ROOT-ZONE HEATING INNOVATIONS IN FLORIDA[1]

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Abstract. Trends in bottom heating in Central Florida are reviewed with emphasis on heat placement and techniques of heat trapping. A study involving three different heating chambers for potted plants is described. Findings indicate that a temperature increase of 4° to 5°F can be achieved within medium in 6-inch pots if chambers are utilized, compared to medium temperature of free standing container-grown plants with heating pipes between them.

REVIEW OF LITERATURE

Most Central Florida greenhouses are heated with forced air heaters that distribute heat rapidly throughout the structure. This is not the most efficient use of heat since many crops root and grow best when root temperatures are between 70° to 80°F, which is above the air temperatures maintained by normal space heating. Mechanisms for placing heat where it is most beneficial to horticultural plants are desirable.

Many warm-water bottom heating systems used in northern United States and Europe for medium and large potted plants involve heating a greenhouse bench top or floor on which the containers rest during crop production. The heating pipes are either placed under the bench, embedded in the floor, or lie on top of the bench or floor surface.

The system being employed by most Central Florida growers equipped with bottom heat is a closed warm-water system composed of a heating unit, a network of distribution pipes and a circulating pump controlled by a thermocouple placed in the root zone and linked to a thermostat (3,5). Water temperatures in pipes range from 100° to 115°F in most systems, which permits heat placement close to plants without root damage. Polyvinylchloride (PVC) and polybutylene pipe are presently

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the most popular types of pipe used for warm water distribution. Pipe spacing is important under these conditions because most media used for propagation and growing horticultural plants are rather good insulators, even when moist. Because of the insulating quality of the media, appropriate amounts of heat should be placed as close to the roots as possible (5,7). The temperature gradient measured in a commercial propagation bench filled with peat to a depth of 4 in. is shown in Figure 1(6). One half-inch diameter schedule 160 PVC water pipes were placed on the bench bottom on 9-in. centers. The soil next to the pipe was 100°F while the soil temperature between the pipes, at pipe level, was 71° to 72°F.

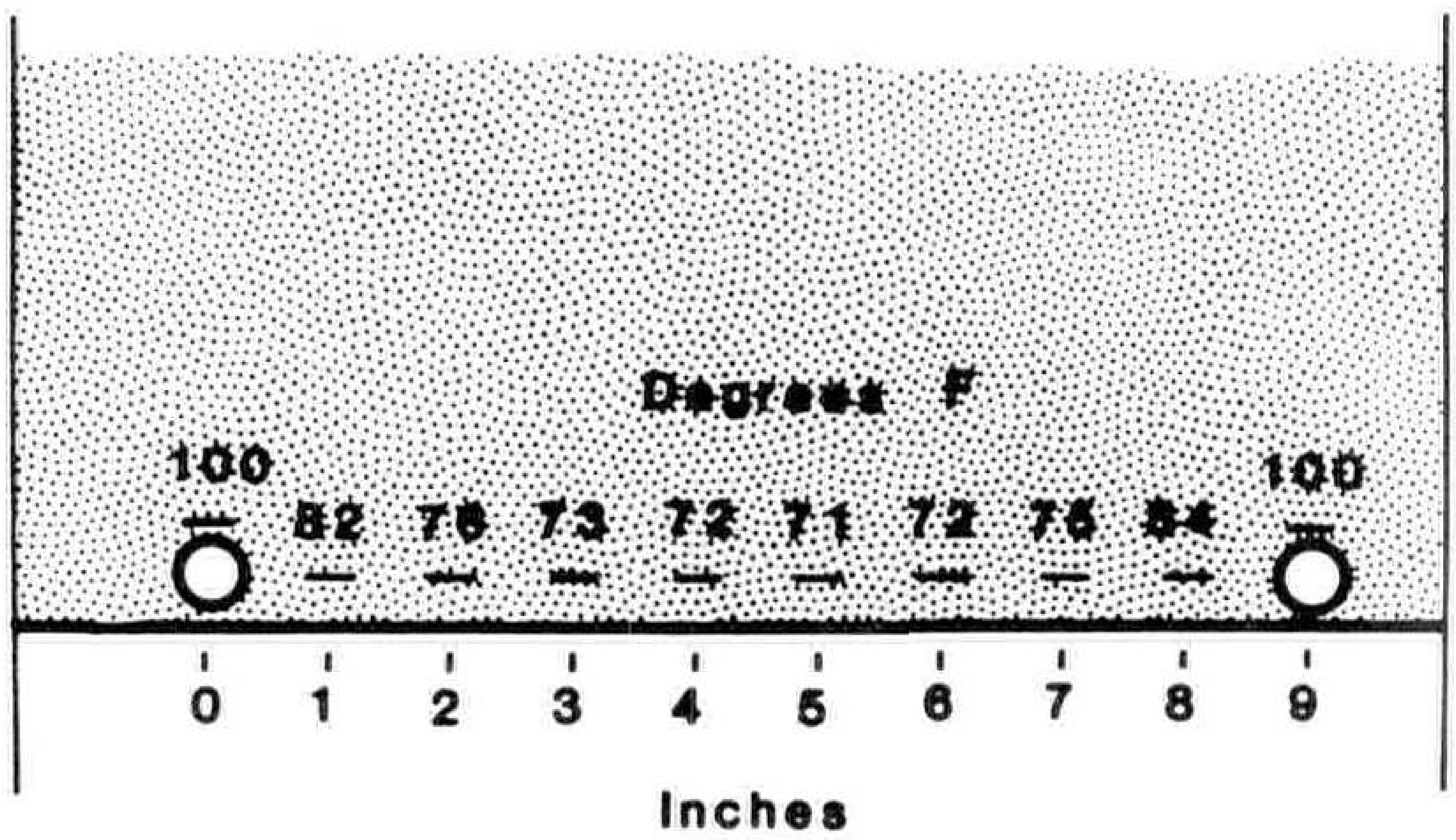

Figure 1. Temperature gradient at pipe level between ½-inch PVC warm water pipes in a propagation bench filled with 4 inches of moist peat moss.

Since most root-zone heating systems in Florida are installed in benches or beds for growing free-standing potted plants, greater efficiency of warming soil in these pots, particularly those spaced on wide centers, can be achieved through chambering techniques to reduce the rate of heat transfer to upper levels of greenhouse (7).

Initial studies in 1980 involved nightly measurements of temperature gradients in 6 in. standard plastic pots filled with Metro-Mix 500 in a greenhouse (7). Figure 2 illustrates the pattern of temperatures recorded in three treatments: 1) non-bottom heated, 2) bottom heated, and 3) bottom heated with chamber around the pot. Bottom heating without the chamber simulated bottom heating as practiced by many growers in northern United States and Europe. There was benefit in bottom heating this way (Treatment 2) because the mean soil temperature was 10°F above non-bottom heated soil. Additional benefit was realized when a chamber was used in conjunction with bottom heating (Treatment 3), with an additional 8°F rise in soil temperature with no additional energy expenditure.

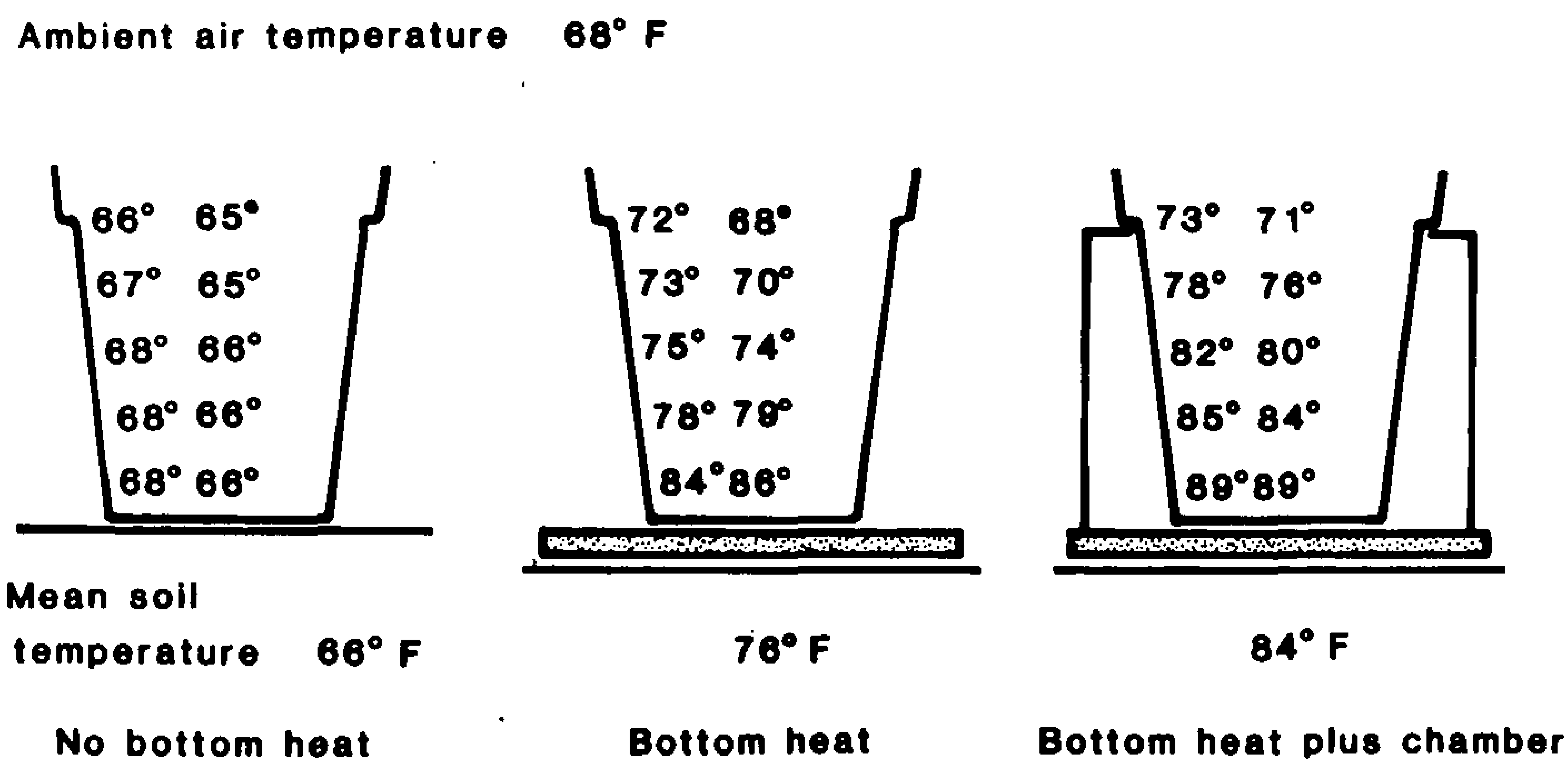

Figure 2. Soil temperature gradients measured in 6-inch pots exposed to no bottom heat, bottom heat, and bottom heat plus a chamber.

MATERIALS AND METHODS

The following work was conducted to determine the effects of chambering 6-in. potted *Aglaonema* 'Silver Queen', which were grown on raised benches equipped with a warm water bottom-heating system. The experiment was conducted in a fiberglass-covered greenhouse lined with 4-mil polyethylene film at Melco Nurseries, Inc., Apopka, during autumn-spring, 1981-1982. Air temperature within the greenhouse was maintained at a minimum of 65°F through use of gas-fired, forced-air unit heaters.

The warm water system used for bottom heat consisted of a hydronic boiler, hot water circulating pump, a network of plastic pipe, and a thermostat with thermocouple to control the circulating pump based on temperature in the pots. A 266,000 BTU liquid propane-fired Raypak hydronic boiler supplied warm water to 17 benches, 5 ft × 64 ft, a total of 5440 ft^2 of actual surface for growing. There were 17 other benches in the same greenhouse range that were not bottom heated. Water was distributed to the benches in PVC pipe ranging from 1- to 2-in. diameter, with 1-in. headers at ends of each bench. Water was transported through 7 16-mm diameter polybutylene pipes positioned on 15-in. spacing between each row of pots running the bench length. Black polypropylene ring clamps secured the pipe to the header adapters.

A ½-hp Craine-Deming pump, model 4353, was used to circulate water through the system upon signal from a Penn thermostat plus thermocouple with an 8-ft. lead used to monitor soil temperature in one pot. The thermostat turned the circulator on as the medium reached 70°F and off at 73°F. The boiler operated only when water was circulated through the system and modulated its fuel consumption downward to 25% of full capacity, depending upon the energy required to reheat the return water.

The warm-water system was installed on existing wire-fabric-covered benches, which were modified slightly through placement of clear, corrugated, 4-oz. fiberglass over the wire fabric to increase bench top rigidity and reduce heat loss through the bottom.

The experiment consisted of 5 treatments: 1) no bottom heat; 2) bottom heat with water pipes exposed without a chamber; 3) bottom heat plus a molded plastic chamber; 4) bottom heat plus a chamber constructed of ¾-in. thick wooden sideboards mounted 6 in. high with 6-mil black polyethylene straps attached across the top, running both the width and length of the chamber to form square openings for pot insertion; and 5) bottom heat and wooden sideboard chamber plus a series of square 3/32-in. thick Microfoam squares, approximately 13 × 13 in., which had a 4-in. diameter hole in the center. The squares rested on the upper pot rim and overlapped the sideboards and adjacent squares to form a chamber. Each treatment consisted of 2 blocks of 24 plants each, with 10 pots used for physical measurements from each treatment.

November 17, 1981, four *Aglaonema* 'Silver Queen' cuttings were stuck per 6-in. standard, white, polypropylene pot containing a medium of peat moss, perlite, and vermiculite in a 2:1:1 ratio by volume. The plants were harvested March 18, 1982, at which time the most developed plants were considered salable. Plants were watered overhead as needed with Dram spray stakes and fertilized with Scotts ProGrow (25-10-10) at the rate of 7 grams per 6-in. pot applied 4 weeks after sticking. Greenhouse light levels were approximately 2000 ft.-c during the experiment.

Temperatures were recorded with an Esterline Angus multipoint recorder equipped with welded copper-constantan thermocouples. Temperatures were measured inside the greenhouse at plant canopy height, in the potting medium, between the pots at sidewall level and outside the greenhouse.

RESULTS

Temperatures were recorded at several positions inside and outside the greenhouse at 7:00 a.m. on February 14, 1982 (Table 1). Bottom heat without a chamber raised the root-zone temperature appoximately 6°F over that of the control. When a pot chambering system was added, an additional 4 to 5°F was gained in the root zone without additional heat energy input. Temperatures in the soil differed only slightly between the different types of chambers. Temperature at the top of the plant canopy over the heated chambers was about 2°F higher then the canopy temperature of control plots.

Table 1. Influence of bottom heat and chambering systems on soil temperatures in 6-inch pots of *Aglaonema* 'Silver Queen'.

Treatment and location	Temperature[z]	
	°C	°F
No bottom heat (control)		
In pot	18.3	64.9
In chamber	17.9	64.2
Over plant canopy	17.7	63.9
Bottom heat (no chamber)		
In pot	21.5	70.7
Between pots	21.2	70.2
Bottom heat + molded plastic chamber[y]		
In pot	24.4	75.9
In chamber	25.0	77.0
Over plant canopy	19.0	66.2
Bottom heat + strap chamber		
In pot	24.4	75.9
In chamber	25.0	77.0
Bottom heat + pot collar chamber		
In pot	23.7	74.7
In chamber	24.4	75.9
Outside greenhouse	5.2	41.4

[z] Temperatures were recorded 7:00 a.m., 2/14/82 at Melco Nurseries, Inc.
[y] Chambers were manufactured by Kenergy Corporation, Orlando, Florida.

Table 2. Growth of *Aglaonema* 'Silver Queen' as influenced by bottom heating techniques.[z,y]

Treatment	Plant ht. (cm)	Fresh wt. of shoot growth 1 pot (g)	New leaves 1 pot (no.)	Dead and Chlorotic leaves/pot (no.)	Root fresh wt/pot (g)
No bottom heat (control)	36.0	66.7	14.8	0.8	15.1
Bottom heat (no chamber)	38.0	86.5	18.6	2.5	24.3
Bottom heat + molded chamber[x]	42.2	101.5	18.3	1.9	21.3
Bottom heat + strap chamber	37.3	86.0	17.1	2.7	21.5
Bottom heat + pot collar chamber	38.8	95.2	18.8	2.7	24.4

[z] Plants harvested from Melco Nurseries, Inc. and measured 3/18/82.
[y] Values expressed are the means of 10 experimental units from each treatment.
[x] Chambers were manufactured by Kenergy Corporation, Orlando, Florida.

There were differences in shoot and root growth of *Aglaonema* as influenced by the bottom-heated treatments (Table 2). Plants which received supplemental bottom heat had considerably more shoot and root growth than non-bottom-heated plants. They also reached salable size 10 weeks earlier than the control. There was slightly less basal leaf loss on non-bottom-heated plants than those receiving bottom heat.

DISCUSSION

Growth of *Aglaonema* 'Silver Queen' in all bottom-heated plots was significantly greater than that of the control. Lack of growth responses to chambered treatments over the non-chambered, bottom-heated treatment is explained by close pot spacing; wide spreading overlap of plant canopy, which created a chamber, and high ambient greenhouse air temperatures maintained by the backup, forced air heaters. The slightly greater lower leaf loss of bottom-heated plants was due to the increased rate of moisture loss from cuttings before roots penetrated the soil mix.

All pot-chambering techniques examined in this study demonstrated the value of utilizing a chamber of some type to create warmer and more uniform soil temperatures within a containerized potting medium. The ultimate in bottom heating technology will be achieved when chambering techniques permit the grower to maintain the desired combination of temperatures in the root medium and plant canopy for specific crops and stages of the crop cycle. This usually requires one system for bottom heating and another for space heating in greenhouses.

Nurserymen should evaluate growth responses of specific crops to bottom heat before investing in elaborate bottom heating equipment. This can be done on a small scale with electrical resistance heating mats plus a thermostat-thermocouple control unit (9,10).

We feel there is a bright future for refined bottom-heating systems in greenhouses to enhance rooting and growth of selected crops. Emphasis should be given to crops which are: 1) high value; 2) responsive to warm soils; and 3) in demand when growth is slow due to a cool root medium.

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PROPAGATION OF *JUNIPERUS CHINENSIS* 'TORULOSA' USING BOTTOM HEAT

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Abstract. The propagation of torulosa juniper, *Juniperus chinensis* 'Torulosa' (*J. chinensis* 'Kaizuka'), in the Florida climate has long presented a problem. Whether this be a climate problem, stock selection, or procedure, has not in the past been determined to any degree of consistency. However, general opinion seems to suggest that bottom heat would be the most conclusive single factor contributing to successful propagation of this plant. It was fully realized at the onset of this experiment at Tampa Wholesale Nursery that bottom heating was not a new process, neither were we pioneering any radically new or innovative techniques for providing the heat. The specific purpose was to design and implement a system that would provide a functional, economical means of producing liners for this operation, as well as to add to existing knowledge of techniques and procedures for propagation of this plant.

REVIEW OF LITERATURE

Determinations of the overall system design were done by evaluating information provided by Dr. R. W. Henley, Extension Specialist in the Ornamental Horticulture Department of the University of Florida, evaluating written descriptions of other existing systems, and from personally evaluating existing operating systems. Initial concerns were that the system design and function be developed in direct coordination with physical facilities into which it was to be built. In addition, this system