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PURPOSE

The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 290 projects at a cost of $25 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf***.

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Creeping Bentgrass Cultivars in the Upper Midwest: Quality and Rate of Annual Bluegrass Invasion

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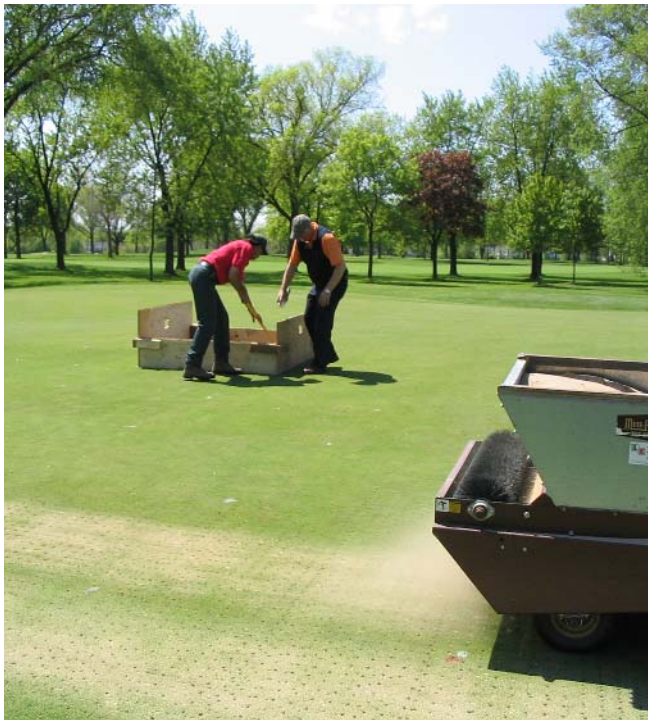
SUMMARY

North Shore Country Club, Glenview, Illinois, located in the northern suburbs of Chicago, was one of the sites selected to evaluate creeping bentgrasses in an on-site cultivar evaluation study jointly funded by the United States golf Association (USGA), the Golf Course Superintendents Association of America (GCSAA), and the National Turfgrass Evaluation Program (NTEP). Besides quality ratings, the trial at North Shore C. C. also collected data on differences in the rate at which annual bluegrass invaded creeping bentgrass cultivars. Among the study's findings:

- All of the cultivars had a five-year mean performance greater than 5, the minimally acceptable putting green quality rating.
- Five cultivars stood out in this study, 'Penn A-1', 'Penn A-4', 'Penn G-1', and 'Penn G-6', and 'L-93'. They were uniquely fine textured with extremely high density, and all produced outstanding putting surfaces.
- There were significant differences among the cultivars in their ability to restrict *Poa annua* invasion. The top statistical group of bentgrasses had a range of 3.5% to 7.5% *Poa* coverage compared to over 20% *Poa* coverage in the 'Penncross' plots.
- Differences in *Poa* invasion may be due to cultivar differences in plant densities, growth habit, differences in growth flushes, and aggressiveness allowing more agressive types to fill cultivation holes, ball marks, and other damage before the *Poa* has a chance to become established.

In 1997, the United States Golf Association (USGA), Golf Course Superintendents Association of America (GCSAA), and National Turfgrass Evaluation Program (NTEP) jointly initiated a program to evaluate newer creeping bentgrass and bermudagrass cultivars on putting greens at 16 sites in the U.S (see: http://www.ntep.org). While cultivar trials at universities and seed companies are commonplace, these trials differed in that they were placed on golf courses where they received traffic and were subject to maintenance regimes of the specific course. University scientists, turfgrass breeders, and course superintendents worked together on this project and all benefited from this real-world opportunity. North Shore Country Club, Glenview, Illinois, located in the northern suburbs of Chicago, was one of the sites selected to evaluate creeping bentgrasses. North Shore is a highly maintained, park-style course.

Turfgrass quality data were collected monthly for the first five growing seasons (1998-2002) after planting. These data provided golf turf managers with real-world performance of the



North Shore Country Club, Glenview, Illinois, located in the northern suburbs of Chicago, was one of the sites selected to evaluate creeping bentgrasses in the on-site study jointly sponsored by the USGA, GCSAA, and NTEP. In addition to quality evaluations, cultivars were evaluated on their abilities to resist invasion by *Poa annua*.

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Name	Sponsor
Backspin	Turf Merchants, Inc.
Cato	Pickseed West, Inc.
Century	Burlingham Seeds, Inc.
Crenshaw	Sunbelt Seeds, Inc.
Grand Prix	LESCO, Inc.
Imperia l	Burlingham Seeds, Inc.
L-93.	Loft's Seed, Inc.
Penn A-1	Tee-2-Green Corp.
Penn A-4.	Tee-2-Green Corp.
Penn G-1	Tee-2-Green Corp.
Penn G-6	Tee-2-Green Corp.
Penncross	Standard entry
Providence	Seed Research, Inc.
Putter	Jacklin Seed Co.
SR 1020	Seed Research, Inc.
SR 1119	Seed Research, Inc.
Trueline	Turf Merchants, Inc.
Viper	International Seeds, Inc.

Table 1. Creeping bentgrass cultivars and suppliers in 1997 NTEP on-site evaluation at North Shore Country Club

newest bentgrasses. Selecting the best turfgrasses for new plantings or for upgrading existing settings is arguably the most important step in the planning-building-planting process. To achieve a desired level of quality in the finished product, new and improved cultivars are the most useful tools available to turf managers. When a grass is well suited to a particular use, environment, and management scheme, it requires fewer labor and pesticide inputs than less adapted types.

But the story didn't end in 2002, the North Shore C.C. green is still yielding interesting research results eight years after planting. More recently, we have evaluated the cultivars for their resistance to invasion by annual bluegrass, the most troublesome weed in golf course turf.

Establishing and Evaluating the On-Site Study

On August 18 and 19, 1997, eighteen creeping bentgrass cultivars (Table 1) were seeded into 5 ft. by 10 ft. plots at a rate of approximately 1.1 pounds per 1,000 sq. ft.. Each plot was replicated three times and the seedbed was a 90:10 USGA-approved sand and Dakota reed sedge peat rootzone amended with various naturally occurring organic fertilizers. The seed was mixed with green sand to achieve a uniform distribution and spread by hand. A lightweight poly-fiber green cover was placed over the plots and irrigation commenced on September 3.

On September 17, 1997, the green was evaluated for percent cover. Because germination was slow due to cool temperatures, two corrective measures were taken. First, Milorganite was applied to the entire study to darken the soil surface in an attempt to warm the seedbed. Second, it was determined that additional seeding should be done. This took place on September 24 spreading approximately 0.52 pounds (lbs) per 1,000 sq. ft. plot combined with Milorganite to achieve uniform seed distribution on each plot. Within a month of the second seeding, the percent cover was evaluated (Table 2) and the plots were mowed. During the 1997-98 winter, plots were covered.

Cultivar	Percent Cover[a]
L-93	85
Penncross	81.7
Putter	78.3
Crenshaw	78.3
Providence	75
Trueline	73.3
Penn A-1	73.3
Backspin	71.7
Viper	71.7
Century	71.7
Penn G-1	71.7
SR 1020	68.3
Penn A-4	68.3
Penn G-6	66.7
Grand Prix (LCB-103)	65
SR 1119	63.3
Cato	60
Imperial	60
LSD 0.05	*NS*

[a]Coverage estimates were taken 10/22/97. Percent cover is represented as mean of the three replications and is a visual estimate of the percentage of the plot covered by living seedlings.

Table 2. Percent cover following seeding of creeping bentgrasses at North Shore Country Club

Cultivar	April[d]	May	June	July	August	Sept	October	5-Year Mean
Penn A-1	7.5 h	7.7 gh	8.1 h	7.6 g	7.0 e	7.3 c-e	7.9 g	7.6 f
Penn A-4.	7.3 gh	8.0 h	7.9 gh	7.2 e-g	6.8 c-e	7.3 c-e	7.6 e-g	7.4 ef
Penn G-6	7.2 f-h	7.5 f-h	7.7 f-h	7.3 fg	7.1 e	7.6 de	7.7 fg	7.4 ef
Penn G-1	6.7 d-h	7.5 f-h	7.6 e-h	7.0 d-f	6.9 de	7.3 c-e	7.8 fg	7.3 e
L-93.	6.9 e-h	7.1 e-g	7.4 d-g	6.9 c-f	6.8 c-e	7.7 e	7.6 e-g	7.2 e
Backspin	6.5 c-g	7.1 e-g	7.0 c-e	6.7 b-e	6.7 b-e	7.0 b-e	7.3 d-g	6.9 d
Grand Prix	6.3 b-e	7.3 fg	7.3 c-f	5.6 a	6.7 b-e	6.7 a-c	6.9 cd	6.9 d
SR 1119	6.3 b-e	7.0 d-f	7.3 c-g	6.5 b-d	6.8 c-e	6.9 b-e	6.9 cd	6.8 d
Imperial	6.4 b-f	7.0 d-f	7.3 c-f	6.6 b-d	6.4 a-d	6.8 a-c	7.1 c-e	6.8 cd
Providence	6.7 d-h	6.9 c-f	7.1 c-f	6.5 b-d	6.3 a-c	6.7 a-c	7.3 c-f	6.8 cd
SR 1020	6.3 b-e	7.2 e-g	6.9 cd	6.3 bc	6.3 a-c	6.9 a-d	6.9 cd	6.7 cd
Trueline	6.3 b-e	6.5 b-e	6.9 cd	6.5 b-d	6.9 de	6.6 a-c	7.3 d-g	6.7 cd
Putter	6.3 b-e	6.9 c-f	6.7 c	6.8 c-f	6.4 a-d	6.5 ab	6.7 b-d	6.6 cd
Cato	5.7 ab	6.3 bc	6.9 cd	6.4 bc	6.3 a-c	6.9 a-d	7.3 c-f	6.5 bc
Viper	5.7 a-c	6.1 b	6.7 c	6.1 ab	6.4 a-d	6.5 a-c	6.7 a-c	6.3 b
Century	5.4 a	6.3 b-d	6.9 cd	6.3 bc	6.2 ab	6.3 ab	6.2 ab	6.2 b
Crenshaw	5.4 a	6.1 b	6.5 b	6.5 b-d	6.4 a-d	6.5 ab	6.2 ab	6.2 b
Penncross	5.9 a-d	5.3 a	5.9 a	6.9 c-f	6.0 a	6.1 a	6.1 a	5.8 a
Monthly Mean	6.4	6.9	7.1	6.7	6.6	6.9	7.1	6.8
LSD $_{0.05}$	0.8	0.7	0.6	0.6	0.6	0.8	0.6	0.3

Means followed by different letters are statistically different at the 0.05 level.
Each cultivar monthly value represents the mean of three replications in each of five years. A 1-9 scale used where 1 = dead turf, 5 = minimally acceptable turf quality, and 9 = supreme quality turf.

Table 3. 1998-2002 quality means for NTEP on-site bentgrass trial at North Shore Country Club

Starting in 1998, the putting green was mowed at 1/8 inch, fertilized with 4-to-6 lbs N/1000 sq/ ft/year, 0.75-to-1.5 lbs P/1000 sq. ft/year, and 5-to-6 lbs K/1000 sq. ft./year. The plots were irrigated and topdressed as necessary. Various organic and inorganic disease controls, soil conditioners, and plant growth regulators were also applied (See http://www.ntep.org) over the course of the study. Turfgrass density was estimated in autumn, 1998.

Beginning in April, 1998, the plots were rated monthly for turfgrass quality using a scale of 1 to 9 where 1 = dead turf, 5 = minimally acceptable turf quality, and 9 = supreme quality turf. These ratings continued through October, 2002 for a total of 35 ratings over the five-year period. Monthly quality means and overall means appear in Table 3. In Table 4, the number of evaluations that each cultivar performance was above the mean for that monthly rating is shown. This number can provide useful insights into how this grass compares to others in the study. We prefer to recommend cultivars that steadily perform above average, rather than pick cultivars that really shine during months (e.g., cooler spring and autumn months), but perform poorly in other months (e.g., hot, summer months).

Results of the Initial Study

By October 22, 1997, this study had made a dramatic turnabout. Some plots were approaching 100 percent cover by this date (Table 2). As quality ratings accumulated, several cultivars separated themselves from the rest of the pack, but it is important to remember that based on quality performance (Table 3). All of the cultivars had a 5-year mean performance greater than 5, the min-

Cultivar	April	May	June	July	Aug	Sept	Oct	5-Year Total
Penn A-1	5	5	5	5	4	4	4	32
Penn G-6	4	4	5	4	5	5	4	31
Penn G-1	3	5	5	5	4	4	4	30
L-93.	4	4	4	3	5	5	5	30
Penn A-4.	4	5	5	5	3	3	4	29
Backspin	3	3	1	3	3	5	4	22
Grand Prix	2	5	4	3	3	2	1	20
Imperial	3	3	3	4	2	2	3	20
SR 1119	2	4	4	1	4	3	1	19
Trueline	3	1	2	2	5	1	4	18
Providence	3	4	2	2	1	1	3	16
SR 1020	2	5	2	0	2	2	2	15
Putter	3	3	0	4	2	1	0	13
Century	1	2	1	3	2	1	1	11
Cato	0	1	1	2	1	2	3	10
Crenshaw	0	1	1	2	1	1	1	7
Penncross	1	0	0	1	1	1	0	4
Viper	0	0	1	0	1	1	0	3

There was a total of 35 monthly ratings, one each month April through October in each of five years (1998 through 2002). Thus, the highest rating a cultivar could achieve was 5 for any month and a 5-year total of 35.

Table 4. Number of ratings during 1998 through 2002 growing seasons in which cultivar quality mean surpassed the monthly mean for all cultivars

imally acceptable putting green quality rating.

Five cultivars stood out in this study. First, all four of the Penn A and G series grasses (‘Penn A-1’, ‘Penn A-4’, ‘Penn G1’, and ‘Penn G6’) performed in this top group. They were uniquely fine-textured with extremely high density and produced outstanding putting surfaces. Among these four grasses, an examination of the data reveals that ‘Penn G1’ was a slow starter - its performance in April was lower than the other three (Tables 3 and 4). Conversely, ‘Penn A4’ did not perform as well as the other three grasses in August or September (Table 4) due to brown patch (*Rhizoctonia spp.*) infestations.

While none of these grasses were totally free of dollar spot, the infestations were far less severe than in other grasses in this study. It is worth noting that plant-protectant chemicals were applied as curative treatments equally over all plots based on observations of the least disease-prone cultivar's symptoms.

The final member of this top-five group was ‘L-93’ creeping bentgrass. ‘L-93’, while of higher density and finer texture than older types such as ‘Penncross’, was slightly more coarse textured and less dense than the four Penn A and G types. It nonetheless produced a high quality putting surface and was generally free of dollar spot. While slow to green in the spring, once ‘L-93’ did green up, its genetic color was similar to ‘Penn A4’, which was slightly darker green than ‘Penn A1’, ‘Penn G1’, or ‘Penn G6’.

Among the other grasses in the study, ‘Crenshaw’ and ‘Century’ tended to be more prone to dollar spot infestations than other grasses in the study. Finally, even ‘Penncross’ creeping bentgrass, the lowest rated grass in the study (Table 3) due to its horizontal growth habit and relatively coarse texture, produced putting green turf that would have been acceptable at many locations.

The Rest of the Story

Poa annua, a common invader on Illinois golf courses, is particularly well adapted to areas

Cultivar	% Poa Invasion†	Dollar Spot Severity§
Penn A-4	3.5 a	2.3 a-d
Grand Prix	4.1 a	4.3 ef
Penn A-1	4.4 a	1.0 a
Penn G-1	5.8 ab	1.8 a-c
Imperial	6.8 ab	6.7 gh
Penn G-6	6.8 ab	1.5 ab
Backspin	7.2 ab	5.0 fg
Century	7.5 a-c	8.3 h
Providence	8.9 b-d	1.8 a-c
SR 1119	9.0 b-d	4.3 ef
Trueline	11.6 c-e	2.0 a-c
Crenshaw	12.1 de	7.7 h
L-93	13.3 e	2.3 a-d
SR 1020	14.7 ef	7.0 h
Putter	15.6 e-g	2.7 a-e
Cato	18.5 f-h	3.2 b-e
Viper	19.0	3.8 d-f
Penncross	20.4 h	3.3 c-f

† Percent *Poa annua* estimated visually in May of 2004 and 2005. Data are the average for both years.

§ Dollar spot severity was rated in August 2004 on a scale of 1-9 where 1=no disease and 9=severe dollar spot pressure.

Table 5. Mean percent *Poa* invasion of bentgrass cultivars at NTEP on-site bentgrass trial at North Shore Country Club, Glenview, IL over 2004 and 2005 evaluations.

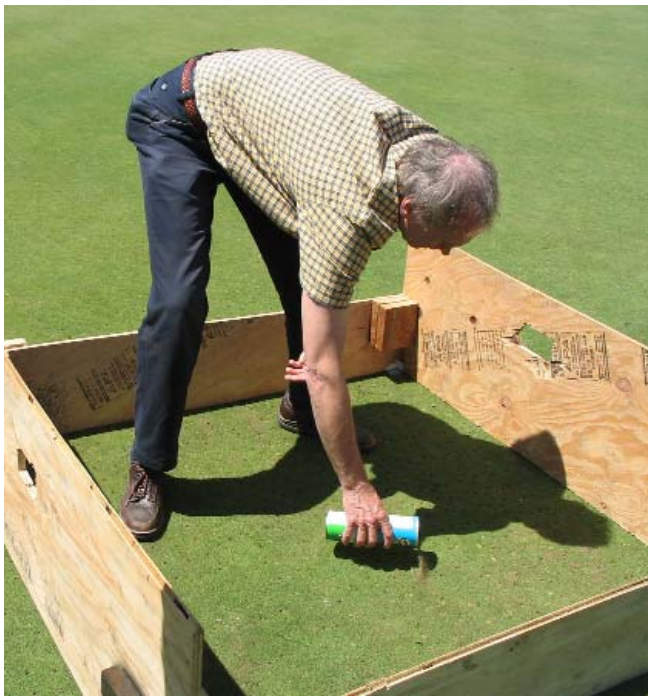
north of Chicago where extreme temperatures are somewhat moderated by Lake Michigan. Additionally, annual bluegrass often makes up large percentages of the putting greens commonly found on older courses. Located less than 10 miles from Lake Michigan and built in 1924, North Shore Country Club is not an exception; populations of *Poa* exist on North Shore's tees, fairways, and greens.

To further test the 18 well-maintained cultivars growing on an existing USGA green at a location where *Poa* succeeds, we began a study to determine if there were differences among the cultivars in their abilities to resist annual bluegrass invasion. In May, 2003, the green was cored using 3/8" spoons. This was the first time the green was mechanically cultivated with the exception of several treatments using Toro's Hydroject. This prepared the green for overseeding. Half of each 5 ft. x 10 ft. plot was then overseeded with 2.8 oz *Poa annua* seed using a 5 ft. x 5 ft. isolation box followed by topdressing.

The *Poa* seed came from clippings collected from the North Shore C. C. fairways during the peak of the *Poa* flowering period. Greenhouse germination tests indicated that 2.8 oz of *Poa* seed contained the equivalent of at least 340,000 viable seeds/1000 sq. ft. The maintenance of the entire study area continued as it was carried out during the initial years of the study (see above). In May, 2004 and May, 2005, we inspected the study area and visually estimated the percent *Poa annua* in both the overseeded and untreated portions of each plot (Table 5 and Table 6). We also estimated the density of the plots in June, 2005.

What Did We See?

Statistical analysis of the percent *Poa* data from 2004 and 2005 showed consistent trends, so data for the two years were combined (Table 5). Overseeding with *Poa* did lead to more *Poa* inva-



Following core aeration in May, 2003, half of each 5'x10' plot was overseeded with 2.8 oz *Poa annua* seed using a 5'x5' isolation box followed by topdressing.

Seed treatment	2004	2005	Year to Year Change
No added *Poa*	5.0	11.3	+ 6.3
Poa overseeded	11.7	14.1	+ 2.4

Table 6. *Poa* populations, averaged over all cultivars, from overseeded versus non-overseeded treatments for NTEP on-site bentgrass trial in 2004 and 2005

sion (Table 6), but all the cultivars had a similar percentage increase due to *Poa* overseeding, so again the data for seeded and unseeded were combined (i.e. averaged, Table 5). Interestingly, the data on overseeding showed that the plots overseeded with *Poa* showed a much smaller increase in *Poa* from 2004 to 2005 than did the plots that were not overseeded (Table 6).

Our statistical analysis indicated that this difference was highly significant, so it was not just chance or a random occurrence, but something caused the overseeded plots to have less of an increase in *Poa*. The best explanation we can offer is that the putting green plots were overseeded with seed collected from the fairways at North Shore Country Club. As other researchers have noted, *Poa* populations adapt to the maintenance conditions under which they are grown. The *Poa* collected from the fairway was not as well-adapted to greens culture as that *Poa* which was already present on the greens. A significant amount of the overseeded *Poa* did not survive from May, 2004 to May, 2005. So the increase in *Poa* population from the native, greens-type *Poa* was partially offset by death of the overseeded *Poa*, resulting in a smaller rate of increase of *Poa* population in the overseeded plots.

But the take home message from this experiment was that there were significant differences among the cultivars in their ability to restrict *Poa annua* invasion. The top statistical group of bentgrasses had a range of only 3.5% to 7.5% *Poa* coverage (% area of the plot covered by annual bluegrass). We consider this amount of invasion to be very low given the green's age and location. Furthermore, this number is even more

There were significant differences among the cultivars in their ability to restrict *Poa annua* invasion. The top statistical group of bentgrasses had a range of 3.5% to 7.5% *Poa* coverage compared to over 20% *Poa* coverage in the 'Penncross' plots.

impressive given over 20% *Poa* coverage in the 'Penncross' plots.

What's the Basis for Differences?

What causes the differences among cultivar resistance to *Poa* invasion? Creeping bentgrass density is certainly one piece of this puzzle. Cultivar density data was collected in 1998 and 2005 (data not shown) and correlated with percent *Poa* in the plots. In both evaluations, correlation between the overall percent *Poa* and 1998 and 2005 density was highly significant with R-values of 0.745 and 0.858 in 1998 and 2005, respectively. An R-value is a measure of how well two variables are correlated: a perfect correlation would have an R-value of 1, while 0 represents no correlation. These R-values suggest that much of increase in *Poa* is probably may be due to lower density in those cultivars.

There may be other explanations that require further study. For example, bentgrass architecture should be examined. It appears that some dense cultivars have a vertical shoot growth that forces *Poa* plants to grow vertically as well, preventing *Poa* from easily spreading into an established clump. The flowers on the vertical *Poa* shoots are more likely to be removed by mowing which may reduce seed spread.

Another contributing factor may be that bentgrass cultivars have flushes of growth at different times. If a bentgrass cultivar has a flush of growth at the time *Poa* seeds are germinating, the bentgrass may be better able to compete with the invader. Another potential explanation is that aggressive bentgrasses may heal more quickly which allows these types to fill cultivation holes, ball marks, and other damage before the *Poa* has a chance to become established.

Percent dollar spot (Table 5) and moss on the green (data not shown) were evaluated in summer 2004. This data did not correlate with the percent *Poa* invading the plots. The lack of correlation between dollar spot and *Poa* was not expected since dollar spot would create openings in the turf where *Poa* might establish. The dollar spot ratings taken in 2004 may not be representative of the occurrence of dollar spot throughout all growing seasons.

Alternatively, *Poa* tends to germinate in the cooler conditions of early fall when dollar spot may be less active. Regardless, we did not see a relationship between dollar spot infection and *Poa* invasion. The dollar spot ratings illustrate that the differences among cultivars are significant. Cultivars 'Century', 'Imperial', 'Crenshaw', and 'SR1020' showed substantial and consistent infection with dollar spot. 'Penn A-1' was unaffected at this rating date by dollar spot, but 'Penn A-4' did show some disease. 'Grand Prix' and 'Imperial', which both had relatively low levels of *Poa*, showed significant dollar spot infection.

In short, selecting a creeping bentgrass solely because it restricts *Poa* invasion is not wise. But when combined with other positive attributes (e.g., putting surface quality, disease resistance, or environmental tolerances), a bentgrass's ability to resist annual bluegrass invasion becomes another consideration to reduce the maintenance challenges associated with fighting *Poa annua* on putting greens.

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