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Uniconazole Effect on Growth and Chlorophyll Content of Pyracantha, Photinia, and Dwarf Burford Holly

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Abstract. Pyracantha, photinia, and dwarf Burford holly were treated with a uniconazole medium drench at 0, 0.5, 1.0, or 3.0 mg · container^{-1} a.i. or a foliar application at the following rates: pyracantha at 0, 50, 100, or 150 mg · L^{-1} a.i.; photinia at 0, 25, 50, or 100 mg · L^{-1} a.i.; and holly at 1, 10, 25, or 50 mg · L^{-1} a.i. Height, width, leaf area per plant, and dry weights of all species decreased as uniconazole drench rate increased. Foliar applications were less effective than drenches in pyracantha and photinia, and holly did not respond to the foliar treatment. Chlorophyll content of pyracantha increased with rate in both application methods. Leaf N, P, and Zn increased in pyracantha and photinia with increasing medium drench rate, but only P was increased in holly. Zn also increased in pyracantha and photinia with foliar applications, but only N in photinia and P in pyracantha increased with increasing uniconazole foliar application rates.

Uniconazole[(E)-1-(4-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl)-1-penten-3-ol] is a plant growth regulator which is similar in structure to several chemicals that reduce plant growth by inhibiting gibberellin biosynthesis (Henry 1985). Uniconazole has been used to reduce size and encourage more desirable plant growth habits in bedding plants and floricultural crops (Barrett and Nell 1986, Starman 1991, Wang and Blessington 1990). It has, however, been used only on a small number of woody ornamental plants, and only under experimental conditions (Henderson and Nichols 1991, Norcini and Knox 1989, Vaigro-Wolff and Warmund 1987). The use of growth regulators in woody plants could be advantageous in maintaining desirable growth habits while reducing the labor costs involved in the current practice of hand pruning. The purpose of this study was to determine the effect of uniconazole on growth of three woody ornamental species, pyracantha (*Pyracantha coccinea,* "Lalandei"), photinia (*Photinia x fraseri*), and dwarf Burford holly (*Ilex cornuta,* "Burfordii Nana").

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Materials and Methods

Uniform liners of pyracantha, photinia, and dwarf Burford holly were planted on December 14, 1989 in a polyethylene greenhouse in 3.8 L pots containing composted pine bark and sand (4:1 by volume) amended with 3.62 kg · m^{-3} 17N-3P-10K slow release fertilizer (Osmocote, Grace-Sierra, Milpitas, CA), 2.27 kg · m^{-3} dolomite, 2.27 kg · m^{-3} gypsum, and 0.68 kg · m^{-3} micronutrients (Micromax, Grace-Sierra, Milpitas, CA). Maximum PPFD was 800 μmol · m^{-2} · s^{-1} at plant height, and maximum/minimum air temperatures were 35/10°C. During establishment, plants were watered as needed and received supplementary weekly fertilization with Peters 20N-4.3P-16.6K at 200 mg · L^{-1} (Grace-Sierra, Milpitas, CA).

On February 23, 1990, plants were treated with a uniconazole medium drench at 0, 0.5, 1.0, or 3.0 mg · container^{-1} a.i. or a foliar application at the following rates: pyracantha at 0, 50, 100, or 150 mg · L^{-1} a.i.; photinia at 0, 25, 50, or 100 mg · L^{-1} a.i.; holly at 0, 10, 25, or 50 mg · L^{-1} a.i. These rates were chosen based on the results of previous experiments on pyracantha (Henderson and Nichols 1991) and with recommendations from the manufacturer for photinia and holly. Soil drenches were applied as 100 ml of solution per container, and foliar applications were made with a CO_2-pressurized backpack sprayer (R&D Sprayers, Inc., Opelousas, LA) with an output of 0.2 L/m^2. The soil surface of plants receiving a foliar spray was covered with plastic before spraying to assure that no uniconazole would enter the growing medium. Plastic was removed when the foliage had dried.

Plant height above the medium surface to the tallest shoot was measured at 3-week intervals beginning the day of application. Plant widths were determined by measuring plant diameter at the

Table 1. Influence of uniconazole applied as a medium drench or foliar spray on height and width at treatment (initial) and harvest (final) of pyracantha, photinia, and dwarf Burford holly.

		Initial		Final	
Species	Rate	Height (cm)	Width (cm)	Height (cm)	Width (cm)
Medium drench (mg · container^{-1} a.i.)					
Pyracantha	0	9.4	13.4	43.8	44.9
	0.5	10.6	13.4	13.6	48.7
	1.0	10.0	12.6	14.2	36.7
	3.0	9.6	12.8	9.0	26.0
	Linear	NS[a]	NS	[b]	[b]
	Quadratic	NS	NS	[b]	[b]
Photinia	0	19.0	12.6	40.3	46.1
	0.5	18.2	9.7	22.4	35.8
	1.0	17.6	12.0	21.8	27.5
	3.0	19.8	10.5	22.8	17.9
	Linear	NS	NS	[b]	[b]
	Quadratic	NS	NS	[b]	[b]
Holly	0	14.9	10.3	23.1	18.9
	0.5	15.0	11.7	18.5	14.8
	1.0	15.1	11.2	17.1	13.6
	3.0	16.0	10.0	16.7	11.6
	Linear	NS	NS	[b]	[b]
	Quadratic	NS	NS	[b]	[b]
Foliar application (mg · L^{-1} a.i.)					
Pyracantha	0	10.7	12.6	44.8	70.4
	50	9.3	11.0	24.1	57.8
	100	11.0	12.7	18.4	54.9
	150	9.4	12.5	12.9	52.5
	Linear	NS	NS	[b]	[b]
	Quadratic	NS	NS	[b]	NS
Photinia	0	18.7	12.5	43.8	44.9
	25	19.3	11.7	42.5	47.8
	50	19.2	13.2	34.7	45.6
	100	18.2	14.0	30.8	43.3
	Linear	NS	NS	[b]	NS
	Quadratic	NS	NS	NS	NS
Holly	0	16.0	10.0	26.4	19.2
	10	14.8	10.2	28.3	18.8
	25	15.1	10.2	25.1	19.4
	50	15.2	11.8	23.7	17.4
	Linear	NS	NS	NS	NS
	Quadratic	NS	NS	NS	NS

[a,b] Nonsignificant or significant at $p = 0.01$, respectively, relative to linear or quadratic responses.

widest point and perpendicular to that point, then averaging the values. At the time of height and width measurements, total leaf chlorophyll content of the uppermost fully expanded leaf of pyracantha and holly was determined with a portable colorimeter (Minolta Chroma Meter Cr200, Ramsey, NJ), calibrated with a white reference plate using the coordinates $Y = 93.7$, $x = 0.314$, and $y = 0.321$. The color space coordinates were $L^*a^*b^*$. Leaf chlorophyll content was determined by measuring leaf color of 50 leaves with the colorimeter, then by removing a 1-cm leaf disc from each area measured. Chlorophyll was extracted in N,N-dimethylformamide (Moran and Porath 1980) and spectrophotometrically measured (Sequoiah-Turner Model 340 Spectrophotometer, Mountain View, CA) at wavelengths of 647 and 664.5 nm. A regression analysis was conducted and the following equations were used to determine total chlorophyll content of pyracantha and holly from the colorimeter:

Total pyracantha chlorophyll (ng · cm^{-2}) =

$$52.08 - 1.49(a^2 + b^2)^{1/2} \; (R^2 = 0.80)$$

Total holly chlorophyll (ng · cm^{-2}) =

$$54.97 - 1.59(a^2 + b^2)^{1/2} \; (R^2 = 0.83)$$

Chlorophyll was not measured in photinia because the red color of the leaves reduced accuracy below acceptable levels.

Twenty-one weeks after treatment, plants were harvested and leaves counted, leaf areas were measured with an LI 3100 area meter (LI-COR, Lincoln, NE), and leaves, shoots, and roots were dried at 45°C for 7 days and weighed. Average area per leaf for each plant was calculated as (total leaf area/number of leaves). Prior to drying, leaf samples were washed in water containing a P-free detergent (Liqui-Nox, Alconox, New York, NY) and rinsed three times with deionized water. After drying, leaf samples were ground, dry-ashed, and analyzed for elemental concentrations using a Perkin Elmer 2380 atomic absorption spectrophotometer (Perkin Elmer, Norwalk, CT). Samples were analyzed for ammonia-based N by the Kjeldahl procedure (Horowitz 1980).

A randomized complete block design with 10 single-plant replications and eight treatments within each cultivar was used. Orthogonal contrasts were used to determine linear and quadratic relationships among uniconazole application rates.

Results

Soil Drench Effects

Height and width of pyracantha and photinia plants treated with the uniconazole medium drench decreased curvilinearly with increased uniconazole rates (Table 1). Height and width of holly also decreased curvilinearly as uniconazole application rate increased (Table 1); however, holly responded to the uniconazole by producing many malformed leaves and extremely short internodes with all concentrations by the end of the experiment.

Chlorophyll content of pyracantha receiving a medium drench of uniconazole increased linearly with uniconazole rate (Table 2). In contrast, there was no relationship between uniconazole application rate and chlorophyll content in holly.

Pyracantha leaf number, stem dry weight, and root dry weight decreased curvilinearly as the uniconazole rate increased (Table 3). Pyracantha leaf area per leaf and per plant, stem dry weight, and root:shoot ratio were inversely related to uniconazole rate. A similar trend occurred in photinia in which the number of leaves per plant, leaf, stem and root dry weight, and root:shoot ratio decreased curvilinearly. Leaf area per leaf was not affected in photinia, but leaf area per plant decreased linearly as uniconazole rate increased. Uniconazole did not affect the number of leaves or root dry weight of holly, but leaf area per leaf and per plant, leaf and stem dry weight, and root:shoot ratio decreased with increasing rates of uniconazole.

Uniconazole applied as a medium drench increased pyracantha leaf concentration of N, P, and Zn, but decreased K curvilinearly (Table 4). Photinia also had increased concentrations of N, P, and Zn when treated with uniconazole, but the other elements tested were not affected. Leaf elemental content in holly was unaffected by uniconazole except P, which was highest at the 1 mg · container^{-1} a.i. rate.

Foliar Application Effects

Pyracantha heights decreased curvilinearly and widths decreased linearly as uniconazole foliar application rate increased (Table 1). Photinia height also decreased linearly with increasing foliar rate, but plant width was not affected. There was no response of holly in either height or width.

Chlorophyll content of pyracantha leaves receiving foliar treatments was positively related to uniconazole rate at week 3, but this relationship was not apparent by week 18 (Table 2). The leaf chlorophyll content in holly was not affected by the foliar applications of uniconazole.

The foliar uniconazole applications resulted in a linear decrease in leaf count, individual leaf area, leaf dry weight, and increased root:shoot ratio (Table 3). Stem dry weight decreased curvilinearly. As uniconazole rate increased, photinia had a linear decrease only in stem and root dry weight, while holly root dry weight decreased curvilinearly.

P and Zn concentrations were positively related to uniconazole application rates (Table 4). Photinia had a curvilinear N response, but Zn increased linearly. A significant curvilinear response was apparent only in Ca content of holly leaves.

Table 2. Chlorophyll content (ng · cm^{-2}) at 3 and 18 weeks after treatment of leaves of pyracantha and dwarf Burford holly receiving a medium drench or foliar spray of uniconazole.

		Weeks after treatment	
Species	Rate	3	18
Medium drench (mg · container^{-1} a.i.)			
Pyracantha	0	25.1	23.0
	0.5	26.0	24.8
	1.0	26.4	27.7
	3.0	26.1	35.7
	Linear	NS[a]	[b]
	Quadratic	NS	NS
Holly	0	35.9	27.3
	0.5	36.2	25.0
	1.0	34.2	20.5
	3.0	34.5	24.9
	Linear	NS	NS
	Quadratic	NS	NS
Foliar application (mg · L^{-1} a.i.)			
Pyracantha	0	24.3	21.8
	50	28.4	23.9
	100	29.5	24.6
	150	30.5	24.4
	Linear	[b]	NS
	Quadratic	NS	NS
Holly	0	32.7	31.9
	10	36.7	36.2
	25	35.0	31.4
	50	34.4	30.0
	Linear	NS	NS
	Quadratic	NS	NS

[a,b] Nonsignificant or significant at p = 0.01, respectively, relative to linear or quadratic responses.

Table 3. Plant growth characteristics of pyracantha, photinia, and dwarf Burford holly treated with a medium drench or foliar spray of uniconazole.

Species	Rate	Leaves/plant	Leaf area (cm^2)		Dry weight (g)			Root:shoot ratio
			Per leaf	Per plant	Leaf	Stem	Root	
Medium drench (mg · container^{-1} a.i.)								
Pyracantha	0	2084	1.29	2664	24.7	21.8	9.5	0.20
	0.5	1378	1.64	2160	21.6	7.3	7.4	0.25
	1.0	1166	1.70	1862	18.1	5.0	6.4	0.28
	3.0	745	1.81	1275	12.2	3.2	5.0	0.33
	Linear	[b]	[c]	[b]	[b]	[b]	[b]	[b]
	Quadratic	[c]	NS[a]	NS	NS	[b]	[c]	NS
Photinia	0	219	14.6	3184	37.6	24.2	13.5	0.22
	0.5	171	16.8	2851	35.5	13.2	9.4	0.20
	1.0	169	16.2	2766	37.3	11.4	8.7	0.20
	3.0	125	15.4	1922	23.2	5.6	7.3	0.25
	Linear	[b]	NS	[b]	[b]	[b]	[b]	[c]
	Quadratic	[c]	NS	NS	[c]	[b]	[b]	[c]
Holly	0	314	5.21	1609	21.2	9.3	6.8	0.22
	0.5	317	3.70	1168	17.7	5.6	7.7	0.32
	1.0	378	3.28	1211	14.6	4.5	6.7	0.35
	3.0	341	1.93	654	10.4	3.7	5.7	0.41
	Linear	NS	[b]	[b]	[b]	[b]	NS	[b]
	Quadratic	NS	[b]	NS	NS	[b]	NS	NS
Foliar application (mg · L^{-1} a.i.)								
Pyracantha	0	2805	1.13	2982	26.9	23.0	9.8	0.20
	50	1845	1.35	2422	22.6	11.4	6.9	0.20
	100	1859	1.41	2540	21.5	10.5	7.6	0.23
	150	1459	1.72	2421	20.7	8.0	7.8	0.27
	Linear	[c]	[b]	NS	[c]	[b]	NS	[c]
	Quadratic	NS	NS	NS	NS	[b]	NS	NS
Photinia	0	196	16.6	3246	39.0	25.0	12.7	0.20
	25	225	13.9	3110	36.6	23.0	12.8	0.22
	50	175	17.1	2944	36.1	19.6	12.4	0.22
	100	189	15.4	2928	34.1	17.2	9.6	0.19
	Linear	NS	NS	NS	NS	[b]	[c]	NS
	Quadratic	NS	NS	NS	NS	NS	NS	[c]
Holly	0	339	5.03	1683	21.7	9.6	6.7	0.22
	10	319	5.47	1738	21.8	9.3	6.5	0.21
	25	374	5.39	1973	24.4	10.0	8.4	0.24
	50	303	4.99	1496	20.1	7.8	6.1	0.21
	Linear	NS	NS	NS	NS	NS	NS	NS
	Quadratic	NS	NS	NS	NS	NS	[c]	NS

[a–c] Nonsignificant or significant at the $p = 0.01$ or 0.05, respectively, relative to linear, or quadratic responses.

Discussion

Past research has evaluated the effect of uniconazole on various species and obtained mixed results depending on application rates and species tested (Henderson and Nichols 1991, Norcini and Knox 1989, Vaigro-Wolff and Warmund 1987). Results of this study are similar to those of past studies, which have shown that pyracantha heights are decreased with uniconazole applications (Henderson and Nichols 1991, Norcini and Knox 1989). The medium drench applications had greater activity than foliar applications. The response of photinia in this experiment also corresponded to height differences noted by Norcini and Knox (1989). While they cited acceptable height reduction of photinia at rates of 2.5 and 5.0 mg/plant a.i. applied as a medium drench, some mechanical pruning was necessary at application time to maintain an acceptable plant. Observations of our photinia plants, which received lower drench rates, revealed questionable plant quality as growth habit tended to be pendulous rather than upright and leaves were malformed on uniconazole treated plants. The holly responded to both foliar and drench treatments with deformed foliage, especially at the higher application rates.

Plants treated with uniconazole tended to have a darker green foliage color than untreated plants.

Table 4. Leaf elemental content of pyracantha, photinia, and dwarf Burford holly receiving a medium drench (mg · container a.i. of uniconazole.

		Dry weight (%)					Dry weight ($\mu g \cdot g^{-1}$)		
Species	Rate	N	P	K	Ca	Mg	Zn	Fe	Mn
Medium drench (mg · container^{-1} a.i.)									
Pyracantha	0	2.35	0.35	1.19	1.58	0.27	71	309	170
	0.5	2.48	0.41	1.10	1.66	0.32	89	446	231
	1.0	2.47	0.45	0.97	1.62	0.33	86	272	177
	3.0	2.75	0.54	0.90	1.72	0.33	113	312	254
	Linear	[b]	[b]	[b]	NS[a]	NS	[b]	NS	NS
	Quadratic	NS	NS	NS	NS	NS	NS	NS	NS
Photinia	0	2.31	0.68	1.44	1.33	0.22	30	79	33
	0.5	2.63	0.85	1.50	1.34	0.23	37	80	32
	1.0	2.55	0.92	1.56	1.40	0.25	36	73	31
	3.0	2.74	0.92	1.43	1.41	0.23	38	73	33
	Linear	[b]	[b]	NS	NS	NS	[b]	NS	NS
	Quadratic	NS	[b]	NS	NS	NS	[b]	NS	NS
Holly	0	1.82	0.20	2.15	0.84	0.27	257	154	618
	0.5	1.92	0.17	1.88	0.78	0.23	276	138	622
	1.0	2.24	0.27	1.95	0.77	0.29	267	145	673
	3.0	2.06	0.18	1.95	0.72	0.27	233	130	493
	Linear	NS	NS	NS	NS	NS	NS	NS	NS
	Quadratic	NS	[c]	NS	NS	NS	NS	NS	NS
Foliar application (mg · L^{-1} a.i.)									
Pyracantha	0	2.38	0.31	1.22	1.59	0.27	71	354	198
	50	2.40	0.38	1.07	1.51	0.29	80	390	207
	100	2.32	0.40	1.11	1.60	0.33	89	367	213
	150	2.36	0.42	1.12	1.63	0.32	87	294	181
	Linear	NS	[b]	NS	NS	NS	[c]	NS	NS
	Quadratic	NS	NS	NS	NS	NS	NS	NS	NS
Photinia	0	2.29	0.80	1.68	1.53	0.38	33	82	42
	25	2.41	0.76	1.69	1.44	0.23	34	77	39
	50	2.48	0.79	1.62	1.47	0.23	35	86	36
	100	2.37	0.95	1.74	1.51	0.24	38	79	38
	Linear	NS	NS	NS	NS	NS	[c]	NS	NS
	Quadratic	[b]	NS	NS	NS	NS	NS	NS	NS
Holly	0	1.80	0.17	2.23	0.69	0.27	216	136	541
	10	1.68	0.17	2.09	0.73	0.26	237	165	515
	25	1.92	0.20	2.21	0.83	0.30	253	137	658
	50	1.77	0.18	1.93	0.79	0.26	277	164	604
	Linear	NS	NS	NS	[c]	NS	NS	NS	NS
	Quadratic	NS	NS	NS	[c]	NS	NS	NS	NS

[a–c] Nonsignificant, or significant at the p = 0.01 or 0.05, respectively, relative to linear, or quadratic responses.

This darker color is desirable to consumers and makes the plant more saleable. In pyracantha, the darker foliage can be attributed to a greater chlorophyll concentration in the leaves. Greater amounts of N, P, and Zn in both pyracantha and photinia may also contribute to the darker foliage color.

The results of this experiment suggest that uniconazole could be used to reduce growth of pyracantha while maintaining plant quality. Uniconazole used at the rates in this study on photinia and holly, however, resulted in plants with questionable ornamental value. This suggests that further research is necessary to determine proper rates for these species.

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