Water Requirements of Five Container-Grown *Acer* Species[1]

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Abstract

Relative water demand, RWD, of 2-year-old containerized seedlings of red maple (*Acer rubrum* L.), sugar maple (*A. saccharum* Marsh.), silver maple (*A. saccharinum* L.), Norway Maple (*A. platanoides* L.) and boxelder (*A. negundo* L.) was determined by comparing potential evapotranspiration rates and actual water consumption values with growth rates for each species. Based on differences in growth rate, each species was determined to be either fast growing (red maple, silver maple, boxelder) or slow growing (sugar maple, Norway maple). Fast growing species used the most water over the 3-month experimental period (June-August), and had the higher RWD. The actual irrigation demand for each species was closely correlated with monthly potential evapotranspiration rates as determined by the Thornthwaite equation.

Index words: evapotranspiration, water consumption, water demand, water management, maple

Introduction

Consumptive water use is one of the most critical aspects of plant cultivation, particularly for container-grown nursery stock (4). For this reason, nursery managers need to be familiar with the water requirements of their plant material, especially during periods of peak water demand, in order to maximize effective use of existing moisture supplies. Prudent use of water resources takes on added significance in light of recent water shortages and of governmental restrictions on agricultural water use in many areas of the United States (1, 11). Water conservation is now recognized as one of the primary considerations in establishing a management strategy for nursery crop production. Consequently, numerous studies have been conducted to determine the relative water requirements of various container-grown plant materials (3, 5, 8, 10).

The purpose of the present investigation was to determine the water requirements of five container-grown *Acer* spp. commonly found in the urban environment. In addition, we wanted to determine potential evapotranspiration rates for each species and to compare these values with the average irrigation demand under two sets of growing conditions. From these observations, it could then be determined if evapotranspiration measurements might be useful for estimating consumptive water use for these particular *Acer* spp.

Materials and Methods

Seventy 2-year-old seedlings of red maple (*Acer rubrum* L.), sugar maple (*A. saccharum* Marsh.), silver maple (*A. saccharinum* L.), Norway maple (*A. platanoides* L.), and boxelder (*A. negundo* L.) were potted in a commercial potting medium (Terra-Lite 500) in 15 cm (6 in) diameter plastic containers during April, 1986. Thirty-five seedlings (7 of each species) were placed out-of-doors on raised benches in a lathhouse with 25% shading [21.4 ± 10.6°C (70.5 ± 19.5°F); 55 ± 26% RH]. The remaining 35 seedlings were placed on benches in a greenhouse under natural photoperiods [28.9 ± 7.7°C (84.0 ± 14.0°F); 56 ± 23% RH]. All seedlings in both locations were hand-watered twice each week with 550 ml (approx. 0.5 qt) of water, a quantity sufficient to thoroughly wet the potting medium in each container. Retained water was determined at each watering by subtracting the volume of leachate collected after 2 hrs in plastic saucers placed under each container. Retained water measured over a one month period was considered equivalent to the average irrigation demand (AID) for any particular species.

To determine changes in plant growth over the duration of the experimental period, the height and width (canopy diameter) of each seedling were measured at the beginning of the study and at 2-week intervals thereafter for 3 months (June through August). These values were summed to obtain a size index (SI) for each species. To insure that nutrients were provided in adequate amounts, all seedlings were watered monthly with 550 ml of commercial fertilizer solution containing 200 ppm each of nitrogen, phosphoric acid, and soluble potash as 20N-8.6P-16.6K (20-20-20).

Since evapotranspiration measurements represent a possible means by which water consumption can be readily estimated, the Thornthwaite method (2) was used to compute potential evapotranspiration (ET_p) for each species. The Thornthwaite equation utilizes air temperature as an index of energy available for evapotranspiration, and assumes that this temperature is correlated with the effects of net radiation on evapotranspiration. By comparing monthly ET_p and AID values, it was possible to determine if ET_p calculations might be useful in estimating water consumption rates in these particular species. Also, by dividing total AID by total ET_p, the relative water demand, RWD (4), for each species could be determined.

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Table 1. Average irrigation demands of five *Acer* species grown in containers for 3 months either out-of-doors (lathhouse) or in a greenhouse.

Species	Average irrigation demand, (AID)[z] (*l*/container) June	July	August	Chi-square comparison[y]
		Lathhouse		
A. rubrum	1.45	2.13	2.60	0.35
A. saccharum	1.11	1.41	1.54	0.12
A. saccharinum	1.70	2.49	2.90	0.33
A. platanoides	1.59	1.18	1.29	0.23
A. negundo	1.78	2.55	3.20	0.44
		Greenhouse		
A. rubrum	4.05	3.91	2.07	0.95
A. saccharum	1.20	1.87	1.94	0.33
A. saccharinum	4.02	4.05	2.45	0.99
A. platanoides	1.88	1.95	1.73	0.08
A. negundo	2.70	4.35	4.30	0.62

[z]Each value represents the mean of 7 seedlings. AID determined by subtracting the volume of leachate from the volume of water applied per container for each month. All seedlings watered twice weekly with 550 ml. Values for seedlings in lathhouse not adjusted for input due to natural precipitation.

[y]Chi-square comparison of AID distribution with total evapotranspiration rate, ET_p, (Table 3), df = 2. All values non-significant.

Results and Discussion

Water consumption values for the *Acer* spp. in this study are found in Table 1. For sugar maple, water consumption was consistently lower for each month of the experimental period in both the lathhouse and the greenhouse. Norway maple, although initially showing AID values comparable to the other species in the lathhouse (June), exhibited substantially lower rates as the season progressed (July and August). In the greenhouse, the water requirements of Norway maple were consistently lower than the average for all other species combined. Therefore, in comparing the total AID for each species over the period of June-August, both sugar and Norway maple seedlings are considerably less than the other 3 species. The reason for these differences in water use is reflected in the growth rate data (Table 2) which indicate substantially less growth in sugar maple and Norway maple seedlings, particularly under greenhouse conditions.

The relationship between water consumption, expressed as AID, and plant growth, expressed by SI (the height and average canopy width summed for each seedling), suggest that the *Acer* spp. used in this study should be categorized as either slow growing (sugar, Norway) or fast growing (red, silver, boxelder). These observations are in general agreement with those previously reported for various *Acer* spp. (6, 7, 9). As expected, the RWD of slow growing species was significantly less than the RWD of faster growing species (Table 2). Although there was a relatively close relationship between slow growth and low RWD, the relationship between rapid growth and high RWD was less exact. For example, red maple seedlings in the greenhouse grew the fastest but had a RWD significantly less than boxelder, which exhibited a growth rate only 66% as great as red maple (Table 2). The relationship between growth rate and RWD was better expressed in greenhouse-grown seedlings, but even here the correlation was not absolute.

Although the purpose of this study was not to compare RWD values in the greenhouse with those in the field (lathhouse), it is interesting to note that these values were consistently lower at the former site (Table 2). Since environmental conditions in the greenhouse favored more rapid rates of transpiration (i.e. higher ambient temperatures, no natural precipitation, lack of artificial shading), one would suspect that RWD might be greater under these circumstances. However, the opposite was true. These observations may be explained on the basis that the lathhouse seedlings, although exhibiting a slower growth rate, were actually much more compact with shorter internodes and a considerably greater number of leaves per plant. In fact, plants in the lathhouse appeared generally more vigorous with healthier, more dense foliage. These factors, coupled with greater air movement in the lathhouse (and its subsequent effect on transpiration), are probably responsible for the greater RWD values noted for plants grown out-of-doors.

Using the method described by Thornthwaite (2), monthly evapotranspiration rates were calculated for seedlings at each site (Table 3), and subsequently compared with monthly AID values for each species (Table 1). These comparisons were made using the chi-square test reported by Fitzpatrick (4). The absence of any significant difference between AID and ET_p in this study suggests a practical application of using evapotranspiration to estimate water consumption values for container-grown *Acer* spp.

Use of water consumption data, particularly RWD, in the nursery needs to be considered in conjunction with other management decisions such as the economic value of the plant material at the end of the production cycle, the length of the production cycle itself, and any regulatory water-use constraints which might significantly influence the production cycle. Container-grown nursery crops with lower RWD values might represent a more conservative investment where chronic water shortages

Table 2. **Average size index and relative water demand of five *Acer* species grown in containers for 3 months either out-of-doors (lathhouse) or in a greenhouse.**

Species	Size index, SI (cm)[z] Initial	Final	Growth rate (SI/mo)	Relative water demand, (RWD)[y]
	Lathhouse			
A. rubrum	37.7	97.3	19.9	244 b[x]
A. saccharum	39.2	41.7	0.8	160 c
A. saccharinum	38.2	84.8	15.5	280 a
A. platanoides	26.2	60.5	11.4	160 c
A. negundo	30.8	71.6	13.2	298 a
	Greenhouse			
A. rubrum	39.9	126.8	29.0	144 b
A. saccharum	33.0	36.7	1.2	72 c
A. saccharinum	33.7	113.8	26.7	151 b
A. platanoides	29.1	42.8	4.6	80 c
A. negundo	30.8	131.5	33.6	163 a

[z]SI determined by summing height and average diameter (2 measurements) for each of 7 seedlings.

[y]RWD determined by dividing total ET_p (Table 3) into total AID (in ml) from Table 1.

[x]Mean values in a column followed by the same letter are not significantly different at the 5% level using Duncan's New Multiple Range Test.

are a problem. On the other hand, in situations where chronic water shortages are unlikely, but acute water supply problems may occasionally arise, faster growing species with higher RWD values may represent the most profitable investment.

Significance to the Nursery Industry

Information presented in this study will be useful to the nursery industry by providing guidelines for helping nurserymen select container-grown plant material for specific moisture conditions. If water tends to be limited because of seasonal droughts, growers may want to utilize one of the faster growing maple species (*A. rubrum, A. saccharinum*), where the plants are likely to obtain optimum size before drought becomes a problem. If, however, irrigation water is regulated or restricted on a routine basis, it may be more desirable to select slower growing species (*A. saccharum, A. platanoides*) since these plants have a lower relative water demand and would tolerate less water over the production cycle. These data can also be used in the selection of maples for planting in above-ground containers in urban areas where water availability may be limited due to container size and/or an adequate supply of natural precipitation.

Table 3. **Potential evapotranspiration rates computed for two locations over a 3-month period.**

Location	Potential evapotranspiration, ET_p (cm)[z] June	July	August	Total
Out-of-doors (lathhouse)	7.5	10.3	7.5	25.3
Greenhouse	22.2	28.6	18.9	69.7

[z]ET_p values computed by the Thornthwaite method. See text for environmental parameters at each location.

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