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Whole-Plant Response of Selected Woody Landscape Species to Uniconazole[1]

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Abstract

Uniconazole was applied as a foliar spray or medium drench to six woody landscape species: 'Sunglow' azalea; flame azalea; 'Spectabilis' forsythia; 'Compacta' holly; 'Nellie R. Stevens' holly; and mountain pieris. One hundred days after uniconazole application, leaf, stem, and top dry weight of all species, except flame azalea and mountain pieris, decreased as uniconazole concentration increased. Compared to controls, stem and leaf dry weight were reduced by uniconazole 18 to 60% and 13 to 32%, respectively, depending on species and method of application. Stem dry weight was reduced to a greater degree, compared to leaf dry weight. For all species, drench application was more effective than foliar spray in reducing leaf, stem, and top dry weight. Leaf area of 'Spectabilis' forsythia and 'Nellie R. Stevens' holly decreased with increasing rates. However, specific leaf weight was not affected. Uniconazole did not significantly affect leaf net photosynthetic rate, stomatal conductance or internal leaf CO_2 concentrations in 'Spectabilis' forsythia or 'Nellie R. Stevens' holly. No phytotoxicity was observed on any species.

Index words: growth retardant, XE-1019, Sumagic, growth regulator

Species used in this study: 'Sunglow' azalea (*Rhododendron* L. sp. 'Sunglow'); flame azalea [*Rhododendron calendulaceum* (Michx.) Torr.]; 'Spectabilis' forsythia (*Forsythia* × *intermedia* Zab. 'Spectabilis'); 'Compacta' holly (*Ilex crenata* Thunb. 'Compacta'); 'Nellie R. Stevens' holly (*Ilex* L. sp. 'Nellie R. Stevens'); and mountain pieris [*Pieris floribunda* (Pursh ex Sims) Benth & Hook].

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

Significance to the Nursery Industry

Uniconazole can provide effective height control as either a drench or spray for container-grown woody landscape plants. However, uniconazole is not equally effective on all species. Specific rates and method of application should be determined based on individual species response. In this study, uniconazole produced acceptable growth reduction for four of six species tested, thus demonstrating the need to develop specific recommendations for particular species.

Introduction

Extensive pruning is required in the production and maintenance of many woody landscape plants. Until recently, use of growth retardants on woody plants remained uneconomical or produced deleterious effects (4, 6). Uniconazole and paclobutrazol have successfully suppressed growth of florist crops (2, 3, 7), fruit and nut trees (5, 11, 19), and

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woody landscape plants (10, 13, 14, 15, 17) with minimum deleterious effects. Thus, these compounds may offer an inexpensive and effective chemical alternative to mechanically pruning woody plants. However, there is still little published research on potential uses of uniconazole in the production and maintenance of woody landscape plants (8, 17).

Paclobutrazol has been reported to inhibit (1, 16), stimulate (9), and have no effect (5) on leaf net photosynthetic rate. There is no quantitative information available regarding uniconazole effects on leaf photosynthesis in woody plants. Therefore, the objective of this study was to determine the effects of uniconazole concentration and method of application (foliar or drench) on leaf, stem, and top growth, and leaf net photosynthetic rate of selected woody landscape plants.

Materials and Methods

The experiment, a randomized complete block design with 10 replications, was conducted on a gravel pad located at North Carolina State University, Research Unit 4, Raleigh.

Uniform, rooted cuttings of 'Sunglow' azalea, 'Spectabilis' forsythia, 'Compacta' holly, and 'Nellie R. Stevens' holly, and seedlings of flame azalea and mountain pieris were potted into 3.8 liter (4 qt) containers on May 8, 1989. Growth medium consisted of milled pine bark [(<13 mm) (0.5 in)] amended with 3.0 kg/m^3 (5 lbs/yd^3) dolomitic limestone and 0.89 kg/m^3 (1.5 lbs/yd^3) Micromax. Fourteen grams (0.5 oz) of Osmocote 18N-2.6P-10K (18-6-12) were surface-applied to each container on May 10, 1989. Soluble salts were monitored weekly utilizing procedures of Wright (20). When the level of soluble salts dropped below 0.25 mMhos on July 29, 1989, Osmocote 18N-2.6P-10K (18-6-12) was reapplied at the previous rate. Plants received 1000 ml (34 oz) of water daily via spray stakes. On May 29, 1989 all plants were pruned to 10 cm (4 in) in height.

Uniconazole rates and method of application were based on manufacturer's recommendations. A wettable, dry granular formulation (50% a.i.) was used for foliar application. Twelve to 15 ml (0.4 to 0.5 oz) of four rates of uniconazole were applied to the foliage of each species with a hand-held sprayer on June 19, 1989 between 6:30 and 8:30 A.M. at the following rates (ppm): 'Sunglow' azalea: 0, 5, 10 or 15; flame azalea: 0, 5, 10 or 15; 'Spectabilis' forsythia: 0, 150, 225 or 300; 'Compacta' holly: 0, 50, 75 or 100; 'Nellie R. Stevens' holly: 0, 25, 50 or 100; and mountain pieris: 0, 10, 25 or 50. The growth medium was covered during application to prevent the spray from contacting the medium surface.

An emulsifiable concentration (500 micrograms a.i./liter) was used for the drench application. One hundred ml (3.4 oz) per container of an aqueous drench application were applied on June 19, 1989 between 8:30 and 9:30 A.M. at the following rates (mg a.i./container): 'Sunglow' azalea: 0, 0.25, 0.50 or 1.0; flame azalea: 0, 0.25, 0.50 or 1.0; 'Spectabilis' forsythia: 0, 1, 3, 5 or 10; 'Compacta' holly: 0, 0.5, 1 or 3; 'Nellie R. Stevens' holly: 0, 0.5, 1, 3 or 5; and mountain pieris: 0, 0.25, 0.5 or 1.0. All species were irrigated 4 hr before foliar application and 24 hr after the drench application.

Growth indices [height + ((width + width) / 2) / 2] were recorded at treatment application and every 30 days thereafter. Top growth (aerial tissue) of each species was harvested 100 days after uniconazole application. Top growth was divided into leaves and stems, dried at 70°C (160°F) for 96 hr and weighed. Top dry weight was determined by combining leaf and stem dry weights. Before drying, leaf area for 'Spectabilis' forsythia and 'Nellie R. Stevens' holly was measured with a LI-COR LI-3000 leaf area meter (LI-COR, Lincoln, Neb.). Specific leaf weight was calculated as leaf dry weight / leaf area. Percent reduction in leaf, stem, and top dry weight, and leaf area compared to a nontreated control, were calculated using the equation: {[control dry weight (leaf area) − treated dry weight (leaf area)] / control dry weight (leaf area)} × 100, with 0% = no reduction in dry weight (leaf area). In addition, plants were evaluated for phytotoxicity 10 days after application and during recording of growth data based on a scale of 1 to 5, with 1 = no visible foliar injury and 5 = severe foliar injury.

Leaf gas exchange was measured with a LI-COR 6200 closed portable infrared gas exchange system on a bright (>1800 μmol/s/m^2), cloudless day (September 8, 1989) between 12:00 and 3:00 PM. Photosynthetically active radiation, air and leaf temperatures, and relative humidity inside the leaf chamber were measured concurrently with gas exchange measurements. Net photosynthetic rate, leaf internal CO_2 concentrations, and stomatal conductance were calculated using the LI-COR 6200 measurements. An attached leaf was placed for 20 s in a 1 liter (1149 cm^3) (70.1 in^3) lexan chamber with 10 cm^2 (0.6 in^2) of leaf area exposed to light and gas flow. Carbon dioxide concentration in the chamber was 305 ± 10 ppm at the start of measurements. The chamber containing the leaf was directed towards the sun and a measurement was commenced immediately after a reduction in CO_2 concentration was observed. Five blocks were randomly chosen and three measurements (subsamples) were taken on the most recently matured leaves on each plant within each block. All measured parameters were averaged over the subsamples for statistical analysis.

Statistical analysis. Data were subjected to analysis of variance and regression analysis (SAS Institute, Cary, NC).

Results and Discussion

Growth indices at 90 days and leaf, stem, and top dry weight were highly correlated ($0.59 < r < 0.94$, $p < 0.01$) for all species, so only data for leaf, stem, and top dry weight are presented. Method of application (foliar or drench) had a significant ($p < 0.05$) effect on plant response. Thus, all data are presented by method of application. Data are not presented for 'Compacta' holly treated with the drench application since they were damaged due to a malfunctioning irrigation system.

After 100 days, leaf, stem, and top dry weight of all species, except flame azalea and mountain pieris, decreased as uniconazole concentration increased, regardless of method of application (Tables 1 to 4). However, the drench applications were more effective than foliar sprays. Various reports have noted that, in general, medium drenches of uniconazole and paclobutrazol are more effective than foliar sprays (8, 10, 17). Flame azalea and mountain pieris were unaffected by uniconazole at the rates used in this study (data not presented). This illustrates that species respond differently to uniconazole.

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Table 1. Effect of uniconazole on leaf, stem, and top dry weight of 'Compacta' holly 100 days after foliar application.

Foliar rate (ppm)	Dry weight (g)		
	Leaf	Stem	Top
0	5.4	4.2	9.6
50	5.4	3.8	9.3
75	4.8	3.2	8.0
100	3.9	2.4	6.3
Significance[z]			
L[y]	*	**	**
Q	NS	NS	NS

[z]NS, *, **Nonsignificant or significant at $p \leq 0.05$ or $p \leq 0.01$, respectively. Zero rate included in analysis.

[y]L = linear, Q = quadratic.

Thirty days after uniconazole application, growth indices of 'Sunglow' azalea and 'Spectabilis' forsythia were significantly affected (data not presented). This was a much quicker response than had been reported for other azaleas and 'Spectabilis' forsythia (17). However, Hamada et al. (7) reported that shoot elongation of tree peony (*Paeonia suffruticosa* Andr.) was significantly affected within 15 days after uniconazole application. Growth indices of 'Compacta' holly and 'Nellie R. Stevens' holly were significantly affected 60 days after application (data not presented). This is similar to earlier reports (17). No phytotoxicity occurred on any species.

Compared to controls, stem and leaf dry weight were reduced by uniconazole 18 to 60% and 13 to 32%, respectively, depending on species and method of application (Table 5). Uniconazole inhibited both internode elongation and

Table 2. Effect of uniconazole on leaf, stem, and top dry weight of 'Spectabilis' forsythia 100 days after foliar or drench application.

Foliar rate (ppm)	Dry weight (g)			Drench rate (mg a.i.)	Dry weight (g)		
	Leaf	Stem	Top		Leaf	Stem	Top
0	42.9	13.2	56.1	0	41.7	12.2	53.9
150	33.7	7.0	40.7	1	34.2	6.9	41.1
225	33.6	6.7	40.3	3	32.1	5.5	37.6
300	32.1	6.7	38.8	5	22.5	3.4	25.9
				10	25.8	3.8	29.6
Significance[z]							
L[y]	**	**	**		**	**	**
Q	*	**	**		**	**	**

[z]NS, *, **Nonsignificant or significant at $p \leq 0.05$ or $p \leq 0.01$, respectively. Zero rate included in analysis.

[y]L = linear, Q = quadratic.

Table 3. Effect of uniconazole on leaf, stem, and top dry weight of 'Nellie R. Stevens' holly 100 days after foliar or drench application.

Foliar rate (ppm)	Dry weight (g)			Drench rate (mg a.i.)	Dry weight (g)		
	Leaf	Stem	Top		Leaf	Stem	Top
0	37.7	17.9	55.6	0	36.0	18.4	54.4
25	30.9	11.3	42.2	0.5	26.0	10.6	36.6
50	28.3	11.5	39.8	1	24.7	8.9	33.6
100	28.5	11.6	40.1	3	23.7	7.3	31.0
				5	23.1	6.6	29.7
Significance[z]							
L[y]	**	**	**		**	**	**
Q	*	**	**		**	**	**

[z]NS, *, **Nonsignificant or significant at $p \leq 0.05$ or $p \leq 0.01$, respectively. Zero rate included in analysis.

[y]L = linear, Q = quadratic.

Table 4. Effect of uniconazole on leaf, stem, and top dry weight of 'Sunglow' azalea 100 days after foliar or drench application.

Foliar rate (ppm)	Dry weight (g)			Drench rate (mg a.i.)	Dry weight (g)		
	Leaf	Stem	Top		Leaf	Stem	Top
0	49.8	19.4	69.2	0	48.8	17.8	66.6
5	41.0	17.0	58.0	0.25	39.5	7.9	47.4
10	40.6	15.9	56.5	0.5	38.7	7.2	45.9
15	39.1	14.6	53.7	1	37.7	7.0	44.7
Significance[z]							
L[y]	**	*	**		*	**	**
Q	**	NS	**		NS	**	**

[z]NS, *, **Nonsignificant or significant at $p \leq 0.05$ or $p \leq 0.01$, respectively. Zero rate included in analysis.

[y]L = linear, Q = quadratic.

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Table 5. Percent reduction in leaf, stem, and top dry weight, and leaf area[z] of five woody landscape species, compared to nontreated controls, 100 days after foliar or drench application of uniconazole.[y]

	% Reduction							
	Foliar application				Drench application			
Species	Leaf	Stem	Top	Leaf area	Leaf	Stem	Top	Leaf area
'Compacta' holly	13	25	18	NA[x]	NA	NA	NA	NA
'Spectabilis' forsythia	23	48	29	26	31	60	38	38
'Nellis R. Stevens' holly	22	36	27	27	32	55	40	46
'Sunglow' azalea	19	18	19	NA	21	59	31	NA

[z]Averaged over all treatment rates, except 0, within each method of application and species.

[y]Percent reduction in dry weight of leaf area was calculated using the equation: {[control dry weight (leaf area) − treated dry weight (leaf area)] / control dry weight (leaf area)} × 100, with 0% = no reduction in dry weight (leaf area).

[x]NA = data not available.

Table 6. Effect of uniconazole on leaf area of 'Spectabilis' forsythia and 'Nellie R. Stevens' holly 100 days after foliar or drench application.

'Spectabilis' forsythia				'Nellie R. Stevens' holly			
Foliar rate (ppm)	Leaf area (cm^2)	Drench rate (mg a.i.)	Leaf area (cm^2)	Foliar rate (ppm)	Leaf area (cm^2)	Drench rate (mg a.i.)	Leaf area (cm^2)
0	3103	0	3206	0	1623	0	1512
150	2403	1	2244	25	1348	0.5	887
225	2315	3	2100	50	1192	1	852
300	2210	5	1873	100	1005	3	757
		10	1776			5	749
Significance[z]							
L[y]	**		**		*		**
Q	*		**		NS		*

[z]NS, *, **Nonsignificant or significant at $p \leq 0.05$ or $p \leq 0.01$, respectively. Zero rate included in analysis.

[y]L = linear, Q = quadratic.

leaf enlargement (16). In this study, stem dry weight was reduced to a greater degree than leaf dry weight. This suggests that stem growth is affected to a greater degree than leaf growth in woody plants. Wood (18) reported that paclobutrazol produced similar results with pecan, [*Carya illinoensis* (Wang.) K. Koch]. Bailey (2) also reported uniconazole reduced stem dry weight in 'Rose Supreme' hydrangea (*Hydrangea macrophylla* 'Rose Supreme'), but did not affect leaf dry weight.

Similar to top dry weight, leaf area of 'Spectabilis' forsythia and 'Nellie R. Stevens' holly decreased with increasing drench and spray rates (Table 6). Reduction in leaf area was similar to top dry weight reduction (Table 5). Uniconazole did not affect specific leaf weight, which averaged 14 and 28 mg/cm^2 for 'Spectabilis' forsythia and 'Nellie R. Stevens' holly, respectively. Bailey and Miller (3) reported similar results for Easter lily (*Lilium longiflorum* Thunb.)

Uniconazole did not affect leaf gas exchange rates in 'Spectabilis' forsythia or 'Nellie R. Stevens' holly. Photosynthetic rate, stomatal conductance, and leaf internal CO_2 concentration averaged 9.2 μmol/m^2/s, 0.17 mol/m^2/s, and 181.1 ppm, respectively for 'Spectabilis' forsythia. Photosynthetic rate, stomatal conductance, and leaf internal CO_2 concentration for 'Nellie R. Stevens' holly averaged 6.8 umol/m^2/s, 0.09 mol/m^2/s and 190.3 ppm, respectively. Similarly, paclobutrazol did not affect leaf photosynthetic rate of 'Fantasia' nectarine (*Prunus persica* L. Batsch. 'Fantasia') (5) or pecan (18). Data reported herein indicate that the growth retardant effects of uniconazole are not associated with any deleterious effects on individual leaf photosynthetic capacity. However, this does not imply that total plant photosynthesis is unaffected. Reduction in leaf area (Table 5) concomittant with a reduction in light penetration into the canopy from an increased compactness of the plant canopy could reduce whole plant photosynthesis rate and photosynthate production (12).

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Rodenticides for the Control of Pine and Meadow Voles in Orchards[1]

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Abstract

Two new anticoagulants (bromadiolone—90% control) and (difethialone—87% control) gave excellent control of voles in field and laboratory tests. The older anticoagulants, chlorophacinone—84% control and diphacinone—75% control, and two zinc phosphide formulations (Bell Labs—84% control and Hopkins—79% control) also gave excellent field control of voles. The Ridall zinc phosphide formulation—61% control, and cholecalciferol (vitamin D_3)—59% control did not perform as well as the other rodenticides previously mentioned. The antibiotic, oxytetracycline, killed from 40% to 80% of pine and meadow voles in laboratory trials when applied to cut apples, but only 10 to 30% when pelletized baits were presented. In a mixed pine and meadow vole orchard population, zinc phosphide raised the ratio of surviving pine to meadow voles while anticoagulants lowered the ratio. Thus, the rotation of rodenticides is thought to be desirable to prevent the shift of one species to the other in mixed populations and to prevent bait shyness from developing to zinc phosphide.

Index words: rodent control, orchard mice, christmas tree, nursery, landscape plantings

Rodenticides used in these studies: Rozol, (Chlorophacinone), 2-[(4-chlorophenyl)phenylacetyl]-1H-indene-1,3(2H)2H-dione; bromadiolone, 3-[3-(4′-Bromo[1,1′-biphenyl]-4-yl)-3-hydroxy-1-phenylpropyl]-4-hydrox-2H-1-benzopyran-2-one; difethialone, [(Bromo-4′-biphenyl-4-yl)-3-tetrahydro-1-2-3-4-naphtyl-1]-3,hydroxy-4-2H-1-benzothiopyran-one-2; diphacinone, 2-(Diphenylacetyl)-1H-indene-1,3(2H)-dione; oxytetracycline, 4-(dimethylamino)-1,4,4 ,5,5 ,6,11,12 -octahydro-3,5,6,10,12,12 -hexahydroxy-6-metyl-1,11-dioxo-2-naphthacenecarboxamide; and Zinc Phosphide (Zn_3P_2).

Significance to the Nursery Industry

Effective pine (*Microtus Pitymys pinetorum*, LeConte) and meadow vole (*Microtus pennsylvanicus*, Ord) control is essential in orchard, Christmas tree, landscape, and nursery plantings, particularly where plantings have been established for over one year. This research was intended to investigate the effectiveness of three new candidate rodenticides in laboratory and field tests, and to monitor the effectiveness of registered baits.

Introduction

Vertebrate pest management experts have recognized that rodents have highly developed senses of taste and smell,

[1]Received for publication March 21, 1991; in revised form May 28, 1991.

[2]Professor and Agricultural Manager, resp.

[3]Appreciation to the following chemical companies for rodenticides: Lipha Chemicals Inc. (Rozol, Ridall, difethialone); Bell Laboratories, Inc. (ZP Rodent Bait AG, diphacinone, bromadiolone, cholecalciferol); Hacco, Inc. (Zinc Phosphide); Pfizer Chemical Inc. (oxytetracycline).

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