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Response of Chrysanthemum to Uniconazole and Daminozide Applied as Dip to Cuttings or as Foliar Spray

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Abstract. Uniconazole and daminozide were used as dip on unrooted cuttings or as foliar spray on pinched *Dendranthema grandiflora* Tzvelev. 'Dalvina' to control height. Stem elongation was determined on cuttings dipped in solutions of 0, 1.25, 2.5, 5, or 10 mg/L uniconazole or cuttings were dipped and later treated with foliar sprays in concentrations of 1.25/5, 1.25/10, 2.5/10, and 5/5 mg/L uniconazole, respectively. Other plants were sprayed once or twice with uniconazole at 10 mg/L. Daminozide treatments included a pre-plant dip/foliar spray application of 1000/2000 mg/L, respectively, or two foliar sprays of 2,000 mg/L. Uniconazole dip alone retarded stem elongation linearly up to 8 weeks after propagation, 5 weeks after pinching, but was not discernible from the control treatment 8 weeks after pinching. Uniconazole at 2.5/10 and 5/5 mg/L as a dip/spray combination resulted in plants 33% shorter than the control at the end of the production. Doubling uniconazole dip or spray treatments from 5 to 10 mg/L provided no additional reduction of stem elongation. The single uniconazole spray and both daminozide treatments had no effect on final height, although daminozide treatments reduced stem dry weight compared to the control. Stem dry weight was reduced by uniconazole dip/spray combinations compared to dip treatments alone. Similarly, inflorescence and root dry weights were also reduced by the highest uniconazole concentrations. Higher concentrations of uniconazole reduced transpiration on a per leaf area basis up to 47% compared to the control at the end of production. In contrast to previous work, leaf area and leaf thickness increased with some uniconazole treatments, while time to anthesis was not affected by any of the treatments.

Uniconazole is a triazole that inhibits gibberellin biosynthesis and was found to reduce transpiration of plants (Davis et al. 1988). Most plant growth regulators reduce transpiration rates through a reduction of leaf area (Abod and Webster 1991, Steinberg et al. 1991). In chrysanthemum that had been treated with uniconazole, transpiration was reduced when plants had reached maturity without affecting leaf area (author's unpublished data). Leaves of triazole-treated plants often appear darker and have a higher chlorophyll content compared to untreated plants (Davis et al. 1988, Wang and Gregg 1989).

While the majority of growth retardants are applied as multiple foliar sprays or medium drenches (Abod and Webster 1991, Bailey and Miller 1989, Barrett et al. 1986, Sanderson et al. 1988), alternative methods of application have been investigated. These include preplant dips of rooted cuttings (McDaniel and Fuhr 1977, Reiss-Bubenheim and Lewis 1984, 1986), unrooted cuttings (Wang and Gregg 1991) or bulbs (Lewis and Lewis 1980), soaking of root cubes (Lewis 1982, Gilbertz and Lewis 1986, Bearce and Singha 1992), or propagation blocks (Witte and Tjia 1976).

Daminozide is currently registered for use in most states as a preplant dip for chrysanthemum cuttings. The label recommends dipping the top of rooted cuttings and potting the plant immediately. For unrooted cuttings, the label requires overnight refrigeration of the treated cuttings before they can be transferred to the potting medium. According to uniconazole label instructions, unrooted cuttings would not require overnight refrigeration, but could be planted immediately after treatment.

Uneven application of plant growth retardants can result in nonuniform growth (Wang and Gregg 1991). Applying uniconazole as a dip on cuttings as compared to foliar spray ensures thorough coverage

of the stem with the retardant, which is critical for highest efficacy (Barrett and Bartuska 1982). Preplant dip could also eliminate multiple foliar sprays to a single application, reducing labor and chemical costs.

The objective of this study was to determine the vegetative and reproductive growth response of the tall chrysanthemum cultivar 'Dalvina' to uniconazole applied as preplant dip to unrooted cuttings, as foliar spray, or combinations of both methods. Two daminozide treatments at recommended label rates were included as a standard practice and were applied as dip/spray or two sprays to compare to untreated and uniconazole-treated plants.

Materials and Methods

Unrooted cuttings of *Dendranthema grandiflora* Tzvelev. 'Dalvina' (8-week tall response group) were obtained from Yoder Brothers (Barberton, OH). Cuttings were dipped for approximately 5 s in a 1000-mg/L daminozide (butanedioic acid mono 2,2-dimethylhydrazide) solution, placed on tissue paper, covered with cheesecloth and stored at 4°C for 20 h. The following day, untreated cuttings were dipped for approximately 5 s in solutions of 0 (control), 1.25, 2.5, 5, or 10 mg/L uniconazole [(E)-(p-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl)-1-penten-3-ol]. All cuttings were immediately inserted, one per 1.8-liter pot, in moist Metro Mix 220 (Grace Sierra, Milpitas, CA) after cut ends had been dipped in 0.1% IBA [4-(3-indolyl) butyric acid] (Sigma, St. Louis, MO). Plants were placed under mist in a greenhouse with 32°/15°C (max/min) day/night temperatures, respectively. After 12 days, plants were transferred to a climate-controlled glasshouse with the following condition: 23(±4)/17(±2)°C day/night temperatures, respectively, and natural photoperiod (14 h) with an average of 30.6 mol/m^2/day photosynthetically active radiation at canopy level under cloudless conditions. Irradiance was measured continuously with a quantum sensor (LI-COR, Lincoln, NE) which was attached to a 21× Micrologger (Campbell Scientific, Logan, UT). Plants were fertilized at each irrigation with Foliage-Pro 9N-3P-6K formulation at a rate of 200 ppm N (Dyna Gro Corp., San Pablo, CA). Each pot was topdressed with one teaspoon of 14N-14P-14K Osmocote, 100 days release (Grace Sierra, Milpitas, CA). The plants were pinched 22 days after the start of propagation and this was referred to as week 0.

The first foliar spray was applied 1 week later when the new shoots had reached a length of about 2 cm. Plants that received two foliar sprays were treated again at week 3. Uniconazole spray was applied at 5 or 10 mg/L and the recommended label volume of 0.19 L/m^2. Daminozide was sprayed to runoff at 2000 mg/L.

Height was measured weekly from the surface of the media to the tallest shoot apex and plant width was determined from the average of two canopy diameter measurements at week 8. Plants were harvested when 50% of the inflorescences per plant were completely open (week 8). Transpiration of plants was determined gravimetrically 1 day before harvest. Relative chlorophyll content was measured on leaves from the upper half of the canopy with a leaf reflectance meter (SPAD-502, Minolta). Leaf area was measured with an area meter (LI-COR, Lincoln, NE). Dry weight of stems, leaves, inflorescences, and roots were determined after the tissues were dried for 3 days at 65°C.

The experiment was arranged as a randomized complete block design with six replications per treatment. Data were analyzed using GLM procedures including planned contrasts for means comparisons (SAS Institute, Cary, NC).

Results

Stem elongation was retarded with increasing concentrations of uniconazole dip treatments for 8 weeks after the start of propagation, 5 weeks after pinching (Table 1). Stem elongation responded linearly to uniconazole concentrations up to 5 mg/L, but doubling the dip concentration to 10 mg/L caused no further delay in stem elongation. After week 5, plants treated with uniconazole dip only were as tall as control plants. The 5- and 10-mg/L dip arrested stem elongation for 5 weeks after the dip treatment. Preplant dip with 1.25 mg/L uniconazole when followed by a spray at 5 or 10 mg/L retarded stem elongation during weeks 4, 5, 6, and 8 compared to the 1.25 mg/L dip only, but the higher spray concentration (10 mg/L) caused no additional retarding effect compared to low concentration (5 mg/L). The dip/spray treatments 1.25/5 and 1.25/10 mg/L resulted in shorter plants compared to two uniconazole sprays of 10 mg/L up to week 3, but no differences in final height were found at week 8. From weeks 3 to 6, the two uniconazole sprays effectively retarded stem elongation such that plants were shorter than the dip/spray treatments by week 6.

Uniconazole applied as dip/spray at 5/5 mg/L resulted in 15–19% shorter plants than the 2.5/10 treatment until week 5, but thereafter plants from both treatments reached the same height. Throughout the experiment, plants from both treatments were shorter than plants treated with 1.25/5 or 1.25/10 mg/L dip/spray, except for week 7 (Table 1). At week 8 they were 33% shorter than the control plants.

Plants treated with a uniconazole preplant dip at 10 mg/L were 57% shorter at week 1 than previously untreated plants that were sprayed with uniconazole at 10 mg/L at week 1. The dip treatment continued to retard stem elongation compared to the spray until week 4, but by week 8 plants from both treatments reached a similar height as control plants (Table 1).

Daminozide dip at 1000 mg/L of the dip/spray treatment inhibited stem elongation only until week 1 compared to the spray treatment, which was untreated at that time. Height of daminozide-treated plants was similar to control plants, except at week 4, but shorter than plants treated with a single uniconazole spray at 10 mg/L up to week 3 (Table 1).

Table 1. Plant height of 'Dalvina' chrysanthemum as affected by uniconazole and daminozide applied as dip on unrooted cuttings and as foliar spray at weeks 1 and 3.

Chemical applied and conc. ($mg \cdot L^{-1}$)	Application method	Plant ht. (cm) Week 0[a]	1	3	4	5	6	7	8
Control (water)	dip	14.5	13.2	16.4	19.7	22.6	24.6	25.8	26.9
Uniconazole									
1.25	dip	12.2	11.7	15.2	18.9	21.8	23.9	24.8	26.9
2.5	dip	10.8	9.9	14.4	18.2	20.8	22.7	25.7	25.9
5	dip	7.3	6.9	12.4	16.4	20.6	23.5	25.2	26.6
10	dip	6.8	6.4	12.5	16.8	20.1	22.2	24.7	26.1
1.25/5	dip/spray	12.8	11.8	14.1	16.3	18.8	20.8	22.3	22.0
1.25/10	dip/spray	12.9	11.8	14.1	15.4	17.7	19.1	20.8	20.8
2.5/10	dip/spray	9.5	9.0	11.2	12.3	14.8	16.3	18.6	18.2
5/5	dip/spray	7.7	7.3	9.1	9.9	12.6	14.5	16.5	17.9
10	spray	16.0	15.0	17.4	18.9	21.5	23.1	24.9	24.3
10/10	spray/spray	14.9	14.2	16.3	16.9	17.5	17.7	19.5	20.6
Daminozide									
1000/2000	dip/spray	12.2	11.1	14.8	18.0	21.3	23.0	25.1	24.9
2000/2000	spray/spray	14.3	13.4	16.3	17.9	20.3	21.8	23.7	23.9
Contrasts									
Uniconazole dip only linear (incl. control)		***[b]	***	***	***	*	NS	NS	NS
Uniconazole dip only quadratic (incl. control)		***	***	***	*	NS	NS	NS	NS
1.25/5 vs. 1.25/10		NS	NS	NS	NS	NS	NS	NS	NS
1.25 vs. 1.25/5 and 1.25/10		NS	NS	NS	***	**	**	NS	***
10/10 vs. 1.25/5 and 1.25/10		**	***	**	NS	NS	*	NS	NS
2.5/10 vs. 5/5		*	*	**	**	*	NS	NS	NS
2.5/10 and 5/5 vs. 1.25/5 and 1.25/10		***	***	***	***	***	***	NS	**
10 dip vs. 10 spray		***	***	***	*	NS	NS	NS	NS
1000/2000 vs. 1000/2000		**	**	NS	NS	NS	NS	NS	NS
control vs. 1000/2000, and 2000/2000		NS	NS	NS	*	NS	NS	NS	NS
10 spray vs. 1000/2000, and 2000/2000		***	***	*	NS	NS	NS	NS	NS

[a] Plant height 1 day before pinching, 22 days after dip treatments.
[b] ***, **, *, NS = Contrasts are significantly different at $p = 0.001, 0.01, 0.05$, respectively, or not significantly different.

Canopies of plants treated with two uniconazole sprays at 10 mg/L or plants treated with 2.5/10 or 5/5 mg/L dip/spray were narrower than those of plants treated with 1.25/5 or 1.25/10 mg/L dip/spray (Table 2). Canopy width was reduced by 25% with a 10-mg/L spray compared to a 10-mg/L dip treatment.

The number of inflorescences per plant was reduced 18% with the two higher dip/spray treatments (2.5/10 and 5/5) of uniconazole compared to the two lower treatments (1.25/5 and 1.25/10). No differences were found between the number of inflorescences among the other treatments (Table 2). Anthesis, evaluated as the time when the ray florets of the first inflorescence per plant were completely unfolded, occurred on all treatments within 3 days during week 8 (data not shown). Uniconazole dip/spray treatments or a single spray at 10 mg/L reduced inflorescence dry weight up to 44% compared to the control (Table 2). Doubling spray concentration from 5 to 10 mg/L after 1.25 mg/L dip treatment reduced inflorescence dry weight.

Uniconazole reduced stem, root, and total plant dry weight up to 62, 28, and 48%, respectively, compared to the control (Table 2). Leaf dry weight ranged from 3.1 to 4.0 g per plant and was not affected by the growth regulators. Both daminozide treatment combinations reduced stem dry matter by 25% compared to the control (Table 2). Root dry weight was reduced by the higher uniconazole dip/spray treatments compared to the lower ones (Table 2). Surprisingly, the maximum root mass was produced by plants treated with one 10-mg/L uniconazole spray, and in comparison, lower root dry weights were found in daminozide-treated plants, also resulting in increased shoot/root ratio (Table 2). Total plant dry weight was reduced by the higher versus the lower uniconazole dip/spray treatments (1.25/5 and 1.25/10 versus 2.5/10 and 5/5) and by the lower dip/spray treatments versus the 1.25 mg/L uniconazole dip treatment alone (Table 2).

Leaf area per plant increased linearly with increasing uniconazole preplant dip concentration,

Table 2. Effects of uniconazole and daminozide applied as dip on unrooted cuttings and as foliar spray on 'Dalvina' chrysanthemum 8 weeks after pinching. Unrooted cuttings were dipped 22 days before pinching, foliar sprays were applied 1 and 3 weeks after pinching.

Chemical applied and conc. ($mg \cdot L^{-1}$)	Application method	Plant width (cm)	No. inflorescences	Dry wt. (g)	
				Stem	Inflorescences
Control (water)	dip	28.2	57	6.8	6.6
Uniconazole					
1.25	dip	27.2	55	6.1	6.3
2.5	dip	28.1	65	5.8	6.5
5	dip	30.5	60	6.0	6.6
10	dip	30.0	58	6.3	6.7
1.25/5	dip/spray	25.7	61	4.3	5.5
1.25/10	dip/spray	23.7	53	3.4	4.5
2.5/10	dip/spray	18.6	50	3.0	4.1
5/5	dip/spray	21.6	43	2.6	3.7
10	spray	22.5	61	4.8	5.7
10/10	spray/spray	17.3	55	2.9	4.2
Daminozide					
1000/2000	dip/spray	24.9	63	5.4	6.5
2000/2000	spray/spray	25.2	71	4.9	6.7
Contrasts					
Uniconazole dip only linear (incl. control)		NS[a]	NS	NS	NS
Uniconazole dip only quadratic (incl. control)		NS	NS	NS	NS
1.25/5 vs. 1.25/10		NS	NS	NS	*
1.25 vs. 1.25/5 and 1.25/10		NS	NS	***	**
10/10 vs. 1.25/5 and 1.25/10		***	NS	*	NS
2.5/10 vs. 5/5		NS	NS	NS	NS
2.5/10 and 5/5 vs. 1.25/5 and 1.25/10		**	*	**	***
10 dip vs. 10 spray		**	NS	**	*
1000/2000 vs. 1000/2000		NS	NS	NS	NS
control vs. 1000/2000 and 2000/2000		NS	NS	***	NS
10 spray vs. 1000/2000 and 2000/2000		NS	NS	NS	*

Chemical applied and conc. ($mg \cdot L^{-1}$)	Dry wt. (g)		Shoot/root ratio	Leaf area (cm^2)	Leaf area (cm^2)/leaf dry wt. (g) ratio	Transpiration ($g \cdot cm^{-2}\ day^{-1}$)
	Root	Total				
Control (water)	2.5	19.8	7.1	717	183	0.17
Uniconazole						
1.25	2.5	18.2	6.2	653	196	0.19
2.5	2.4	18.3	6.7	709	196	0.17
5	2.3	18.7	7.1	797	212	0.15
10	2.6	19.3	6.4	787	209	0.16
1.25/5	2.4	15.6	5.6	743	216	0.13
1.25/10	2.1	13.4	5.6	774	225	0.10
2.5/10	1.8	12.2	5.7	732	223	0.10
5/5	1.8	11.3	5.5	697	222	0.10
10	2.7	17.2	5.5	778	194	0.13
10/10	2.2	13.1	5.0	743	201	0.09
Daminozide						
1000/2000	2.3	18.0	6.9	723	195	0.15
2000/2000	2.3	17.5	6.7	721	195	0.13
Contrasts						
Uniconazole dip only linear (incl. control)	NS	NS	NS	*	**	NS
Uniconazole dip only quadratic (incl. control)	NS	NS	NS	NS	*	NS
1.25/5 vs. 1.25/10	NS	NS	NS	NS	NS	NS
1.25 vs. 1.25/5 and 1.25/10	NS	**	NS	*	***	***
10/10 vs. 1.25/5 and 1.25/10	NS	NS	NS	NS	**	NS
2.5/10 vs. 5/5	NS	NS	NS	NS	NS	NS
2.5/10 and 5/5 vs. 1.25/5 and 1.25/10	**	**	NS	NS	NS	NS
10 dip vs. 10 spray	NS	NS	NS	NS	NS	NS
1000/2000 vs. 1000/2000	NS	NS	NS	NS	NS	NS
control vs. 1000/2000 and 2000/2000	NS	NS	NS	NS	NS	NS
10 spray vs. 1000/2000 and 2000/2000	*	NS	**	NS	NS	NS

[a]***,**,*,NS = Contrasts are significantly different at p = 0.001, 0.01, 0.05, respectively, or not significantly different.

reaching a maximum with the 5-mg/L dip treatments (Table 2). A follow-up spray with 5 or 10 mg/L increased leaf area 15–18%, but decreased transpiration 35–47% compared to the 1.25-mg/L dip alone (Table 2). Single applications of uniconazole as dip or spray and both daminozide treatments had no effect on transpiration of mature plants, although there was a trend of decreasing transpiration for plants treated with increasing concentrations of uniconazole. Daily water use per plant ranged between 67 g for plants sprayed twice with 10 mg/L uniconazole and 128 g for plants treated with a preplant dip of 10 mg/L uniconazole, showing a similar trend as transpiration (Table 2).

Leaf area/leaf dry weight ratio, a measure of leaf thickness, showed a linear and quadratic response with increasing concentrations of uniconazole preplant dip (Table 2). Lower ratios and therefore thicker leaves were found in plants treated with two 10-mg/L uniconazole sprays or a 1.25-mg/L dip versus the 1.25-/5- and 1.25-/10- mg/L dip/spray application. Relative chlorophyll content did not differ between treatments 1 day before harvest.

Discussion

Uniconazole dip applied to unrooted cuttings at concentrations between 1.25 and 10 mg/L retarded stem elongation linearly up to 5 weeks after pinching. Higher dip concentrations (5 to 10 mg/L) arrested stem elongation for 5 weeks after the dip treatment while control plants doubled their height. After 8 weeks, plants treated with uniconazole dips had grown as tall as the untreated controls. In contrast, Reiss-Bubenheim and Lewis (1986) found sequential height reduction at the end of the production period when rooted chrysanthemums cuttings were treated with preplant dips of increasing concentrations of ancymidol and daminozide. However, they reported heights only at the time of anthesis, and lower concentrations of retardants may have controlled stem elongation earlier in the development.

Uniconazole dip with 1.25 mg/L followed by a foliar spray of 5 or 10 mg/L a week after pinching or two uniconazole sprays at 10 mg/L applied 1 and 3 weeks after pinching reduced stem elongation as desired for commercial purposes. Doubling uniconazole dip or spray concentration from 5 to 10 mg/L failed to further retard stem elongation. Therefore, combinations of uniconazole preplant dips up to 5 mg/L could provide sufficient control of stem elongation if followed by a foliar spray of 5 mg/L or lower. Higher dip concentrations will require a lower concentration of the follow-up spray.

A single spray of uniconazole and all daminozide applications were not effective in controlling stem elongation at the end of the production period. Although these rates were based on commercial recommendations, previous research determined that seasonal variation, particularly in light intensity, during the production period can lead to heterogeneous height control when the same application rates of growth retardants are used (Reiss-Bubenheim and Lewis 1986, v. Hentig and Hass 1981). Therefore application rates should be adjusted to individual greenhouse conditions, plant cultivars, and growing season.

Daminozide treatments reduced stem dry weight compared to the control, although they had no effect on final plant height. Stem dry weight was reduced significantly by all uniconazole treatments that reduced either canopy width or height at week 8 (Tables 1, 2).

Although root growth is affected by triazoles, results are contradictory (Davis et al. 1988). Root growth is often less inhibited than shoot growth, and, therefore, triazole-treated plants have decreased shoot/root ratios compared to untreated plants (Williamson et al. 1986, Wieland and Wample 1985, Jaggard et al. 1982). In the study reported here root dry weight was considerably less inhibited than stem dry weight. Shoot/root ratios were less affected than stem dry weight and decreased between 0 and 30% compared to the control. Shoot/root ratios of paclobutrazol-treated peach decreased by 56%, whereas shoot and root dry weight decreased by 73 and 42%, respectively, compared to control plants (Williamson et al. 1986). In sugar beet treated with paclobutrazol, a 70% reduction of shoot/root ratio was reported (Jaggard et al. 1982).

Delayed anthesis was reported when higher concentrations of uniconazole were applied to Easter lilies (Bailey and Miller 1989) or hibiscus (Wang and Gregg 1991). Time to anthesis was not affected by any treatment in this experiment, although the higher concentrations of uniconazole caused excessively short plants, fewer inflorescences, and lower inflorescence dry weight. Preplant dips of chrysanthemum with daminozide had no effect on anthesis (Reiss-Bubenheim and Lewis 1986), whereas higher concentrations of daminozide applied through the rooting substrate delayed anthesis, particularly in fall and winter (v. Hentig and Hass 1981). The high-light intensity in the experiment reported here may have prevented delayed anthesis, which occurred under low-light intensity production conditions (v. Hentig and Hass 1981).

Darker green leaves, often correlated with increased chlorophyll content, are characteristic for triazole-treated plants (Davis et al. 1988, Wang and

Gregg 1989). Chlorophyll content could increase due to concentration effects of a reduced leaf area (Davis et al. 1988). However, similar to the experiment reported here chlorophyll content was not affected in paclobutrazol-treated apple leaves (Wieland and Wample 1985) or in mature *Ligustrum* leaves treated with uniconazole (Steinberg et al. 1991).

Leaf area increased in response to uniconazole preplant dip in contrast to many other reports. No explanation can be offered regarding the lowest leaf area or highest transpiration in response to the 1.25-mg/L dip treatment. Reduced leaf areas were found for Easter lilies after uniconazole was applied as a foliar spray (Bailey and Miller 1989) or as drench to *Ligustrum* (Steinberg et al. 1991). Paclobutrazol also reduced leaf area of sugar beet (Jaggard et al. 1982), apple (Wieland and Wample 1985), *Tilia, Betula* (Abod and Webster 1991), and peach (Williamson et al. 1986).

Decreased leaf thickness in response to higher uniconazole concentrations in the experiment reported here contrasts with results reported for paclobutrazol-treated pecan seedlings (Wood 1984) and sugar beet (Jaggard et al. 1982). Compared to leaf thickness, fewer differences in response to uniconazole concentrations were observed for leaf area and transpiration.

Uniconazole at higher concentrations reduced transpiration at week 8 as reported before (Davis et al. 1988). In many cases this is due to decreased leaf area (Davis et al. 1988, Abod and Webster 1991, Steinberg et al. 1991), whereas in the experiment reported here leaf area of uniconazole-treated plants increased, but plants tended to use less water on a per leaf area basis. Overall, changes in transpiration appear to be more related to changes in plant height than to leaf area or leaf thickness.

The shorter internodes of uniconazole-treated plants resulted in a more compact canopy, which could decrease transpirational demand through increased shading and decreased vapor pressure deficit. Altered stomatal conductance (Davis et al. 1988) or anatomical changes of leaves (Gao et al. 1988) were previously found to be responsible for reduced transpiration. Increased shading could also contribute to thinner leaves in uniconazole-treated plants. Shading may be less important in woody plants, where often a smaller portion of the total canopy structure is affected by uniconazole. In contrast, 80% of the leaves of 'Dalvina' chrysanthemum are located in the lower half of the canopy and shading effects may explain discrepancies in leaf area, leaf thickness, and transpiration in response to uniconazole treatment compared to previous reports.

In summary, uniconazole applied as 1.25-/5- and 1.25-/10-mg/L preplant dip/spray combination or as two foliar applications of 10 mg/L effectively reduced stem elongation as desired for commercial purposes without affecting the number of inflorescences or time to anthesis. Preplant dips of unrooted cuttings eliminated the need for one of two foliar sprays, reducing labor and chemical costs. Daminozide applied at 1000/2000 mg/L dip/spray or two 2000 mg/L sprays had no effect on final plant height or width, but reduced stem dry weight. Contrary to previous studies, higher concentrations of uniconazole increased leaf area and decreased leaf thickness.

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