION IN PLASTIC BAGS[1]

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Abstract. **A technique of plant production in a prepackaged unit of peat-lite mix or similar growing medium, referred to as the poly-pot-pack (PPP), is described. Emphasis is given to conservation of moisture, fertilizer, pesticides, plastic, cardboard boxes, paper sleeves and fuel through use of the PPP. Sanitation and ease of handling features of the PPP and PPP-grown plants are also mentioned. Facts suggest the PPP is most likely to find application with high value crops which require long distance shipping.**

Nurserymen and florists in the United States have grown plants in a variety of containers made from different materials including: wood, clay, steel, plastic (solid, foam and film), asphalt impregnated paper, peat, wood composition and paper composition. Most containers used by horticulturists are rigid or semi-rigid to confine a given volume of root medium to a specific shape and support the plant during its development. The rigid container has been the standard in the nursery industry until recently when plastic film bags have been used for commercial crop production.

In 1966 Boodley and Sheldrake (5) reported that cut chrysanthemums could be grown in 4- or 6-inch diameter polyethylene film tubes filled with Cornell peat-lite mixes and perforated in the top only for planting. In 1967 Henley (6) described growing cut chrysanthemums in peat-lite mixes contained in mats, 3.5 x 38 x 60 inches, fabricated from 4-mil, black polyethylene film perforated on the top for planting and the bottom for drainage. Open-top plastic bags for growing seedlings and finished plants have been studied by other investigators (8, 9, 10, 11, 13). During the past few years there has been renewed interest in plant production in horizontal, media-filled plastic tubes (12).

The idea of a single unit as medium container is not new to horticulturists involved with propagation of small plants. Products such as Jiffy-7®s, Jiffy-9®s, BR-8® blocks, Kys-Kubes, Rootcubes® and Horticubes® have been used successfully for some time. The primary differences in the technique described in this paper are: the growing medium in the PPP is loose, it may range from less than a pint to several gallons and the finshed plant may be several inches to several feet in height.

The objective of this paper is to describe a different container-media system in which a specific volume of clean root medium is sealed within a plastic film package made to fit the dimensions of an anchorage container during the growing process. The packaged medium will remain clean during storage and requires no "soil" handling during planting. As proposed, the package is perforated below for drainage and above for insertion of seed, seedling, cutting (unrooted or rooted) or air layer. Prior to insertion of the propagule, the package is placed in an anchorage pot which forms the root ball and supports of the growing plant. The finished plant, with attached root medium package, is removed from the anchorage container, packed and shipped. This unit will be referred to as the poly-pot-pack (PPP).

The PPP-grown plant should have a well developed root system within the package and a top matching industry standards (2) for containers 1 to 2 sizes larger than the PPP. Such a unit requires additional support considerations, such as staking or guying in shadehouses or outside where wind is a factor, and more frequent irrigations during the final stages of production. Since most of the root medium surface, including the top, is covered with polyethylene, PPP-grown plants are excellent candidates for drip or modified capillary mat.

The finished PPP-grown plant can be plunged into an ornamental container of the same inside dimensions as the root ball or larger containers, using extra root medium, either peat-lite mixes or hydroponic clay particles, placed around the package. Several vertical cuts running the length of the PPP sidewall will permit extension of roots to medium outside the film. Use of PPP-grown plants actually eliminates the need for discarding the production pot, which is frequently done, by the northern wholesaler, retailer or interiorscaper.

Advantages of the PPP

Experiments have shown that *Dieffenbachia maculata* (Lodd.) G. Don growth in the PPP is equivalent or greater than plants grown in conventional pots (Table 1). Nonpublished research findings with PPP-grown *Ficus benjamina* L. indicate comparable growth can be expected in both pot-grown and PPP-grown plants.

A study using *Dieffenbachia maculata* in 6-inch pots and PPPs of clear and black 4-mil polyethylene demonstrated that the PPP saved approximately 40% of the moisture re-

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Table 1. Influence of container type on top growth of *Dieffenbachia maculata*.[z]

Treatment	Top growth Height (inch)	New leaves (no.)	Fresh wt (oz)
6-inch standard pot	4.5 a[y]	5.4 a	4.1 a
6-inch PPP (clean 4-mil polyethylene)	4.9 a	7.1 c	5.7 b
6-inch PPP (black 4-mil polyethylene)	5.2 a	6.3 b	5.4 b

[z]Adapted from Henley (7).
[y]Mean separation within columns by Duncan's multiple range test, 1% level.

quired by plants in pots (7). This experiment was conducted in a humid greenhouse during the months of December through April, during which time *Dieffenbachia* growth is slow, which may account for the high percentage moisture conserved by the PPP. Preliminary work with *Ficus benjamina* in a greenhouse at the Agricultural Research Center–Apopka during the summer suggests the PPP moisture conserving feature is partially masked as plants mature because much more water is lost through transpiration.

Since the PPP deflects more water from overhead irrigation or rainfall than conventional open-top pot it lends itself to drip irrigation. A combination of the PPP, drip irrigation and fertilizer injection will give plant producers maximum control of moisture and nutrient regimes in the root medium, regardless of weather conditions, and, at the same time, conserve significant amounts of water and fertilizer.

Another production consideration involving the PPP is weed control. Prior to package perforation the PPP medium is weed free. Introduced weed seed will be shielded from most of the root medium by the film package, leaving only small areas around the stem base for establishment. If needed, use of minute amounts of selective preemergent herbicides around the stems could complete the weed control program.

Efforts to conserve non-renewable natural resources are being made by most industries, including agriculture. It was estimated that 5,180 tons of plastic pots, flats excluded, were distributed in Florida in 1977 (4). The volume of container-grown products has increased since then, so it is reasonable to assume that the amount of plastic used in pots has increased. According to the USDA Crop Reporting Board (1, 3) the value of foliage plants produced in Florida increased by a factor of approximately 1.3 from 1977 to 1980. Using this factor it is estimated Florida consumption of plastic for pots in 1980 was approximately 6,734 tons.

Since only the plastic film package, and not the anchorage container is replaced with each crop using the PPP, this system represents a notable savings of plastic. Presumably the anchorage pots, if constructed of thick black plastic, would last indefinitely under greenhouse conditions and for several years in the field. Table 2 shows the weight of plastic used in construction of conventional containers and PPPs in 2 container sizes. The difference in plastic needed for construction of PPPs vs. conventional plastic pots in 6-inch standard pots and 2-gal nursery pots were factors of approximately 8 and 11, respectively. If approximately 6,700 tons of plastic pots were used in Florida in 1980, it is possible that approximately 6,030 tons of plastic could be saved annually by conversion to the PPP system.

The greatest potential for use of the PPP is probably in the production of medium to large container grown plants for interior use. Since the cost of the PPP will be greater than the equivalent combination of conventional pot plus

Table 2. Weight comparisons of plastic in conventional molded polypropylene pots and the polyethylene film in the bag-pot in 2 sizes.

Container size and type	Weight[z] (oz)
6-inch diameter standard polypropylene copolymer pot (R-600-2)[y]	2.38
Bag of 4-mil polyethylene for 6-inch standard pot	0.28
2-gal polypropylene copolymer nursery pot (C-20)[y]	7.37
Bag of 4-mil polyethylene for 2-gal nursery pot (C-20)	0.67

[z]Mean value of 5 containers.
[y]Code used by Better Plastics, Inc., Apopka (now Reb Plastics, Avon Lake, Ohio).

root medium, the economic advantage must lie with packing, shipping and ease of handling a high value product. As an example, it costs approximately \$1.35 per ft³ to ship foliage plants from Apopka to New York City by commercial carrier, in less than trailer load lots. If the number of plants packed within a given space can be increased, the shipping cost per plant will be reduced, which should more than offset the PPP cost. Table 3 illustrates the shipping cost

Table 3. Shipping box space utilization of 36-inch tall *Ficus benjamina* grown in 2 container types and the influence of container type on total plant cost to buyer.

Specification	Container type: 2-gal molded plastic pot	PPP to fit a standard 6-inch diameter pot
Number of plant-container units per shipping box, 23 x 18 x 36 inches (8.63 ft³)	6	12-16-20[z]
Cost per plant for shipping from Apopka to New York City, LTL (less than trailer load) (\$)[y]	1.94	.97-.73-.58
Wholesale plant cost + shipping from Apopka to New York City per unit (\$)[x]	6.69	5.72-5.48-5.33
Shipping cost to New York City expressed as percent of total wholesale cost to buyer (plant + shipping) (%)	29	16-13-11

[z]Number packed per box will vary with density of plant top.
[y]Based on cost at \$1.35 per ft³.
[x]Based on cost of \$4.75 per plant. Assumption is made that both units would sell for the same price since plant tops are of equivalent size.

savings if plants are packed on-side and in higher densities than plants grown in conventional molded pots which must be packed upright. Using the PPP which fits a 6-inch standard pot, there can be a savings of \$.97, 1.21 and 1.36 per 36-inch tall *Ficus benjamina* shipped from Apopka to New York City using packing densities of 12, 16 and 20 plants, respectively, per 36 x 23 x 18-inch box compared to shipping 6 *Ficus benjamina* with the same top size in 2-gal pots upright per box of the same capacity. Along with the shipping cost saving is a built-in savings of fuel used to transport the plants.

Another area of savings through use of the PPP is packaging materials. Packing boxes constructed of 250 lb. test corrugated cardboard with dimensions of 23 x 18 x 36 inches cost \$1.78 per unit. Sleeves for 36-inch tall plants in 2-gal pots cost \$.13 each. Table 4 illustrates the box and sleeve cost savings when PPP-grown plants are packed on-side.

Table 4. Utilization of boxes and sleeves for packing 36-inch tall *Ficus benjamina* grown in 2 container sizes.

Specification	Container type: 2-gal molded plastic pot (packed upright)	Container type: PPP to fit standard 6-inch diameter pot (packed on-side)
Number of plant-container units per shipping box with a capacity of 8.63 ft^3	6	12-16-20[z]
Box dimensions	23 x 18 x 36 inches	36 x 23 x 18 inches
Number of boxes required/plant	.167	0.083-0.063-0.05
Box cost per plant ($)[y]	.30	.15-.11-.09
Number of sleeves required/plant	6	0-0-0
Sleeve cost per plant ($)[x]	.13	0-0-0
Total cost of box and sleeve/plant ($)	.43	.15-.11-.09

[z]Number packed per box will vary with density of plant top.
[y]Cost to shipper for a 23 x 18 x 36-inch box (250 lb. test corrugated cardboard) is approximately $1.78.
[x]Cost to shipper for a paper sleeve for a 2-gal container-grown plant 36-inches tall is approximately $.13.

These savings are $.28, .32 and .34 per plant packed 12, 16 and 20 units per box, respectively. The combined savings in shipping cost and packing materials is $1.25, 1.53 and 1.70 per plant, 36 inches high.

Present procedure for shipping most small to medium size (up to 4- or 5-inches) foliage plants from Florida by commercial plant carriers is to box, with small plants, or sleeve and box, with medium size plants (5- or 6-inches and up). Plants in conventional containers are placed in a wax-impregnated corrugated cardboard box with the container bases down to prevent loss of root medium and mechanical plant damage from heavy pots shifting in the packing box. A few boxes are partitioned with extra cardboard to prevent plant shifting. Paper sleeves are used to draw stems and leaves into a conical form which prevents them from being torn or bruised during the shipping process.

The present packing procedures, although satisfactory in most cases to protect the plant during shipping, leave considerable wasted space in the upper level of the box which is not entirely filled, even though boxes are manufactured in graduated sizes to accommodate different size plants. It is anticipated that PPP-grown plants with reasonably flexible foliage can be shipped on their sides, a procedure which will greatly increase the efficiency of box space utilization. As an example, many foliage plants grown in 8-inch diameter standard pots or 2-gal nursery pots are shipped, 6 units to a box, in boxes with a base dimension of 23 x 18 inches. Twelve to 16 PPP-grown plants, with the same top size as plants in 8-inch or 2-gal pots, can be placed upright in the same size box due to the smaller and slightly pliable root ball of the PPP. If the same plants are packed on their sides, alternating orientation of the PPP from end to end, approximately 12-20 plants can be shipped in the same container volume. With on-side packing, the box height should be the smallest dimension to minimize mechanical damage to foliage. It is anticipated that certain plants with brittle leaves or stems will not lend themselves to on-side packing and shipping.

Utilization of on-side packing has other subtle advantages. There can be considerable standardization of box sizes and shapes because, within a given box, plant orientation can be changed to accommodate different plant species and different plant sizes. Box standardization would decrease the box inventory which packers must stock. Fewer box sizes would also increase efficiency of loading trailers. It is estimated that present trailer loads rarely fill more than 90% of the total available volume because of the array of box sizes used.

At present, volume, not weight is the major factor which determines cost of shipping plants by truck or van containers. Until such time that weight specifications are established by truckers or the plant buyers, it is doubtful that many nurserymen will seriously consider using light weight media for their container grown plants. Table 5 provides a weight comparison of *Ficus benjamina* of similar size grown in 2-gal nursery pots filled with a mixture of 3 peat:1 sand (v:v) and plants grown in PPPs filled with Metro-Mix®-350 (a peat-lite mix prepared by W. R. Grace & Company, Cambridge, Mass.). Note that the 37-inch tall *Ficus benjamina* in 6-inch PPP which were slightly moist weighed approximately 22 oz while similar plants in 2-gal containers with a very moist peat-sand mixture weighed approximately 36 oz. It is not uncommon to have plants in heavy mixes shipped in very moist condition.

Table 5. Weight comparison of root media and plants grown in different container systems.

Container system	Dry weight (oz)	Wet weight[z] (oz)	Very moist (oz)	Slightly moist[y] (oz)
44.0 fl oz of Metro-Mix 350[x]	11.7	26.1	—	—
44.0 fl oz of 3 peat:1 sand (v:v)[x]	42.7	59.1	—	—
37-inch tall *Ficus benjamina* grown in PPPs containing 44.0 fl oz Metro-Mix 350[w]	—	41.1	—	22.1
39-inch tall *Ficus benjamina* grown in 2-gal pots (C-20) containing 3 peat:1 sand (v:v)[x]	—	152.4	136.0	—

[z]Containers irrigated 1 hr before measurement.
[y]Soil was considered to be within the ideal moisture range for shipping.
[x]Mean value from 5 measurements.
[w]Mean value from 10 measurements.

The usage of peat-lite mixes or similar light weight root media becomes a very important consideration when plants are shipped on-side because some stacking will usually be required and some foliage will be compressed by the PPP as orientation of plants is alternated, end to end during the packing process. A small amount of weight from the soft PPP should not mechanically damage foliage of most plants.

It is difficult to predict how much the PPP would cost in a given size, because there are no commercial soil blenders which package soil in small tailored packages to conform to dimensions of anchorage pots or ornamental planters. The pack cost would depend upon media components used, sophistication of packaging, size of unit, volume produced and competition. It is possible that a large PPP user could set up machinery for in-house fabrication of PPP units.

Conclusions

The poly-pot-pack system of plant production offers growers an opportunity to produce high quality plants and conserve several natural resources or products including: water, fertilizers, pesticides, cardboard, paper and fuel. The PPP-grown plant would be easier to handle, because of size and weight, through most stages of production, packing, transportation and utilization. It is difficult to anticipate how well the PPP will be received by plant producers and buyers, both wholesale and retail. Acceptance or rejection of the PPP-system of plant production and utilization will be based on economics.

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INFLUENCE OF CULTURAL CONDITIONS ON SIMULATED SHIPPING OF *FICUS BENJAMINA* L.[1]

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Abstract. **Quality of *Ficus benjamina* grown in 63% shade, as measured by plant grade, height, and leaf retention after 12 wk under an interior environment following a period of 0, 5, 10, or 15 days of simulated shipping, was improved over plants grown in full sun or 30% shade. An increase in fertilizer during the production phase also improved height and plant grades, but resulted in greater leaf drop. Increase in storage time increased leaf drop, but was additive and did not interact with light or fertilizer levels. The majority of leaves dropped the first 8 wk after simulated shipping was initiated.**

Acclimatization studies have improved acceptability of foliage plants, but producers and those in marketing chains think transportation and storage requirement studies represent additional potential means for market penetration. Mass marketers particularly would prefer to store foliage plants at distribution centers and deliver to sales units on an as needed basis. Producers, on the other hand, would like to lengthen the shipping/storage period to allow better penetration into existing markets and develop new markets, such as the European Economic Community. Because of associated costs of shipping container-grown foliage plants, use of truck or shipboard containers appears to be the only economical system. Truck transport is acceptable in the U.S. because shipping periods rarely exceed 5 days, while 10 to 15 days are required for a shipboard container to reach Europe.

Research on *Ficus benjamina* (1, 3) has shown that best quality plants for the consumer could be produced with an acclimatization process which provides shade during the production cycle and moderate nutrition. Research (8) with *Ficus benjamina* with factorial combinations of 30 and 60% shade and 80 and 160 mg N/8-inch pot per wk, and simulated shipping durations of 0, 6, 12, or 18 days showed trees receiving the lowest light level and lowest fertilizer level performed better after removal from simulated shipping. Several producers have stated they were shipping sun-grown trees and were not experiencing shipping problems. Other researchers (5, 6) have also shown benefits derived from acclimatization of *Ficus benjamina,* although even acclimatized plants are subject to severe leaf drop if they are allowed to dehydrate during shipping (7).

Because of conflicting input on shipping quality of *Ficus benjamina,* we initiated this experiment to compare sun-grown plants with shade-grown plants under a simulated shipping environment where plants were watered to prevent dehydration leaf drop.

Materials and Methods

A 3 x 2 x 4 factorial experiment in randomized block design with 6 replications was initiated April 4, 1978, to determine what effect 3 production light levels and 2 production fertilizer levels would have on *Ficus benjamina* L. (weeping fig) at 4 simulated shipping durations. Weeping fig were potted in 2-gal pots containing Florida sedge peat and builder's sand (3:1 by volume), and amended with 10 lb. dolomite/yd^3 and 3 lb. Perk/yd^3 (a micronutrient blend manufactured by Estech General Chemicals Corp., Chicago, IL). Light level treatments were full sun, 30, and 63% shade (13,000, 9000, and 4800 ft-candles). Two fertilizer levels of 19-3-8 (N-P-K) Osmocote, 9 and 18 g per pot, were surface applied April 20, 1978, and August 29, 1978, (equivalent to 1800 and 3600 lb. N/acre/yr); and plants were placed in simulated shipping durations of 0, 5, 10, and 15 days.

Weeping fig were grown under appropriate shade levels for 6 months where they received overhead irrigations as needed (2 or 3 a week) and temperatures of 55° minimum to 100°F maximum. October 19, 1978, 36 control plants (0 simulated shipping) were placed in conditioning rooms with a light intensity of 75 ft-candles, measured at plant height, for 12 hr daily from Cool White fluorescent lamps. Temperature within rooms was maintained at 68 to 75°F, with a realtive humidity of 60 ± 5%, and plants were individually watered twice a week. The remaining plants were individually paper-sleeved and placed in simulated shipping chambers where temperatures were maintained at 60 to 65°F

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