

Flowering and Growth of *Phalaenopsis* Orchids following Growth Retardant Applications

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Abstract. Bare-root, mature, hybrid *Phalaenopsis* seedlings were dipped in one of three growth retardant solutions for 5 seconds or sprayed with a growth retardant 4 weeks following planting during inflorescence elongation. Dipping the entire plant in daminozide (2500, 5000, or 7500 mg-liter⁻¹) before planting delayed flowering by 5-13 days, whereas foliar applications had no effect. Paclobutrazol (50, 100, 200, or 400 mg-liter⁻¹) or uniconazole (25, 50, 100, or 200 mg-liter⁻¹) dips did not affect the bloom date but effectively restricted inflorescence growth below the first flower (stalk). Increasing concentrations produced progressively less growth. Foliarly applied retardant treatments were less effective than dipping. Flower size, flower count, and stalk thickness were unaffected by treatments. Dipping in high concentrations of paclobutrazol (200 or 400 mg-liter⁻¹) or uniconazole (100 or 200 mg-liter⁻¹) caused plants to produce small, thick leaves. During the second bloom season, inflorescence emergence and bloom date were progressively delayed by increasing concentrations of paclobutrazol and uniconazole. Neither retardant affected flower count or size. Foliarly applied daminozide increased stalk length. In another experiment, foliar paclobutrazol treatment restricted stalk growth more effectively when sprayed before inflorescence emergence. Its effect progressively decreased when treatment was delayed. Paclobutrazol concentrations from 125 to 500 mg-liter⁻¹ were equally effective in limiting stalk elongation when applied to the foliage. Chemical names used: butanedioic acid mono (2,2-dimethylhydrazide) (daminozide); (E)-1- (p-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl)-1-pentan-3-ol (uniconazole); (2RS, 3RS) -1-(4-chlorophenyl)-4,4-dimethyl-2-(1-H-1,2,4-triazol-1-yl) pentan-3-ol (paclobutrazol).

The demand for *Phalaenopsis* (moth orchid) as a potted flowering plant has increased rapidly in recent years (Thomas, 1992; Vasquez and Frier, 1991). In addition to domestic propagation, >250,000 plants were imported to the United States in 1992. This orchid has a relatively low light requirement (Poole and Seeley, 1977; Taiwan Sugar Corp., 1989) and a bloom period often surpassing 2-3 months. *Phalaenopsis* is easier to grow than many other orchids (Gordon, 1990; McDowell, 1992; Wang, 1992).

One goal of current breeding research is to introduce more compact selections of moth orchids for the commercial trade. Although dwarf cultivars with small flowers are avail-

able (Gavin and Griesbach, 1991; Griesbach, 1985), most *Phalaenopsis* cultivars with large flowers have long inflorescences, which results in high shipping costs for the taller boxes that must be used. An assessment of commercially available growth retardants for controlling inflorescence length would be helpful. Because *Phalaenopsis* is a perennial and often reblooms for the consumer, the long-term effect of growth retardants on future growth and flowering must be evaluated. Therefore, our experiments were conducted to determine the immediate and long-term impact of three growth retardants on *Phalaenopsis* flowering and growth. The effect of paclobutrazol, applied at various stages of inflorescence development, on flowering also was evaluated.

Materials and Methods

Effect of various growth retardants. Bare-root, mature seedlings of a white-flowered *Phalaenopsis* hybrid [*P. amabilis* (L.) Blume × *P. Mount Kaala* 'Elegance'] with five to seven leaves spreading 30-35 cm were imported from Taiwan (Taiwan Sugar Corp., Taipei) by airfreight. Plants were in transit for 9 days and remained turgid with no visible

inflorescences on arrival (13 Oct. 1991). Eleven groups of eight plants were immersed for 5 sec in an aqueous solution of daminozide at 2500, 5000, or 7500 mg-liter⁻¹ (B-Nine SP; Uniroyal Chemical, Middlebury, Conn.); paclobutrazol at 50, 100, 200, or 400 mg-liter⁻¹ (Bonzi, Sandoz, Chicago); or uniconazole at 25, 50, 100, or 200 mg-liter⁻¹ (Sumagic; Valent U.S.A., Walnut Creek, Calif.) immediately following arrival. We dipped control plants in water. Then all plants were planted.

The medium consisted of equal volumes perlite (No. 3; Grace-Sierra, Fogelsville, Pa.) horticultural-grade charcoal, and Metro Mix 250 (Grace-Sierra, Milpitas, Calif.) amended with 250 g Micromax/m³ (Grace-Sierra, Milpitas). Among the charcoal particles, 35% were >8 mm; 21% were 8-6.3 mm; 32% were 6.3-4 mm; and 14% were <4 mm.

A total of 48 additional plants were potted, and after 4 weeks when flower spikes had started to elongate, plants were given a foliar spray of water, daminozide (2500 or 5000 mg-liter⁻¹), paclobutrazol (250 or 500 mg-liter⁻¹), or uniconazole (100 or 200 mg-liter⁻¹). All solutions contained 0.05% Tween 20 (Fisher-Biotech, Fair Lawn, N.J.). The spray solution was used at an average rate of 12 ml/plant. The medium surface was not covered during spraying to simulate a commercial practice. The air was 27C at the time of treatment. Single-plant experimental units were replicated eight times. Treatments were arranged in a randomized complete-block design. We conducted regression analyses within each application method, using the concentration of each retardant as the independent variable.

Plants were placed on a greenhouse bench and received a maximum photosynthetic photon flux from 460 (Oct. 1991) to 270 (Jan. 1992) μmol-m⁻²-s⁻¹ at noon. All pots were irrigated by hand with water containing 0.5 g 20N-8.6P-16.6K water-soluble fertilizer (Grace-Sierra) per liter.

We started to collect data when the fifth flower opened; our data included first flower width, number of flowers on the main inflorescence, total inflorescence length, and date that the first flower became fully open. We also recorded inflorescence length between the base and first flower (stalk), its diameter at the middle of the fourth internode, and internode length between the first and second flowers.

To determine retardant effects on long-term plant performance, plants were watered, fertilized, and maintained on the same bench. The average greenhouse air was 22.7 (day)/16.5C (night) in Jan. 1992 and 32.9 (day)/25.7C (night) in July 1992.

We started examining the plants daily on 1 Aug. 1992, recording date of inflorescence emergence from a leaf base and data similar to those collected during the previous season. Length and width of the uppermost fully matured leaf were determined. The experiment ended in Apr. 1993.

Effects of paclobutrazol at various stages. *Phalaenopsis* (Snow Swallow × Hisa Nasu) plants with 30- to 35-cm leaf span, propagated by tissue culture, were grown in 470 cm³ New

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Paclobutrazol also restricted internode length between the first two flowers. Its effect was greater when the applications were progressively delayed (Table 3). Perhaps the limited mobility of paclobutrazol molecules in plant tissues decreased the ability to restrict

elongation when applied early (Barrett and Bartuska, 1982; Wang, 1991). Paclobutrazol did not affect the stalk diameter.

Early stage, *Phalaenopsis* inflorescence elongation may result primarily through cell division. Therefore, early growth retardant

application exerts a greater effect by limiting the number of cells. Daminozide limited the cell count of chrysanthemum [*Dendranthema × grandiflorum* (Ramat.) Kitamura] internode to one-third that of a nontreated plant (Jin et al., 1992). Uniconazole also curtails cell count and size, resulting in short hibiscus pedicels (Wang and Dunlap, 1994).

Concentration effect. Neither the number of paclobutrazol applications at 125 to 500 mg-liter⁻¹ nor the paclobutrazol concentration had an effect on flower size or number (Table 4). Stalk length was restricted in all treated plants, with little dosage effect. The internode length between the first two flowers was shorter as the result of one paclobutrazol application at all concentrations. Surprisingly, two applications had no effect. Also, paclobutrazol concentrations had no effect on stalk diameter (Table 4).

Because plants produced inflorescences uniformly, plants of various stages had to be selected and treated on several dates. This procedure invalidated evaluation of paclobutrazol on bloom date in the second experiment. However, plants treated at the pre-emergence stage, resulting in the shortest stalk, bloomed at the same time as the nontreated plants (Table 3). Therefore, as observed in the first experiment, paclobutrazol treatments probably did not accelerate or delay flowering in the current season.

This study demonstrates that paclobutrazol and uniconazole successfully control *Phalaenopsis* inflorescence length without affecting visual flower quality. However, when used at high concentrations, these substances will delay or prevent the following year's bloom, as well as cause the production of more small, thick leaves. Daminozide is not suitable for controlling the inflorescence length of *Phalaenopsis*.

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Table 2. Effect of three growth retardants on second-year performance of *Phalaenopsis* orchids.

Retardant rate (mg-liter ⁻¹)	Inflorescence emergence (days) ^y	First flower bloom (days) ^y	No. flowers	Stalk ^z		No. new leaves	Uppermost fully expanded leaf	
				Length (cm) ^x	Diam (mm) ^w		Length (cm)	Width (cm)
Control 0	48	139	10.0	57.8	6.58	4.3	23.4	10.4
<i>Preplant dip</i>								
Daminozide 2500	43	138	12.1	62.5	6.48	4.5	21.6	10.6
5000	51	150	10.1	57.9	6.41	4.6	18.8	10.0
7500	36	133	11.0	58.5	6.45	4.4	21.1	10.1
Significance	NS	NS	NS	NS	NS	NS	NS	NS
<i>Paclobutrazol (P)</i>								
50	47	139	10.8	53.4	6.40	4.8	20.5	10.8
100	55	151	10.3	54.1	6.10	6.0	19.3	10.5
200	75	170	10.7	46.9	6.23	6.3	21.0	10.7
400	91	177	10.4	33.2	6.01	6.0	12.8	9.9
Significance ^v	L***	L**	NS	L***	NS	L*Q*	L***	NS
<i>Uniconazole (U)</i>								
25	94	183	9.0	28.0	5.24	5.8	10.6	9.5
50	103	192	9.5	31.7	5.73	7.0	11.0	10.0
100	109	192	9.0	24.7	5.53	6.2	6.4	7.0
200	100	194	8.8	23.9	4.98	4.8	8.4	8.2
Significance	L**Q***	L**Q**	NS	L***Q***	L**	Q*	L***Q***	L*Q*
P vs. U	***	***	*	***	**	**	***	***
<i>Foliar spray</i>								
Daminozide 2500	30	116	11.9	58.1	6.36	5.1	23.8	10.5
5000	36	133	11.6	67.6	6.95	4.4	23.7	10.1
Significance	NS	Q*	NS	L*	NS	NS	NS	NS
<i>Paclobutrazol</i>								
250	72	163	10.3	49.4	6.05	4.7	22.0	11.1
500	90	181	10.8	48.9	6.36	7.4	17.6	11.3
Significance	L***	L***	NS	L*	NS	L***	L**	NS
<i>Uniconazole</i>								
100	83	170	10.1	43.4	6.16	6.7	15.3	11.0
200	80	169	9.3	35.4	6.09	6.9	8.9	9.0
Significance	L*	L*	NS	L***	NS	L**	L***	NS

^zStalk refers to the part of an inflorescence below the first flower.

^yDay 0 = 1 Sept. 1992 (the date that the first inflorescence started to emerge).

^xLength from plant attachment to first flower.

^wDiameter is between the third and fourth internode.

^vL = linear; Q = quadratic.

NS, ***, ***, ***, Nonsignificant or significant at $\alpha = 0.05, 0.01, \text{ or } 0.001$, respectively.

Table 3. Effect of paclobutrazol at 250 mg-liter⁻¹ on *Phalaenopsis* orchid flowering when treated at various stages of flower spike development.^z

Stage or length of flower spike (cm)	Inflorescence			First flower	
	Length ^y		Diam (mm)	Bloom ^x (days)	Width (cm)
	A (cm)	B (cm)			
Pre-emergence	22.1 f	4.5 b	5.9 ab	94.0 a	10.2 c
Emergence	27.8 e	4.3 b	5.6 ab	87.7 b	10.2 c
1.0	31.5 d	4.2 bc	5.6 b	78.5 e	10.3 c
2.5	35.5 c	3.9 cd	5.5 b	87.8 b	10.2 c
5.0	37.8 bc	3.9 cd	6.0 a	81.4 de	10.6 ab
7.5	39.0 b	3.7 de	5.7 ab	87.1 bc	10.4 bc
10.0	40.5 b	3.5 e	5.8 ab	84.3 cd	10.6 a
Control	48.7 a	4.9 a	5.8 ab	93.5 a	10.2 c

^zMean separation within columns by Duncan's multiple range at $\alpha = 0.05$. Differences in flower count (7.9-8.9) were nonsignificant.

^yA = distance between the base and the node bearing the first flower; B = internode length between the first two flowers.

^xDay 0 = 5 Nov. 1992.

Table 4. Effect of paclobutrazol at various concentrations on the flowering response of *Phalaenopsis* orchids.^z

Rate (mg·liter ⁻¹)	First flower		No. flower	Inflorescence		
	Bloom ^y (days)	Width (cm)		Length ^x		Diam ^w (mm)
				A (cm)	B(cm)	
0	93.5 a	10.2 a	8.1 a	48.7 a	4.9 a	5.8 ab
125	83.8 b	10.1 a	8.3 a	35.9 b	4.4 b	5.8 ab
125 × 2	81.1 bc	10.1 a	8.1 a	35.5 b	4.8 a	5.5 b
250	78.5 c	10.3 a	7.9 a	31.5 c	4.2 b	5.6 b
250 × 2	79.6 bc	10.2 a	8.7 a	36.2 b	4.8 a	6.0 a
500	80.0 bc	10.3 a	8.2 a	33.5 bc	4.1 b	5.8 ab

^zMean separation within columns by Duncan's multiple range test at $\alpha = 0.05$.

^yFor 0 and 250 mg·liter⁻¹, day 0 = 5 Nov. 1992; for all others, day 0 = 18 Nov. 1992.

^xA = distance between the base and the node bearing the first flower; B = internode length between the first two flowers.

^wMeasured at the middle of the fourth internode.

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