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Drought Resistance of Selected Bermudagrass {*Cynodon Dactylon* (L.) Pers.} Accessions

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ABSTRACT

This study was conducted to determine the relative drought resistance of 15 bermudagrass (*Cynodon dactylon* L.) accessions. Plants were grown in pots filled with field soil. After the full establishment of the plants, relative drought resistance of the accessions was determined using leaf firing and percent of the plant recovery. ET (evapotranspiration), root proline content, total root length and root diameter were also determined. There were significant differences among the accessions for their drought resistance, proline content, total root length and root diameter. However, there were no significant differences among the accessions for their total ET. The 88-Khl and 17-GNl accessions were the most drought resistant; whereas, 11-Ns had the lowest drought resistance. There was no significant relation between drought resistance and root diameter, root proline content and ET; however, the correlation between drought resistance and total root length was significant. Significant differences among the accessions for their drought resistance suggest that selection of bermudagrass for drought resistance among the accessions may be possible.

Key Words: Bermudagrass; Drought; Proline; Evapotranspiration

INTRODUCTION

Bermudagrass {*Cynodon dactylon* (L.) pers.} is one of the most widely used warm season turfgrass, especially in tropic and subtropical regions. Bermudagrass is a drought and salt resistant species that spreads rapidly by stolons and rhizomes.

Irrigation water supply for turfgrass in arid and semiarid regions is a major problem. One strategy to reduce turfgrass irrigation needs is to use drought resistant cultivars (Carrow *et al*., 1990). Mechanisms of drought resistance include drought avoidance, tolerance and escape (Levitt, 1980; Beard, 1989).

A major component of drought resistance is the development and maintenance of a deep, extensive and viable root system and proline content (Youngner, 1985; Beard, 1989; Thomas 1987; Marcum *et al*., 1995; Carrow, 1996; Huang *et al*., 1997b). Selection of turfgrass cultivars with low evapotranspiration (ET) rates is needed because water conservation is an important concern (Beard, 1989; Beard *et al*., 1992).

Genetic modification of turfgrasses by breeding for drought tolerance is a valid approach. However, it is time-consuming and demands sustained efforts. Although bermudagrass is drought resistant (Kim, 1987), there are differences between various genotypes and accessions (Beard & Sifers, 1997).

The objective of this study was to compare bermudagrass accessions for their relative drought resistance, select drought resistant accessions and find possible relation between drought resistance and total root length, root diameter, root proline content and ET.

MATERIALS AND METHODS

Seventy six accessions of *Cynodon* spp. were collected from Isfahan, Charmahal and Bakhtiari, Gilan and Mazandaran provinces, Iran. After first screening for visual (leaf color, texture & density) and functional (growth) quality, fifteen accessions were selected (Table I). Tifdwarf {*Cynodon dactylon* × *Cynodon transvaalensis* (Burtt Davy)} was also used because of its high quality (leaf color, texture, density & dwarfness) and well- documented relative drought resistance. The selected accessions were taken to the Department of Botany, University of Isfahan. The species were identified to be *Cynodon dactylon* (L.). Four sprigs with 3-4 nodes of each accession were planted in pots (60 cm high, 15 cm diameter) filled with about 14.5 kg of dried calcareous silty clay soil (organic mater 2%, available P 36 mg kg^{-1}, available K 780 mg kg^{-1}, electrical conductivity 1.7 dSm^{-1} & pH 7.4) and grown under natural conditions (Table II). Pots were irrigated at 3 day intervals, which was sufficient to saturate the medium and allow drainage out of the bottom of pots (FC 19.4 ($^{w}/_{w}$) + 15%). Pots were arranged in a completely randomized block design with six replications (each pot as one replication) and repeated twice. They were fertilized by 53 mg N kg^{-1} soil fortnightly and clipped at 3 cm height (Hays *et al*., 1991). After full establishment of the plants (about two months), irrigation was ceased and percentage of leaf firing was

Table I. Description of regions from which C*ynodon dactylon* L. were collected

Accession	Latitude	Altitude (m)	Habitat type	Annual rainfall (mm)	Mean Daily temperature (°C)
3- Gf	31°, 50′ N	2200	Field	308	12.6
7-Gg	31, 33′ N	1900	Natural grassland	308	12.6
9-Lg	31, 33′ N	1930	Natural grassland	308	12.6
11-Ns	33° 32′ N	1800	Riverside	155	16.0
13-Ns	33° 32′ N	1800	Riverside	155	16.0
15-Bs	33° 32′ N	1300	Riverside	126	16.0
17-GNl	36° 40′	15	Roadside	864	16.8
19-Gcr	37° 19′	-15	Roadside	1067	16.5
21-Sg	32° 19′ N	2060	Natural grassland	305	12.9
27-Il	32° 37′ N	1577	Riverside	122	16.2
39-Il	32° 37′ N	1573	Lawns	122	16.2
44- Il	32° 37′ N	1570	Riverside	122	16.2
52-Chg	32° 46′ N	2150	Natural grassland	247	12.6
83-Vi	32° 24′ N	1450	Riverside	120	16.5
88-Khl	32° 38′ N	1600	Roadside	122	16.2

Table II. Environmental conditions of experimental site during the study.

Month	Evaporation (mm)	Mean precipitation (mm)	Duration of sunshine (hr.)	Mean relative humidity (%)	Mean temperature (°C)
June	362	0	278	27.0	28.2
July	394	0	346	24.0	29.3
August	281	2	331	26.0	25.9
September	195	0	296	23.9	19.3
October	115	0	230	43.2	15.3

visually assessed (Carrow, 1996; Carrow & Duncan, 2003) every other day (Beard & Sifers, 1997) at 11:00 A.M. throughout the water stress periods, using a scale of 0 to 100% (0 being no symptom & 100% being complete leaf firing). After ceasing irrigation, ET was measured by weighing the pot every 3 days.

After the shoot of each accession appeared to be dead, the pots were sliced for measuring root characters for three replications. Total root length and average of root diameter were measured by a leaf area meter (Delta-T Scan Image Analysis system). Proline content in the root was determined according to Bates (1973).

Other three replications of each accession, when appeared to be dead, were taken to a greenhouse with daily temperature of 27°C maximum/15°C minimum and turf recovery was assessed by the percent green shoot development following re-watering of the plants after 33 days.

Treatment effects were determined by the analysis of covariance, using the clipped plant materials in each replicate of treatments as covariate. Differences among treatment means within a accession were separated by least significant difference (protected-LSD) at the $P \leq 0.05$. Using the Pearson correlation procedure, total root length, root diameter, root proline content and ET were compared with days to complete leaf firing. To compare the percentage of leaf firing and shoot recovering, an Arc Sin transformation was first performed on the data.

RESULTS

Leaf firing and shoot recovery assessments of bermudagrasses for their relative drought resistance are shown in Table III. There were significant differences among accessions. Tifdwarf, 88-Khl and 17-GNl had the least leaf firing, whereas 11-Ns had the highest leaf firing among the accessions after 25 and 36 days. The 17-GNl accession recovered 78.2% after 12days of rewatering; whereas, 17- GNl, Tifdwarf, 88-Khl, 7-Gg and 3-Gf recovered more than 90% after 33 days of rewatering.

Significant differences among accessions were measured for total length of root, root diameter and proline content (Table IV). The 15-Bs, 88- Khl and 17-GNl exhibited a high total root length and the 7-Gg had the lowest root length. The highest root diameter was found for 7-Gg and 3-Gf and the lowest was found for Tifdwarf. The 7-Gg had the highest proline content, whereas 15-Bs possessed the lowest.

There were significant differences among the accessions for their ET, 15 days after the stress. The 7-Gg, 52-Chg, Tifdwarf and 3-Gf had highest ET and 44.Il had the lowest ET. However, there were no significant differences among the accessions for their total ET (Table V).

Total root length was significantly correlated with days to complete leaf firing of bermudagrass accessions, whereas no significant correlation was evident between root diameter, root proline content, ET and days to complete leaf firing (Table VI).

DISCUSSION

This study documented differences among bermudagrass accessions regarding their ability to resist drought. The accessions were collected from different locations, therefore they have different adaptability to stresses, including drought due to their genetic differences (Hays *et al.*, 1991; Beard & Sifers, 1997).

The shoot recovery following rewatering of the plants didn't reach full value as reported by Huag *et al.* (1997a); and differed from Beard and Sifers (1997) that showed full recovery of bermudagrasses following rewatering.

Tifdwarf exhibited high drought resistance and similar results were reported by Beard and Sifers (1997). They showed that among the C*ynodon dactylon* (L.) genotypes, those originating from warm climatic conditions tended to rank in the top of the group in terms of both dehydration avoidance and drought resistance and those developed in the cooler climates tended to rank poorest; whereas, hybrid (*C. dactylon* × *C. transvalensis*) cultivars were ranked between the two groups for dehydration avoidance. In this study, all the accessions were collected from temperate climates. Therefore, they were expected to be less drought resistance than Tifdwarf.

The results showed differences among the accessions regarding total root length and root diameter as reported by Casnoff and Beard (1985), Hays *et al.* (1991), Beard *et al.* (1992), Huang *et al.* (1997a). Previous studies by Aguilo and Medrano (1994) revealed that *Lolium perenne* (L.) ecotypes had different proline contents. Present study also indicated that bermudagrass accessions had different proline contents.

Green *et al.* (1990) reported no differences in ET rated among 11 well-watered zoysiagrass (*Zoysia* spp.) genotypes and Atkins *et al.* (1991) reported the same for well-watered St. Augustinegrass [*Stenotaphrum Secumdatum* (Walt.) Kuntz] genotypes. However, Shearman (1989) reported significant ET rate variation among 12 well-watered perennial ryegarss (*Lolium perenne* L.) cultivars. Beard *et al.* (1992) reported significant ET rate variation among 24 well-watered bermudagrass (*Cynodon* spp.) genotypes. Our study showed that ET declined during progression in all accessions, because of stomata closure (Carrow, 1995; Miller, 2000) but the time and severity of reductions varied among the accessions. ET was significantly different among the accessions up to 15 days after water cessation, but there were no significant differences thereafter.

Leaf firing provides a good assessment of overall turfgrass drought resistance (Carrow & Duncan, 2003). Results of correlation between days to complete leaf firing of accessions and total root length, root diameter and root proline content suggest that there is a significant relationship between total root length and drought resistance as reported by Kim (1987), Torbert *et al.* (1990), Hays *et al.* (1991), Carrow (1996) and Huang *et al.* (1997a). However, there were no significant correlation between drought resistance of the accessions and root diameter as observed by Jackson and Coldwell (1989) and differ by Ethrington (1987). Root proline content has no significant relation to drought resistance as reported by Aguilo and Medrano (1994), while

Table III. Leaf firing percent from 25 and 36 days after drought stress and the percent of shoot recovery 12 and 33 days from the initiation of irrigation for 15 accessions of *Cynodon dactylon* and Tifdwarf

Accessions	Leaf firing (%)		Shoot recovery (%)	
	d 25	d 36	d 12	d 33
3- Gf	87.5 bc**	97.5 a**	45.0 bc*	90.0 ab**
7- Gg	84.2 c	96.8 ab	48.3 bc	90.7 ab
9- Lg	93.7 ab	98.3 a	56.7 abc	66.7 c
11– Ns	96.0 a	99.0 a	56.7 abc	76.7 c
13- Ns	90.0 abc	98.3 a	46.7 bc	76.7 c
15- Bs	94.0 ab	98.2 a	45.0 bc	70.0 cd
17- GNl	66.7 d	90.3 bc	78.2 a	97.3 a
19- Gcr	87.5 bc	97.7 a	33.3 c	78.3 bc
21- Sg	90.8 abc	97.3 a	35.0 bc	63.3 d
27- Il	88.5 abc	97.8 a	45.0 bc	70.0 cd
39- Il	94.2 ab	98.2 a	53.3 bc	63.3 d
44- Il	89.2 abc	97.8 a	63.3 ab	75.0 cd
52- Chg	88.2 bc	97.0 ab	46.7 bc	78.3 bc
83- Vi	92.5 ab	98.0 a	58.3 abc	75.0 cd
88- Khl	55.0 e	87.7 dc	53.3 bc	93.0 a
Tifdwarf	26.7 f	81.2 d	55 abc	95.0 a
LSD (0.05)	7.6	6.9	21.4	12.3
C.V. (%)	8.01	6.24	25.0	9.39

Means followed by the same letter in a column are not significantly different from each other (*, ** Significant at P= 0.05 or 0.01, respectively).

Table IV. Mean total root length, root diameter and proline content after water stress regimes for 15 bermudagrass accessions and Tifdwarf.

Accessions	Total length (m)	Diameter (mm)	Proline (μM)
3- Gf	251 hi**	0.763 a	51.5 b
7- Gg	177 I	0.767 a	74.4 a
9- Lg	384 cdefgh	0.650 bcdef	31.3 cd
11- Ns	397 cdefg	0.687 abcde	34.8 bcd
13- Ns	325 efgh	0.703 abcd	50.6 bc
15-Bs	595 a	0.590 ef	22.6 d
17- GNl	493 abc	0.613 def	37.2 bcd
19- Gcr	295 fghi	0.603 def	42.3 bcd
21- Sg	278 ghi	0.730ab	47.9 bc
27- Il	450 bcde	0.643 bcdef	35.4 bcd
39- Il	330 efgh	0.673 abcdef	53.1 b
44-Il	412 cdef	0.673 abcdef	36.3 bcd
52- Chg	470 abcd	0.610 def	42.1 bcd
83- Vi	355 defgh	0.727 abc	45.9 bc
88- Khl	558 ab	0.627 cdef	37.3 bcd
Tif dwarf	484 abcd	0.573 f	41.3 bcd
LSD 0.05	134	0.101	19.8
C.V. (%)	20.5	9.10	27.7

** Means followed by the same letter in a column are not significantly different from each other at P = 0.01

Table V. Average evapotranspiration (ET) of bermudagrass accessions during stress period and 15 days after the start of stress

Accession	ET after 15 days (mm day^{-1})	ET (total) (mm day^{-1})
3- Gf	15.2 a**	2.33
7- Gg	15.7 a	2.35
9- Lg	10.8 bcde	2.28
11- Ns	8.15 de	2.32
13- Ns	12.5 abc	2.32
15- Bs	12.4 abc	2.38
17- GNl	11.4 bcd	2.34
19- Gcr	11 bcde	2.34
21- Sg	13.9 ab	2.26
27- Il	8.38 de	2.28
39- Il	9.85 cde	2.42
44 – Il	7.87 e	2.27
52- Chg	15.5 a	2.29
83- Vi	11.3 bcd	2.29
88- Khl	12.3 abc	2.42
Tifdwarf	15.3 a	2.34
LSD 0.05	3.45	0.47
C.V. (%)	25.1	19.0

** Means followed by the same letter in a column are not significantly different from each other at P = 0.01

Table VI. Correlation coefficient (r) indicating dependence of days to complete leaf firing of accessions on total root length, root diameter, root proline content and ET

Variable	Correlation coefficient (r)
Total root length	0.51*
Root diameter	-0.46
Root proline content	0.02
Evapotranspiration (ET)	-0.25

* Significant at P= 0.05

Thomas (1987) showed increasing proline content in the root of *Lolium perenne* (L.) under drought stress. There was a negative correlation between ET and drought resistant. Carrow (1996), Beard and Sifers (1997) and Guo *et al*. (2001) showed the relationship between ET and drought resistance. The present study showed that significant differences exist among the accessions regarding their drought resistance, and therefore it may be possible to select drought resistance accession. Furthermore, selection of drought resistance among accessions may be possible based on total root length.

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