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How Do Warm-Season Grasses React to Deficit Irrigation in California?

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A total of 20 entries of bermudagrass, zoysiagrass, and buffalograss irrigated at 30%, 45%, or 60% ET_o. Photo taken on Sept 11, 2019.

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The Bottom Line:

Twenty warm-season turfgrasses comprising three species were irrigated at three reference evapotranspiration (ET_o) replacement levels (60% ET_o, 45% ET_o, and 30% ET_o) from June to October 2019 and evaluated for visual turfgrass quality and percent green cover using digital image analysis. Broad variation was observed among species and entries. Overall, bermudagrass maintained the best color and quality under deficit irrigation followed by zoysiagrass and then buffalograss. Most bermudagrass and zoysiagrass entries maintained >60% green cover at 60% ET_o, while bermudagrass maintained acceptable quality during every month except September. Only UCR 17-8, a local bermudagrass genotype, maintained green cover of 60% or higher at 45% ET_o replacement in most months, and Tahoma 31 had comparable green coverage from June to September at the same ET_o replacement. Starting from September, green cover of all entries dropped below 20% at the 30% ET_o replacement.

Justification

Water conservation is increasingly important when selecting turfgrass species and cultivars. Different practices have been investigated in order to reduce water use while maintaining quality turfgrass. Warm-season turfgrasses are generally more drought resistant than cool-season grasses and thus are recommended in regions where they are adapted. Furthermore, deficit irrigation is a common practice for water conservation in areas where water is limited or restricted. In this study, three species of warm-season grasses (bermudagrass, buffalograss, and zoysiagrass) were evaluated under deficit irrigation conditions.

Objectives

The objective of this study was to determine the amount of water needed to sustain acceptable turfgrass quality and to identify cultivars and species best adapted to drought and deficit irrigation.

Materials and Method

The study was conducted at the UC Riverside turfgrass research facility in Riverside, CA (Plant Hardness Zone 9b). Turf was established on 22 June 2018 on a Hanford fine sandy loam. Three species (bermudagrass, zoysiagrass, and buffalograss) with a total of 20 entries were evaluated in replicate plots (Table 1). The study area was maintained under fairway conditions, mowed 3 times per week at 0.5 inch, and fertilized with 0.5 lbs N/month during the growing season. Weather data are presented in Table 2. Plots were subjected to deficit irrigation at 60%, 45% and 30% ET_o replacements from 1 June to 15 Oct 2019. Little or no natural precipitation was recorded during that time period. Thereafter, non-limiting irrigation was returned for turf recovery.

During the deficit irrigation period, plots were evaluated monthly for turf quality on a scale from 1-9 (9 = best). On the same day, percent green cover was recorded using digital image analysis (DIA). Visual turf quality and percent green cover were also determined in December following reintroduction of non-limiting irrigation combined with rainfall. Data were subjected to analysis of variance (ANOVA). When necessary, multiple comparisons of means were assessed using Fisher's protected least significant difference test at the 0.05 probability level.

Results

In 2019, the tested entries showed a wide range of variability in response to deficit irrigation (Tables 3 and 4). Only the entry by date interaction affected turf quality, so data were averaged across ET_o (Table 3). We observed a broad variation of turf quality both within and among species (Table 3, Figs. 1-1, 1-2, and 1-3). Among bermudagrasses, from June to August, entries FB1628, Tahoma 31, and UCR 17-8 appeared in the top statistical groups for at least the first 2 months, regardless of ET_o replacement (Table 1). In the later stages of deficit irrigation from September to October, Dog Tuff, TifTuf, UCR 17-8, and UCR BF1 had higher quality in both months. Among zoysiagrasses, the experimental line FAES 1306 consistently exhibited better quality compared to other entries. Small differences were observed between the two buffalograsses. Among the three species, bermudagrass showed better drought and heat responses compared to zoysiagrass or buffalograss in late summer (Figs. 1-1, 1-2, and 1-3). Concerning ET_o replacement, starting from July, there was a significant reduction in turfgrass quality at the 30% ET_o replacement compared to 45 and 60% ET_o replacements (Fig. 2). Thereafter, the 45% ET_o replacement significantly reduced turfgrass quality compared to the 60% ET_o replacement (Fig. 2). Averaged across all entries, turfgrass irrigated at 60% ET_o sustained acceptable quality most of the time (except September) during the study period.

Evapotranspiration, entry, and month interaction affected green cover; therefore, data are presented for each ET_o replacement. At 30% ET_o replacement, all entries except Cody buffalograss had > 80% green cover in June, one week after initiating the deficit treatment (Table 4-1). The greatest separation among entries was observed in July. Entries such as Premier Pro bermudagrass dropped in green cover to 28.4%, while other bermudagrasses such as FB 1628, OKC 1221, Tahoma 31, TifTuf, Tifway, and UCR 17-8 had green cover above 70%. Green cover continued to decrease in August and September. At 45% ET_o, green cover in October ranged from 20 to 66% for bermudagrass, 15 to 17% for buffalograss, and 17 to 35% for zoysiagrass (Table 4-2). After four months of the deficit irrigation treatment, UCR experimental selection UCR 17-8 and UCR BF1 maintained 66% green cover, higher than all other entries besides Dog Tuff. At 60% ET_o, the percent green cover of all tested entries ranged from 31% to 83% in October (Table 4-3). Entries TifTuf and UCR 17-8 had green cover over 80% after 4-months of deficit irrigation treatment. Differences were also observed among species (Figs 3-1, 3-2, and 3-3). At all ET_o replacements, bermudagrass had relatively higher green cover (Figs 3-1, 3-2, and 3-3). On the other hand, buffalograss consistently exhibited the lowest green cover at 60% ET_o replacement (Fig 3-3).

Quality in late fall also varied among entries (Table 5). Buffalograsses turned dormant with 2% or less green cover on 12 December 2019. Meanwhile, zoysiagrass green cover ranged between 3% to 65%, and no cultivar had acceptable quality at any ET_o replacement. Several entries of bermudagrass exhibited acceptable quality including FB 1628 at 30% ET_o and 45% ET_o, TifTuf at 30% ET_o, 45% ET_o, and 60% ET_o, Tifway at 45% ET_o, and UCR 17-8 at 30% ET_o.

In summary, according to the tested entries in this study, bermudagrass was the most drought-resistant species in comparison to zoysiagrass and buffalograss. Among bermudagrass entries, UCR 17-8 performed well under water deficit conditions. TifTuf and Tahoma 31 showed green cover comparable to UCR 17-8 at 30% and 45% ET_o replacements, respectively. In contrast, buffalograss did not perform well under the study conditions, probably due in part to the low mowing height in which all grasses were maintained. This is an ongoing study and will be repeated in 2020 and 2021.

UCR 17-8 is a bermudagrass hybrid created by our breeding program in 2013. It was selected from ca. 500 hybrids due to performance and uniformity, along with tolerance to drought and winter color retention. UCR 17-8 is characterized by dark green color and high density, and is best adapted for fairways or athletic fields. For the past 7 years it has been tested in various environments across California, from the desert to cooler, northern areas. Currently UCR 17-8 is undergoing fairway tests on golf courses in Northern California along with 3 other UCR entries and 7 commercial cultivars, and is competing well in those locations. UCR 17-8 has high potential for commercial release in the near future.

Acknowledgments

Thanks to the National Turfgrass Evaluation Program (NTEP) and the US Golf Association (USGA) for financial support of this research.

Table 1. Entry list for the 2018 National Warm-Season Water Use and Drought Resistance Test. Riverside, CA.

Entry No.	Name	Species	Sponsors
1	Tifway	Bermuda	Standard Entry
2	Dog Tuff	Bermuda	Todd Valley Farms
3	ASC 118	Bermuda	Allstar Seed Co.
4	ASC 119	Bermuda	Allstar Seed Co.
5	OKC 1221	Bermuda	Oklahoma Ag.Expt. Station
6	Premier Pro	Bermuda	Sod Pro Services
7	Tahoma 31	Bermuda	Sod Pro Services
8	TifTuf ™	Bermuda	Univ. of Georgia
9	JSC 2009-6-s	Bermuda	Johnston Seed Co.
10	Monaco	Bermuda	Barenbrug USA
11	Meyer	Zoysia	Standard Entry
12	Stellar	Zoysia	Turfgrass Development, Inc.
13	FAES 1306	Zoysia	Univ. of Florida
14	FAES 1307	Zoysia	Univ. of Florida
15	FB 1628	Bermuda	Univ. of Florida
16	Prestige	Buffalo	Todd Valley Farms
17	Cody	Buffalo	Standard Entry
18	UCR 17-8	Bermuda	Univ. of California Riverside
19	UCR BF1	Bermuda	Univ. of California Riverside
20	UCR BF2	Bermuda	Univ. of California Riverside

Table 2. Environmental data collected and reported by the California Irrigation Management System (CIMIS) for Station 44 (Riverside) during the study, Riverside, CA. Weather station located nearby the study area.

Month	Total ET_o (in)	Total Precipitation (in)	Avg Max Air Temperature (°F)	Avg Min Air Temperature (°F)	Avg Air Temperature (°F)	Avg Soil Temperature (°F)
May	4.95	0.97	71.2	52.6	60.8	66.9
June	6.49	0.02	83.1	60	69.7	73.4
July	8.03	0.01	91.2	62.7	75.8	74.9
Aug.	7.68	0	93.3	62.5	76.6	74.3
Sep.	5.76	0.01	87.6	62	73.8	74.4
Oct.	5.11	0	82.9	52.8	67	64

Table 3. Turf quality among 20 warm-season turfgrass entries under deficit irrigation in 2019. Data were recorded on 6 June, 4 July, 1 August, 5 September, and 3 October, 2019.

Entry	Species	Turf quality				
		June	July	Aug.	Sep.	Oct
ASC 118	Bermuda	5.3	5.0	5.2	3.8	4.0
ASC 119	Bermuda	5.1	5.0	5.3	3.8	4.1
Dog Tuff	Bermuda	6.9	5.9	5.8	4.4	5.7
FB 1628	Bermuda	8.1	8.0	6.4	3.9	5.1
JSC 2009-6-s	Bermuda	6.1	5.4	4.9	3.6	4.1
Monaco	Bermuda	6.1	6.6	5.2	4.0	4.4
OKC 1221	Bermuda	7.0	7.0	5.0	4.1	3.9
Premier Pro	Bermuda	6.9	5.6	4.2	3.3	3.8
Tahoma 31	Bermuda	7.0	8.1	6.7	4.2	4.8
TifTuf ™	Bermuda	7.3	6.4	6.0	4.5	5.3
Tifway	Bermuda	8.0	6.4	5.7	4.1	5.2
UCR 17-8	Bermuda	8.1	6.6	6.3	4.6	5.2
UCR BF1	Bermuda	7.6	6.3	5.8	4.8	5.5
UCR BF2	Bermuda	8.0	6.2	5.6	4.0	5.1
Cody	Buffalo	5.0	5.0	4.7	4.0	3.3
Prestige	Buffalo	6.0	5.6	4.2	3.8	3.5
FAES 1306	Zoysia	8.2	7.4	5.3	3.8	4.8
FAES 1307	Zoysia	7.2	6.8	5.0	3.4	4.2
Meyer	Zoysia	6.1	4.9	3.9	3.0	3.4
Stellar	Zoysia	7.8	7.0	5.1	3.1	3.8
LSD**		0.6				

*Results are pooled across three ET_o replacements (reference evapotranspiration, 30, 45 and 60%), and three replicates.

**To determine statistical differences among entries, subtract one entry's mean from another entry's mean. Statistical differences occur when this value is larger than the corresponding LSD value ($P < 0.05$).

Table 4-1. Percent green cover of 20 warm-season turfgrasses entries under 30% ET_o in 2019. Data were recorded on 6 June, 4 July, 1 August, 5 September, and 3 October, 2019.

Entry	Species	Green cover (%) at 30% ET_o				
		June	July	Aug.	Sep.	Oct.
ASC 118	Bermuda	85.9	49.4	14.0	9.3	9.7
ASC 119	Bermuda	84.6	52.9	17.8	12.6	13.3
Dog Tuff	Bermuda	84.8	54.3	24.4	11.6	18.6
FB 1628	Bermuda	96.3	80.9	31.1	9.3	13.5
JSC 2009-6-s	Bermuda	93.3	39.8	3.4	2.8	4.2
Monaco	Bermuda	92.3	59.3	11.7	3.6	4.4
OKC 1221	Bermuda	95.8	70.8	9.4	2.5	2.4
Premier Pro	Bermuda	95.7	28.4	0.7	1.2	1.6
Tahoma 31	Bermuda	95.4	82.9	21.5	2.3	3.9
TifTuf ™	Bermuda	97.3	70.8	31.0	13.0	14.5
Tifway	Bermuda	97.0	73.4	14.0	1.0	6.8
UCR 17-8	Bermuda	97.5	76.3	27.3	13.0	19.5
UCR BF1	Bermuda	97.3	54.4	4.2	2.8	6.0
UCR BF2	Bermuda	96.5	48.5	1.8	1.9	3.1
Cody	Buffalo	72.5	36.2	8.4	3.6	1.3
Prestige	Buffalo	81.0	39.4	1.7	1.1	2.0
FAES 1306	Zoysia	97.6	65.0	2.1	0.3	1.7
FAES 1307	Zoysia	96.6	46.4	1.3	1.1	1.8
Meyer	Zoysia	93.8	35.8	1.4	0.2	0.4
Stellar	Zoysia	97.2	55.7	1.4	0.1	0.1
LSD*		15.5				

*To determine statistical differences among entries, subtract one entry's mean from another entry's mean. Statistical differences occur when this value is larger than the corresponding LSD value ($P < 0.05$).

Table 4-2. Percent green cover of 20 warm-season turfgrass entries under 45% ET_o in 2019. Data were recorded on 6 June, 4 July, 1 August, 5 September, and 3 October, 2019.

Entry	Species	Green cover (%) at 45% ET_o				
		June	July	Aug.	Sep.	Oct.
ASC 118	Bermuda	86.7	65	42.5	41.2	40.9
ASC 119	Bermuda	82.5	53.9	33.5	31.9	34.3
Dog Tuff	Bermuda	91	74	38.8	37.6	51.3
FB 1628	Bermuda	95.7	85.5	60.7	43.8	49.1
JSC 2009-6-s	Bermuda	94.3	69.5	22.8	20.3	34.3
Monaco	Bermuda	93	76	34.8	29.7	38.8
OKC 1221	Bermuda	96.9	83.4	32.4	15.2	20.1
Premier Pro	Bermuda	94.4	59.1	4.8	8.9	20.7
Tahoma 31	Bermuda	97.0	87.7	73.9	45.6	36.4
TifTuf ™	Bermuda	96.9	71.2	45.6	35.9	40.4
Tifway	Bermuda	98.1	79.5	34.8	18.9	26
UCR 17-8	Bermuda	98.6	79.2	72	58.8	66
UCR BF1	Bermuda	97	67.9	32.4	49.7	66
UCR BF2	Bermuda	97.4	70.4	22.5	28.9	33.9
Cody	Buffalo	70.7	48.9	27.4	21.1	15.1
Prestige	Buffalo	84.1	52.9	10	9.1	17.1
FAES 1306	Zoysia	97.9	83.7	22.1	17.3	34.7
FAES 1307	Zoysia	96.2	77.2	25.6	12.2	22.4
Meyer	Zoysia	87.9	48.5	16.6	13.7	17.6
Stellar	Zoysia	96.9	76.1	30.1	13.5	16.9
LSD*		15.5				

*To determine statistical differences among entries, subtract one entry's mean from another entry's mean. Statistical differences occur when this value is larger than the corresponding LSD value ($P < 0.05$).

Table 4-3. Percent green cover of 20 warm-season turfgrasses entries under 60% ET_o in 2019. Data were recorded on 6 June, 4 July, 1 August, 5 September, and 3 October, 2019.

Entry	Species	Green cover (%) at 60% ET_o				
		June	July	Aug.	Sep.	Oct.
ASC 118	Bermuda	83.9	64.5	41.5	56.2	45.1
ASC 119	Bermuda	83.9	60.1	45.0	57.4	50.1
Dog Tuff	Bermuda	89.7	77.3	53.7	69.1	71.6
FB 1628	Bermuda	96.8	86.2	75.9	72.7	76.3
JSC 2009-6-s	Bermuda	92.3	75.8	67.4	68.6	62.0
Monaco	Bermuda	92.6	79.6	74.3	73.5	68.4
OKC 1221	Bermuda	96.9	83.1	67.6	64.1	71.1
Premier Pro	Bermuda	97.2	70.0	37.5	40.9	48.5
Tahoma 31	Bermuda	96.3	90.3	86.1	81.3	72.8
TifTuf ™	Bermuda	97.8	76.9	69.4	75.5	82.7
Tifway	Bermuda	98.1	79.7	69.1	64.7	73.6
UCR 17-8	Bermuda	97.5	88.0	81.4	84.5	81.1
UCR BF1	Bermuda	97.0	78.2	57.1	86.0	79.1
UCR BF2	Bermuda	97.4	78.2	53.8	73.8	71.4
Cody	Buffalo	69.9	52.8	34.3	38.9	30.8
Prestige	Buffalo	81.7	57.6	22.8	32.0	41.4
FAES 1306	Zoysia	97.8	86.1	69.6	63.5	75.7
FAES 1307	Zoysia	94.5	77.2	61.8	60.5	65.8
Meyer	Zoysia	85.3	69.0	44.1	51.0	68.5
Stellar	Zoysia	95.1	82.7	47.0	33.7	53.0
LSD*		15.5				

*To determine statistical differences among entries, subtract one entry's mean from another entry's mean. Statistical differences occur when this value is larger than the corresponding LSD value ($P < 0.05$).

Table 5. Turf quality and green cover of 20 warm-season turfgrasses entries under three ET_o levels on 12 December, 2019.

Entry	Species ETo	Turf quality			Green cover (%)		
		30	45	60	30	45	60
ASC 118	Bermuda	3.0	2.7	3.0	32.1	20.9	19.8
ASC 119	Bermuda	3.0	2.8	2.3	35.3	18.5	15.8
Dog Tuff	Bermuda	5.0	4.3	4.7	47.9	40.8	31.2
FB 1628	Bermuda	6.3	6.5	5.7	70.2	72.3	61.6
JSC 2009-6-s	Bermuda	4.3	4.2	4.0	46.3	48.8	32.2
Monaco	Bermuda	4.0	3.8	3.5	50.7	40.0	28.6
OKC 1221	Bermuda	3.2	3.7	5.2	26.2	28.9	45.3
Premier Pro	Bermuda	3.3	3.3	4.3	30.6	35.3	35.9
Tahoma 31	Bermuda	5.0	4.0	3.7	39.2	25.8	22.3
TifTuf ™	Bermuda	6.2	6.5	6.0	60.5	75.8	72.1
Tifway	Bermuda	5.8	6.0	5.5	63.7	53.9	55.2
UCR 17-8	Bermuda	6.3	5.2	5.0	72.1	71.7	64.9
UCR BF1	Bermuda	4.8	5.5	5.2	38.0	52.5	51.1
UCR BF2	Bermuda	5.0	5.5	5.3	30.2	53.3	48.9
Cody	Buffalo	1.2	1.0	1.0	0.3	0.2	0.2
Prestige	Buffalo	1.5	1.0	1.3	2.0	0.3	1.1
FAES 1306	Zoysia	3.8	4.5	5.2	34.2	57.6	55.8
FAES 1307	Zoysia	3.8	3.8	5.7	34.5	38.0	64.6
Meyer	Zoysia	2.0	1.3	1.2	10.2	5.3	3.3
Stellar	Zoysia	4.8	4.5	2.5	48.4	52.5	21.0
LSD*		1.2			17.5		

*To determine statistical differences among entries, for each parameter, subtract one entry's mean from another entry's mean. Statistical differences occur when this value is larger than the corresponding LSD value ($P < 0.05$).

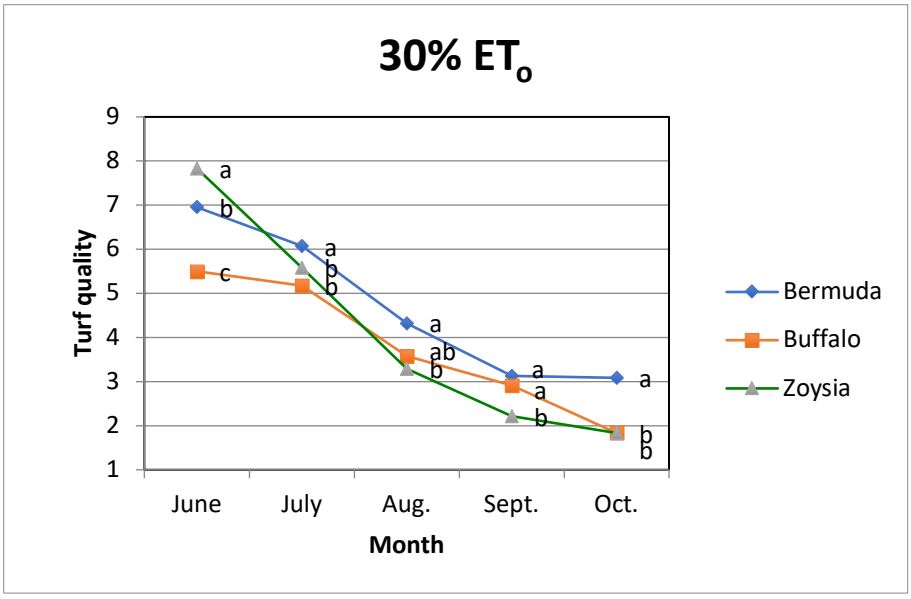


Fig. 1-1. Turf quality of three species under 30% ET_o in 2019. Data were recorded on 6 June, 4 July, 1 August, 5 September, and 3 October, 2019.

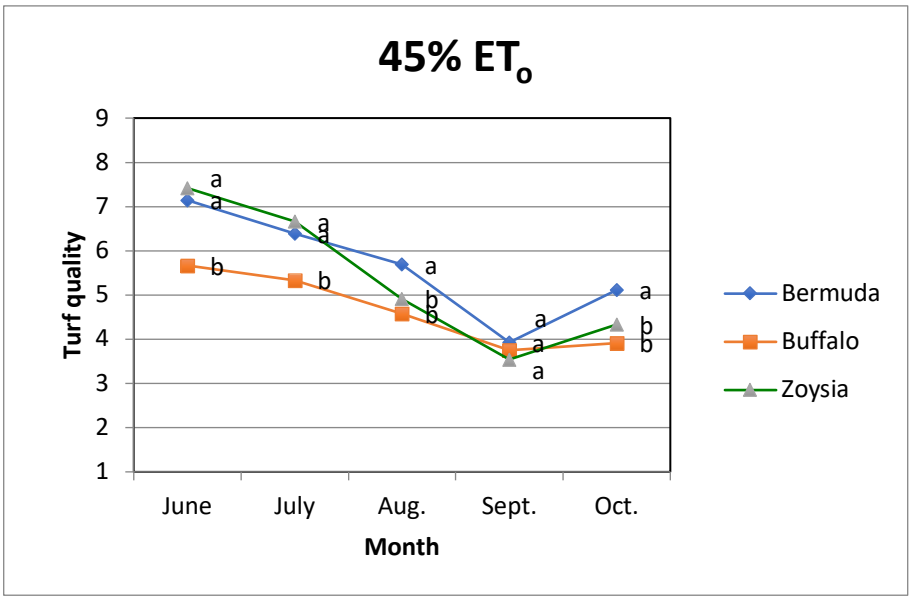


Fig. 1-2. Turf quality of three species under 45% ET_o in 2019. Data were recorded on 6 June, 4 July, 1 August, 5 September, and 3 October, 2019.

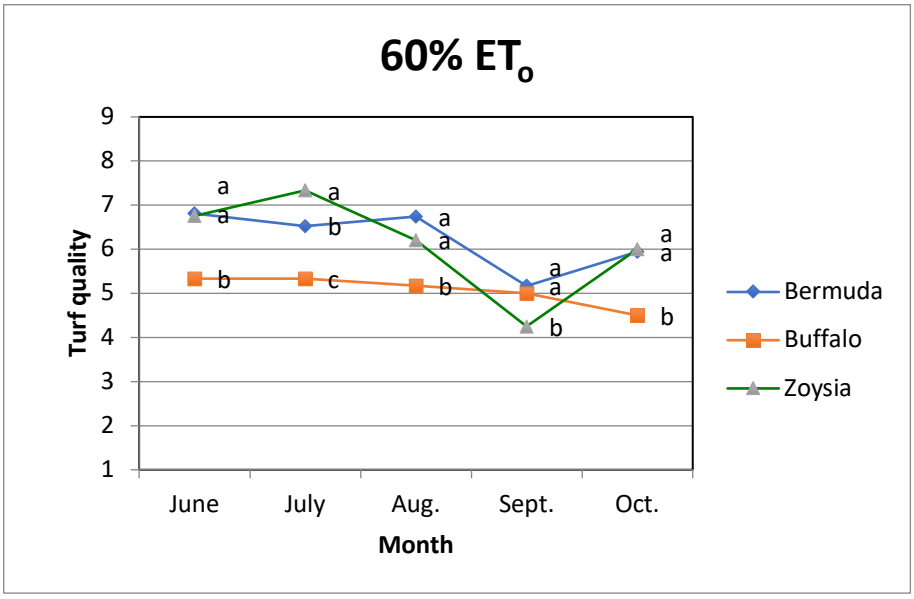


Fig. 1-3. Turf quality of three species under 60% ET_o in 2019. Data were recorded on 6 June, 4 July, 1 August, 5 September, and 3 October, 2019.

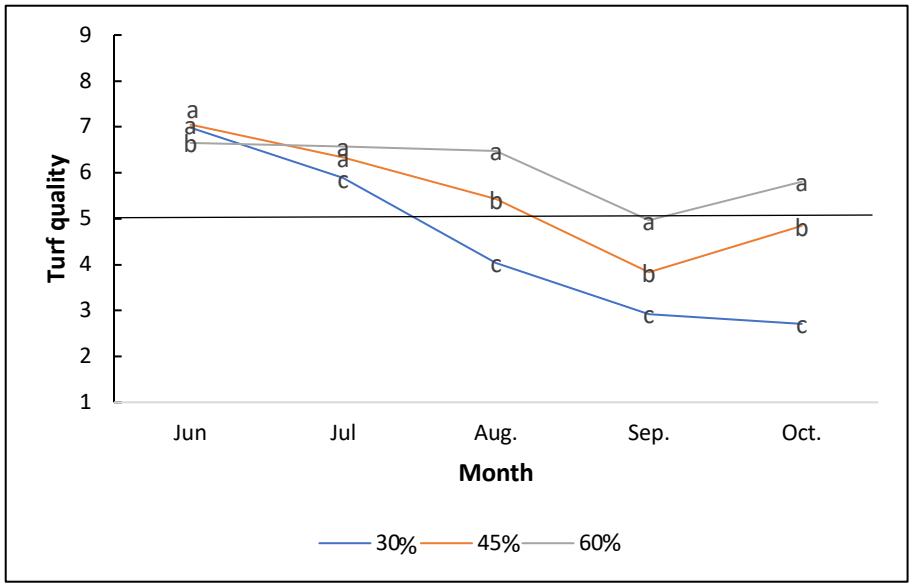


Fig 2. Turf quality of three species under three deficit ET_o levels (30%, 45%, and 60%) in 2019. Data were recorded on 6 June, 4 July, 1 August, 5 September, and 3 October, 2019.

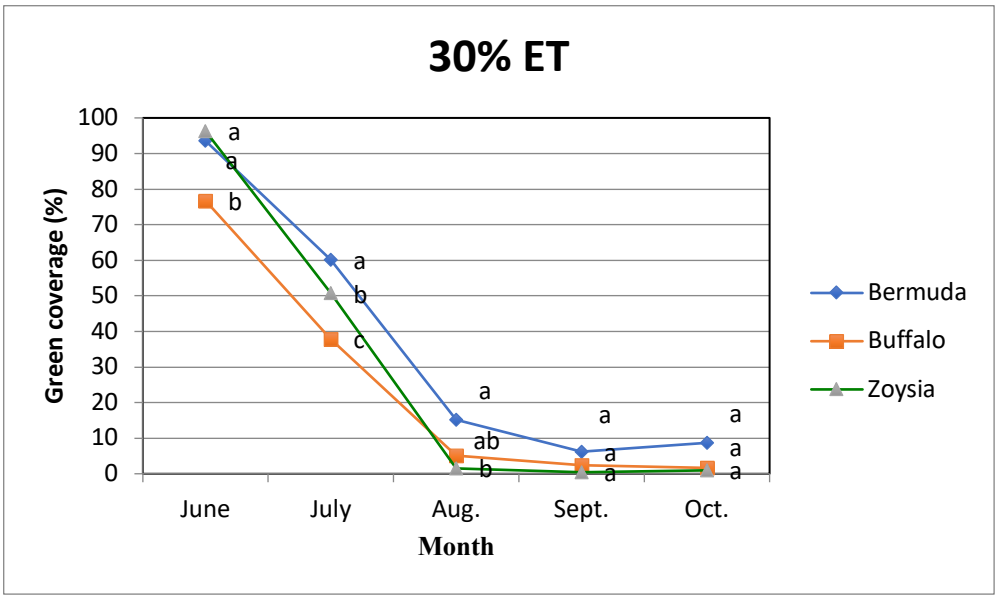


Fig. 3-1. Green cover of three species under 30% ET_o levels in 2019. Data were recorded on 6 June, 4 July, 1 August, 5 September, and 3 October, 2019.

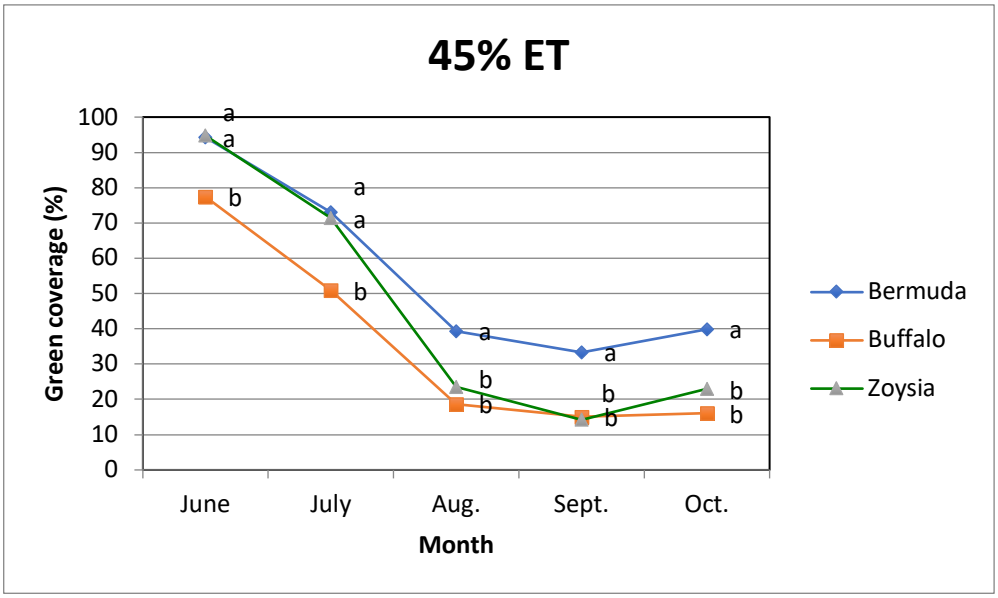


Fig. 3-2. Green cover of three species under 45% ET_o levels in 2019. Data were recorded on 6 June, 4 July, 1 August, 5 September, and 3 October, 2019.

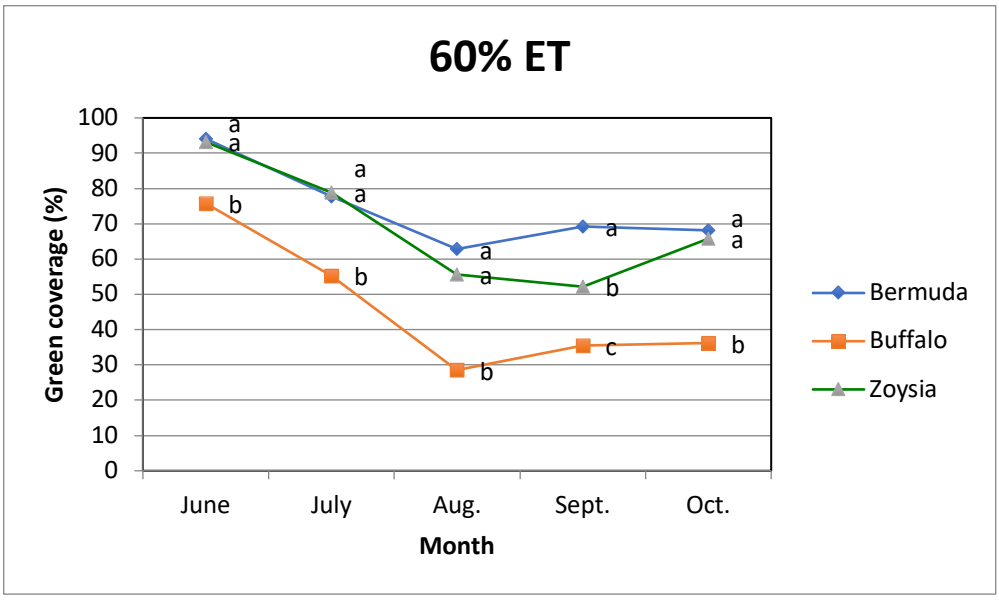
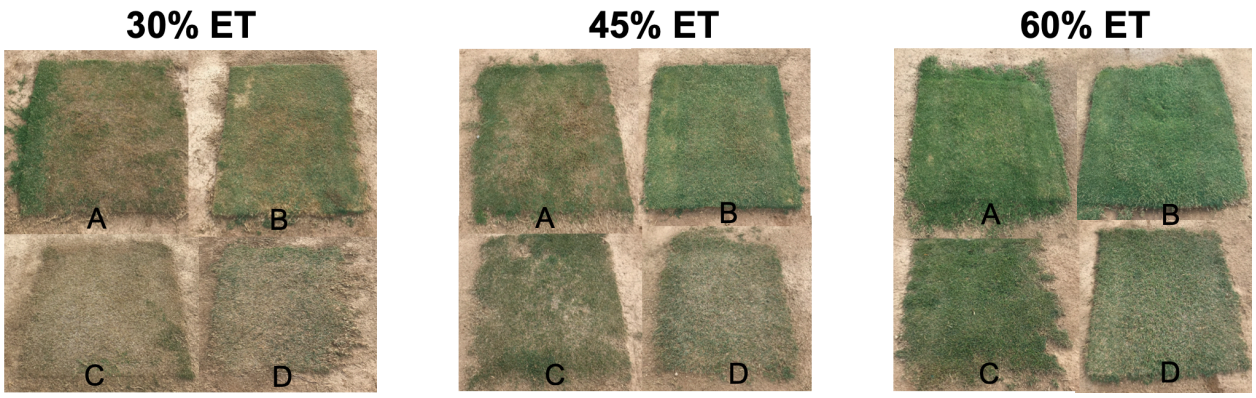


Fig. 3-3. Green cover of three species under 60% ET_o levels in 2019. Data were recorded on 6 June, 4 July, 1 August, 5 September, and 3 October, 2019.



A: TifTuf (Bermuda) B: UCR 17-8 (Bermuda) C: Meyer (Zoysia) D: Cody (Buffalo)

Fig. 4. Photos of representative cultivars and a local experimental selection. Irrigation treatments were initiated on 1 June 2019 and pictures taken on 26 September, 2019.