2003 NTEP Bentgrass Putting Green Cultivar Evaluation Performance Data, 2007

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Objective: To evaluate the performance of various commercially available and experimental bentgrass cultivars when managed under simulated putting green conditions in co-operation with the National Turfgrass Evaluation Program (NTEP).

Procedures: This experiment has been evaluated continuously from Sept., 2003 through 2007 at the W.H. Daniel Turfgrass Research and Diagnostic Center, West Lafayette, IN. This trial initially included 32 bentgrass cultivars both, creeping bentgrasses and velvet bentgrasses planted in plots measuring 1.5 m x 1.5 m with three replications of each cultivar. The trial is located on a clay-based native soil push-up research putting green that has accumulated approximately 3 inches of a sand topdressing mixture. It is located in full-sun, receives approximately 3 lbs. of N per 1000 ft^2 yr^{-1}, irrigation to supplement natural rainfall and is mowed daily during the growing season at 0.140 inches with a triplex mower, core cultivated twice annually and supplementally topdressed with a moderate amount of sand on two other occasions during periods of active growth. Fungicides are applied primarily to control dollar spot on a curative basis. In 2007, however, fungicides were applied preventatively to assess seasonal cultivar performance without significant disease pressure. These soil and moderate maintenance intensity programs are fairly common throughout our location in the upper cool-humid region.

Data collected included visual ratings for: turfgrass quality on a 1-9 scale where; 1 = poor, 9 = optimum greenness, density and uniformity and 6 = acceptable putting green turf. Additionally cultivars were periodically rated for genetic color, shoot density, leaf texture, spring green-up, fall color retention and canopy smoothness. All characteristics were rated on a 1-9 scale where 1 = worst values and 9 = darkest, densest, finest, earliest greening, best color retention or most smooth. In addition, dollar spot was rated by counting the number of infection centers per plot.

The study design was a completely randomized block with three replications. All data was subjected to analysis of variance using the SAS system (Statistical Analysis Systems Institute Inc., Cary, N.C.) general linear model procedure and treatment means separated using Fisher's protected least significant difference (LSD) test at the p=0.05 level.

Results: Originally when this trial was planted in Sept. 2003 it contained 32 bentgrass cultivars, six velvet cultivars interspersed with 26 creeping bentgrass cultivars. In 2007, the velvet bentgrasses were removed from further evaluation due to the fact they had become severely contaminated with creeping bentgrass and individual cultivars could no longer be visually distinguished. For the 2007 growing season, the quality values varied throughout the observation months with generally lower values in April, May and October and higher values observed in June, July and August (Table 1). For overall mean quality, sixteen of the 26 cultivars were in the top statistical category for mean annual turf quality with the highest numerical values occurring for Shark and Penn A-1. Of the more commonly recognized and widely planted cultivars both Penn A-1 and Penn A-4 were also in this group while many of the older cultivars including Penncross, Providence, Pennlinks, and L-93 were in the lower statistical group.

When evaluating annual performance from year to year for the 2004-2007 study years, five cultivars (Benchmark DSR, Independence, T-1, Authority and Penn A-1) were in the top statistical category in each of the four years (Table 2). In addition to annual quality, summer, June-August, bentgrass performance was also determined. For this,

three cultivars, (Authority, Benchmark DSR and the experimental cultivar, 13-M) were in the top statistical category for all four study years (Table 3) for the summer months.

Visual appearance or quality is a function of characteristics such as, shoot density, leaf texture, greenness, and stand uniformity. As expected there was considerable cultivar variability for leaf texture, genetic color and Spring green-up and late fall color retention there was (Table 4). A consistent green color throughout the growing season is a desirable trait. For spring green-up, about one-half of the cultivars greened up faster than the remaining cultivars. For late-fall color retention, however, two cultivars, CY-2 and Declaration had superior fall color retention when rated in December, 2007.

Resistance to disease and weed pests is a desirable trait to maintain a high degree of surface uniformity. Dollar spot was rated as the number of infection centers per plot in late-summer and fall of 2005 and 2006. These values ranged from 0 to 47 infection centers per plot and significant differences among cultivars were observed. The majority, 22 of the 26 cultivars evaluated were significantly more resistant to dollar spot than the most susceptible cultivars, Crenshaw, Backspin, Penn A-4, and Independence. In addition to dollar spot resistance, resistance to annual bluegrass encroachment is a serious concern for golf course managers and in this trial four cultivars, Penncross, Pennlinks , Providence and Pennlinks II, were significantly more prone to annual bluegrass invasion than the other 22 cultivars with 2.2-4.7 % of the plot area affected, while the remaining cultivars generally had $\leq$ 1.5 %.

Characteristics like shoot density also affected functional characteristics like canopy smoothness between mowings (Figure 1). For summer shoot density, twelve cultivars were in the top statistical group for shoot density in both 2005 and 2007 (Table 6). The relationship between visual shoot density and canopy smoothness was somewhat weak, however, three improved cultivars (Tyee, MacKenzie and Benchmark DSR) had bumpy surfaces compared to older cultivars with historically lower shoot densities.

This trial will continue for one more growing season and will provide five consecutive years of data for many of the new bentgrass cultivars. This trial is an excellent one in which to observe genetic improvement, particularly among the Penn cultivars. There are several generations represented, and as expected the one time industry standard, Penncross, is among one of the poorest performers. This should be no surprise as it is more than fifty years old. Only slightly better than Penncross is Pennlinks which is no different than Pennlinks II. Both of these, however, are inferior to Penn A-4 which is only barely similar to the most superior Penn A-1 which has one of the highest numerical value/ranking. In our trial the major difference associated with the higher value of Penn A-1 versus A-4 is the severe susceptibility of A-4 to dollar spot in our study location. This can be corrected by more regular fungicide applications, however, if the current goal in turf management is to maintain turf areas with fewer chemical inputs then less susceptible cultivars like Declaration should be considered.

The results of this trial are relevant to a moderately maintained putting green located in the upper cool-humid region. Cultivar performance may be slightly different where management intensity is increased (e.g. lower mowing height with a walk-mower, more frequent mowing, cultivars grown on a sand-based rootzone). More information regarding this study and the cultivar performance information for other regions can be accessed at the National Turfgrass Evaluation Program's website located at http://www.ntep.org.

Acknowledgments:

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Table 1. Visual quality ratings for 26 creeping bentgrass cultivars evaluated under simulated putting green conditions on a native soil putting green during the 2007 growing season at the W.H. Daniel Turfgrass Research and Diagnostic Center, West Lafayette, IN.

NTEP Entry #	Cultivar	Type	April	May	June	July	Aug.	Sept.	Oct.	Mean
			Visual quality (1-9 rating scale) †							
23	Shark (23R)	creeping	7.0	7.7	8.5	8.8	8.7	8.3	8.3	8.3
2	Penn A-1	creeping	6.7	7.8	8.7	8.6	8.8	7.8	8.8	8.3
7	T-1	creeping	7.3	8.3	8.5	8.7	8.3	7.8	7.7	8.2
24	MacKenzie (SRX 1GPD)	creeping	7.0	8.1	8.9	8.0	8.5	8.0	8.2	8.2
10	Declaration	creeping	6.7	7.9	8.7	8.4	8.8	7.7	8.3	8.2
21	007 (DSB)	creeping	6.7	7.5	8.6	8.7	9.0	7.5	8.3	8.1
13	Authority (235050)	creeping	6.7	8.3	8.7	8.6	8.4	7.3	8.0	8.1
25	Tyee (SRX 1GD)	creeping	7.3	7.9	8.7	8.3	8.8	7.3	8.0	8.1
15	Kingpin (9200)	creeping	6.7	8.0	8.1	8.3	8.6	7.8	8.3	8.1
11	Independence	creeping	6.7	7.9	8.4	8.4	8.8	7.7	7.3	8.0
3	Benchmark DSR	creeping	7.3	8.1	8.3	8.0	8.7	7.7	7.7	8.0
5*	CY-2	creeping	7.0	7.8	8.3	8.3	9.1	7.2	7.7	8.0
6	Alpha	creeping	7.3	7.5	8.3	8.5	8.5	7.8	7.3	8.0
17*	IS-AP 9	creeping	6.7	8.2	8.4	8.7	8.3	7.0	8.0	8.0
27	Penn A-4	creeping	7.0	7.3	8.3	8.5	8.7	7.8	7.5	8.0
14	Bengal	creeping	6.7	8.0	8.2	8.3	8.4	7.0	7.8	7.8
20	Memorial (A03-EDI)	creeping	7.0	7.3	8.1	8.4	8.1	7.0	7.7	7.7
9*	13-M	creeping	6.3	7.0	7.8	8.2	8.5	7.3	7.7	7.6
1	LS-44	creeping	6.7	7.3	7.8	8.3	8.3	7.0	7.3	7.6
30	Backspin	creeping	5.7	7.3	8.0	7.8	7.9	7.3	6.7	7.4
28	L93	creeping	6.3	6.8	7.7	7.5	7.9	7.2	6.7	7.3
31	Pennlinks	creeping	5.7	6.7	7.5	7.3	7.9	6.7	7.0	7.1
29	Crenshaw	creeping	6.0	6.5	7.1	7.4	7.6	7.0	6.7	7.0
26	Pennlinks II	creeping	5.7	5.8	7.1	7.1	7.0	6.5	6.7	6.6
32	Providence	creeping	5.0	6.2	7.0	7.0	6.8	6.3	6.0	6.5
4	Penncross	creeping	5.7	6.0	6.3	6.5	6.8	6.0	6.7	6.3
	LSD (0.05) ‡		1.0	0.8	0.7	0.7	0.8	0.8	1.3	0.5

† Turf quality was rated on a 1-9 scale with 1=poor quality turf, 9= greenness, density and uniformity and 6=acceptable putting green turf.

‡ LSD = least significant difference. The LSD values at the bottom of each column represent the minimum difference between any two entries necessary to be 95% confident that the difference is not attributable to chance according to Fishers protected LSD t-test.

* Indicates an experimental cultivar not yet commercially available.

Table 2. Mean annual visual turfgrass quality and overall study quality for 32 bentgrass cultivars evaluated under simulated putting green conditions on a native soil putting green during the 2004-2007 growing seasons at the W.H. Daniel Turfgrass Research and Diagnostic Center, West Lafayette, IN.

NTEP Entry #	Cultivar	Type‡	Evaluation Period 2004	2005	2006	2007	Study
			---------- Visual quality (1-9 rating scale) † ----------				
3	Benchmark DSR	CBG	7.3	8.1	7.3	8.0	7.7
11	Independence	CBG	7.3	8.2	7.1	8.0	7.6
7	T-1	CBG	7.0	8.3	7.1	8.2	7.6
13	Authority (235050)	CBG	7.0	8.0	7.4	8.1	7.6
9*	13-M	CBG	7.7	7.8	7.2	7.6	7.6
2	Penn A-1	CBG	7.0	8.0	7.1	8.3	7.6
14	Bengal	CBG	7.0	7.8	7.3	7.8	7.5
17*	IS-AP 9	CBG	7.2	8.1	6.6	8.0	7.5
15	Kingpin (9200)	CBG	6.9	7.6	7.3	8.1	7.5
5*	CY-2	CBG	6.9	7.7	7.0	8.0	7.4
6	Alpha	CBG	6.5	7.9	6.9	8.0	7.3
10	Declaration	CBG	6.6	7.9	6.5	8.2	7.3
21	007 (DSB)	CBG	6.6	7.7	6.7	8.1	7.3
1	LS-44	CBG	6.6	7.8	6.9	7.6	7.2
24	MacKenzie (SRX 1GPD)	CBG	6.1	7.1	6.4	8.2	6.9
25	Tyee (SRX 1GD)	CBG	6.0	6.5	6.6	8.1	6.8
20	Memorial (A03-EDI)	CBG	6.3	6.8	6.3	7.7	6.8
23	Shark (23R)	CBG	5.1	6.7	6.1	8.3	6.5
26	Pennlinks II	CBG	5.6	6.5	5.8	6.6	6.2
4	Penncross	CBG	5.6	6.1	5.9	6.3	6.0
29	Crenshaw	CBG	6.6	5.3	4.3	7.0	5.8
30	Backspin	CBG	6.3	4.8	4.1	7.4	5.7
32	Providence	CBG	6.6	5.1	4.2	6.5	5.6
28	L93	CBG	6.1	4.8	4.2	7.3	5.6
31	Pennlinks	CBG	6.1	4.7	4.3	7.1	5.5
27	Penn A-4	CBG	5.2	4.4	4.4	8.0	5.5
16	Villa (IS-AC 1)	VBG	7.5	8.1	6.9	---	7.5
18	Venus (EFD)	VBG	7.2	8.0	7.1	---	7.4
12	Legendary	VBG	6.7	7.9	6.9	---	7.2
19	Vesper	VBG	6.8	7.9	6.8	---	7.2
8	SR 7200	VBG	6.7	7.4	7.0	---	7.0
22	Greenwich	VBG	6.3	7.0	6.6	---	6.6
	LSD (0.05) §		0.4	0.4	0.6	0.5	0.3

† Turf quality was rated on a 1-9 scale with 1=poor quality turf, 9= greenness, density and uniformity and 6=acceptable putting green turf.

‡ CBG = Creeping bentgrass, VBG = Velvet bentgrass.

§ LSD = least significant difference. The LSD values at the bottom of each column represent the minimum difference between any two entries necessary to be 95% confident that the difference is not attributable to chance according to Fishers protected LSD t-test.

* Indicates an experimental cultivar not yet commercially available.

Table 3. Summer (June-Aug.) visual quality ratings for 32 bentgrass cultivars evaluated under simulated putting green conditions on a native soil putting green during the 2004-2007 growing seasons at the W.H. Daniel Turfgrass Research and Diagnostic Center, West Lafayette, IN..

NTEP Entry #	Cultivar	Type	Evaluation Year 2004	2005	2006	2007
			---------- Visual quality (1-9 rating scale) † ----------			
23	Shark (23R)	CBG	4.5	6.9	6.2	8.6
21	007 (DSB)	CBG	6.2	8.1	7.1	8.5
2	Penn A-1	CBG	6.8	8.2	7.5	8.5
10	Declaration	CBG	6.0	7.9	6.5	8.4
11	Independence	CBG	6.9	8.3	7.1	8.3
7	T-1	CBG	6.3	8.4	7.2	8.3
27	Penn A-4	CBG	4.4	4.6	4.1	8.3
6	Alpha	CBG	5.8	8.1	7.1	8.3
24	MacKenzie (SRX 1GPD)	CBG	5.5	7.3	6.6	8.3
5*	CY-2	CBG	6.5	7.8	7.0	8.2
15	Kingpin (9200)	CBG	6.8	7.6	7.6	8.2
25	Tyee (SRX 1GD)	CBG	5.5	6.4	6.8	8.2
13	Authority (235050)	CBG	7.0	8.0	7.5	8.2
3	Benchmark DSR	CBG	7.4	8.0	7.5	8.2
17*	IS-AP 9	CBG	6.9	8.1	6.6	8.1
14	Bengal	CBG	6.8	7.8	7.7	8.0
9*	13-M	CBG	8.0	7.7	7.2	8.0
20	Memorial (A03-EDI)	CBG	5.9	6.8	6.6	7.9
1	LS-44	CBG	6.2	7.8	7.1	7.8
30	Backspin	CBG	6.0	5.1	4.0	7.7
28	L93	CBG	5.9	5.0	4.1	7.6
31	Pennlinks	CBG	5.6	4.9	4.2	7.4
29	Crenshaw	CBG	6.4	5.4	4.1	7.3
26	Pennlinks II	CBG	4.8	6.4	6.1	7.0
32	Providence	CBG	6.4	5.4	4.2	6.7
4	Penncross	CBG	5.0	6.0	6.0	6.5
16	Villa (IS-AC 1)	VBG	7.5	8.0	6.7	---
18	Venus (EFD)	VBG	6.8	7.9	7.0	---
12	Legendary	VBG	6.0	7.9	7.2	---
19	Vesper	VBG	6.5	8.0	6.7	---
8	SR 7200	VBG	6.6	7.3	7.2	---
22	Greenwich	VBG	5.8	7.0	6.7	---
	LSD (0.05) §		0.6	0.5	0.8	0.6

† Turf quality was rated on a 1-9 scale with 1=poor quality turf, 9= greenness, density and uniformity and 6=acceptable putting green turf.

‡ CBG = Creeping bentgrass, VBG = Velvet bentgrass.

§ LSD = least significant difference. The LSD values at the bottom of each column represent the minimum difference between any two entries necessary to be 95% confident that the difference is not attributable to chance according to Fishers protected LSD t-test.

* Indicates an experimental cultivar not yet commercially available.

Table 4. Visual shoot density, leaf texture, genetic color, spring green-up and fall color retention ratings for 26 creeping bentgrass cultivars evaluated under simulated putting green conditions on a native soil putting green during the 2007 growing season at the W.H. Daniel Turfgrass Research and Diagnostic Center, West Lafayette, IN.

NTEP Entry #	Cultivar	Shoot Density	Leaf Texture	Genetic Color	Spring Green-up	Fall Color
		26 June	26 June	26 June	26 Mar.	12 Dec.
		---------- Visual rating (1-9 rating scale) † ----------				
23	Shark (23R)	9.0	8.7	8.0	7.3	5.3
25	Tyee (SRX-1GD)	8.8	9.0	7.5	6.3	6.0
10	Declaration	8.8	7.8	8.2	7.3	6.7
21	007 (DSB)	8.8	7.8	7.8	8.7	5.0
7	T-1	8.7	8.7	9.0	7.0	4.7
24	MacKenzie (SRX 1GPD)	8.7	8.0	7.7	7.7	5.7
13	Authority (235050)	8.5	9.0	8.2	7.3	4.0
11	Independence	8.5	8.2	7.7	7.7	5.3
17*	IS-AP 9	8.3	8.8	8.5	8.3	3.3
2	Penn A-1	8.3	8.7	8.7	8.0	5.0
5*	CY-2	8.3	8.7	7.5	7.7	6.7
3	Benchmark DSR	8.3	8.3	8.0	8.0	4.3
6	Alpha	8.3	8.0	7.8	8.3	5.0
27	Penn A-4	8.3	7.7	8.5	7.7	4.7
14	Bengal	8.2	8.3	7.8	8.0	6.0
9*	13-M	8.2	7.5	7.3	7.0	6.0
31	Pennlinks	8.2	7.0	8.0	8.0	5.0
15	Kingpin (9200)	8.0	8.0	7.7	8.3	5.7
1	LS-44	7.8	8.3	8.7	6.3	4.0
30	Backspin	7.8	7.0	7.0	7.3	4.7
20	Memorial (A03-EDI)	7.7	7.7	8.0	8.0	5.7
29	Crenshaw	7.3	7.0	8.5	7.3	3.0
28	L-93	6.8	7.2	8.3	6.7	5.3
26	Pennlinks II	6.8	6.7	8.0	6.7	4.7
32	Providence	6.5	5.7	8.2	6.7	4.3
4	Penncross	6.0	6.0	8.2	6.7	4.7
	LSD (0.05) ‡	1.1	1.1	0.8	1.6	1.0

† Cultivars were rated for genetic color, shoot density, leaf texture, spring green-up, fall color retention and canopy smoothness on a 1-9 scale where 1 = worst values and 9 = darkest, densest, finest, earliest greening, best color retention.

‡ LSD = least significant difference. The LSD values at the bottom of each column represent the minimum difference between any two entries necessary to be 95% confident that the difference is not attributable to chance according to Fishers protected LSD t-test.

* Indicates an experimental cultivar not yet commercially available.

Table 5. Mean dollar spot ratings and annual bluegrass encroachment for 26 creeping bentgrass cultivars evaluated under simulated putting green conditions on a native soil putting green during the 2007 growing season at the W.H. Daniel Turfgrass Research and Diagnostic Center, West Lafayette, IN.

		Dollar spot		Annual bluegrass
NTEP Entry #	Cultivar	27 Oct. 2005	12 Aug. 2006	6 June 2006
		---- infection centers per plot †-----		-- % infestation ‡--
4	Penncross	7	13	4.3
26	Pennlinks II	2	4	3.7
32	Providence	18	13	3.7
31	Pennlinks	0	3	2.2
29	Crenshaw	47	40	1.5
28	L93	1	4	1.2
1	LS-44	1	7	1.1
20	Memorial (A03-EDI)	0	1	0.6
21	007 (DSB)	2	6	0.5
14	Bengal	12	4	0.4
17*	IS-AP 9	0	3	0.4
3	Benchmark DSR	0	3	0.3
15	Kingpin (9200)	2	1	0.3
6	Alpha	4	10	0.1
7	T-1	9	14	0.1
30	Backspin	28	11	0.1
25	Tyee (SRX 1GD)	8	7	0.1
5*	CY-2	0	0	0.1
23	Shark (23R)	9	1	0.1
9*	13-M	0	2	0.0
13	Authority (235050)	8	5	0.0
24	MacKenzie (SRX 1GPD)	5	10	0.0
27	Penn A-4	22	22	0.0
2	Penn A-1	2	4	0.0
10	Declaration	1	1	0.0
11	Independence	18	27	0.0
	LSD (0.05) §	17	19	1.8

† Cultivars were rated for susceptibility to dollar spot by counting the number of individual infection centers in each plot.

‡ Annual bluegrass encroachment was rated on a 0-100% linear scale where 0 = no annual bluegrass present and 100=complete plot coverage.

§ LSD = least significant difference. The LSD values at the bottom of each column represent the minimum difference between any two entries necessary to be 95% confident that the difference is not attributable to chance according to Fishers protected LSD t-test.

* Indicates an experimental cultivar not yet commercially available.

Table 6. Mean summer density and canopy smoothness ratings for 26 creeping bentgrass cultivars evaluated under simulated putting green conditions on a native soil putting green at the W.H. Daniel Turfgrass Research and Diagnostic Center, West Lafayette, IN.

NTEP Entry #	Cultivar	Shoot Density		Canopy Smoothness
		2005	2007	
		---------- Visual rating (1-9 scale) † ----------		
25	Tyee (SRX-1GD)	8.7	8.8	5.7
7	T-1	8.0	8.7	7.7
23	Shark (23R)	8.3	9.0	8.0
32	Providence	5.3	6.5	9.0
26	Pennlinks II	5.7	6.8	8.3
31	Pennlinks	5.0	8.2	8.7
4	Penncross	5.0	6.0	9.0
27	Penn A4	7.8	8.3	8.3
2	Penn A1	7.7	8.3	8.0
20	Memorial (A03-EDI)	7.3	7.7	8.3
24	Mackenzie (SRX 1GPD)	8.8	8.7	6.0
1	LS44	7.3	7.8	8.3
28	L93	7.3	6.8	8.7
15	Kingpin (9200)	8.7	8.0	7.0
17*	IS-AP9	8.0	8.3	7.7
11	Independence	8.3	8.5	7.7
10	Declaration	7.0	8.8	7.7
5*	CY-2	7.3	8.3	8.0
29	Crenshaw	6.7	7.3	9.0
14	Bengal	7.7	8.2	7.3
3	Benchmark DSR	8.0	8.3	6.7
30	Backspin	6.0	7.8	8.7
13	Authority (235050)	8.3	8.5	8.3
6	Alpha	8.0	8.3	8.0
9*	13-M	7.0	8.2	8.0
21	007 (DSB)	8.3	8.8	7.7
	LSD (0.05) ‡	1.0	1.1	1.0

† Cultivars were rated for shoot density and canopy smoothness on a 1-9 visual scale where 9 = densest or most smooth canopy.

‡ LSD = least significant difference. The LSD values at the bottom of each column represent the minimum difference between any two entries necessary to be 95% confident that the difference is not attributable to chance according to Fishers protected LSD t-test.

* Indicates an experimental cultivar not yet commercially available.

Figure 1. Visual of shoot density affected canopy smoothness 24 hours between mowings as evidenced by the bumpy appearance of this canopy prior to morning mowing.