Proc. Fla. State Hort. Soc. 97:280-282. 1984.

INFLUENCE OF TEMPERATURE AND DURATION ON SIMULATED SHIPPING OF SMALL POTTED FOLIAGE PLANTS[1]

Charles A. Conover and Richard T. Poole[2]
University of Florida, IFAS,
Agricultural Research and Education Center,
2807 Binion Road, Apopka, FL 32703

Additional index words. Aphelandra, Epipremnum, Maranta, Nephrolepis, Philodendron, Pilea, Syngonium.

Abstract. **Seven foliage plant genera,** Aphelandra, Epipremnum, Maranta, Nephrolepis, Philodendron, Pilea, **and** Syngonium **were grown to salable size in 10-cm pots. Plants were then placed under simulated shipping conditions of 10, 13, 16, or 19°C for 7, 14, 21, or 28 days prior to placement in a low light interior environment. Plants were graded at time of removal from shipping containers and again 2 weeks later. Plant grade decreased as simulated shipping time increased for all genera, with 14 days being maximum for quality retention of most plants. Highest grades for most genera were maintained when plants were shipped at 13 or 16°C.**

Interest in long-term shipping of foliage plants has increased during the last several years due to market development in Europe (7) and other areas. Most foliage plants shipped to Europe are in pot sizes of 20 cm or larger and from 0.5 to 2 m in height. Research on long-term shipping, simulated shipping or storage has been conducted on foliage plants in 15-cm or larger diameter containers for durations of up to 28 days (3, 5, 6). Poole, et al. (8, 9) and ben-Jaacov, et al. (1, 2) examined potential for shipping large foliage plants and found that a temperature range between 13 and 16°C was best for most genera. They also found that most genera tested could tolerate simulated shipment for 2 to 4 weeks. Based on observations made during the Floriade shipments (3) and of research (1, 8, 9), Conover and Poole published a suggested list of shipping temperatures and durations for 36 genera (6). Plants listed did not include many of the more important smaller foliage plants grown by the foliage industry (11). This paper reports results of research established to determine whether foliage plants grown and sold in smaller pot sizes could survive long-term simulated shipment.

Materials and Methods

Seven foliage plant species including *Aphelandra squarrosa* Nees. 'Dania', *Epipremnum aureum* Bunt., *Maranta leuconeura* E. Morr., *Nephrolepis exaltata* Schott. 'Bostoniensis', *Philodendron scandens oxycardium* Bunt., *Pilea pubescens* Liebm. 'Silver Tree' and *Syngonium podophyllum* Schott. 'White Butterfly' were obtained from commercial growers in 7.5-cm pots or as rooted cuttings and potted in 10-cm pots August 10, 1983. The potting medium was composed of sedge peat: pine bark: cypress shavings 2:1:1 v/v/v amended with 0.7 kg Micromax and 4.2 kg dolomite/m^3. Plants were grown in a glasshouse under recommended light and nutritional regimes (4), irrigated 3 times per week and provided temperatures between 18 and 32°C.

Treatment variables were factorialized and included 4 temperatures, 10; 13; 16; and 19°C, and 4 simulated shipping durations, 7; 14; 21; and 28 days. Treatments were replicated 6 times and experimental units were single 10-cm pots. Treatments were initiated October 12, 1983 when plants to be shipped for 4-week durations were placed in dark coolers to simulate shipping with other treatments following every 7 days. Plants were held in standard non-waxed cardboard boxes which were closed to maintain a humidity level of 85 ± 10% and treatment temperatures within ± 1°C.

All plants were removed from simulated shipping November 9, 1983 and placed in interior rooms with a light intensity of 15 μmol m^{-2}sec^{-1} from Cool White fluorescent lamps for 12 hr daily, temperature of 25 ± 1°C, relative humidity of 60 ± 10% and irrigations as needed (usually 1 or 2 times per week) for evaluation.

Plants were graded at time of removal from simulated shipping and again 2 weeks later, grades were 1 = poor not acceptable, 3 = good, acceptable and 5 = excellent quality, highly acceptable.

Results and Discussion

Plant quality overall at time of removal from simulated shipping was similar to that 2 weeks later. Since most foliage plants require a period of reestablishment after long-term shipping to assume normal shape after being packed for long periods, selection of data taken after a 2-week recovery period appeared most appropriate. Plant quality decreased linearly for *Aphelandra, Maranta,* and *Syngonium* as storage temperature increased, indicating that best quality could be maintained at 10 or 13°C (Table 1). Reductions in plant quality for these genera were associated mainly with lower leaf loss that could have been caused by carbohydrate depletion due to high respiration rate or possibly ethylene evolution. Increasing storage temperature was both linear and quadratic on *Philodendron,* with 13°C best for quality maintenance (Table 1). However, 19°C reduced plant quality of *Philodendron* and may have been caused by ethylene damage as reported on *Philodendron* by Marousky (10).

Temperature indicated a quadratic response on *Epipremnum, Nephrolepis* and *Pilea,* with both 13 and 16°C providing best plant quality (Table 1). Reduction in quality for *Nephrolepis* was mainly because of tip burn; while 10°C caused chilling damage on *Epipremnum* and *Pilea* and leafdrop was increased at 19°C for both genera.

There was a linear decrease in plant quality for all genera with time, although all genera tested tolerated simulated shipping for 14 days without large losses in plant quality. Except for *Aphelandra,* all other genera were commercially unacceptable after 28 days simulated shipment, which is in contrast with acceptable quality for most large foliage plant genera tested previously (3, 6, 8).

Comparing grade losses due to shipping duration across the genera tested shows some interesting trends. *Aphelandra* had the smallest decrease in quality (0.9 of a grade) with increased duration as compared to the other genera. Both *Nephrolepis* and *Maranta* (Fig. 1) lost about 2.5 grades, or more than 50% of total quality after 28 days of simulated shipment, with other genera losing 1.0 to 2.0 grades. Small foliage plants utilized in these experiments tolerated only 7 to 14 days of simulated shipment without large losses in plant grade, although careful selection of shipping temperature could partly compensate for long

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[1] Florida Agricultural Experiment Stations Journal Series No. 5883.

[2] Professor and Center Director, Professor and Plant Physiologist, respectively.

Table 1. Effect of simulated shipping temperatures and durations on foliage plant quality.

Treatment	*Aphelandra squarrosa*	*Epipremnum aureum*	*Maranta leuconeura*	*Nephrolepis exaltata* '*Bostoniensis*'	*Philodendron scandens oxycardium*	*Pilea* 'Silver Tree'	*Syngonium* 'White Butterfly'
Temperature (°C)							
10	3.5	2.9	3.4	3.3	3.8	3.1	3.4
13	3.7	3.4	3.4	3.6	4.0	4.0	3.1
16	3.3	3.5	3.0	3.7	3.6	3.9	3.1
19	3.2	3.0	2.8	3.3	3.1	3.4	2.8
Significance[z]							
Linear	0.05	NS	0.01	NS	0.01	NS	0.05
Quadratic	NS	0.01	NS	0.01	0.01	0.01	NS
Duration of shipping (Days)							
7	4.0	3.9	4.1	4.5	4.4	4.4	3.5
14	3.3	3.6	3.7	4.3	3.7	3.6	3.7
21	3.4	3.0	2.7	3.2	3.6	3.5	2.5
28	3.1	2.4	2.2	2.0	2.9	2.9	2.8
Significance[z]							
Linear	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Quadratic	NS	NS	NS	0.01	NS	NS	NS
Control plants (Not shipped)	4.0	4.5	4.1	4.5	4.5	4.6	4.1

[z]0.05 = significant at 5% level, 0.01 = significant at 1% level and NS = not significant.

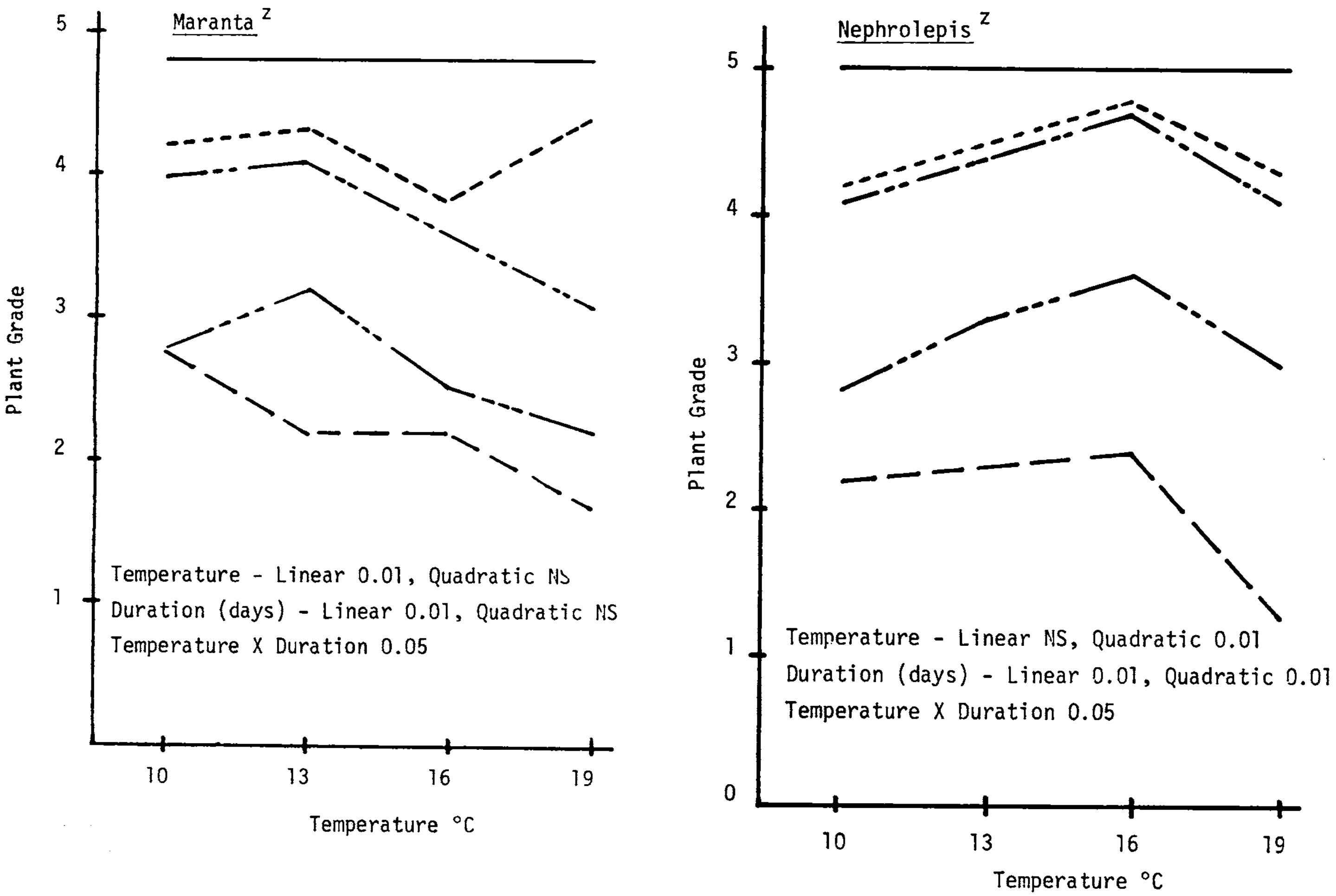

Fig. 1. Interaction of temperature and duration of simulated shipping on plant grades of *Maranta leuconeura* and *Nephrolepis exaltata* 'Bostoniensis'. Information within figures is as follows: ———— = control, plants not shipped; - - - - - - - = shipping duration 7 days; — · · — · · — = shipping duration 14 days; — · · · — · · · — = shipping duration 21 days; —— —— — = shipping duration 28 days. 0.05 = significant at 5% level, 0.01 = significant at 1% level and NS = not significant.