Water Use and Average Growth Index of Five Species of Container Grown Woody Landscape Plants[1]

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Abstract

Liners of *Juniperus horizontalis* Moench 'Wiltonii', *Ilex crenata* Thunb. 'Rotundifolia', *Rhododendron* x L. 'Hershey's Red', *Pyracantha* x M.J. Roem 'Teton', and *Photinia* x *fraseri* Dress were grown to saleable size in 3.1 l (1 gal) containers. Plant water consumption was measured during 336 days from June 24, 1986, to June 19, 1987. Pyracantha consumed the most water (50.4 l (13.3 gal)/plant) while photinia consumed the least water (37.8 l (10.0 gal)/plant). Based on the increase in growth index per liter of water consumed, photinia used water most efficiently. Growth index, pan evaporation, or growth index and pan evaporation were the best predictors of plant water use.

Index words: water use efficiency; water consumption; evapotranspiration
Species used in this study: Blue rug juniper (*Juniperus horizontalis* Moench 'Wiltonii'); 'Rotundifolia' holly (*Ilex crenata* Thunb. 'Rotundifolia'); 'Hershey's Red' azalea (*Rhododendron* x L. 'Hershey's Red'); 'Teton' pyracantha (*Pyracantha* x M.J. Roem 'Teton'); Fraser photinia (*Photinia* x *fraseri* Dress)

Introduction

Water conservation and management in nurseries is becoming an important issue as water supplies become limited or restricted due to drought or competition for water with urban areas. Water use efficiency in nurseries could be improved by grouping plants with similar water requirements and by scheduling irrigation based on plant needs. Nursery irrigation requirements are largely determined by plant species, time of year, and geographic location (11). Environmental factors such as rainfall, light intensity, temperature, relative humidity, and windspeed also influence irrigation demand, and these factors vary with time of year and geographic location. Other factors that affect water use are plant size, plant growth rate, and stage of plant development.

Until recently, little interest was expressed in water use of container-grown landscape plants. The necessity of adequate drainage after heavy rains has resulted in a production system that encourages excess irrigation: plants grown in porous, well-drained growing media are very tolerant of overwatering, but unforgiving when irrigation is neglected. With the evolution of plant management as an important issue, data on water use has been published for potted chrysanthemums (12), foliage plants (7, 8), tropical and subtropical landscape plants (2, 3, 4), and selected temperate woody landscape plants (1, 9). Objectives of this study were to record luxury water use throughout one year of a simulated production cycle of five species of container-grown landscape plants commonly produced in north and central Florida.

Materials and Methods

Liners of *Juniperus horizontalis* Moench 'Wiltonii', *Ilex crenata* Thunb. 'Rotundifolia'. *Rhododendron* x L. 'Hershey's Red', *Pyracantha* x M.J. Roem 'Teton', and *Photinia* x *fraseri* Dress were grown in 16 × 16.5 cm (6.25 × 6.5 in) containers (1 gal) filled to within 2.5 cm (1 in) of the top with a pine bark, sphagnum peat, sand medium (2:1:1 by vol). A slow release 18N-2.6P-9.9K fertilizer (Osmocote 18-6-12, Sierra Chemical Co., Milpitas, CA) was incorporated in the medium at 5.9 kg/m^3 (10 lbs/yd^3) and surface applied at 9g (0.3 oz) per container every 4 months thereafter. Six plants of each species were randomly arranged on each of 3 tables under an open-sided structure covered with clear vinyl to exclude rainfall but allow ambient relative humidity, wind, and an average of 67% full sunlight.

Plants were irrigated with 250 ml water (0.5 in/pot) every 1 to 5 days as needed so that leachate volume was at least 25 ml/pot (0.05 in/pot) per irrigation. Leachate was collected, and the amount retained by the medium was considered as the amount lost by evapotranspiration since the previous irrigation (i.e., water use). Average water use was calculated for each plant during 336 days of the 352 day period from June 24, 1986, to June 19, 1987. Problems with the irrigation system precluded leachate collection for the period October 6 through October 22, 1986, and after June 19, 1987.

Plant height and width were measured every 4 to 6 weeks to calculate a growth index [(height + width)/2]. A plant was considered quiescent or dormant when consecutive measurements showed an increase in growth index less than two times the standard deviation of the species' mean growth index. Juniper plants were considered saleable upon attaining a growth index of 25 to 30, and the remaining species were judged saleable upon attaining a growth index of 40 to 45.

The first groups of pyracantha and photinia plants grew rapidly and required replacement with liners in order to obtain year-round data on water use (Fig. 1 and 2). Less

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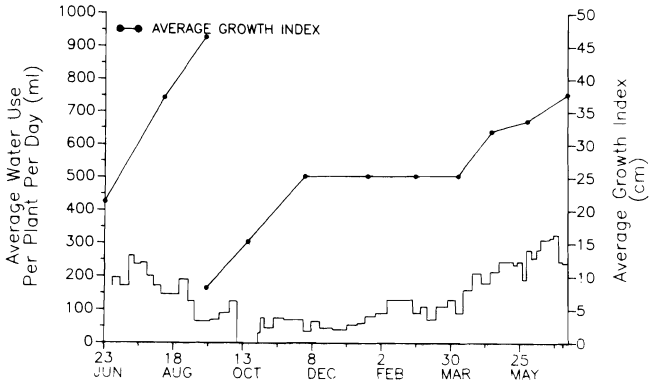

Fig. 1. Average water use per plant per day and growth index of 'Teton' pyracantha from June 24, 1986, through June 19, 1987. Water use data not collected for October, 1986. Growth index = [(height ± width)/2)].

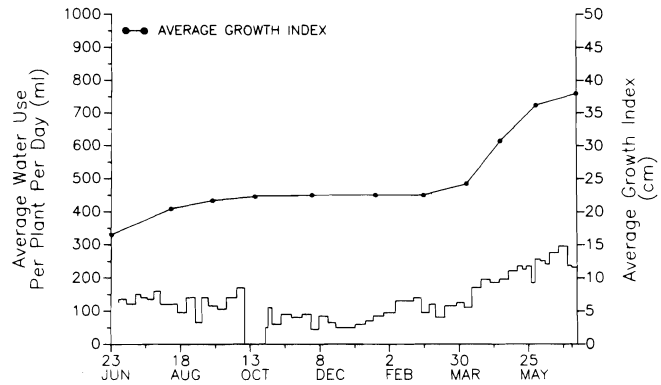

Fig. 3. Average water use per plant per day and growth index of 'Hershey's Red' azalea from June 24, 1986, through June 19, 1987. Water use data not collected for October, 1986. Growth index = [(height ± width)/2)].

favorable growing conditions during winter and quiescence/dormancy resulted in longer production times for the second crops.

Azaleas ceased growing earliest in autumn and pyracantha plants resumed growth in spring latest of the 5 species (Fig. 1 to 5). The duration of quiescence/dormancy ranged from 11 weeks for photinia to almost 24 weeks for azalea (Table 1).

Analysis of variance was performed on each variable in the randomized complete block design (with tables serving as blocks). Maximum and minimum temperatures and evaporation from a Class A evaporation pan were recorded daily from a site located 110 meters (120 yards) from the experiment (Table 2). To determine possible predictors of plant water use, multiple linear regression was used to correlate water use with plant growth index, species, evaporation from a Class A evaporation pan, and potential evapotranspiration as calculated by the Thornthwaite method (2, 10).

Results and Discussion

Pyracantha and azalea plants consumed the largest amounts of water and photinia plants consumed the least water for the entire 336 day period (Table 1). During active growth, weekly water use was greatest for azalea and least for photinia (Table 1). Although this study cannot be directly compared to others, the values of water use/week during active growth (Table 1) are within reported ranges for water consumption during summer for temperate, sub-tropical, and tropical woody plants (2, 3, 4, 9).

Actual amounts of irrigation applied to nurseries in central Florida ranges from 142 to 282 cm/year (56 to 111 in/year) in 1973, 1975, and 1976 (5), not including the average annual rainfall of 140 cm (55 inches). For the container size used in this experiment, these values are equivalent to 28 to 56 l (7.4 to 14.8 gal) of irrigation applied per container, plus an additional 28 l (7.4 gal) per container from rainfall. The actual fraction of this amount used to provide for the water requirements of the plants cannot be determined since the 28 to 56 l (7.4 to 14.8 gal) include additional water necessary to account for efficiency of the irrigation system, specific plant species and sizes, actual environmental conditions, leaching requirements, and losses due to evaporation, drift, and deflection by foliage. However, based on the water requirements for the species studied here, it is probable that some nurseries irrigate far in excess of plant water requirements.

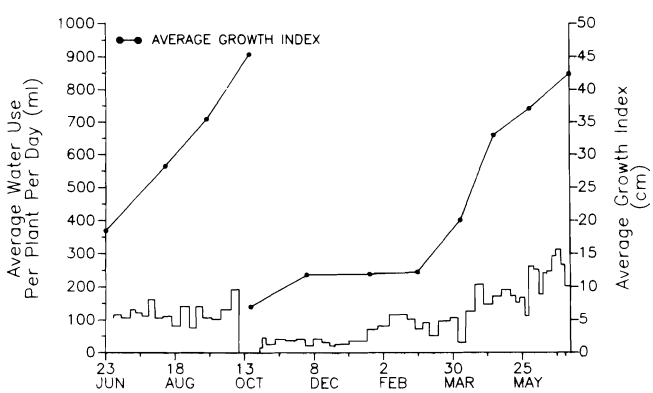

Fig. 2. Average water use per plant per day and growth index of *Photinia* × *fraseri* from June 24, 1986, through June 19, 1987. Water use data not collected for October, 1986. Growth index = [(height ± width)/2)].

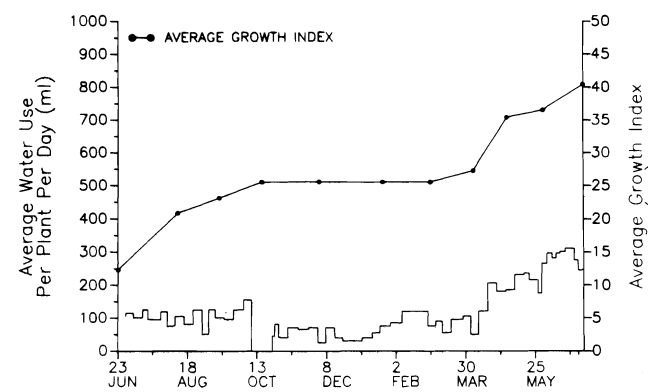

Fig. 4. Average water use per plant per day and growth index of 'Rotundifolia' holly from June 24, 1986, through June 19, 1987. Water use data not collected for October, 1986. Growth index = [(height ± width)/2)].

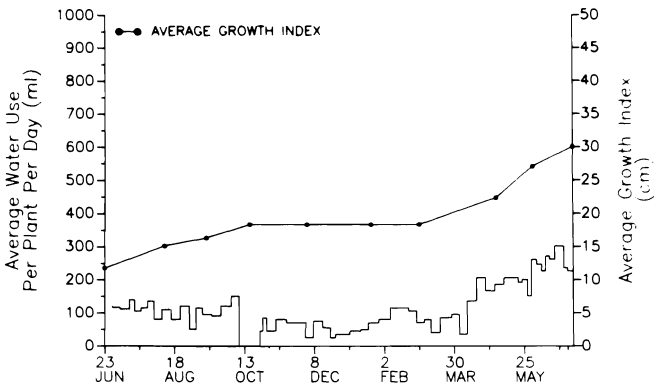

Fig. 5. Average water use per plant per day and growth index of blue rug juniper from June 24, 1986, through June 19, 1987. Water use data not collected for October, 1986. Growth index = [(height ± width)/2)].

Table 2. Mean monthly maximum and minimum temperatures and pan evaporation at Monticello, Florida, from June 1986 through June 1987.

Year	Month	Maximum Temperature (°F)	Minimum Temperature (°F)	Class A Pan Evaporation (in)
1986	Jun	94	68	0.26
	Jul	93	71	0.27
	Aug	90	69	0.18
	Sep	89	68	0.18
	Oct	81	56	0.18
	Nov	76	57	0.10
	Dec	64	46	0.07
1987	Jan	60	38	0.08
	Feb	64	41	0.10
	Mar	71	49	0.16
	Apr	76	48	0.22
	May	86	62	0.22
	Jun	89	68	0.20

The increase in growth index per liter of water consumed can be considered a rough estimate of water use efficiency. Photinia plants used water most efficiently while blue rug juniper and azalea were least efficient (Table 1). Blue rug juniper's low efficiency of water use and relatively high total water consumption (comparable to 'Rotundifolia' holly) are not compatible with *Juniperus* species' reputation for being drought tolerant. However, some drought tolerant plants do not use water efficiently when soil moisture is adequate, as it was in this experiment (6).

Previous studies have shown strong relationships between plant water use and estimates of potential evapotranspiration (2, 4, 9). For this study, regression analysis found pan evaporation or growth index to be acceptable indicators for water use for all species except for growth index with pyracantha (Table 3). The combination of pan evaporation plus growth index proved to be the best predictor.

Significance to the Nursery Industry

Over the course of almost 1 year, average luxury water use by 5 species of landscape plants in 16 × 16.5 cm containers (6.25 × 6.5 in) ranged from 50.4 l/container (13.3 gal/container) for 'Teton' pyracantha to 37.8 l/container (10.0 gal container) for photinia. In decreasing order of total water use, the species were 'Teton' pyracantha, 'Hershey's Red' azalea, 'Rotundifolia' holly, blue rug juniper, and photinia. Based on increase in growth index per liter of water consumed, photinia used water most efficiently, followed by 'Teton' pyracantha. These results indicate that maximum water requirements of container-grown plants are primarily determined by plant species and plant size. Results suggest that measurements of plant size and estimates of potential evapotranspiration might be used to estimate nursery water requirements for a given species.

Table 1. Water use and characteristics of growth of 5 species of containerized woody landscape plants from June 24, 1986, through June 19, 1987. Species was significant at the 1% level or less for each characteristic.

	'Hershey's Red' Azalea	'Rotundifolia' Holly	'Wiltonii' Juniper	'Teton' Pyracantha[z]	Photinia[y]
Active Growth					
Duration (wks)	27.3 ± 1.0[x]	29.2 ± 0.6	30.1 ± 0.9	34.6 ± 0.4	39.9 ± 0.7
Water Use (l)	34.4 ± 1.1	33.1 ± 0.7	32.5 ± 1.0	40.8 ± 0.8	33.5 ± 1.6
Avg. Water Use per week (l/wk)	1.27 ± 0.03	1.14 ± 0.03	1.09 ± 0.03	1.18 ± 0.02	0.85 ± 0.04
Increase in Growth Index (cm)	21.2 ± 0.5	27.3 ± 0.8	18.6 ± 0.8	54.4 ± 1.1	55.8 ± 2.9
Increase in Growth Index (cm) per liter of water consumed	0.63 ± 0.03	0.83 ± 0.04	0.58 ± 0.03	1.34 ± 0.03	1.67 ± 0.06
Quiescence					
Duration (wks)	23.7 ± 1.0	21.8 ± 0.6	20.8 ± 0.9	16.4 ± 0.4	11.1 ± 0.7
Water Use (l)	13.8 ± 0.8	10.2 ± 0.6	9.4 ± 0.7	9.6 ± 0.3	4.3 ± 0.4
Avg. Water Use per week (l/wk)	0.58 ± 0.02	0.46 ± 0.02	0.44 ± 0.02	0.59 ± 0.02	0.38 ± 0.02
Total Water Use (l)	48.2 ± 0.9	43.3 ± 1.1	41.9 ± 0.9	50.4 ± 0.8	37.8 ± 1.7

[z]Two crops were produced: the first crop from June 24, 1986, through September 3, 1986, and the second crop from September 3, 1986, through June 19, 1987.

[y]Two crops were produced: the first crop from June 24, 1986, through October 6, 1986, and the second crop from October 6, 1986 through June 19, 1987.

[x]Numbers represent the mean ± standard error for 18 plants.

Table 3. R^2 values for linear regression models expressing the relationships between water use of each of 5 species and pan evaporation, PET by the Thornthwaite method, and growth index.

Variables in Model	'Hershey's Red' Azalea	'Rotundifolia' Holly	'Wiltonii' Juniper	'Teton' Pyracantha	Photinia
Pan Evaporation	.57	.51	.55	.73	.69
PET-Thornthwaite	.15	.26	.25	.27	.41
Growth Index	.71	.56	.68	.33	.69
Thornthwaite and Growth Index	.67	.72	.81	.26	.49
Pan Evaporation and Growth Index	.86	.79	.88	.79	.78

Literature Cited

1. Davies, F.T., Jr. and T. Marsh. 1986. Water relations of selected landscape plants. Proc. Southern Nurserymen's Assoc. Res. Conf. 31:245–246.

2. Fitzpatrick, G. 1980. Water budget determinations for container-grown ornamental plants. Proc. Fla. State Hort. Soc. 93:166–168.

3. Fitzpatrick, G. 1983. Plant growth response to water rationing in a container nursery. HortScience 18:187–189.

4. Fitzpatrick, G. 1983. Relative water demand in container-grown ornamental plants. HortScience 18:760–762.

5. Harrison, P.E. 1976. Irrigation water applied in three commercial ornamental container nurseries. Proc. Fla. State Hort. Soc. 89:311–313.

6. Levitt, J. 1980. Drought tolerance. p. 129–186 *In* Responses of Plants to Environmental Stresses, Vol 2, Water, Radiation, Salt, and Other Stresses. Academic Press, New York, NY.

7. Poole, R.T. and C.A. Conover. 1982. Influence of leaching, fertilizer source and rate, and potting media on foliage plant growth, quality, and water utilization. J. Amer. Soc. Hort. Sci. 107:793–797.

8. Poole, R.T. and R.W. Henley. 1980. Fertilization and water use of *Dieffenbachia maculata* and *Peperomia obtusifolia*. Proc. Fla. State Hort. Soc. 93:162–164.

9. Roberts, B.R. and V.M. Schnipke. 1987. Water requirements of five container-grown *Acer* species. J. Environ. Hort. 5:173–175.

10. Rogers, J.S. and G.A. Marlowe, Jr. 1977. Water needs of Florida vegetable crops. University of Florida, IFAS, Water Resources Council publication WRC-2.

11. Smajstrla, A.G. and F.S. Zazueta. 1987. Estimating irrigation requirements of sprinkler irrigated container nurseries. Proc. Fla. State Hort. Soc. 100:343–348.

12. Stanley, C.D. and B.K. Harbaugh. 1984. Estimating daily water use for potted chrysanthemum using pan evaporation and plant height. HortScience 19:287–288.