

1995
ANNUAL PROGRESS REPORT
BREEDING AND DEVELOPMENT
OF BENTGRASS

Submitted By:

Dr. M. C. Engelke
Professor
Turfgrass Breeding and Genetics
with
Dr. Ikuko Yamamoto
Assistant Research Scientist
and
Jamie M. Mills
Research Assistant
Turfgrass Breeding and Genetics

Texas Agricultural Experiment Station - Dallas
Texas A&M University System

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**1994 RESEARCH REPORT
BREEDING AND DEVELOPMENT OF BENTGRASS**

EXECUTIVE SUMMARY

Principle Investigator: Dr. M. C. Engelke
Co-Investigator: Dr. I. Yamamoto
Technical Support: Ms. J. M. Mills
Student Intern: Ms. M. H. Delambre
Research Period: 1 November 1994 through 1 November 1995.

CRENSHAW and CATO were released in April 1993. Considerable success has been realized in the performance and utility of both grasses especially throughout the southern United States. CATO was been licensed to Pickseed West, Tangent, Oregon and was commercially available in quantity in the fall 1994. CRENSHAW was been licensed to Lofts Seed, Inc. Bound Brook, N.J. and was commercially available with limited supplies in 1993. CRENSHAW's performance has steadily increased its demand in 1994 and regardless of increased production, seed was in heavy demand far exceeding available supply. Syn1-88 is a reselection from Seaside and has been optioned to Pick Seed West for increase and will be commercially available in 1995. Syn1-88 is recognized for its low maintenance requirements and excellent salt tolerance and is being released as a utility bentgrass targeted to replace "Seaside" Creeping Bentgrass with quality similar to the standard "Pennncross".

A series of four synthetic creeping bentgrass populations were developed in 1992 and designated as the Syn92 - Series. These populations (varieties) were devised to incorporate stronger physiological and pathological traits to form biologically stronger stress tolerant grasses. Each population is represented by 4 to 10 parental lines which were further selected and combined based on floral initiation, leaf texture, color and field performance under close mowing and cultivation. Burlingham & Sons have an option agreement with Texas A&M for testing and evaluation rights on Syn92-1 and Syn92-5 creeping bentgrasses. Turf Merchant Inc, and Scotts have a joint option for testing and evaluation of Syn92-2. These three were entered into the 1993 NTEP Creeping Bentgrass Trials and are performing well. Sufficient seed stocks of Syn92-4 has permitted limited testing and evaluation at selected sites. Syn92-4 is available for more extensive testing and evaluation.

Vegetative selections were identified in the production fields in Oregon from among the progeny of the advanced lines and will be included in test to evaluate total plant performance at TAES-Dallas including vegetative growth characters, turf quality, disease resistance, insect resistance, traffic and salinity tolerance, heat tolerance and root growth characters.

1995 RESEARCH REPORT BREEDING AND DEVELOPMENT OF BENTGRASS

Dr. M. C. Engelke, Dr. I. Yamamoto, Ms. J. M. Mills, and Ms. M. H. Delambre

I. INTRODUCTION

The bentgrass breeding program is a cooperative research project funded jointly by the Texas Agricultural Experiment Station (TAES), the United States Golf Association (USGA), and Bentgrass Research, Inc. (BRI). This project was initiated in April 1985. Semiannual progress reports are submitted 1 May, and annual reports are submitted 1 November each year. This report, with the May 1995 INTERIM REPORT, constitutes the 1995 Annual Progress Report for the Bentgrass Breeding Program.

II. PROFESSIONAL AND TECHNICAL SUPPORT

Ms. Jamie M. Mills holds the position of Research Assistant since June 1993. She has a BS degree in Horticulture from Texas A&M University. **Ms. Marielle Delambre** has worked on the project for the past 6 months as a foreign exchange student from Institut Supérieur d'Agriculture - Membre de l'Université Catholique de Lille, Lille Cedex, France. She has worked closely with Ms. Mills in research of bentgrass breeding.

Dr. Ikuko Yamamoto (Assistant Research Scientist) joined the Turfgrass Breeding Program in February 1995. Dr. Yamamoto's responsibilities focus on breeding and development of bentgrasses by conventional methods and molecular genetic techniques. She works closely with Dr. Phillip Colbaugh for evaluation and screening of disease-resistant germplasm and attempts to introduce the resistant characteristics into susceptible cultivars. She also works to develop a reliable evaluation method of population shift in overseeded or blended greens. Approximately 40% of her time is devoted to the bentgrass project.

III. STATUS OF BENTGRASS RELEASES

THE 1988 SERIES OF CREEPING BENTGRASSES

CATO (Syn4-88) and **CRENSHAW** (Syn3-88) were officially released in April 1993. CATO was licensed to Pick Seed West, Tangent, OR, with the first commercial seed being available in the fall 1994. CRENSHAW was released

and licensed to Loft Seeds and became commercially available in 1993. Both CATO and Crenshaw have received high acceptance in the industry and are being targeted as the new standards by which other cultivars are being compared. Crenshaw is distinguished by its high seed yield, aggressive growth habit, excellent heat and drought tolerance and ability to withstand high traffic conditions. Crenshaw is susceptible to dollar spot disease and is therefore often used in blends with other bentgrasses. Alone or in combination, Crenshaw has exceeded expectations in performance and persistence throughout the bentgrass regions of the country. It is rapidly being accepted as an elite superior bent for use in Japan and is presently in the UPOV trials of Europe. CATO is a finer textured less aggressive turf with good genetic color, heat tolerance and persistences with excellent reports in performance under moderated to heavy use from Houston, TX to upstate New York to Washington State. CATO is tolerant to dollar spot, brown patch and damping-off. A certified blend of CATO and Crenshaw is marketed as C-n-C and is being widely used in the industry.

A 20-acre field of **Syn1-88** was established in 1994 in anticipation of release in 1995. The variety was submitted to the Texas A&M Plant Release Committee for release in August 1995. Due to minor revisions requested by the PRC, its official release has been delayed. Regardless, Pick Seed has been awarded a license option and increased production in 1995 with the additional 60 acres. Presently approximately 15,000 pounds of seed are available.

THE 1992 SERIES OF CREEPING BENTGRASSES

The 1992 series of creeping bentgrasses are presently in the 1993 National Turfgrass Evaluation Program and are identified as Syn92-1, Syn92-2, Syn92-4 and Syn92-5. Approximately 5 pounds of seed were harvested from each breeder field in 1993 for entry in to the NTEP. Production in 1994 and 1995 ranged from 35 - 50 pounds for each of the varieties permitting further testing and evaluation. In our attempts to be more efficient in our breeding program, we were able to enter in to cooperative agreements with members of industry to aid in further development of these grasses. Through the options contracts, the licensees to date involve two contracts involving three of the 92 series grasses.

1) Specifically, E. F. Burlingham & Sons, Forest Grove, OR, has received an option agreement on Syn92-1 and Syn92-5 effective September 1994 for advanced testing and evaluation of these varieties. Limited acreage of each was planted in the fall of 1994 permitting evaluation of seed production potential as well as providing enough seed to expand the field testing throughout a broader region of the country.

Syn92-1 is a six clone synthetic for which the parents were selected for

uniformity in plant type and leaf color. Individual clones comprising this clone include: TAES 2831, 3153, 3250, 3307, 3794 and 3799. Sufficient seed was harvested 1993 to enter Syn92-1 into the National Turf Evaluation Trials. Approximately 40 pounds of seed were harvested in 1994. Burlingham has initiated a 5+ acre seed increase planting from which sufficient seed will be available in 1995 for advanced testing. I would generally classify Syn92-1 to be in the late maturity group. It should be a reasonably good seed yielder. Heavy selection for plant type and flowering occurred in 1993, with minimal selection pressure primarily for floral niching in 1994 results in a variety possessing multiple physiological and pathological advantages over existing cultivars.

The second variety chosen by Burlingham and Sons is **Syn92-5** a seven clone synthetic (Table IV-2e), is earlier and potentially one of the highest yielding of the experimental varieties under development. The variety is coarser texture with intermediate to good genetic color. Individual clones comprising this clone include: TAES 2833, 2845, 2916, 2922, 3106, 3293 and 3307. Sufficient seed was harvested 1993 to enter Syn92-5 into the National Turf Evaluation Trials. Approximately 50 pounds of seed were harvested in 1994. Burlingham has initiated a 5+ acre seed increase planting from which sufficient seed will be available in 1995 for advanced testing. Sufficient seed should be available of this variety to provide for extensive testing and evaluation in 1995 and beyond.

- 2) Scott's and Turf Merchants (TMI) executed a joint option agreement with Texas A&M for the production and marketing rights to **Syn92-2**.

Syn9-2 is a four clone synthetic for which the parents were selected for disease resistance with special emphasis *Rhizoctonia* and *Pythium* type diseases. In 1990 this was recognized as population N (Table 4 and 5, 1990 annual report). This includes clones TAES 2859, 2916, 2922, and 3276. Syn92-2 is a medium late maturity group with good seed production potential. Sufficient seed was harvested in 1993 to enter this experimental in the national turf trials and in 1994 approximately 40 pounds were produced. Syn92-2 is moderately coarse textured with an intermediate leaf type. This particular grass is under negotiations for option to obtain for advanced testing and evaluation by a partnership between two major turf distributors. Notification of contract will be announced when signatures and terms are finalized.

Syn92-4 is the only variety that is still available from the 92 Series. Yet unspoken for, Syn92-4 is a seven clone synthetic which is one of the latest maturity groups under increase. Individual clones comprising this

clone include: TAES 2852, 2915, 2916, 2922, 3153, 3225 and 3307. No seed was harvested from this nursery in 1993, however sufficient seed was produced during 1994 for advanced testing.

IV. OREGON BREEDER FIELDS

1995 BREEDER PERFORMANCE NURSERIES will be established in Oregon in November 1995 which included three individual polycross populations which have been selected for multiple physiological characteristics with special emphasis on disease resistance (dollar spot), density, texture and color. These breeder nurseries will be identified as Syn96-1, Syn96-2, Syn96-3. Sufficient seed will be harvested in the fall of 1996 for limited field testing with production targeted to enter in the 1997 National Bentgrass Trials. See notes referencing the Parent-Progeny Polycross Populations next section.

The Syn92 series breeder nurseries have been discontinued in their third year with sufficient seed to establish foundation seed stock fields. Two of these cultivars have been optionally licensed to Burlinghams for testing and evaluation and one to Scotts/TMI.

V. PARENT-PROGENY POLYCROSS POPULATION

The parent-progeny polycross population under evaluation in a modified soil based putting green was established in 1993 from crosses made during 1990. Each parental line or TAES accession was used in one or more polycross isolation nurseries identified as A through N (Table 1). Seed was harvested from maternal clone for each polycross. Replicated Parent-Progeny nursery was established for most maternal clones in April 1993. Six progeny and its maternal plant were planted in parent progeny rows (18" x 126") with each plot measuring 18" x 18". The plots were arranged in a Randomized Complete Block design with three replications.

A total of 10 polycross populations, involving 28 maternal lines, are under evaluation for turf quality and general field performance. The objective of this study is to evaluate the parental performance based on progeny performance. Simultaneously, we will have the opportunity to select superior progeny for additional testing and evaluation. Quality notes were reported on the individual plants throughout the summer of 1993.

Distinct parental lines have been identified with superior multiple physical characters (MPC) to construct the 1996 series of bentgrasses. Data was accumulated over the past 3 years and assessed to make field selections for propagules recently sent to Oregon. Based on evaluations of turf quality, rate of spread, disease resistance, color quality and heat tolerance, our interests pointed towards three top populations and thirteen maternal clones. This nursery is presently maintained at 5/32 inches mowing height. Selection criteria were exceptional disease resistance, fine texture and dark green color. After reviewing the data, visual comparisons were made by walking the field and selecting those plots based on dark green color and texture. Population N was selected for its desirable disease resistance, while population E was selected for its dark green color and disease resistance. Population L showed excellent disease resistance as well as having desirable texture and color. Of the maternal selections, we chose thirteen of the twenty-eight maternal clones. TAES2915 was the selection for fine texture. Disease resistant clones noted in the trial are TAES2845, TAES2833, TAES2922, TAES2852, TAES2831, TAES2916, TAES3225, TAES2856, and TAES3293. Those clones also selected for their superior dark green color characteristics are TAES2922, TAES2852 and TAES3307.

VI.1993 NTEP Sand-Modified Bentgrass Green Evaluations at TAES-Dallas

The National Turfgrass Evaluation Program Sand-Modified Bentgrass Green trial (NTEP, 1989) established in 1993 focuses on identifying cultivars with significant improvements in environmental adaptability. At TAES-Dallas, we have evaluated this field trial for several performance characteristics including: root lengths, turf density, disease resistance, and overall turf quality. Through these evaluations we hope to find stronger bentgrasses which are more disease-resistant, more durable and require less irrigation and fertilization, for golf greens. The trial contains 30 entries of creeping bentgrass, 16 of which are commercially available industry standards. The 1993 NTEP Modified Soil Bentgrass Green was seeded as a field trial October 1993. We established the green in 1987 according to USGA specifications. The 30 entries are in 1.5 x 3m plots. The green was seeded at a rate of 1lb per 1,000 ft². Milorganite was mixed with the seed as a carrier. The green was top-dressed with silica based, greens grade sand each week during establishment. Routinely the green is lightly top-dressed once per month from September through April. Fertilizer is applied bi-weekly at .25lb N/1,000 ft². The green is mowed 5 days per week at 155mm(5/32"). Notes were taken for establishment and represented as percent green stand. Turf quality (Table 3) notes were recorded monthly on a 1 - 9 rating system, where 9= best plot and 5 is the minimum acceptable level of turf quality. The components contributing to the turf quality rating are density, uniformity, smoothness, color and texture. Root depth measurements began in October 1994 and taken monthly, using a soil corer(3.3cm diam.) to a depth of approximately 30cm, depending on ground depth.

Tiller count measurements are taken monthly by a soil corer(1.8cm diam.) to an approximate depth of 5-6cm. The collected cores are taken to the lab, and the tillers are counted under magnified glass. We count only the rooted tillers at their growing points on the soil surface. The tiller counts are used to estimate the density of the turfgrass. The trial was designed as a randomized complete block with three replications. The data is analyzed by analysis of variance(ANOVA) using SAS statistical software (SAS Institute, Inc., 1985). When the ANOVA *F*-statistic is significant ($\alpha = 0.05$), we used a Waller-Duncan *k*-ratio *t*-test to separate the means. We summarize turfgrass performance using a turf performance index (TPI; Engelke, et. al., 1993). TPI is the number of times an entry is rated in the top statistical group. Although constrained by the assumptions of the underlying statistical procedures, the TPI is a dimensionless statistic. The TPI can be accumulated across trials, years and locations, and yield valuable information regarding the relative consistency of turfgrass performance of each of the entries.

Rate of Establishment (Table 1): No statistical differences were noted among varieties until April 1994. Syn92-5 had the best establishment rate (8.0), followed by 'Crenshaw', 'SR1020' and 'Pennncross'. BAR As 493, G-2 and MSUEB were the slowest to establish.

Root Depths (Table 2): Significant differences in depth of rooting were only observed in January 1995 and March 1995. In January 1995, 'Trueline', 'Providence' and Bar As 493 were shorter than all other entries, and in March 95 'Cato', 'Southshore', 'Providence' and A-4 were shorter. Overall mean root depth was not significantly different among varieties; however, Syn92-2, 'Seaside' and G-2, tended to grow deeper. Root depths will be continually monitored throughout the year.

Tiller Counts (Table 3): There were no significant differences among entries in tiller counts until May 1995. In May 1995, tiller count of A-1 was significantly higher than other entries. Although most of the varieites increased tillers, 17 varieties possessed significantly more tillers than others. The high density varieties include: Syn92-1, A-1, G-6, A-4, SR1020, Syn92-2, etc.

Turf Quality (Table 4): Significant differences in turf quality among varieties were determined 16 months after seeding, March 1995, for the first time. Lack of maturity during establishment might mask the genetical differences among entries in the early period. Overall average turf quality was significantly higher for Regent, SR1020, C & C, Crenshaw, Southshore, Providence, A-4 and Pennncross. Based on the TPI, Regent, Pro/Cup, Crenshaw, Southshore, Pennncross, ISI-Ap-89150, Syn1-88 and C&C were ranked in the best group. Table 5 is the summary of TPI values over all observations made at the TAES-Dallas center during 1994-1995. A total of 27 observations were made regardless of the characteristics measured. The maximum TPI = 27 was not attained by any of the cultivars, but a TPI = 26 was attained by three cultivars, Crenshaw, Pennncross and Syn1-88. This statistic allows us to further refine the evaluation process utilization all possible information collected of turf performance.

VII. VEGETATIVE CREEPING BENTGRASS SELECTIONS

Assessment of genotype performance continues in the greenhouse, field and laboratory, with screening of germplasm. Approximately 73 superior plants were selected from the breeder fields of Syn92-1 through Syn92-5 in Brooks and St. Paul, OR, and are being evaluated for vegetative growth, heat and salinity tolerance, root growth and turf quality beginning in 1993 (Table 4) and for genetic color (Table 5). It is interesting to note the origin of many of the vegetative plants. Eighteen of the 73 vegetative clones are progeny of parental clone 2922, 11 from parental clone 3307, 10 from parental clone 3153, and nine

from parental clone 3794. These four parents account for over 65% of all of the vegetative selections. Root heat tolerance, salinity, and root growth characteristics, are planned for the near future assessment along with field turf quality parameters. Future studies will include disease and insect resistance and vegetative growth rates and establishment characteristics.

Results from the 1994 spread ratings showed TAES4067, TAES4097 and TAES4109 to be the most vigorous spreading clones. Least vigorous comparatively to the trial were TAES4039, TAES4046, TAES4071, TAES4083, TAES4095 and 'CATO'. Color ratings were evaluated on a scale of 1-9, where 9=best on the field. TAES4073, TAES4082 and TAES4055 showed significantly darker color. TAES4039 and 'Seaside' were not significantly different. The most disease resistant clones were TAES4045, TAES4071, TAES4088 and TAES4089 with the highest mean (9.0) and TPI (2). In turf quality, the higher rated clones were many with a TPI totaling 3. Means set some clones apart such as the highest rated TAES4045 (7.3). Other clones with a mean of 7.2 were: TAES4076, TAES4089, 'Crenshaw' and 'Seaside'. Clones showing an exceptional resilience to scalp damage with a TPI=3 along with high means were Syn1-88 (8.8), TAES4081 (8.7) TAES4089 (8.6) and 'Penncross' (8.6).

VIII. SCREENING GERMPLASM FOR INSECT RESISTANCE

Dr. James A Reinert assumed full time research responsibilities in July 1994 and in addition to previous work (see Appendix B), has initiated more intensive host-plant resistance studies involving numerous turfgrass species involving the creeping bentgrasses. A portion of the support provided by USGA is being directed to support activities in the area of host-plant resistance studies.

Future work will be directed toward screening the hybrids of numerous germplasm lines in search for additional sources of resistance to insects such as: fall army worm, black cut worm, tropical sod webworm.

IX. Introduction of Disease-Resistant Characteristics to Susceptible Cultivars

Dr. Yamamoto, in collaboration with Dr. Colbaugh, focuses her research on the introduction of disease-resistant characteristics into susceptible cultivars. Using recently developed techniques, and working in cooperation with Dr. Andrew Paterson (Soil and Crop Science Dept, College Station, TX), she will attempt to identify and isolate gene(s) responsible for specific disease resistance.

Currently, we are working to introduce dollar-spot resistant characteristics into 'Crenshaw' creeping bentgrass. 'Crenshaw' is a synthetic cultivar from six

parental clones, one of which, we suspect, may be very susceptible to the disease. The first screening tests are conducted by inoculating *Sclerotinia homoeocarpa* into the parental clones. After evaluation, the resistant characteristics will be introduced to the susceptible clone by recurrent selections or by gene transfer. During the selection, the susceptible clone may be replaced by one of its progeny that is similar to the parent, morphologically and physiologically, but possesses the resistant characteristics.

To apply genetic engineering techniques, first of all, we need to develop an adequate tissue-culture system for creeping bent. Several studies reported tissue-culture systems for bentgrasses; however, most of them developed systems for embryo (seed) derived callus. Since seeds are genetically heterozygous in cross-pollinated cultivars (e.g. most of the creeping bentgrasses), plants regenerated from seed-derived callus are genetically different from each other, and the parental plant. From a breeder's point of view, working with vegetative tissue parts from parental clones is the most straightforward and quickest approach to improve existing cultivars (e.g. 'Crenshaw') by genetic engineering. Therefore, we are currently developing a tissue-culture system using vegetative tissue parts, crown, of parental clones.

X. Electrophoretic Identification of Population Shift in Overseeded or Blended Greens

A quick transition with minimal interruption of play is desirable when putting greens are overseeded with new cultivars. Studies of physical and chemical practices have been conducted for this purpose; however, there is no simple method to measure the population shifts. To facilitate the area of study as well as to provide the scientific evidence of cultivar transition, Dr. Yamamoto proposed the use of electrophoresis. In this technique, the green's composition is estimated by comparing the isoenzyme banding patterns from the overseeded green with those of standard blends (proportional blends made in laboratory). The technique is simple and reliable; hence, it will provide practical benefits. Currently, we are examining population shift in 'Crenshaw'-overseeded-'Pennncross' greens, and monitoring competition between 'Crenshaw' and 'Cato.' The research progress will be presented in a poster at 1995-ASA meeting, St. Louis, MO.

XI. TABLES

Table 1. Accumulative turf performance indices for bentgrasses in Parent- Progeny Polycross trials at TAES-Dallas.

#Pos	12	7	1	1	1	3	22	
	93	94	20Feb95	20Apr95	19Jul95	95	Total	% of
	TPI	TPI	tq	ds	cq	TPI	TPI	Total
L	9	2	7.3a	8.2a	6.7a	3	14	63.6
E	4	4	6.9a	7.8a	6.3a	3	11	50.0
N	6	2	6.7a	8.2a	6.2	2	10	45.5
I	6	3	5.4	4.9	5.6	0	9	40.9
K	4	3	6.1	8.2a	6.7a	2	9	40.9
B	5	2	6.0	8.5a	6.1	1	8	36.4
J	5	2	6.2	8.3a	5.9	1	8	36.4
C	2	3	7.3a	8.5a	6.5a	3	8	36.4
P	3	2	6.5	7.8a	6.1	1	6	27.3
A	2	2	6.0	8.5a	6.0	1	5	22.7
D	1	2	6.5	8.5a	5.5	1	4	18.2
2915	9	6	7.6a	8.0a	6.8a	3	18	81.8
2845	9	6	6.3	8.2a	6.5a	2	17	77.3
3153	7	6	6.9a	8.3a	6.5a	3	16	72.7
2833	7	7	7.0a	8.7a	6.2	2	16	72.7
2922	10	4	6.3	8.5a	6.3a	2	16	72.7
2852	7	6	7.2a	8.9a	6.0	2	15	68.2
2831	5	7	7.2a	8.2a	6.4a	3	15	68.2
3307	8	5	6.8a	7.3	6.5a	2	15	68.2
2916	7	5	7.3a	8.7a	6.6a	3	15	68.2
3271	7	3	6.0	6.3	5.8	0	10	45.5
3276	8	5	6.6a	6.7	5.5	1	14	63.6
3225	7	6	6.1	8.7a	6.1	1	14	63.6
2856	7	3	7.2a	7.9a	6.5a	3	13	59.1
2859	7	2	6.8a	8.1a	6.3a	3	12	54.5
3293	6	5	5.3	9.0a	5.6	1	12	54.5
3250	6	5	5.8	7.8a	6.2	1	12	54.5
2784	6	3	7.3a	8.0a	6.1	2	11	50.0
2799	4	4	6.6a	8.3a	5.8	2	10	45.5
3165	7	2	5.8	8.8a	6.0	1	10	45.5
3283	7	2	5.6	6.3	6.0	0	9	40.9
2798	8	0	6.0	9.0a	6.0	1	9	40.9
2794	3	4	6.3	9.0a	6.1	1	8	36.4
3106	3	5	5.6	6.5	5.5	0	8	36.4
3171	4	1	6.1	7.9a	6.3a	2	7	31.8
3141	4	1	6.6a	8.6a	5.6	2	7	31.8
3285	4	3	5.4	5.8	5.9	0	7	31.8
9999	5	2	6.0	7.4	6.1	0	7	31.8
3120	4	3	6.3	7.3	6.0	0	7	31.8

¹Observations included in calculation of Turfgrass Performance Index (TPI) which is the frequency of occurrence an entry was in the highest statistical grouping (a). Rounding error may result in similar values in different statistical groups.

²Means within this column are for comparison of parental lines only and those followed by an "A" indicate performance was in the highest statistical group using the Waller-Duncan k-ratio t test (k=100).

³Means within a column followed by an "a" indicate performance was in the highest statistical group using the Waller-Duncan k-ratio t test (k=100).

Table 2. Establishment ratings¹ during 1993-94 for the 1993 NTEP Sand-Modified Bentgrass Trial at TAES-Dallas.

Entry	Date				Mean	TPI ²
	18Nov	21Dec	05Feb	26Apr		
'18th Green'	2.0 ^{ns}	4.7 ^{ns}	5.0 ^{ns}	5.3a	4.3 ^{ns}	4
'Regent'	3.0	7.3	7.0	7.0a	6.1	4
BAR As 493	0.7	2.7	3.3	4.0	2.7	3
VAR Ws 42102	1.7	3.7	4.3	6.3a	4.0	4
'Trueline'	1.3	4.0	5.7	5.7a	4.2	4
'Seaside'	2.3	5.3	7.3	6.7a	5.4	4
'Cato'	3.3	4.3	5.7	5.3a	4.7	4
'Pro/Cup'	2.7	4.7	5.7	5.7a	4.7	4
'Crenshaw'	3.3	5.7	7.0	7.3a	5.8	4
'Southshore'	3.3	5.7	7.3	7.0a	5.8	4
'Providence'	3.0	3.0	7.7	6.7a	5.1	4
'SR1020'	3.7	6.7	6.3	7.3a	6.0	4
Syn92-1	2.3	3.7	6.0	6.7a	4.7	4
Syn92-2	2.0	5.3	6.7	6.3a	5.1	4
Syn92-5	2.3	5.3	7.0	8.0a	5.7	4
'Penncross'	3.3	6.3	7.3	7.3a	6.1	4
A-1	2.7	5.0	6.7	6.7a	5.3	4
A-4	3.7	6.3	7.7	7.0a	6.2	4
G-2	2.3	3.0	5.0	4.7	3.8	3
G-6	2.3	3.7	6.0	5.7a	4.4	4
'Pennlinks'	1.7	3.7	3.7	6.3a	3.8	4
DG-P	1.7	4.7	6.0	6.0a	4.6	4
MSUEB	1.7	3.3	3.7	5.0	3.4	3
L-93	2.0	5.0	5.7	6.0a	4.7	4
'Lopez'	1.7	4.3	5.7	7.0a	4.7	4
'Tendez'	2.3	5.3	6.0	6.0a	4.9	4
ISI-Ap-89150	2.0	5.7	6.0	6.3a	5.0	4
'Syn1-88'	2.3	4.3	5.7	5.7a	4.5	4
'C & C'	2.3	5.0	6.0	6.7a	5.0	4
'Dominant'	1.3	5.0	7.0	6.3a	4.9	4

¹Ratings were based on a tenth percent of growth within a plot.

² TPI is the turf performance index which is the number of times an entry was rated in the top statistical group

'a' indicates entry was in the highest statistical group. 'ns' indicates means were not significantly based on ANOVA F-test.

Table 3. Root Depth ratings¹ during 1994-95 for the 1993 NTEP Sand-Modified Bentgrass trial at TAES-Dallas.

Entry	Date					Mean	TPI ²
	27Oct94	24Jan95	06Mar95	15May95	10Aug95		
'18th Green'	22.0 ^{ns}	24.1a	18.5a	18.1 ^{ns}	12.1 ^{ns}	19.0 ^{ns}	5
'Regent'	21.3	21.9a	22.1a	18.8	12.4	19.3	5
BAR As 493	21.5	20.3	24.3a	18.4	14.7	19.8	4
VAR Ws 42102	21.2	22.5a	19.8a	21.8	12.0	19.5	5
'Trueline'	22.2	20.9	18.9a	22.5	12.8	19.5	4
'Seaside'	23.0	26.3a	21.8a	23.6	13.4	21.6	5
'Cato'	22.7	25.5a	17.6	18.1	11.4	19.1	4
'Pro/Cup'	21.2	22.5a	21.0a	20.5	11.1	19.3	5
'Crenshaw'	21.3	25.1a	22.1a	21.7	11.2	20.3	5
'Southshore'	20.5	21.7a	16.4	23.3	14.2	19.2	4
'Providence'	20.8	21.2	17.5	20.8	10.3	18.1	4
'SR1020'	20.2	21.9a	19.8a	19.4	11.8	18.6	5
Syn92-1 2	1.5	23.6a	20.9a	20.5	12.9	19.9	5
Syn92-2 2	3.7	26.6a	25.7a	24.6	12.9	22.7	5
Syn92-5 2	2.8	24.7a	20.0a	21.7	13.0	20.4	5
'Penncross'	20.3	21.5a	19.9a	22.7	13.3	19.5	5
A-1	20.5	22.5a	22.7a	25.2	13.3	20.8	5
A-4	22.2	24.8a	17.3	22.3	13.0	19.9	4
G-2	21.5	26.4a	21.2a	23.8	14.7	21.5	5
G-6	21.0	22.5a	19.3a	20.4	16.8	20.0	5
'Pennlinks'	23.2	21.5a	21.8a	20.5	13.2	20.0	5
DG-P	22.3	22.2a	20.4a	20.1	15.5	20.1	5
MSUEB	20.7	25.2a	21.0a	22.0	12.8	20.3	5
L-93	20.8	24.2a	20.9a	20.4	15.2	20.3	5
'Lopez'	23.2	21.5a	21.0a	20.5	13.1	19.9	5
'Tendez'	21.3	20.0a	19.7a	20.5	11.9	18.7	4
ISI-Ap-89150	21.8	22.7a	20.7a	18.6	12.7	19.3	5
'Syn1-88'	21.5	23.7a	22.6a	21.5	12.8	20.4	5
'C & C'	20.8	23.5a	20.2a	22.4	10.9	19.6	5
'Dominant'	23.7	24.5a	20.1a	23.1	11.6	20.6	5

¹Root depth ratings were based on the longest root (mm) measured in a plot.

² TPI is the turf performance index which is the number of times an entry was rated in the top statistical group

'a' indicates entry was in the highest statistical group. 'ns' indicates means were not significant based on ANOVA F-test.

Table 4. Tiller Count ratings¹ during 1994-95 for the 1993 NTEP Sand-Modified Bentgrass trial at TAES-Dallas.

Entry	Date					Mean	TPI
	09Dec94	23Jan95	01Mar95	23May95	14Jul95		
'18th Green'	44.7 ^{ns}	47.0 ^{ns}	40.3 ^{ns}	41.0	63.0a	47.2 ^{ns}	4
'Regent'	36.0	41.0	41.0	47.7	50.3	43.2	3
BAR As 493	40.3	38.7	38.0	30.0	61.7a	41.7	4
VAR Ws 42102	50.3	53.7	48.0	60.0	55.7	53.5	3
'Trueline'	39.7	46.3	44.7	43.3	61.0a	47.0	4
'Seaside'	43.3	37.3	49.0	32.3	52.3	42.9	3
'Cato'	40.7	54.0	46.3	60.0	70.3a	54.3	4
'Pro/Cup'	41.0	43.0	42.0	43.3	58.3	45.5	3
'Crenshaw'	46.3	42.3	47.7	65.0	66.7a	53.6	4
'Southshore'	49.3	45.7	46.7	60.7	61.7a	52.8	4
'Providence'	41.7	48.3	42.3	59.0	50.0	48.3	3
'SR1020'	46.0	54.0	46.0	51.3	72.3a	53.9	4
Syn92-1	55.3	49.7	58.0	44.0	81.0a	57.6	4
Syn92-2	42.3	47.0	44.0	49.3	72.0a	50.9	4
Syn92-5	50.7	44.0	50.3	50.0	52.3	49.5	3
'Pennncross'	49.0	32.3	39.7	39.7	60.3a	44.2	4
A-1	53.0	51.3	50.0	75.0a	80.0a	61.9	5
A-4	54.7	59.0	52.7	52.3	76.0a	58.9	4
G-2	44.7	40.7	48.3	49.7	65.7a	49.8	4
G-6	44.3	50.3	52.0	55.7	76.3a	55.7	4
'Pennlinks'	43.7	43.7	52.7	44.0	51.7	47.1	3
DG-P	35.7	48.0	40.3	41.0	56.7	44.3	3
MSUEB	42.0	43.7	51.0	53.0	66.0a	51.1	4
L-93	49.3	43.0	53.0	38.3	62.3a	49.2	4
'Lopez'	40.7	47.7	57.3	48.7	57.3	50.3	3
'Tendez'	41.3	41.7	44.0	54.0	51.0	46.4	3
ISI-Ap-89150	55.0	47.0	50.0	58.7	47.3	51.6	3
'Syn1-88'	40.0	48.7	44.7	41.7	56.3	46.3	4
'C & C'	47.7	47.3	47.3	53.3	58.0	50.7	3
'Dominant'	46.0	40.3	54.0	56.3	64.7a	52.3	4

¹Tiller count ratings were based on number of tillers in a 1.5cm diameter sample per plot.

² TPI is the turf performance index which is the number of times an entry was rated in the top statistical group (does not include overall mean).

'a' indicates entry was in the highest statistical group. 'ns' indicates means were not significantly based on ANOVA F-test.

Table 5. Turf Quality¹ ratings during 1994-95 for the 1993 NTEP Sand-Modified Bentgrass Trial at TAES-Dallas.

Entry	1994					1995								13(Total Poss.)	
	07Jan	20Jun	11Jul	17Aug	13Oct	02Jan	02Feb	22Mar	13Aug	17May	19Jun	03Aug	11Aug	Mean	TPI
'18th Green'	5.0 ^{ns}	6.8 ^{ns}	6.3 ^{ns}	7.3 ^{ns}	6.5 ^{ns}	6.7 ^{ns}	6.7 ^{ns}	5.8	6.2	7.0a	7.0a	6.7 ^{ns}	7.0 ^{ns}	6.5	11
'Regent'	7.3	8.0	7.3	7.3	7.0	7.0	6.5	7.2a	7.0a	7.8a	8.0a	7.0	7.3	7.3a	13
BAR As 493	3.3	5.8	4.8	6.7	6.2	6.7	6.0	6.2	6.2	6.3a	6.3a	6.3	6.3	5.9	11
VAR Ws 42102	4.7	6.5	5.3	7.0	6.7	7.7	7.0	6.2	6.2	6.8a	6.7a	6.0	6.3	6.4	11
'Trueline'	4.7	6.7	6.0	6.3	6.7	7.7	6.8	7.0	7.0a	5.8a	6.0	6.3	6.0	6.4	11
'Seaside'	6.0	6.5	5.5	7.0	6.2	6.3	6.3	6.8	6.8a	6.3a	6.7a	7.0	7.3	6.5	12
'Cato'	5.3	6.3	5.7	6.7	6.3	7.0	7.0	6.8	6.5a	7.0a	7.0a	7.0	7.0	6.6	12
'Pro/Cup'	5.7	7.2	6.3	7.7	6.7	6.7	6.5	7.2a	6.8a	6.5a	6.7a	6.0	6.7	6.7	13
'Crenshaw'	7.3	7.2	6.5	7.7	6.8	7.3	6.8	7.2a	6.7a	7.2a	7.3a	6.0	7.3	7.0a	13
'Southshore'	5.7	7.2	7.2	7.3	6.8	7.3	6.8	7.2a	6.8a	8.0a	8.3a	6.3	6.3	7.0a	13
'Providence'	6.0	7.7	7.5	7.7	7.0	7.3	7.0	5.7	6.3a	8.0a	8.0a	6.7	6.7	7.0a	12
'SR1020'	6.3	7.7	7.2	8.3	7.3	7.7	7.0	6.2	6.2	7.3a	7.7a	6.3	6.7	7.1a	11
Syn92-1	5.7	6.3	6.0	7.7	6.5	7.3	7.2	6.8	7.0a	7.0a	7.0a	6.3	6.3	6.7	12
Syn92-2	4.7	6.8	5.8	7.3	6.7	6.7	6.7	5.8	6.3a	6.3a	6.3a	5.7	5.7	6.2	12
Syn92-5	5.0	7.3	7.0	7.0	6.8	6.7	6.3	7.0	7.0a	7.5a	7.7a	6.7	6.3	6.8	12
'Penncross'	7.3	7.2	6.3	7.3	6.8	6.7	6.8	7.2a	7.2a	6.8a	7.0a	6.3	6.0	6.8a	13
A-1	5.7	7.3	6.2	7.3	7.3	7.0	6.3	6.7	6.3a	6.8a	7.0a	7.0	6.7	6.7	12
A-4	6.0	7.7	6.8	7.7	7.0	7.7	7.3	6.0	6.0	7.0a	7.0a	7.0	7.3	7.0a	11
G-2	4.7	6.3	5.7	7.0	6.7	6.3	6.3	6.0	6.0	7.0a	6.3a	6.3	5.7	6.2	11
G-6	4.7	6.7	6.2	7.3	7.3	6.3	6.3	6.7	6.5a	7.7a	7.7a	6.3	6.0	6.6	12
'Pennlinks'	3.7	7.2	6.5	7.3	7.0	7.0	6.5	6.7	7.0a	6.8a	6.7a	6.0	6.3	6.5	12
DG-P	5.0	7.0	6.2	7.7	6.8	6.7	6.3	6.2	6.3a	7.2a	7.3a	6.3	7.0	6.6	12
MSUEB	4.0	6.3	5.2	7.7	6.3	6.3	6.7	5.8	6.0	7.5a	7.5a	6.3	6.3	6.3	11
L-93	3.3	7.5	6.8	8.0	7.2	6.7	7.0	6.2	6.0	7.5a	7.7a	7.0	6.3	6.7	11
'Lopez'	4.3	7.0	6.0	7.7	6.3	6.3	6.5	5.7	5.7	7.5a	7.7a	6.3	6.3	6.4	11
'Tendez'	3.7	6.2	5.7	7.3	6.8	6.0	6.7	6.0	6.0	7.7a	7.7a	6.7	6.7	6.4	11
ISI-Ap-89150	5.0	6.7	6.5	8.0	6.8	6.7	7.0	7.2	6.5a	7.8a	7.7a	6.7a	7.0	6.9	13
'Syn1-88'	4.7	7.3	6.2	7.3	7.2	6.3	7.2	7.2a	6.8a	6.7a	6.7a	6.3	6.7	6.7	13
'C & C'	6.7	6.8	6.2	8.3	6.8	6.7	6.8	7.7a	7.2a	7.7a	7.3a	7.0	7.0	7.1a	13
'Dominant'	5.3	7.7	6.7	8.0	6.5	6.7	6.3	6.0	6.0	6.2a	5.7	7.3	6.7	6.5	10

¹Turf quality ratings were based on 1-9 scale, where 9 is the best and 5 is the minimum acceptable turf quality.²TPI is the turf performance index which is the number of times an entry was rated in the top statistical group (does not include overall mean).³MSD is the minimum significant difference between means based on the Waller-Duncan *k*-ratio *t*-test(*k*-ratio=100). 'a' indicates entry was in the highest statistical group. 'ns' indicates means were not significantly based on ANOVA *F*-test.

