Long-term Performance of Warm-season Turfgrass Species under Municipal Irrigation Frequency Restrictions

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Abstract. Landscape irrigation frequency restrictions are commonly imposed by water purveyors and municipalities to curtail domestic water use and to ensure adequate water supplies for growing populations during times of drought. Currently, published data are lacking concerning irrigation frequency requirements necessary for sustaining acceptable levels of turfgrass quality of commonly used warm-season turfgrass species. The objective of this 3-year field study was to determine comparative turfgrass quality of drought-resistant cultivars of four warm-season lawn species in the south-central United States under irrigation frequency regimes of 0, 1, 2, 4, and 8× monthly. Turfgrasses used in the study were based on previously reported drought resistance and included ‘Riley’s Super Sport’ (Celebration®) bermudagrass [*Cynodon dactylon* (L.) Pers.], ‘Palisades’ zoysiagrass (*Zoysia japonica* Steud.), ‘Floritam’ st. augustinegrass [*Stenotaphrum secundatum* (Walt.) Kuntze], and ‘SeaStar’ seashore paspalum (*Paspalum vaginatum* Swartz). During each growing season, slightly reduced irrigation volumes and bypassed events resulted from the 8× monthly treatment (34.95 cm, 38.13 cm, and 27.33 cm) compared with the 4× monthly treatment (35.36 cm, 40.84 cm, and 28.70 cm) in years 1, 2, and 3, respectively. For the once weekly treatment, the average fraction of reference evapotranspiration (ET_0) supplied by effective rainfall and irrigation during the summer months was 1.22, 0.67, and 0.83 in years 1, 2, and 3, respectively, and was generally adequate to support acceptable turfgrass quality of all warm-season turfgrasses evaluated. Under the less than weekly irrigation frequency, st. augustinegrass and seashore paspalum generally fell to below acceptable quality levels because the average fraction of ET_0 supplied by effective rainfall and irrigation during the summer months of years 2 and 3 was 0.51, 0.39, and 0.26 for the 2× monthly, 1× monthly, and unirrigated treatments, respectively. Bermudagrass generally outperformed all other species under the most restrictive irrigation frequencies and also did not differ statistically from zoysiagrass. These results show that as irrigation frequency is restricted to less than once per week, species selection becomes an important consideration.

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Turfgrass landscapes provide numerous functional and aesthetic benefits in urban environments (Beard and Green, 1994); however, supplemental water, via irrigation, is often required when rainfall is not sufficient to sustain plant health (Emmons, 1995). Depending on geographic location, water used for outdoor purposes such as turfgrass irrigation has been found to comprise about 30% to 60% or more of domestic water uses (Fernald and Purdum, 1998; Hermitte and Mace, 2012; Mayer et al., 1999). This surge in demand increases risk of water shortages, particularly when high population growth or exceptional drought conditions occur (Baumann et al., 1998; Sisser et al., 2016). To combat this demand, water

purveyors and municipalities often enact landscape watering restrictions (Milman and Polsky, 2016; St. Hilaire et al., 2008).

Commonly, municipal water restrictions are designed to limit landscape irrigation to specific days of the week and/or times of the day (Dziegielewski and Kiefer, 2010; Kenney et al., 2004). For instance, The Southwest Florida Water Management District (2018) uses year-round conservation measures in which lawn watering is limited to no more than twice per week. In contrast, the City of Santa Fe (n.d.), NM, limits watering to three days per week with no irrigation from 10 AM to 6 PM from May to October. In combination with either year-round or seasonal irrigation restrictions, some municipalities or water districts implement restrictions that vary based on the status of their water supply. For example, the San Antonio Water System (SAWS) operates on a tiered or “stage” system in which restrictions are based on water level status of their primary water source: the Edwards aquifer (SAWS, 2017). Along with other conservation measures, the SAWS approach to water conservation has resulted in significant water savings for the San Antonio area (SAWS, 2017).

Municipalities often enact more stringent conservation strategies during severe water shortages caused by drought. For example, SAWS stage 3 water restrictions allow for landscape watering only once every 14 d, whereas stage 4 restrictions may prohibit landscape irrigation entirely until wells are recharged. In 2007, the state of Georgia banned outdoor watering entirely because of severe drought (Campana et al., 2012). In 2011, as the state of Texas experienced its worst single-year drought on record, ≈1000 water systems in the state implemented watering restrictions, and many areas within the state were instructed to cease outdoor watering completely (Gholson et al., 2019; Schmidt and Garland, 2012; Thomas, 2012).

Although the mechanisms by which municipalities and water purveyors enact landscape irrigation restrictions vary, the restrictions may often persist over consecutive years and take place in the presence of rainfall, even if received in sporadic or limited amounts. Furthermore, many homeowner associations, municipalities, and water purveyors have interest in knowing how infrequently water can be applied while maintaining aesthetically pleasing turf. It is difficult to answer this question, given that previous research has focused primarily on either survivability and recovery from prolonged drought periods (Steinke et al., 2010, 2011) or performance under frequent irrigation at defined ET_0 levels (Fontanier et al., 2017; Hejl et al., 2016; Wherley et al., 2014). As such, the extent to which warm-season turfgrass species are able to persist and/or maintain acceptable appearance under limited irrigation frequency or unirrigated conditions receiving only rainfall is largely unknown.

Therefore, the objective of this 3-year field study was to determine comparative turfgrass quality of drought-resistant cultivars

representing four warm-season lawn species in the south-central United States under irrigation frequency regimes of 0, 1, 2, 4, and 8× monthly.

Materials and Methods

Study design and treatment layout. This study was conducted from 2016–19 at the Texas A&M University Turfgrass Field Research Laboratory, College Station, TX. The soil at the study site was characterized as a Boonville fine sandy loam (fine, montmorillonitic, thermic, Vertic Albaqualf). Chemical testing performed at the initiation of the study period indicated that all soil macro- and micronutrient concentrations in plots were sufficient. Drought-resistant cultivars of four widely used warm-season turfgrass species for the region were selected for use in the study: ‘Riley’s Super Sport’ (Celebration®) bermudagrass [*Cynodon dactylon* (L.) Pers.], ‘Palisades’ zoysiagrass (*Zoysia japonica* Steud.), ‘Floratum’ st. augustinegrass [*Stenotaphrum secundatum* (Walt.) Kuntze], and ‘SeaStar’ seashore paspalum (*Paspalum vaginatum* Swartz).

The study was arranged as a split-plot design with three replicate plots per treatment. Irrigation frequency (0, 1, 2, 4, or 8× monthly), based on commonly imposed municipal irrigation restrictions in the region, was the whole-plot factor, whereas grass species (bermudagrass, zoysiagrass, st. augustinegrass, or seashore paspalum) was the subplot factor. Irrigation frequency whole plots measured 6.1 × 6.1 m, whereas species subplots measured 1.2 × 1.2 m. Subplots were established from single 25-cm² plugs planted in July 2016 and allowed to establish for 1 year until a plot size of 1.2 × 1.2 m was achieved. During the establishment period (July 2016–June 2017), plots were irrigated two to three times weekly to encourage grow-in and to prevent wilt. To encourage rapid grow-in of plots from July through Oct. 2016 and May through June 2017, plots were fertilized monthly at a rate of 3.7 g-m⁻² using a 21–7–14 N–P–K fertilizer (American Plant Food Corp., Galena Park, TX) containing 64% N as sulfur-coated urea and the remainder as ammoniacal N. During the remainder of 2017 through 2019, N was applied between May and October at 3.7 g-m⁻² every 6 weeks using the same previously mentioned fertilizer. All plots were mowed during the establishment and study period using a rotary mower at a 6.3-cm height of cut, representative of a typical lawn height for the region, with clippings returned to plots. Pre-emergence herbicides were applied to plots during February and September of all years of the study using oxadiazon (Ronstar G, Bayer Environmental Sciences) at an active ingredient rate of 2.25 kg-ha⁻¹. Henceforth, the 2017, 2018, and 2019 growing seasons are referred to as years 1, 2, and 3, respectively.

Irrigation treatments. Irrigation frequency treatments were imposed from July through October of year 1, from late May through October of year 2, and from late May through August of year 3. No irrigation was applied during the

slow-growth/dormant-season months of November through April. The 1, 2, and 4× monthly frequency treatments received irrigation at a depth of 2.5 cm beginning Monday night of each planned irrigation event. The 8× monthly treatment was irrigated twice weekly to a depth of 1.25 cm, resulting in 2.5 cm per week. This amount was calculated based on the depth of water needed to replenish available water within a fine sandy loam soil with a 17.8-cm root zone (U.S. Department of Agriculture–Natural Resources Conservation Service, 1998). Irrigation events were cycle-soaked Monday night to Tuesday morning each week for the 1, 2, and 4× monthly treatment, and applied Tuesday morning and Friday morning for the 8× monthly treatment. Whole-plot irrigation was supplied via four in-ground rotor sprinklers (T5; The Toro Co., Windom, MN) located at the corners of each plot and were measured to have a precipitation rate of 3 cm-h⁻¹. Each replicate whole plot was controlled individually by a valve and flow meter that were audited monthly to ensure accuracy of applied irrigation. All irrigation was applied between the hours of 10 PM and 8 AM, and cycle soak methods were used during all irrigation applications to prevent water runoff. The only water unirrigated plots received after the establishment period was from natural precipitation, which was measured onsite and accounted for throughout the study period (Table 1). For the 4 and 8× monthly irrigation treatments, the irrigation schedule was adjusted to account for effective rainfall received in the 72-hour period before the scheduled irrigation. For the 1 and 2× monthly

treatments, irrigation events were delayed one week if rainfall ≥ 2.5 cm occurred during the week before the scheduled irrigation. Effective rainfall was calculated using a method developed by the Texas A&M AgriLife Extension Service (2015), which assumes the first 2.5 cm of rainfall is 100% effective, rainfall of 2.5 to 5 cm is 67% effective, and rainfall > 5 cm is considered 0% effective. A summary of all rainfall and irrigation events during the measurement periods is provided in Table 2. Real-time weather data for the study were accessed through the Texas ET Network (texaset.tamu.edu), with data obtained from an onsite weather station (Campbell Scientific, Logan, UT). Reference evapotranspiration was calculated using the FAO Penman-Monteith equation (Allen et al., 1998).

Evaluation of turfgrass quality. Turfgrass quality data were collected on a twice monthly schedule during the summer months of year 1 (July–Aug. 2017), year 2 (May–Aug. 2018), and year 3 (May–Aug. 2019). Data were not collected until July of year 1 because plots had not yet reached full establishment. Plots were evaluated for turfgrass quality using a modified National Turfgrass Evaluation Program visual quality ranking system, which uses a 1- to 9-point scale for turfgrass quality (Morris and Shearman, 1998) based on combined turfgrass attributes including color, density, and uniformity. For reference, a value of 1 indicates completely dead or dormant brown turf, a value of 5 represents minimum acceptable quality, and 9 indicates perfect green turf.

Table 1. Daily mean reference evapotranspiration (ET_o) and precipitation amounts for the 2017–19 study period.

Month	Daily mean ET _o (mm)			Monthly total precipitation (cm)		
	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
June	—	6.27	5.35	—	6.19	11.94
July	6.68	6.36	6.11	0.97	4.45	1.24
August	5.42	6.41	6.25	47.49	0.51	4.69
September	4.87	3.51	—	1.72	15.75	—
October	3.81	2.88	—	5.91	35.53	—

Table 2. Total number of rainfall and irrigation events with corresponding effective rainfall depth, irrigation volumes applied, and cumulative water received (effective rainfall + irrigation) for each irrigation frequency treatment during years 1 through 3 of the irrigation study.

Yr ²	Irrigation frequency	Rain events (n)	Irrigation events (n)	Effective rainfall (cm)	Irrigation applied (cm)	Cumulative water received (cm)
1	Unirrigated	12	0	26.11	0.00	26.11
	1× monthly	12	4	26.11	10.16	36.27
	2× monthly	12	8	26.11	20.32	46.43
	4× monthly	12	14	26.11	35.36	61.47
	8× monthly	12	30	26.11	34.95	61.06
2	Unirrigated	45	0	50.04	0.00	50.04
	1× monthly	45	6	50.04	15.24	65.28
	2× monthly	45	11	50.04	27.94	77.98
	4× monthly	45	17	50.04	40.84	90.88
	8× monthly	45	34	50.04	38.13	88.17
3	Unirrigated	26	0	19.81	0.00	19.81
	1× monthly	26	3	19.81	7.62	27.43
	2× monthly	26	7	19.81	16.15	35.96
	4× monthly	26	13	19.81	28.70	48.51
	8× monthly	26	24	19.81	27.33	47.14

²Years 1, 2, and 3 irrigation and rainfall data are for July through Oct. 2017, late May through Oct. 2018, and late May through Aug. 2019, respectively.

Data analysis. At the conclusion of the project, all data were subjected to analysis of variance procedures using the general linear model of SPSS (ver. 25.0; IBM, Armonk, NY). When significant treatment $\times$ year interactions were detected, data were presented separately by year. Means were compared using Tukey's honestly significant difference test using a significance level of $P \leq 0.05$.

Results and Discussion

Environmental conditions and water applied during summer. Cumulative effective rainfall during the irrigation treatment period was 26.11 cm, 50.04 cm, and 19.81 cm for years 1, 2, and 3, respectively (Table 2). During the initial month of irrigation treatments (July 2017), seasonal evaporative demand coupled with below-average monthly irrigation treatments (the two highest application frequencies) replenished only 48% and 45% of monthly ET_o (Table 3). This would have produced an estimated 20% to 25% irrigation deficit compared to consumptive water requirements for warm-season turfgrass, which have been reported to average 60% of ET_o (Wherley et al., 2015). Also during this time, the 1 and 2 $\times$ monthly irrigation treatments received only 12% and 25% of monthly ET_o , respectively, which would have produced a 60% to 80% irrigation deficit (Table 3). However, these deficits were replenished quickly by above-average rainfall in late August of year 1, which resulted in each treatment receiving at least 148% of ET_o during the month (Table 3). During year 2, below-average rainfall in August resulted in only 54% of ET_o being replaced by the most frequent irrigation schedule (Table 3). In contrast, unirrigated plots received only 7% and 24% of ET_o during the months of July and August in year 3, respectively (Table 3), resulting in an estimated 88% and 60% irrigation deficit, respectively.

With the exception of the 4 and 8 $\times$ monthly irrigation treatments, total irrigation applied increased with increased frequency (Table 2). Irrigation applied and cumulative water received were similar to slightly greater

in the 4 $\times$ monthly compared with the 8 $\times$ monthly irrigation frequency treatment as a result of the timing of rainfall events and method of scheduling irrigation.

Effects of irrigation frequency on mean visual turfgrass quality. Analysis of variance showed a highly significant ($P < 0.001$) month-by-irrigation frequency interaction on turfgrass visual quality for each year of the study (Table 4). In year 1, despite a large water deficit in July, each irrigation treatment supported acceptable (≥ 5 points) turfgrass quality (when pooling across all species), which is likely a result of residual soil water from the establishment period as well as the shorter duration of the water deficit (Table 5). When pooling across all species during July of year 2, the unirrigated treatment resulted in unacceptable turfgrass quality, and did not significantly differ from the 1 or 2 $\times$ monthly treatments (Table 5). Irrigation limited to 1 $\times$ monthly supported acceptable turfgrass quality until August of year 2, at which time only the 4 and 8 $\times$ monthly treatments showed acceptable turfgrass quality (Table 5). By June of year 3, turfgrass quality within all irrigation frequency treatments except the unirrigated control had recovered to acceptable levels. This could be attributed to nearly double the historical average rainfall received (137 cm) between September of year 2 and May of year 3 (Table 5). Rainfall in this amount is atypical for this region, given average rainfall amounts during this period are 78 cm. However, by July of year 3, the 2 and 1 $\times$ monthly frequency treatments had fallen to unacceptable quality levels (Table 5). These results suggest that when pooling across all species, weekly irrigation is generally required to support minimally acceptable turfgrass quality if applied over consecutive seasons.

In practice, most municipal water restrictions requiring less than 1 $\times$ weekly irrigation are only implemented periodically. How a more dynamic system of restrictions may influence turfgrass quality can only be speculated from these data. Water restrictions aim to reduce water use, but they are only as effective as the enforcement mechanism (Ozan and Alsharif, 2013). As lawns wilt or fire in response to drought stress during municipal water restriction periods, it is

Table 4. Analysis of variance table for month (M), irrigation frequency (IF), and species (S) effects and interactions on turfgrass visual quality during the 3-year study.

Variable	P value		
	Year 1	Year 2	Year 3
M	NS	***	**
IF	*	***	***
S	NS	***	***
M $\times$ IF	***	***	***
M $\times$ S	NS	***	NS
IF $\times$ S	NS	***	*
M $\times$ IF $\times$ S	NS	NS	NS

Year-by-treatment interactions were significant, so data are presented separately by year.

NS, *, **, ***Nonsignificant or significant at $P = 0.05$, 0.01, or 0.001, respectively.

Table 5. Average monthly turfgrass visual quality for each year as affected by irrigation frequency.

Yr	Irrigation frequency	June	July	August
1	Unirrigated	—	6.75 ab	6.13 b
	1 $\times$ monthly	—	6.67 ab	6.42 b
	2 $\times$ monthly	—	6.83 a	6.25 b
	4 $\times$ monthly	—	6.58 ab	7.08 a
	8 $\times$ monthly	—	6.25 b	7.08 a
	P value		*	***
2	Unirrigated	5.42 c	4.38 b	1.88 d
	1 $\times$ monthly	5.58 bc	5.04 b	3.37 c
	2 $\times$ monthly	5.67 bc	5.17 b	4.58 b
	4 $\times$ monthly	6.17 ab	6.38 a	5.25 ab
	8 $\times$ monthly	6.63 a	6.71 a	6.08 a
	P value	***	***	***
3	Unirrigated	4.83 a	4.67 a	3.63 c
	1 $\times$ monthly	5.17 a	4.53 a	4.13 bc
	2 $\times$ monthly	5.17 a	4.94 a	4.67 ab
	4 $\times$ monthly	5.08 a	5.00 a	5.33 a
	8 $\times$ monthly	5.08 a	4.81 a	5.46 a
	P value	NS	NS	***

Data are pooled across species. Means with the same letter are not significantly different based on Tukey's honestly significant different test at $P \leq 0.05$.

NS, *, **, ***Nonsignificant or significant at $P = 0.05$, 0.01, or 0.001, respectively.

possible that on allowable watering days, homeowners may overapply water (beyond soil field capacity) with the intention to aid in recovery or in hopes of maintaining quality. As such, without proper enforcement mechanisms, water savings could be somewhat negated. Further research is needed to ascertain the amount of irrigation per event that would allow for optimal turfgrass quality under longer irrigation intervals.

Species response to irrigation frequency. There were highly significant irrigation frequency-by-species interactions for turfgrass quality during years 2 ($P < 0.001$) and 3 ($P < 0.05$) (Table 4). When pooling across months during year 2, unirrigated (rainfall only) conditions led to unacceptable turfgrass quality in all species. Turfgrass quality of seashore paspalum (3 of 9 points) was significantly less than that of zoysiagrass (4.2 of 9 points), st. augustinegrass (4.5 of 9 points), and bermudagrass (4.7 of 9 points) in year 2 with only rainfall (Fig. 1).

Table 3. Fraction of reference evapotranspiration supplied by effective rainfall and irrigation by irrigation frequency treatments for each year and month during the study period.

Yr	Irrigation frequency	June	July	August	September	October
1	Unirrigated	—	0.00	1.48	0.13	0.34
	1 $\times$ monthly	—	0.12	1.48	0.31	0.34
	2 $\times$ monthly	—	0.25	1.79	0.52	0.77
	4 $\times$ monthly	—	0.48	1.95	1.04	0.98
	8 $\times$ monthly	—	0.45	1.87	1.48	1.01
2	Unirrigated	0.30	0.23	0.03	1.45	2.70
	1 $\times$ monthly	0.43	0.35	0.15	1.69	2.99
	2 $\times$ monthly	0.57	0.48	0.28	1.93	3.27
	4 $\times$ monthly	0.68	0.83	0.51	2.11	2.99
	8 $\times$ monthly	0.70	0.74	0.54	1.95	2.98
3	Unirrigated	0.69	0.07	0.24	—	—
	1 $\times$ monthly	0.85	0.20	0.37	—	—
	2 $\times$ monthly	0.91	0.33	0.50	—	—
	4 $\times$ monthly	1.07	0.71	0.72	—	—
	8 $\times$ monthly	1.07	0.60	0.69	—	—

Fig. 1. Warm-season turfgrass visual quality as influenced by irrigation frequency regimes for years 2 and 3. The solid horizontal line indicates the minimum acceptable quality. Data are pooled across months. Means with the same letter are not significantly different based on Tukey's honestly significant difference test at $P \leq 0.05$ for each irrigation frequency. ns, not significant.

In year 3 of the study, bermudagrass was able to maintain acceptable quality under all irrigation frequency treatments, and it supported significantly greater turfgrass quality compared with st. augustinegrass at all frequencies, although differences were not significant under the 8× monthly treatment (Fig. 1). Interestingly, zoysiagrass supported statistically similar turfgrass quality to bermudagrass under all irrigation frequencies and during all years of the study. However, zoysiagrass turfgrass quality fell to below-acceptable levels for the 1× monthly and unirrigated treatments during both years 2 and 3.

The superior drought resistance and ability to maintain acceptable quality under infrequent irrigation observed in bermudagrass have been attributed to its strong drought avoidance attributes, which include deep rooting potential and somewhat lower evapotranspiration rates compared with other species (Carrow, 1995, 1996). Although prior

studies have characterized *Zoysia* spp. as having relatively shallow root systems, making them more sensitive to drying soil than bermudagrass (Carrow, 1996; Qian and Engelke, 1999), the cultivar used in our study ('Palisades') was shown previously to have a relatively high root dry weight in comparison with 14 other zoysiagrass genotypes (Jespersen and Schwartz, 2018). 'Palisades' also showed a stronger propensity for deep (25–50 cm) rooting compared with six other (predominantly finer texture) zoysiagrasses in a 2-year Dallas, TX, field study (Wherley et al., 2014). Hong and Bremer (2020) determined in a study conducted in Manhattan, KS, that reduced turfgrass damage resulted from irrigating Meyer Japanese lawngrass at 20% to 30% × ET_0 . However, it is difficult to relate these findings to when irrigation frequency is restricted, because these irrigation amounts were supplied weekly.

St. augustinegrass maintained similar turfgrass quality to bermudagrass and zoysiagrass in years 1 and 2. However, relatively high rainfall and wet soil conditions received during Fall of year 2 contributed to high incidence of large patch disease (*Rhizoctonia solani*) in plots, which limited recovery from drought stress between years 2 and 3. Consequently, turfgrass quality of st. augustinegrass in year 3 (which ranged from ≈4–5 of 9 points) was significantly less than that of bermudagrass and zoysiagrass across all irrigation frequency treatments except 8× monthly. It was also lower than that of seashore paspalum at all irrigation frequencies except for the unirrigated treatment (Fig. 1). In a study conducted in the 2015 and 2016 growing seasons in Dallas, TX, numerous st. augustinegrass genotypes required no irrigation events to maintain ≥50% green cover in either growing season (Meeks and Chandra, 2019). As such, it is possible that other st. augustinegrass genotypes could respond better to the irrigation restrictions used in our study.

In years 2 and 3, seashore paspalum was only able to achieve acceptable quality at the highest two (4 and 8× monthly) irrigation frequencies (Fig. 1). In year 2, turfgrass quality of the unirrigated and 2× monthly frequency treatments was significantly less for seashore paspalum than for all other species. In year 3, turfgrass quality for the unirrigated treatment was significantly less for seashore paspalum than for bermudagrass or zoysiagrass (Fig. 1). Although not yet widely used as a warm-season amenity lawn grass in most of the United States, the response of seashore paspalum to the most stringent irrigation frequencies is consistent with the findings of Jespersen et al. (2019), who reported 'SeaStar' seashore paspalum demonstrated the poorest drought response in a greenhouse study involving 'Celebration' bermudagrass, two hybrid bermudagrasses, and two other seashore paspalum cultivars.

This study sought to determine minimal irrigation frequencies needed to support an acceptable aesthetic quality of commonly used warm-season turfgrass species. As such, the data should not be misinterpreted as representative of irrigation amounts required for survival. A number of previous studies have reported on the potential of warm-season grasses to enter dormancy, survive, and recover from severe, longer term drought periods (Hejl et al., 2016; Hong and Bremer, 2020; Steinke et al., 2010, 2011). Unfortunately, at the current time, most communities and/or homeowner associations do not tolerate the straw-colored appearance of dormant lawns (Ozan and Alsharif, 2013; Steinberg, 2006), which remains a challenge for the long-term viability of turfgrass in the modern landscape.

Conclusion

Landscape watering restrictions are commonly enforced as water purveyors and municipalities seek to mitigate discretionary domestic water use to ensure adequate water supplies for growing populations and during

times of drought. Application of such policies has rarely considered irrigation frequency requirements needed to support acceptable appearance among turfgrass species. Our results from this 3-year field study indicate that, on average, the warm-season turfgrass species used were able to maintain acceptable visual quality while being irrigated at frequencies limited to once per week in this central Texas climate. Among the four species included, bermudagrass (cultivar Celebration) maintained acceptable visual quality across the broadest set of irrigation frequencies. Zoysiagrass (cultivar Palisades) performed similarly to bermudagrass at most irrigation frequencies, suggesting that selection of drought-resistant cultivars within a given species is an important consideration when selecting drought-adapted landscape grasses. Continued research in this area is important for helping to understand more fully species limitations to irrigation restrictions, and future studies should be conducted in the absence of rainfall, which may have influenced the results of this study to some degree. Collectively, these studies will become increasingly important as municipal irrigation frequency restrictions become more common.

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