Research Note

PLANT WATER LOSS IN A SHADED ENVIRONMENT: A PILOT STUDY

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Microclimates have been found to directly influence water loss from landscape plants. Whitlow and Bassuk noted significant interactions between urban microclimates and water loss from street trees in New York City (6). Kjelgren and Clark found that growth and physiological responses of sweetgum trees were linked to microclimate at 3 diverse locations in Seattle, Washington (3). They reported a 50% increase in pan evaporation in a paved site relative to a park or an "urban canyon" site. Zajicek and Heilman reported an increase in water use (approximately 20–30%) from crape myrtle plants in mulched plots compared to bare-soil or turf plots (7). This finding was attributed to the higher surface temperatures of the mulch relative to that of the other surfaces. Similarly, water use has been found to be highest for shrubs adjacent to east- and west-facing walls due to radiation emitted from building walls (2).

Similar to plant water loss increases that have been found to occur in high evaporative microclimates, water loss reductions may occur in low evaporative microclimates, such as a shaded environment. The objectives of this pilot study were twofold: 1) to provide an indication of the magnitude of water loss difference between plants in a shaded environment and the same species in a sunny environment, and 2) to provide direction for future investigations. Our general purpose was to provide landscape managers with some basis for making water budget adjustments appropriate for plantings that occur in shaded environments.

Methods and materials. This study was conducted at the Hewlett-Packard Corp. office park in Palo Alto, California. Four test species (3 trees and 1 shrub) were selected: coast redwood (*Sequoia sempervirens*), southern magnolia (*Magnolia grandiflora*), sweetgum (*Liquidambar styraciflua*), and dwarf tobira (*Pittosporum tobira* 'Wheeler's Dwarf'). Individuals of each species were of uniform size and were growing in 5-gal containers. Plants remained in their containers throughout the experiment. Although plants were only visually inspected for size (leaf areas were not measured), differences in leaf area among individuals of a species were judged to be no greater than 10%.

Three plants (replicates) of each species were placed in each of 2 microclimate test sites: 1) the knoll—a large, mounded area planted with English ivy and exposed to full sun throughout the day, and 2) the courtyard—an open-air courtyard (approximately 75 ft x 75 ft) of an office building, with walls approximately 35 ft high that cast shade on the test location throughout the afternoon. Courtyard test plants were further shaded by being placed under the canopy of a Brazilian pepper tree in the northeast corner of the courtyard. The knoll was selected as a reference location to identify water loss differences between plants in shade (courtyard) and those in full sun. All plants were spatially separated at each location so that one did not shade or protect another.

Plant water loss, microclimate, and pan evaporation measurements were made over a 2-week period in August 1992. Plant water loss was determined gravimetrically by weighing plants shortly after irrigation and again after 48 hours. The weight difference was considered to be transpirational water loss for the 2-day period. At each irrigation,

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rootballs were fully saturated. Weight measurements were made after drainage had ceased (approximately 1 hour) using an Ohaus I-10 high-capacity digital scale (1.0 g readability). Measurements were made between 6:00 and 8:00 A.M. on level weighing platforms. Prior tests indicated that all plants contained some available water after 2 days at each location. All plants were irrigated after each measurement period, allowed to drain, and weighed again to begin the next treatment period. Water loss via soil evaporation was minimized using white cardboard boxes fastened securely over the top of each container. Boxes also shaded the sides of the containers.

Wind speed, temperature, light intensity, and relative humidity were measured at each site. All measurements were made at 2:00 P.M. on 9 days through the treatment period. An LED vane anemometer was used to measure windspeed (mph), while a combination hygrometer and digital thermometer (Cole Parmer) was used to measure relative humidity and temperature. Light intensity was monitored with a digital light meter (Lutron LX 101 Lux Meter). The hygrometer-thermometer unit was suspended inside a white cardboard box with one side removed and ventilation holes cut in the remaining sides. An equilibration period was allowed at each site before readings were taken.

Pan evaporation was measured at each site using #2 galavanized washtubs. Pans were filled with water to a predetermined level and evaporation measured periodically using a common ruler. Preliminary measurements had determined that washtub evaporation was 94% of that from a Class A pan. Washtubs were covered with plastic netting to exclude birds and other wildlife. Washtubs have been shown to be useful for scheduling irrigation in agricultural crops (4,5).

Results and discussion. Lower temperature, windspeed, and light intensity readings, but higher humidity levels were found in the courtyard (Table 1). Temperatures were an average of 5° F higher at the knoll, and wind speed was 4 mph higher. Average light intensity was approximately 100 times greater at the knoll.

Water loss in the courtyard was significantly less than that at the knoll for all species (Tukey-Kramer HSD 0.05), ranging from 47% less for sweetgum to 73% less for dwarf tobira (Figure 1). Magnolia and redwood showed reductions of 56% and 60%, respectively. A mean reduction of 58% was found for all species combined. Water loss variation among species most likely resulted from differences in canopy size, canopy configuration, and inherent transpirational rate. Relative difference in water loss from washtubs was closer in magnitude to dwarf tobira than that for tree species, with a 74% reduction found in the courtyard compared to the knoll.

Table 1. Microclimate readings (means and ranges) at each location over the 14-day study period.

	Courtyard		Knoll	
	Range	Mean	Range	Mean
Temperature (F)	72–85	77	75–88	82
Relative humidity (1%)	38–62	45	35–50	42
Wind speed (mph)	0–4	2	2–9	6
Light intensity (lux x 100)	7.0–11.5	8.2	250–1050	860

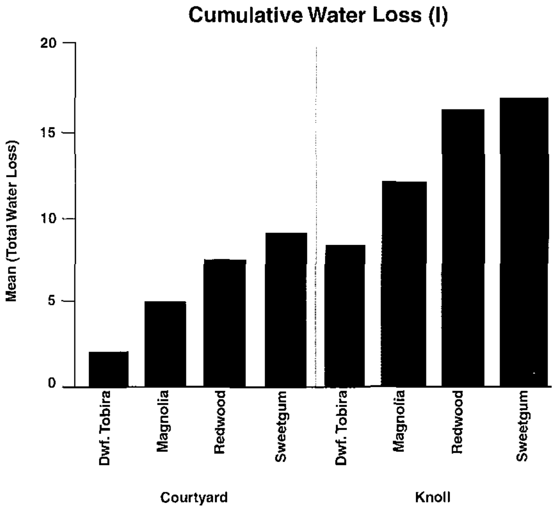

Figure 1. Cumulative water loss (l) for 4 landscape species at 2 sites over a 14-day period. Water loss was significantly less in the courtyard for all 4 species when compared with the knoll.

It should be noted that these findings are for container plants under well-watered conditions, i.e., where water is continually available. When water deficits occur, plant response varies and differential effects on water loss may be found (1). Plants that are not irrigated frequently, therefore, may not respond to microclimate effects to an extent equivalent to those that are irrigated frequently. In addition, water loss characteristics of plants in the ground may differ from those in containers and some adjustments may be needed to precisely apply results to established plantings.

Nonetheless, results from this study provide some evidence that water loss from species in a shaded, wind-protected environment can be substantially less than that for the same species in a fully exposed environment. Here, an average water loss reduction of 58% was found. This suggests that relative to full-sun conditions, an irrigation budget reduction of equivalent magnitude may be appropriate for microclimates with similar shading characteristics. Of course, there are many levels of shading in landscapes, and water budget adjustments will need to consider both the level and duration of the shading effect for the particular site.

As a pilot study, this work also was conducted to provide direction for further work. Since these results only apply to the site studied, future investigations that include other sites of varying levels of shade would permit a broader application of results. In addition, an expansion of the experiment to include other species and an extension of the treatment time would be useful.

Literature Cited

1. Clark, J. and R. Kjelgren. 1991. *Water as a limiting factor in the development of urban trees.* J. Arboric. 16: 203–208.
2. Heilman, J., C. Brittin, and J. Zajicek.1989. *Water use of shrubs as affected by energy exchange with building walls.* Agr. For. Meteorol. 48: 345–357.
3. Kjelgren, R. and J. Clark. 1994. *Urban microclimates and growth of sweetgum street trees.* Arboricultural Journal 18: 401–417.
4. Smajstria, A., F. Zazueta, G. Clark, and D. Pitts. 1989. *Irrigation scheduling with evaporation pans.* Fla. Coop. Ext. Ser. Bul. 254.
5. Westensen, G. and T. Hanson. 1981. *Irrigation scheduling using wash tub evaporation pans.* Proc. Amer. Soc. Agr. Eng. Irrigation Scheduling Conf. Publ. 23-81. pp.144–149.
6. \Whitlow, T. and N. Bassuk. 1988. *Ecophysiology of urban trees and their management - The North American experience.* HortScience 23: 542–546.
7. Zajicek J. and J. Heilman. 1991. *Transpiration by crape myrtle cultivars surrounded by mulch, soil, and turfgrass surfaces.* HortScience 26: 1207–1210.

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Zusammenfassung. Es wurde eine Studie geleitet, um die Auswirkungen von Baumschutzhülsen auf das Wachstum und das Überleben von drei Eichenarten und einer Douglasie in mediterranem Klima zu bewerten. Die Bäume wurden in bewässerte und unbewässerte Pflanzlöcher gesetzt, sie wurden umgeben von Baumschutzhülsen oder Fegeschutzbändern und ihr Höhen- und Dickenzuwachs jährlich gemessen. In den nicht bewässerten Pflanzugen verbesserten die Baumschutzmaßnahmen das Überleben der Eichen aber sie produzierten keinen nennenswerten Zuwachs an Höhe oder Umfang gegenüber ungeschützten Pflanzungen. In bewässerten Pflanzungen war das Wachtum und die Überlebensrate deutlich größer als bei unbewässerten Pflanzungen. Die bewässerten Bäume mit Baumschutz zeigten deutlich größere Überlebensraten als ungeschützte Bäume.