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Turfgrass

Water Use of St. Augustinegrass and Bahiagrass under Varying Nitrogen Rates

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ABSTRACT

In Florida, state agencies are concerned about St. Augustinegrass [*Stenotaphrum secundatum* (Walt.) Kuntze] for being a possible high water user and excess (N) applications in home lawns. This has resulted in a desire by some municipalities to substitute St. Augustinegrass with bahiagrass (*Paspalum notatum* Flügge). Consequently, the aim of this study was to determine the effect of different N fertilizer rates on water use and turf quality of bahiagrass and St. Augustinegrass commonly used in residential yards. The experiment was a split-plot randomized complete block design repeated over two trials. Whole plots arranged in blocks consisted of either bahiagrass cultivar 'Pensacola' or St. Augustinegrass cultivar 'Floratam'. Subplots consisted of two N rates (98 and 294 N kg ha^{-1} yr^{-1}). Water use rates, was influenced by grass type and by N rates with bahiagrass having higher water use rates (WURs) than St. Augustinegrass in one of the two trails. The high N rate increased turfgrass WURs but only in Trial 1. In both trials clipping yields (CY) were greater for bahiagrass than St. Augustinegrass. Furthermore, the higher N rate produced greater CY than the lower N rate. All treatments produced acceptable turfgrass quality when averaged for each trial though, not for ever cycle. Bahiagrass generally produced superior quality ratings than St. Augustinegrass. In addition, the higher N rate always produced higher quality scores than the lower N rate.

Turfgrass landscapes provide many aesthetic and functional benefits to residents and also opportunities for recreation. However, to maintain an acceptable turfgrass landscape, irrigation inputs are required when rainfall is insufficient (Aronson et al., 1987). In fact, the application of water to residential landscapes is a major use of potable water (Baum et al., 2005). For example, water use in Florida by residential homes accounts for 61% of the public supply category with the average household using 71% of its total water consumption for irrigation use (Baum et al., 2005). As a result, many municipalities across the nation have enacted water restrictions to limit residential irrigation to conserve potable water (e.g., South Florida Water Management District). Some municipalities also offer programs for replacing grass with xeriscepes in an effort to reduce landscape irrigation (City of Glendale, 2010).

Turfgrass is a major component of urban vegetation and considerable work has been done measuring its WURs, which is the total amount of water required for turfgrass growth plus the quantity lost by transpiration and evaporation (evapotranspiration) (ET) from the soil and plant surfaces (Aronson et al., 1987; Beard, 1973; Fu et al., 2004; Fry and Butler, 1989; Kim and Beard, 1988; Park et al., 2005; Youngner et al., 1981). Water loss by grass via ET is influenced by several factors, including climate, plant morphological and anatomical factors, and management practices. Major climatic factors include wind speed (Danielson et al., 1979; Davenport, 1965, p. 54–60), solar radiation (Feldhake et al., 1983; Shearman and Beard, 1973) atmospheric vapor pressure, and temperature (Beard, 1973). Management practices include N fertilization rate (Barton et al., 2009; Ebdon et al., 1999; Feldhake et al., 1983; Mantell, 1966; Shearman and Beard, 1973), fertilizer source (Saha et al., 2005), mowing height and frequency (Brian et al., 1981; Feldhake et al., 1983; Fry and Butler, 1989; Shearman and Beard, 1973), use of growth regulators (Borden and Campbell, 1987), and soil water availability (Brian et al., 1981; DaCosta and Huang, 2006; Kneebone et al., 1992). Furthermore ET varies with turfgrass species (Aronson et al., 1987; Fry and Butler, 1989; Fu et al., 2004; Kim and Beard, 1988; Youngner et al., 1981) and within cultivar of the same species (Bowman and Macaulay, 1991; Ebdon and Petrovic, 1998; Kopec et al., 1988; Shearman, 1986; Salaiz et al., 1991).

St. Augustinegrass [*Stenotaphrum secundatum* (Walt.) Kuntz] is one of the most predominately used grass species for residental lawns in the southeastern United States. In Florida alone, St. Augustinegrass is grown on approximately 70% of the lawns with an additional 24,164 ha harvested annually from sod production (Busey, 2003; Haydu et al., 2005). 'Floratam' is the most extensively used cultivar due mainly to its resistance to chinch bugs (*Blissus insularis* Barber). However, in more recent years this resistance has been broken state wide in Florida (Nagata and Cherry 2003). Recently, many state regulators in Florida have criticized St. Augustinegrass for its high WURs, as a recent study showed that irrigation for residential landscape accounted for 64% of total residential water use (approximately 141 mm mo^{-1}) for homes surveyed in Central Florida (Haley et al., 2007). This

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Abbreviations: CY, clipping yields; ET, evapotranspiration; FC, fertilizer cycle; TWURs, total water use rates; WURs, water use rates.

has resulted in a desire by some municipalities to substitute St. Augustinegrass with bahiagrass, which is commonly perceived to use less water (Lower ET) than St. Augustinegrass under irrigated conditions. For example in Orlando, FL the Orange County commissioners recently had 1 ha of St. Augustinegrass replaced with bahiagrass to reduce water use in the county. However, limited data have indicated comparable ET rates for St. Augustinegrass Floratam and bahiagrass Penescola in a greenhouse experiment (Miller and McCarty, 2001).

In addition to WURs, N inputs for St. Augustinegrass lawns have also received great interest due to environmental concerns (Erickson et al., 2001; 2008). Currently, the recommended N rates for South Florida are 196 to 294 kg ha^{-1} yr^{-1} for St. Augustinegrass and 98 to 196 kg ha^{-1} yr^{-1} for bahiagrass (Trenholm et al., 2000). Few studies have examined the effects of N rates on turfgrass WURs. Although Barton et al. (2009) reported reduced ET at low N rates in Kikuyu turfgrass [*Pennisetum clandestinum* (Hochst. ex Chiov)], the authors suggested that application of the minimum N for turfgrass quality was an approach for decreasing water consumption by turf. However, the implication of these findings for other grass species in other environments is not well understood. Consequently, the aim of this study was to determine the effect of different N fertilizer rates on WURs and turf quality of two warm season grasses commonly used in residential yards in the southeastern United States.

MATERIALS AND METHODS

Experimental Site and Design

The study was conducted at the University of Florida's Institute of Food and Agricultural Sciences, Fort Lauderdale Research and Education Center (26°03′ N, 80°13′ W) on stands of bahiagrass and St. Augustinegrass grown on a mined 'mason' sand (Table 1) (Atlas Peat and Soil, Inc.) that was low (<0.5%) in organic matter and had a pH of 7.9 ± 0.2. The experiment consisting of 16 turfgrass plots in a split-plot randomized complete block design with four replications. Whole plots (8 by 4 m) arranged in blocks consisting of either bahiagrass cultivar Pensacola or St Augustinegrass cultivar Floratam. One of two N rates (98 and 294 N kg ha^{-1} yr^{-1}) was applied to subplots (4 by 2 m). Nitrogen rates were split equally over six application dates in 2006–2007 (Trial 1) and again in 2007–2008 (Trial 2). In 2006–2007 N was applied on 12 Oct., 12 Dec. 2006 and 15 Mar., 17 Apr., 18 June, and 16 Aug. 2007. In 2007–2008 N was applied on the 11 Oct., 21 Dec. 2007 and 20 Feb., 21 Apr., 23 June, and 3 Sept. 2008. Each application date represented the start of a new fertilizer cycle (FC). Spray grade granular urea (46–0–0) was used as the source (PCS Sales, Inc. Northbrook, IL) of N and applied with a backpack CO_2–pressurized (30 psi) sprayer equipped with two flat-fan TeeJet 8010 nozzles on 510 mm spacing. Immediately following N applications turfgrass received 13 mm of irrigation to reduce N loss to volatilization and reduce burn potential (Bowman et al., 1987). In addition to N fertilization, P and K from triple superphosphate (0–46–0) and muriate of potash (0–0–63) were applied at the rates of 196 and 392 kg ha^{-1} yr^{-1} to maintain acceptable soil test values. The fertilizers were split equally every 90 d. Additionally, macro- and micronutrients were applied as Harrell's Max Minors containing Mg 1%, S 3.5%, B 0.02%, Cu 0.25%, Fe 4%, Mn 1%, Zn 0.6%, and Mo 0.0005% at 12 L ha^{-1} every 90 d. Throughout the duration of the experiment plots received 2.5 mm of irrigation every day except when more than 6.4 mm of precipitation occurred. When precipitation events were >6.4 mm then irrigation for the following day was voided. Plots were maintained at a height of cut of 75 mm using a rotary mower and clippings were removed.

Table 1. Percentage by weight of mineral particle fractions contained in the root zone used for construction of the field study area

Name	Size range	Weight
	mm	%
Fine gravel	2.0–3.4	0
Very coarse sand	1.0–2.0	2
Coarse sand	0.5–1.0	7
Medium sand	0.25–0.50	23
Fine sand	0.15–0.25	27
Very fine sand	0.05–0.15	34
Silt	0.002–0.05	7
Clay	<0.002	0

Measures of Turfgrass Quality and Clipping Growth

Turfgrass visual quality was assessed biweekly using a 1–9 scale (9 = dark green, 1 = dead/brown turf, and 6.5 = minimally acceptable turfgrass (Carrow, 1997). Turfgrass clipping samples for shoot growth were harvested from a 2.24 m^2 area within each plot using a rotary mower set at a height of 75 mm approximately weekly or more frequently when necessary. Samples were oven dried at 60°C for 48 h to a constant weight.

Measures of Water Use

To measure water use, large lysimeters were installed on top of a 300 mm sand base in the center of each subplot. The lysimeters were constructed from plastic drums 920 mm high, 597 mm diam., with a 13 mm thick wall, (U.S. Plastics Corporation) with a flat bottom which had a threaded opening already manufactured into the container for easy drainage pipe installations. The lysimeters were fitted with 19 mm polyvinyl chloride (PVC) drainage pipe, spliced to allow for lysimeter drainage and individually installed on the foundation. A 90-degree elbow joint was attached to the drainage orifice, which was subsequently connected to a 10 m section of 24 mm diam. Schedule 40 PVC pipe that ran to a collection station. At the collection station each pipe was allocated its own 20 L polyethylene container. Each lysimeter had a stainless steel screen (1 mm mesh) over the orifice at the bottom of the lysimeter. This subsequently was covered with a 100-mm layer of filter gravel (>14 mm 1%, 12–14 mm 7.5%, 9–12 mm 10.5%, 6.73–9 mm 28%, 6–6.73 mm 41%, 4–6 mm 7%, 2–4 mm 3.5%, <2 mm 1.5%) which was overlaid by a 50 mm layer of choker sand (>2 mm 0.1%, 1–2 mm, 7.6%, 0.5–1.0 mm 26%, 0.25–0.5 mm 45.6%, 0.15–0.25 mm 19.1%, 0.053–0.15 1.2%, <0.053 0.6%). Similarly a layer was installed outside the lysimeter so the soil profiles were alike. Subsequently, mason sand was packed around, between, and within each of the lysimeters to a depth of 855 mm. Perimeter irrigation systems were installed on each of the main plots. The irrigation system comprised of 24 mm diam. Schedule 40 PVC pipe with rotor Rainbird 3500 sprinklers placed in each corner adjusted to spray an inward quarter circle.

St. Augustinegrass and bahiagrass were sodded in their designated plots. Additionally, berm areas were also sodded with

Table 2. Total rainfall, total irrigation, and average daily air temperature for each cycle of the trials at Ft. Lauderdale, FL.

Study† period	Cycle	No. days	Rainfall	Irrigation	Min. air temp.	Max. air temp.	Avg. air temp.
			mm		°C		
2006–2007	1	60	173	145	6	31	23
	2	92	120	213	8	30	22
	3	32	57	69	12	29	22
	4	61	348	127	12	34	25
	5	58	525	162	15	35	27
	6	55	435	91	22	35	28
	Total	358	1658	807	–	–	–
2007–2008	1	70	210	178	10	32	24
	2	60	142	135	3	30	21
	3	60	157	137	8	32	23
	4	62	158	145	17	35	26
	5	71	439	112	21	35	28
	6	63	432	170	22	32	26
	Total	386	1538	877	–	–	–

† 2006–2007 Cycle 1, 12 Oct. 2006 to 11 Dec. 2006; Cycle 2, 12 Dec. 2006 to 14 Mar. 2007; Cycle 3, 15 Mar. 2007 to 16 Apr. 2007; Cycle 4, 17 Apr. 2007 to 17 June 2007; Cycle 5, 18 June 2007 to 15 Aug. 2007; Cycle 6, 16 Aug. 2007 to 10 Oct. 2007; 2007–2008 Cycle 1, 11 Oct. 2007 to 20 Dec. 2007; Cycle 2, 21 Dec. 2007 to 19 Feb. 2008; Cycle 3, 20 Feb. 2008 to 20 Apr. 2008; Cycle 4, 21 Apr. 2008 to 22 June 2008; Cycle 5, 23 June 2008 to 2 Sept. 2008; Cycle 6, 3 Sept. 2008 to 5 Nov. 2008.

St. Augustinegrass. Within the first week after sod installation, a blended granular fertilizer (26–3–11) was applied to all the plots at a rate of 50 kg N ha^{-1} yr^{-1}.This was followed a month later with an application of 6–6–6 at a rate of 50 kg N ha^{-1} yr^{-1}. Before the actual initiation of the trials, grass was allowed to establish for a period of 6 mo. Throughout the first 3 mo of the establishment period irrigation was applied three times a week at 13 mm per application. However, for the final 3 mo of establishment, irrigation was adjusted to 2.5 mm per day.

Water use rates were determined by using the following calculation WURs = (rainfall + irrigation) – (percolate + runoff) (Park et al., 2005). Runoff was omitted from the equation, as it was never observed. Rainfall data was obtained from a Florida Automated Weather Network (FAWN) station which was located within 500 m of the test site. Percolate volumes were measured weekly and more frequently following precipitation events exceeding 25 mm.

Analysis of Data

All data were analyzed for normality using the Shapiro-Wilk W test. Homogeneity of variance was also checked graphically. Clipping yields and WURs were totaled for each fertilizer cycle and year. Quality ratings were averaged over each FC and trial. Analyses were performed on individual fertilizer cycle–trial data because the length of the fertilizer cycles varied from trial to trial. All data were subjected to analysis of variance with PROC GLM (SAS Institute, 1999) and means were separated using Fisher's Least Significant Difference (LSD) at the t-probability level of 0.05.

RESULTS

Climate

Average daily temperatures ranged from 22 to 28°C for Trial 1 (12 Oct. 2006–10 Oct. 2007) and 21 to 28°C for Trial 2 (11 Oct. 2007–5 Nov. 2008) (Table 2). However, in both trials air temperatures were generally lower in FC1, FC2, and FC3 compared to FC4, FC5, and FC6. Rainfall varied slightly between trials. During Trials 1 and 2 plots received a total of 1658 mm and 1538 mm of rainfall (Table 2). Furthermore, rainfall in both trials was generally greater during FC4, FC5, and FC6 compared to FC1, FC2, and FC3.

Turfgrass Growth and Quality

Clipping yields were affected by grass ($P < 0.01$) and N rate ($P < 0.01$) in both trials (Tables 3 and 4). Clipping yields from each FC (Trial 2, FC3) were greater for bahiagrass than St. Augustinegrass (Tables 3 and 4). Total clipping yields for each trial were approximately four times greater from bahiagrass compared to St. Augustinegrass, averaging 6988 and 1510 kg ha^{-1} for Trial 1 and 4457 and 1369 kg ha^{-1} for Trial 2, respectively. In general both grasses produced the greatest CYs during FC4, F C5, and FC6 (Tables 3 and 4). Additionally, the higher N rate (averaged across grasses) significantly increased CYs by about 60% for each trial. In both trials, for each cycle except FC1 and FC3 in Trial 1 increasing the N rate from 98 to 294 kg ha^{-1} yr^{-1} significantly increased clipping yields.

Both grass species and N rates produced acceptable quality (>6.5) when averaged across each trial. Bahiagrass quality scores were equal to or higher than St. Augustinegrass across both trials but were only significantly different in ($P < 0.05$) in three out of the 12 cycles (Tables 5 and 6). Although, the higher N rate always produced higher quality scores than the lower N rate. It was only significantly higher in FC1, FC2, FC3, and FC5 in trial 1 (Table 5) and FC3, FC6 in Trial 2 (Table 6). Although the lower N rate produced acceptable quality when averaged across trials, there were times when quality was not acceptable, such as FC3 in Trial 1 and FC2, FC3, and FC6 in Trial 2.

Turfgrass Water Use Rate

Total water use rate (TWURs) was greater ($P < 0.05$) from bahiagrass compared to St. Augustinegrass during Trial 1, averaging 1508 and 1286 mm, respectively (Table 7). However, no significant difference was seen between the grasses during Trial 2 (Table 8). In Trial 1, bahiagrass showed significantly greater WURs in three out of the six cycles, but bahiagrass WURs were only significantly greater in one cycle out of the six cycles in Trial 2 (Tables 7 and 8). In general, both grasses had higher WURs during FC4, FC5, and FC6 of both trials. The high N

Table 3. Trial 1 treatment means (*n* = 4) for dry weight of clippings of bahiagrass and St. Augustinegrass at two N application rates.

Factor		2006–2007						
		FC1	FC2	FC3	FC4	FC5	FC6	Total
		kg ha^{-1}						
Grass (G)								
Bahiagrass		250	205	335	1316	2463	2373	6988
St. Augustinegrass		44	89	89	233	564	492	1510
Significance		**	ns†	*	*	**	**	**
LSD 0.05		81	–	194	1005	846	586	2328
Nitrogen, kg ha^{-1} yr^{-1}								
98		134	99	189	567	1211	1107	3307
294		204	195	234	982	1817	1759	5191
Significance		ns	*	ns	*	*	*	*
LSD 0.05		–	66	–	398	544	447	1490
G × N interaction								
Bahiagrass	98	236	161	311	1051	2200	2020	5978
Bahiagrass	294	354	250	359	1581	2726	2727	7998
St. Augustinegrass	98	33	18	68	83	222	193	636
St. Augustinegrass	294	55	29	109	383	906	790	2384
Significance		ns	ns	ns	ns	ns	ns	ns

* $P < 0.05$.
** $P < 0.01$.
† ns, $P > 0.05$.

rate ($P < 0.05$) increased TWURs by about 8% in Trial 1, no significant difference was found in Trial 2 (Tables 7 and 8).

DISCUSSION

With increasing concern over scarcity of water resources, pressure has been placed on residents to reduce water use, especially when it comes to irrigation of landscape areas such as yards and flower beds. While St. Augustinegrass is the most widely used grass for home yards in Florida, it has been suggested that bahiagrass should be used instead for its lower water use. In this study the quality, growth and WURs of two grasses were compared under well-watered conditions using two N rates commonly applied by the lawn care industry. Results indicate that St. Augustinegrass WURs were comparable or less than bahiagrass maintained in field conditions.

In the current study the TWURs for St. Augustinegrass were 1286 mm during Trial 1 and 1200 mm during Trial 2, which is higher than that reported previously for St. Augustinegrass by Stewart and Mills (1967) 1067 mm yr^{-1} and Park et al. (2005) 855 mm yr^{-1}. Total WURs for both grasses was higher during Trial 1 than Trial 2. A similar trend was observed in CYs, whereby yields were greater in Trial 1 than

Table 4. Trial 2 treatment means (*n* = 4) for dry weight of clippings of bahiagrass and St. Augustinegrass at two N application rates.

Factor		2007–2008						
		FC1	FC2	FC3	FC4	FC5	FC6	Total
		kg ha^{-1}						
Grass (G)								
Bahiagrass		393	nd†	145	659	2066	1193	4457
St. Augustinegrass		105	nd	171	128	367	598	1369
Significance		**		ns‡	*	**	**	**
LSD 0.05		146		–	349	780	302	1552
Nitrogen, kg ha^{-1} yr^{-1}								
98		186	nd	65	257	985	700	2193
294		312	nd	251	529	1449	1091	3633
Sig.		*		*	**	*	*	*
LSD 0.05		74		128	141	377	322	1000
G × N interaction								
Bahiagrass	98	399	nd	102	490	1812	1039	3783
Bahiagrass	294	446	nd	188	827	2321	1346	5130
St. Augustinegrass	98	32	nd	29	24	157	360	601
St. Augustinegrass	294	178	nd	314	232	577	836	2137
Significance		ns		ns	ns	ns	ns	ns

* $P < 0.05$.
** $P < 0.01$.
† nd = No data was collected during this cycle.
‡ ns, $P > 0.05$.

Table 5. Trial 1 treatment means (*n* = 4) for turfgrass quality of bahiagrass and St. Augustinegrass at two N application rates.

Factor		2006–2007						
		FC1	FC2	FC3	FC4	FC5	FC6	Avg.
		1–9						
Grass (G)								
Bahiagrass		7.2	6.9	7.0	7.5	7.1	7.0	7.2
St. Augustinegrass		6.6	6.6	6.6	6.7	6.8	6.8	6.7
Significance		***	ns†	ns	ns	ns	ns	ns
LSD 0.05		0.3	–	–	–	–	–	–
Nitrogen, kg ha^{-1} yr^{-1}								
98		6.7	6.5	6.4	6.8	6.7	6.8	6.7
294		7.2	7.1	7.1	7.4	7.2	7.1	7.2
Significance		**	*	*	ns	*	ns	*
LSD 0.05		0.3	0.6	0.5	–	0.3	–	0.4
G × N interaction								
Bahiagrass	98	7.0	6.8	6.6	7.3	7.0	7.0	7.0
Bahiagrass	294	7.4	7.2	7.3	7.7	7.2	7.2	7.4
St. Augustinegrass	98	6.3	6.2	6.3	6.3	6.4	6.7	6.4
St. Augustinegrass	294	7.0	7.1	6.8	7.1	7.2	7.0	7.1
Significance		ns	ns	ns	ns	ns	ns	ns

* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.
† ns, $P > 0.05$.

Trial 2. Increased evaporative demand coupled with reduced water inputs during Trial 2 (Table 2) likely contributed to the lower CYs seen during Trial 2, which may explain why TWURs was lower in Trial 2 compared to Trial 1.

Throughout both trials WURs was generally comparable between both grasses, and in some cases WURs were even greater for bahiagrass compared to St. Augustinegrass (Tables 7 and 8). This may be explained by the fact that bahiagrass produced significantly greater CYs than St. Augustinegrass, thus requiring more water to support the increased growth (Barton et al., 2009; Brian et al., 1981). For example, Barton et al. (2009) found that growth accounted for 75% of the variation in ET in kikuyu turfgrass. Furthermore, differences in WURs between bahiagrass and St. Augustinegrass may also be explained by leaf orientation and shoot density differences between the two grasses: St. Augustinegrass has a higher shoot density and a substantial horizontal leaf orientation compared to bahiagrass which has a more vertical leaf orientation and a low shoot density (Kim and Beard, 1988). This vertical leaf orientation and lower shoot density of bahiagrass leads to lower canopy resistance and thus higher ET rates compared to a grass that has a higher canopy resistance (Kim and Beard, 1988; Brian et al., 1981). Water use rates were generally higher in FC4, FC5, and FC6 of each trial. This may be attributed to the greater canopy leaf area

Table 6. Trial 2 treatment means (*n* = 4) for turfgrass quality of bahiagrass and St. Augustinegrass at two N application rates.

Factor		2007–2008						
		FC1	FC2	FC3	FC4	FC5	FC6	Avg.
		1–9						
Grass (G)								
Bahiagrass		7.1	7.0	7.0	7.3	7.3	7.0	7.1
St. Augustinegrass		6.6	6.4	6.3	6.5	6.5	6.4	6.5
Significance		ns†	ns	*	*	ns	ns	ns
LSD 0.05		–	–	0.5	0.7	–	–	–
Nitrogen, kg ha^{-1} yr^{-1}								
98		6.6	6.4	6.3	6.7	6.7	6.3	6.5
294		7.0	7.0	7.0	7.1	7.1	7.1	7.1
Significance		ns	ns	*	ns	ns	*	ns
LSD 0.05		–	–	0.5	–	–	0.4	–
G × N interaction								
Bahiagrass	98	7.0	6.8	6.8	7.1	7.0	6.7	6.9
Bahiagrass	294	7.3	7.3	7.4	7.5	7.5	7.4	7.4
St. Augustinegrass	98	6.3	5.9	5.7	6.3	6.4	5.9	6.1
St. Augustinegrass	294	6.9	6.7	6.6	6.7	6.6	6.8	6.7
Significance		ns	ns	ns	ns	ns	ns	ns

* $P < 0.05$.
† ns, $P > 0.05$.

Table 7. Trial 1 treatment means (*n* = 4) for water use rates of bahaiagrass and St. Augustinegrass at two N application rates.

Factor		2006–2007						
		FC1	FC2	FC3	FC4	FC5	FC6	Total
		mm						
Grass (G)								
Bahiagrass		177	189	114	309	345	374	1508
St. Augustinegrass		122	159	88	238	321	360	1286
Significance		*	–	*	**	–	–	*
LSD 0.05		15	20	11	65	27	10	80
Nitrogen, kg ha^{-1} yr^{-1}								
98		136	160	95	270	319	361	1342
294		162	188	106	277	347	372	1452
Significance		**	*	*	ns†	*	*	*
LSD 0.05		15	20	11	–	27	10	80
G × N interaction								
Bahiagrass	98	170	192	113	326	342	373	1516
Bahiagrass	294	183	187	114	293	349	375	1500
St. Augustinegrass	98	102	128	78	214	297	349	1168
St. Augustinegrass	294	142	190	98	261	346	370	1405
Sig.		ns	ns	ns	ns	ns	ns	ns

* $P < 0.05$.
** $P < 0.01$.
† ns, $P > 0.05$.

and higher evaporative demand due to higher temperatures and longer photoperiod. Throughout the duration of the experiment wilting was never observed in any of the plots. Thus, each grass was evaluated under nondeficit conditions. However, it should be noted that even though bahiagrass used more water than St. Augustinegrass at times in our study, bahiagrass may require less frequent and total irrigation, since bahiagrass has a greater capacity to avoid water stress compared to St. Augustinegrass (Miller and McCarty, 2001) subsequently requiring less frequent irrigation. In addition, bahiagrass has the ability to survive periods when water is not available through its capacity for dehydration avoidance (McCarty and Cisar, 1995) which allows the grass to green up after watering. St. Augustinegrass does not encompass such a mechanism. Therefore, when water becomes limiting the grass normally enters drought and can potentially die. Even though bahiagrass used more water under well-watered conditions in our study, it may be able to survive water deficit conditions better than St. Augustinegrass, thus allowing it to survive under lower and more infrequent water inputs.

Water use rates were also affected by N fertilization rates; however these differences were relatively modest, especially in comparison to the difference between species. Reducing N fertilizer rates by 67% resulted in a 5 to 8% reduction WURs per trial. Similar results were reported for kikuyugrass when decreasing N rates reduced ET (Barton et al., 2009). The reduction in WURs at low N was likely due to the lower water use associated with

Table 8. Trial 2 treatment means (*n* = 4) for water use rates of bahiagrass and St. Augustinegrass at two N application rates.

Factor		2007–2008						
		FC1	FC2	FC3	FC4	FC5	FC6	Total
		mm						
Grass (G)								
Bahiagrass		184	139	220	276	294	185	1298
St. Augustinegrass		159	126	205	264	265	181	1200
Significance		*	ns†	ns	ns	ns	ns	ns
LSD 0.05		14	–	–	–	–	–	–
Nitrogen, kg ha^{-1} yr^{-1}								
98		165	134	208	261	269	179	1215
294		179	131	217	279	290	187	1283
Significance		*	ns	ns	ns	ns	ns	ns
LSD 0.05		14	–	–	–	–	–	–
G × N interaction								
Bahiagrass	98	184	143	221	272	291	182	1293
Bahiagrass	294	185	135	219	280	297	188	1304
St. Augustinegrass	98	146	125	196	250	247	175	1138
St. Augustinegrass	294	173	127	215	278	283	186	1261
Sig.		ns	ns	ns	ns	ns	ns	ns

* $P < 0.05$.
** $P < 0.01$.
† ns, $P > 0.05$.

reduced leaf area and CY production seen at low N (Brian et al., 1981; Barton et al., 2009). In the future if water restrictions are heightened for home yards, manipulating of N rates may be a possible management strategy in reducing water use rates of grasses and ultimately conserving water. Throughout the duration of the experiment both grasses produced acceptable turfgrass quality scores demonstrating that both grasses can be used to produce aesthetically pleasing home yards with reduced inputs of irrigation and N. However, CYs showed that St. Augustinegrass (approximately 260%) responded much more to fertilization than bahiagrass (approximately 35%), which was remarkably consistent across both trials. Nevertheless, increasing N rates from 98 to 294 kg ha^{-1} yr^{-1} improved quality in Trials 1 and 2 for both grasses. Finally, clipping production varied greatly between grass species. Bahiagrass growth rate was generally higher than St. Augustinegrass which increased the frequency of mowing especially during FC4, FC5, and FC6 of each trial. This may not be favored by homeowners as it may increase fuel, labor costs, and waste disposal of clippings (Fluck and Busey, 1988). Further work is needed to evaluate bahiagrass response to lower N rates and irrigation as it may be possible to reduce the N rate without compromising turf quality. This may help in reducing WURs rates due to the reduction in growth and the risk of N leaching.

CONCLUSIONS

While the results from this experiment varied across trials, some general conclusions can be made regarding grasses and N management impacts on WURs. First, under nonlimiting water and high N rates, bahiagrass cultivar Pensacola had comparable or higher WURs than St. Augustinegrass cultivar Floratam. Second, both St. Augustinegrass and bahiagrass can be used to produce acceptable quality lawns. However, bahiagrass may require more maintenance due to the faster growth rate especially during the warmer wetter summer months in south Florida. Finally, N rate of 98 kg ha^{-1} yr^{-1} was able to reduce WURs annually though it did not always produce acceptable quality.

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