Research *You Can Use*

Bentgrasses and Bermudagrasses for Today's Putting Greens

On-site testing yields important performance data.

BY KEVIN MORRIS

As the popularity of golf continues to increase worldwide, golf course owners, managers, and superintendents are asking for grasses that produce superior quality and fast putting surfaces, especially during periods of intense use. And with environmental concerns at an all-time high, new grasses need to produce this high quality with less water, fertilizer, and pesticides. This is a daunting challenge for plant breeders, with more than 17,000 U.S. golf courses located in highly varied climatic zones and receiving different levels of management expertise and available resources.

Improvement of grasses for use on putting greens is an ongoing process. Plant breeders are constantly searching for that "perfect" cultivar that encompasses dark green color, fine leaf texture, high density, and excellent disease, insect, drought, heat, and cold resistance. New cultivars also need to have high traffic tolerance, quick establishment, and good seed or vegetative production to keep them affordable. Although no single cultivar has been developed that has all of these desired qualities, consumers look to purchase those cultivars that contain what they consider the most desirable traits for their areas.

The on-site cultivar trials were established on participating golf courses where golfers could practice putting, chipping, and pitching. It was decided that cultivars exposed to golf course traffic stresses would produce the most applicable information.

EARLY ON

As golf gained popularity in the U.S. in the early 1900s, the grasses available for putting greens were very limited. Many greens consisted of closely mowed grasses that already existed in pastures or other grassy areas, or they consisted of South German bentgrass (*Agrostis* spp.) mixtures or locally adapted bermudagrass (*Cynodon* spp.) strains. Improved cultivars of vegetatively propagated creeping bentgrass (*Agrostis stolonifera L.*) such as Arlington, Cohansey, Toronto, and Congressional were selected and released in the 1930s and 1940s (2,4).

Penncross creeping bentgrass, released in 1954, quickly became popular for putting greens because its quality matched or exceeded the existing vegetatively propagated cultivars, yet it was seed propagated, which significantly reduced establishment costs (1). These traits made Penncross the most popular putting green cultivar in the U.S. for more than 30 years.

For putting greens in the warmer, southern U.S., Tifgreen bermudagrass was released in 1956 and produced superior quality compared to other bermudagrass cultivars (1). In 1965, Tifdwarf bermudagrass, a dwarf mutant selection from Tifgreen, was released (1). Tifdwarf produced better quality at lower mowing heights than Tifgreen and quickly became the standard cultivar for putting surfaces in tropical, subtropical, and low desert areas.

As faster, higher quality putting surfaces were demanded in the late 1970s, cutting heights continued to be lowered on putting greens. This led to a gradual reduction of heights of cut to where the majority of U.S. courses had settled on ⅛" to 5/32" as their preferred greens height. At these cutting heights, however, the standard cultivars Penncross, Tifgreen, and Tifdwarf began to exhibit more disease, heat, drought, and scalp-

ing. The need was increasing for improved cultivars with better disease, heat, and drought resistance, as well as the ability to produce high quality putting at the new, lower cutting heights.

Along with this need for improved putting green cultivars came the need to test these cultivars on a national scale. The National Turfgrass Evaluation Program (NTEP) initiated its first national trials of bentgrass for putting greens in 1989. Data from 29 university locations averaged over four years beginning in 1990 showed that only two entries, Providence and PRO/CUP, out of a total of 22, performed statistically better than Penncross (5,6). However, in a subsequent national bentgrass putting green trial initiated in 1993 at 27 university locations, 21 entries performed statistically better than Penncross in data averaged over four years and all locations (7).

BACK TO THE FUTURE

As many new cultivars and experimental selections were developed in the mid-to-late 1990s, the need was increasing for a new bentgrass trial. At about the same time, several improved ultradwarf bermudagrass cultivars were being developed for southern golf courses to address the same problem of high putting quality at low mowing heights. These new ultradwarfs also needed to be compared in national performance trials.

However, many golf course superintendents and some researchers questioned the usefulness of NTEP data collected at universities that may not be managed as intensively as actual, in-play putting greens. To address this issue, NTEP, the United States Golf Association Green Section (USGA), and the Golf Course Superintendents Association of America (GCSAA) agreed in 1997 to jointly fund and cooperate in an on-site testing program. Instead of comparing newly released cultivars at university field stations, bentgrasses and bermudagrasses intended for putting green use were to be planted on participating golf courses, much as they were in the 1920s and 1930s. This was to ensure that the trials would receive the level of maintenance commonly practiced on high-level golf courses and face the traffic stresses from golfers.

With significant funding from the USGA, new putting greens were built on 16 golf courses across the United States according to USGA recommended construction methods (Table 1). These greens were intended to be used as practice putting, chipping, or target greens, and thus receive the same real-life stresses that golf course turfs must endure.

Eighteen creeping bentgrass cultivars were seeded at eight sites in fall 1997 or spring 1998. Seven bermudagrass cultivars were established at three sites in the summer of 1998. Five of the sites established both bentgrass and bermudagrass on-site trials. A cooperating university turfgrass scientist was assigned to each trial site for the establishment and data collection of each trial (Table 1).

ON-SITE CREEPING BENTGRASS TRIAL

The on-site trials were limited to commercially available cultivars or those selections close to commercialization. Seventeen creeping bentgrasses were

Table 1

Test locations used in evaluating creeping bentgrass and bermudagrass cultivars in NTEP's on-site testing program.

Golf Course	Location	Superintendent	Research Cooperator
Bentgrass only			
Crystal Springs Golf Course	Burlingame, CA	Ray Davies	Dr. Ali Harivandi, California Cooperative Extension
Fox Hollow at Lakewood	Lakewood, CO	Bruce Nelson	Dr. Tony Koski, Colorado State University
Lassing Pointe Golf Course	Florence, KY	Jerry Coldiron	Dr. A. J. Powell, University of Kentucky
North Shore Country Club	Glenview, IL	Dan Dinelli	Dr. Tom Voigt, University of Illinois
Purdue Univ. Kampen Course	West Lafayette, IN	Jim Scott	Dr. Zac Reicher, Purdue University
TPC at Snoqualmie Ridge	Snoqualmie, WA	Tom Wolff	Dr. Gwen Stahnke, Washington State University
Westchester Country Club	Rye, NY	Joe Alonzi	Dr. James Murphy, Rutgers University
Westwood Golf Course	Vienna, VA	Walter Montross	Dr. David Chalmers, Virginia Tech University
Bentgrass and Bermudagrass			
Bent Tree Country Club	Dallas, TX	Keith Ihms	Dr. Milt Engelke, Texas A&M University
C.C. of Birmingham	Birmingham, AL	Lee McLemore	Dr. Elizabeth Guertal, Auburn University
C.C. of Green Valley	Green Valley, AZ	Mike Bates	Dr. David Kopec, University of Arizona
The Missouri Bluffs	St. Charles, MO	Alan Zelko	Dr. Barb Corwin, University of Missouri
SCGA Members Club	Murrieta, CA	John Martinez	Dr. Robert Green, University of California-Riverside
Bermudagrass only			
Country Club of Mobile	Mobile, AL	Ron Wright	Dr. Bryan Unruh, University of Florida
Jupiter Island Club	Hobe Sound, FL	Rob Kloska	Dr. John Cisar, University of Florida
Lakeside Country Club	Houston, TX	Mike Sandburg	Dr. Richard White, Texas A&M University

Table 2

Mean turfgrass quality, genetic color, and density ratings of creeping bentgrass cultivars grown on golf course practice greens.[1,2]

Entry	Turf Quality	Genetic Color	Spring Density	Summer Density	Fall Density
BACKSPIN	6.6	5.9	7.6	7.3	7.5
CATO	6.2	6.6	6.9	6.9	7.0
CENTURY	6.8	5.8	7.8	7.7	7.9
CRENSHAW	6.4	6.9	7.2	6.9	7.0
GRAND PRIX	6.7	6.0	7.4	7.6	7.5
IMPERIAL	6.7	6.1	7.8	7.7	7.3
L-93	6.8	6.9	7.5	7.2	7.5
PENN A-1	7.1	6.6	8.0	7.8	7.7
PENN A-4	7.3	6.8	8.4	8.2	8.1
PENNCROSS	5.3	5.4	5.9	5.6	5.4
PENN G-1	6.9	6.7	7.8	7.8	7.7
PENN G-6	6.7	6.6	7.6	7.5	7.5
PROVIDENCE	6.3	6.5	7.0	6.4	6.7
PUTTER	5.9	5.9	6.0	6.2	6.3
SR1020	6.4	6.3	7.1	6.9	7.0
SR1119	6.6	7.0	7.6	7.3	7.1
TRUELINE	6.1	6.4	6.8	6.7	6.5
VIPER	6.1	6.9	6.8	6.6	6.8
LSD[3]	0.1	0.2	0.4	0.4	0.4

[1]On-site Bentgrass Test, data collected from 1998 to 2001 at 13 sites.

[2]Rating scale used is 1-9; 9 = ideal turf, dark green color, maximum density.

[3]LSD (Least Significant Difference) statistic at the 5% (0.05) confidence level rating. Cultivar means must be more than this value apart to be deemed statistically significant.

entered by sponsoring companies, with one standard entry, Penncross, being included by NTEP. Entries were seeded in 50 sq. ft. plots and replicated three times. Seeding rate was 25 grams per plot or 1.1 lbs. per 1,000 sq. ft.

Pre-plant soil preparation and post-plant care varied from site to site but followed generally accepted practices of fertilization, pH adjustment, irrigation, and mowing. These greens were used for practice by golfers. Since cutting, moving, and replacing cups would compromise the integrity of plots, target flags were used instead of cutting actual cups.

Monthly turfgrass quality ratings were collected. Quality ratings include all the factors that are important to turfgrass managers, including color, density, texture, uniformity, disease or insect damage, drought, and heat and cold injury. Other required data included genetic color, spring green-up, leaf texture, and putting speed as measured by a modified Stimpmeter (3). Other information, such as disease and insect damage, winter injury, percent living ground cover, frost tolerance, and thatch accumulation was recorded if the cooperator found it reasonable and feasible to collect.

ON-SITE BERMUDAGRASS TEST

This trial was established at eight locations (Table 1) in spring and summer of 1998. All entries were vegetatively propagated cultivars. Planting rate was 24 3 in. × 3 in. plugs (live plant material and soil) of each entry per plot. Each plug was broken into many small pieces (sprigs) and hand planted. Plots were then rolled and irrigated carefully so that sprigs were not washed from their planting site. Some sites also used a lightweight planting cover to protect the sprigs from erosion.

Five new cultivars were submitted for inclusion in the trial, and Tifgreen and Tifdwarf were included as comparative standards. As with the bentgrass trial, each green was used for practice by golfers. Maintenance was performed by the golf course superintendent in a manner similar to the other greens on the course or other bermudagrass greens in the area. Data collection methods and Stimpmeter measurements were identical to those used in the bentgrass trial.

CREEPING BENTGRASS PERFORMANCE

After four years of data collection, Penn A-4 has been the outstanding entry in this trial. Turfgrass quality ratings (see Table 2) averaged over the four years and 13 sites show Penn A-4 alone in the top statistical grouping (mean turf quality = 7.3, LSD = 0.1), followed by Penn A-1 (7.1) and Penn G-1 (6.9). Surprisingly, Century, a cultivar that has turf quality ratings in the middle statistical grouping of the 1998 Official Bentgrass Test, is next with a turf quality rating of 6.8, making it statistically equal to Penn G-1 and L-93 (turf quality rating = 6.8). This may have been due to Century's susceptibility to dollar spot (*Sclerotinia homoeocarpa*). The superintendents managing the on-site trials effectively controlled dollar spot through the use of preventative fungicide applications. In contrast, the official trial sites at university field stations are encouraged to allow disease development before treating, lowering overall quality ratings.

Penn A-4 also was very consistent across locations. At ten of 13 locations, turf quality ratings of Penn A-4 from 1998 to 2001 placed it as the highest-scoring entry. Penn A-4 was the only entry to finish in the top statistical group for turf quality at each location averaged over the entire four-year period.

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The highest genetic color ratings in the on-site trial belonged to SR1119 (genetic color = 7.0, LSD = 0.2), with L-93, Crenshaw, and Viper just below (6.9), but statistically equal to SR1119. Highest genetic color ratings did not belong to the cultivars with the highest overall turfgrass quality. However, top-performing entries, such as Penn A-4, Penn G-1, and Penn A-1 rated high for genetic color. The exception is Century, which rated almost at the bottom of all the entries.

Density ratings in each of spring, summer, and fall were very consistent over the three-year period. Penn A-4 had the highest density rating in each season. In spring, Penn A-1 had the next highest density rating (8.0), statistically equal to Penn A-4 (8.4, LSD = 0.4). Summer density of Penn A-4 (8.2, LSD = 0.4) placed it in the same statistical group as Penn G-1 (7.8) and Penn A-1 (7.8). Fall density ratings had Century (7.9), Penn A-1 (7.7), and Penn G-1 (7.7) in the same statistical group as Penn A-4 (8.1, LSD = 0.4).

Annual bluegrass (*Poa annua*) invasion is a major problem in many areas of the U.S. for those golf courses wishing to limit its presence on putting greens. Density ratings also seem to impact the percentage of annual bluegrass in the turf stand. Data collected from the Murrieta, Calif., site in December 2001 showed that Penn A-4, Penn G-6, Penn A-1, and Penn G-1 had the least amount of annual bluegrass after four years. Other new cultivars such as Century, L-93, Imperial, Providence, Putter, and Viper had significantly more *Poa annua*. Cato, SR1020, and Penncross had the greatest invasion of annual bluegrass after four years.

For golf course superintendents, any cultivar difference in ball roll or putting speed is important. Stimpmeter ratings were collected at the different sites on 46 total dates over the four-year period. Data collected on 32 of those rating dates yielded Stimpmeter ratings with no statistical differences among any entries. Stimpmeter ratings on six dates had statistically significant differences between only the top and bottom entries.

Table 3

Mean turfgrass quality, genetic color, and density ratings of bermudagrass cultivars grown on golf course practice greens.[1,2]

Entry	Turf Quality	Genetic Color	Spring Density	Summer Density	Fall Density
CHAMPION	6.1	6.6	6.5	6.4	7.7
FLORADWARF	5.8	6.6	6.1	5.7	6.9
MINI-VERDE	6.4	7.1	6.9	7.0	8.0
MS-SUPREME	6.0	6.3	6.3	6.4	6.8
TIFDWARF	5.9	6.6	6.5	6.2	7.3
TIFEAGLE	6.3	6.7	6.8	6.9	7.8
TIFGREEN	5.0	5.3	5.1	5.4	5.8
LSD[3]	0.2	0.3	1.0	0.8	0.5

[1]On-site Bermudagrass Test, data collected from 1998 to 2001 at 8 sites.

[2]Rating scale used is 1-9; 9 = ideal turf, dark green color, maximum density.

[3]LSD (Least Significant Difference) statistic at the 5% (0.05) confidence level rating. Cultivar means must be more than this value apart to be deemed statistically significant.

BERMUDAGRASS PERFORMANCE

Bermudagrasses that can tolerate ⅛ in. mowing heights with the density of some of the best bentgrasses are new to the turfgrass industry. Five entries, Mini-Verde, Tif Eagle, Champion, MS-Supreme, and Floradwarf, were included in this trial along with two standard entries, Tifdwarf and Tifgreen. Data were collected in summer and fall of 1998, which mainly reflected the rate of establishment, and then during the growing seasons of 1999-2001. One site, The Missouri Bluffs Golf Course in St. Charles, Missouri, suffered complete kill during the winter of 1998-99. Therefore, data were collected only in 1998.

Turfgrass quality ratings from the four years and eight sites (Table 3) show Mini-Verde (turf quality = 6.4, LSD = 0.2) and Tif Eagle (6.3) at the top, with Champion (6.1) slightly below, statistically equal to Tif Eagle but statistically below Mini-Verde. MS-Supreme at 6.0 was statistically equal to Champion but did not perform statistically as well as Mini-Verde or Tif Eagle in data averaged over all locations. Floradwarf (5.8) was statistically below Mini-Verde, Tif Eagle and Champion as well as being statistically equal to the standard entry Tifdwarf (5.9). Tifgreen was clearly at the bottom with a turf quality rating of 5.0. A closer examination of the data revealed that some entries performed better or equal to Mini-Verde or Tif-Eagle at individual sites, but not averaged over all sites.

Mini-Verde had the highest average genetic color ratings at 7.1 (LSD = 0.3), statistically higher than all other entries. Density ratings in spring showed little statistical difference among all the entries. Mini-Verde finished with the highest average density rating in

An important part of putting green performance is disease resistance. Here, Dr. Peter Landschoot (left), turfgrass pathologist, discusses that aspect of cultivar performance with golf course superintendent Tom Wolff at the TPC at Snoqualimie Ridge site in Washington state.

summer (7.0, LSD = 0.8), however, statistically better than only Floradwarf and Tifgreen. Fall density ratings showed more statistical differences, with Mini-Verde, Champion, and TifEagle in the top statistical group.

The high color and density ratings most likely have resulted in the excellent turf quality ratings for these grasses. In addition, as with the bentgrasses, Stimpmeter ratings produced very little statistical difference among the entries. Out of 19 Stimpmeter rating dates, ten showed no statistical differences among any of the entries, while five ratings produced statistical differences between only the top and bottom entries.

ACKNOWLEDGMENTS

The author would like to thank the USGA and GCSAA for their significant financial support, as well as technical support for this research. In addition, we wish to acknowledge those seed companies and breeders that submitted their entries for inclusion into these trials and their financial support. Finally, many thanks go to the golf course superintendents, golf courses, and research cooperators involved in this project. Without their excellent cooperation and efforts, a research project of this magnitude and scope would not have been possible.

LITERATURE CITED

1. Alderson, James, and W. Curtis Sharp. 1994. Grass Varieties in the United States. Agriculture Handbook No. 170. United States Department of Agriculture, Washington, D.C.
2. Beard, J. B. 1973. Turfgrass: Science and Culture. Prentice-Hall, Inc., Englewood Cliffs, N.J.
3. Gaussoin, R., J. Nus, and L. Leuthold. 1995. A Modified Stimpmeter for Small-Plot Turfgrass Research. *HortScience* 30(3):547-548.
4. Grau, Fred V. 1948. Golf is Played on Grass. Yearbook of Agriculture. United States Department of Agriculture, Washington, D.C.
5. Morris, K. N., and R. C. Shearman. 1994a. 1989 National Bentgrass Test (Modified Soil – Green), Final Report 1990-93. National Turfgrass Evaluation Program. NTEP No. 94-15. Beltsville, Md.
6. Morris, K. N., and R. C. Shearman. 1994b. 1989 National Bentgrass Test (Native Soil – Green), Final Report 1990-93. National Turfgrass Evaluation Program. NTEP No. 94-16. Beltsville, Md.
7. Morris, K. N., and R. C. Shearman. 1998. 1993 National Bentgrass Test (Putting Green), Final Report 1994-97. National Turfgrass Evaluation Program. NTEP No. 98-12. Beltsville, Md.
8. Shearman, R. C., and K. N. Morris. 1998. NTEP Turfgrass Evaluation Workbook. NTEP Turfgrass Evaluation Workshop, October 17, 1998, Beltsville, Md.

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The Southern California Golf Association's golf course at Murietta, Calif., tested the new cultivars' abilities to resist invasion by annual bluegrass. Newer cultivars like Penn A-4, Penn A-6, Penn A-1, and Penn G-1 had the least amount of *Poa annua* after four years of testing.