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RESPONSE OF FOUR FOLIAGE PLANTS TO HEATED SOIL AND REDUCED AIR TEMPERATURES[1]

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Abstract. **Tip cuttings of** Dieffenbachia maculata **(Lodd.) G. Donn 'Exotic Perfection Compacta' and** Aglaonema commutatum **Schott 'Silver Queen' and single eye cuttings of** Epipremnum aureum **(Linden and Andre) Bunt, and** Philodendron scandens oxycardium **(Schott) Bunt. were propagated in combinations of 4 minimum air temperatures, 45°, 50°, 55° and 60°F (7.2°, 10°, 12.7°, 15.5°C), and 2 soil temperature treatments; controlled 70°F (21°C) minimum and variable. Maintaining minimum soil temperatures at 70°F reduced production times for rooted** Dieffenbachia **and** Aglaonema **tips by 45% and of** Epipremnum **and** Philodendron **suitable for 3 inch pots by 35% and 25%, respectively, regardless of minimum air temperature. Minimum air temperature had little effect on** Dieffenbachia **or** Aglaonema **root number and length at 70°F soil temperature. Similarly shoot length and number of leaves of** Philodendron **and** Epipremnum **were not affected by minimum air temperatures with 70°F soil temperature. Plant quality was uniformly high in all crops at the 70°F soil minimum for all air temperatures except** Epipremnum **which was chlorotic at 45°F.**

A description of a warm water in-bench heating system is included.

Central Florida tropical foliage plant nurserymen heat their greenhouses in winter to maintain production for the lucrative mid-winter and spring market. Before the fuel crises of the early and late 1970's, a 70°F minimum night temperature was the standard practice in the Apopka-Lake County area. Space heating equipment, fired by then cheap liquid propane (LP) or number 2 fuel oil, was widely used to provide supplemental heating because of its low cost and adaptability. By 1978 LP and number 2 fuel prices were surging upward and growers responded by reducing thermostat settings. The current minimum temperature recommendation for tropical foliage plant production is 65°F but a 1980 survey indicated 72% of central Florida growers responding maintained 60°F or less (4). A 60°F air temperature from space heating results in soil temperatures in the mid to upper 50's (1). At temperatures less than 65°F production schedules of many tropical foliage varieties lengthen. Growers report that normally 3 inch *Philodendron* can be produced in 8 to 9 weeks at 65 to 70°F but 12 to 13 weeks are required at 60°F minimum, *Aglaonema* 'Silver Queen' tips root within 40 days at 70° but take twice as long at 60°F. Yet it is no longer economically feasible to heat greenhouses to 70°F. It was under these circumstances that warm water soil heating was evaluated.

Several papers have been written discussing the beneficial effects of soil heating on plant growth (1, 2, 3, 5, 6). This experiment was conducted to determine if maintaining soil at a 70°F minimum temperature could overcome the growth retarding effects of reduced minimum night air temperatures and to determine the lowest air temperature in combination with 70°F minimum soil temperature under which certain cold sensitive tropical foliage plants could be produced without sacrificing quality and turnover time.

Materials and Methods

The Lake County Vocational-Technical Center greenhouse was divided into 4 quadrants, each with its own natural gas fired space heater and thermostat. One of four minimum air temperature treatments, 45°, 50°, 55° and 60° was assigned to each quadrant. A 20 foot (6.1 m) section of 1 raised bed per quadrant was outfitted with the warm water soil heating apparatus and heated beds in all 4 quadrants were connected to central water heating and pumping units (a description of the system follows below). Soil temperature was maintained at or above 70°F. The remaining 10 feet of each bed was left unheated and soil temperature varied with air temperature. Tip cuttings of *Dieffenbachia* 'Exotic Perfection Compacta' and *Aglaonema* 'Silver Queen' and single eye cuttings of *Philodendron scandens oxycardium* and *Epiprenum aureum* were planted in blocks in heated and unheated sections of the bed on January 23, 1981. Verlite Company's Vergro Container Mix was used as the propagating medium and cuttings were under intermittent mist (5 sec/30 min, 8 hr/day). Data gathered from *Dieffenbachia* and *Aglaonema* include; time to first visible roots, number and length of roots at weekly intervals on 10 plants and quality of the finished product at harvest and from *Philodendron* and *Epipremnum;* stem length and number of leaves on 10 plants at monthly intervals and plant quality rating at harvest.

The warm water soil heating design used in this study was similar to designs presently in use by innovative central Florida nurseries. A 45,000 BTU natural gas fired water heater warmed water to 110° to 115°F. A Bell and Gossett 1/6 horsepower pump moved warm water from the water heater through a 2 inch PVC main to the beds. A 1 inch PVC riser carried warm water to bed height where the flow was diverted through a series of 3/4 inch black plastic radiating pipes. Radiating pipes were spaced 6 inches (15.24 cm) apart and carried warm water down the bed to the return main. Water was then channelled back to the water heater to complete the circuit. A thermostat measuring soil temperature controlled the pump and water temperature was thermostatically controlled at the water heater.

Temperatures were recorded on representative cold and warm nights at multiple positions in each quadrant including; warm soil, cool soil, crop canopy and ambient air at 18 inches (45.7 cm) above the bed. An Esterline Angus multipoint data acquisition system with welded copper-constanton thermocouples was used to collect temperatures.

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Results and Discussion

The warm water soil heating design used in this experiment was capable of maintaining a 70°F minimum soil temperature in the 4 minimum air temperature quadrants. Soil temperatures in non-heated soil varied with ambient air temperature and, in the higher air temperature treatments, reflected ambient air temperature after a 2 to 3 hour lag period. Temperature differential between heated and unheated soil approached 20°F (9.4°C) in the 45°F quadrant and 16°F (7.5°C) in the 60°F quadrant (Figures 1, 2).

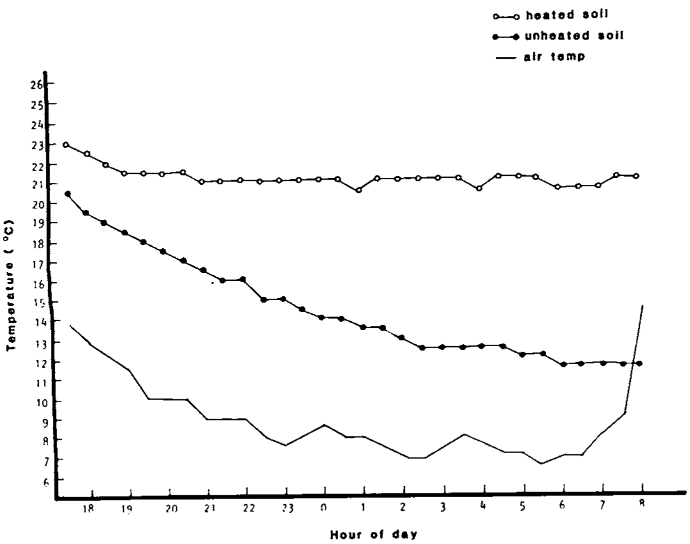

Fig. 1. Effect of warm water soil heating on soil temperatures in the 45°F (7.2°C) minimum air temperature quadrant, February 4, 5, 1981.

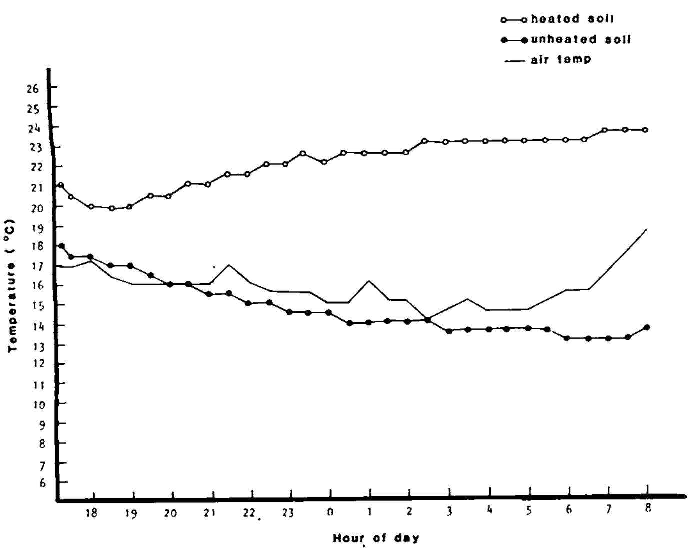

Fig. 2. Effect of warm water soil heating on soil temperatures in the 60°F (15.5°C) minimum air temperature quadrant, February 4, 5, 1981.

Heating soil to 70°F minimum stimulated root development in *Dieffenbachia* and *Aglaonema* and shoot and leaf development in *Philodendron* and *Epipremnum* despite the relatively low air temperatures.

Dieffenbachia 'Exotic Perfection Compacta'. *Dieffenbachia* tip cuttings planted in warm soil struck roots in 4 days regardless of minimum air temperature compared to 10 days for cuttings stuck in the variable soil temperature plots. Roots grew more rapidly in warmed soil compared to unheated soil. Minimum air temperature had little effect on root number or length at 70°F minimum soil temperature (Tables 1, 2). Similarly, plant quality was not affected by minimum air temperatures when soil heating was provided (Table 3).

Table 1. Effect of soil and air temperature on root number of *Dieffenbachia* "Exotic Perfection Compacta" tip cuttings.

Min air temp	45°	50°	55°	60°
		70°F min soil temp		
Date				
23 Jan	0	0	0	0
30 Jan	5.2 (1.7)[z]	4.1 (1.7)	3.9 (2)	4.6 (1.5)
6 Feb	8.6 (1.8)	7.4 (1.4)	8.0 (1.2)	7.8 (1.5)
11 Feb	9.7 (1.7)	9.0 (1.6)	10.0 (2.5)	10.5 (1.3)
		Variable soil temp		
Min air temp	45°	50°	55°	60°
Date				
23 Jan	0	0	0	0
30 Jan	0	0	0	0
6 Feb	0	0	0	0
13 Feb	3.8 (1.9)	1.9 (1.8)	2.8 (1.3)	5.6 (2.8)
20 Feb	10.8 (2.4)	14.8 (3.5)	14.8 (4.6)	11.7 (2.3)
6 Mar	14.1 (2.0)	11.1 (3.1)	12.2 (5.6)	12.4 (6.4)

[z]Numbers in parenthesis are standard deviations.

Table 2. Effect of soil and air temperature on root length (mm) of *Dieffenbachia* "Exotic Perfection Compacta" tip cuttings.

Min air temp	45°	50°	55°	60°
		70°F min soil temp		
Date				
23 Jan	0	0	0	0
30 Jan	6.5 (2)[z]	5.2 (2.1)	6.2 (1.9)	7.0 (3.2)
6 Feb	34.8 (9.4)	29.0 (6.2)	38.5 (6.2)	36.2 (10)
11 Feb	58.8 (9.6)	50.6 (7.2)	68.9 (13.1)	60.8 (10.2)
		Variable soil temp		
Min air temp	45°	50°	55°	60°
Date				
23 Jan	0	0	0	0
30 Jan	0	0	0	0
6 Feb	0	0	0	0
13 Feb	1.7 (.9)	1.4 (.4)	2.1 (.9)	3.7 (5.6)
20 Feb	17.1 (4.8)	14.4 (9.3)	18.5 (4.8)	18.8 (4.7)
6 Mar	61.0 (10)	45.4 (10.9)	65.9 (12.8)	44.2 (10.4)

[z]Numbers in parenthesis are standard deviations.

Table 3. Effect of soil and air temperature on plant quality of four foliage plants at harvest.[z]

Min air temp	45°	50°	55°	60°
		70°F min soil temp		
Crop				
Dieffenbachia	4.0	4.0	4.5	4.0
Aglaonema	4.0	4.0	4.0	4.5
Philodendron	4.0	4.0	4.3	4.5
Epipremnum	2.5	3.5	3.5	4.0
		Variable soil temp		
Min air temp	45°	50°	55°	60°
Crop				
Dieffenbachia	3.0	3.0	3.5	4.0
Aglaonema	2.0	2.5	2.5	4.0
Philodendron	3.0	3.0	3.3	3.5
Epipremnum	2.0	2.5	3.0	3.5

[z]Plant quality scale 1-5 with 5 = best and 1 = worst.

Aglaonema 'Silver Queen'. Tip cuttings struck roots in 18 days and were harvested at 38 days when soil heating was provided at all minimum air temperatures while cuttings in non-soil heated plots took 35 days to strike roots and were not harvested until 71 days. Roots grew more rapidly in warmed soil compared to unheated soil. Minimum air temperature had little effect on root number or length at 70°F minimum soil temperature (Tables 4, 5). Plant quality was not affected by minimum air temperature when soil heating was provided (Table 3).

Table 4. Effect of soil and air temperature on root number of *Aglaonema* "Silver Queen" tip cuttings.

Min air temp	45°	50°	55°	60°
	70°F min soil temp			
Date				
23 Jan	0	0	0	0
30 Jan	0	0	0	0
6 Feb	0	0	0	0
13 Feb	7.2 (5.9)[z]	6.7 (4.2)	9.3 (3.1)	5.5 (3.2)
20 Feb	20.0 (5.5)	14.2 (5.4)	14.1 (6.4)	12.5 (5.9)
4 Mar	26.8 (7.8)	26.4 (7.2)	28.1 (5.4)	23.6 (6.3)
	Variable soil temp			
Date				
23 Jan	0	0	0	0
30 Jan	0	0	0	0
6 Feb	0	0	0	0
13 Feb	0	0	0	0
20 Feb	0	0	0	0
4 Mar	2.4 (1.6)	1.5 (.92)	1.0 (1.2)	1.2 (.8)
17 Mar	9.3 (4.4)	1.2 (1.2)	6.6 (3.2)	2.3 (3.2)
3 Apr	10.5 (5.1)	2.5 (2.7)	9.6 (4.8)	6.4 (4.1)

[z]Numbers in parenthesis are standard deviations.

Table 5. Effect of soil and air temperature on root length (mm) of *Aglaonema* "Silver Queen" tip cuttings.

Min air temp	45°	50°	55°	60°
	70°F min soil temp			
23 Jan	0	0	0	0
30 Jan	0	0	0	0
6 Feb	0	0	0	0
13 Feb	3.7 (1.4)	2.1 (1.7)	3.8 (2.4)	1.7 (1.8)
20 Feb	17.0 (6.4)	6.0 (3.2)	12.4 (9.9)	10.2 (5.4)
4 Mar	47.5 (19.8)	41.0 (10.3)	43.8 (11.0)	37.5 (10.1)
	Variable soil temp			
Date				
23 Jan	0	0	0	0
30 Jan	0	0	0	0
6 Feb	0	0	0	0
13 Feb	0	0	0	0
20 Feb	0	0	0	0
4 Mar	2.1 (3.4)	0.8 (.4)	1.6 (4.8)	0.8 (6.5)
17 Mar	6.1 (2.8)	1.2 (1.3)	4.7 (2.6)	1.7 (2.9)
3 Apr	18.9 (10.4)	4.1 (4.5)	14.8 (4.2)	10.4 (5.8)

[z]Numbers in parenthesis are standard deviations.

Philodendron scandens oxycardium and *Epipremnum aureum*. Single eye cuttings of both crops planted in heated soil on January 23, 1981 were harvested as plants suitable for 3 inch pots at 9 weeks in all minimum air temperature treatments. *Philodendron* cuttings planted on the same date in non-heated soil reached the same stage of development 12 weeks after sticking and *Epipremnum* 14 weeks after sticking. Minimum air temperature had little effect on shoot length in either crop (Tables 6, 7). *Epipremnum* leaf number was not affected by minimum air temperature (Table 8) but *Philodendron* leaf number did vary (Table 9). Minimum air temperature had little effect on *Philodendron* plant quality at harvest when soil heating was provided (Table 3). However, *Epipremnum* grown at 45°F minimum was chlorotic (Table 3).

Table 6. Effect of soil and air temperature on shoot length (mm) of *Philodendron scandens oxycardium* single eye cuttings.

Min air temp	45°	50°	55°	60°
	70°F min soil temp			
Date				
23 Jan	0	0	0	0
20 Feb	34.5 (13.2)[z]	26.2 (11.5)	13.8 (7.2)	29.8 (12.3)
27 Mar	80.5 (18.4)	76.9 (14.9)	73.5 (18.2)	84.4 (23.1)
3 Apr	90.2 (25.3)	106.4 (16.2)	82.1 (31.6)	84.0 (20.6)
	Variable soil temp			
Date				
23 Jan	0	0	0	0
20 Feb	5.6 (2.0)	6.0 (3.4)	5.5 (2.5)	6.3 (2.7)
27 Mar	46.4 (13.3)	31.4 (22.5)	37.4 (12.0)	29.5 (13.9)
3 Apr	34.4 (6.5)	40.0 (12.4)	36.2 (8.1)	28.3 (7.6)

[z]Numbers in parenthesis are standard deviations.

Table 7. Effect of soil and air temperature on shoot length (mm) of *Epipremnum aureum* single eye cuttings.

Min air temp	45°	50°	55°	60°
	70° min soil temp			
Date				
23 Jan	no shoot developed			
20 Feb	35.3 (11.7)[z]	7.7 (8.8)	31.5 (12.3)	45.0 (2.1)
27 Mar	99.5 (26)	103.1 (36)	112.5 (28.7)	60.3 (25)
3 Apr	93.6 (25.5)	116.0 (30.4)	91.1 (27.6)	94.4 (19.7)
	Variable soil temp			
Date				
23 Jan	no shoot developed			
20 Feb	12.8 (4.0)	5.7 (4.6)	17.2 (17.8)	15.7 (12.6)
27 Mar	29.9 (13.0)	22.7 (8.1)	20.8 (9.0)	31.5 (9.0)
3 Apr	30.7 (8.0)	23.5 (13.1)	25.0 (17.1)	19.0 (4.9)

[z]Numbers in parenthesis are standard deviations.

Table 8. Effect of soil and air temperature on leaf number of *Epipremnum aureum* single eye cuttings.

Min air temp	45°	50°	55°	60°
	70° min soil temp			
23 Jan	no new leaves			
20 Feb	no new leaves			
27 Mar	3.1 (.8)[z]	2.5 (.6)	2.3 (.6)	2.3 (.46)
3 Apr	3.0 (.4)	3.1 (.54)	3.0 (.45)	3.0 (0)
	Variable soil temp			
23 Jan	no new leaves			
20 Feb	no new leaves			
27 Mar	0.6 (.31)	0.6 (.31)	0.7 (.40)	0.0
3 Apr	1.0 (.77)	0.6 (.49)	1.1 (.3)	0.2 (.4)
8 May	2.0 (.54)	1.4 (.42)	2.0 (.41)	1.1 (.46)

[z]Numbers in parenthesis are standard deviations.

Table 9. Effect of soil and air temperature on leaf number of *Philodendron scandens oxycardium* single eye cuttings.

		70° min soil temp		
Min air temp	45°	50°	55°	60°
Date				
23 Jan		no new leaves		
20 Feb		no new leaves		
27 Mar	1.4 (.64)[z]	1.2 (.4)	0.6 (.66)	0.9 (.54)
3 Apr	1.6 (.49)	1.5 (.5)	0.8 (.4)	1.9 (.83)
		Variable soil temp		
Min air temp	45°	50°	55°	60°
23 Jan		no new leaves		
20 Feb		no new leaves		
27 Mar		no new leaves		
3 Apr	0.2 (.4)	0.4 (.49)	0.3 (.46)	0.6 (.49)
24 Apr	1.2 (.37)	1.7 (.27)	1.6 (.44)	2.0 (.35)

[z]Numbers in parenthesis are standard deviations.

Results of these experiments indicate high quality foliage plants can be produced at reduced air temperatures if soil heating is provided. Warm water soil heating to 70°F minimum reduced winter production time for rooted *Dieffenbachia* and *Aglaonema* tips by 45% and for *Epipremnum* and *Philodendron* suitable for 3 inch pots by 35% and 25%, respectively, at the minimum air temperatures tested. Data showed that even cold sensitive crops such as *Epipremnum* and *Aglaonema* respond to soil heating without evident chilling damage despite being subjected to air temperatures known to inflict damage. Based on these results, growers who wish to maximize fuel efficiency and increase winter production of tropical foliage might experiment with 50°F minimum air temperature and 70 to 75°F minimum soil temperatures.

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DOLOMITE AND FLUORIDE AFFECT FOLIAR NECROSIS OF CHAMAEDOREA SEIFRIZII AND CHRYSALIDOCARPUS LUTESCENS[1]

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Additional index words. tipburn, superphosphate, palm.

Abstract. **Experiment 1, a 5 x 3 factorial, was conducted with 5 fluoride (F) variables, 0, 68, or 136 mg F from 20% single superphosphate or 34 or 68 mg F from NaF/15 cm pot, and 3 dolomite levels, 0, 3, or 6 kg/m³. Three 2-3 leaf seedlings of** Chamaedorea seifrizii **Burret. or** Chrysalidocarpus lutescens **H. Wendl./15 cm pot was used as an experimental unit. Foliar necrosis and leaf F content were evaluated 5 months after experiment initiation. Plants in media containing superphosphate had the most necrosis but additions of NaF to the medium did not produce necrosis. Plants in media containing dolomite had the least necrosis and tissue F. Additions of superphosphate and NaF had little effect on soil pH or electrical conductivity. Dolomite increased pH, but did not alter electrical conductivity. Experiment 2 was conducted with 2 F sources, 20% SP and NaF, at 34 mg F/15 cm pot, and 0 or 4 kg dolomite/m³. Pots were filled with same medium as in Experiment 1 and no plants were utilized. Medium was leached every 1, 5, 8, and 11 days. Leachate was analyzed for F content. Dolomite greatly decreased soluble F.**

Chamaedorea seifrizii (reed palm) and *Chrysalidocarpus lutescens* (areca palm) are two of the more popular palms used for interiorscaping. Palms are produced from seed and are salable as soon as the first true leaf appears; however, palms used for interiorscaping are much larger.

Foliar tipburn and necrosis is a major production problem with these palms. Fluoride induced damage has been reported on parlor palm (*Chamaedorea elegans* Mart.) (2), and tip necrosis of areca palm has been attributed to high soluble salts levels (4). After the tips become necrotic, necrosis sometimes enlarges and entire leaflets of the areca and seifrizii palms collapse. Necrotic spotting in lower areas of the leaflets is often associated with the tipburn. Since research (2) indicated foliar necrosis and tipburn of parlor palm was related to the amount of fluoride (F) found in foliar tissue, an experiment was conducted to determine if dolomite and F in 20% superphosphate (20% SP) or sodium fluoride (NaF) influenced foliar necrosis of areca and seifrizii palm.

Materials and Methods

Experiment 1

A 5 x 3 factorial experiment in a randomized block design included 5 F variables, 0, 68, or 136 mg F from 20% SP incorporated/15 cm pot (about 0, 3, or 6 kg 20% SP/m³) or 34 or 68 mg F from NaF/15 cm pot (F equivalent to 1.5 or 3 kg 20% SP/m³), and 3 dolomite levels, 0, 3, or 6 kg/m³. The experiment was initiated July 16, 1980, with 2-3 leaf seedlings in a medium of peat:builder's sand (3:1 by volume) containing 1 kg Perk/m³. Three seedlings/15 cm diameter pot was the experimental unit for each species. There were 4 replications with reed palm and 8 with areca. Plants were placed in a glass greenhouse shaded to receive

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