Determining Plant Water Use and Crop Coefficients of Selected Nursery and Landscape Plants

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Objectives

Landscape irrigation increases dramatically during summer months throughout Texas and the South West of the U.S. Thus, conserving and reducing the amount of water used for landscape irrigation is critically important. The ultimate goal of this project was to increase landscape irrigation efficiency by minimizing over-watering. The specific objective was to determine and compare the actual water use and crop coefficients of selected ornamental shrubs grown in containers (nursery practices) and drainage lysimeters, similar to landscape conditions and to find out if the water use between the two culture systems is convertible.

Methods

The following species were purchased in 1-gallon containers from a local nursery: abelia (*Abelia grandiflora* 'Edward Goucher'), butterfly bush (*Buddleia davidii* 'Burgundy'), holly (*Ilex vomitoria* 'Pride of Houston'), evergreen euonymus (*Euonymus japonica*), and oleander (*Nerium oleander* 'Hardy Pink'). Ten plants in each species were transplanted to 3-gallon containers and were placed in the field in early July and closely spaced to simulate nursery practice. Seven plants from each species were transplanted to the 15-gallon drainage lysimeters in middle June to simulate landscape conditions. After several weeks of acclimatization, water use measurement was initiated in early July.

Water use of container-grown plants was determined by irrigating to container capacity, allowing each to drain completely and then weighing them. The plants were then reweighed after 24 hours. The difference between the beginning and ending weights is the water used over the 24 hours, in cubic centimeters or milliliter (ml).

ET_{crop} (cm) = Volume of water use (cm^3)/container surface area (cm^2)

Crop coefficient was calculated as the following: $K_c = ET_{crop}/PET$

PET was calculated using the weather data recorded in the same field plot.

Water use (ET) of the plants in the lysimeters was estimated by monitoring the soil moisture depletion using the ECH_2O soil moisture probes, a multiplexer, and a datalogger. The 3-gal containers and the 15-gal lysimeters, which were buried in the ground, had the same diameter (25 cm) at the very top of the container. Therefore, same container surface area (490 cm^2) was used for estimating crop coefficients (Kc). Although rainfall was recorded, it was difficult to quantify the amount of rain getting into the lysimeters because of the various shapes of canopies that intercepted rain. Therefore, soil moisture content data were excluded on days when irrigation or rainfall occurred.

Plants in 3-gallon containers (the inner-side plants were being studied)(left).

Plants in 15-gallon drainage lysimeters (right).

Results

The growth index determined in October for butterfly bush and oleander plants were much higher (Table 1) in the lysimeters, where growing conditions were similar to those in a landscape, than that for container-grown plants. Leaf area of butterfly bush and oleander increased approximately 300 percent in two months. Since plants in the lysimeters were planted in June, the plants in lysimeters in August were larger than those of the same species in the containers. Abelia and euonymus grew better in the containers, possibly due to the differences in growing media or the micro-environment in the two culture systems. Holly grew similarly in the two systems

Due to the differences in plant size and leaf area, water use of plants was expressed in daily water use per plant and per unit leaf area (Table 2). The average leaf area determined in August and October was used. In both culture systems, water use per plant was highest in butterfly bush and oleander, which had the highest growth index, while abelia and euonymus had the lowest water use. However, holly had the highest water use per unit leaf area, euonymus and oleander had the lowest, while abelia and butterfly bush had slightly lower water use per unit leaf area than that of holly. For the same species, water use per unit leaf area was similar in both culture systems. This indicates that plant water use in a landscape situation can be accurately estimated through the same plant species that are grown in containers, which can be achieved readily by weighing the containers.

The crop coefficient (Kc) of abelia and euonymus was slightly higher in the containers because of larger leaf area. Kc of butterfly bush in the lysimeters was 3.3 times that of container-grown plants because leaf area in the lysimeter was 3.1 times that of container-grown plants. Similarly, Kc of oleander in the lysimeters was much higher than that of container-grown plants. Therefore, Kc of an individual plant is highly dependent on not only plant species, but also on the leaf area of the plant or growth rate.

In summary, water use and crop coefficient differed by species, growth, and months or days for both culture systems. Water use per unit leaf area of the same species was similar in two culture systems. Crop coefficient of the same species was also similar for the two culture systems when growth index was similar. Therefore, water use of landscape plants can be accurately estimated from container-grown plants, provided that growth index and leaf area can be quantified. The information obtained from study can be used to improve landscape irrigation by grouping plants with similar water use and by scheduling irrigation according to plant needs. When applying this information to landscape situation, planting densities as well as growth rate need to be considered.

Table 1. Growth index [((canopy width 1 + canopy width 2)/2 + height)/2] and leaf area of abelia (*Abelia grandiflora* 'Edward Goucher'), butterfly Bush (*Buddleia davidii* 'Burgundy'), holly (*Ilex vomitoria* 'Pride of Houston'), evergreen euonymus (*Euonymus japonica*), and oleander (*Nerium oleander* 'Hardy Pink') grown in containers and drainage lysimeters.

Species	Abelia	Euonymus	Butterfly bush	Holly	Oleander
Growth index (cm)					
Lysimeter	42.5	38.1	98.6	59.1	88.5
Container	37.1	38.8	54.9	51.7	62.6
t-test	NS z	NS	***	NS	***
Leaf area (cm²)					
August					
Lysimeter	297	1327	773	568	2050
Container	249	1271	233	454	1712
t-test	NS	NS	***	*	NS
October					
Lysimeter	454	1586	3059	706	7655
Container	570	2519	977	460	2205
t-test	NS	**	***	*	***
Leaf area increase (%) from August to October					
Lysimeter	53	20	296	24	274
Container	129	98	319	1	29

z NS, *, **, *** nonsignificant, significant at $P = 0.05, 0.01, 0.001$, respectively.

Table 2. Average water use and crop coefficients of abelia (*Abelia grandiflora* 'Edward Goucher'), butterfly Bush (*Buddleia davidii* 'Burgundy'), holly (*Ilex vomitoria* 'Pride of Houston'), evergreen euonymus (*Euonymus japonica*), and oleander (*Nerium oleander* 'Hardy Pink') grown in containers and drainage lysimeters over four months.

Species	Abelia	Euonymus	Butterfly bush	Holly	Oleander
Water use per plant (L/d)					
Lysimeter	0.23	0.30	1.13	0.46	1.16
Container	0.31	0.39	0.39	0.40	0.54
t- test	NS	NS	***	NS	***
Water use per unit leaf area(mL/cm²/d)					
Lysimeter	0.60	0.21	0.59	0.72	0.24
Container	0.76	0.20	0.64	0.87	0.28
t-test	NS	NS	NS	NS	NS
Crop coefficient					
Lysimeter	0.84	1.20	4.37	1.78	4.30
Container	0.93	1.29	1.29	1.30	1.74
t-test	NS	NS	***	NS	***

z NS, *, **, *** nonsignificant, significant at $P = 0.05, 0.01, 0.001$, respectively.