centage of cuttings that rooted and by inhibiting the development of roots near the cutting base. No interactions were observed between stockplant etiolation or banding of stems and exogenously applied catechol.

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Growth of Four Tropical Foliage Species Treated with Paclobutrazol or Uniconazole

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Abstract. Uniconazole and paclobutrazol were tested for their effects on greenhouse production of four foliage species. Soil drenches of uniconazole retarded shoot and petiole elongation of *Brassia actinophylla* Endl. Paclobutrazol reduced shoot elongation, but required higher doses than uniconazole and did not reduce petiole growth. Foliar sprays with either retardant at 12.5 mg-liter⁻¹ resulted in short stems on lateral shoots of *Codiaeum variegatum* (L.) Blume 'Karen' after pinching, but soil drenches at low rates were less effective. Soil drenches of uniconazole or paclobutrazol were equally effective in reducing stem growth of *Syngonium podophyllum* Schott 'White Butterfly' and increasing leaf width, but had no effect on the rate of leaf production or blade length. Both retardants induced short petioles in this species. Severe growth reduction occurred on *Plectranthus australis* R. Br. even at the lowest rates of uniconazole and paclobutrazol (0.025 and 0.20 mg/pot, respectively) as soil drenches. Production of lateral shoots was inhibited for *P. australis* by both retardants. Chemical names used: (E)-1-(p-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl)-1-penten-3-ol (uniconazole); (2RS,3RS)-1-(4-chlorophenyl)-2-(1,1-dimethylethyl)-(H-1,2,4-triazol-1-yl)-Dentan-3-ol (paclobutrazol).

Research to determine the effect of uniconazole and paclobutrazol on tropical foliage plants has been limited. Uniconazole retarded plant growth and promoted secondary branching in *Peperomia obtusifolia*, but reduced leaf size (Mansour and Poole, 1987). Plant growth, rate of leaf production, and leaf size of *Ficus benjamina* were reduced by drenching the medium with paclobutrazol (LeCain et al., 1986). Since foliage plants are often produced under heavy shade and in close proximity, controlling plant height by means of retardant application would make plants sturdier and more attractive. *Brassia*

actinophylla has long internodes and petioles when produced under shade. *Codiaeum variegatum* 'Karen', after pinching, produces lateral shoots with long stems under the lowest leaf, making plants unattractive. *Syngonium podophyllum* and *Plectranthus australis* have long internodes, making plants less compact. The objective of this study was to determine the effect of paclobutrazol and uniconazole on growth characteristics of the above four tropical foliage species during summer production.

Two-liter pots filled with Sunshine Mix No. 1 (a peat-lite mix without bark; Fisons, Vancouver, B. C., Canada) were used in all experiments. Plants were grown in shade-houses covered with polypropylene shade fabric and a layer of polyethylene (0.15 mm thick), providing a maximum photosynthetic photon flux of 420 $\mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$. Plants were irrigated with water containing a 24 N-3.4P-13.3K water soluble fertilizer at 0.83 g-liter⁻¹ (W.R. Grace, Fogelsville, Pa.) when medium surface became light in color. Air tem-

peratures ranged between 15 and 39°C. Growth retardant drench and spray solutions contained 0.1% Tween 20. Soil drenches were applied as 150-ml solutions.

Seedlings of *B. actinophylla* averaging 15 cm tall were planted one per pot on 1 Mar. 1988. Plants received soil drenches of uniconazole (XE-1019, Sumagic, Valent U. S. A., Richmond, Calif.) at 0, 0.025, 0.050, 0.10, 0.20, 0.40, 0.80 or 1.00 mg/pot or paclobutrazol (PP-333, Bonzi, Sandoz Crop Protection, Chicago) at 0, 0.20, 0.40, 0.60, 0.80, 1.00, or 1.20 mg/pot on 26 Apr. 1988. The youngest fully expanded leaf on each plant was tagged at treatment. Plants were evaluated on 18 July 1988 for number of new leaves, stem growth (measured from the tagged node to stem apex), overall plant height (measured from pot rim to the tallest point), and petiole length of the three most acropetal fully expanded leaves. Each plant was an experimental unit, and treatments were replicated 10 times using a randomized complete-block design (RCBD).

Shoot tip cuttings of *C. variegatum* 'Karen' with stems averaging 10 cm long were taken on 26 Feb. 1988 and rooted one per pot in 2-liter pots under intermittent mist for 60 days. Rooted cuttings were grown under the same conditions as given for *B. actinophylla*. Spray applications of uniconazole or paclobutrazol at 0, 12.5, 25, 50, or 75 mg-liter⁻¹ were made on 8 June 1988, immediately after cutting the shoots to 10 cm. Plants were sprayed to run-off with an average of 20 ml/plant, while the medium surface was covered with polyethylene to prevent the solution from getting into pots. Another group of plants received soil drenches containing uniconazole or paclobutrazol at 0, 0.50, 0.10, 0.20, or 0.40 mg/plant. Each retardant and method of application was a separate experiment. Plants were arranged in a RCBD with a single plant per pot as an experimental unit, and treatments were replicated six times. Plants were evaluated on 15 July 1988 for number of lateral shoots and for the length of the first internode on the two uppermost shoots.

S. podophyllum 'White Butterfly' were planted one per pot on 3 Feb. 1988. Each plant received a soil drench of uniconazole (0, 0.025, 0.05, 0.10, 0.20, 0.40, 0.60, or 0.80 mg/pot) or paclobutrazol (0, 0.20, 0.40, 0.60, 0.80, or 1.00 mg/pot) on 27 Apr. 1988. The uppermost leaf on each plant was labeled before treatment. Plants were arranged in a RCBD with eight replications per treat-

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Table 1. Effect of uniconazole and paclobutrazol as a soil drench on the growth of *Brassica actinophylla*.

Amount (mg/pot)*	No. of new leaves	Stem elongation (cm)	Plant ht (cm)	Petiole length (cm) ^y		
				Node		
				1	2	3
<i>Uniconazole</i>						
0	4.1	19.5	51	30	30	29
0.025	4.0	19.3	47	26	30	28
0.050	4.2	14.3	43	27	29	26
0.10	3.7	6.6	33	25	25	25
0.20	3.9	4.5	27	19	20	22
0.40	3.4	3.4	25	15	16	22
0.80	3.4	3.5	25	14	15	21
1.00	3.2	2.8	22	11	13	18
Significance	L**	L**Q**	L**	L**Q**	L**Q**	L**Q**
<i>Paclobutrazol</i>						
0	4.4	21.7	52	28	32	29
0.20	4.1	19.3	50	31	31	28
0.40	4.0	15.6	48	32	31	29
0.60	4.0	10.3	43	31	32	28
0.80	3.9	10.5	42	32	27	29
1.00	3.4	8.8	42	32	28	25
2.00	3.5	4.1	33	29	23	22
Significance	L**	L**Q**	L**	Q*	L**	L**

^aPots 16.4-cm diameter, 2 liters; 150-ml drench volume.

^bFirst (1), second (2), and third (3) fully expanded leaves from the stem apex.

*, ** Significant at $P = 0.05$ or 0.01 , respectively. L = linear and Q = quadratic response.

Table 2. Effect of paclobutrazol and uniconazole and method of application on the growth of *Codiaeum variegatum* 'Karen'.

Retardant	Amount	No. of shoots	Shoot length (cm) ^z	
			1	2
<i>Foliar spray</i>				
Paclobutrazol	(mg·liter ⁻¹)			
	0	6.2	18.8	19.8
	12.5	6.7	6.3	2.2
	25	6.5	2.5	2.9
	50	6.7	1.7	1.3
	75	6.0	1.4	1.2
Significance		NS	L**Q**	L**Q**
Uniconazole				
	.0	8.5	18.0	20.0
	12.5	7.8	6.8	1.8
	25	8.2	2.0	1.1
	50	6.8	1.3	1.1
	75	6.8	1.1	1.1
Significance		NS	L**Q**	L**Q**
<i>Soil drench</i>				
Paclobutrazol	(mg/pot) ^y			
	0	7.2	19.1	20.0
	0.05	6.8	17.2	17.8
	0.10	6.8	11.4	7.8
	0.20	6.2	3.7	1.7
	0.40	7.2	1.8	1.3
Significance		NS	L**Q**	L**Q**
Uniconazole				
	0	9.3	19.3	19.8
	0.05	6.3	19.1	18.8
	0.10	5.8	16.7	14.9
	0.20	4.8	13.2	9.9
	0.40	6.7	7.3	5.3
Significance		Q**	L**	L**

^aFirst (1) and second (2) lateral shoots from the top.

^bPots 16.4-cm diameter, 2 liters; 150-ml drench volume.

NS, **Nonsignificant or significant at $P = 0.01$, respectively. L = linear and Q = quadratic response.

ment. Number of new leaves, length of the main stem, overall plant height, blade width and length, and petiole length of the uppermost leaf were determined on 16 Aug.

Rooted, single-node cuttings of *P. australis*, each with one lateral shoot, were

planted on 9 Mar. 1988. All lateral shoots were removed on 13 Apr., and the node above the uppermost fully elongated internode was tagged on each plant. On the same day, plants received soil drenches of uniconazole at 0, 0.025, 0.050, 0.10, 0.20, 0.40, 0.60, or 0.80

mg/pot. Soil drenches of paclobutrazol were applied at 0, 0.20, 0.40, 0.60, 0.80, or 1.00 mg/pot. Any lateral shoot emerging below the tagged node was removed. Number of new leaf pairs, stem growth (from the tagged node to the uppermost visible node) since treatment application, number of lateral shoots, and node number and length of the first lateral shoot above the tag were determined on 26 July 1988. Data were subjected to regression analysis by the use of SAS programming.

Uniconazole and paclobutrazol reduced all measured characteristics in *B. actinophylla*, with greater effect at increasing rates (Table 1). Uniconazole appeared to have more effect in retarding plant elongation than paclobutrazol at comparable rates. At 0.20 mg/pot, uniconazole and paclobutrazol decreased new shoot growth by 77% and 11%, respectively. Both retardants decreased the rate of leaf production at high rates. Since more than half of the overall height in untreated plants was contributed by the petiole of the uppermost leaf, a reduction in petiole elongation is necessary to give effective height control. Uniconazole was effective in reducing petiole growth (Table 1), whereas paclobutrazol increased petiole length of the youngest leaf at the intermediate rates. The retarding effect of uniconazole on petiole elongation appeared to last longer than paclobutrazol. However, rates of uniconazole higher than 0.20 mg/pot caused excessive stunting and plants were commercially unacceptable.

Number of lateral shoots produced by *C. variegatum* 'Karen', was unaffected by spray application of either retardant (Table 2). Soil drench of paclobutrazol resulted in fewer lateral shoots. Foliar application of uniconazole and paclobutrazol were similarly effective in retarding shoot elongation. Plants sprayed with doses higher than 12.5 mg-liter⁻¹ were too short. Soil drenches also gave control of shoot elongation at increasing rates. Both retardants, at the lowest rate of spray application and intermediate rates of soil application, resulted in a greater reduction in shoot elongation on the second, rather than on the uppermost, lateral shoot (Table 2).

Rate of leaf production by *S. podophyllum* 'White Butterfly' was unaffected by the retardants (data not shown). Both uniconazole and paclobutrazol resulted in short plants by retarding stem and petiole elongation. Shoot growth was reduced by about one-third at the lowest rate of each retardant. Width of the uppermost leaf blade increased with increasing rates of either retardant (Table 3). Leaf blade length was unaffected by any treatment. Ancymidol was found to increase leaf size slightly in a previous study (Wang, 1987).

All growth retardant treatments resulted in excessive reduction of *P. australis* growth (Table 4). There was almost no lateral shoot growth once a growth retardant was applied. However, application of retardants at the end of greenhouse production may markedly reduce shoot elongation in an interior environment, thereby increasing the aesthetic value

Table 3. Effect of uniconazole and paclobutrazol as a soil drench on the growth of *Syngonium podophyllum* 'White Butterfly'.

Amount (mg/pot) ²	Stem length (cm)	Plant ht (cm)	Blade width (cm)	Petiole length ¹ (cm)
<i>Uniconazole</i>				
0	13.1	44.3	12.3	32.5
0.025	9.1	40.2	11.8	31.8
0.050	7.2	40.1	12.0	30.9
0.10	8.1	37.4	12.0	30.7
0.20	7.7	36.5	12.5	28.5
0.40	7.3	37.4	13.5	28.4
0.80	8.3	36.1	13.4	26.6
Significance	Q*	L**Q**	L**	L**
<i>Paclobutrazol</i>				
0	14.2	44.4	11.7	34.0
0.10	8.9	39.1	12.1	31.2
0.20	8.5	36.6	12.3	27.5
0.40	8.4	35.5	12.5	27.7
0.60	8.6	32.0	12.5	25.6
0.80	6.8	33.7	12.5	23.1
1.00	6.5	34.4	13.2	24.0
Significance	L**	L**Q**	L**	L**Q**

¹Pots 16.4-cm diameter, 2 liters; 150-ml drench volume.

²Measured on the uppermost, fully expanded leaf on the main shoot.

NS, *, **Nonsignificant or Significant at $P = 0.05$ or 0.01 , respectively. L = linear and Q = quadratic response.

Table 4. Effect of uniconazole and paclobutrazol as a soil drench on the production of *Plectranthus australis*.

Amount (mg/pot)*	No. of new leaf pairs	Stem elongation (cm)	No. of lateral shoots	First lateral shoot	
				No. of nodes	Length (cm)
<i>Uniconazole</i>					
0	14.0	43.9	16.1	9.6	37.3
0.025	8.6	3.8	1.9	2.9	0.4
0.050	8.1	3.3	2.3	2.9	0.4
0.10	5.6	2.3	1.4	1.9	0.2
0.20	4.3	1.9	0.9	0.9	0.1
0.40	4.1	2.1	0.1	0.3	0
0.60	4.0	2.0	0	0	0
0.80	3.8	1.8	0	0	0
Significance	L**Q**	L**Q**	L**Q**	L**Q**	L**Q**
<i>Paclobutrazol</i>					
0	14.0	42.0	16.8	9.3	31.9
0.20	11.6	7.9	3.9	3.4	1.5
0.40	7.8	3.0	1.5	2.3	0.3
0.60	7.3	2.7	2.0	2.3	0.3
0.80	6.3	2.4	1.1	1.8	0.2
1.00	4.3	1.8	0.9	1.3	0.1
Significance	L**Q**	L**Q**	L**Q**	L**Q**	L**Q**

¹Pots 16.4-cm diameter, 2 liters; 150-ml drench volume.

**Significant $P = 0.01$. L = linear and Q = quadratic response.

of this species. We observed that new leaves on the treated plants appeared to be thicker and greener than those of the controls.

Results from this study show that uniconazole and paclobutrazol could be used for height control on all four species tested. However, the optimal rate of application and sensitivity of plants to each retardant may vary greatly from one species to another. Application of these retardants requires great caution to eliminate the possibility of crop loss or prolonged production time.

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