BOTANICAL COMPARISONS OF TWELVE CREEPING BENTGRASS (AGROSTIS STOLONIFERA) CULTIVARS IN A WARM-HUMID CLIMATE

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MATERIALS AND METHODS

The twelve creeping bentgrass (*Agrostis stolonifera*) cultivars assessed were seeded at 1.0 lb per 1,000 sq. ft. (0.5 kg/100 m^2) in October of 1993, into 8 x 8 foot (2.4 x 2.4 m) plots with 3 replications. The root zone consisted of a 10 inch (250 mm) depth of 100% sand which met USGA sand particle size distribution specifications, placed over a subsurface drain line system.

A moderately intensive cultural system was followed on the experimental area, except for the very close cutting height. The bench setting of the mower was 1/8 inch (3.2 mm) year round. All turfs were mowed 5 times per week with a 22-inch (55.7 cm) wide, walking greensmower, with the clippings removed. Nitrogen fertilization was applied 10 times per year with an annual total of 6 lb per 1,000 sq. ft. (3 kg N/100 m^2). A total of 5.4 lb per 1,000 sq. ft. (2.7 kg K/100^2) was applied annually , while phosphorus was applied as needed based on an annual soil test. Irrigation was applied as needed to prevent visual wilt of the turf. Topdressing was applied 4 times annually at a rate of (0.14 m^3 100/m^2). Turf cultivation with 2.4 inch (60 mm) long, 0.24 inch (6.4 mm) diameter solid tines was practiced twice annually. Fungicides were applied only when needed to prevent a serious turf loss. In 1996 thiophanate methyl was applied on 21 May and 19 July, while tridimefon was applied on 7 October. No significant visual turf loss attributed to pests was observed during the 2 assessment periods.

Five comparative turf-related assessments were conducted on each of the two dates as follows: (a) Visual turfgrass quality estimates were based on a composite of two main components: uniformity of appearance and shoot density. The rating scale used was 9 = best and 1 = poorest. (b) Shoot density counts were made from 1.3 square inch (855 mm^2) turf plugs. Each turf sample was washed and the shoots separated for counting. (c) Thatch/mat depth and the length of the longest intact root were measured with a metric rule. (d) The shoot/thatch/mat biomass was harvested, washed, dried for 24 hours at 105°C, and then weighed. (e) Vertical root distribution was determined by washing the root biomass free of soil, separating it into 2 inch (50 mm) segments, drying at 105°C for 24 hours, and then weighing. The total root biomass was the weight of all roots from each plug sample. All data from this study were analyzed by analysis of variance using the LSD t Test at the 5 % level. The October assessments were made on a split plot arrangement of 3 replications.

The climate at the experimental site near Rolesville, North Carolina, is warm and humid from June to October of most years, with mild winters. A weather data summary for each month from March to mid-October of 1996 in east-central North Carolina is shown in Table 1. Included are the monthly maximum and minimum temperatures, the monthly daily averages for high and low temperatures, and the precipitation as rainfall per month and year-to-date.

During the summer stress period the daily minimum low temperature exceeded 75.2°F (24°C) for 4 days in June and 8 days in July, and exceeded 71.6°F (21°C) for 6 days in May, 15 days in June, 20 days in July, 9 in August, and 3 days in September. For the 90 days of midsummer the daily minimum low temperature exceeded 71.6°F (21°C) on 52% of the days. Rainfall events of 0.5 inch (13 mm) per day occurred twice in May, 3 times in June, 8 times in July, 9 times in August, 5 times in September, and 3 times during the first 10 days in October. There were 6 rain events exceeding 2 inches (50 mm) per day during these months.

Table 1. A summary of 1996 weather data monitored at the study site in Pinehurst, North Carolina.

Weather parameter	Month							
	March	April	May	June	July	August	September	mid-October
	Temperature - °F (°C)							
maximum	77 (25)	91 (33)	97 (36)	100 (38)	99 (37)	97 (36)	95 (35)	82 (28)
minimum	18 (-8)	34 (1)	45 (7)	61 (11)	63 (17)	63 (17)	41 (5)	
average daily high	61 (16)	79 (26)	64 (28)	93 (34)	91 (33)	91 (33)	86 (30)	72 (22)
average daily low	45 (7)	55 (13)	63 (17)	72 (22)	73 (23)	70 (21)	64 (18)	59 (15)
	Rainfall - inches (mm)							
monthly total	4.0 (102)	3.6 (90)	1.4 (36)	2.9 (74)	9.5 (241)	9.6 (243)	8.6 (218)	5.4 (136)

This paper presents comparative botanical assessments of 12 creeping bentgrass (*Agrostis stolonifera*) cultivars at two times during the year under the conditions of the study as described in the next section. Quantitative assessments were conducted on 17 to 21 May 1996, at the termination of a favorable growing period, and on 16 to 20 October 1996, at the termination of a severe summer heat stress season.

RESULTS

Turfgrass Quality. There were significant differences in visual turfgrass quality among the creeping bentgrass cultivars at each of the 2 assessment dates. In May at the end of the favorable growth period, the visual turfgrass quality ratings varied from a high of 7.7 to a low of 3.3. Penn G-2 and Penn A-1 had the highest visual turfgrass quality, followed by Penn G-6, Penncross, and Penneagle; and then PennLinks, Southshore, and Seaside II.

Table 2. Comparative assessments of visual turfgrass quality, mat/thatch depth, shoot/thatch/mat dry weight, and shoot density for 12 creeping bentgrass cultivars as assessed on 17 to 21 May 1996, at the end of the favorable growing season.

Cultivar	Visual turfgrass quality	Mat/thatch depth (mm)	Shoot/mat/thatch dry weight (g/dm²)	Shoot density (number/dm²)
Penn G-2	7.7 a*	15 ab*	84 a*	3,547 a*
Penn G-6	5.5 b	17 a	53 c	3,304 ab
Penn A-1	7.0 a	15 ab	68 b	3,134 ab
Southshore	4.8 c	13 bc	59 c	2,430 bc
SR 1020	4.2 d	14 b	42 d	2,332 bc
Penneagle	5.2 b	11 c	34 e	2,284 bc
Seaside II	4.7 c	13 bc	44 d	2,162 cd
Cobra	4.2 d	11 c	81 a	2,095 d
Crenshaw	3.3 e	11 c	46 d	1,976 e
Cato	4.3 d	11 c	39 e	1,636 f
Penncross	5.3 b	15 ab	37 e	1,369 g
PennLinks	4.9 c	16 ab	71 b	1,353 g

* Means followed by the same letter in the same column are not significantly different at the 5% level LSD t-Test.

In October at the end of the hot-humid season, the range in visual turfgrass quality was from a high of 5.8 to a low of 3.0. Penn G-2, Seaside II, Penncross, and Penn G-6 had the highest ratings; followed by Southshore and Penn A-1. Cobra had the lowest visual turfgrass quality, followed by Crenshaw and SR 1020.

Mat/Thatch Depth. There were no excessive accumulations of mat/thatch through 1996. Significant differences in mat/thatch depths among some of the creeping bentgrass cultivars were found. The mat/thatch depths in May ranged from a low of 11 mm for Crenshaw, Cobra, Cato, and Penneagle, with Seaside II and Southshore not significantly different; to a high of 17 mm for Penn G-6, with PennLinks, Penn G-2, Penn A-1, and Penncross not significantly different. In October the range in mat/thatch depths was from 7 mm for SR 1020 to 18 mm for Penn G-2 and Penneagle, with Penn G-6 and Penn A-1 not significantly different.

Table 3. Comparative assessments of visual turfgrass quality, mat/thatch depth, shoot\thatch\mat dry weight, and shoot density for 12 creeping bentgrass cultivars as assessed on 16 to 20 October 1996, after the hot-humid stress season.

Cultivar	Visual turfgrass quality	Mat/thatch depth (g/dm^2)	Shoot/mat/thatch dry weight (g/dm^2)	Shoot density (number/dm^2)
Penn G-2	5.8 a*	18 a*	63 a*	3,313 a*
Penn G-6	5.3 b	14 a	41 c	3,046 a
Penn A-1	4.7 b	14 a	44 c	2,767 b
Seaside II	5.7 a	11 b	39 c	2,542 c
SR 1020	3.3 e	7 d	30 d	2,066 d
Penneagle	4.0 de	18 a	49 b	2,054 d
Southshore	5.0 b	11 b	42 c	1,963 d
Crenshaw	3.3 e	9 c	22 f	1,863 d
Cobra	3.0 f	9 c	47 b	1,783 d
Penncross	5.7 a	13 b	27 e	1,603 e
Cato	4.0 de	9 c	25 f	1,567 e
PennLinks	4.3 c	11 b	48 b	1,533 e

*Means followed by the same letter in the same column are not significantly different at the 5% level LSD t-Test.

Shoot/Thatch/Mat Dry Weight. In May the Penneagle had the least shoot/mat/thatch dry weight at 34 g dm^2, with Penncross and Cato not significantly different. Penn G-2 had the most shoot/mat/thatch dry weight at 84 g/dm^2, with Cobra not significantly different; followed by PennLinks and Penn A-1.

In October the Crenshaw, Cato, and Penncross had the least shoot/mat/thatch dry weights at 22, 25 and 27 g dm^2, respectively; followed by SR 1020 and Seaside II. Penn G-2 was the highest at 63 g/dm^2, followed by Penneagle, PennLinks, Cobra, Penn A-1, Southshore, and Penn G-6.

Shoot Density. There were significant differences among the 12 creeping bentgrass cultivars at each of the 2 assessment dates. A large intraspecific variability in shoot density was found among the 12 cultivars at the 1/8 inch (3.2 mm) cutting height, ranging from 3,547 to 1,353 per sq dm in May and from 3,313 to 1,533 per sq dm in October.

In May the Penn G-2 had the highest shoot density at 3,547 per dm^2; followed by Penn G-6 and Penn A-1, with all 3 cultivars above 3,000 shoots dm^{-2} at the 1/8 inch (3.2 mm) cutting height. PennLinks and Penncross had the lowest shoot densities in May at 1,353 and 1,369 per dm^2, respectively. The other 7 cultivars were intermediate in shoot density ranging from 2,430 to 1,636 per dm^2.

In October the Penn G-2 has the highest shoot density at 3,313 per dm^2, with Penn G-6 not significantly different; followed by Penn A-1 and Seaside II. Intermediate in shoot density were 5 cultivars ranging from 2,066 to 1,783 per dm^2.

Longest Intact Root Length. In May all 12 cultivars had roots extending below the 4 inch (100 mm) depth, with Penn G-2 being the deepest at 145 mm. In October the Penn G-2 had the deepest root depth of 116 mm and was the only cultivar with a root depth greater than 4 inches (100 mm). Next in root depth were Cobra and Penn G-6 at 97 and 87 mm, respectively. Six cultivars were intermediate in root depth ranging from 79 to 73 mm. Crenshaw, followed by Cato and SR 1020, had the least root depth at 58, 63, and 68 mm, respectively.

Table 4. Comparative assessments of length of the longest intact root, root biomass at 3 depths and total root biomass 12 creeping bentgrass cultivars as assessed on 17 to 21 May 1996, at the end of the favorable growing season.

Cultivar	Length of longest root (mm)	Root Biomass Dry Weight (g/dm²)			
		0 to 2 inch (0-50 mm) depth	2 to 4 inch (50-100 mm) depth	4 to 6 inch (100-150 mm) depth	Total
Penncross	139 a*	82 a*	18.2 a*	0.3 c*	101 a*
Penn G-2	145 a	77 a	16.4 a	0.3 c	94 a
Penn G-6	107 c	63 b	18.0 a	0.1 d	80 ab
Penn A-1	139 a	64 b	3.0 c	0.4 b	67 b
Southshore	132 a	50 c	15.0 a	0.2 d	65 b
SR 1020	127 b	54 c	3.5 c	0.5 a	58 c
Seaside II	117 c	48 d	11.0 b	0.4 b	59 c
Penneagle	125 b	48 d	9.0 b	0.4 b	57 c
PennLinks	138 a	43 d	11.0 b	0.4 b	54 c
Cobra	142 a	22 f	1.0 d	0.4 b	23 d
Cato	130 a	21 g	1.0 d	0.1 d	22 e
Crenshaw	120 b	13 g	1.0 d	0.2 d	14 f

*Means followed by the same letter in the same column are not significantly different at the 5% level LSD t-Test.

Root Biomass. Root biomass is a critical factor in determining turfgrass survival from various stresses. Both total biomass and biomass at each of 3 intermediate depths are presented in the following subsections, expressed as dry weight in g/dm².

Table 5. Comparative assessments of length of the longest intact root, root biomass at 3 depths, and total root biomass for 12 creeping bentgrass cultivars assessed on 16 to 20 October 1996, after the hot-humid stress season.

Cultivar	Length of longest root (mm)	0 to 2 inch (0-50 mm) depth	Root 2 to 4 inch (50-100) depth	Biomass Dry Weight (g/dm²) 4 to 6 inch (100-150 mm) depth	Total
Penn G-2	116 a*	48 a*	1.3 b*	1.5 a*	51 a*
Penncross	74 c	42 ab	3.3 a	0.0 b	45 ab
PennLinks	73 c	31 bc	1.2 b	0.0 b	26 cd
Penn A-1	79 c	24 c	1.6 b	0.0 b	26 cd
Penn G-6	87 b	23 c	1.0 c	0.0 b	24 d
Seaside II	74 c	23 c	0.8 c	0.0 b	24 d
Southshore	73 c	22 c	1.5 b	0.0 b	24 d
Penneagle	74 c	22 c	1.0 c	0.0 b	23 d
SR 1020	68 d	15 d	0.6 c	0.0 b	16 e
Cobra	97 b	13 de	0.9 c	0.0 b	16 e
Cato	63 d	3 f	1.0 c	0.0 b	4 f
Crenshaw	58 e	2 f	0.8 c	0.0 b	3 f

*Means followed by the same letter in the same column are not significantly different at the 5% level LSD t-Test.

0 to 2 inch Depth. At the May assessment, Penncross and Penn G-2 had the highest root biomass in the upper 2 inches (50 mm); followed by Penn A-1 and Penn G-6. In October Penn G-2 and Penncross, followed by PennLinks, had the highest root biomass levels in the upper 2 inches, ranging from 48 to 31 grams.

2 to 4 inch Depth. In May the Penncross, Penn G-6, Penn G-2 and Southshore were highest in root biomass ranging from 18 to 15 grams, followed by PennLinks, Seaside II, and Penneagle ranging from 11 to 9 grams. All 12 creeping bentgrass cultivars had minimal root biomass levels at the 2 to 4 inch (50 to 100 mm) depth by October. Penncross ranked the best at 3.3 grams.

4 to 6 inch Depth. The May and October assessments showed low root biomass levels at this depth for all 12 cultivars, when mowed at 1/8 inch (3.2 mm). In October the Penn G-2 was the only creeping bentgrass cultivar with roots below the 4 inch (100 mm) depth.

Total Root Biomass. In May the total root biomass of Penncross and Penn G-2 were the greatest at 101 and 94 grams, respectively; followed by Penn G-6, Penn A-1, and Southshore. Intermediate in total root biomass were 4 cultivars. Crenshaw had the least root biomass at 14 grams, followed by Cato and Cobra. These data indicate that major differences in rooting may occur among the creeping bentgrass cultivars.

In October the Penn G-2 was the highest at 51 grams; followed by Penncross at 45 grams and PennLinks at 32 grams . Intermediate were 5 cultivars ranging from 26 to 23 grams. Crenshaw at 3 grams and Cato at 4 grams were the lowest in total root biomass at the 1/8 inch (3.2 mm) cutting height after a hot-humid stress period. Again, these results indicate that major differences in rooting may occur among the creeping bentgrass cultivars even when subjected to severe heat stress.

DISCUSSION

The results revealed significant variations among the 12 creeping bentgrass cultivars under the conditions of this study at a 1/8 inch (3.2 mm) cutting height in such botanical characteristics as thatch/mat depth, shoot/mat/thatch dry weight, shoot density, longest intact root, and root biomass vertical distribution. The variations among cultivars occurred for both the May assessment, following favorable conditions for growth, and for the October assessment period, following a humid-hot summer stress period.

The May data comparing botanical characteristics among cultivars, as assessed in North Carolina, would be indicative of the capability of each cultivar under similar environmental conditions in cooler climates. Confirmation of this association would require comparable types of studies in different climatic regions. Finally, the turfs were 3 years of age at the time of these botanical assessments. To make final conclusions as to the overall performance of the creeping bentgrass cultivars under stressful conditions imposed by humid-hot climates requires a longer time period in order to encompass tolerances or susceptibilities to multiple pest and environmental stresses.

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