

Establishment of a Standard Screening Method for Drought Tolerance in Creeping Bentgrass

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- Drought tolerance of creeping bentgrass varied in genotypes and growth stages.
- ‘Bengal’ had high root and shoot growth under drought conditions at the germination and seedling growth stage. ‘Penn A-4’, ‘L-93’, ‘T-1’, ‘Pinup’, ‘Cobra 2’, ‘Putter’, ‘Pennlinks II’, and ‘Kingpin’ had the same level of root growth as ‘Bengal’ but lower shoot biomass.
- ‘SR 1150’, ‘007’, ‘Bengal’, ‘Declaration’, ‘T-1’, ‘Focus’, ‘Cobra 2’, ‘Pennlinks II’, and ‘V8’ showed high root length and clipping dry weight under drought conditions during the vegetative growth, in which ‘SR 1150’ and ‘007’ also show high visual quality.

The objective of this project is to determine the reliability of selecting drought-tolerant creeping bentgrass in a polyethylene glycol (PEG) - hydroponic culture.

Twenty-three creeping bentgrass cultivars were germinated in PEG solutions (0.0, -0.3, and -0.6 MPa) for four weeks (W). The experiment was setup as a split-plot design, with the whole-plot factor being PEG concentration and the sub-plot factor being bentgrass cultivar. Data were collected on root length (RL), root dry weight (RDW), and shoot dry weight (SDW). RL decreased with an increase of drought severity, while SDW was not affected by drought (Table 1). RL ranged from 7.9 cm in ‘Penn A-4’ to 4.6 cm in ‘Independence’ at W4. ‘Bengal’ had a SDW of 218.0 mg, higher than all other grasses. The cultivar x drought interaction (Table 1) observed in RDW was mostly due to the close ranking of RDW in the large number of cultivars evaluated in the present study. Overall, ‘Penn A-4’ and ‘Independence’ had the highest and lowest RDW, respectively (Table 1). Drought tolerance was also evaluated during the vegetative growth on RL, clipping dry weight (CDW), and quality. RL and CDW decreased with increasing drought levels (Table 2). The longest and shortest roots were observed in ‘007’ and ‘Penn A-1’, respectively, at W5. ‘SR 1150’ had a total CDW of 74.0 mg, 90% higher than ‘MaCkenzie’. Most grasses showed acceptable quality (≥ 6) at 0.0 MPa (Table 3). The number of cultivars which had acceptable quality at -0.3 MPa decreased from six (‘SR 1150’, ‘007’, ‘T-1’, ‘Pennlinks II’, ‘Focus’, and ‘Alpha’) at W1 to three (‘SR 1150’, ‘007’, and ‘Independence’) at

W3, and no cultivars performed adequately at W5. At -0.6 MPa, only 'Alpha' showed acceptable quality at W1.

Creeping bentgrass drought tolerance was evaluated under the putting green and fairway conditions in 2015 (July 7 – Sept. 29) and 2016 (July 1 – Sept. 8) (Figures 1 and 2). Drought stress was simulated by withholding irrigation during the study period and canopy reflectance and visual quality were recorded. The experimental setup was a RCBD with three replicates. Significant differences were only observed in the stress index (R_{710}/R_{810}) on Aug. 12 and 24, 2015 and Aug. 22 and 30, 2016 in the putting green and on Aug. 24, 2015 and Aug. 24 and 30, 2016 in the fairway (Table 4). However, all grasses provided acceptable quality on all the evaluation dates (data not shown). It was probably due to a combination of frequent precipitation, high water holding capacity of clay soil at the research site, and cool climate of the upper Northern region. No comparisons were made between the results from the PEG-hydroponic system and the field study due to limited variations observed in bentgrass performance under the field conditions.

Table 1. Root length (cm), root dry weight (mg), and shoot dry weight (mg) of creeping bentgrass seedlings grown under drought.

	Root length (cm)				Root dry weight (mg)	Shoot dry weight (mg)
	Week 1	Week 2	Week 3	Week 4		
Drought (MPa)						
0.0	3.0	4.9	6.2	7.4	12.2	108.1
-0.3	1.7	3.8	5.8	7.4	36.7	122.3
-0.6	1.3	2.3	3.7	4.9	19.9	103.7
LSD ($P \leq 0.05$)	0.2	0.2	0.3	0.4	0.3	ns
Cultivar						
Penn A-4	2.5	4.7	6.3	7.9	32.7	123.5
L-93	2.1	4.0	6.4	7.6	26.7	97.0
T-1	2.1	3.9	5.5	7.5	30.7	106.1
Pinup [†]	2.3	3.8	6.0	7.4	26.1	153.4
Cobra 2 [†]	2.3	3.9	5.8	7.4	27.3	107.1
Memorial	1.8	3.7	5.5	7.3	18.8	69.8
Putter	1.9	3.9	5.5	7.2	24.4	102.1
South shore	2.2	4.2	5.5	7.1	24.0	105.6
Kingpin	2.2	4.0	5.5	7.1	32.7	154.6
Pennlinks II	2.0	3.6	5.0	7.1	25.0	103.2
Bengal	2.2	3.7	5.4	7.0	24.9	218.0
Crystal Bluelinks	2.2	3.7	5.4	7.0	23.2	142.6
V8 [†]	2.4	4.1	5.4	6.6	21.2	98.6

Penn A-1	1.9	4.0	5.5	6.6	18.3	105.9
Focus [†]	2.1	3.7	5.4	6.4	22.4	113.5
Declaration	2.3	3.7	5.2	6.2	24.4	140.3
Alpha	1.7	3.1	4.5	6.0	31.0	107.0
Mackenzie	2.0	3.5	5.0	6.0	19.9	92.1
Tyee	2.0	3.5	4.7	5.9	22.5	99.3
Penncross	1.4	2.7	4.3	5.4	13.1	61.3
SR 1150	1.6	3.0	4.2	5.2	13.1	94.8
007	1.3	2.7	3.9	5.1	13.8	75.8
Independence	1.0	2.5	3.7	4.6	12.2	90.2
LSD ($P \leq 0.05$)	0.5	0.7	0.9	1.2	8.6	60.6
Drought x cultivar	ns	ns	ns	ns	*	ns

ns and * mean not significantly different and significantly different at $P \leq 0.05$ level, respectively.

[†]Creeping bentgrass cultivar not included in the field study.

Table 2. Root length (cm) and clipping dry weight (mg) of mature creeping bentgrass grown under drought.

	Root length (cm)			Clipping dry weight (mg)			
	Week 1	Week 3	Week 5	Week 1	Week 3	Week 5	Total
Drought (MPa)							
0.0	1.9	4.3	6.1	28.8	44.7	20.5	94.0
-0.3	1.8	2.7	4.0	24.7	11.5	14.8	51.1
-0.6	1.2	2.3	2.5	17.9	5.4	2.8	26.2
LSD ($P \leq 0.05$)	0.5	0.6	0.8	4.0	2.8	2.4	5.9
Cultivar							
007	3.3	5.0	6.5	24.7	31.2	15.3	71.1
Penn A-4	1.8	3.5	6.1	23.4	15.7	16.2	55.4
Pinup [†]	1.6	3.9	5.6	29.3	19.2	7.9	56.3
Tyee	2.4	3.8	5.4	24.6	16.5	10.7	51.8
Independence	1.8	3.7	5.4	20.2	20.4	15.3	55.8
Pennlinks II	2.4	4.0	5.4	23.1	24.3	14.1	61.4
Bengal	0.5	3.3	5.2	35.1	20.5	15.6	71.2
Cobra 2 [†]	0.4	2.9	5.0	20.6	27.5	16.0	64.1
SR 1150	1.4	3.5	4.8	31.7	24.6	17.7	74.0
Focus [†]	2.0	3.6	4.7	23.6	24.9	16.0	64.5
V8 [†]	1.6	3.1	4.7	22.6	26.0	12.7	61.3
Declaration	2.4	3.7	4.3	30.1	23.8	14.5	68.5
T-1	1.8	3.3	4.3	27.6	23.2	14.7	65.5

Kingpin	2.1	3.3	4.1	28.4	27.5	12.2	68.1
Putter	1.7	2.9	4.1	25.8	19.5	10.0	55.2
Memorial	2.1	3.3	4.0	20.5	18.3	10.5	49.3
South shore	1.4	2.6	3.7	29.8	18.7	9.4	57.9
L-93	1.4	2.1	3.2	21.2	17.4	10.9	49.5
Crystal Bluelinks	1.2	2.1	3.2	20.6	12.1	8.7	41.4
Mackenzie	0.9	2.4	3.1	17.0	12.6	9.3	39.0
Alpha	1.1	1.8	3.0	18.5	20.2	14.6	53.3
Penncross	0.6	1.7	2.8	15.4	13.2	10.5	39.1
Penn A-1	0.6	1.6	2.3	14.3	15.5	10.1	39.9
LSD ($P \leq 0.05$)	1.5	1.8	2.2	11.1	7.7	6.6	16.2
Drought x cultivar	ns	ns	ns	ns	ns	ns	ns

ns means not significantly different at $P \leq 0.05$ level.

†Creeping bentgrass cultivar not included in the field study.

Table 3. Visual quality of mature creeping bentgrass grown under drought. Visual quality was rated with a 1 – 9 scale, in which 9 = optimal quality, 6 = acceptable quality, and 1 = dead grass.

Cultivar	Week 1			Week 3			Week 5		
	0.0 MPa	-0.3 MPa	-0.6 MPa	0.0 MPa	-0.3 MPa	-0.6 MPa	0.0 MPa	-0.3 MPa	-0.6 MPa
SR 1150	7.0	6.3	5.0	7.0	6.3	4.7	6.7	5.3	3.3
Focus [†]	7.0	6.0	4.0	7.0	5.7	3.7	5.7	4.3	2.0
007	7.0	6.3	4.0	6.0	6.0	4.0	5.0	4.3	3.7
Pennlinks II	7.0	6.0	5.3	6.7	5.7	4.7	5.0	4.3	3.7
T-1	7.0	6.0	4.0	6.3	5.7	3.3	5.7	4.3	2.3
Alpha	7.0	6.0	6.0	7.0	5.7	5.3	6.0	4.7	5.3
Independence	7.0	5.7	5.0	7.0	6.0	4.3	6.7	4.7	4.0
Mackenzie	7.0	5.0	4.0	6.7	4.0	2.7	6.0	3.0	1.3
Cobra 2 [†]	7.0	5.0	5.3	7.0	5.0	5.0	6.3	3.7	3.3
Tyee	7.0	5.3	4.0	6.7	4.7	3.0	5.3	3.3	2.3
Declaration	7.0	5.7	5.0	5.7	5.7	4.7	5.3	4.0	3.3
Bengal	7.0	4.7	4.3	7.0	4.7	4.0	6.0	3.0	3.7
V8 [†]	7.0	5.0	5.0	6.7	4.7	4.7	4.7	3.7	3.7
L-93	7.0	5.3	3.7	6.7	4.3	2.7	5.7	2.7	2.0
Putter	7.0	5.0	3.7	6.3	5.3	2.7	6.0	2.7	1.3
Penncross	7.0	5.7	3.3	7.0	5.0	2.0	6.7	4.3	1.3
South shore	7.0	5.0	3.7	5.7	5.3	2.3	3.3	3.7	2.0
Crystal Bluelinks	7.0	4.7	3.3	6.3	3.7	2.7	5.7	2.7	1.7

Penn A-4	7.0	5.0	4.7	6.7	4.7	4.7	5.7	3.3	4.0
Penn A-1	7.0	5.3	3.3	6.3	5.0	2.0	5.0	3.0	1.7
Memorial	7.0	5.0	4.3	6.7	5.7	3.3	5.0	3.7	2.0
Pinup [†]	7.0	5.3	3.3	5.7	5.0	2.3	5.3	4.3	1.7
Kingpin	7.0	5.0	4.0	6.3	5.0	4.0	4.7	3.7	2.3
LSD ($P \leq 0.05$)	ns	ns	1.5	ns	ns	1.6	1.6	1.6	1.8

ns means not significantly different at $P \leq 0.05$ level.

[†]Creeping bentgrass cultivar not included in the field study.

Table 4. Stress index [R_{710}/R_{810} , R and the subscript numbers indicate the light reflectance at the specific wavelength (nm)] of creeping bentgrass managed under the putting green and the fairway conditions.

Cultivar	Putting green				Fairway		
	2015		2016		2015	2016	
	Aug. 12	Aug. 24	Aug. 22	Aug. 30	Aug. 24	Aug. 22	Aug. 30
L-93	0.29	0.35	0.39	0.39	0.36	0.35	0.34
T-1	0.30	0.31	0.36	0.36	0.31	0.32	0.31
Alpha	0.30	0.34	0.39	0.38	0.30	0.31	0.29
Putter	0.31	0.35	0.43	0.42	0.34	0.33	0.32
Southshore	0.29	0.36	0.40	0.40	0.34	0.32	0.32
Kingpin	0.32	0.36	0.43	0.42	0.30	0.32	0.31
Crenshaw [†]	0.31	0.35	0.39	0.39	0.37	0.30	0.30
Imperial [†]	0.31	0.36	0.42	0.42	0.33	0.36	0.34
Century [†]	0.32	0.36	0.42	0.41	0.35	0.36	0.34
Penncross	0.32	0.36	0.42	0.43	0.34	0.35	0.34
A-4	0.30	0.35	0.39	0.39	0.35	0.32	0.33
Crystal bluelinks	0.31	0.36	0.39	0.38	0.33	0.35	0.34
Alister [†]	0.30	0.36	0.43	0.46	0.35	0.35	0.32
Pennlinks II	0.31	0.35	0.39	0.40	0.35	0.34	0.33
Penn A-1	0.32	0.35	0.42	0.42	0.37	0.34	0.33
Penn G-6 [†]	0.31	0.35	0.42	0.42	0.34	0.33	0.32
007	0.30	0.33	0.44	0.46	0.31	0.34	0.34

MacKenzie	0.30	0.33	0.47	0.45	0.34	0.34	0.33
Tyee	0.30	0.34	0.41	0.42	0.32	0.32	0.32
SR 1150	0.31	0.36	0.43	0.45	0.33	0.38	0.37
Memorial	0.30	0.35	0.39	0.38	0.34	0.33	0.34
Independence	0.30	0.34	0.39	0.37	0.30	0.32	0.30
Declaration	0.31	0.36	0.46	0.46	0.33	0.36	0.36
LS – 44 [†]	0.29	0.34	0.39	0.39	0.37	0.32	0.32
Bengal	0.28	0.35	0.37	0.37	0.33	0.35	0.33
LSD ($P \leq 0.05$)	0.02	0.03	0.06	0.05	0.04	0.04	0.03

[†]Creeping bentgrass cultivar not included in the hydroponic experiments as it is no longer commercially produced.

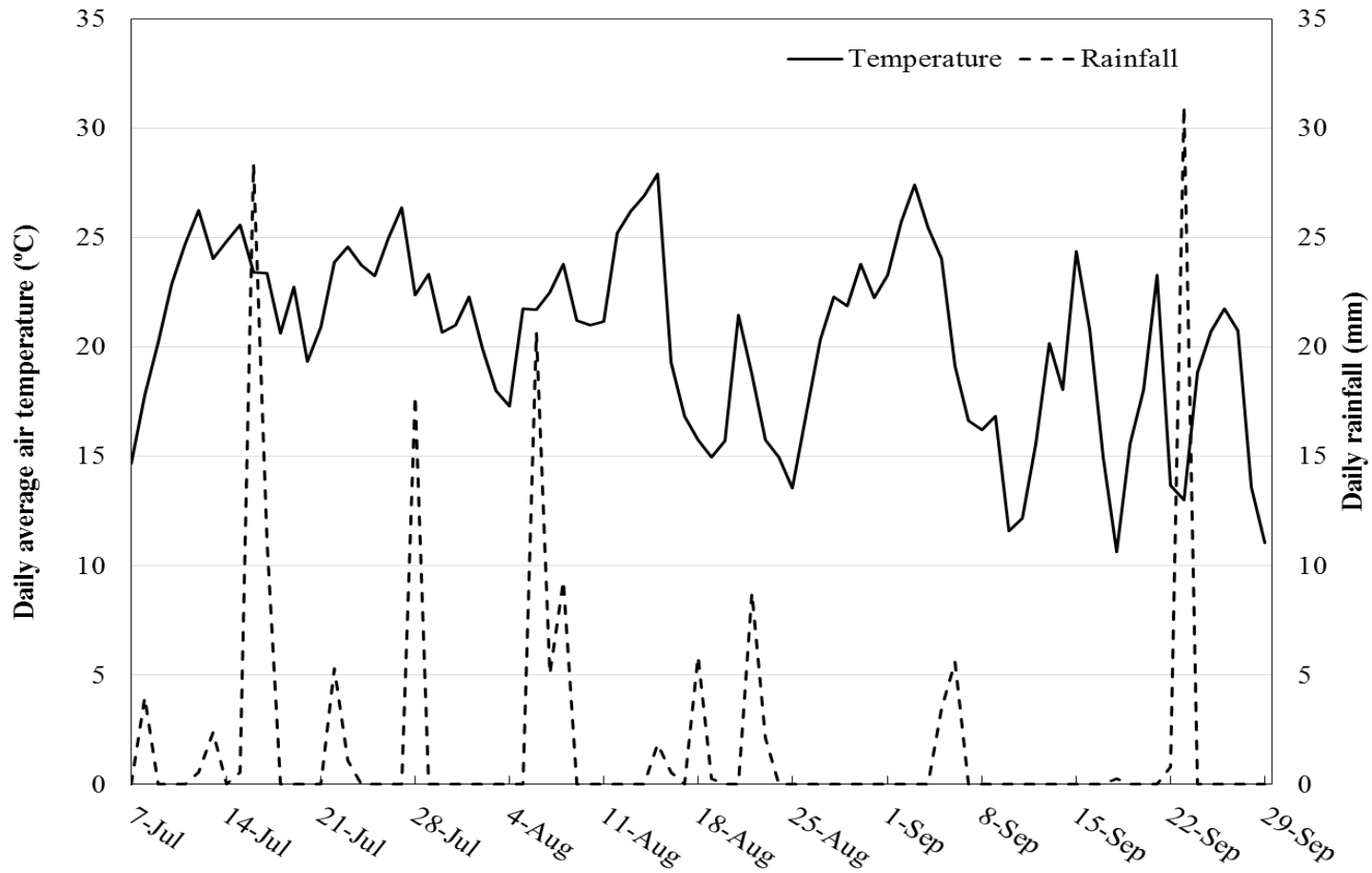


Figure 1. Daily average air temperature (°C) and rainfall (mm) from July 8 to Sept. 29, 2015.

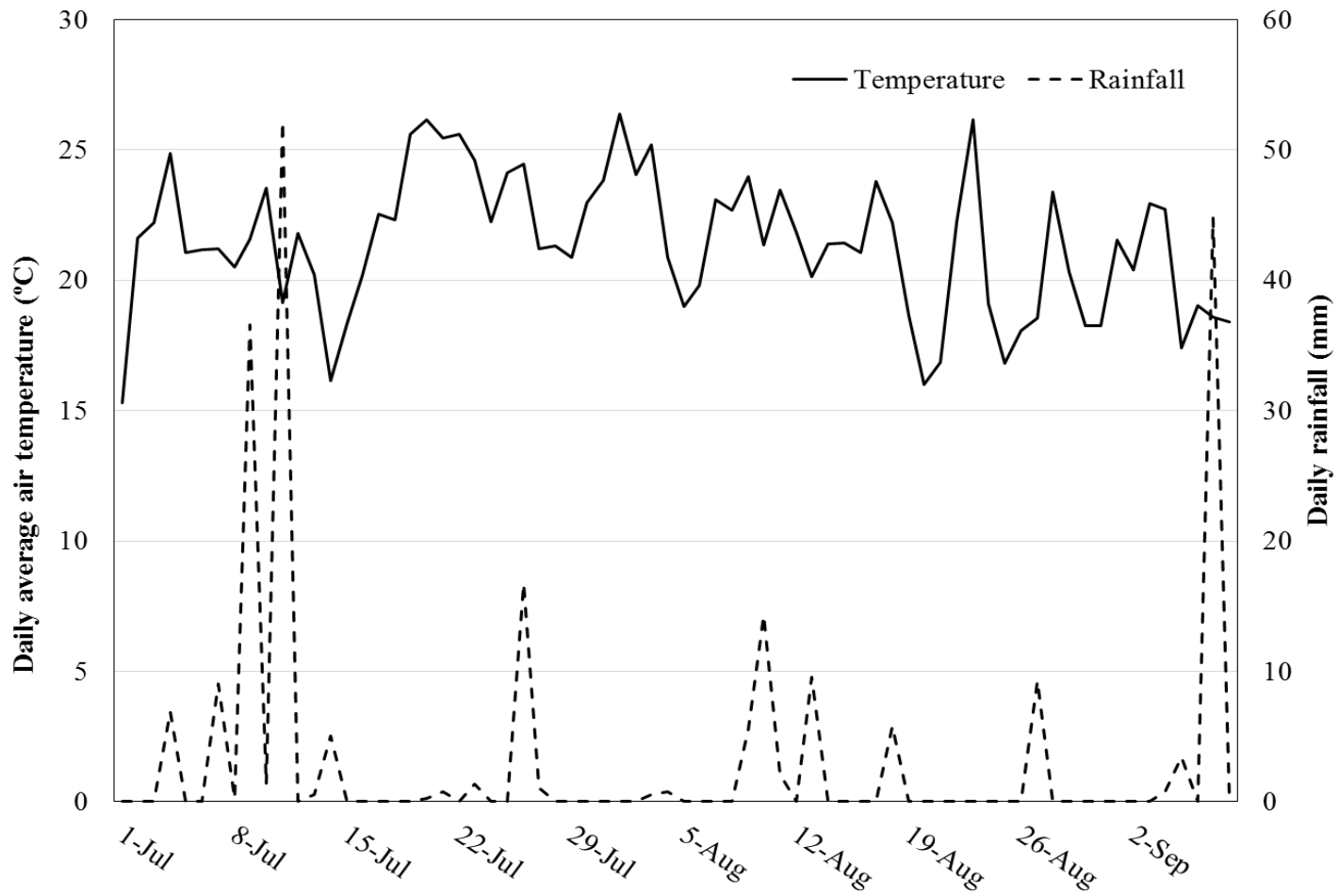


Figure 2. Daily average air temperature (°C) and rainfall (mm) from July 1 to Sept. 8, 2016.