Irrigation Volume and Fertilizer Rate Influence Growth and Leaching Fraction from Container-Grown *Gardenia jasminoides*©[1]

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INTRODUCTION

Over irrigating is a common problem in container-plant production because of poor uniformity and efficiency of irrigation systems (Fare et al., 1992) and the preference of growers to deal with the consequences of applying too much water vs. too little (Yeager et al., 2010). Along with this, many growers apply large amounts of fertilizer out of concern that lower fertilizer applications could negatively impact growth (Owen et al., 2008; Tyler et al., 1996). The combination often excessive irrigation and high fertilizer rates leads to significant leaching of fertilizers, which has a negative environmental impact as the leachate enters local ecosystems (Lea-Cox and Ross, 2001). Many states now have laws and regulations regarding nutrient runoff from nurseries necessitating that growers better manage the irrigation and fertilization applications (Beeson et al., 2004).

Growers have already adopted more effective irrigation practices including cyclic irrigation, drip irrigation, and grouping similar sized containers (Yeager et al., 2010; Tyler et al., 1996). Better management practices for fertilization and nutrient leaching have also been adopted, including using controlled-release fertilizers that last throughout the production period and monitoring substrate nutrient levels (Yeager et al., 2010). However, to irrigate and fertilize more efficiently more research is needed examining how plant growth is affected by reduced irrigation and fertilization.

It seems likely that fertilizer inputs can be reduced if irrigation is applied more efficiently because more efficient irrigation reduces leaching. With reduced leaching, more fertilizer remains in the container and available to the plant. Our objective was to determine how irrigation volume and fertilizer rate affect growth and leaching fraction of *Gardenia jasminoides*. Our hypothesis is that more efficient irrigation can reduce the fertilizer requirements without impacting plant growth, while reducing the leaching fraction.

MATERIALS AND METHODS

The experiment took place at the University of Georgia horticulture farm in Watkinsville, Georgia, from July to October 2012. Rooted cuttings of *Gardenia jasminoides* 'Madga I', Heaven Scent® gardenia were planted in #2 black plastic containers in a pine bark substrate with micronutrients, gypsum, and lime incorporated. Plants were given time for root establishment before irrigation treatments were applied. Fertilizer treatments were applied at planting.

Treatment combinations included fertilizer rates of 100, 50, and 25% of bag rate and irrigation application rates of 66, 100, 132, or 165 ml per irrigation event for a total of 12 treatment combinations. Controlled release fertilizer (Florikan 18-6-8) was incorporated into the upper part of the substrate at 40 g per plant (100%), 20 g per plant (50%), or 10 g per plant (25%). Irrigation was controlled via a soil moisture sensor automated irrigation system similar to that described by Nemali and van Iersel (2006). Irrigation was applied to maintain a 35% volumetric water content (VWC) for the control treatment (100% fertilizer rate, 66 ml irrigation treatment) and was applied via dribble rings with pressure compensated drip emitters. Substrate moisture readings were taken every 20 min, and when the substrate moisture of the control plants dropped below 35% VWC, all treatments in a replication were irrigated. Thus, all plants within a replication were watered the same number of times, but with different amounts of water each time. The

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experimental design was a randomized complete block with four replications. There were four plants for each treatment combination in each replication.

Leachate was collected in 10-gal. containers. Rainwater was excluded from the container, so that only rainwater that had moved through the substrate was included in the leachate (Fig. 1). Plant height and width as well as leachate volume were measured biweekly. Irrigation volumes and rainfall were measured daily throughout the experiment. Growth index was calculated as (height + width1 + width2)/3. Leaching fraction was calculated as leachate volume/(irrigation volume + rainfall volume).

RESULTS AND DISCUSSION

Growth index increased quadratically over the course of the experiment (Fig. 2). At the conclusion of the experiment, the growth index of all treatment combinations, except those receiving the 25% fertilizer treatment, was larger than the control (66 ml, 100% fertilizer) (Table 1). Dunnett's multiple comparisons analysis of growth indices at the conclusion of the experiment shows that the only significantly different treatment combinations from the control were the 100% (165 ml irrigation) and 50% (132 ml irrigation) treatment combinations which were 13% greater. The similar growth indices in the 100 and 50% fertilizer treatments for all irrigation volumes shows the potential for using reduced fertilizer applications along with moderate irrigation volumes to grow salable plants of *Gardenia*.

Irrigation volumes were inversely related to rainfall because rainfall increased the VWC of the substrate above the 35% threshold, therefore irrigation did not occur. The impact of irrigation volume and fertilizer rate on leaching fraction differed for the biweekly leachate collections. Large rainfall volumes (2-4 in. total rainfall volumes) during the time between collections created similar leaching fractions for all treatment combinations (Fig. 4, top and middle graphs). The clearest impact of treatments can be seen during the last 2 weeks, during which it did not rain. For this collection time, both irrigation volume ($P<0.001$) and the interaction between irrigation volume and fertilizer rate ($P=0.006$) affected the leaching fraction.

Tyler et al. (1996) found that irrigation applied to reach a high (0.4-0.6) or low (0.0-0.2) leaching fraction did not affect shoot growth of *Cotoneaster* × *suecicus* (syn. *dammeri*) 'Skogholm'. These findings are similar to those in this study with irrigation volume not significantly affecting growth. In contrast to our study, in which growth with the moderate fertilizer applications (50%) was not significantly different than high applications (100% rate) (Fig. 3), Tyler et al. (1996) found that reducing fertilizer application rate by 50% did significantly reduce growth. However, Cabrera (2004) also reported that moderate fertilizer applications can be used without reducing plant quality.

Further research investigating fast vs. slow growing species, high vs. low fertilizer requirements, and high vs. low water use would give a clearer picture of how irrigation and fertilization can be altered in a production environment to reduce inputs while producing salable plants. The results of this study suggest that reduced fertilizer rates can be used in combination with efficient irrigation to produce salable plants. As more states are impacted by laws and regulations regarding nutrient runoff from nurseries and existing laws become more strictly enforced, it will become imperative that growers adopt more efficient fertilization and irrigation practices.

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Table 1. Growth index of *Gardenia jasminoides* 'Madga I', Heaven Scent® gardenia at the conclusion of the four month study and percent difference in growth index by treatment combination from the control (2 min irrigation, 100% fertilizer) treatment.

		Growth index (mm)	Difference from control (%)	P<0.05
100% Fertilizer	66 ml	188.5		
	100 ml	203.1	8	
	132 ml	204.8	9	
	165 ml	213.1	13	*
50% Fertilizer	66 ml	196.4	4	
	100 ml	208.2	10	
	132 ml	212.2	13	*
	165 ml	197	5	
25% Fertilizer	66 ml	189.9	1	
	100 ml	182.7	-3	
	132 ml	180.6	-4	
	165 ml	134.1	-4	

*Dunnett's multiple comparison (significance at P<0.05).

Fig. 1. The setup for leachate collection/rainfall exclusion.

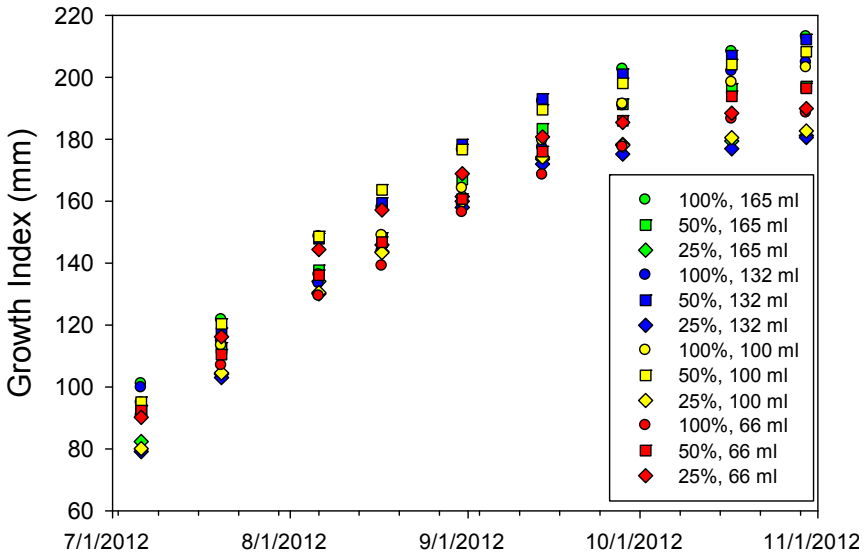

Fig. 2. Growth index (mm) of *Gardenia jasminoides* 'Madga I', Heaven Scent® gardenia over the course of the four month study.

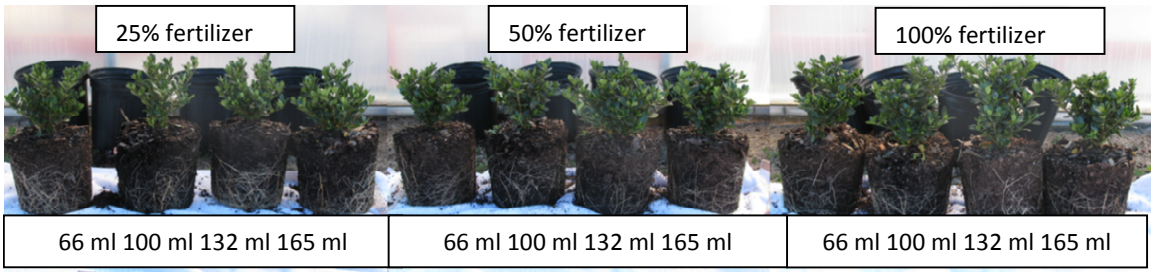

Fig. 3. Photos of plants showing all treatment combinations at the conclusion of the experiment. Treatments are 25% fertilizer rate to the left, 50% in the center, and 100% to the right and irrigation volumes are from 66-165 ml moving left to right in all pictures.

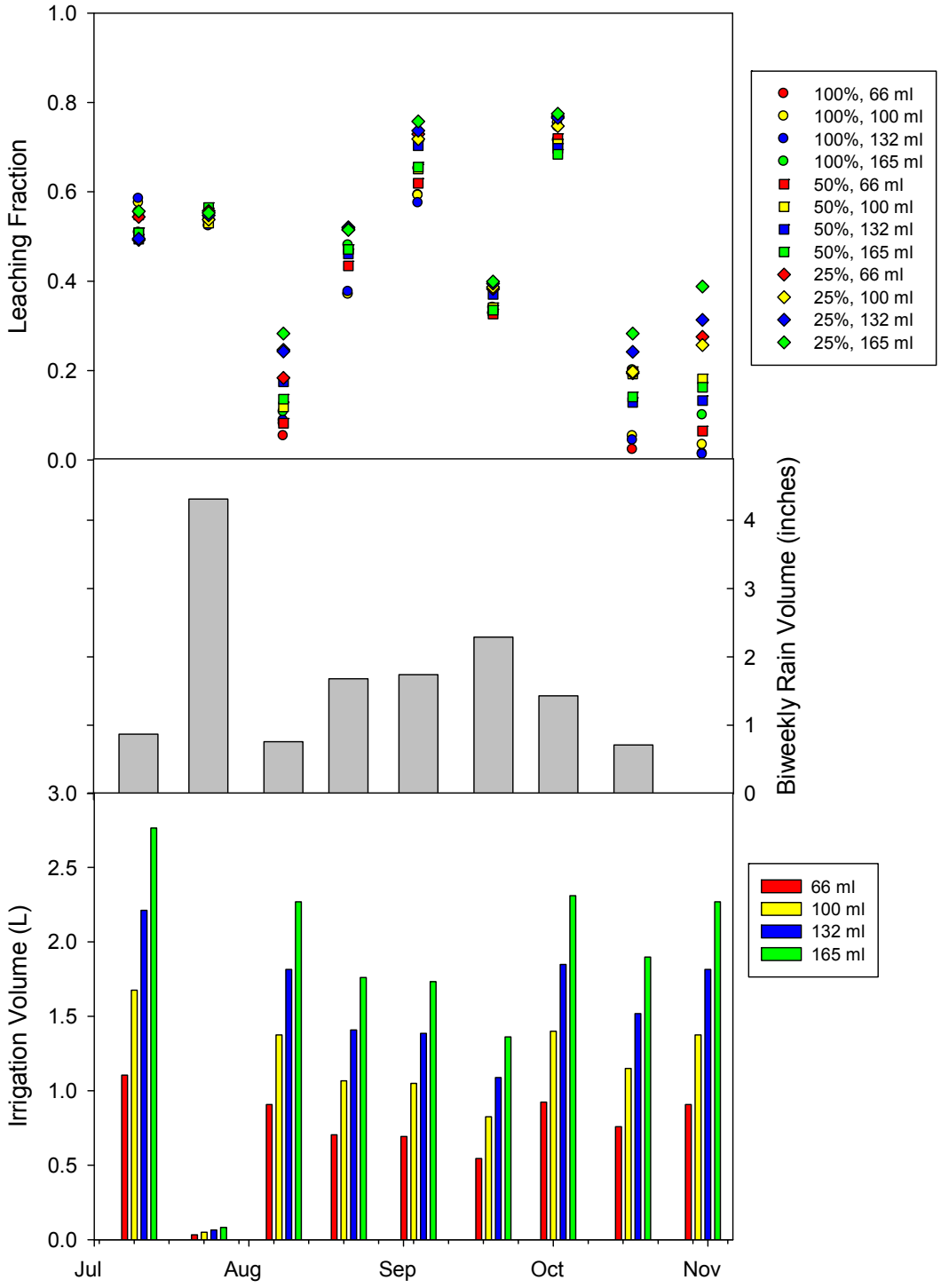

Fig. 4. Leaching fraction (irrigation volume + rainfall/leachate volume) (top graph), biweekly rainfall volume (inches) (middle graph), and biweekly irrigation volume (L) over the course of the 4 month study.