Landscape Species Performance under Irrigation Levels based on Reference Evapotranspiration

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Abstract

Landscape irrigation scheduling using reference evapotranspiration (ET_0) information is being adopted by the industry with little research-based information relevant to landscape performance. The objective of this study was to determine the aesthetic response of 30 species to irrigation treatments based on ET_0. Experimental plots were established in Encinitas, California, consisting of nine, 1920 ft^2 blocks allowing three drip irrigation treatments replicated three times. Treatments initially were 0.36, 0.24, and 0.12 ET_0, but were adjusted to 0.36, 0.18, and 0.0 ET_0 during the second and third years of the study. The aesthetic quality of 16 species was reduced with reduced irrigation. Many of these species performed well at the 0.36 and 0.18 ET_0 treatments but suffered at 0.0 ET_0. Quality was not affected by irrigation treatment in 11 species. The results show that ET_0 treatments affect landscape quality for some species and acceptable appearance can be maintained with reduced irrigation.

INTRODUCTION

The use of reference evapotranspiration (ET_0) information for scheduling irrigations and for determining water allotments for landscapes is being adopted by water purveyors, agencies, landscape architects, and maintenance personnel. Although ET_0 information is available in California from a statewide network utilizing local weather station data, the information must be adjusted using a crop coefficient (K_c) or correction factor for use in scheduling irrigations for different plant materials. Many scientific studies have established K_c values for agricultural crops based on ET_0 and yield response. K_c values have also been determined for cool and warm season turfgrasses (Gibeault, et al.1990). However, there is little research-based information relevant to landscape ornamental plant materials. One confounding factor is that landscape plant materials are valued for their appearance and the yield concept is not relevant. Landscapes are also difficult to characterize because they often consist of small plantings of numerous species. In addition, some species utilized for landscapes have the ability to maintain acceptable aesthetic quality under reduced irrigation (Pittenger, et al. 2001). The objectives of this project were to determine the response of 30 ornamental species to irrigation treatments based on ET_0 and to further refine estimates of ornamental plant water needs for acceptable aesthetic appearance.

MATERIALS AND METHODS

The study was conducted at Quail Botanical Gardens in Encinitas, California, which has a coastal Mediterranean climate. The soil is a Chesterton fine sandy loam [fine, kaolinitic, thermic Abruptic Durixeralf] with pH 6.8 and ECe 1.7 dS m^{-1}. The soil available water is approximately 1.2 $in.ft^{-1}$ soil.

The experiment was a randomized complete block design with three irrigation treatments and three replicates for a total of nine blocks. Each 1920 ft^2 block was separated by an 8 ft walkway and divided into 30 square, 64 ft^2 experimental units (plots). Thirty woody shrub species were selected for the experiment (Table 1). Each 64 ft^2 plot contained four individual plants of each species with the exception of *Chamaerops humilis* and *Correa alba*, which contained five and six test plants, respectively. The planting locations for each species within blocks were randomized to minimize bias resulting from factors such as shading, root competition, and block edge effects. The plants were transplanted from one gallon containers between December 1994 and February 1995.

Each block was irrigated using Roberts Irrigation Ro-Drip tubing with three equally spaced drip lines running across each plot. The tubing contained 3.0 gal/hr emitters spaced at 1.0 ft, which resulted in a precipitation rate of 0.17 in/hr. The drip lines were connected to buried PVC pipe with a valve, pressure regulator, and meter for each irrigated block. Distribution uniformity of the irrigation system was approximately 0.90. For establishment, plants received irrigation based on tensiometer readings and assessment with a soil probe to achieve maximum vigor and growth rate.

Irrigation treatments of 0.36, 0.24, and 0.12 ET_0 were initiated in June 1996. During 1997 and 1998, irrigation treatments were adjusted to 0.36, 0.18, and 0.0 ET_0 because initial treatments were not significantly affecting plant quality in many of the species. ET_0 data from the California Irrigation Management Information System (CIMIS) weather station in Oceanside were used for irrigation scheduling. A 0.5 inch irrigation was applied when the accumulated ET_0 of a given treatment (projected soil moisture deficit) reached 0.5 inch. Irrigation scheduling by this method resulted in different intervals between applications and different amounts of water applied over a season among the treatments, but similar penetration of water (12-18 in.) into the root zone at each irrigation event. No additional water was applied to compensate for non-uniformity of the irrigation system. Irrigation treatments were applied during the summer and fall months, while rainfall and irrigation supplied equal amounts of water among treatments during the winter and spring (Table 2).

Cultural practices included fertilization, weed control, and minimal pruning. The study plots received approximately 2.0 lb. per 1000 ft^2 N per year. Hand weeding and preemergent (oxadiazon) and systemic (glyphosate) herbicides were used to control weed problems on the site. Coarse wood chip mulch was spread three inches deep along pathways between blocks and in open areas within blocks to control weeds, protect irrigation lines, and reduce evaporation.

Data collection consisted of measurements of plant height, ratings of aesthetic quality, water applied, and observational notes. The visual rating of aesthetic quality was recorded 12 times during the study using a 1 to 9 scale where 1 = dead or dying plants, 5 = aesthetically unacceptable in a landscape, and 9 = optimum appearance (Pittenger, et al. 2001). Ratings were based on the density, vigor, color, and uniformity for each species. Analyses of variance of the height and quality data for each observation date were performed and mean separation was calculated using Fisher's (protected) LSD tests at the $P = 0.05$ significance level.

RESULTS AND DISCUSSION

Applied water, rainfall, and ET_0 data for the three-year study are summarized in Table 2. All plant materials (hereafter referred to by genus name) performed well in the study with the exceptions of *Chamaerops*, *Ceanothus*, and *Salvia*. These species failed to establish adequately for treatment replication. Two species, *Echium* and *Myoporum* performed so well that they overgrew the plot area and were removed or severely pruned during the second year of the study. Analysis of variance (AOV) of data from the entire experiment indicated that there were significant differences between irrigation treatments and interaction between species response and irrigation treatment. Height data indicated that there were significant differences in growth of several species due to irrigation treatment. This could have significant implications for maintaining these species adequately with minimal green waste production. However, we feel that the type of measurements taken were not precise enough to characterize the treatment effects.

Figure 1 contains charts illustrating aesthetic performance of representative species. Data is not shown for species that responded similarly. AOV of aesthetic quality data indicated that there were significant differences due to irrigation treatments in 16 of the species studied. Performance of these species was typically reduced at the lower irrigation treatment (0.18 or 0.0 ET_0) in the late summer and fall months and not significantly different for the remainder of the year. These species can be divided into several groups based on their response to the 0.0 ET_0 treatment. In *Arbutus* (Figure 1-A), *Arctostaphylos*, and *Calliandra*, more water resulted in higher aesthetic rating. Performance at the 0.0 treatment was usually less than at the 0.36 treatment and at the lower limit of what we would consider acceptable in the landscape. Plants of these species in the 0.0 ET_0 treatment recovered during the winter months. In *Otatea*, *Pittosporum*, and *Xylosma* (Figure 1-B), the response was similar but aesthetic quality of plants in the 0.0 ET_0 treatment dropped below the acceptable level during the summer and fall. Nevertheless, these species recovered each year. In *Correa*, *Escallonia*, *Lantana*, *Leptospermum*, *Phormium* (Figure 1-C), *Rhaphiolepis*, *Teucrium*, and *Westringia*, plants in the 0.0 ET_0 treatment either died or were severely injured and failed to recover.

In eight species (*Artemisia, Cistus*, *Echium*, *Grevillea*, *Heteromeles*, *Myoporum*, *Prunus,* and *Pyracantha*), there were no significant differences in appearance among treatments and their quality was consistently rated at 6.0 or greater (acceptable for landscapes). Response of *Cistus* (Figure 1-D) was representative of these eight species. *Prunus* performance remained greater than 6.0 for most of the study but varied year to year probably due to general climatic or species adaptation factors rather than irrigation amount. Similarly, *Artemisia* needed some renovation after three growing seasons to maintain acceptable appearance.

Aesthetic appearance of *Cassia* (Figure 1-E), *Galvezia*, and *Leucophyllum*, was not significantly different between treatments but their ratings were less than 6.0 from late summer through winter, which meant they were unacceptable as landscape ornamentals for part of each year regardless of irrigation treatment. Although not significant, there was a trend for *Galvezia* to perform better with less water.

Hibiscus (Figure 1-F) and *Ligustrum* expressed reduction in quality over the three-year period in all treatments and severe injury at the 0.0 ET_0 treatment indicating that these plant materials were probably under-irrigated even at the highest treatment level.

In conclusion, several species of shrubs, many of them common landscape plants, appear capable of providing acceptable landscape performance with very low amounts of summer irrigation in coastal Mediterranean areas such as coastal urban southern California. Eight shrub species performed well with no irrigation during the treatment periods (*Artemisia*, *Cistus*, *Echium*, *Grevillea*, *Heteromeles*, *Myoporum*, *Prunus* and *Pyracantha*), while 13 species were able to do so with 0.18 ET_0 (*Arbutus*, *Arctostaphylos*, *Calliandra*, *Correa*, *Escallonia*, *Lantana*, *Leptospermum*, *Otatea*, *Phormium*, *Pittosporum*, *Rhaphiolepis*, *Westringia*, and *Xylosma*). Data for these 21 species suggest that in the landscape, acceptable appearance is possible for a wide range of applied water levels. While *Teucrium* performed well only at the 0.36 ET_0 treatment, *Hibiscus* and *Ligustrum* were probably under-irrigated at this level. Future studies need to be performed to verify these findings in climates with higher ET_0 values and to further document growth reduction without loss of aesthetic quality at reduced irrigation levels. These findings provide useful information for incorporation into irrigation scheduling procedures and for landscape water conservation programs.

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Table 1. Genus, species, citation, and common names of plant materials studied.

Genus, Species, and Citation	Common Name
Arbutus unedo 'Compacta', L.	Compact strawberry tree
x*Arctostaphylos* 'Pacific Mist', (L.) Spreng.	Bearberry
Artemisia x 'Powis Castle', L.	Wormwood
Calliandra haematocephala, Hassk.	Pink powder puff
Cassia artemisioides, Gaud.	Feathery cassia
Ceanothus griseus horizontalis 'Yankee Point', McMinn.	Carmel creeper
Chamaerops humilis, L.	Mediterranean fan palm
Cistus purpureus, Lam.	Orchid spot rock rose
Correa alba 'Ivory Bells', Andr.	White Australian correa
Echium fastuosum, Jacq.	Pride of Madeira
Escallonia x *exoniensis* 'Fradesii', Veitch.	Frades escallonia
Galvezia speciosa, Gray.	Bush snapdragon
x*Grevillea* 'Noell', Knight.	Noell grevillea
Heteromeles arbutifolia, M.J.Roemer.	Toyon
Hibiscus rosa-sinensis, L.	Rose of China
Lantana montevidensis, Briq.	Trailing lantana
Leptospermum scoparium, J.R.Forst.& G.Forst.	New Zealand tea tree
Leucophyllum frutescens 'Green Cloud', I.M.Johnst.	Texas ranger
Ligustrum japonicum 'Texanum', Thunb.	Texas privet
Myoporum x 'Pacificum', Banks & Sol. ex Forst.f.	Myoporum groundcover
Otatea acuminata, (Munro)C.E.Calderon & Soderstr.	Mexican bamboo
Phormium tenax, J.R.Forst.& G.Forst.	New Zealand flax
Pittosporum tobira, Ait.	Mock orange
Prunus caroliniana, Ait.	Carolina cherry laurel
Pyracantha koidzumii 'Santa Cruz', Rehd.	Santa Cruz pyracantha
Rhaphiolepis indica, Lindl.	Indian hawthorn
Salvia leucantha, Cav.	Mexican bush sage
Teucrium chamaedrys, L.	Germander
Westringia rosmariniformis, Sm.	Rosemary bush westringia
Xylosma congesta, Merrill.	Shiny xylosma

Table 2. ET_0, precipitation and applied irrigation water (inches) for treatment periods from June 1996 through October 1998.

Dates (inclusive)	ET_0 (in.)	Precipitation (in.)	Water Applied (in.) 0.36 ET_0	0.18 ET_0	0.0 ET_0
Jun 1996 to Oct 1996	27.5	-	10.4	6.9	3.0
Nov 1996 to May 1997	25.2	12.3	4.9	4.7	4.8
June 1997 to Oct 1997	27.2	-	8.9	4.8	0
Nov 1997 to Mar 1998	12.1	21.5	0	0	0
Apr 1998 to Oct 1998	36.6	-	13.4	7.3	0

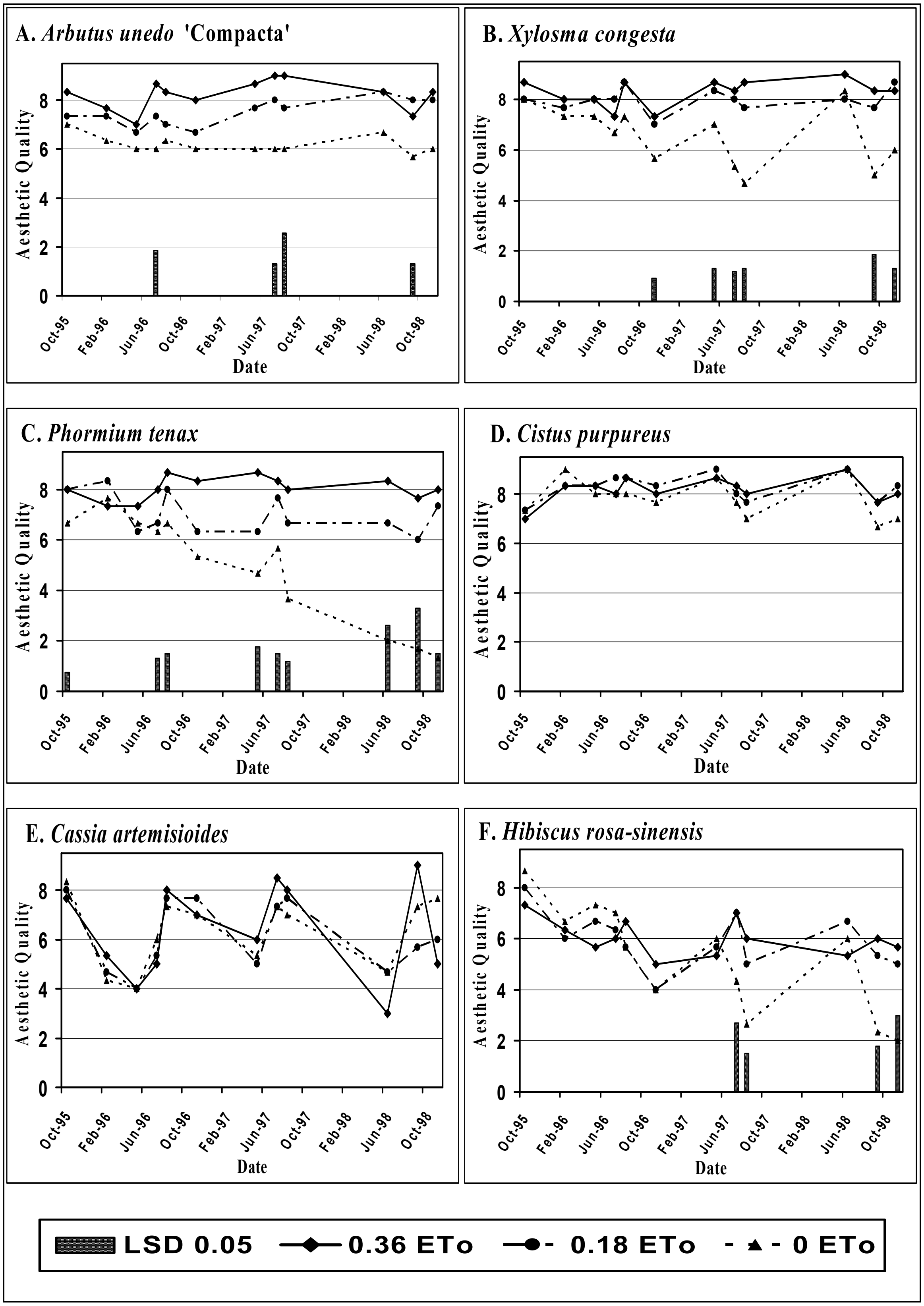

Figure 1.A-F. Aesthetic quality and LSD values (on dates when significant) for landscape species given 0.36, 0.18, and 0.0 ET_0 treatments from October 1995 to October 1998.