Effects of Irrigation Rate and Media on Growth of *Acer rubrum* L. in Large Containers[1]

Chris A. Martin, Harry G. Ponder, and Charles H. Gilliam[2]
Department of Horticulture
Alabama Agricultural Experiment Station
Auburn University
Auburn University, AL 36849

Abstract

Acer rubrum L. seedlings were grown in 38 l (#10) containers with 4 irrigation rates of 50%, 100%, 200%, 400% replacement of net evaporation and 3 media types of 100% pine bark; pine bark:sand (4:1 by vol); pine bark:sand (3:2 by vol). A spray stake irrigation system was used to irrigate. Height growth was not affected by irrigation rate. Caliper growth increased cubicly and linearly with increased irrigation rate during the first and second years, respectively. Media affected height and caliper growth the second year only. Height and caliper growth increased linearly with increased sand content. An increase in irrigation rate produced a larger root system, while an increase in sand content increased primary and secondary root growth.

Index words: red maple, spray stake, net evaporation, shade trees, landscape trees

Introduction

Landscape shade tree production in large containers is becoming an increasingly important component of the nursery industry in the Southeastern United States. Selecting irrigation systems, schedules, and growth media are major parameters affecting plant growth. A more efficient alternative to the standard practice of overhead irrigation is the placement of a spray stake in each individual container (4). Previous work has demonstrated that net evaporation from a Class A pan can be used in scheduling irrigation of field grown nursery stock (2, 7, 8); however, the correlation between net evaporation and irrigation rate applied to container grown plants is not defined. Increasing sand content in a pine bark and sand medium (v/v) has decreased water percolation rate and cation exchange capacity (CEC) and increased pH and bulk density (1). The objectives of this study were to determine the effects of irrigation rate, based on net evaporation from a Class A pan, and media type on height, caliper, and root growth of red maple (*Acer rubrum*) in 38 l (#10) containers.

Materials and Methods

One-year-old, field-grown, bare-root seedlings of red maple were potted in 38 l (#10) containers in April 1985. Forty liners were planted into each of 3 growth media: 1) pine bark, 2) pine bark:sand (4:1 equal parts by vol), and 3) pine bark:sand (3:2 equal parts by vol). All media were amended with 1.2 kg/m^3 (2.0 lb/yd^3) superphosphate, 0.9 kg/m^3 (1.5 lb/yd^3) Micromax, 8.3 kg/m^3 (14 lb/yd^3) Osmocote 18N-2.6P-9.9K (18-6-12), and 0.6 kg/m^3 (1.0 lb/yd^3) Aqua-Gro (wetting agent). Containers were spaced 72 cm (28 in) on center. Irrigation rates of 50%, 100%, 200% and 400% replacement of net evaporation from a Class A pan were evaluated with each growth medium. The experimental design was a 4 $\times$ 3 factorial arrangement with 10 single-tree replications in a completely randomized block.

A spray stake irrigation system was installed with one Chapin Type N Spray Tube (manufactured by Chapin Watermatics Inc. of Watertown, NY 13601) per pot. A 90-cm (35.0 in) section of #3 heavy wall polyethylene tubing [0.46 cm (0.18 in) O.D.] was inserted into 1.88 cm polyethylene pipe [2.06 cm (0.80 in) I.D.]. Daily evaporation from a Class A pan and rainfall were recorded throughout the study (12). Trees were irrigated from May to October 1985, and March to September 1986, with each successive accumulation of 1.27 cm (0.50 in) daily net evaporation. Water replacement was based upon the surface area of each container occupying 1379 cm^2 (1.5 ft^2).

Tree height and caliper [5 cm (2 in) above the medium] were measured monthly during the growing seasons. At the end of the study, roots of 4 trees per treatment were washed and separated into 3 categories: 1) primary roots (greater than or equal to 10 mm ($\geq$0.5 in) in diameter); 2) secondary roots (less than 10 mm ($\leq$0.05 in) in diameter; and 3) fibrous roots (less than 2 mm ($\leq$0.1 in) in diameter). Root dry weights were determined.

Results and Discussion

After one growing season, height growth was similar regardless of irrigation rate or medium (Table 1). In June 1986 height growth increased with increasing water, however, by July, height growth was not affected by irrigation rate. In 1986 height growth increased linearly as the sand content increased. Trees grown in the 3:2 pine bark sand medium averaged height increases 33% greater than trees grown in the 4:1 pine bark sand medium, and 92% greater than those in 100% pine bark. Height growth during the second growing season was reduced by greater than 55% from the first growing season for all treatments. Greater than 67% of all height growth for 1986 occurred prior to June, with trees irrigated at 400% replacement of net evaporation increasing only 14% from June to September. Since container volume and media type determine the reservoir of fluids available for uptake by the plant (10), reduced height growth in 1986, compared to 1985, suggests that as tree size increased, container volume, media structure, and texture became limiting factors affecting the availability of

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[2]Former Graduate Teaching Assistant, Professor, and Associate Professor, resp.

Table 1. **Effect of irrigation and media on height and caliper of container grown red maple.**

Treatment	Mean cumulative increase			
	Height		Caliper	
	Oct. 16, 1985[z]	Sept. 16, 1986[y]	Oct. 16, 1985	Sept. 16, 1986
	(cm)	(cm)	(mm)	(mm)
Irrigation rate				
50% net evaporation	75.4	22.6	7.88	6.98
100% net evaporation	84.1	24.8	10.30	6.76
200% net evaporation	82.7	32.0	10.74	8.20
400% net evaporation	91.5	26.8	11.57	8.42
Media composition				
100% pine bark	82.3	18.2	10.35	5.59
80% pine bark: 20% sand (4:1 v/v)	88.8	26.3	10.20	7.47
60% pine bark: 40% sand (3:2 v/v)	79.1	34.9	9.82	9.68
Significance				
Irrigation rate—linear	NS[x]	NS	**	**
—cubic	NS	NS	**	NS
Media type-linear	NS	**	NS	**
Irrigation rate × media type—linear	NS	NS	NS	NS

[z]Mean cumulative increase in height or caliper (1985) = height or caliper at date of measurements minus height at potting.
[y]Mean cumulative increase in height or caliper (1986) = height or caliper at date of measurements minus last height measurement of 1985.
[x]Nonsignificant (NS) or significant 5% (*) or 1% (**).

Table 2. **Effect of irrigation and media on root dry weight of red maple, 1986.**

Treatment	Dry weight (g)			
	Primary roots (≥10 mm diameter)	Secondary roots (<10 mm)	Fibrous roots (<2 mm)	Total weight
Irrigation rate				
50% net evaporation	58.3	50.8	84.2	193.4
	(30.2%)[z]	(26.3%)	(43.5%)	(100.0%)
100% net evaporation	77.2	65.5	116.0	258.7
	(29.8%)	(25.4%)	(44.8%)	(100.0%)
200% net evaporation	101.6	85.3	134.1	321.2
	(31.6%)	(26.6%)	(41.8%)	(100.0%)
400% net evaporation	112.8	86.1	163.1	361.9
	(31.1%)	(23.8%)	(45.1%)	(100.0%)
Media composition				
100% pine bark	62.6	60.1	112.7	235.4
	(26.6%)	(25.5%)	(47.9%)	(100.0%)
80% pine bark: 20% sand (4:1 v/v)	87.1	73.2	133.7	294.0
	(29.6%)	(24.9%)	(45.5%)	(100.0%)
60% pine bark: 40% sand (3:2 v/v)	112.8	82.6	126.7	322.1
	(35.0%)	(25.7%)	(39.3%)	(100.0%)
Significance				
Irrigation rate—linear	**[y]	**	**	**
—quadratic	NS	**	NS	**
Media type—linear	**	*	NS	**
Irrigation rate × media type—linear	NS	NS	NS	NS

[z]Percentage of total weight.
[y]Nonsignificant (NS) or significant 5% (*) or 1% (**) level.

water and nutrients. This conclusion is supported by previous work (3) which evaluated the influence of container size on growth of *Pyrus calleryana* 'Bradford'.

During both growing seasons, caliper growth of red maple increased as irrigation rate increased (Table 1). These data differ from those of Ponder et al. (10) who reported that caliper of field-grown red maple was not affected by increased irrigation rates. In 1985 caliper increased cubicly with increased irrigation rate. By October caliper growth of trees irrigated at 100% replacement of net evaporation was 31% greater than 50% replacement of net evaporation and only 9% less than 400% replacement of net evaporation. In 1986 caliper growth increased linearly with increased irrigation rate. By September caliper growth of trees irrigated at 200% replacement of net evaporation was 21% greater than 100% replacement of net evaporation and only 3% less than 400% replacement of net evaporation. Media affected tree caliper in 1986 only. Increased sand in the media resulted in a linear increase in caliper growth. Unlike height growth, caliper growth occurred more uniformly during both growing seasons. Our data support the postulate of Kramer and Kozlowski (5, 6) that the controlling mechanisms regulating caliper and height growth function independently.

Root growth of red maple was influenced by irrigation rate (Table 2). Primary and fibrous root growth increased linearly and secondary root growth increased quadratically with increased irrigation rates. This differs from the findings of Ponder et al. (9) where field-grown red maple had suppressed fibrous root growth when irrigated at higher water flow rates. This difference may be attributed to the fact that container media are better drained than field soils.

Root growth was influenced by media type (Table 2). Root dry weight of primary and secondary roots increased linearly with increased sand in the media; however, media type had no effect on fibrous root dry weight. Regardless of treatment, about 43% of the total root dry weight was comprised of fibrous roots. This appears to be double the percentage of fibrous roots reported in earlier studies evaluating the effects of irrigation on root distribution of species grown in the field (8, 9, 10).

Significance to the Nursery Industry

Increased sand content in the medium increased height and caliper growth of red maple the second year. However, its effectiveness as a growth medium may be restricted due to increased weight affecting shipping and handling. These experiments show that irrigation scheduling of container grown nursery stock using a spray stake irrigation system can be linked to net evaporation from a Class A pan. Trunk caliper, a primary criterion in determining shade tree price, increased as irrigation rates increased. Increased irrigation rates also produced a larger root system which should enhance tree performance upon transplanting into the landscape. Careful selection of container media and proper management of the water application rate may result in larger trees of increased value for the nurseryman.

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