Irrigation and Pruning Affect Growth Water Use Efficiency of two Desert-Adapted Shrubs

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Abstract

Amenity landscapes often require supplemental water application in situations of low soil water availability; such as in root restricted urban settings, during unusual or seasonal periods of low precipitation, or in arid regions where irrigation is essential year round. In the arid western United States, there is growing public concern about the long-term viability of water resources. Recent trends in landscaping include the use of drought-adapted trees and shrubs in low water use landscape designs, and some municipalities restrict the use of turf and offer incentives to convert to xeric designs. Paradoxically, planting schemes and maintenance practices often include excessively dense plantings and over irrigation of xeriphytic species, which must then be frequently pruned to limit over crowding and obstruction of roads and walkways. Water use efficiency (WUE) of two Southwest landscape shrubs, *Nerium oleander* 'Sister Angus' *(oleander)* and *Leucophyllum frutescens* var. green cloud (texas sage), was determined in a field study in response to 2x3 factorial treatment of irrigation volume (high or low volume) and pruning frequency (every 6 weeks, 6 months, or unpruned). WUE was defined as the ratio of total biomass produced to volume of irrigation water applied over one year. Shrub biovolume was measured before and after every pruning event or every 3 months. All biomass pruned from shrubs was weighed. After one year's growth, 12 unpruned control shrubs of each species and irrigation treatment were harvested to determine allometric relationships between standing biovolume and standing biomass. Greatest total biomass production occurred for shrubs receiving the high irrigation volumes or shrubs left unpruned. WUE was highest for unpruned shrubs receiving low irrigation volumes and was lowest for the 6-week pruned shrubs receiving high irrigation volumes. These data suggest that frequent pruning lowered WUE of well-watered oleander and texas sage.

INTRODUCTION

In urban landscapes, irrigation is often necessary to sustain landscape plant aesthetic quality. In the arid southwest United States, drip irrigation of landscape shrubs is common, although there is increasing public concern about the long-term viability of fresh water resources. In response to these concerns, recent landscaping trends include use of desert or drought-adapted plants in low water-use landscape planting designs and some municipalities restrict turf area and dictate choices for ornamental tree and shrub species in public areas. Some cities offer rebates to homeowners who install or convert to landscape designs intended to conserve water (City of Tempe, 2001; El Paso Water Utilities, 2001; Las Vegas Valley Water District, 2001). However, in the Phoenix metropolitan area in south central Arizona, we found that suburban homeowner irrigation practices were not congruent with landscape design motif (Martin and Stabler, 2001).

Contemporary urban landscapes are often characterized by space limitation, yet Southwest landscape architectural planting schemes frequently include dense plantings of xeriphytic shrubs. Ensuing over-irrigation of these closely spaced, desert or drought-

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adapted shrubs encourages lush growth that can quickly obstruct landscape view lines, walkways and roads and require frequent shearing to ameliorate these obstructions. Little is known about the effects of pruning on landscape shrub performance.

We hypothesized that irrigation and pruning practices, that are common in the region for drought-adapted landscape shrubs, might have a negative impact on their WUE. Data presented here convey results from the first year of an ongoing and long-term controlled field study of the effects of maintenance practices on amenity landscape performance. Specifically, we report how drip irrigation volume and pruning frequency affected shrub growth and WUE of two regionally common landscape shrubs.

MATERIALS AND METHODS

During May 1999, we established 14-100 m^2 landscape field plots at an urban research site in Phoenix, AZ, USA (33° 26' N 112° 00'W). Each plot was planted with six 3.8-liter container-grown clones of *Nerium oleander* 'Sister Agnes' (oleander) and *Leucophyllum frutescens* var. green cloud (Texas sage). Shrubs in all plots were drip irrigated with similar volumes of water for the first 6 months after transplanting, and thereafter were subjected to a 2x3 factorial treatment combination of drip irrigation volume (high or low volume) and shrub pruning frequency (sheared every 6 weeks; headed back once every 6 months, or unpruned control) for one year. The volume of water applied to each plot was monitored using Precision® totalizing water meters, and irrigations were scheduled to give shrubs in the high irrigation plots about twice as much water as shrubs in the low volume plots. The volume of water applied to shrubs in both irrigation treatments was ramped seasonally higher in summer and lower in winter based on a previous assessment of the range of landscape irrigation application volumes by local residents (Martin and Stabler, 2001).

Within each irrigation treatment, all shrubs in two plots (eight plots total) were frequently sheared with manual or power hedgers every 6 weeks (n=12 replicates per species) or infrequently headed back every 6 months (n=12 replicates per species). Shrubs in three plots within each irrigation treatment (six plots total) were left unpruned as controls (n=18 shrub replicates per species).

Volume of all shrubs (height x north/south width x east/west width, assuming a box shape) was measured every 3 months and before and after each pruning event. Biomass pruned from each plant was oven dried for 5 days at 60°C and weighed. Shoots from 12 of the unpruned control shrubs of each species and irrigation treatment harvested after one year of treatment application by severe renewal pruning and were used to develop allometric relationships between shrub volume, standing biomass, and total shoot mass produced. WUE was calculated as the ratio of total shoot mass (standing biomass plus biomass pruned) to the total volume of irrigation water applied to each shrub for one year.

For all statistical comparisons, an analysis of variance (ANOVA) was calculated using a general linear model procedure and Type IV sums of squares (SAS version 6.03; SAS Inst., Cary, NC). Tukey's Studentized Range Test was used to identify significant differences between variable responses to treatment effects, $P \leq 0.05$.

RESULTS AND DISCUSSION

Total above ground biomass production of oleander was affected by an interaction of irrigation and pruning treatments (P=0.04). Under high irrigation, oleander shrubs left unpruned and those headed back every 6 months produced about 1.7 times more shoot mass than shrubs that were sheared every 6 weeks (Table 1). Under low irrigation, unpruned oleander produced about 1.5 times more shoot mass than shrubs that were either frequently sheared or infrequently headed back.

Biomass production of Texas sage was not affected by a treatment interaction (P=0.65), but did show main effects. Texas sage shrubs given high volumes of water produced about 1.5 times more shoot mass than those given low volumes (Table 1). Texas sage shrubs left unpruned produced about 1.5 times more total shoot mass than those that were either infrequently or frequently pruned.

The WUE of both species was affected by an interaction of irrigation volume and pruning frequency ($P < 0.01$). In general, unpruned shrubs given low irrigation volumes had the highest WUE while those that were frequently sheared and given high irrigation volumes had the lowest WUE (Table 2). Under high volume irrigation regimes, WUE of oleander and Texas sage left unpruned or infrequently headed back was about 2.0 or 1.6 times higher, respectively, than for shrubs frequently sheared. In contrast, WUE within the low volume irrigation treatment of oleander and Texas sage shrubs left unpruned was about 2.1 or 2.2 times greater, respectively, than for shrubs sheared frequently or infrequently headed back.

Results from this study showed that increased irrigation volumes stimulated shoot growth of oleander and Texas sage, but that increased biomass production was partially offset by pruning. Though oleander and Texas sage given the lower volumes of water did not grow as much as those given the higher water volumes, these shrubs generally had higher WUE and showed no symptoms of drought stress or unacceptable appearance. These data suggest that irrigation requirements of shrubs like oleander and Texas sage might be considerably lower than the amounts typically applied by local homeowners (Martin and Stabler, 2001), and that adjustments to irrigation scheduling might be used in lieu of frequent shearing to control plant growth in urban settings.

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Tables

Table 1. Shoot biomass production by *Nerium oleander* 'Sister Agnes' (oleander) and *Leucophyllum frutescens* var. green cloud (Texas sage) for one year in response to drip irrigation volume and pruning frequency treatments.

Irrigation volume	Pruning frequency	Total shoot mass (kg)
Oleander (Interactive effects)		
High	6 week	1.43[z]b
	6 month	2.38 a
	Unpruned control	2.48 a
Low	6 week	0.98 b
	6 month	1.13 b
	Unpruned control	2.12 a
Texas sage (Main effects)		
High		1.01 a
Low		0.68 b
	6 week	0.58 b
	6 month	0.65 b
	Unpruned control	1.16 a

[z] Values are treatment means; n=42 for irrigation treatments, n=24 for pruned treatments, n=36 for unpruned controls. Within treatments, values followed by the same letter are not significantly different by Duncan's Multiple Range Test, α=0.05.

Table 2. Interactive effects of irrigation volume and pruning frequency on water use efficiency (WUE) of *Nerium oleander* 'Sister Agnes' (oleander) and *Leucophyllum frutescens* var. green cloud (Texas sage).

Irrigation volume	Pruning frequency	WUE (kg / 1000 L)
Oleander		
High	6-week	0.56[z]b
	6-month	1.24 a
	Unpruned control	0.95 a
Low volume	6-week	0.99 b
	6-month	1.14 b
	Unpruned control	2.25 a
Texas sage		
High volume	6-week	0.28 b
	6-month	0.42 a
	Unpruned control	0.48 a
Low volume	6-week	0.46 b
	6-month	0.46 b
	Unpruned control	1.03 a

[z] Values are treatment interaction means. Within each irrigation treatment level, n=12 for 6 week (frequent) and 6 month (infrequent) pruning treatments, and n =18 for unpruned controls. Mean values followed by the same letter within irrigation treatment are not significantly different by Duncan's Multiple Range Test, α=0.05.