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Modification of Hibiscus Growth by Treating Unrooted Cuttings and Potted Plants with Uniconazole or Paclobutrazol

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Abstract. Unrooted cuttings of *Hibiscus rosa-sinensis* L. "Seminole Pink" were soaked for 5 s in a solution containing 25, 50, 75, or 100 mg L^{-1} uniconazole or paclobutrazol, rooted, and then potted and allowed to grow without pinching. Uniconazole was more effective than paclobutrazol in suppressing stem growth and number and length of lateral shoots. Uniconazole and paclobutrazol, at the 25 mg L^{-1} concentration, resulted in stem growth 75 and 25%, respectively, of the control, with further reduction at higher rates. Flowering was delayed by the highest rate of uniconazole but not paclobutrazol. Flower number was reduced by both retardants, without any effect on flower size. Plants treated with uniconazole had short pedicels regardless of the rates, whereas paclobutrazol did not affect pedicel length. A second experiment used unrooted cuttings being soaked in a solution containing 0, 12.5, 25, or 50 mg L^{-1} uniconazole or having the lower 2.5 cm of the stem dipped in a solution containing 0, 50, 100, or 200 mg L^{-1} uniconazole. Plants were pinched after potting. Soaking resulted in more efficient height control than dipping. Lateral shoot number was reduced by soaking but not dipping. All treated plants had smaller stem diameters. Flower size was unaffected regardless of method of treatment and the type of retardant applied. In a third experiment, soil drenches with uniconazole at a rate as low as 0.05 mg/pot resulted in excessive growth retardation. Soil drenches with paclobutrazol at 0.05–0.20 mg/pot reduced shoot growth, flower number, and pedicel length, but did not affect days to bloom.

Uniconazole and paclobutrazol are plant growth retardants for use on floriculture crops, which suppress stem elongation by the inhibition of gibberellic acid biosynthesis (Hamilton and Law 1987). Although plant growth retardants have been shown to be effective in controlling plant height, improper use can result in phytotoxicity (Barrett and Nell 1987, Gilbertz and Lewis 1986) or severely stunted growth (Cox and Keever 1988, Wilfret 1987). Since these compounds are not readily translocated out of treated leaves (Richardson and Quinlan 1986), it is necessary to wet the stem during foliar application (Barrett and Bartuska 1982). Furthermore, the uneven application of plant growth retardants can result in nonuniform growth. Dipping the root system of a cutting in a solution containing a retardant prior to planting provided effective height control in poinsettia (Gilbertz and Lewis 1986) and chrysanthemum (Reiss-Bubenheim and Lewis 1986). Dipping the entire unrooted cuttings or the cut end of unrooted cuttings in a growth retardant solution may give effective height control during production.

The objectives of this study were to investigate changes in vegetative growth and flowering of hibiscus following different application methods of two triazole plant growth retardants.

Materials and Methods

The plant material used in this study was *Hibiscus rosa-sinensis* L. "Seminole Pink," a cultivar with large leaves and pink single flowers.

Effect of Soaking Unrooted Cuttings in a Plant Growth Retardant Solution on Growth

Healthy, 10-cm long terminal cuttings were taken before 10 a.m. from stock plants grown in a commercial nursery under 1200 $\mu mol\ s^{-1}\ m^{-2}$ maximum photosynthetic photon flux (PPF). Following transport to the laboratory, cuttings were randomly divided into groups of 10 and soaked for 5 s in an aqueous solution containing uniconazole or paclobutrazol at rates of 0 (control), 25, 50, 75, or 100 mg L^{-1} with 0.1% Tween 20 as a wetting agent.

Table 1. Effect of a 5-s soak of unrooted cuttings in uniconazole or paclobutrazol on subsequent growth and flowering of *Hibiscus rosa-sinensis* "Seminole Pink" after 24 weeks.

Rate of retardant (mg L^{-1})	Total height (cm)	Stem growth (cm)	No. of lateral shoots > 2 cm	Length of lateral shoot (cm)	Flower			
					Days to bloom	Number	Diameter (cm)	Pedicel (cm)
Uniconazole								
0	44.4	38.9	8.4	22.6	94	11.4	15.0	5.7
25	15.2	9.6	3.1	9.8	88	7.1	14.6	3.0
50	11.9	7.8	2.1	8.8	89	5.6	14.5	3.2
75	8.1	3.1	1.7	4.2	98	2.4	13.9	3.3
100	8.7	3.7	1.6	4.9	116	1.7	14.3	2.8
Significance								
Linear	**	**	**	**	*	**	NS	**
Quadratic	**	**	**	**	**	NS	NS	*
Paclobutrazol								
0	43.8	37.7	8.3	22.4	98	11.0	14.7	5.3
25	36.1	29.8	5.9	21.7	99	9.3	14.7	5.5
50	34.2	27.6	6.4	22.8	101	9.0	14.8	5.0
75	23.1	17.2	5.0	16.6	102	6.1	14.0	5.2
100	20.6	15.9	5.4	14.3	103	6.0	15.6	5.0
Significance								
Linear	**	**	*	*	NS	**	NS	NS
Quadratic	NS	NS	NS	*	NS	NS	NS	NS
Retardant	**	**	**	**	NS	**	NS	**

NS, statistically nonsignificant; *, significant at the 5% level; **, significant at the 1% level.

The cuttings were rooted for 5 weeks in a mist propagation bed, then moved to a greenhouse bench. Three weeks later, seven uniformly rooted cuttings were selected from each treatment and transplanted into 2-L pots filled with Sunshine Mix No. 1 (a commercial peat-lite mix, Fisons Western, Vancouver, B.C., Canada). Plants were grown unpinched under 1000 μmol s^{-1} m^{-2} maximum PPF, and irrigated with 1.0 g L^{-1} 20N-8.6P-16.6K water soluble fertilizer (W. R. Grace, Fogelsville, PA, USA) when the medium surface appeared dry and the pot weight was light. When the first flower of each plant bloomed, the blooming date, flower diameter, and pedicel length were recorded. Sixteen weeks after planting, each plant was evaluated for total height (from medium surface to the uppermost node), length of stem growth, number of lateral shoots (>2 cm in length), and the length of the longest lateral shoot. One plant per pot represented an experimental unit. Treatments were replicated seven times in a randomized complete block design.

Effect of Soaking and Dipping Unrooted Cuttings in Plant Growth Retardant Solutions on the Growth of Pinched Plants

More cuttings were taken from the same source after the completion of the above experiments. Groups of 10 cuttings each were soaked for 5 s in solutions containing 0, 12.5, 25, or 50 mg L^{-1} uniconazole or had the basal 2.5 cm of the freshly harvested cuttings dipped for 5 s in a solution containing 0, 50, 100, or 200 mg L^{-1} uniconazole, rooted, and transplanted into 2-L pots. Plants were pinched 2 days after transplanting to determine the effect of retardants on lateral shoot growth. Cultural practices were the same as above. Data were taken 16 weeks after potting and included total height (from pot rim to the uppermost visible node); number of lateral shoots; length, stem diameter (1.5 cm above the branching point), and leaf number of the top lateral shoot; days to bloom; number of flowers; and diameter and pedicel length of the first flowers.

Effect of Plant Growth Retardant Soil Drench on Growth

Additional untreated, rooted cuttings from the above source were transplanted into 2-L pots after 8 weeks of rooting and cultured as above. One week after transplanting, plants received soil drenches of uniconazole at 0, 0.05, or 0.1 mg/pot or paclobutrazol at 0, 0.05, 0.1, or 0.2 mg/pot in 100 ml of solution. There was no leaching resulting from soil drenches. Data were collected as detailed above. Again, one plant per pot represented an experimental unit and each treatment was replicated seven times in a randomized complete block design.

Results

Soaking the entire unrooted hibiscus cuttings in a growth retardant solution was effective in controlling plant height as measured 24 weeks after treatment, with uniconazole exerting a greater effect than paclobutrazol (Table 1). Uniconazole and paclobutrazol applied at 25 mg L^{-1} reduced stem growth by 75 and 25%, respectively. Both retar-

Table 2. Effect of soaking the entire cutting or dipping the basal 2.5 cm of cutting for 5 s in uniconazole solutions of various concentrations prior to rooting on subsequent vegetative growth and flowering responses of pinched *Hibiscus rosa-sinensis* "Seminole Pink."

			Top lateral shoot			Flower		
Uniconazole (mg L^{-1})	Total height (cm)	No. of lateral shoots	Length (cm)	Stem diameter (mm)	Leaf no.	Number	Diameter (cm)	Pedicel length (cm)
Soak								
0	28.5	3.5	21.6	5.8	12.5	3.5	15.4	6.8
12.5	21.1	3.1	13.1	4.5	11.4	4.3	14.0	5.4
25.0	17.2	2.7	10.4	4.4	11.0	3.4	14.7	5.0
50.0	13.6	2.5	10.0	4.4	10.0	1.5	13.9	4.4
Significance								
Linear	**	**	**	**	**	NS	NS	**
Quadratic	**	NS	*	**	NS	NS	NS	NS
Dip								
0	26.5	3.8	19.9	5.6	12.7	2.7	15.3	7.3
50	26.1	3.4	18.7	5.3	11.4	2.4	14.4	6.6
100	20.8	3.4	12.9	4.7	11.0	4.7	14.9	5.6
200	21.7	3.5	13.8	4.6	11.1	2.6	15.2	6.1
Significance								
Linear	**	NS	**	**	*	NS	NS	*
Quadratic	NS	NS	NS	NS	NS	NS	NS	*

NS, statistically nonsignificant; *, significant at the 5% level; **, significant at the 1% level.

dants restricted lateral shoot growth relative to the control. Uniconazole, but not paclobutrazol, delayed flowering at the 100 mg L^{-1} concentration. Both retardants reduced flower number without affecting flower size. Uniconazole resulted in short pedicel, but paclobutrazol had no effect.

In the second experiment, soaking cuttings in a solution containing 12.5 mg L^{-1} uniconazole was effective in controlling lateral shoot growth (Table 2). Dipping the cut end of unrooted cuttings in uniconazole solutions resulted in reduced total height and lateral shoot growth as uniconazole concentration increased (Table 2). The number of lateral shoots was reduced by the soak treatment. Stem diameters were smaller and pedicels were shorter in the treated plants as compared to that of the control. Soaking unrooted cuttings in high concentrations of uniconazole and paclobutrazol reduced flower number (Table 1), but not at uniconazole concentrations below 50 mg L^{-1} (Table 2). Again, treatments did not have any effect on flower size.

"Seminole Pink" hibiscus appeared to be extremely sensitive to soil application of uniconazole (Table 3). The rate of 0.05 mg/pot was excessive, producing new growth only 7% that of the untreated plants, with fewer and smaller flowers. Leaves on these plants were small and severely crinkled, resulting in plants which would be judged commercially unacceptable. Paclobutrazol at the 0.05 mg/pot rate offered good height control, whereas higher rates also resulted in excessive growth reduction.

Discussion

This study clearly shows that briefly dipping the cut end, or soaking the whole unrooted hibiscus cuttings, in an appropriate plant growth retardant solution prior to rooting can provide satisfactory height control during greenhouse production. To achieve a similar degree of growth control, a higher concentration of a plant growth retardant is needed for the basal dip than for soaking the whole cutting, possibly due to the smaller amounts of the plant growth retardant absorbed in the dip treatment. Treating rooting cubes with or dipping rooted cuttings in growth retardant solutions prior to planting has been shown to provide successful height control on other flowering crops, such as poinsettia (Gilbertz and Lewis 1986) and chrysanthemum (Reiss-Bubenheim and Lewis 1986).

The results of this and a previous study (Wang and Gregg 1989) suggest that different cultivars of a single plant species may display diverse sensitivities to uniconazole. While a uniconazole soil drench at rates of 0.05 or 0.1 mg/pot provided good height control and acceptable quality of "Jane Cowl" hibiscus (Wang and Gregg 1989), the growth of "Seminole Pink" was excessively stunted. Maus (1987)

Table 3. Effect of uniconazole or paclobutrazol soil drench on the production of *Hibiscus rosa-sinensis* "Seminole Pink."

Rate of retardant (mg/pot)	Total height (cm)	Stem growth (cm)	Lateral shoots >2 cm		Flower			
			Number	Length (cm)	Days to bloom	Number	Diameter (cm)	Pedicel length (cm)
Uniconazole								
0	39.9	31.0	8.1	24.7	85	14.9	15.0	5.4
0.05	14.3	2.2	0.6	2.0	81	3.7	13.6	2.5
0.10	14.2	2.1	0	1.4	81	3.3	13.1	2.5
Significance								
Linear	**	**	**	**	NS	**	*	**
Quadratic	**	**	**	**	NS	**	NS	**
Paclobutrazol								
0	39.7	30.7	7.1	22.6	85	11.4	14.9	5.2
0.05	22.4	11.5	3.6	21.0	86	8.9	14.9	5.4
0.10	18.8	7.7	3.6	9.2	86	5.6	14.8	3.9
0.20	16.7	4.6	3.0	6.4	92	4.6	14.1	4.1
Significance								
Linear	**	**	**	**	NS	**	NS	*
Quadratic	**	**	*	NS	NS	NS	NS	NS

NS, statistically nonsignificant; *, significant at the 5% level; **, significant at the 1% level.

applied 0.71–2.82 mg/pot of uniconazole to "Seminole Pink" grown in 11.5-cm pots and observed 30 cm shoot growth in the treated plants, compared to 60 cm in the control during a production time similar to that in experiment 1 of this study. The discrepancy between the results of the two studies may have been caused by different media. Maus' medium contained 50% pine bark, which was previously shown to make paclobutrazol, an analog of uniconazole, unavailable for absorption by plant roots when applied as a soil drench (Wainwright and Bithell 1986). Like paclobutrazol, uniconazole might be tightly adsorbed to the bark in a growing medium, reducing its availability to plant roots.

Inhibition of lateral shoot production was obvious for all treatments with the exception of uniconazole applied by dipping. However, Maus (1987) showed that uniconazole induced the growth of lateral shoots. Wallerstein and Hackett (1989) showed that GA_3 greatly stimulated lateral shoot growth in *Hedera helix*, whereas ancymidol, a GA biosynthesis inhibitor, had no effect.

Plants receiving uniconazole had less growth when compared to those receiving paclobutrazol at a similar rate, suggesting that either uniconazole was relatively more mobile in plant tissue or had more biological activity than paclobutrazol. It was noted that, in both dip and drench treatments, the effect of uniconazole on limiting shoot elongation continued when that of paclobutrazol started to diminish. Paclobutrazol was found to be relatively unstable in peach seedlings, with particularly high rates (≈90%) of breakdown in leaves (Early and Martin 1988). In general, a smaller amount of uniconazole is required than paclobutrazol to give a similar degree of growth control (Barrett et al. 1986, Wang and Blessington 1990).

Uniconazole inhibited pedicel elongation, whereas paclobutrazol had no effect when cuttings were soaked in a plant growth retardant solution prior to rooting. Privé et al. (1989) discovered that application of paclobutrazol on apple trees resulted in short pedicels; however, the length of epidermal and cortical cells in those pedicels did not differ from that of untreated trees (Privé et al. 1989).

It has been demonstrated that application of ancymidol induced slow shoot growth and quiescence in *Hedera helix*, whereas GA_3 resulted in fast shoot growth and a reduction of meristem size (Wallerstein and Hackett 1989). GA is known to induce rejuvenization of plants in their adult phase (Rogler and Hackett 1975a), whereas growth retardants were shown to stabilize the mature form (Rogler and Hackett 1975b). It may be possible that the response of hibiscus plants to triazole GA biosynthesis inhibitors, such as uniconazole and paclobutrazol, is similar to the maturation phenomenon, resulting in a temporary phase change causing slow cell division and reduced shoot growth.

References

Barrett JE, Bartuska CA (1982) PP333 effects on stem elongation dependent on site of application. HortScience 17:737–738

Barrett JE, Nell TA (1987) Efficacy and phytotoxicity of paclobutrazol and XE-1019 on vinca. Proc Fla Soc Hortic Sci 100:382–383

Barrett JE, Peacock ME, Nell TA (1986) Height control of *Exacum* and *Chrysanthemum* with paclobutrazol, XE-1019, flurprimidol and RSW-0411. Proc Fla State Hortic Soc 99:254–255

Cox DA, Keever GJ (1988) Paclobutrazol inhibits growth of zinnia and geranium. HortScience 23:1029–1030

Early JD, Martin GC (1988) Translocation and breakdown of ^{14}C-labeled paclobutrazol in "Nemaguard" peach seedlings. HortScience 23:196–200

Gilbertz AA, Lewis AJ (1986) Poinsettia response to pre-plant rooting-cube application of ancymidol and chlormequat. Sci Hortic 29:173–180

Hamilton RH, Law DM (1987) The effect of S-3307 on the IAA levels in elongating stem of Alaska pea. In: Cosgrove DJ, Knievel DP (eds) Physiology of cell expansion during plant growth. The American Society of Plant Physiologists, Maryland, pp 313–314

Maus WL (1987) Effect of paclobutrazol and uniconazole-P on *Hibiscus rosa-sinensis*. Proc Fla Soc Hortic Sci 100:373–375

Privé J-P, Elfving DC, Practor JTA (1989) Paclobutrazol, gibberellin, and cytokinin effects on growth, development, and histology of apple pedicels and fruits. J Am Soc Hortic Sci 114:273–278

Reiss-Bubenheim D, Lewis AJ (1986) Pre-plant application of growth retardants to pinched and unpinched chrysanthemum cuttings. Sci Hortic 28:159–164

Richardson PJ, Quinlan JD (1986) Uptake and translocation of paclobutrazol by shoots of M.26 apple rootstock. Plant Growth Regul 4:347–356

Rogler CE, Hackett WP (1975a) Phase change in *Hedera helix:* Induction of the mature to juvenile phase by gibberellin A_3. Physiol Plant 34:141–147

Rogler CE, Hackett WP (1975b) Phase change in *Hedera helix:* Stabilization of the mature form with abscission acid and growth retardants. Physiol Plant 34:148–152

Wainright H, Bithell H (1986) Influence of compost type on the activity of paclobutrazol soil drenches. Sci Hortic 29:15–20

Wallerstein I, Hackett WP (1989) The effects of pulse and continuous treatments with gibberellic acid and triiodobenzoic acid on the growth and rejuvenization of mature-phase *Hedera helix* plants. Israel J Bot 38:217–227

Wang YT, Blessington TB (1990) Growth of four tropical foliage species treated with paclobutrazol or uniconazole. HortScience 25:202–204

Wang YT, Gregg LL (1989) Uniconazole affects vegetative growth, flowering, and stem anatomy of hibiscus. J Am Soc Hortic Sci 114:927–932

Wilfret GJ (1987) Height retardation of Easter lilies grown in containers. Proc Fla State Hortic Soc 100:379–382