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# Effect of Uniconazole and Limited Water on Growth, Water Relations, and Mineral Nutrition of "Lalandei" Pyracantha

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**Abstract.** Pyracantha (*Pyracantha coccinea* M. J. Roem. "Lalandei") plants were treated with uniconazole at 0.5 mg ai container$^{-1}$ as a medium drench, 150 mg ai L$^{-1}$ as a foliar spray, or left untreated. Plants from all 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, and transpiration rates were higher in nonacclimated than acclimated plants. Uniconazole did not affect leaf water potential, leaf conductance, or transpiration rate. Acclimated plants had smaller leaf areas and leaf, stem, and root dry weights than nonacclimated or nonstressed plants. Plants drenched with uniconazole had the lowest stem and root dry weights. 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. Calcium concentration was increased in plants receiving either medium drench or foliar applications.

Access to ample clean water is vital to nursery crop production. Nursery producers located near urban areas often use the same water as nearby municipalities. Potential 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 may increase crop survival and plant quality during critical times when water is limited.

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, leaf conductance, and leaf water potential 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 growth, water relations, and mineral nutrition of "Lalandei" pyracantha (*Pyracantha coccinea* "Lalandei").

## Materials and Methods

### *Plant Culture*

Uniform rooted cuttings of "Lalandei" pyracantha were planted in 3.8 L containers on October 19, 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, California), 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 μmol m$^{-2}$ s$^{-1}$ at plant height, and maximum/minimum air temperature 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 $L^{-1}$ N. After establishment, plants received uniconazole treatments of 0.5 mg ai $container^{-1}$ as a soil drench, 150 mg ai $L^{-1}$ as a foliar spray, or no uniconazole on January 7, 1990. These rates provided optimal plant quality in previous studies testing dose responses (Henderson and Nichols 1991, Frymire and Cole 1992). Medium drench applications were made in 50 ml of solution per container, which was completely absorbed by the growing medium. The foliar sprays were applied using a $CO_2$-pressurized backpack sprayer with an output of 0.2 L $m^{-2}$. The medium surface of pots receiving the 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 (nonacclimated 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 4-day stress cycles were based on plant water potential data from a preliminary experiment which yielded no overnight recovery when water was withheld for 5 days (data not shown). The nine uniconazole-water regime treatments included 12 containerized plants per treatment.

## *Water Relations Measurements*

Water potential ($\Psi_L$) and osmotic potential ($\Psi_\pi$) 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 h of the final day of the stress cycle and the following morning at 05:00 h to determine afternoon and predawn $\Psi_L$, respectively. Plants were irrigated and $\Psi_\pi$ was determined upon rehydration after the final day of the stress cycle. Leaf discs were cut and sealed in the psychrometers at 13:15 h 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 six plants per treatment with a LI-1600 steady-state porometer (LI-COR, Lincoln, NE) immediately following afternoon $\psi_L$ measurements. Porometer readings were obtained from the third uppermost fully expanded leaf at 14:45 to 16:00 h.

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 h. 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 3 h, blotted dry, and weighed to determine the turgid weight (TW). Dry weights (DW) were determined after drying in an oven at 60°C for 24 h, 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, and leaf areas were determined with a LI-3100 area meter (LI-COR, Lincoln, NE). 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. Leaves, shoots, and roots were dried at 44°C for 7 days and then weighed. 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) were subplot treatments. Analysis of variance procedures were performed on all data and LSD values were calculated for significant main effects and interactions.

# Results

## *Water Relations*

There were no significant interactions between watering regime and uniconazole treatment for any measurement of water status (Table 1). Nonacclimated plants had a 59% higher $E$ than acclimated plants on the final day of the stress cycle. RWC did not differ among watering regimes. Leaf conductance of nonstressed plants was three times higher than that of nonacclimated plants, and five times higher than in acclimated plants. Predawn and afternoon $\Psi_L$ and $\Psi_\pi$ were 25%, 38%, and 29% lower, respectively, in nonacclimated and acclimated plants than in nonstressed 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 2). Acclimated

**Table 1.** Transpiration ($E$), leaf conductance ($g$), relative water content (RWC), and leaf water potential ($\psi_L$) determined on the final day of the stress cycle and osmotic potential ($\psi_\pi$) determined after rehydration 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 | — | 295.6 | 91.8 | −2.0 | −1.4 | −1.9 |
| | Drench | — | 229.1 | 93.5 | −2.0 | −1.5 | −2.0 |
| | Foliar | — | 297.2 | 95.8 | −1.9 | −1.8 | −1.8 |
| Nonacclimated | None | 9.4 | 64.0 | 97.0 | −2.6 | −2.1 | −2.3 |
| | Drench | 12.3 | 132.2 | 94.1 | −2.3 | −1.9 | −2.3 |
| | Foliar | 10.8 | 52.2 | 94.8 | −2.6 | −2.3 | −2.5 |
| Acclimated | None | 5.7 | 34.5 | 92.1 | −2.6 | −2.2 | −2.6 |
| | Drench | 6.6 | 47.8 | 90.4 | −2.3 | −2.2 | −2.5 |
| | Foliar | 8.0 | 47.9 | 89.3 | −2.6 | −2.3 | −2.4 |
| Significance ($LSD_{0.05}$): | | | | | | | |
| Main effects | | | | | | | |
| Watering regime | | 1.3[a] | 51.8 | 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 |

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

**Table 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[a] | 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 |

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

**Table 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[a] | 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 |

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

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). Acclimated plants had a 16% higher N concentration than either nonstressed or nonacclimated plants and a 13% higher P concentration than nonacclimated plants. Manganese concentration of plants receiving uniconazole as a medium drench was 20% and 11% higher than that of plants receiving no uniconazole or uniconazole as a foliar spray, respectively. A similar trend in P concentration occurred with plants receiving a medium drench having 32% more P than nontreated plants and 19% more than plants receiving a foliar application. Potassium concentration was 8% less in plants receiving the medium drench application compared to those receiving foliar applications. Plants of the medium drench and foliar treatments had 9% and 6% higher Ca concentrations, respectively, than nontreated plants.

## Discussion

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

The reduced moisture availability in acclimated and nonacclimated treatments resulted in lower $\Psi_L$, $\Psi_\pi$, 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 (Frymire and Cole 1992, 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. Uniconazole and other similar compounds have previously been shown to affect leaf elemental concentration (Frymire and Cole 1992, Zeller et al. 1991); however, the elements affected and amount of the effect appear to depend on species and cultivar. These increases have been attributed to a concentration of the elements in tissues when growth rate decreases (Marcelle et al. 1981), changes in the rate of nutrient uptake by treated plants (Himelrick et al. 1976), and changes in nutrient translocation rate (Wieneke et al. 1971).

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's influences on plant growth, and potentially on water relations, are of economic value in current production schemes.

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