Irrigation Requirements of Container-grown Woody Plants

submitted by
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Abstract:

Up to eighty percent of the 1.3 billion woody plants produced by U.S. nurseries each year are grown in containers. However, limited research has been done to determine how much irrigation water is required by these plants. A university study was completed at The Ohio State University during the 2003 growing season and then corroborated nationally during the 2004 growing season to help establish BMP for irrigating container-grown woody plants.

Based upon this controlled testing, the adjusted irrigation rate required for "Heritage" riverbirch was found to be only 1.08 liters per cm of trunk caliper per unit ET per hour and 0.71 liters per cm of trunk caliper per unit ET per hour for pin oak. Thus, during peak Evapo-Transpiration conditions, a 1.5 inch caliper pin oak uses only 1.29 liters of water over the course of a day while commercial U.S. nurseries typically apply over 15 liters a day, or 10.6 times more than is required.

Background:

According to the July 2004 USDA survey of nursery production, approximately 1.3 billion single stem woody plants are being grown in the U.S. It was also been estimated by Brooker, Hinson, and Turner in 2000 that approximately 80% of these plants are grown in containers in the largest horticulture production states. Furthermore, the trend in the industry is toward growing in Pot N Pot containers larger than #10 rather than in the field. This leads to a conservative estimate of 138 million plants being grown nationally in large containers.

Introduction

It is noted that very few controlled research studies have been conducted to determine the actual irrigation requirements for these 138 million containerized plants. Thus the question of how much water is really needed by the plant was largely unanswered. The purpose of this study was to determine season long evaporation transpiration rates (adjusted for tree caliper, unit ET and unit time) and thus a value for the actual required irrigation volumes for typical woody plants grown in #15 (15 gallon) containers irrigated when delivered at low delivery rates.

Materials and Methods

Two species, "Heritage" riverbirch (*Betula nigra* "Heritage ") and pin oak (*Quercus palustris*), were grown in #15 sized containers at the Department of Horticulture and Crop Science, The Ohio State University, Columbus, Ohio during the 2003 growing season. The #15 sized containers were filled to within 2.5 cm of the container rim, resulting in a total filled volume of approximately 41 liters. Two different growing medium were used. Haydite:Comtil (3:1 by vol) medium was used so that roots could be separated from the medium when harvested.

Another group of plants were grown in Pine bark:Comtil (3:1 by vol). The pine bark medium had 67% total pore space and 48% water filled pore space at field capacity, resulting in an estimated 19.7 liters of water. The Haydite medium had 47% total pore space and 41% water filled pore space at field capacity, resulting in an estimated 16.8 liters of water. (Comtil is a composted municipal sewage sludge produced by the City of Columbus). Four foot tall, 1/2" to 5/8" caliper, container-grown whips were transplanted into the #15 sized containers in late April 2003 and placed outdoors without any form of protection.

Two irrigation methods were used to provide daily moisture directly to the containers: TOh Products ContainerTenders^{tm} (Model number 1721C, 0.1 to 0.5 gallons per hour [GPH]) and Roberts Spot Spitters^{tm} (Model No. 030.001005, 3.0 to 3.6 GPH). The Container Tenders^{tm} (Figure 1) were operated under 12 PSI for an estimated rate of 0.99 liters per hour (LPH). The Container Tenders^{tm} were run for 120 minutes per day thus applying 1.98 liters of water per day per container. In comparison, two Spot Spitters^{tm} were used per container at pressures ranging from 20 to 25 PSI per container and delivered a total of 22.8 to 27.4 LPH. The Spot Spitters^{tm} ran for 40 minutes per day thus delivering 15.3 to 18.3 liters per day per container. A standard 150 mesh screen filter was used for all irrigation water. The filter was cleaned monthly.

All plants were fertigated with 100 ppm N from 21-7-7 Peters water soluble fertilizer (O. M.Scotts and Sons, Maryville, OH). At this concentration, Container Tenders^{tm} delivered 198 mg N per day while the Spot Spitters^{tm} delivered 1672 mg N per day (when using a mean irrigation volume of 16.72 liters at 22.5 PSI).

Periodically, the actual water used by the plants was estimated by weight differences: initial saturated container-medium-plant weight minus container-medium-plant weight after a given time interval. The procedure was as follows: sample containers were saturated early in the morning (900 hours), allowed to drain for one hour and then weighed. This weight was used as the saturated weight and represents the maximum water holding capacity of the container-plant system. After approximately five hours of exposure to central Ohio sunlight, the containers were re-weighed (1500 hours). The weight difference was attributed to evapo-transpiration. This procedure was repeated for each of the next two days. Total Haydite Pin Oak container weights were between 47 and 51 kg in the morning and 45 and 49 kg, five hours later.

After determining the saturated container weight, an initial morning reading on an ET gauge was recorded (Model A Evapo-transpiration simulator, [Ben Meadows.com] fitted with a ceramic alfalfa leaf standard). Upon weighing the containers after 8 hours, the ET gauges water level was again recorded. The difference between the initial and final ET readings was the daily ET value based on the alfalfa leaf standard. Evapo-transporation was expressed as liters of water per unit trunk caliper per ET per unit time. Because ET was estimated between 900 and 1500 hours on sunny days, it represents the maximum daily ET value and thus reflects the maximum irrigation rate actually required by these species using these delivery modalities.

Three randomly selected plants per media, irrigation system, and species were harvested following the third day of weighing. Harvesting was done in June, July, August and October. Total plant fresh weight, caliper, height, total leaf area and root and leaf dry weight were recorded (Table 1).

Table 1. 2003 Water Use Data

Species	Irrigation system	Caliper (mm)	Height (cm)	Total leaf area (cm^2)
Pin Oak	Container Tender	37[a]	251	16631
	Spot Spitter	34	246	15066
'Heritage'	Container Tender	39	313	18738
	Spot Spitter	41	348	28000
P-values	Pin oak	0.411	0.827	0.740
	Heritage' Riverbirch	0.441	0.173	0.004

[a] Each value is the mean of 12, single plant replications.

Follow up studies are being conducted around the country during the 2004 growing season to corroborate these results. (Ohio State University, Oklahoma State University, Oregon State University, Virginia Tech Hampton Roads AREC, Cornell Cooperative Extension).

Results and Discussion

Season long evaporation transpiration rates:

Based upon the 2003 study, the average adjusted water use for "Heritage" riverbirch grown in #15 sized containers was found to be 1.08 liters per unit ET per hour between 900 and 1500 hours. The average adjusted water use for pin oak grown in 15 gallon containers was found to be 0.71 liters per unit ET per hour between 900 and 1500 hours (Column 1 of Table 2).

Initial results from the national 2004 study reflect that there is some slight differences in the average adjusted water use for a given species grown around the country (Table 2). The reasons for these difference are being investigated as additional data comes in from the test sites.

These adjusted water use values can be used as a starting point when designing optimum irrigation systems and the required application rates to containers. For Example: A quick calculation yields that a 3.8cm (1.5inch) caliper pin oak requires an average of only 1.29 liters (0.3 gallons) of water over the course of a day. Similarly, a 3.8 cm (1.5 inch) caliper "Heritage" riverbirch requires an average of only 1.78 liters (0.26 gallons) of water over the course of a day.

It is noted that some commercial U.S. nurseries typically apply 15 to 18 liters a day or more with spray stakes. (10.6 times more than the average required). Comparing these numbers suggest that current irrigation and fertility programs typically used in American nurseries for containers are inefficient.

A word of caution....the wide range of values for the data summarized in Table 2 suggests the need for some additional analysis. This analysis is currently taking place with the cooperating professors and the participating companies. The full paper and follow-on results from the 2004 growing season will be available soon obtained at: www.containertender.com

Plant Growth:

There were few statistical differences in end-of-season growth between plants grown with Container Tenders^{tm} or Spot Spitters^{tm} (Table 1) even though 88% less water and fertilizer was delivered to the Container Tender^{tm}plants.

For "Heritage" riverbirch, plants grown under Container Tenders^{tm} had less leaf area (18,738 vs 28,000 averaged cm^2).

There were no significant differences in pin oak growth when grown under either irrigation method, or in either media. The largest pin oak plants were grown under a combination of Haydite medium and Container Tender^{tm} irrigation system.