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Using Digital Image Analysis to Evaluate Divot Recovery Rates among Cultivars of Creeping Bentgrass

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Abstract
Creeping bentgrass (Agrostis stolonifera L.) creates a dense, high-quality playing surface for intensely managed turf areas on golf courses. Its popularity is partially due to its aggressive lateral growth, which allows this species to partially recuperate in areas continuously subject to wear and divoting. Plant breeding has led to the development of a host of improved cultivars that possess enhanced turfgrass characteristics. Recently developed cultivars of creeping bentgrass possess greater shoot densities.

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Introduction

Creeping bentgrass (*Agrostis stolonifera* L.) creates a dense, high-quality playing surface for intensely managed turf areas on golf courses. Its popularity is partially due to its aggressive lateral growth, which allows this species to partially recuperate in areas continuously subject to wear and divoting. Plant breeding has led to the development of a host of improved cultivars that possess enhanced turfgrass characteristics. Recently developed cultivars of creeping bentgrass possess greater shoot densities.

The increase in shoot density helps impede invasion from annual bluegrass, an inevitable inhabitant of intensely managed turf swards. Although many believe the improved cultivars of creeping bentgrass create an improved playing surface, there are questions about the ability of these recently developed cultivars to spread laterally compared with traditional cultivars. This lack of comparative data among cultivars may partially be due to the subjectivity and time necessary for data collection. More recently, digital image analysis (DIA) has been shown to be an effective and accurate method of obtaining objective, reproducible measures of turfgrass cover.

Managing injury from divots is important in order to maintain maximum turfgrass cover and uniform playing conditions. The objectives of our research were to determine differences in the recuperative potential and shoot density cultivars of creeping bentgrass and to investigate the relationship between recuperative potential and shoot density.

Materials and Methods

Divot injury was simulated on June 3, 2009 and June 1, 2010 by removing a core of turf and soil from plots of 23 commercially available cultivars of creeping bentgrass and a single cultivar of colonial bentgrass and backfilling with native soil. Penncross served as the control and the remaining cultivars represented improved cultivars.

Plots measured 5 × 5 ft and were arranged as a randomized complete block with three replications. Maintenance was designed to simulate golf course fairway conditions with mowing performed two or three times weekly at 0.5 in., irrigation applied to prevent drought stress, and applications of a soluble fertilizer (18-0-24) every 14 d supplied 0.25 lb N and 0.33 lb K/1,000 ft^2.

Digital images of each plot were taken semiweekly in order to evaluate data by using DIA. Data was collected starting the day of injury and continued until full recovery or until dollar spot lesions interfered with the DIA analysis. Percentage cover was determined through DIA by using Sigma ScanPro.

Two cores from each plot were collected in June 2009 and 2010 and stored at -20°C for evaluation of shoot density. Shoot density was determined by counting the number of live tillers in each core.

Results and Discussion

We observed differences in divot recovery rates for the 24 cultivars in 2010 but not in 2009. In 2009, all cultivars had divot recovery rates similar to Penncross (Table 1). However, differences were detected in shoot density counts [tillers/dm^2] among the cultivars. The cultivar 007 had the greatest shoot density among cultivars and the cultivars T-1, SR 1150, Alpha, Kingpin, and Declaration all had shoot density counts similar to cultivar 007. In addition, orthogonal polynomial contrasts indicated differences in shoot density counts between Penncross and all other cultivars. Cultivars 007, Declaration, Kingpin, Alpha, SR 1150, T-1, Bengal, MacKenzie, Tyee, and Penn G-6 had shoot density counts 27 to 57 percent greater compared with Penncross. Recently developed cultivars of creeping bentgrass consistently produced shoot densities > 1,500 tillers/dm^2 and orthogonal polynomial contrasts showed a difference between Penncross and all other cultivars. Despite differences among cultivars in shoot density counts, no correlation was found between shoot density and divot recovery rates in 2009.

In 2010, divot recovery rate values ranged from 1.32 to 2.71 with a mean of 2.15 (Table 1). The most rapidly recovering cultivar (Putter) exhibited a divot recovery rate 105 percent greater compared with the slowest recovering cultivar (Kingpin). The cultivars SR 1150, T-1, and Kingpin had divot recovery rates 52 to 86 percent slower compared with Penncross. Three of the five cultivars with the greatest divot recovery values also had the lowest shoot density counts.

Our findings also revealed an inverse relationship between shoot density and divot recovery rate in 2010 indicating that cultivars with lower shoot densities were able to recover quicker from divots compared with cultivars with greater shoot densities. The cultivar T-1 had the second slowest divot recovery rate and the second highest shoot density, whereas Putter had the highest divot recovery rate and second lowest shoot density.

The results of this research indicate that cultivars of creeping bentgrass can differ in their recuperative potential. The increased shoot densities of recently developed cultivars of creeping bentgrass may hinder their recuperative potential compared with lower shoot density cultivars. This trade-off between recuperative potential and shoot density needs to be considered when selecting cultivars for specific use areas. Higher shoot density cultivars may be better suited for areas where lower populations of annual bluegrass are desired. Alternately, lower shoot density cultivars may be better suited for areas where damage from divoting is severe and recovery is important.

Table 1. Creeping bentgrass divot recovery rate and shoot density by cultivar for 2009 growing season.

Cultivar[†]	Divot recovery rate[‡]	Shoot density
	recovery d^{-1}	dm^2
Imperial	2.02	1,416
Penn G-6	1.89	1,485
007	1.87	1,836
Crystal Bluelinks	1.86	1,392
Alister[§]	1.86	1,181
SR 1150	1.82	1,602
Southshore	1.80	1,088
L-93	1.80	1,400
Century	1.79	1,392
Penncross	1.78	1,170
Memorial	1.75	1,181
MacKenzie	1.74	1,509
Penn A-4	1.71	1,252
Tyee	1.71	1,509
Putter	1.70	1,263
LS-44	1.69	1,380
Pennlinks II	1.68	1,298
Declaration	1.68	1,660
Crenshaw	1.68	1,380
Bengal	1.66	1,521
Alpha	1.66	1,602
T-1	1.63	1,556
Kingpin	1.59	1,614
Independence	1.58	1,439
Mean	1.75	1,422
$LSD_{0.05}$[¶]	NS	302**

†Cultivars sorted according to divot recovery rate.
‡Data were collected semiweekly and were fit to the linear model [Divot Recovery = R × DAI], where R is the rate of increase and DAI is the number of days after divot injury.
§Colonial bentgrass cultivar.
¶NS, *, ** – nonsignificant, and significant at $P \leq 0.05$ and $P \leq 0.01$, respectively.

Table 2. Creeping bentgrass divot recovery rate and shoot density by cultivar for 2010 growing season.

Cultivar[†]	Divot recovery rate[‡]	Shoot density
	recovery d^{-1}	dm^2
Putter	2.71	1,170
Crenshaw	2.62	1,333
Alpha	2.57	1,532
Penncross	2.46	1,181
Pennlinks II	2.42	1,170
Penn G-6	2.41	1,275
LS-44	2.39	1,438
MacKenzie	2.36	1,298
Southshore	2.34	1,252
Century	2.33	1,345
Penn A-4	2.32	1,474
Independence	2.28	1,544
Imperial	2.24	1,392
Crystal Bluelinks	2.18	1,287
Bengal	2.03	1,275
Alister[§]	2.03	1,380
Declaration	2.01	1,521
Memorial	1.98	1,286
007	1.87	1,509
L-93	1.84	1,591
Tyee	1.71	1,532
SR 1150	1.62	1,532
T-1	1.50	1,579
Kingpin	1.32	1,369
Mean	2.15	1,386
$LSD_{0.05}$[¶]	0.81*	NS

† Cultivars sorted according to divot recovery rate.
‡Data were collected semiweekly and were fit to the linear model [Divot Recovery = R × DAI], where R is the rate of increase and DAI is the number of days after divot injury.
§Colonial bentgrass cultivar.
¶ NS, *, ** – nonsignificant, and significant at $P \leq 0.05$ and $P \leq 0.01$, respectively.