Table 1. Phytotoxicity of foliar application of Mancozeb to Lemondrop Marigolds.

Rate[1] (g ai./liter)	Damage rating[2]
2.45	2.8 a
4.90	3.3 b
0	1.3 c[3]

[1]Applied 16 days after emergence.
[2]Any two means followed by the same lower case letter are not significantly different at the 5% level by Duncan's Multiple Range Test. Scale of 0 to 5 with 0 = no damage and 5 = leaf death.
[3]Damage due to *Liriomyza* sp. not Manzate 200.

Table 2. Response of marigold cultivars to Mancozeb.

Cultivar	Damage rating[1]
Apollo	0 a
Doubloon	0 a
First Lady	0 a
Lemondrop	2.8 b

[1]Any two means followed by the same lower case letter are not significantly different at the 5% level by Duncan's Multiple Range Test. Scale of 0 to 5 with 0 = no damage and 5 = leaf death.

ken, and tannish in color. Damage appeared 3-5 days after application and was most evident on leaves that were fully expanded at time of application. Residue and injury was less evident on leaves that were immature during application. Leaves with damage ratings of three or higher wilted and died in seven to ten days.

No damage by Mancozeb was observed on 'Apollo', 'Doubloon', and 'First Lady' at the 1X rate (Table 2). Residue on non-affected cultivars appeared white and powdery.

Experiments supported the recommendation that bedding plant growers should avoid the use of Mancozeb on the Dwarf French Marigold 'Lemondrop'. This fungicide formulation of Maneb plus zinc is also sold under the names Dithane M-45, Fore, Manzate 200 and Mancofol (4). Before largescale application on Dwarf French Marigold cultivars, all Maneb plus zinc formulations should be tested.

The reason less damage occurred on immature leaves of Lemondrop is not clear. There may be more waxy cuticular deposits or "bloom" on immature leaves than on mature leaves. This may explain why less residue is left on immature leaves. Surface wax resists wetting by sprays (1). Therefore, less fungicide stays on the leaf resulting in less phytotoxicity. This concept needs further testing.

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PACLOBUTRAZOL AND IRRADIANCE LEVEL AFFECT GROWTH OF *MAGNOLIA GRANDIFLORA* 'GLEN ST. MARY'

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Additional index words. growth retardant, inflorescence, photosynthesis

Abstract. **Eight month old rooted cuttings of *Magnolia grandiflora* 'Glen St. Mary' were potted one per one-gallon container in February 1988. Trees were placed in a glass greenhouse and grown under two irradiance levels (no additional light exclusion and 80% light exclusion) during the spring and summer of 1988. On 19 April and 20 May 1988, paclobutrazol was applied as a soil drench at five concentrations from 0 to 50 mg/pot. Changes in height and number of leaves, shoot and root dry weights, photosynthetic rate, and stomatal resistance were greater for sun-grown trees compared to shade-grown trees. Flower initiation occurred earlier for shade-grown trees than sun-grown trees. As paclobutrazol application rate increased, changes in height and number of leaves decreased linearly and photosynthetic rate increased quadratically for sun-grown trees, whereas changes in height decreased quadratically for shade-grown trees.**

An increase in the popularity of interior landscaping has created an apparent opportunity for the inclusion of selected indigenous species. Temperate-zone plants may prove more cost effective than standard tropical foliage plants for use in the interiorscape due to a greater tolerance to local environmental fluctuations. *Magnolia grandiflora* 'Glen St. Mary' is a semi-dwarf, non-patented cultivar with dense, brown pubescence on the under-side of the leaf. As a container specimen, 'Glen St. Mary' magnolia has excellent potential for use in interiorscapes, especially shopping malls, entry ways to commercial office complexes, and indoor/outdoor atriums.

Chemical manipulation of growth may increase the time a plant can be maintained in a container size. Growth retardants have been used to manipulate plant growth and development in containers (2,5,11). Paclobutrazol is an inhibitor of gibberellin biosynthesis that decreases shoot ex-

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tension and internode length of several tree species (3,8,12). Paclobutrazol has also been implicated to buffer plant response to environmental stress. Paclobutrazol affected resistance to osmotic root stress and water useage of apple (13,14).

Postproduction quality of trees placed in low light interiorscapes may be related to light conditions encountered during production (6,7,10). Determining the appropriate production light level for different tree species could increase interior longevity.

Materials and Methods

A 5-month experiment was conducted during the spring and summer of 1988 to evaluate the effect of two irradiance levels and five paclobutrazol application rates on growth and development of *Magnolia grandiflora* 'Glen St. Mary'. Fifteen to 20-cm cuttings were rooted in 100% perlite under mist during the late summer of 1987. Rooted cuttings were potted one per 10-cm container and overwintered in an unheated glass greenhouse under natural daylength. Magnolias were then transplanted into one-gallon containers 2 months prior to the initiation of treatments. Metro-mix 500 growth medium (Grace and Co., USA) was amended with 3.0 kg/m^3 dolomitic limestone, and 0.9 kg/m^3 Micromax micronutrient fertilizer (Sierra Chemical Co., Milpatas, CA). On 19 April and 20 May, trees were treated with paclobutrazol applied as a soil drench, at 0, 6, 12, 25, and 50 (mg/pot). Magnolia root systems are coarse textured with few secondary and fibrous roots. A second drench was applied to ensure exposure of roots to the active compound. On 19 April, trees were separated and grown under two irradiance levels (no additional light exclusion and 80% light exclusion) in a glass greenhouse (39/24°C day/night). Magnolias were fertilized weekly with 500 ml of soluble Peters (20N-8.7P-16.7K) at 100 ppm N.

Photosynthetic rate and stomatal resistance were measured on 11 September using a portable photosythesis system (LI-6200 model, LI-COR Inc., Lincoln NE). Measurements were initiated one hour before solar noon (1200 HR EDT) on a mostly clear day and required 2 hours to complete. PPFD was approximately 1360 μmol m^{-2} s^{-1} (no light exclusion) and 280 μmol m^{-2} s^{-1} (80% light exclusion), respectively. A one-quarter liter cuvette was used to take measurements on five replicated trees per treatment. One measurement consisted of the mean of three consecutive samples with CO_2 drawdowns of 15 ppm using leaf areas of 17.5 cm^2. On 19 April and 20 September, tree height (crown to the base of the tallest apical bud), number of leaves, and number of laterals were recorded. Variable differentials were then calculated and are presented in the results as growth variables. On 21 September, trees were harvested and leaf area was measured using a portable leaf meter (LI-3000 model, LI-COR Inc., Lincoln NE). Root systems were thoroughly washed, separated from shoots, and dry weights determined.

The experimental design was a two by five factorial arranged as a completely randomized block with nine single tree replicates. The data were analyzed (Statistical Analysis System, Raleigh, N.C.) using analysis of variance and regression. Regression coefficients were tested for homogeneity of fit using the F test.

Table 1. Effects of irradiance level on change in height (dHG), change in leaf number per tree (dLF), photosynthetic rate (PS), and stomatal resistance (SR) of *Magnolia grandiflora* 'Glen St. Mary'.

Irradiance level	dHG (cm)	dLF	PS (umol m^{-2} s^{-1})	SR (cm sec^{-1})
No exclusion	23.4	21.4	8.8	1.6
80% exclusion	8.7	13.6	3.9	0.74
PR>F	.0001	.0001	.0001	.0045

Results and Discussion

Irradiance level affected all measured variables except change in the number of lateral shoots and leaf area. Paclobutrazol application did not influence change in the number of shoot laterals, leaf area, shoot and root dry weights, and stomatal resistance. Paclobutrazol application interacted with irradiance level to affect photosynthetic rate, change in height, and change in number of leaves per tree.

Sun-grown trees had changes in height that were 168% greater and changes in leaf number per tree that were 57% greater than respective changes in shade-grown trees (Table 1). These data disagree with Keever et al. (10) who reported that southern magnolia grown under full-sun were smaller compared to those grown under 64% light exclusion. Photosynthetic rate and stomatal resistance for shade-grown trees were reduced by 57% and 55%, respectively, compared to sun trees (Table 2). Shoot dry weight, root dry weight and shoot to root ratios were reduced by 59%, 49%, and 21%, respectively, for shade trees compared to sun trees (Table 2). Although average leaf area was not different due to irradiance level, specific leaf weights were reduced by 52% for shade trees compared to sun trees suggesting that shade leaves were thinner than sun leaves with a reduced number of palisade/mesophyll layers per cm^2 of leaf area (9). This hypothesis is further validated by the reduction in shade-grown magnolia photosynthetic rate.

Paclobutrazol application rate influenced changes in height and number of leaves, and photosynthetic rate of magnolia for sun-grown trees and change in height for shade-grown trees. As application rate increased for sun-grown trees, changes in height and number of leaves decreased linearly (Fig. 1 & 2), and photosynthetic rate increased quadratically (Fig. 3). These data are in agreement with earlier studies (1,11). However, increased photosynthetic rates with increased growth retardant does not appear logical (8). It should be noted that photosynthetic data were recorded on 11 September, nearly four months after the second treatment application date. By this time trees treated with higher application rates were recommencing elongation whereas trees treated with lower appli-

Table 2. Effect of irradiance level on dry weights, shoot to root ratio (S/R), and specific leaf weight of *Magnolia grandiflora* 'Glen St. Mary'.

Irradiance level	Shoot (g)	Root (g)	S/R	Specific leaf weight (g/cm^2)
No exclusion	24.3	7.7	3.3	0.29
80% exclusion	10.0	3.9	2.6	0.14
PR>F	0.0001	0.0001	0.0042	0.0001

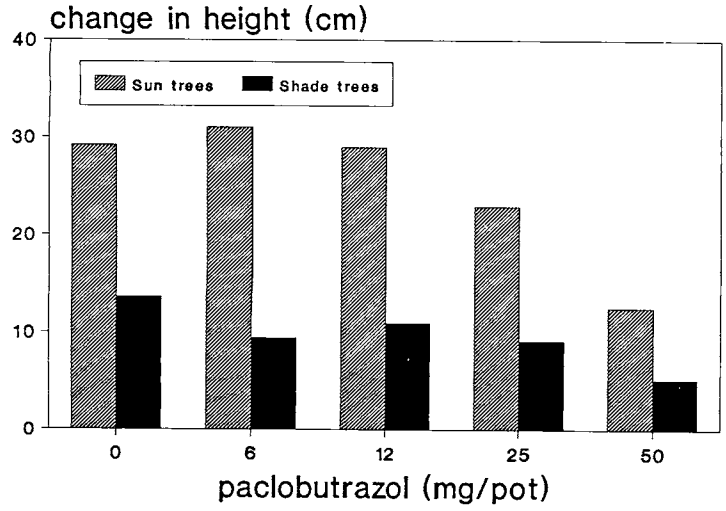

Fig. 1. Paclobutrazol affects change in height of *Magnolia grandiflora* 'Glen St. Mary'.
Response of sun trees, PR>F=.0001, $y=-0.427x+33.768$;
Response of shade trees, PR>F=.0367, $y=-0.003x^2+0.084x+9.498$;

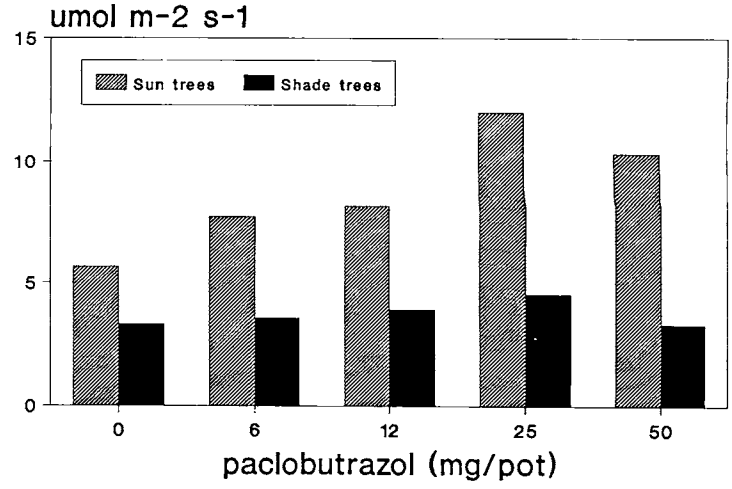

Fig. 3. Paclobutrazol affects photosynthetic rate of *Magnolia grandiflora* 'Glen St. Mary'.
Response of sun trees, PR>F=.0001, $y=-0.006x^2+0.367x+5.402$;
Response of shade trees, PR>F=.1893;

cation rates had experienced a growth phase earlier. This implies that an increased photosynthetic rate per leaf was required to accommodate an increased growth sink compared to trees grown at lower application rates and the effect of paclobutrazol applied as a soil drench under the described conditions is not capable of manipulating growth of magnolia for 4 months. For shade-grown trees, paclobutrazol influenced height growth only (Fig. 1). As application rate increased, change in height decreased quadratically. This appears to suggest that as irradiance level is decreased, the application rate needed to generate a significant reduction in height needs to be increased.

Formation of lateral shoots appeared to be a function of apical inflorescence development and was not different due to irradiance or growth retardant level. The formation of flower buds stimulated the development of lateral shoots. The result was an observed lag in height growth. Seventy-eight percent of sun-grown trees and 31 percent of shade-grown trees initiated floral development; however, flower initiation of shade-grown trees occurred during the first two months of the treatment period, while flower initiation of sun trees occurred during the last two months of the treatment period. This suggests that flower initiation of magnolia may be partially regulated by irradiance level. Further work in this area could be beneficial to nurserymen as flowers were small, short lived with petal abscission occurring less than one day following full anthesis. Individual trees that flowered tended to remain smaller compared to those that did not. Rooted cuttings of magnolia are capable of producing flowers; however, the energy requirements for anthesis appeared too great to maintain adequate growth during the early production phase.

In conclusion, reduction in irradiance level by 80% has been shown to restrict growth of 'Glen St. Mary' magnolia and possibly influence flower initiation or time to anthesis. Paclobutrazol applied as a soil drench influenced growth of sun trees for less than four months. Further research is needed to determine the post-production response of magnolia cultivars placed in interior environments and to determine if any advantages are derived from reduced irradiance levels or growth retardants.

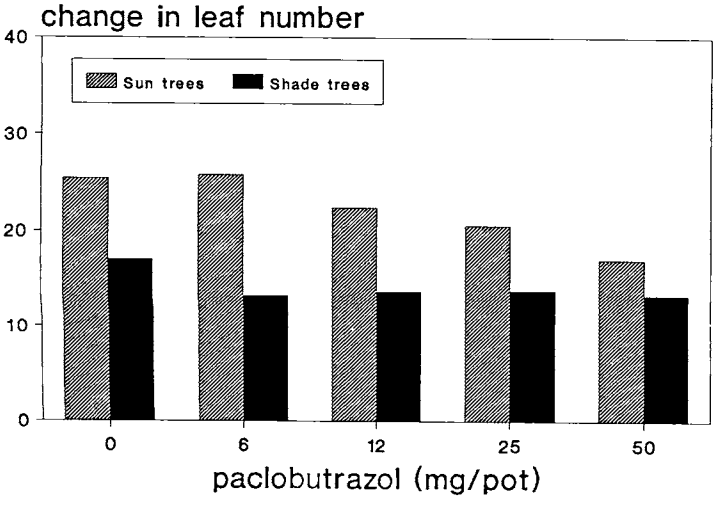

Fig. 2. Paclobutrazol affects change in leaf number per tree of *Magnolia grandiflora* 'Glen St. Mary'.
Response of sun trees, PR>F=.0001, $y=-0.166x+25.44$;
Response of shade trees, PR>F=.6628;

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INFLUENCE OF PACLOBUTRAZOL ON FOLIAGE PLANTS

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Abstract. **Two factorial experiments were initiated to test effects of paclobutrazol (Bonzi) on growth of foliage plants. The first experiment involved paclobutrazol and maximum summer temperatures; the second, paclobutrazol alone. Paclobutrazol rates as low as ½ mg/6 inch pot retarded growth of *Codiaeum variegatum* Blume 'Norma' and 'Banana', *Ficus lyrata* Warb., and *Gardenia jasminoides* Ellis, but not *Radermachera sinica* Hemsl or *Spathiphyllum* N.E. Br. 'Bennett'. Gardenias grew equally at 90-105°F maximum temperature and *R. sinica* were taller at 100°F, but other test plants grew best at 90-95°F maximum temperature.**

Extensive research has been directed to the use of growth retardants in controlling height of fruit trees (1, 13, 14, 18) and flowering ornamental plants such as poinsettia (4, 11, 16, 17) and chrysanthemum (3, 10, 12). Until recently, however, the use of growth retardants on foliage plants had received relatively little interest from researchers. Nevertheless, the work done so far has yielded some very promising results (2, 5, 6, 7, 8, 9, 15). The purpose of this study was to explore the feasibility of using paclobutrazol on a variety of foliage plants to improve their growth habits and marketability.

Materials and Methods

Two experiments were initiated to test effects of paclobutrazol on growth of selected foliage plants.

Experiment 1. This 4x4 experiment was initiated 4 Aug. 1987. Six-inch pots of *C. variegatum* 'Norma', *F. lyrata*, *G. jasminoides*, *R. sinica* and *S.* 'Bennett' in Vergro Container Mix fertilized with 5 g of 19-6-12 ($N–P_2O_5–K_2O$) slow-release fertilizer/6-inch pot were placed in sections of a greenhouse with thermostats set at a maximum of 90, 95, 100 or 105°F. Paclobutrazol was applied 4 Aug. 1987 at 0, 2, 4 or 6 mg per 6-inch pot [0.5 ml of Bonzi with 0.4% paclobutrazol (a.i.) in 120 ml of solution/6-inch pot applied for 2 mg active material]. For the duration of the experiment, maximum light was about 2,000 ft-c and minimum temperature varied between 65 and 75°F depending upon time of year. Pots were watered three times a week. There were three replications per treatment. Plant height was taken 2 Dec. 1987 and the experiment was terminated.

Experiment 2. On 10 Dec. 1987, 6-inch pots of *C. variegatum* 'Norma' and *C. v.* 'Banana', *F. lyrata* and *R. sinica* were fertilized using the same fertilizer and rate as in Experiment 1. Paclobutrazol at 0, 0.5, 1.0, 1.5 and 2.0 mg per 6-inch pot was applied 17 Dec. 1987 in 120 ml of solution as described in Experiment 1. These plants were grown in the same greenhouse as plants in the previously described experiment and were on the same watering regime. During Experiment 2, temperatures were maintained at a maximum of 90°F and a minimum of 65°F, while light intensities were 1500 ft-c maximum. There were 16 replications per treatment. Data were taken and experiment terminated on 26 April 1988 for *R. sinica* and 13 June 1988 for the other three plants.

Results and Discussion

Experiment 1. Temperature affected growth of *C.* 'Norma', *F. lyrata*, *S.* 'Bennett' and *R. sinica*. Maximum growth was obtained at temperatures up to 95°F for 'Norma', 105°F for *F. lyrata*, and 90°F for *S.* 'Bennett'. There was no significant difference in heights of *G. jasminoides* at any temperature tested. Best maximum temperature for *R. sinica* appears to be 100°F (Fig. 1).

All applications of paclobutrazol virtually stopped growth of *C.* 'Norma', *F. lyrata* and *G. jasminoides*. The growth retardant also slowed growth of *R. sinica* but had no effect on height of *S. 'Bennett' (Fig. 2). There was no interaction effect.*

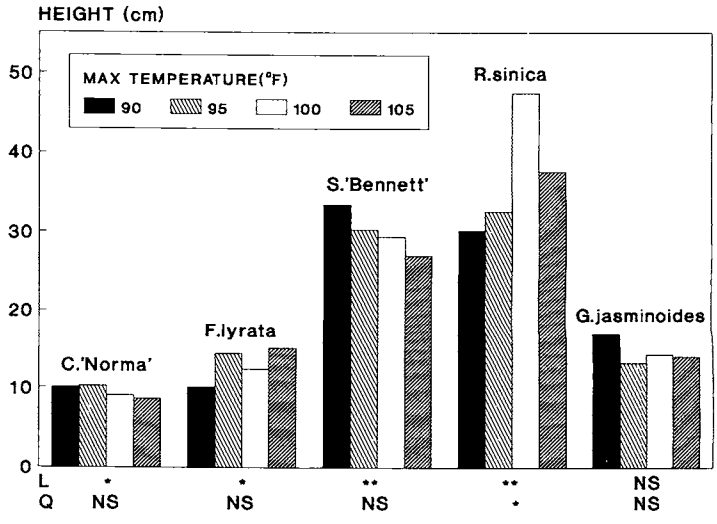

Fig. 1. Temperature effects on foliage plant growth. Fertilizer applied 7/28/87; paclobutrazol applied 8/4/87; data taken 12/2/87.

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