Research Reports

Effects of Pinching, Number of Cuttings per Pot, and Plant Growth Regulators on Height Control of Purple Firespike

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SUMMARY. Purple firespike (*Odontonema callistachyum*), native to Central America, has potential for use as a new flowering potted plant. The effects of number of pinches (zero, one, or two) and number of cuttings (one, two, or three) per 6-inch pot were evaluated on the control of plant height. Plant height was suppressed as the pinch number increased. The greatest reduction was recorded with one cutting per pot and two pinches. The maximum number of branches per pot was recorded with two pinches and three cuttings per pot. In a second experiment, plant growth regulators (PGR) were also tested for efficacy of height control; 2 weeks after pinching, foliar sprays of paclobutrazol, flurprimidol, daminozide, chlormequat, and a tank-mix of daminozide + chlormequat or media drenches of paclobutrazol, uniconazole, or flurprimidol were applied. Plant height, leaf area, and leaf dry weight were recorded at 3, 6, and 9 weeks after PGR application. Maximum height control was obtained with uniconazole drench at 8 ppm, resulting in plants 22 cm tall, 61% shorter than the untreated control (56 cm); however, it resulted in severe leaf distortion. Plant height was 56% and 46% shorter than the control using drenches of paclobutrazol at 30 ppm and flurprimidol at 15 ppm, respectively. Daminozide spray at 2000 ppm and tank-mix of daminozide + chlormequat at 4500/1500 ppm suppressed stem elongation by 20.3% and 19%, respectively. Plants treated with paclobutrazol drench at 30 ppm reduced leaf area and leaf dry weight compared with other PGRs. Chlormequat spray at tested concentrations was ineffective for controlling firespike plant growth. The most attractive potted plants were produced using a drench application of paclobutrazol at 10 or 15 ppm.

Purple firespike is native to Mexico and Central America. It is a large and showy perennial shrub growing to ≈2 m tall with an

upright habit. The plant has a high potential for introduction as a flowering potted plant because of its shiny

dark green leaves and attractive terminal or axillary lavender to purple spikes of flowers (Riffle, 1998). However, without height control, firespike grows too tall exceeding the commercial requirements for potted plants. Thus, control of firespike stem elongation is necessary to provide desirable marketable products.

Numerous techniques have been used to control height and produce marketable plants. Pinching is the removal of the apical bud to overcome apical dominance and promote lateral branch development and is an economical practice that can be used to keep the plant short with more synchronous flowering (Larson, 1985). Pinching controls plant height, enhances plant width, and increases the number of branches (Beniwal et al., 2003; Rakesh et al., 2003). For example, pinching decreased plant height significantly in some cultivars of hydrangea (*Hydrangea macrophylla*) under long days (Anderson et al., 2009).

Application of PGRs is the most common cultural technique to control stem elongation and produce compact plants. Plant growth retardants are used to reduce excess shoot growth without affecting plant productivity. Most growth retardants act by inhibiting gibberellic acid biosynthesis in plants, which is involved in stem elongation (Rademacher, 2000). Several growth retardants are currently recommended for controlling height of floriculture crops. Triazoles, including uniconazole and paclobutrazol, are one of the largest commercially used groups of PGRs to control plant height and produce compact plants (Gibson and Whipker, 2001; Krug et al., 2005; Schluttenhofer et al., 2011; Warner and Erwin, 2003). Chlormequat and daminozide are growth regulators frequently applied to limit plant height in poinsettia [*Euphorbia pulcherrima* (Boldt, 2008; Currey and Lopez, 2011; Karunananda and Peiris, 2010; Lopez and Runkle,

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Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
0.4075	gal/100 ft ²	L·m ⁻²	2.4542
2.54	inch(es)	cm	0.3937
6.4516	inch ²	cm ²	0.1550
16.3871	inch ³	cm ³	0.0610
28.3495	oz	g	0.0353
28,350	oz	mg	3.5274 × 10 ⁻⁵
1	ppm	mg·L ⁻¹	1
(°F - 32) ÷ 1.8	°F	°C	(°C × 1.8) + 32

2007)]. Also, the tank-mix of daminozide + chlormequat has been used effectively to control plant height (Gibson and Whipker, 2003; Lewis et al., 2004). Flurprimidol is similar to paclobutrazol and uniconazole in both chemical structure and mode of action. It is effective as a foliar spray and substrate drench for height control (Currey and Lopez, 2011; Krug et al., 2005, 2006; Whipker et al., 2006).

Information on height control and the effects of PGRs on purple firespike in greenhouse production is limited or nonexistent. The objective of this study was to evaluate the efficacy of five PGRs, along with pinching and number of cuttings on height control of purple firespike.

Materials and methods

On 3 June 2013, 10-cm cuttings of purple firespike were made from stock plants grown under long days to eliminate the possibility of floral initiation occurring before experimental treatments. The cuttings were rooted in 32-cell trays (each cell = 175 cm³) containing commercial potting substrate (Sunshine Mix 1; Sun Gro Horticulture, Bellevue, WA). Four weeks later, the rooted cuttings were transplanted to 6-inch-diameter pots and grown under natural daylength in a polyethylene covered greenhouse with evaporative pad cooling. The greenhouse air temperature set points were 23 and 18 °C, (day/night). The plants were fertigated using 200 ppm nitrogen from a 20N-4.4P-16.6K liquid fertilizer (Peters Peat-Lite 20-10-20; Scotts, Marysville, OH). One, two, or three cuttings were planted per pot. Pinching treatments included a non-pinched control, one pinch, or two pinches. The first pinch was applied after 14 d growth when plants averaged 6 cm tall and had an established root system. They were soft-pinched by removing the terminal growing point including one or two youngest leaf pairs for best branching results. Four weeks later, the second pinch left four to five nodes per shoot to produce side shoots and shape the plant for a more symmetrical form.

DATA ANALYSIS. Treatments were a factorial of one, two, or three cuttings per pot and zero, one, or two pinches during production. The experimental design was a randomized complete design with treatments replicated five times. Numbers of branches greater

than 1 inch in length and plant height (from the pot rim to the top of the foliage) of each plant were recorded weekly from the start of the experiment. Data were analyzed using the general linear models procedure of SAS (version 9.3; SAS Institute, Cary, NC).

In a second experiment, on 20 June 2013, purple firespike cuttings were rooted as previously described. Rooted cuttings then were transplanted to 6-inch-diameter pots. Plants were pinched 2 weeks after transplanting leaving two to three nodes. The greenhouse temperature set points were 23 and 18 °C (day/night). Plants were irrigated and fertilized as in the pinching experiment. Growth retardants were applied when the new shoots were 3 to 5 cm long (≈ 14 d after pinching). Five PGRs at various rates were evaluated including foliar sprays of chlormequat (Cycocel; OHP, Mainland, PA) at 1000, 2000, or 3000 ppm; daminozide (Dazide; Fine Americas,

Walnut Creek, CA) at 2000, 3000, or 5000 ppm; tank-mix of daminozide + chlormequat at 4500/1500, 3000/1000, or 1500/500 ppm; uniconazole (Sumagic; Valent USA Corp., Walnut Creek, CA) at 15 ppm; or flurprimidol (Topflor; SePRO, Corp., Carmel, IN) at 15, 30, or 45 ppm applied at a spray solution volume of 0.5 gal/100 ft². Substrate drenches of paclobutrazol (Bonzi; Syngenta Crop Protection, Greensboro, NC) at 30, 25, 20, or 10 ppm (3.6, 3, 2.4, or 1.2 mg/pot); uniconazole at 8, 5, or 2.5 ppm (0.96, 0.60, or 0.30 mg/pot); or flurprimidol at 15, 10, or 5 ppm (1.8, 1.2, or 0.6 mg/pot) were applied to the substrate surface. An untreated control (0 ppm) was also included.

Plant height was measured weekly and at termination of the study, leaf area and leaf dry weight were also recorded. The experimental design was a randomized complete design with treatments replicated 10 times.

Fig. 1. Effects of number of pinches and number of cuttings per pot on plant height (A) and number of branches (B) of purple firespike. Cuttings were planted one, two, or three per pot and pinching treatments included zero, one, or two pinches. Means were separated using Fisher's protected least significant difference test at $P \leq 0.05$; 1 cm = 0.3937 inch.

Data were analyzed using general linear models procedure of SAS to determine most effective PGR and rate for height control of purple firespike. Means were separated using Fisher's protected least significant difference test at $P \leq 0.05$.

Results and discussion

Pinching and number of cuttings affected plant height and number of primary branches per pot. Pinching treatments resulted in shorter plants after 6 weeks compared with non-pinched plants (Fig. 1A). The tallest plants were obtained using one cutting per pot and no pinching (36.6 cm). It was mainly due to nonpinched plants growing in their original upright habit without height restriction. One cutting, twice pinched resulted in the shortest plants (16.2 cm) that were 56% shorter than the control plants; however, they were not different from those with two cuttings, twice pinched. In a study conducted by Bañón et al. (2001), pinching more effectively restricted final oleander

(*Nerium oleander*) plant height compared with applications of chlormequat. The results of this study agree with the results obtained by Ryagi et al. (2007) who also found carnation (*Dianthus caryophyllus*) plant height was significantly decreased in plants twice pinched compared with one pinching. Number of branches also increased (Fig. 1B). The number of branches per pot increased significantly as number of cuttings and pinches increased. The greatest number of branches (18) per pot was recorded using three cutting per pot and pinched twice. One cutting with no pinching had the least number of primary branches (three) per pot; however, it was not different from one cutting with one pinch and two cuttings with no pinch. Previous studies have shown pinching effectively decreased plant height and increased number of branches in chrysanthemum [*Chrysanthemum × grandiflorum* (Grawal et al., 2004)] and carnation (Pathania et al., 2000). Pinching of the apical bud diminishes apical dominance, which

plays an important role in longitudinal growth. Therefore, removing the apical buds leads to an increase in lateral buds and decrease in plant height (Rema and Khader, 1997; Thakral et al., 1991). The beneficial effects of pinching may be an increased number of flowers because of an increase in primary branches and plant height control by removing apical dominance. For instance, to produce an attractive poinsettia in a 6.5-inch pot, plants should be pinched once for a final height of 16 to 18 inches (Ecke et al., 2004). Based on our results, using one cutting per pot with two pinches made the most attractive compact plants with eight potential flowering branches, even when not in bloom.

Increasing rates of all growth retardants limited stem elongation and thus final plant height (Table 1). Nine weeks after PGR application, final plant height ranged from a minimum of 22 cm with 8 ppm uniconazole drench to a maximum of 56 cm

Table 1. Effects of plant growth regulators (PGR) on plant height, leaf dry weight, and leaf area of purple firespike plants pinched 2 weeks after potting to leave two to three nodes and treated with PGRs when new shoots were 3–5 cm.

Treatment	Rate (ppm) ^z	Application method	Plant ht (cm) ^z			Leaf dry wt (g) ^z	Leaf area (cm ²) ^z
			Week 3	Week 6	Week 9		
Control			37.4 a ^y	45.8 a	56.0 a	45.6 a	3,668 a
Chlormequat	1000	Spray	32.1 b	41.4 bc	53.9 ab	48.2 ab	3,414 ab
	2000	Spray	30.0 bcd	39.8 cd	52.2 abc	43.3 abc	3,313 bcde
	3000	Spray	29.9 bcd	38.9 cde	50.1 bcd	43.0 bc	3,270 bcde
Daminozide	2000	Spray	29.4 ed	35.8 fghi	46.2 defg	45.1 abc	3,334 ab
	3000	Spray	28.3 def	34.5 ghi	45.0 efg	44.8 bc	3,280 abc
	5000	Spray	28.1 def	34.2 hi	43.7 fgh	43.6 bcd	3,171 abcd
Tank-mix ^x	1500/500	Spray	31.9 bc	42.8 b	52.0 abc	42.6 cde	2,984 bcdef
	3000/1000	Spray	29.5 cde	37.3 defg	47.3 cdefg	37.9 e	2,764 fgh
	4500/1500	Spray	26.7 fgh	34.6 ghi	45.6 defg	36.1 e	2,685 ghi
Paclobutrazol	10	Drench	16.8 kl	21.4l mn	39.9 hi	35.4 f	2,173 ghij
	15	Drench	15.8 kl	19.9 mno	35.6 hi	34.8 fgh	2,047 hij
	20	Drench	15.7 kl	18.3 op	31.9 jk	33.9 fgh	1,996 hig
	30	Drench	14.7 l	16.5 p	24.6 l	31.0 h	1,677 j
Uniconazole	2.5	Drench	20.5 i	22.9 kl	34.1 jk	37.8 gf	2,129 fgh
	5	Drench	18.1 ijk	19.9 mno	24.2 l	36.3 gh	1,751 ghi
	8	Drench	17.0 kl	18.6 nop	22.0 l	35.5 h	1,689 ghij
	15	Spray	19.7 ij	25.6 k	36.4 ij	38.6 fgh	2,018 efgh
Flurprimidol	15	Spray	29.1 def	37.6 def	49.0 bcde	41.4 cde	2,978 bcdef
	30	Spray	25.5 gh	36.7 efgh	46.7 d-g	39.9 de	2,842 defg
	45	Spray	24.5 h	33.8 ij	43.6 gh	38.5 e	2,613 efgh
	5	Drench	17.5 ijk	22.7 lm	35.7 ij	35.4 f	2,136 ghij
	10	Drench	17.2 k	20.6 l-o	33.1 jk	32.0 fgh	2,049 ij
	15	Drench	17.1 kl	19.0 nop	30.4 k	31.2 fgh	1,990 j
PGR			*** ^w	***	***	***	***
Rate (PGR)			***	***	***	***	***
LSD ^y			1.5	1.7	3	2.97	233

^z1 ppm = 1 mg·L⁻¹, 1 cm = 0.3937 inch, 1 g = 0.0353 oz, 1 cm² = 0.1550 inch².

^yMeans separation using Fisher's protected least significant difference test at $P \leq 0.05$.

^xTank-mix = chlormequat + daminozide.

^w***Significant at $P \leq 0.001$.

for control plants. The shortest plants were 61% shorter than the control plants; however, an undesirable effect of high rates of uniconazole was leaf crinkling (visual observations). Plants treated with 30-ppm paclobutrazol drench resulted in an aesthetically more appropriate shape and height (24.6 cm) without any negative effects on the leaves; however, there was no significant difference between paclobutrazol at 30 ppm and uniconazole at 8 ppm drenches. Suppression of stem elongation was visible for all treatments after 3 or 6 weeks; however, with measuring plant height weekly, a uniconazole drench of 5 or 8 ppm and a paclobutrazol drench of 30 ppm appeared to have longer lasting height control and more uniform results even after 9 weeks compared with other PGR treatments. These two PGRs have a similar mode of action (Rademacher, 2000), but affected height control differently in purple firespike. Chlormequat, daminozide, and flurprimidol spray were least effective in height control compared with other treatments; however, plant height decreased linearly with increasing rates of these PGRs. The final height in plants sprayed with chlormequat at the lowest rates were similar to control plants but were slightly shorter as PGR concentration increased (Table 1). However, foliar sprays of chlormequat at the rates of 2000 and 3000 ppm resulted in severe marginal leaf chlorosis or chlorotic spotting. The tank-mix of daminozide + chlormequat suppressed plant height at all concentrations. The lowest tank-mix rate resulted in plants taller than the higher rates, but there was no difference in plant height between the two higher tank-mix rates. The higher rates of tank-mix sprays suppressed plant height more than chlormequat alone, but less than daminozide. Plants sprayed with daminozide at rates of 2000, 3000, and 5000 ppm were 18%, 20%, and 22% shorter, respectively, than control plants (Table 1). Although height reduction in plants treated with daminozide was significant, higher concentrations or multiple applications may be needed to adequately control height. Drench applications of flurprimidol resulted in shorter plants than spray applications (Table 1). Final plant height using 45-ppm flurprimidol spray was 22% shorter than control plants and similar to plants sprayed with 5000 ppm daminozide.

At concentrations of 10 and 15 ppm flurprimidol drench, plants were 41% and 46% shorter, respectively, than untreated plants. Growth control with 15 ppm flurprimidol drench was comparable to paclobutrazol at 20 ppm. These results agree with Whipker et al. (2004) who reported flurprimidol drenches at 2 ppm were more effective on 'Pacino' pot sunflowers (*Helianthus annuus*) than flurprimidol sprays of ≥ 30 ppm. Plants treated with 8 ppm uniconazole, 30 ppm paclobutrazol, and 15 ppm flurprimidol drenches had thicker and darker green leaves. Zhao and Wang (2008) found suppressed internode elongation occurred due to a reduction in cell length but not cell number.

Leaf dry weight and leaf area were affected by the growth retardants. All PGR treatments resulted in less leaf area than the control. Leaf dry weight decreased when plants were treated with PGRs. Plants treated with a 30-ppm paclobutrazol drench had a 32% reduction in leaf dry weight compared with the control at 45.6 g (Table 1). Similar results were obtained for 10- and 15-ppm flurprimidol drench with 30% and 32% leaf dry weight less than the control, respectively. These findings agree with Cho et al. (2002) who reported paclobutrazol reduced leaf area and fresh and dry weight of cucumber (*Cucumis sativus*). Leaf area of cucumber decreased 54% over the control when paclobutrazol and uniconazole drenches at 30 and 8 ppm, respectively, were applied.

Drench applications of paclobutrazol or uniconazole at the highest rates restricted the height of purple firespike the most. However, high concentrations of uniconazole may produce plants with crinkled leaves and may be too short to be marketable. An aesthetically pleasing potted plant of purple firespike would be well branched and compact in height and may be achieved by planting one cutting per 6-inch pot and pinching ≈ 14 d after potting followed by a second pinch ≈ 4 weeks later to leave four to five nodes. This resulted in a plant ≈ 16.2 cm tall and well branched. Alternatively, PGRs may be used to control excessive stem elongation in purple firespike. Drench applications of uniconazole 8 ppm, paclobutrazol 30 ppm, or flurprimidol 15 ppm resulted in plants 22 to 30 cm in height

and proportional to the container. Although the plants in this study were not grown to flowering, flower spikes in firespike can add ≈ 12 to 15 cm additional height (observational data).

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