Effect of Fertilizer Source on Water Use of St. Augustinegrass and Ornamental Plants

Subhrajit K. Saha and Laurie E. Trenholm¹

Environmental Horticulture Department, University of Florida, P.O. Box 110675, Gainesville, FL 32611

J. Bryan Unruh

West Florida Research and Education Center, University of Florida, Jay, FL 32565

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Abstract. Due to increasing consumption of water in landscapes and concern over conservation of water resources, this study was conducted to determine the effect of fertilizer source on water consumption of turf and ornamentals and to compare total water use (WU) of st. augustinegrass and ornamentals. The experiment was performed in a climate-controlled greenhouse at the G.C. Horn Turfgrass Field Laboratory at the University of Florida in Gainesville. 'Floratum' st. augustinegrass (*Stenotaphrum secundatum* Walt. Kuntze) was compared to a mix of common Florida ornamentals including canna (*Canna generalis* L.H. Bailey), nandina (*Nandina domestica* Thunb.), ligustrum (*Ligustrum japonicum* Thunb.), and allamanda (*Allamanda cathartica* L.). All plants were grown in 300-L plastic pots in Arredondo fine sand. There were three fertilizer treatments [quick-release fertilizers (QRF) 16–4–8 and 15–0–15, and slow-release fertilizer (SRF) 8–4–12] applied at 4.9 g N/m² every 60 days. Water was applied as needed to maintain turgor and turfgrass pots were mowed weekly. Experimental design was a randomized complete block design with four replications. Visual quality ratings and time domain reflectometry (TDR) data were collected weekly. Both turf and ornamentals consumed less water and had higher water use efficiency (WUE) when treated with SRF. Ornamentals consumed from 11% to 83% more water than turf, depending on season. These results may have implications in future research on irrigation management to verify WUE between turf and ornamentals in an urban landscape.

Water use (WU) in home landscapes is under increasing scrutiny due to population growth. Turfgrass is often cited as a high water user in the landscape, and in some cases, there has been legislation limiting turf use in landscapes. Cultural factors have been shown to influence turfgrass WU and evapotranspiration (ET). Feldhake et al. (1983) reported that turf receiving monthly N applications throughout the growing season used 13% more water than turf receiving one fertilizer application for the year.

Water lost via ET also depends on environmental, morphological, and anatomical factors. Environmental factors include relative humidity (Carrow, 1995; Nonami and Boyer, 1990), wind speed, soil moisture, and shade (Takakura et al., 2000). Morphological factors include leaf pubescence and degree of cuticular wax present on the leaves (Peacock and Dudeck, 1984). Plant water consumption may also depend on anatomical factors such as leaf area index, leaf orientation, and texture (Ebdon and Petrovic, 1998), and shoot density (Kim and Beard, 1988). Higher turfgrass ET rates were found to be associated with increased shoot density (Biran

et al., 1981; Feldhake et al., 1983; Parr et al., 1984). Lower ET rates were reported with reduced shoot growth in bermudagrass (*Cynodon dactylon* L.) (Devitt and Morris, 1989) and st. augustinegrass (Green et al., 1990).

Deep rooting and the ability to maintain viable roots were found to be important mechanisms in drought resistance of turfgrass (Huang et al., 1997), although Carrow (1996) reported that rooting depth was not always positively correlated with ET rankings. Gibbens and Lenz (1996) reported that the deeper roots of ornamental plants allow them to extract large volumes of water stored from rainfall and past irrigations, which may result in less frequent irrigation of shrubs compared to turf.

While the differences in how plant species consume water may result in different irrigation requirements, they do not necessarily reflect

water use efficiency (WUE). WUE may be defined in various ways, including ratio of biomass produced per unit of water used or as the measure of photosynthesis per volume of water consumed. In a mixed sward of orchardgrass (*Dactylis glomerata* L.), creeping red fescue (*Festuca rubra* L.), and bromegrass [*Bromus inermis* (Leyss.) Lindm.], Krogman (1967) observed that up to a certain level of crop growth, factors that promoted growth, such as N, also promoted WUE. Christians (1998) noted that higher N use might decrease WUE in grasses.

In perennial landscape plants, irrigation management is critical for conservation of water and for the health of the plants, but limited information is available about effects of fertilizer source on WUE. Turf and ornamentals coexist in the landscape and generally receive similar fertilization and irrigation regimes, which may actually increase plant WU. Therefore, the objectives of this study were to determine the effect of fertilizer source on WU and WUE and to compare WU of st. augustinegrass and ornamentals.

Materials and Methods

The research was performed in a climate-controlled greenhouse at the G.C. Horn Memorial Turfgrass Field Laboratory at the University of Florida in Gainesville. 'Floratum' st. augustinegrass and a combination of ornamentals that included *Canna generalis*, *Ligustrum japonicum* 'Lake Tresca', *Nandina domestica* 'Harbor Dwarf', and *Allamanda cathartica* were established in large plastic pots in May 2002. The pots measured 0.8 m in diameter × 0.4 m tall with a volume of 300 L.

Pots were placed on reinforced metal tables in the greenhouse. Gravel (5 cm) was placed at the bottom of each pot, and a mesh cloth was placed over the gravel to retain the media. Pots were filled with Arredondo fine sand (loamy, siliceous, hypothermic, Grossarenic Paleudalt). Mature st. augustinegrass sod was harvested from a research field and planted to fully cover the container. Ornamental plants grown in 2.8-L containers were acquired from a retail nursery. One of each species was planted in the ornamental treatment pots. Cypress mulch was applied to the soil surface of ornamental pots at a depth of 2.5 cm. Plants were allowed to establish for a 2-month period before treatments began.

Three fertilizer treatments were used: quick-release fertilizer (QRF) 16–4–8 (ammonium sulfate, concentrated superphosphate, and potassium chloride), QRF 15–0–15 (am-

Table 1. Irrigation schedule (L) in six fertilizer cycles (FCs).

FC	Water applied ²			
	WF	IW ₁	IW ₂	IW ₃
First FC (July to September)	4	16	12	24
Second FC (September to November)	4	16	10	12
Third FC (November to January)	4	8	8	12
Fourth FC (January to March)	4	8	8	12
Fifth FC (March to May)	4	9	9	38
Sixth FC (May to July)	4	20	20	40

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¹To whom reprint requests should be addressed; e-mail ltrenholm@ifas.ufl.edu.

²WF = water applied with fertilizer, IW₁ = water applied before first leaching event, IW₂ = water applied between first and second leaching event, and IW₃ = water applied between second and third leaching event.

Table 2. Effects of fertilizer source on water consumption (L) of st. augustinegrass in six fertilizer cycles (FCs).

Fertilizer	FC 1 July to September	FC 2 September to November	FC 3 November to January	FC 4 January to March	FC 5 March to May	FC 6 May to July	Avg July to July
QRF 15-0-15	105.9 a ^z	88.1 a	70.6 a	68.7 a	116.1 a	136.4 a	97.7 a
QRF 16-4-8	101.7 ab	86.4 a	71.7 a	64.8 a	119.3 a	140.3 a	97.3 a
SRF 8-4-12	94.1 b	79.2 a	65.2 a	60.1 a	112.4 b	132.1 a	90.5 a
P value	0.08	NS	NS	NS	0.009	NS	NS

^zMeans followed by the same letter do not differ significantly at $P < 0.05$.^{NS}Nonsignificant.Table 3. Effects of fertilizer source on water consumption (L) of ornamentals^z in six fertilizer cycles (FCs).

Fertilizer	FC 1 July to September	FC 2 September to November	FC 3 November to January	FC 4 January to March	FC 5 March to May	FC 6 May to July	Avg July to July
QRF 15-0-15	116.0 a ^y	126.2 a	110.2 a	124.7 a	166.3 a	181.4 a	137.5 a
QRF 16-4-8	113.6 a	122.0 ab	108.2 a	128.5 a	164.5 a	184.5 a	136.9 a
SRF 8-4-12	106.5 a	114.9 b	98.2 b	100.4 b	140.7 b	168.0 b	121.4 a
P value	NS	0.03	0.008	0.009	0.04	0.03	NS

^zOrnamentals included *Canna generalis*, *Ligustrum japonicum*, *Nandina domestica*, and *Allamanda cathartica*.^yMeans followed by the same letter do not differ significantly at $P < 0.05$.^{NS}Nonsignificant.

monium sulfate and potassium chloride), and a slow-release fertilizer (SRF) 8-4-12 (polymer-coated sulfur-coated urea, ammonium phosphate, and polymer-coated potassium sulfate). Treatments were applied six times at 2-month intervals (17 July, 19 Sept., and 20 Nov. 2002 and 17 Jan., 18 Mar., and 21 May 2003) at a rate of 4.9 g N/m² to both turf and ornamentals. Each of these 2-month periods is referred to as one fertilizer cycle (FC).

Irrigation schedules varied by season, with the same irrigation rates applied to both turf and ornamentals (Table 1). Leaching events were conducted three times over the course of the FC to ensure adequate sample for analysis of nitrates and phosphates from the leachate. WU values were derived from the following equation: $WU = WF + (IW_1 + WU_1) + (IW_2 + WU_2) + (IW_3 + WU_3)$, where WF = water applied with fertilizer (4 L); IW_1 = water applied before first leaching event, excluding WF; IW_2 = water applied between first and second leaching event; IW_3 = water applied between second and third leaching event; $WU_n = WA_n - WL_n$, where n = leaching event number (n = 1, 2, 3); WA_n = water applied to a pot on a leaching event; and WL_n = water leached from a pot on a leaching event.

WUE was measured as biomass production per unit water applied. Roots and shoots were dried and weighed for root WUE (WUE_R) and shoot WUE (WUE_S). Total WUE (WUE_T) was calculated as the sum of root and shoot mass. These measurements were taken at termination of the experiment and analyzed to determine WUE over the year and during FC 6 (May to July 2003).

Turf was mowed every week with hand-held clippers at a height of 9 cm. Clippings were removed. A micronutrient blend (STEP, The Scotts Co., Marysville, Ohio) was applied at a rate of 6.7 g/m² in September 2002 to both turf and ornamentals. Bifenthrin was applied to the turf at a rate of 4 g/L⁻¹ to control a minor infestation of armyworm (*Spodoptera* spp.). Ligustrums were treated with 2% insecticide oil during November 2002 to control a scale (*Hemiberlesia lataniae*) infestation. Greenhouse temperature was monitored using a temperature datalogger (Hobo; Onset

Computer Corp., Bourne, Mass.) and light intensity at different canopy levels was measured weekly with a quantum sensor (LI-250; LI-COR, Inc., Lincoln, Neb.). At termination of the experiment, shoots and roots from each pot were harvested and dried for 24 hours at 75 °C. Ornamental roots were excavated and washed but were not separated by plant species due to the intermingling of roots.

Experimental design was a randomized complete block model with four replications. Data were analyzed with the SAS analytical program (SAS institute, Inc. 2003) to determine treatment differences at $P < 0.05$. Means were separated with Fisher's LSD.

Results and Discussion

Effect of fertilizer on WU of st. augustinegrass and ornamentals. Averaged over the year, there were no differences in st. augustinegrass

WU due to fertilizer treatment (Table 2). However, in FC 1, while plants were establishing, turf treated with QRF 15-0-15 used 11% more water than turf receiving SRF 8-4-12. In FC 5 (March to May), SRF treated turf used nearly 5% less water than turf receiving QRF treatments. These results may indicate that during times of accelerated growth or establishment, slower growth from SRF resulted in lower WU by turf. Similar results were observed by Feldhake et al. (1983) and Biran et al. (1981), where SRF treated turf consumed less water than QRF treated turf.

Ornamentals also showed variation in water consumption due to fertilizer source (Table 3). Plants receiving SRF 8-4-12 consumed less water in FC 3 to 6 (November to July). In FC 2 (September to November), QRF 15-0-15 treated plants consumed 9% more water than those receiving SRF. Plants treated with SRF had less shoot mass than the QRF treated

Table 4. Water use efficiency (WUE) of st. augustinegrass and ornamentals^z measured (g·L⁻¹) during fertilizer cycle (FC) 6 (May to July) and averaged over the year.

Fertilizer	FC 6 (May to July)			Averaged yearly		
	WUE _{Shoot}	WUE _{Root}	WUE _{Total}	WUE _{Shoot}	WUE _{Root}	WUE _{Total}
Turfgrass						
QRF 15-0-15	7.9 a ^y	1.2 a	9.1 a	11.1 a	1.7 a	12.7 a
QRF 16-4-8	7.6 a	1.2 a	8.8 a	11.0 a	1.7 a	12.7 a
SRF 8-4-12	6.5 b	1.1 a	7.6 b	9.5 a	1.5 a	11.1 a
P value	0.02	NS	0.01	NS	NS	NS
Ornamental						
QRF 15-0-15	3.7 a ^y	10.3 a	13.9 a	4.8 a	13.6 a	18.4 a
QRF 16-4-8	3.7 a	9.9 a	13.7 a	4.9 a	13.4 a	18.4 a
SRF 8-4-12	2.8 b	8.6 a	11.5 a	3.9 a	12.1 a	16.0 a
P value	0.04	NS	NS	NS	NS	NS

^zOrnamentals included *Canna generalis*, *Ligustrum japonicum*, *Nandina domestica*, and *Allamanda cathartica*.^yMeans followed by the same letter do not differ significantly at $P < 0.05$.^{NS}Nonsignificant.Table 5. Comparison of water use efficiency (WUE) of st. augustinegrass and ornamentals^z (g·L⁻¹) in fertilizer cycle (FC) 6 and over the year.

Fertilizer	FC 6 (May to July)			Averaged yearly		
	WUE _{Shoot}	WUE _{Root}	WUE _{Total}	WUE _{Shoot}	WUE _{Root}	WUE _{Total}
Turf	7.4 a ^y	1.1 b	8.6 b	10.5 a	1.6 b	12.2 b
Ornamentals	3.4 b	9.6 a	13.0 a	4.6 b	13.0 a	17.6 a
P value	0.0001	0.0001	0.0001	0.0001	0.0001	0.0003

^zOrnamentals included *Canna generalis*, *Ligustrum japonicum*, *Nandina domestica*, and *Allamanda cathartica*.^yMeans followed by the same letter do not differ significantly at $P > 0.05$.

Fig. 1. Water use of turf and ornamentals over six fertilizer cycles and averaged over the year. Means differed significantly ($P = 0.05$) between turf and ornamentals for all cycles.

plants (data not presented), suggesting that increased shoot growth is correlated with water consumption. This is in contrast to results of Broschat (1995), who observed less biomass production in *Spathyphyllum* treated with QRF as compared to SRF.

Effect of fertilizer on WUE. Turf treated with QRF had higher WUE_T and WUE_S in FC 6 (Table 4), but no differences were observed when WU was averaged over the year. Similarly, QRF treated ornamentals had higher WUE_S in FC 6 (Table 4), but no differences were found when WU was averaged over the year.

Shoot WUE_S was higher in st. augustinegrass than in ornamentals both in FC 6 and when averaged over the entire year (Table 5). This was in contrast to WUE_R and WUE_T , both of which were higher in ornamentals than in st. augustinegrass during FC 6 and when averaged over the entire year (Table 5). The WUE_S of turf is not surprising, since turfgrass growth increases rapidly in response to water as compared to ornamentals. However, root production in mature ornamentals is greater than in turf (Gibbens and Lenz, 2001), resulting in greater WUE_R and WUE_T in ornamentals.

Comparison of water consumption by st. augustinegrass and ornamentals. In all fertilizer cycles, st. augustinegrass consumed less water than ornamentals (Fig. 1). WU of ornamentals during fertilizer cycles ranged from 11% to 83% more than turf. Averaged over the year, water consumption of ornamentals was 39% more than in turf. Results may differ in a landscape setting, where ornamentals are not space bound and can forage more deeply for water.

Minimal differences in WU between plant types occurred during FC 1 (July to September). This cycle was part of the establishment period, during which time ornamentals had less shoot and root mass and therefore used

less water than when mature. Greater differences in water consumption were found in FCs 3 and 4 (November to mid-March), when st. augustinegrass was in a somewhat dormant state as compared to ornamentals. Canna was the only ornamental that went dormant, which was noted by senescent foliage. The lack of dormancy in the remaining ornamentals resulted in higher WU of ornamentals as compared to st. augustinegrass during winter months.

Conclusions

Both st. augustinegrass and ornamentals consumed less water when treated with SRF, particularly during establishment or times of optimal growth. Higher WUE_S and WUE_T occurred in turf treated with QRF in FC 6, with no differences when averaged over the year. Ornamentals had greater WUE_S when treated with QRF.

Results showed that, on average, ornamentals consumed 39% more water than st. augustinegrass, which varied from 11% to as high as 83%, depending on the season. The greatest difference in water consumption was found during winter, when st. augustinegrass remained semi-dormant and ornamentals continued to grow.

This research provides preliminary data upon which in situ research should be expanded. Results obtained here may vary in an actual landscape setting due to root growth and branching habits, differences in ET rate in an open environment, and other variables that would be present in a landscape. Additional research is needed to verify WUE between turf and ornamental plants in an urban landscape. Similarly, this research only evaluated one turfgrass and four ornamental species. Results may vary if other species were evaluated.

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