Bermudagrass is a widely used turfgrass species because of its desirable color, density and durability.

Drought Tolerance of Six Bermudagrass Cultivars

By C.M. Baldwin, H. Liu, L.B. McCarty, and W.L. Bauerle

Bermudagrass (*Cynodon* spp.), the most widely used warm-season turfgrass in the southern United States, is regarded as a drought-tolerant turf (Plate 1). However, it still requires sufficient water to maintain desirable turf (Turgeon, 2005).

Because of extended drought conditions in the Southeast in past years and concerns of water sources, water allocation for turfgrass irrigation continues to be debated. Therefore, selection of drought stress-tolerant cultivars is becoming an increasingly more important issue in turfgrass management.

Cultural practices to conserve water include proper mowing, fertilization and irrigation regimes. Higher mowed turfgrass allows for a deeper root system leading to a more water efficient turf. Excessive fertilization can adversely affect water uptake and high nitrogen application promotes increased shoot growth at the expense of root growth.

However, iron, manganese, potassium and calcium applications improve drought tolerance by increasing root depth, allowing plant water extraction deep in the soil profile. A best management practice is to irrigate deeply and infrequently for best overall turfgrass quality as drier conditions slow shoot growth and increase root growth and leaf water content (McCarty, 2005).

Turfgrass species have two main mechanisms for surviving drought conditions, including drought avoidance and tolerance (Turgeon, 2005). Drought avoidance mechanisms allow a plant to postpone tissue dehydration when available moisture is low by reducing transpiration (Fry and Huang, 2004). Drought tolerance allows the plant to maintain cell turgor at low water potential (Turgeon, 2005) by allowing an osmotic adjustment to maintain cell turgor and delay leaf wilt (Fry and Huang, 2004). Other turf species, such as buffalograss (*Buchloe dactyloides* (Nutt.) Englem) and tall fescue (*Festuca arundinacea* Schreb.), avoid drought stress by transporting deep soil water upward at night (hydraulic lift) (Fry and Huang, 2004).

Previous research has also reported differences in warm- and cool-season turfgrass drought responses (Karsten and MacAdam, 2001 and Schann et al., 2003). Therefore, the objective of this greenhouse study was to determine the response and drought tolerance of six bermudagrass cultivars to five-, 10- and 15-day irrigation intervals.

A two-year replicated greenhouse study was conducted at Clemson (S.C.) University in 2003 and 2004 to determine the drought tolerance of six selected bermudagrass cultivars (Table 1).

Three water stress treatments consisted of five- , 10- and 15-day irrigation intervals with a watered daily control. After each drought interval (5d, 10d, and 15d), plants were brought back to field capacity. Length of the study was one month and treatments were arranged in a randomized complete block design with four replications. Lysimeter dimensions were 15 centimeters (cm) or 6 inches in diameter and 46 cm (18 inches) in height filled with 10.14 cm (4 inches) of gravel and 30.48 cm (12 inches) of sandy loam topsoil. Soil was collected from the Clemson University athletic practice fields during renovations in May 2000.

Each cultivar was provided a complete fertilizer (16-4-8) at a rate of 48.83 kilograms of nitrogen per hectare every two weeks.

Data collection

Soil volumetric water content was measured in the top 15 cm and recorded daily between 11:30 a.m. and 1:30 p.m. using a ThetaProbe soil moisture sensor (ML2, Delta-T Devices Ltd., Cambridge CB5 OEJ, England).

Turf quality was visually rated from 1 to 9, where 1 = brown, dead turf, 7 = minimal acceptable turf, and 9 = healthy, green turf. Evapotranspiration rates were calculated by weighing each lysimeter every third day between 11:30 a.m. and 1:30 p.m. to determine water loss.

At the end of the study, roots were extracted from the soil and soil removed by washing. Roots were then clipped from the base of the shoot tissue and placed in an oven at 80 degrees Celsius (176 degrees Fahrenheit) and dried for 48 hours. Once dried, samples were weighed for total root biomass.

Data analysis

All statistical computations were conducted using analysis of variance (ANOVA) within the

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TABLE 1

Bermudagrass cultivars selected for a greenhouse study to evaluate drought tolerance.

Species	Propagation	Sponsor	Scientific Name
'SWI-1012'	Seeded	Seeds West, Inc.	*Cynodon dactylon* (L.) Pers. var. *dactylon*)
'Arizona Common'	Seeded	Standard Entry	*Cynodon dactylon* (L.) Pers. var. *dactylon*)
'Tift No. 3'	Vegetative	Wayne Hanna -- USDA-ARS	*C. dactylon* X *C. tans vaalensis*
'Tifsport'	Vegetative	Standard Entry	*C. dactylon* X *C. tansvaalensis*
'Aussie Green'	Vegetative	Greg Norman Turf Co.	*C. dactylon* X *C. tansvaalensis*
'Celebration'	Vegetative	Sod Solutions	*C. dactylon* X *C. tansvaalensis*

TABLE 2

Turfgrass quality of each selected cultivar recorded weekly without drought stress and with five days (5d) of water stress.

	Control					5d				
Turfgrass	Day 1	Week 1	Week 2	Week 3	Week 4	Day 1	Week 1	Week 2	Week 3	Week 4
	Turfgrass Quality (1-9)§									
SWI¶	6.6abc†	6.9bc	7.3a	7.1ab	7.0a	6.3ab	5.8c	6.6ab	6.1a	6.1
AC	5.9c	5.9d	6.4d	6.1c	6.3b	5.3b	5.0c	5.1c	4.9b	5.3
TN3	6.4bc	6.8c	7.0bc	6.9ab	6.8ab	6.5a	6.0bc	5.8bc	5.9b	5.8
TS	6.4bc	6.6c	6.6cd	6.8b	7.1a	6.3ab	6.0bc	6.0bc	6.1a	6.0
AG	7.3a	7.5ab	7.5ab	7.3ab	7.4a	7.1a	6.9ab	7.0a	6.8a	6.5
CN	7.0ab	7.6a	7.8a	7.4a	7.4a	7.1a	7.1a	7.0a	6.8a	6.5
LSD	0.76	0.71	0.55	0.56	0.76	1.03	1.11	0.94	1.19	0.90
p-value	0.01‡	0.01	0.01	0.01	0.03	0.01	0.01	0.01	0.03	0.06

†Values within a column followed by the same letter are not significantly different at $P<0.05$ by protected LSD.

‡Indicates statistical difference at $p=0.05$.

§Turfgrass quality based on a scale of 1 - 9, 1 = brown/dead turf, 7 = minimally acceptable turf, 9 = healthy/green turf.

¶Abbreviations: SWI='SWI-1012', AC='Arizona Common', TN3='Tift.No3', TS='Tifsport', AG='Aussie Green', CN='Celebration'.

TABLE 3

Turfgrass quality of each selected cultivar recorded weekly with ten (10d) and 15 days (15d) of water stress.

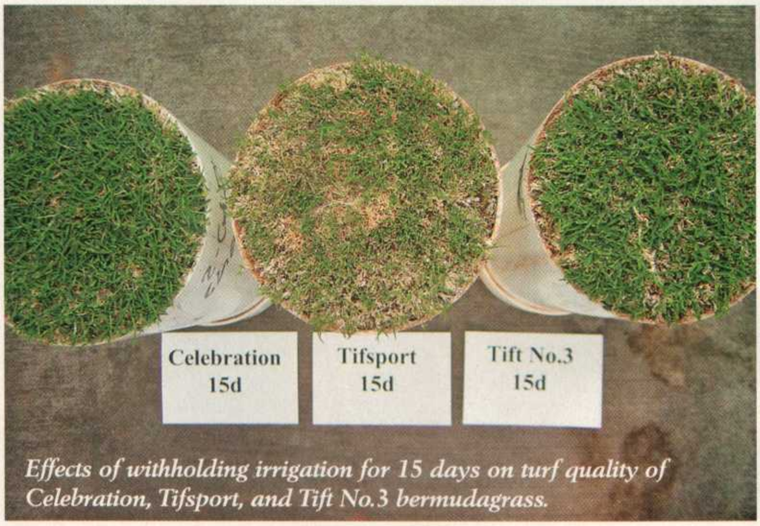
	10d					15d				
Turfgrass	Day 1	Week 1	Week 2	Week 3	Week 4	Day 1	Week 1	Week 2	Week 3	Week 4
	Turfgrass Quality (1-9)§									
SWI¶	6.8abc†	6.3	6.4	5.1	4.8a	6.8ab	6.4ab	5.6a	5.3	3.8
AC	6.1c	5.8	5.0	4.4	3.0b	5.8c	4.8c	4.0b	3.9	2.6
TN3	6.1c	5.6	5.6	5.3	5.1a	6.1bc	5.5abc	5.4a	4.8	4.3
TS	6.3bc	5.9	6.3	5.5	5.6a	6.5abc	5.3bc	4.8ab	4.3	4.4
AG	7.1ab	6.1	6.0	5.5	4.6a	7.3a	6.5a	5.8a	5.3	4.0
CN	7.3a	6.9	6.5	6.0	4.8a	7.1a	6.4ab	5.7a	5.4	3.8
LSD	0.92	1.22	1.11	1.32	1.18	0.81	1.13	1.04	1.21	1.28
p-value	0.05‡	0.36	0.08	0.26	0.01	0.01	0.01	0.01	0.08	0.10

†Values within a column followed by the same letter are not significantly different at $P<0.05$ by protected LSD.

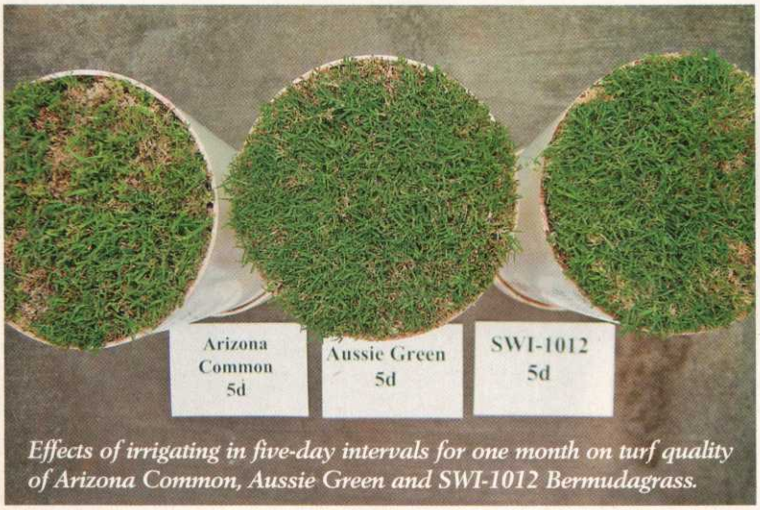
‡Indicates statistical difference at $p=0.05$.

§Turfgrass quality based on a scale of 1 - 9, 1 = brown/dead turf, 7 = minimally acceptable turf, 9 = healthy/green turf.

¶Abbreviations: SWI='SWI-1012', AC='Arizona Common', TN3='Tift.No3', TS='Tifsport', AG='Aussie Green', CN='Celebration'.

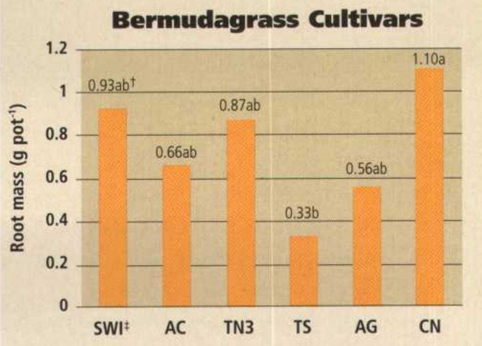


Effects of withholding irrigation for 15 days on turf quality of Celebration, Tifsport, and Tift No.3 bermudagrass.



Effects of irrigating in five-day intervals for one month on turf quality of Arizona Common, Aussie Green and SWI-1012 Bermudagrass.

FIGURE 1

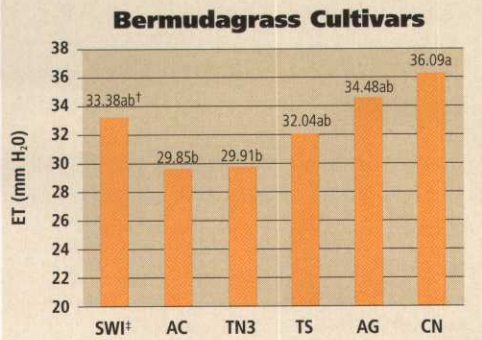


Comparison of six bermudagrass cultivars total root biomass after two fifteen-day (15d) irrigation cycles.

†Mean data points followed by the same letter are not significantly different.

‡Abbreviations: SWI='SWI-1012', AC='Arizona Common', TN3='Tift.No3', TS='Tifsport', AG='Aussie Green', CN='Celebration'.

FIGURE 2



Comparison of six bermudagrass cultivars total evapotranspiration (ET) rates after two fifteen-day (15d) irrigation cycles.

†Mean data points followed by the same letter are not significantly different.

‡Abbreviations: SWI='SWI-1012', AC='Arizona Common', TN3='Tift.No3', TS='Tifsport', AG='Aussie Green', CN='Celebration'.

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Statistical Analysis System (SAS Institute, 1999). Means were separated by Fisher's Least Significant Difference (LSD) test. An alpha of 0.05 was used for all parameters measured.

Tables 2 and 3 list weekly variations in visual total quality (TQ) ratings. When irrigated daily for four weeks, Aussie Green and Celebration maintained a highest quality rating of 7.4. Also, Aussie Green and Celebration were able to maintain an acceptable TQ rating (>7) at week two (five-day treatment) showing 27-percent and 17-percent higher quality ratings compared to Arizona Common and Tift No.3 (Table 2). At the 10-day and 15-day drought intervals, all cultivars saw dramatic reductions in TQ by week one (Table 3).

Previous field studies indicate TQ increases as turf is irrigated in two and four-day intervals rather than daily (Johnson, 2003 and Jordan et al., 2003). Results from this study indicate that irrigating in 10- and 15-day intervals has negative affects on TQ, however, results may differ in a field study as turf could access water deep in the soil profile.

After two 15-day water cycles, Celebration produced 70-percent greater total root biomass than Tifsport (Figure 1). All cultivars receiving daily irrigation produced roots in the top 10.2 cm to 12.7 cm, while cultivars at the 15-day treatment produced roots greater than 30.4 cm (Data not shown). This was expected, as root length and growth increase as water becomes limited. The main function of a root is to intercept water and nutrients and as water decreases, roots continue growing downward in the soil profile in search of water.

Johnson (2003) reported prairie junegrass

(*Koeleria macrantha* (Ledeb.)) root system absorbed water at 30 cm when irrigated in four- to six-day intervals. Bonos and Murphy (1999) also noted an increase in Kentucky bluegrass (*Poa pratensis L.*) cultivar root growth as drought stress was imposed.

Statistical differences were observed for evapotranspiration (ET) rates (Figure 2).

Celebration and Aussie Green had 17-percent and 13-percent greater ET than Arizona Common and Tift No. 3. This data possibly indicates these cultivars undergo a greater osmotic adjustment leading to an enhanced response to drought compared to the other four cultivars. However, further investigation of water potential data is needed to verify this.

Conclusions

Watering turfgrass during extended intervals should proceed with caution as only two cultivars, Aussie Green and Celebration, maintained acceptable turf quality after two weeks at the 5d treatment. As drought stress was imposed longer than the 5d interval, all cultivars quickly declined in turf quality.

Celebration produced superior rooting with a 70-percent increase compared to Tifsport and as drought intervals increased, root depth increased. Also, Celebration had 17-percent greater ET than Arizona Common after two 15-day irrigation cycles.

Future studies should investigate the response of these cultivars to other soil types. Also, screening new cultivars from the National Turfgrass Evaluation Program for drought tolerance may prove beneficial for turfgrass breeders.

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