Water Relations and Growth of Vinca Following Chemical Growth Regulation[1]

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Abstract

Growth of vinca (*Vinca major* (L.)) was limited by either a medium drench application of uniconazole of 2 or 4 mg a.i. per pot or a foliar spray application of 2, 4, or 6.25 mg a.i. per plant, both applied in 25 ml (0.75 fl oz) of water. Shoot length, leaf number, leaf area, leaf dry weight and stem dry weight averaged over uniconazole treatments were 51%, 45%, 32%, 33%, and 38% less than control plants, respectively. When compared to control plants, water use of chemically treated plants was reduced by 35% due to the reduction of leaf area and also lower stomatal conductance readings. Stomatal conductance readings of chemically treated plants were 2 to 5 times less than control plants indicating the plant size was not the only factor affecting plant water use.

Index words: uniconazole, growth retardant, water relations, *Vinca major.*

Growth regulator used in this study: (E)-1-(4-chlorophenyl)-4,4-dimethyl-2-(1,2,4,triazol-l-y-l)-1-penten-3-ol (uniconazole).

Significance to the Nursery Industry

Control of growth and reduction of water applied through irrigation are two management practices constantly facing nursery managers. The research reported here provides an alternative to high labor mechanical pruning procedures through the use of a chemical growth regulator—uniconazole. Growth of vinca plants was reduced 51–56% with either a soil drench or a foliar spray application of uniconazole. Reduction of plant size was partially responsible for lower water use of chemically treated vinca plants, but lower stomatal conductance rates were also recorded for these plants. Lower stomatal conductance rates indicate that plant size was not the only influencing factor on reducing water use of chemically treated plants.

These results indicate the management practice of using growth regulators, such as uniconazole, not only has the potential of decreasing high labor costs due to mechanical pruning, but may also reduce water use of plants through modification of physiological mechanisms. The modification of physiological mechanisms within the plant may also confer on these plants the ability to withstand drought conditions in both nursery and the landscape settings.

Introduction

Control of growth has long been an important factor in the management of container-grown nursery plants and ornamental plants in the urban environment. Control traditionally has been accomplished by mechanical pruning, but recently the use of growth-regulating chemicals has gained acceptance (17). The effects of these practices on plant water use will become increasingly important as water resources become more limited or expensive.

Both pruning and chemical growth retardants can reduce water use as a result of a reduction in the leaf area. In the former, leaf area is physically removed, while in the latter, the physiology of leaf and/or shoot growth is changed (3, 10, 11, 12, 13). There are also many reports that plants treated with chemical growth retardants exhibit a reduction in water use not related to changes in leaf area (3, 7, 12, 14). The available evidence suggests that the reduced water use is due to the inhibition of stomatal opening (8) or to anatomical changes in water transport or related tissues (4, 15).

Vinca is a low maintenance ground cover which is increasing in popularity for use in the landscape (18). At the present time, labor intensive hand pruning is required to produce high quality, container-grown plants (9). Growth regulators including ancymidol, chlormequat, and daminozide have been used for many years in the production of greenhouse crops, including poinsettias and chrysanthemum, to reduce vegetative growth (3, 8). These chemicals when used at growth suppressing rates on trees and shrubs, can cause phytotoxic symptoms such as terminal bud death, desiccation, foliar discoloration and distortion, and abscission of young expanded leaves (2). Uniconazole (XE-1019, Sumagic, Valent U.S.A., Walnut Creek, CA), a gibberellin biosynthesis inhibitor, can control the growth and form of woody ornamentals including glossy abelia (*Abelia* x *grandiflora*), ligustrum (*Ligustrum japonicum*), photinia (*Photinia* x *fraseri*), and crepe myrtle (*Lagerstromia indica*) (5, 16). This compound produces few phytotoxic effects and in some cases has improved plant quality (2).

Uniconazole has potential to reduce maintenance expenses and improve stress resistance by reducing plant growth and altering plant water relations (12). Plant water relations are affected by altering stomatal morphology and function, xylem production, root:shoot ratios, leaf area, and leaf conductance (7, 12). The objective of this study was to quantify the effect of uniconazole on growth and water relations of vinca.

Materials and Methods

Plant growth experiment. Vinca liners were transplanted into 3.8 liter (#1) containers filled with a composted pine bark:sand (4:1, by vol) mixture on August 23, 1989. The media was amended with 3.7 kg/m^3 (8 lb/yd^3) 18N-2.6P-10K (18-6-14) fertilizer (Osmocote, Grace-Sierra, Milpitas, CA), 3.7 kg/m^3 (8 lb/yd^3) gypsum (Sof-n-soil, United States Gypsum Co., Chicago, IL), 3.7 kg/m^3 (8 lb/yd^3) dolomitic limestone (Lloyd-Joyce Ag., College Station, TX) and 74.2

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g/m^3 (72 oz/yd^3) fritted trace elements (Peters #503, W.R. Grace & Co., Fogelsville, PA). Irrigation was applied as needed. The experiment was conducted in a glass greenhouse with a photosynthetic photon flux of 400–1000 µmol/m^2/s^1, 12 hr photoperiod, a relative humidity of 80 ± 11% and day and night temperatures of 26 ± 2C (79 ± 4F) and 22 ± 2C (72 ± 4F), respectively.

On September 26, 1989, shoot terminals were pruned to 12 cm (4.8 in) and uniconazole (10% WP) was applied at 0, 2 or 4 mg a.i. per plant as a foliar spray or per pot as a root drench both in 25 ml (0.75 fl oz) of solution. On November 16, 1989, the experiment was terminated and leaf area, leaf number, total shoot length and leaf and stem dry weights were recorded.

There was one plant per pot as an experimental unit in a completely randomized design with four replications. The design was analyzed as a one-way classification model with an analysis of variance.

Water use experiment. Vinca liners were transplanted in 3.8 liter (#1) containers on November 14, 1990, filled with fritted clay (Balcones Minerals Corp., Flatonia, TX):soilless mix (Peat-lite Mix, Redi Earth, Terra-Lite, W.R. Grace & Co., Cambridge, MA) (2:1, by vol.) amended with 3.7 kg/m^3 (8 lb/yd^3) 18N-2.6P-10K (18-6-14) fertilizer (Osmocote, Grace-Sierra, Milpitas, CA). On March 5, 1991, shoots were pruned to 35 cm (14 in) and uniconazole was applied as a 25 ml (0.75 fl oz) foliar spray at the rate of 0 or 6.25 mg a.i. per plant. Due to the lower growth reduction response of foliar spray application in the first experiment, a higher rate of uniconazole was used. Greenhouse conditions for this experiment were identical to those in the plant growth experiment. The study was conducted as a completely randomized design with nine replications and analyzed with a two sample t test.

Whole plant water use was obtained by weighing (± 0.1 g, 0.035 oz) the pots daily with a Mettler PM 16 balance. The pots were covered with plastic and weighed before and after watering; thus, weight changes could be attributed solely to transpiration. Soil moisture tension was recorded daily with a moisture meter (Instamatic moisture meter, AMI Medical Electronic, Inc., Taiwan). Both treatments were subjected to drying periods. During these periods at least half of the initially well-watered plants in each treatment were allowed to wilt, and media allowed to dry to approximately –0.73 to –0.75 MPa. At that time, all plants of that treatment were rewatered, creating independent dry-down cycles for each treatment. Stomatal conductance was recorded on March 8 and 17 and April 1 and 22 between 1300 and 1530 hr prior to rewatering. These dates corresponded with the end of a dry-down cycle for both treatments. Stomatal conductance was measured with a LI-1600 steady state porometer (LI-COR Inc., Lincoln, NE). Measurements were made on two fully expanded, sunlit leaves per plant of five plants per treatment. The untreated vinca was harvested on April 24, 1991 (experiment length 51 days), while the uniconazole treated vinca was harvested on April 30, 1991 (experiment length 57 days). Total length, leaf and stem dry weight and leaf area were measured at harvest.

Table 1. Effects of uniconazole soil drench or foliar spray applications on growth parameters of vinca 52 days following treatment.

Treatment	Total shoot length (cm)	Total leaf number	Total leaf area (cm^2)	Total leaf dry weight (g)	Total stem dry weight (g)
Medium drench (mg a.i./pot)[z]					
2	778.0[y]	195.3	1029.6	5.02	5.71
4	336.2	137.0	858.8	3.30	2.88
Foliar spray (mg a.i.)[z]					
2	622.6	189.3	1099.4	5.58	5.29
4	576.7	161.0	921.7	4.72	4.71
Control[x]	1196.8	310.3	1447.7	7.00	7.47
Significance[w]					
Rate	NS	NS	NS	NS	NS
Application	NS	NS	NS	NS	NS
Rate ∞ Application	**	*	*	**	**
Contrasts[v]					
Control vs Others	***	***	*	***	***
Drench (2 mg vs 4 mg)	**	NS	NS	**	**
Spray (2 mg vs 4 mg)	*	*	NS	*	*
Drench vs Spray (4 mg)	*	NS	NS	*	**

[z]In 25 ml of solution.

[y]Mean of four replicates measured on November 16, 1989.

[x]No treatment.

[w]Analysis of variance for rate, application and interactions.

[v]Orthogonal contrasts

*,**,***,NSSignificant at P = 0.05, 0.01, 0.001 or nonsignificant, respectively.

Results and Discussion

Plant growth. At the end of the 52 day experiment, uniconazole reduced all growth parameters compared to control plants while still producing marketable plants (Table 1). The most effective treatment was the 4 mg drench treatment with a significant reduction of plant shoot length (56%, 72%), leaf dry weight (34%, 53%) and stem dry weight (50%, 61%) compared to plants drenched with 2 mg uniconazole and control plants, respectively (Table 1). Owings et al. (9) reported similar results with the use of uniconazole foliar spray, effectively reducing and containing Asiatic jasmine (*Trachelospermum asiaticum*) runners. Knox and Norcini (6) reported that drench treatments of uniconazole decreased the overall size of containerized pyracantha (*Pyracantha Koidzium* 'wonderberry'), photinia (*Photinia* x *fraseri*) and ligustrum (*Ligustrum* x *ibilium*) plants, with up to 50% reduction at the highest uniconazole levels. Uniconazole drench application also produced shorter hibiscus (*Hibiscus rosa-sinensis*) plants with fewer total leaves and smaller stem diameters (15). The 4 mg drench treatment more effectively reduced vinca growth than did the foliar application at the same rate. Shoot length, leaf dry weight and stem dry weight of drenched plants were reduced 41%, 30% and 39% respectively compared to foliar treated plants at the same rate (Table 1).

Water use. When the 6.25 mg a.i. rate of uniconazole was applied as a foliar spray, growth reduction results were similar to the 4 mg a.i. drench rate in the first experiment and plants were marketable quality. The uniconazole application reduced vinca shoot length 56%, leaf number 46%, leaf area 50%, leaf dry weight 34%, and stem dry weight 36% as compared with the control (Table 2). When compared to the control, total water use of treated plants was reduced by 35% during the 51 to 57 day experiment (Table 2). In poinsettia,

Table 2. Analysis of variance and means for the effects of a 6.25 mg a.i./pot uniconazole foliar spray on growth parameters and water use of vinca.

Treatment	Total shoot length (cm)	Total leaf number	Total leaf area (cm^2)	Total stem dry weight (g)	Total stem dry weight (g)	Total water use (g)	Water use per day (g/d^1)
Control[z]	1225.3[y]	465.3	1243.4	6.97	9.05	3270.3	65.4
Uniconazole[x]	541.7	251.8	626.0	4.59	5.83	2121.3	37.9
Significance[w]							
Treatment	***	***	***	***	***	***	***

[z]Control received no treatment.

[y]Mean of 9 replicates measured at experiment termination. (Control April 24, 1991; Treated April 30, 1991).

[x]6.25 mg a.i./pot uniconazole foliar spray.

[w]Analysis of variance for treatment (no treatment or uniconazole-treated).

***Significant at P = 0.001.

water loss was directly correlated to leaf area in growth regulator treated plants suggesting decreased whole plant transpiration was due to reduced leaf area (3). Steinberg et al. (11) also reported that reduced water use in growth regulator treated ligustrum plants was due strictly to differences in plant size and leaf area.

On March 8, 1994, there was no significant difference in stomatal conductance readings between treated and control plants (Table 3). On the following 3 dates, when stomatal conductance readings were taken, significant differences were noted between treated and control plants. Stomatal conductance for the vinca control was two to four times higher than in the uniconazole treated vinca (Table 3). Lower stomatal conductance readings for treated plants indicate that plant size may not be the only factor affecting plant water use. Asamoah and Atkinson (1) reported total water use per plant and transpiration per unit leaf area were reduced by paclobutrazol treatment of cherry while stomatal resistance increased 17% when compared to the controls. Steinberg et al. (12) also reported lower stomatal conductance and transpiration rates for plants treated with uniconazole compared to control plants which they attributed partially to lower stomatal densities of the treated plants.

We have shown that uniconazole has the potential to reduce the water use of vinca not only by the reduction of leaf area, but also by the modification of physiological mechanisms within the plant. The reduced water use of treated plants may confer a greater ability to withstand periods of drought and may indicate less water would be required during nursery production.

Table 3. Analysis of variance and means for the effects of a 6.25 mg a.i./pot uniconazole foliar spray on stomatal conductance ($mmol/m^2/s^1$) of vinca on four representative days.

	1991			
Treatment	March 8	March 17	April 1	April 22
Control[z]	246.6[y]	346.6	102.1	244.2
Uniconazole[x]	199.5	83.9	74.3	126.6
Significance[w]				
Treatment	NS	***	**	**

[z]Control received no treatment.

[y]Stomatal conductance ($mmol/m^2/s^1$) means of 9 replicates.

[x]6.25 mg a.i./pot uniconazole foliar spray

[w]Analysis of variance for treatment (no treatment or uniconazole-treated).

,*,[NS]Significant at P = 0.01, 0.001 or nonsignificant, respectively.

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