Timing of Overhead Irrigation Affects Growth and Substrate Temperature of Container-grown Plants

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Significance to Industry: Overhead irrigation timing had a significant effect on plant growth and container temperature. Plants that were irrigated both during the afternoon (12:00 pm, 3:00 pm, and 6:00 pm) and all day (6:00 am, 12:00 pm, and 6:00 pm) significantly outperformed plants irrigated during predawn hours (3:00, 5:00, and 7:00 am). Growers should avoid letting the container substrate dry out by late afternoon. Our data suggests that growers may want to investigate irrigating at times other than early morning.

Nature of Work: Pine bark based container substrates, common in the southeastern United States, have low moisture retention properties; therefore, daily irrigation during the growing season is required to maximize plant growth. Current "best management practices" state that overhead irrigation should occur during the early morning hours (before 1000 HR) (Yeager et al., 1997). A recent survey of Alabama nurseries stated that most nurseries (> 60%) are following this recommendation (Fain et al., 2000). Recent research, however, has demonstrated that microirrigation applied during other times of the day may increase plant growth.

Microirrigation applied at 1200, 1500, and 1800 HR produced 63% greater total plant dry weight of *Cotoneaster dammeri* 'Skogholm' ('Skogholm' cotoneaster) compared to cotoneaster irrigated at 0300, 0500, and 0700 HR (Warren and Bilderback, 2002). Reduced substrate temperature from 1800 to 2200 HR and increased rates of photosynthesis accounted for the increase in growth. Beeson (1992) working with four woody ornamentals also reported increased growth when microirrigation was applied during the day in contrast to predawn (0600 HR). He attributed the increased growth to lower daily accumulated water stress. Similarly, microirrigation with either two cycles applied at 0500 and 1300 HR or three cycles applied at 0500, 1100, and 1500 HR increased growth of red maple (*Acer rubrum* L.), winged elm (*Ulmus alata* Michx.), live oak (*Quercus virginiana* Mill) and crepe myrtle (*Lagerstroemia indica* L.) compared to a single cycle (Beeson and Haydu, 1995). Ruter (1998) also reported that microirrigation applied with 3 cycles at 0800, 1200, and 1600 HR or 4 cycles at 0800, 1100, 1300, and 1600 HR increased shoot dry weight of 'Okame' Cherry (*Prunus x incamp* 'Okame') by 40% compared to a single cycle at 0800 HR. Thus, irrigating during the day may increase growth by reducing heat load and minimizing water stress in the latter part of the day. Growers frequently ask if these results are applicable to overhead irrigation. A single study has examined the effect of timing of overhead irrigation on plant growth, Keever and Cobb (1985) reported that overhead irrigation during the day (1300 HR or split application at 1000 and 1500 HR) reduced substrate and canopy temperature

that they proposed enhanced top and root growth of *Rhododendron* x 'Hershey's Red' compared to irrigation at 2000 HR. Therefore, our objective was to evaluate the effects of timing of overhead irrigation on growth of 'Skogholm' cotoneaster and substrate temperature.

The study was a randomized complete block design with 4 replications with three containers in each plot. Rooted cuttings of *Cotoneaster dammeri* 'Skogholm' were potted into one gallon containers in an 8 pine bark : 1 sand (by vol) substrate amended with 1.2 kg/m^3 (2 lbs/yd^3) dolomitic limestone on May 17, 2003. Each plant was fertilized at potting with 5.0 g N (0.18 oz) from 17-5-10 (5-6 month with minors, Pursell Technology, Sylacauga, AL). Containers were watered as needed during the predawn hours until treatments were initiated May 30, 2003.

Leaching fraction (LF) is defined as the volume leached from a container divided by the total amount applied to that container. The daily total volume of irrigation to maintain a 0.2 LF within each treatment was divided into three equal parts and applied at the following times: 0300, 0500, and 0700 HR (predawn); 1200, 1500, and 1800 HR (afternoon); or 0600, 1200, and 1800 HR (all day). Leaching fraction was monitored weekly. Irrigation was applied overhead [961P, 120 liters/hr (32 gal/hr), Agridor Ltd., Rosh Ha Ayin, Israel].

Substrate temperatures were measured in two containers in every replication (total of 8 thermocouples/treatment) for the entire study. One copper-constantan thermocouple was positioned in the substrate halfway down the container profile 1 in from the container wall on the southern exposure in each container. Thermocouples were connected to a Hobo datalogger (Onset Computer Corp., Pocasset, MA). Temperature data were recorded every 5 min and averaged over each 60-min interval. Maximum, minimum, and average temperature along with time of maximum, and time of minimum were recorded every 60 min.

After 117 days, tops (aerial tissue) were removed (total of 12 containers / treatment). Roots were placed over a screen and washed with a high pressure water stream to remove substrate. Tops and roots were dried at 65C (150F) for 5 days and weighed. Data were subjected to analysis of variance procedures. Treatment means were separated by Fishers protected LSD, $P = 0.05$. The following variables were determined: total plant dry weight = top dry weight + root dry weight; water utilization efficiency (WUE) = irrigation volume retained in substrate ÷ total plant dry weight (milliliters of water required to produce 1 g plant dry mass); and root : top ratio = root dry weight ÷ top dry weight.

Results and Discussion: A total of 40.5 L, 50.5 L, and 37.5 L (10.7 gal, 13.2 gal, and 9.9 gal) of irrigation water was applied to predawn, afternoon, and all day, respectively resulting in LFs of 0.25, 0.19, and 0.22, for predawn, afternoon, and all day, respectively. Plants irrigated all day and PM had significantly greater top dry weight compared to predawn irrigation (Table 1). Top dry weight was ≈ 31% heavier when irrigated with afternoon and all day compared to predawn. When irrigated with microirrigation top dry weight of 'Skogholm' cotoneaster was 71% heavier when irrigated with afternoon compared to predawn. Root dry weight

was unaffected by irrigation timing. All day irrigation timing had higher WUE requiring 134 ml per g of plant dry mass (10.3 pints/oz) compared to 175 ml per g of plant dry mass (14.0 pints/oz) when irrigated predawn (Table 1). This is an increase of 23%. Water use efficiency of predawn and afternoon were similar. This may be a consequence of irrigation water lost to evaporation when irrigating during the afternoon. Data herein suggests that if daily irrigation is restricted to early morning hours, growth will be significantly reduced compared to plants grown with irrigation applied during the day.

Time of daily maximum temperature for containers irrigated predawn, afternoon, and all day were similar (1630 HR). Data from Aug. 26, 27, and 28 are presented in Fig. 1. Daily maximum temperature ranged from 46 to 48C, 44 to 46C, and 39 to 41C (115 to 118F, 111 to 115F, and 102 to 106F) for predawn, all day, and afternoon irrigation, respectively. Containers irrigated with afternoon had significantly lower temperatures from 1100 to 2400 HR compared to predawn for most days. This difference in temperature in combination with available water could have a significant impact on photosynthesis and subsequent plant growth (Ruter and Ingram, 1990).

Literature Cited:

1. Beeson, R.C. 1992. Restricting overhead irrigation to dawn limits growth in container grown woody ornamentals. HortScience 27:996-999.
2. Beeson, R.C. and J. Haydu. 1995. Cyclic microirrigation in container-grown landscape plants improves plant growth and water conservation. J. Environ. Hort. 13:6-11.
3. Fain, G.B, C.H. Gilliam, K.M. Tilt, J.W. Olive, and B. Wallace. 2000. Survey of best management practices in container production nurseries. J. Environ. Hort. 18:142-144.
4. Keever, G.J. and G.S. Cobb. 1985. Irrigation scheduling effects on container media and canopy temperature and growth of 'Hershey's Red' azalea. HortScience 20:921-923.
5. Ruter, J.M. 1998. Pot-in-pot production and cyclic irrigation influence growth and irrigation efficiency of 'Okame' cherries. J. Environ. Hort. 16:159-162.
6. Ruter, J.M. and D.L. Ingram. 1990. ^{14}Carbon-labelled photosynthesis partitioning in *Ilex crenata* 'Rotundifolia' as supraoptimal root-zone temperatures J. Amer. Soc.Hort. Sci. 115:1008-1013.
7. Yeager, T.H., C.H. Gilliam, T.E. Bilderback, D.C. Fare, A.X. Niemiera, and K.M. Tilt. 1997. Best Management Practices Guide for Producing Container-Grown Plants. Southern Nurs. Assoc., Marietta, GA.
8. Warren, S.L. and T.E. Bilderback. 2002. Timing of low pressure irrigation affects plant growth and water utilization efficiency. J. Environ Hort. 20:184-188.

Table 1. Effect of overhead irrigation timing on top, root, and total plant dry weight, root : top ratio, and water utilization efficiency (WUE).

Irrigation timing[z]	Top (g)	Root (g)	Total (g)	Root : Top[y]	WUE[x] (ml/g)
Predawn	146 c[w]	27 a	173 b	0.17 a	175 a
All day	186 a	33 a	219 a	0.18 a	134 b
Afternoon	197 a	34 a	231 a	0.17 a	177 a

[z]Predawn = irrigation at 0300, 0500, and 0700 HR; All day = 0600, 1200, and 1800 HR; Afternoon = 1200, 1500, and 1800 HR.

[y]Root : top ratio = root dry weight ÷ top dry weight.

[x]WUE = millliters water ÷ g total dry mass.

[w]Means within columns followed by the same letter are not significantly different as determined by Fisher's protected LSD, P = 0.05.

Fig. 1. Effect of irrigation timing on substrate temperature. Predawn = irrigation at 0300, 0500, and 0700 HR; All day = 0600, 1200, and 1800 HR; Afternoon = 1200, 1500, and 1800 HR.