EFFECT OF UNICONAZOLE ON GROWTH AND WATER RELATIONS OF WOODY ORNAMENTALS

By

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EFFECT OF UNICONAZOLE ON GROWTH

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PREFACE

The purpose of this study was to determine the effect of uniconazole treatments on growth and water relations of woody ornamentals. Two experiments were performed to accomplish the objectives. The first experiment used three plant species, pyracantha, photinia, and holly, and four treatment rates for uniconazole medium drench and foliar application treatments. The effect of uniconazole on plant growth and chlorophyll content was determined in this study. The second experiment evaluated the response of pyracantha growth and water relations to uniconazole medium drench or foliar applications in combination with three irrigation regimes.

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CHAPTER I

INTRODUCTION

The production of high quality plants with minimal monetary inputs is the goal of nursery production firms. Pruning to maintain a desirable plant form is a labor intensive process and may result in the spread of disease organisms throughout a nursery crop. Practices which reduce the need for pruning could result in lower production costs as labor needs are reduced, and disease problems are reduced because wounding is eliminated.

Availability and quality of water can be limiting in nursery production. In areas of low rainfall or during periods of drought, municipalities often invoke water conservation practices such as rationing (Knox, 1989). Even in areas where water is generally plentiful, its use may be limited due to various contaminants (Ranier and Frink, 1989). Any practice which reduces plant water consumption during plant production would be beneficial to nursery producers.

Uniconazole [XE 1019 (Sumagic)] ((E)-1-(p-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl)-1-penten-3-ol) is a plant growth regulator which reduces growth by inhibiting gibberellic acid synthesis (Henry, 1985). Uniconazole has been effective in reducing size and improving structure of seasonal flowering plants such as poinsettia (*Euphorbia pulcherrima* Willd.), chrysanthemum (*Chrysanthemum x morifolium* Ramat.) (Wilfret, 1986) and annual bedding plants (Barrett and Nell, 1986.).

Uniconazole has also reduced growth of several woody plants. Height of forsythia (*Forsythia spectabilis* Spaeth) (Vaigro-Wolff and Warmund, 1987), hibiscus (*Hibiscus rosa-sinensis* L.) (Newman et al., 1989), privet (*Ligustrum ovalifolium* Hassk.), American sycamore (*Platanus occidentalis* L.), yellow poplar (*Liriodendron tulipifera* L.) and apple (*Malus domestica* Borkh) (Sterret, 1988) were reduced, as were stem and leaf dry weight of 'Wonderberry' pyracantha (*Pyracantha koidzummi* (Hayata) Rehd. 'Wonderberry'), photinia (*Photinia x fraseri* Dress) and ibolium privet (*Ligustrum x ibolium* E. F. Coe) (Norcini and Knox, 1989). Despite this reduced growth, uniconazole is not widely used on woody plants because species differ in their responses to various rates and application methods. For example, 15 mg ai $liter^{-1}$ applied as a foliar spray on hibiscus resulted in foliar distortion (Newman et al., 1989) and uniconazole applied at 2.5 or 5.0 mg ai $plant^{-1}$ resulted in excessively short internodes in privet and pyracantha (Norcini and Knox, 1989).

Uniconazole has also affected physiological processes other than plant growth in some species. Henderson and Nichols (1991) noted darker green leaves with uniconazole treatments on 'Lalandei' pyracantha (*Pyracantha coccinea* M. J. Roem. 'Lalandei'). Leaf chlorophyll concentration of hibiscus was increased with increasing rates of uniconazole (Wang and Gregg, 1989). However, Steinburg et al. (1991a) found that chlorophyll content of recently expanded ligustrum leaves was 27% lower in treated than in control plants.

Uniconazole has also affected flowering of some woody ornamentals. Uniconazole enhanced flowering of camellia (*Camellia sasanqua* Thunb.) (Keever and McGuire, 1991), and photinia (Norcini and Knox, 1989). However, uniconazole medium drenches of 0.025 to 0.2 mg pot^{-1} on young hibiscus resulted in delayed flowering and fewer flowers than untreated plants (Wang and Gregg, 1989).

Uniconazole may also affect plant responses to drought conditions. Uniconazole has been associated with higher xylem pressure potentials in forsythia when water was limited (Vaigro-Wolff and Warmund, 1987). Well-watered potted hibiscus plants treated with uniconazole had a sap flow rate nearly three times lower than that of untreated plants (Steinberg et al., 1991b). Uniconazole-treated hibiscus used less water than nontreated plants.

Decreased water availability influences many plant processes, including anatomy, biochemistry, morphology, and physiology (Kramer, 1969). Drought stress results in a general reduction in plant size by reducing turgor pressure in the cell which in turn reduces cell expansion. Reduced cell expansion along with less cell division results in smaller plants. Kramer (1969) hypothesized that reduced synthesis of natural growth regulators such as gibberellins and cytokinins in the roots also influences the reduced growth observed in plants subjected to water stress.

Besides reducing growth, limited moisture influences the stomata of plants. Stomata may close during early stages of water stress, reducing transpiration and resulting water loss (Kozlowski, 1972). Stomatal closure may occur prior to visible wilting and they remain closed as drought continues.

With reduced transpiration rates, water stress may also hinder nutrient uptake by plant roots (Viets, 1972). As the soil dries toward the wilting range, mass flow of water to the roots, transport of ions by diffusion, and root development into new soil ranges may all be inhibited. Henderson and Davies (1990) found that drought acclimated roses (*Rosa hybrida* L. 'Ferdy') had a lower Ca concentration and a higher N and Mn concentration than non-drought acclimated roses. Plants may be able to absorb and store minerals they need when the soil moisture availability is high (Viets, 1972).

Plants employ several mechanisms for survival of drought conditions. They may tolerate drought stress through osmotic adjustment, thus maintaining turgor potential (Dale and Sutcliffe, 1986). In addition, plants may avoid drought stress through leaf abscission (Kramer, 1969). Henderson and Davies (1990) found that when plant water was limited, leaf abscission and the resulting decreased leaf area and shoot dry weight in acclimated roses resulted in a better water status compared to non-acclimated plants under drought stress.

Water potential is a function of the chemical potential of water which is measured as the energy per unit volume of water and is expressed in traditional pressure units (Slatyer, 1967). Water potential has gained wide acceptance as a measure of plant water status. It is commonly measured with a pressure chamber (Scholander et. al., 1965) or with thermocouple psychrometers (Monteith and Owen, 1958).

Another measure of plant water status is relative water content (RWC) (Weatherley, 1950), previously referred to as relative turgidity (Hsiao, 1973). RWC is the percent water content of a tissue relative to the water content of the same tissue at full turgor. It may be calculated as:

RWC = ((fresh weight - dry weight) / (turgid weight - dry weight)) X 100.

The objectives of these studies were: 1) to determine the effectiveness of foliar and medium drench applications of uniconazole on the growth of dwarf Burford holly (*Ilex cornuta* Lindl. and Paxt. 'Burfordii Nana'), photinia (*Photinia x fraseri* Dress), and pyracantha (*Pyracantha coccinea* M. J. Roem. 'Lalandei'), and 2) to determine the effect of uniconazole on water relations and growth of 'Lalandei' pyracantha.

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CHAPTER II

EFFECT OF UNICONAZOLE MEDIUM DRENCH AND FOLIAR APPLICATIONS ON GROWTH AND CHLOROPHYLL OF PYRACANTHA, PHOTINIA, AND DWARF BURFORD HOLLY

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ABSTRACT

Pyracantha (*Pyracantha coccinea* M. J. Roem. 'Lalandei'), photinia (*Photinia x fraseri* Dress), and dwarf Burford holly (*Ilex cornuta* Lindl. and Paxt. 'Burfordii Nana') were treated with 0, 0.5, 1.0, or 3.0 mg ai container^{-1} uniconazole as a medium drench, or a foliar application at the following rates: Pyracantha at 0, 50, 100, and 150 mg ai liter^{-1}, photinia at 0, 25, 50 and 100 mg ai liter^{-1}, and holly at 0, 10, 25, and 50 mg ai liter^{-1}. Height, width, leaf area per plant, and dry weights of all three species decreased as uniconazole drench rate increased. Foliar applications were less effective in all species, but the holly had essentially no response to the foliar treatment. Leaf N, P, and Zn increased in pyracantha with increasing 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.

Keywords: *Pyracantha coccinea* 'Lalandei', *Photinia x fraseri*, *Ilex cornuta* 'Burfordii Nana', growth regulation.

Abbreviations: PPFD = photosynthetic photon flux density

INTRODUCTION

Uniconazole ((E)-1-(p-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl)-1-penten-3-ol) is a plant growth regulator which inhibits gibberellin biosynthesis (Henry, 1985). It has been successfully used to restrict growth of several seasonal flowering plant species and bedding plants (Wilfret, 1986; Barrett and Nell, 1986). The effect of uniconazole on woody plants has, however, been variable depending on species and application rate.

Uniconazole reduced growth of forsythia (Vaigro-Wolff and Warmund, 1987), hibiscus (Newman et al., 1989), 'Lalandei' pyracantha (Henderson and Nichols, 1991), 'Wonderberry' pyracantha, Fraser photinia, and ibolium privet (Norcini and Knox, 1989). However, high application rates resulted in very short internodes in privet and 'Wonderberry' pyracantha (Norcini and Knox, 1989) and foliar distortion in hibiscus (Newman et al., 1989). The use of uniconazole in production of woody plants could be advantageous if it reduced the need for pruning. Pruning is a cultural practice which is necessary to maintain desirable plant height and shape, but it is labor intensive and therefore costly.

The objective of this study was to determine the effect of uniconazole foliar spray and medium drench applications on growth of pyracantha (*Pyracantha coccinea* M. J. Roem. 'Lalandei'), photinia (*Photinia x fraseri* Dress), and dwarf Burford holly (*Ilex cornuta* Lindl. and Paxt. 'Burfordii Nana').

MATERIALS AND METHODS

Plant culture. - Uniform liners of pyracantha (*Pyracantha coccinea* 'Lalandei'), photinia (*Photinia x fraseri*), and dwarf Burford holly (*Ilex cornuta* 'Burfordii Nana') were transplanted into 3.8 liter containers on 13 December 1989. Liners were transplanted into a 4 pine bark:1 sand (by volume) amended with 4.7 kg m^{-3} 17N-3.6P-10K slow release fertilizer (Osmocote, Grace-Sierra, Milpitas, CA), 3.0 kg m^{-3} gypsum, 3.0 kg m^{-3} dolomite, and 0.9 kg m^{-3} micronutrients (Micromax, Grace-Sierra, Milpitas, CA). Plants were established in a polyethylene greenhouse for 10 weeks with a maximum PPFD of 800 µmol m^{-2} s^{-1} at plant height and maximum/minimum air temperatures of 33/23 C, then treated on 23 February 1990 with a medium drench of 0, 0.5, 1.0 or 3.0 mg ai $container^{-1}$ or a foliar spray at the following rates: pyracantha at 0, 50, 100, and 150 mg ai $liter^{-1}$, photinia at 0, 25, 50, and 100 mg ai $liter^{-1}$, and dwarf Burford holly at 0, 10, 25, and 50 mg ai $liter^{-1}$. Medium drench applications were made in 50 ml of solution per container, while the foliar sprays were applied using a CO_2-pressurized backpack sprayer to runoff. The medium surface in pots receiving a foliar spray was covered with plastic before spraying to assure that no uniconazole would enter the growing medium. Plastic was removed after the foliage had dried.

Plant biomass measurements. - Plant height and width were measured at application and at three week intervals thereafter. Plant height was measured from the medium surface to the tallest shoot apex. Plant width was determined by measuring the diameter of the plant at the widest point and perpendicular to that point and averaging the values.

At the time of height and width measurements total leaf chlorophyll content of the uppermost fully expanded leaf was determined with a portable colorimeter (Minolta Chroma Meter Cr200, Ramsey, NJ) calibrated to a white reference plate using the color 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 removing a 1-cm leaf disc from each area measured. Chlorophyll was extracted in 3 ml of N,N-dimethylformamide (Moran and Porath, 1980). After 24 hours, absorbance of the solution at 647 and 664.5 nm was determined using a Sequoia-Turner 340 spectrophotometer (Sequoia-Turner, Mountain View, CA). A regression analysis was conducted and the following equations were used to determine total chlorophyll content (Inskeep and Bloom, 1985) of pyracantha and holly from the colorimeter:

$$\text{Total Pyracantha Chlorophyll (ng/cm}^2\text{)} = 52.08 - 1.49(a^2 + b^2)^{1/2} \quad (R^2 = .80)$$

$$\text{Total Holly Chlorophyll (ng/cm}^2\text{)} = 54.97 - 1.59(a^2 + b^2)^{1/2} \quad (R^2 = .83)$$

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

Twenty-one weeks after uniconazole application, plants were harvested, leaves were counted, and leaf areas were measured with a LI-3100 area meter (LI-COR, Lincoln, Neb.) and leaves, shoots, and roots were dried at 44 C for seven days then weighed.

Prior to drying, leaves were washed in 0.1 N HCl, followed by a P-free detergent solution (Liquinox, Alconox Inc., New York, NY) and rinsed twice in deionized water to remove any elements which may have been deposited on the leaf surface. After drying, samples were ground to pass through a 20-mesh screen, 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 macro-Kjeldahl procedure (Horowitz, 1980) and for P colorimetrically (Page et al., 1982).

Statistics. - A randomized complete block design with 10 single plant replications and 8 treatments within each species was used. Orthogonal contrasts were used to determine linear and quadratic relationships among uniconazole application rates.

RESULTS

Medium Drench Applications. - Height of pyracantha and holly treated with the uniconazole medium drench was not affected until nine weeks after treatment when height decreased curvilinearly with increasing rates (Table 2.1). Photinia treated with a medium drench also decreased in height curvilinearly as uniconazole concentration increased beginning six weeks after application (Table 2.1).

Pyracantha and photinia width decreased linearly at week 3 and curvilinearly beginning at week 6 with increasing uniconazole rate (Table 2.2). Medium drench applications reduced width of holly plants linearly in week 6 and 9 and curvilinearly thereafter with increasing uniconazole rates. Uniconazole treated holly produced many malformed leaves and extremely short internodes with all concentrations by the end of the experiment.

There was a positive linear correlation between medium drench application rate and chlorophyll concentration in pyracantha leaves beginning six weeks after application (Table 2.3). In contrast, there was no relationship between uniconazole application rate and chlorophyll content in holly except at 15 weeks after application when there was a curvilinear response.

Pyracantha leaf number, stem dry weight, and root dry weight decreased curvilinearly with increasing uniconazole rates (Table 2.4). Pyracantha leaf area per leaf increased linearly with increasing uniconazole rates, while leaf area per plant decreased linearly with increasing rates. A similar trend occurred in photinia in which the number of leaves per plant and leaf, stem, and root dry weight decreased curvilinearly. 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 area per leaf and leaf area per plant and leaf and stem dry weight decreased with increasing rates of uniconazole.

Pyracantha leaf N, P and Zn concentrations increased but K decreased linearly with increasing medium drench rates (Table 2.5). Photinia leaf P and Zn increased curvilinearly while N increased linearly with increasing rate. Leaf elemental concentration in holly was unaffected by uniconazole, except P which was highest at the 1 mg ai $container^{-1}$ rate.

Foliar Applications. - Pyracantha and photinia heights decreased as uniconazole foliar application rate increased beginning three weeks after application (Table 2.6). Height of holly was not affected until nine weeks after application when there was a linear decrease with increased concentration (Table 2.6). Holly width was unaffected by uniconazole throughout the study period (Table 2.7).

Chlorophyll content of pyracantha leaves receiving foliar treatments was positively related to uniconazole rate through 9 weeks after treatment (Table 2.8), then became curvilinearly related at 15 weeks after treatment and was not significantly related to uniconazole treatment by 18 weeks. Holly chlorophyll content was unaffected by foliar applications of uniconazole.

Foliar applications of uniconazole resulted in a linear decrease in pyracantha leaf count, individual leaf area and leaf dry weight (Table 2.9). Stem dry weight decreased curvilinearly with increasing application rates. There was a negative linear relationship between photinia stem dry weight with uniconazole foliar application rates. Foliar applications did not affect the harvest parameters measured in holly.

P and Zn concentrations were positively related to uniconazole application rates in pyracantha (Table 2.10). Photinia had a curvilinear N response, but Zn increased linearly. A significant curvilinear response was apparent only in Ca concentration of holly leaves.

DISCUSSION

Past research which evaluated the effect of uniconazole on various species 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 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, possibly due to better uptake by roots than leaves or lack of transport from leaves to other plant parts (Oshio and Izumi, 1986). 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 ai/plant applied as a medium drench, some mechanical pruning was necessary at application to maintain an acceptable plant. Observations of our photinia plants, which received lower drench rates, revealed questionable plant quality. Growth habit tended to be pendulous rather than upright and leaves were malformed. Holly responded to drench treatments with deformed foliage, especially at higher application rates.

Plants treated with uniconazole tended to have a darker green foliage color than untreated plants. This darker green color is desirable to consumers and makes the plant more saleable. In pyracantha, the darker green foliage can be attributed to a greater chlorophyll concentration in the leaves. Wang and Gregg (1989) also reported increased chlorophyll concentration in hibiscus treated with uniconazole. 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 rates in this study on photinia and holly, however, resulted in plants with poor ornamental value. Further research is necessary to determine proper rates for these species.

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Table 2.1. Influence of medium drench applications of uniconazole on height of pyracantha, photinia, and dwarf Burford holly.

	Plant height (cm)							
	Weeks after treatment							
Application rate	0	3	6	9	12	15	18	21
				Pyracantha				
0	9.4	13.8	15.4	21.5	26.4	33.6	45.0	51.3
0.5	10.6	13.8	13.0	13.5	15.1	13.5	13.6	11.2
1.0	10.0	14.0	13.9	13.9	13.1	11.7	14.2	12.7
3.0	9.6	11.6	11.3	10.1	10.3	10.7	9.0	9.7
Linear	NS	NS	NS	**	**	**	**	**
Quadratic	NS	NS	NS	*	**	**	**	**
				Photinia				
0	19.0	20.9	23.3	26.2	33.4	35.5	40.3	42.9
0.5	18.2	20.1	22.6	23.4	24.0	23.0	22.4	21.7
1.0	17.6	18.9	18.7	20.2	21.3	22.1	21.8	23.4
3.0	19.8	21.4	21.4	21.9	21.7	21.6	22.9	22.5
Linear	NS	NS	NS	**	**	**	**	**
Quadratic	*	*	**	**	**	**	**	**
				Holly				
0	14.9	15.2	17.2	22.1	20.0	22.1	23.1	28.5
0.5	15.0	15.4	16.0	17.9	18.1	17.8	18.5	18.6
1.0	15.1	15.5	15.2	16.3	16.2	16.2	17.1	17.0
3.0	16.0	16.4	15.8	16.5	16.8	16.5	16.7	17.0
Linear	NS	NS	NS	*	NS	*	**	**
Quadratic	NS	NS	NS	**	*	**	**	**

NS, *, ** Nonsignificant or significant at P = 0.05 or 0.01, respectively with respect to linear or quadratic responses.

Table 2.2. Influence of medium drench applications of uniconazole on width of pyracantha, photinia, and dwarf Burford holly.

	Plant width (cm)							
	Weeks after treatment							
Application rate	0	3	6	9	12	15	18	21
				Pyracantha				
0	13.4	25.7	32.1	40.6	50.1	56.9	70.8	80.7
0.5	13.4	23.5	28.6	33.5	39.4	44.2	48.7	47.1
1.0	12.6	20.8	24.5	28.1	30.4	33	36.7	36.9
3.0	12.8	20.2	21.2	22.7	23.8	23.2	26.0	27.1
Linear	NS	**	**	**	**	**	**	**
Quadratic	NS	NS	*	**	**	**	**	**
				Photinia				
0	12.6	16.6	20.3	23.4	33.2	38.8	46.1	48.1
0.5	9.7	13.3	16.6	18.6	24.0	29.4	35.8	43.2
1.0	12.0	14.4	15.9	16.9	19.3	22.9	27.5	30.7
3.0	10.5	12.5	13.7	14.1	15.2	18.1	17.9	19.3
Linear	NS	**	**	**	**	**	**	**
Quadratic	NS	NS	*	**	**	**	**	*
				Holly				
0	10.3	10.8	13.1	16.2	18.6	18.1	18.9	22.6
0.5	11.7	11.9	12.9	13.5	13.6	13.7	14.8	16.5
1.0	11.2	11.3	12.5	12.8	12.9	12.6	13.6	14.0
3.0	10.0	10.7	10.7	11.4	11.2	11.2	11.6	12.2
Linear	NS	NS	*	**	**	**	**	**
Quadratic	NS	NS	NS	NS	**	**	**	**

NS, *, ** Nonsignificant or significant at $P = 0.05$ or 0.01, respectively with respect to linear or quadratic responses.

Table 2.3. Influence of medium drench applications of uniconazole on chlorophyll content of pyracantha and dwarf Burford holly.

	Chlorophyll ($ng{\cdot}cm^{-2}$)						
	Weeks after treatment						
Application rate	3	6	9	12	15	18	21
	Pyracantha						
0	25.3	26.5	22.5	26.6	19.2	23.0	19.9
0.5	26.0	28.8	27.5	29.1	27.5	24.8	26.7
1.0	26.4	31.2	29.0	30.6	29.4	27.7	30.3
3.0	26.1	33.9	35.4	36.0	33.2	35.7	34.3
Linear	NS	**	**	**	**	**	**
Quadratic	NS	NS	NS	NS	NS	NS	**
	Holly						
0	35.9	19.4	18.3	31.9	35.9	27.3	23.6
0.5	36.1	28.7	22.4	22.4	21.2	25.0	22.1
1.0	34.2	28.1	23.3	30.7	25.0	20.5	24.7
3.0	34.5	30.4	29.0	29.6	30.0	24.9	28.8
Linear	NS	NS	NS	NS	NS	NS	NS
Quadratic	NS	NS	NS	NS	*	NS	NS

NS, *, ** Nonsignificant or significant at P = 0.05 or 0.01, respectively with respect to linear or quadratic responses.

Table 2.4 Influence of medium drench applications of uniconazole on leaf number, individual leaf area, plant leaf area, and leaf, stem, and root dry weight of pyracantha, photinia, and dwarf Burford holly.

Application rate	Leaf number	Individual leaf area (cm^2)	Plant leaf area (cm^2)	Leaf dry weight (g)	Stem dry weight (g)	Root dry weight (g)
			Pyracantha			
0	2084	1.29	2664	24.7	23.0	9.5
50	1378	1.64	2160	21.6	7.3	7.3
100	1166	1.70	1862	18.1	5.0	6.4
150	745	1.81	1275	12.2	3.2	5.0
Linear	**	*	**	**	**	**
Quadratic	*	NS	NS	NS	**	*
			Photinia			
0	219	14.64	3184	37.6	24.2	13.5
25	171	16.84	2851	35.5	13.2	9.4
50	169	16.23	2766	37.3	11.4	8.7
100	137	15.59	2152	26.7	7.8	7.7
Linear	**	NS	**	**	**	**
Quadratic	*	NS	NS	NS	**	**
			Holly			
0	314	5.21	1609	21.2	9.3	6.8
10	317	3.70	1168	17.7	5.6	7.7
25	379	3.28	1211	14.6	4.5	6.7
50	341	1.93	654	10.4	3.7	5.7
Linear	NS	**	**	**	**	NS
Quadratic	NS	**	NS	NS	**	NS

NS,*,** Nonsignificant or significant at P=0.05 or 0.01, respectively with respect to linear or quadratic responses.

Table 2.5 Influence of medium drench applications of uniconazole on leaf elemental concentration of pyracantha, photinia, and dwarf Burford holly.

	Dry weight (%)					Dry weight (ug/g)		
Application rate	N	P	K	Ca	Mg	Zn	Fe	Mn
				Pyracantha				
0	2.35	0.35	1.19	1.58	0.27	71	309.0	170
0.5	2.48	0.41	1.10	1.66	0.32	89	446.0	231
1.0	2.47	0.45	0.97	1.62	0.33	86	272.4	177
3.0	2.75	0.54	0.90	1.72	0.33	113	312.4	254
Linear	**	**	**	NS	NS	**	NS	NS
Quadratic	NS	NS	NS	NS	NS	NS	NS	NS
				Photinia				
0	2.31	0.68	1.44	1.33	0.22	30	79.2	33
0.5	2.63	0.85	1.50	1.34	0.23	37	80.0	32
1.0	2.55	0.92	1.56	1.40	0.25	36	72.8	31
3.0	2.74	0.92	1.43	1.41	0.23	38	72.6	33
Linear	**	**	NS	NS	NS	**	NS	NS
Quadratic	NS	**	NS	NS	NS	*	NS	NS
				Holly				
0	1.82	0.20	2.15	0.84	0.27	257	154.2	618
0.5	1.92	0.17	1.88	0.78	0.23	276	138.2	622
1.0	2.24	0.27	1.95	0.77	0.29	267	144.8	673
3.0	2.06	0.18	1.95	0.72	0.27	233	129.8	493
Linear	NS	NS	NS	NS	NS	NS	NS	NS
Quadratic	NS	*	NS	NS	NS	NS	NS	NS

NS, *, ** Nonsignificant or significant at P = 0.05 or 0.01, respectively with respect to linear or quadratic responses.

Table 2.6 Influence of foliar applications of uniconazole on height of pyracantha, photinia, and dwarf Burford holly.

	Plant height (cm)							
	Weeks after treatment							
Application rate	0	3	6	9	12	6	18	21
				Pyracantha				
0	10.7	16.9	19.7	25.7	28.5	36.0	44.8	52.4
0.5	9.3	11.3	11.0	14.2	20.0	22.5	24.1	35.7
1.0	11.0	13.6	13.1	13.9	15.9	19.6	18.5	21.8
3.0	9.4	10.5	9.9	10.3	13.4	15.7	12.9	18.7
Linear	NS	**	**	**	**	**	**	**
Quadratic	NS	NS	**	**	NS	NS	**	*
				Photinia				
0	18.7	21.2	24.7	28.7	34.4	39.6	43.8	47.6
0.5	19.3	20.3	21.1	26.5	33.5	36.2	42.5	46.3
1.0	19.2	19.2	19.2	21.7	25.5	30.3	34.7	36.5
3.0	18.2	18.4	18.4	20.0	23.1	27.3	30.8	35.8
Linear	NS	**	**	**	**	**	**	**
Quadratic	NS	NS	**	NS	NS	NS	NS	NS
				Holly				
0	16.0	16.4	18.9	22.6	24.3	24.5	26.4	35.6
0.5	14.9	14.9	18.4	23.3	22.4	23.7	28.3	33.5
1.0	15.1	14.7	16.8	20.0	21.0	22.1	25.1	30.3
3.0	15.2	15.4	16.5	18.7	18.5	19.2	23.7	27.3
Linear	NS	NS	NS	*	*	*	NS	**
Quadratic	NS	NS	NS	NS	NS	NS	NS	NS

NS, *, ** Nonsignificant or significant at P = 0.05 or 0.01, respectively with respect to linear or quadratic responses.

Table 2.7 Influence of foliar applications of uniconazole on width of pyracantha, photinia, and dwarf Burford holly.

	Plant height (cm)							
	Weeks after treatment							
Application rate	0	3	6	9	12	6	18	21
				Pyracantha				
0	12.6	24.3	30.6	41.2	53.5	57.5	70.4	75.7
0.5	11.0	16.1	17.2	23.6	35.4	44.0	57.8	58.0
1.0	12.7	17.7	18.6	23.9	31.3	43.6	54.9	59.1
3.0	12.5	17.2	18.1	20.6	28.3	40.0	52.5	51.3
Linear	NS	**	**	**	**	**	**	**
Quadratic	NS	**	**	**	**	*	NS	NS
				Photinia				
0	12.5	15.5	19.2	22.4	34.6	40.0	44.9	47.1
0.5	11.7	14.0	17.5	22.2	34.5	39.8	47.8	49.7
1.0	13.2	14.5	15.9	21.9	29.8	38.9	45.6	48.4
3.0	14.0	14.7	15.5	20.0	25.6	37.4	43.3	50.2
Linear	NS	NS	*	NS	NS	NS	NS	NS
Quadratic	NS	NS	NS	NS	NS	NS	NS	NS
				Holly				
0	10.2	10.1	12.4	15.9	18.8	18.7	19.2	23.8
0.5	10.2	10.4	14.4	17.9	19.2	19.3	18.8	24.5
1.0	11.8	11.9	13.9	17.1	18.0	17.6	19.4	22.9
3.0	11.0	11.9	13.3	15.9	16.3	16.7	17.4	22.9
Linear	NS	*	NS	NS	NS	NS	NS	NS
Quadratic	NS	NS	NS	NS	NS	NS	NS	NS

NS, *, ** Nonsignificant or significant at P = 0.05 or 0.01, respectively with respect to linear or quadratic responses.

Table 2.8. Influence of foliar applications of uniconazole on chlorophyll content of pyracantha and dwarf Burford holly.

	Chlorophyll content ($ng \cdot cm^{-2}$)						
	Weeks after treatment						
Application rate	3	6	9	12	15	18	21
				Pyracantha			
0	24.6	25.8	23.3	26.9	20.9	21.8	23.7
50	29.0	33.5	27.5	27.4	25.3	23.9	22.6
100	29.5	33.9	28.7	27.9	23.9	24.6	24.4
150	30.5	34.5	33.8	30.6	21.6	24.4	24.9
Linear	**	**	**	NS	NS	NS	NS
Quadratic	NS	**	NS	NS	*	NS	NS
				Holly			
0	32.7	18.1	19.3	26.1	35.6	31.9	19.6
10	36.7	16.9	17.8	32.5	38.4	36.2	17.5
25	35.0	27.6	23.1	29.4	36.1	31.4	26.1
50	34.4	21.3	23.5	30.8	37.3	30.0	12.3
Linear	NS	NS	NS	NS	NS	NS	NS
Quadratic	NS	NS	NS	NS	NS	NS	NS

NS, *, ** Nonsignificant or significant at $P = 0.05$ or 0.01, respectively with respect to linear or quadratic responses.

Table 2.9 Influence of foliar applications of uniconazole on leaf number, individual leaf area, plant leaf area, and leaf, stem, and root dry weight of pyracantha, photinia, and dwarf Burford holly.

Application rate	Leaf number	Individual leaf area (cm^2)	Plant leaf area (cm^2)	Leaf dry weight (g)	Stem dry weight (g)	Root dry weight (g)
			Pyracantha			
0	2805	1.13	2982	26.9	23.0	9.8
50	1845	1.35	2422	22.9	11.4	6.9
100	1859	1.41	2540	21.5	10.5	7.6
150	1459	1.72	2421	20.7	8.0	7.8
Linear	*	**	NS	*	**	NS
Quadratic	NS	NS	NS	NS	**	NS
			Photinia			
0	196	16.59	3246	39.0	25.8	12.5
25	225	14.36	3199	37.8	21.6	11.5
50	175	17.07	2944	36.1	19.6	12.4
100	189	15.41	2928	34.1	17.2	9.6
Linear	NS	NS	NS	**	**	NS
Quadratic	NS	NS	NS	NS	NS	NS
			Holly			
0	339	5.03	1683	21.7	9.6	6.7
10	319	5.47	1738	21.8	9.3	6.5
25	373	5.39	1973	24.5	10.0	8.4
50	303	4.99	1496	20.1	7.8	6.1
Linear	NS	NS	NS	NS	NS	NS
Quadratic	NS	NS	NS	NS	NS	NS

NS,*,** Nonsignificant or significant at P=0.05 or 0.01, respectively with respect to linear or quadratic responses.

Table 2.10 Influence of medium drench applications of uniconazole on leaf elemental concentration of pyracantha, photinia, and dwarf Burford holly.

Application rate	Dry weight (%) N	P	K	Ca	Mg	Dry weight (ug/g) Zn	Fe	Mn
				Pyracantha				
0	2.38	0.31	1.22	1.59	0.27	71	354.0	198
0.5	2.40	0.38	1.07	1.51	0.29	80	390.2	207
1.0	2.32	0.40	1.11	1.60	0.33	89	367.0	213
3.0	2.36	0.42	1.12	1.63	0.32	87	294.2	181
Linear	NS	**	NS	NS	NS	*	NS	NS
Quadratic	NS	NS	NS	NS	NS	NS	NS	NS
				Photinia				
0	2.29	0.80	1.68	1.53	0.38	33	82.0	42
0.5	2.41	0.76	1.69	1.44	0.23	34	76.6	39
1.0	2.48	0.79	1.62	1.47	0.23	35	86.2	36
3.0	2.37	0.95	1.74	1.51	0.24	38	78.6	38
Linear	NS	NS	NS	NS	NS	*	NS	NS
Quadratic	NS	NS	NS	NS	NS	NS	NS	NS
				Holly				
0	1.80	0.17	2.23	0.69	0.27	216	135.6	541
0.5	1.68	0.17	2.09	0.73	0.26	237	165.2	515
1.0	1.92	0.20	2.21	0.83	0.30	253	137.2	658
3.0	1.77	0.18	1.93	0.79	0.26	277	163.6	604
Linear	NS	NS	NS	*	NS	NS	NS	NS
Quadratic	NS	NS	NS	*	NS	NS	NS	NS

NS, *, ** Nonsignificant or significant at P = 0.05 or 0.01, respectively with respect to linear or quadratic responses.

CHAPTER III

EFFECT OF UNICONAZOLE AND LIMITED WATER ON GROWTH AND WATER RELATIONS OF 'LALANDEI' PYRACANTHA

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ABSTRACT:

Pyracantha (*Pyracantha coccinea* M. J. Roem. 'Lalandei') were treated with uniconazole at 0.5 mg ai container^{-1} as a medium drench, 150 mg ai liter^{-1} as a foliar spray, or received no uniconazole. Plants from all uniconazole treatments were placed under three water regimes: Drought acclimated, nonacclimated and later exposed to drought, or nonstressed. Acclimated plants were conditioned by seven 4-day stress cycles (water withheld), while nonacclimated were well-watered prior to a single 4-day stress cycle at the same time as the seventh drought cycle of acclimated plants. Nonstressed plants were well-watered throughout the study. Nonstressed plants had higher leaf water potentials and leaf conductances than acclimated and nonacclimated plants, which recieved limited water; however, transpiration rates were higher in nonacclimated than acclimated plants. Uniconazole did not affect any water relations parameter measured. Acclimated plants had smaller leaf areas and leaf, stem, and root dry weights. Stem and root dry weights were particularly low when the uniconazole medium drench had been previously applied. Acclimated plants also contained higher N concentrations than nonacclimated or nonstressed plants and higher P concentrations than nonacclimated plants. Uniconazole medium drench treatments increased levels of Mn and P, and Ca was increased in plants receiving either medium drench or foliar applications.

Keywords: *Pyracantha coccinea* 'Lalandei', growth regulator, drought stress

Abbreviations: E=transpiration; DW=dry weight; FW=fresh weight; g=stomatal conductance; ψ_L=leaf water potential; ψ_π=osmotic potential; PPFD=photosynthetic photon flux density; RWC=relative water content;

INTRODUCTION

Access to ample clean water is vital to the production of nursery crops. Nursery producers located near urban areas often compete for the same water as nearby municipalities. This competition for water may be a problem during periods of drought or in areas with limited rainfall, since municipalities often invoke water rationing to curb water consumption. Nursery practices which reduce water usage are advantageous when water is limited since these may increase crop survival and plant quality during critical times.

The plant growth retardant, uniconazole ((E)-1-(p-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl)-1-penten-3-ol), has been shown to affect the water relations of some woody plants. Forsythia plants treated with uniconazole exhibited higher xylem pressure potentials than untreated plants when water was withheld (Vaigro-Wolff and Warmund, 1987), while treated potted hibiscus had a sap flow rate nearly three times lower than that of untreated plants (Steinberg et. al. 1991b). Water use of potted hibiscus treated with uniconazole was reduced, an effect which became more pronounced with time.

The objective of this study was to determine the effect of uniconazole medium drench and foliar applications on water relations and growth of 'Lalandei' pyracantha (*Pyracantha coccinea* 'Lalandei').

MATERIALS AND METHODS

Plant culture. - Uniform rooted cuttings of 'Lalandei' pyracantha were planted in 3.8 liter containers on 19 October 1990. The medium consisted of 4 pine bark:1 sand (by volume) amended with 4.7 kg m^{-3} 17N-3.6P-10K slow release fertilizer (Osmocote, Grace-Sierra, Milpitas, CA), 3.0 kg m^{-3} gypsum, 3.0 kg m^{-3} dolomite, and 0.9 kg m^{-3} micronutrients (Micromax, Grace-Sierra). Plants were grown in a polyethylene greenhouse with a maximum PPFD of 800 μ mol m^{-2} s^{-1} at plant height, and maximum/minimum air temperatures of 25/20 C. During a 12 week establishment period, plants were watered as needed and received supplementary weekly fertilizations with Peters 20N-4.3P-16.6K at 200 mg $liter^{-1}$ N. After establishment, plants received uniconazole treatments of 0.5 mg ai $container^{-1}$ as a soil drench, 150 mg ai $liter^{-1}$ as a foliar spray, or no uniconazole treatment on 7 January 1990. Medium drench applications were made in 50 ml of solution per container, while the foliar sprays were applied using a CO_2-pressurized backpack sprayer to runoff. The medium surface in pots receiving a foliar spray was covered with plastic before spraying to assure that no uniconazole would enter the growing medium. Plastic was removed after the foliage had dried.

After establishment, water was withheld from one third of the plants in each uniconazole treatment for six 4-day drought cycles; these plants are referred to as acclimated. All other plants were well-watered during these cycles. After six drought cycles, the acclimated plants and one-half of the well-watered plants (non-acclimated plants) in each uniconazole treatment received one 4-day stress cycle (water withheld), hereafter termed the stress cycle. The other one-half of the nonacclimated plants were not stressed and received water daily throughout the study. The nine uniconazole-water regime treatments included 12 containerized plants per treatment.

Water relations measurements. - Water potential (ψ_L) and osmotic potential (ψ_π) were determined in six plants per treatment using leaf cutter psychrometers (J.R.D. Merrill, Logan, UT) coupled with a PR-55 psychrometer microvoltmeter (Wescor, Logan, UT) as described by Smith and Ager (1988). Leaf discs were cut from the third uppermost fully expanded leaf of each plant at 13:15 hour and 05:00 hour of the final day of the stress cycle and the following morning to determine afternoon and predawn ψ_L. Plants were irrigated and ψ_π was determined upon rehydration after the final day of the stress cycle. Leaf discs were cut and sealed in the psychrometers at 13:15 hour and frozen at -30 C overnight.

All microvoltmeter readings were made after psychrometers had equilibrated to 30 C in a water bath. Leaf conductance (g) was measured on 6 plants per treatment with a LI-1600 steady-state porometer (LI-COR, Lincoln, NE) immediately following afternoon ψ_L measurements. Porometer readings were obtained from the third uppermost fully expanded leaf at 14:45 to 16:00 hour.

Whole plant transpiration (E) was determined gravimetrically (Graham et al., 1987) on 12 plants per treatment in acclimated and nonacclimated plants. On the first day of the final cycle, plants were irrigated, allowed to drain, and containers of 12 plants per treatment were covered with polyethylene bags, which were secured around the plant crown. Plants were weighed daily at 17:00 hour. From these data and leaf areas measured at harvest, E was determined.

Leaf relative water content (RWC) in six plants per treatment was determined on the last day of the stress cycle. A 1 cm diameter leaf disc was removed from the third uppermost fully expanded leaf of each plant and the fresh weight (FW) was determined. Discs were floated on deionized water for three hours, blotted dry, and weighed to determine the turgid weight (TW). Dry weights were determined after drying in an oven at 60 C, and RWC was calculated by the equation:

$$RWC = ((FW - DW)/(TW - DW)) \times 100.$$

Plant biomass measurements. - Twelve plants per treatment were harvested upon completion of the study. Leaves were counted, leaf areas were determined with a LI-3100 area meter (LI-COR, Lincoln, NE), and plant leaves, shoots, and roots were dried at 44 C then weighed.

Before drying, leaves were washed in 0.1 HCl, followed by a P-free detergent solution (Liquinox, Alconox Inc., New York, NY) and rinsed twice in deionized water. to remove any elements which may have been deposited on the leaf surface. After drying, samples were ground to pass through a 20-mesh screen, 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 macro-Kjeldahl procedure (Horowitz, 1980) and for P colorimetrically (Page et al., 1982).

Statistics. - The experimental design was a split block with six two-plant replications. The three irrigation regimes (acclimated, nonacclimated, and nonstressed) were main plot treatments, and the three uniconazole treatments (medium drench, foliar application, and untreated) where subplot treatments. Analysis of the variance procedures were performed on all data and LSD values were calculated for significant main effects and interactions.

RESULTS

Water relations. - On the final day of the stress cycle, there were no significant interactions between watering regime and uniconazole treatment for any measurement of water status (Table 3.1). Nonacclimated plants had a higher E than acclimated plants on the final day of the stress cycle. RWC did not differ among watering regimes. Nonstressed plants had higher g, afternoon and predawn ψ_L, and ψ_π compared to nonacclimated and acclimated plants. There were no significant differences between uniconazole treatments for any measurement of water relations.

Plant biomass. - Significant interactions occurred between watering regimes and uniconazole treatments for leaf area and leaf and stem dry weights (Table 3.2). Acclimated plants had lower leaf areas, and leaf, stem, and root dry weights than either nonstressed or stressed plants. Stem and root dry weights were particularly low in plants which had received uniconazole as a medium drench regardless of watering regime. Foliar applications had little effect on plant growth in any irrigation treatment.

Leaf elemental concentration. - There were no significant interactions between watering regime and uniconazole treatment on leaf elemental concentrations (Table 3.3). Acclimated plants had a higher N concentration than either nonstressed or nonacclimated plants and a higher P concentration than nonacclimated plants. Plants receiving uniconazole as a medium drench had higher Mn and P concentrations than either foliar treated or nontreated plants and lower K concentrations than plants receiving foliar applications. Plants of both uniconazole treatments had higher Ca concentrations than nontreated plants.

DISCUSSION

Past research has shown that uniconazole may affect water relations of some woody plant species (Steinberg et al., 1991a, 1991b; Vaigro-Wolff and Warmund, 1987). Results of the present study are in contrast to those of Vaigro-Wolff and Warmund (1987) who noted an increase in ψ_L in forsythia with uniconazole when water was limited. Steinberg et al. (1991a) also reported that uniconazole did not affect g, E, or ψ_L of ligustrum, although treated plants did use less water. This implies that differences in water consumption between treated and nontreated plants may be due to differences in leaf area or plant biomass.

The reduced moisture availability in acclimated and nonacclimated treatments resulted in lower ψ_L, ψ_π, and g, as expected. The similarity of acclimated and nonacclimated plants in values of all water relations parameters measured, however, suggests that acclimation was minimal in the pyracantha in this study, despite the decreased leaf area in the acclimated plants.

Uniconazole medium drench applications reduced leaf area and leaf, stem, and root dry weights, as in previous studies (Henderson and Nichols, 1991; Norcini and Knox, 1989). The foliar applications, however, had little effect on plant growth, possibly due to inadequate application rates or inability of plants to translocate the chemical out of the leaves (Oshio and Izumi, 1986).

Leaf elemental concentration was affected by both the irrigation treatments and the uniconazole treatments. Lower N and P concentrations in nonstressed plants could be attributed to dilution of N and P concentration per unit dry weight (Johnson et al.,

1980) or potential leaching of nutrients from the growing medium (Henderson and Davies, 1990).

Uniconazole medium drench treatments increased P and Mn concentrations while both drench and foliar applications increased Ca. These increases may also be due to equal total amounts in the plant but smaller plant biomass over which to distribute nutrient elements.

The results of this experiment suggest that uniconazole at the rates tested has little effect on plant water relations of pyracantha. Further experimentation with other rates, species, and levels of stress is necessary to determine whether uniconazole influences on plant growth and potentially on water relations are of economic value in current production schemes.

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Table 3.1. Transpiration (E), leaf conductance (g), relative water content (RWC), leaf water potential (ψ_L), and osmotic potential (ψ_π) of pyracantha treated with uniconazole and exposed to three watering regimes.

Watering regime	Uniconazole treatment	Transpiration mg m^{-2} s^{-1}	Leaf conductance mmol m^{-2} s^{-1}	Relative water content (%)	Afternoon leaf water potential (MPa)	Predawn leaf water potential (MPa)	Afternoon osmotic potential (MPa)
Nonstressed	None	-	295.61	91.8	-2.0	-1.4	-1.9
	Drench	-	229.13	93.5	-2.0	-1.5	-2.0
	Foliar	-	297.18	95.8	-1.9	-1.8	-1.8
Nonacclimated	None	9.41	63.95	97.0	-2.6	-2.1	-2.3
	Drench	12.34	132.22	94.1	-2.3	-1.9	-2.3
	Foliar	10.75	52.24	94.8	-2.6	-2.3	-2.5
Acclimated	None	5.71	34.50	92.1	-2.6	-2.2	-2.6
	Drench	6.62	47.75	90.4	-2.3	-2.2	-2.5
	Foliar	8.00	47.91	89.3	-2.6	-2.3	-2.4
SIGNIFICANCE ($LSD_{0.05}$):							
Main effects							
Watering regime		1.29[z]	51.81	NS	0.2	0.2	0.2
Uniconazole treatment		NS	NS	NS	NS	NS	NS
Interactions							
Watering regime means for the same or different uniconazole treatment		NS	NS	NS	NS	NS	NS
Uniconazole treatments for the same watering regime		NS	NS	NS	NS	NS	NS

[z]Not significant (NS) or LSD at the 5% level.

Table 3.2. Leaf area and leaf, stem, and root dry weights of pyracantha treated with a medium drench or foliar application of uniconazole and exposed to three watering regimes.

Watering regime	Uniconazole treatment	Leaf area (cm^2)	Dry weight (g)		
			Leaf	Stem	Root
Nonstressed	None	2518	21.7	22.5	9.7
	Drench	2122	18.3	9.6	7.2
	Foliar	2313	20.4	21.4	8.9
Nonacclimated	None	2535	20.3	21.1	9.2
	Drench	1947	17.8	9.2	6.5
	Foliar	2496	21.2	23.4	9.2
Acclimated	None	1725	15.2	13.8	6.1
	Drench	1633	17.2	8.0	5.1
	Foliar	1369	13.2	12.3	5.2
Significance ($LSD_{0.05}$):					
Main effects					
Watering regime		185[z]	2.0	3.2	0.9
Uniconazole treatment		256	NS	2.5	1.1
Interactions					
Watering regime means for the same or different uniconazole treatment		732	7.7	6.6	NS
Uniconazole treatment means for the same watering regime		447	NS	8.2	NS

[z]Not significant (NS) or LSD at 5% the level.

Table 3.3. Leaf elemental concentrations of pyracantha treated with a medium drench or foliar application of uniconazole and exposed to three watering regimes.

Watering regime	Uniconazole treatment	Dry weight (%)					Dry weight (µg/g)		
		N	P	K	Ca	Mg	Zn	Fe	Mn
Nonstressed	None	2.55	0.28	1.00	1.75	0.22	141	33	199
	Drench	2.68	0.38	1.01	1.89	0.22	146	31	223
	Foliar	2.55	0.29	1.08	1.96	0.21	140	37	212
Nonacclimated	None	2.57	0.26	1.06	1.79	0.20	142	36	190
	Drench	2.61	0.34	1.01	1.92	0.21	136	32	228
	Foliar	2.52	0.30	1.05	1.85	0.20	128	28	201
Acclimated	None	2.84	0.30	1.09	1.79	0.17	122	40	208
	Drench	3.07	0.39	1.02	2.01	0.21	141	32	266
	Foliar	3.03	0.34	1.14	1.84	0.19	126	38	236
SIGNIFICANCE ($LSD_{0.05}$):									
Main Effects									
Watering regime		0.10[z]	0.03	NS	NS	NS	NS	NS	NS
Uniconazole treatment		NS	0.03	.06	.10	NS	NS	NS	20
Interactions									
Watering regime means for the same or different uniconazole treatment		NS	NS	NS	NS	NS	NS	NS	NS
Uniconazole treatments for the same watering regime		NS	NS	NS	NS	NS	NS	NS	NS

[z]Not significant (NS) or LSD at the 5% level.

CHAPTER IV

SUMMARY

The production of high quality plants with minimal inputs is the goal of nursery production firms. Labor is one of the greatest expenses in nursery crop production because of the diversity of plants produced and their various cultural needs. The reduction of labor and other inputs could lead to increased profits for the producer and savings passed on to the consumer. Pruning to maintain a desirable plant appearance is a labor intensive process and can result in the spread of disease organisms throughout a nursery crop. The successful use of growth regulators could lead to reduced labor costs and less disease. In the first experiment, three plant species, pyracantha, photinia, and dwarf Burford holly received uniconazole, a plant growth regulator, as either a medium drench or foliar spray at four rates. This test was conducted to determine whether uniconazole could control growth and maintain a desirable plant form, and thereby reduce or eliminate the need for pruning. Results of our study revealed that uniconazole could be used to reduce growth while retaining plant quality of pyracantha. Uniconazole also controlled growth of photinia and holly, but plants exhibited some undesirable characteristics such as malformed foliage and pendulous or extremely compact growth habits, thereby reducing their salability. Treated plants did have darker green foliage, an attractive asset. The darker green foliage of pyracantha could be attributed to an increased chlorophyll concentration in the leaves.

Uniconazole medium drench applications increased concentrations of N, P, and Zn in photinia and pyracantha, but reduced concentrations of K in pyracantha. Foliar applications had a similar, but less pronounced effect on leaf elemental concentrations in pyracantha and photinia. Uniconazole had little effect on holly leaf elemental concentration.

Availability of plenty of clean water is important to the nursery producer. Without adequate water supplies, production of a high quality nursery crop would be impossible. In our second experiment, we evaluated the response of pyracantha growth and water relations to medium drench or foliar applications of uniconazole. Uniconazole had no effect on the water relations of pyracantha in this study. Pyracantha did respond to decreased water availability. Nonstressed plants exhibited a higher afternoon and predawn water potential, osmotic potential, and leaf conductance.

Uniconazole medium drenches reduced growth of pyracantha in the second study. Foliar applications did not reduce plant growth significantly, however, these plants tended to be smaller than nontreated plants. Acclimated plants were significantly smaller than other plant plants because of the limited moisture availibility.

Uniconazole medium drenches increased concentrations of Mn and P and both medium drench and foliar uniconazole applications increased Ca concentration. Watering regimes also affected elemental concentrations, with acclimated plants having a higher N concentration than other either nonstressed or nonacclimated plants and a higher P concentration than stressed plants.

From these studies, we concluded that uniconazole could be used to reduce growth of pyracantha while maintaining plant quality, but would have little effect on water relations of pyracntha. Uniconazole used at rates in the first study on photinia and holly resulted in plants of questionable ornamental value.

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APPENDIX

SUPPLEMENTAL PLANT WATER RELATIONS DATA FOR CHAPTER III

Table A.1. Afternoon (PM) and predawn (AM) leaf water potentials (MPa) of pyracantha treated with a medium drench or foliar application of uniconazole and exposed to three irrigation regimes.

Watering regime	Uniconazole treatment	Day of stress cycle 1		2		3		4	
		PM	AM	PM	AM	PM	AM	PM	AM
Nonstressed	None	-1.66	-1.12	-1.49	-1.41	-1.46	-1.29	-1.97	-1.43
	Drench	-1.58	-1.20	-1.72	-1.42	-1.57	-1.20	-2.05	-1.48
	Foliar	-1.69	-1.48	-1.24	-1.56	-1.39	-1.52	-1.87	-1.83
Stressed	None	-1.62	-1.44	-1.53	-1.85	-1.61	-1.40	-2.59	-2.08
	Drench	-1.46	-1.33	-1.27	-1.64	-1.52	-1.48	-2.28	-1.90
	Foliar	-1.83	-1.22	-1.55	-1.55	-1.67	-1.83	-2.63	-2.34
Acclimated	None	-2.07	-1.67	-1.98	-1.90	-2.12	-1.95	-2.64	-2.20
	Drench	-1.81	-1.56	-1.52	-1.69	-1.66	-1.96	-2.33	-2.24
	Foliar	-2.23	-1.65	-2.00	-1.74	-1.76	-1.68	-2.62	-2.31
SIGNIFICANCE ($LSD_{0.05}$):									
Main Effects									
Watering regime		0.25	0.18	0.24	NS	0.22	0.21	0.23	0.21
Uniconazole treatment		NS	NS	NS	NS	NS	NS	NS	NS
Interactions									
Watering regime means for the same or different uniconazole treatment		NS	NS	0.41	NS	NS	0.63	NS	NS
Uniconazole treatment means for the same watering regime		NS	NS	0.43	NS	NS	NS	NS	NS

Table A.2. Daily transpiration (mg m^{-2} s^{-1}) of pyracantha under three watering regimes.

Watering regime	Day of stress cycle		
	2	3	4
Stressed	6.28	7.38	10.83
Acclimated	4.75	5.56	6.78
$LSD_{0.05}$	0.35	0.52	1.29

Table A.3. Daily transpiration (mg m^{-2} s^{-1}) of pyracantha treated with uniconazole.

Watering regime	Day of stress cycle		
	2	3	4
None	5.63	6.53	7.56
Drench	4.89	5.70	9.48
Foliar	6.04	7.18	9.38
$LSD_{0.05}$	0.60	0.78	NS

Table A.4. Relative leaf water content (%) of pyracantha under three watering regimes.

Watering regime	Day of stress cycle		
	2	3	4
Nonstressed	88.5	93.6	93.7
Stressed	93.6	95.4	95.3
Acclimated	89.8	90.7	90.6
$LSD_{0.05}$	NS	NS	NS

Table A.5. Relative leaf water content (%) of pyracantha treated with uniconazole.

	Day of stress cycle		
Uniconazole treatment	2	3	4
None	89.0	94.8	93.6
Drench	91.3	91.6	92.7
Foliar	91.6	93.1	93.3
$LSD_{0.05}$	NS	NS	NS

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