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ANNUAL PROGRESS REPORT

BREEDING AND DEVELOPMENT OF ZOYSIAGRASS

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Executive Summary

Principal Investigator: Dr. M.C. Engelke
Co-Investigators: Dr. Ikuko Yamamoto
Mr. Samuel K. Riffell

Research Period: 1 November 1994 through 1 November 1995

The zoysiagrass breeding program has expanded its personnel base with the addition of Dr. Ikuko Yamamoto, Ph. D. (Pennsylvania State Univ., 1994) as an Assistant Research Scientist. Dr. Yamamoto is working closely with Drs. Colbaugh and Reinert in heritability of host-plant resistance mechanisms. Her research employs both conventional and biotechnical approaches to genetic recombination, with additional collaborations with Dr. Andrew Patterson (Soil and Crop Science Dept., Texas A&M Univ., College Station, TX). Additional germplasm has been introduced to the program from Japan and China. Several progeny populations of previous hybrids and recent introductions are under evaluation. Over the past several years, greater emphasis has been directed to salinity tolerance (initiated by Dr. Ken Marcum, now University of Arizona.), shade tolerance (Ms. Sharon Morton, now Pott's Fellow in Ph. D. Program, Texas A&M Univ.), water-use requirements (Dr. Richard White, now Associate Professor, Texas A&M Univ.), and establishment technology (Dr. Bridget Ruemmele, now Assistant Professor, Univ. of Rhode Island).

Five zoysiagrasses, DALZ8502 (*Z. matrella*: fine texture), DALZ8507 (*Z. matrella*: medium-fine texture), DALZ8512 (*Z. japonica*: medium-coarse texture), DALZ8514 (*Z. japonica*: medium-coarse texture), and DALZ9006 (*Z. matrella*: medium-fine texture) will be submitted for release in the fall 1995. Three of them are presently under foundation increase at TAES-Dallas to serve as planting stock for registered and/or certified production. High productivity is one of the superior characteristics of these new lines. In contrast to the "standard" cultivar 'Meyer,' which requires 12 to 24 months between crop cycles, DALZ8512 and DALZ8514 can be harvested two to three times every 24 months. DALZ8502 also produces two to three crops every 24 months at Dallas; however, this selection may not provide sufficient winter hardiness at northern locations. DALZ8507 and DALZ9006 produce a crop on a 9- to 12-month cycle. Among them, DALZ8507 has been ranked Number One in the National Trials since 1993 at 24 locations, evidently suggesting its superior characteristics as a turf, and excellent adaptability to the wide-range of environments.

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M. C. Engelke, S. K. Riffell and I. Yamamoto

Introduction

The zoysiagrass breeding and development program is in its eleventh year of funding through the United States Golf Association. Initiated in May 1984, the cooperative efforts between the Texas Agricultural Experiment Station and the USGA have continued to develop improved zoysiagrasses for the golf and turf industry. This report details research activities between 1 November 1994 through 1 November 1995.

Technical Support Personnel

Mr Samuel K. Riffell (Former Research Associate) served the turfgrass breeding program in September 1994 through August 1995. Mr. Riffell holds a M. S. in Environmental Studies from Baylor University. Approximately 80% of Mr. Riffell's time was spent on the zoysiagrass project. Mr Riffell has entered a Ph D program at Michigan State University.

Dr. Ikuko Yamamoto (Assistant Research Scientist) joined the Turfgrass Breeding Program in February 1995. Dr. Yamamoto's responsibilities focus on breeding and development of zoysiagrasses by conventional methods and molecular genetic techniques. She is working closely with Drs. Phillip Colbaugh and James Reinert with the primary objective of evaluating and introducing disease- and insect-resistant characteristics to susceptible DALZ lines. Approximately 40% of her time is devoted to the zoysiagrass project.

Greenhouse and Laboratory Progress

Germplasm Maintenance

Germplasm Library

The zoysiagrass germplasm library inventory continues to be updated. Seed has been tested for germination potential, and seedlings have been planted in the greenhouse. Progeny of zoysiagrasses recently brought to the program from China and Japan have been obtained both from specific crosses and from open-pollination. These progeny will become part of the germplasm library, and will be screened by greenhouse and field procedures.

Germplasm in Quarantine

Texas A&M Research and Extension Center at Dallas serves as a working quarantine import facility in cooperation with APHIS and the USDA-ARS Plant Quarantine Facility. In this capacity, and under the direction of Dr. M. C. Engelke, plant materials collected or shipped from overseas are simultaneously introduced into the United States through APHIS, and TAES-

Dallas for purposes of scientific studies under isolated conditions. Any vegetative materials introduced from other countries are subjected through two time spaced viral screening (serology) procedures by the ARS Plant Quarantine Lab. The process generally requires 1 to 2 years to accomplish. At TAES-Dallas, any agronomic increase or evaluations are conducted in the quarantine space only. Limitation imposed on the use of material restrict manipulations to include floral initiation studies, self-pollination, hybridizations, and seed harvest. Seeds harvested from the plants are not subject to isolation; hence, they can be moved into the mainstream research program. Using the seed harvested, and in cooperation with ARS, only a limited number of plants require full serological tests.

Screening Germplasm Resources for Insect/Mite Resistance

Dr. James A Reinert assumed full time research responsibilities in July 1994 and in addition to previous work (Reinert and Engelke 1992; Engelke, et. al. 1994; Reinert, et. al. 1994), he has initiated more intensive host-plant resistance studies involving numerous turfgrass species including zoysiagrass and creeping bentgrass. A portion of the support provided by USGA is being directed to support activities in the area of host-plant resistance studies with both of these species. To date, studies have been completed on advanced germplasm lines identified as DALZ lines which were included in the National Turf Evaluation Program (NTEP) trials. The results were reported in the International Turfgrass Society Research Journal, and Texas Turfgrass Research Reports.

Fall Armyworm (Spodoptera frugiperda)

Selected zoysiagrass genotypes in the 1993 NTEP trail were evaluated for their potential resistance to the fall armyworm. Two preliminary experiments were conducted (Reinert, et. al., 1994). In the first experiment, larvae were grown on 12 experimental and commercial cultivars of zoysiagrass. Survivorship was monitored for 21 d. In a second similar experiment, larvae were allowed to feed on a highly susceptible variety (DALZ8516) for 4 d before being transferred to nine different zoysiagrass cultivars/lines.

In both experiments, DALZ8507 showed true resistance to the fall armyworm: no larvae survived more than 17 d in either experiment. Emerald, Belair, Meyer, Korean Common, El Toro, and DALZ8501 were highly tolerant, and DALZ8502, DALZ8508, and DALZ8512 were moderately tolerant. However, in the second experiment, where larvae were grown on susceptible hosts for 4 d, Belair, El Toro, Emerald and Meyer were more susceptible. DALZ8514 and DALZ8516 were highly susceptible in both experiments. Thus, DALZ8507 may possess vertical resistance to fall armyworm, while other tolerant lines may have horizontal resistance. Belair, El Toro, Emerald and Meyer can avoid fall armyworm only when larvae are young.

Tropical Sod Webworm (Herpetogramma phaeopteralis)

According to the previous studies, DALZ8507 and DALZ8501 were highly resistant to tropical sod webworm, and Emerald and DALZ8512 were moderately tolerant (Reinert and Engelke 1992; Engelke

et. al. 1994). The tropical sod webworm is widely spread over the area where zoysiagrasses will be utilized; therefore, intensive studies about resistance mechanisms in zoysiagrasses are important. The entries of the 1991 NTEP trial are currently expanded for further research.

Zoysiagrass mite (Eirophyes zoysiae)

The zoysiagrass mite is one of the most insidious pests in Korea and Japan, the origin of *Zoysia* spp. Now established in the United States, it threatens to become a serious pest for zoysiagrasses. Previous study found that Emerald, DALZ8508, DALZ8516, and DALZ9006 were resistant, while Belair, DALZ8502, DALZ8507, and Meyer were susceptible (Reinert et. al. 1993; Engelke et. al. 1994).

Future Work

To investigate insect-resistant mechanisms of zoysiagrasses, we maintains all entries of the 1991 NTEP trial in a polyhouse. Screening tests will be conducted on hybrids, crosses, and other germplasm lines. Dr. Reinert is currently examining changes in the levels of resistance/tolerance under different nutritional and/or environmental (seasonal) conditions.

Screening Germplasm Resources for Disease Resistance

The spread of many problematic turfgrass diseases is generally facilitated by warm, moist conditions in highly fertile environments. In many situations, these conditions are created by intensive cultural practices. More drought- and stress-tolerant cultivars can, therefore, simultaneously reduce disease problems by reducing the requirement for fertilization and irrigation. DALZ lines, such as DALZ8502, DALZ8507, DALZ8512, DALZ8514, and DALZ9006, were developed for excellent drought or other stress conditions, and hence, disease problem could be overcome by diminishing cultural practices. However, identification and development of disease-resistant cultivars are still important. We have conducted several screening tests for zoysiagrass resistance/tolerance to *Rhizoctonia*, *Pythium*, and *Sclerotinia,* with Dr. Philip F. Colbaugh, plant pathologist at the Dallas Research Station. Dr. Colbaugh has researched biological and environmental factors of disease in several turfgrass species.

Rhizoctonia Blight (Rhizoctonia solani)

According to the *R. solani* inoculation tests on twenty-four zoysiagrass cultivars/lines, Meyer, DALZ9006, DALZ8507, and DALZ8502 were found to be moderately tolerant (percentage infection < 30%). Among them, Meyer and DALZ8502 showed excellent recovery from disease. DALZ8512 and DALZ8701 were the most susceptible in DALZ lines (Appendix B).

Pythium Blight (Pythium aphanidermatum)

Among 40 zoysiagrasses examined for resistance/tolerance to *P. aphanidermatum*, DALZ8512, DALZ8514, Meyer, Emerald, and El Toro were found to be highly tolerant (percentage foliar blight < 10%). DALZ8507 and DALZ8502 were relatively susceptible (Appendix C).

Dollar Spot (Sclerotinia homoeocarpa)

Ten zoysiagrass cultivars/lines were inoculated with *S. homoeocarpa*. In general, fine-textured cultivars/lines are more susceptible than coarse-textured ones. In this study, coarse-textured cultivars, Belair, El Toro, Meyer, DALZ8516, were found to be resistant. However, the percentage infection of DALZ fine-textured lines, DALZ8501, DALZ8502, and DALZ8508, were not significantly different from that of corse-textured cultivars/lines. On the other hand, a commercial fine-textured cultivar, Emerald, and an experimental line, TAES3477, were significantly more infected by *S. homeocarpa* (Appendix D).

Future Work

A portion of USGA support will be channeled to further investigations of *Rhizoctonia* blight and *Sclerotinia* dollar spot resistance among the NTEP zoysiagrasses, particularly the DALZ lines under consideration for commercial release. Future work will also focus on collecting information about two zoysiagrass diseases for which our knowledge is incomplete: zoysiagrass rust and zoysia patch. We have only observed the zoysiagrass rust once at TAES-Dallas; therefore, information from field trials at other locations is desired. We are similarly restrained in our ability to address the response of germplasm lines to zoysia-patch disease because of its erratic occurrence in our field trials. Zoysia patch has the potential to become a severe problem for zoysiagrass and identification of the causal agent remains a high priority.

Multiple Pest/Disease Resistance

Results from previous studies (insects and disease resistance) are summarized in Table 1. As shown in the table, some of the commercial and experimental cultivars/lines

Table 1. Summary of disease and insect/mite resistance.

	Disease resistance			Insect/mite resistance		
Line/cultivar	Dollar spot	Phy. blt	Rhizo blt	TSW[1]	ZM[1]	FAW[1]
DALZ8501	M[2]	S	S	R	M	M
DALZ8502	M	M	R	S	S	M
DALZ8507	-	M	M	R	S	R
DALZ8508	M	M	M	M	R	M
DALZ8512	-	R	M	M	M	S
DALZ8514	-	R	M	M	S	S
DALZ8516	R	R	M		R	S
DALZ9006	-	M	M	M	R	-
Belair	R	R	S		S	M
El Toro	R	M	M	M	M	M
Emerald	S	M	M	M	R	M
Meyer	R	R	R	S	S	M

[1] TSW = toropical sod webworm; ZM = zoysia mite; FAW = fall armyworm.

[2] R = resistant; M= moderately resistant; S = susceptible.

are resistant/tolerant to two or more diseases and insects. Since multiple pest-resistant characteristics are highly desirable for newly introduced cultivars, we will continue this area of study, and would like to develop new cultivars which are resistant/tolerant to major zoysiagrass pests.

Introduction of Insect-Resistant Characteristics to Susceptible Lines

Dr. Yamamoto, in collaboration with Dr. Reinert, has begun research which will hopefully lead to the introduction of resistant characteristics into susceptible zoysiagrass lines/cultivars. To accomplish the transfer of insect-resistant gene(s) from resistant lines to susceptible lines, Dr. Yamamoto employs both conventional recurrent selection techniques and newly developed methods of molecular and genetic engineering.

In the conventional methods, a susceptible DALZ line (recurrent parent) is crossed with a resistant line (donor parent), and F1 progeny that possess resistant characteristics are backcrossed with the recurrent parent. Backcrossed progeny (BC1F1) are repeatedly back-crossed (BC2F1, BC3F1, BC4F1....) with the recurrent parent, that regains the original genetic composition of the susceptible line, with the exception of the resistant characteristics. Initial crosses for recurrent selection techniques have already been made and progeny will soon be tested for resistant characteristics. To date, we have F1 progeny from DALZ8501 x DALZ8502, DALZ8501 x DALZ8512, DALZ8502 x DALZ8501, DALZ8512 x DALZ8501, and DALZ8512 x DALZ8502. Additional crosses will be made when DALZ8507 and DALZ8516 begin to flower.

Using more recently developed techniques, and working in cooperation with Dr. Andrew Paterson (Soil and Crop Science Dept, College Station, TX), Dr. Yamamoto will attempt to identify and isolate the DNA sequences responsible for insect resistance in resistant lines. As the first step for achieving our goal, an adequate tissue-culture system for zoysiagrasses should be developed. Although, several studies were conducted on other turfgrass species, to date, only limited studies were conducted on zoysiagrasses. In addition, most of the recent progresses in turfgrass tissue-culture system were seen in the studies using 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. To improve the existing superior cultivars or plant materials by genetic engineering (gene transfer), tissue-culture system developed from vegetative tissue parts must be established. Therefore, Dr. Yamamoto is currently working with "crown" tissue for inducing callus and regenerating plants.

From a breeder's point of view, working with vegetative tissue parts is the most straightforward and quickest approach for developing zoysiagrass, which are predominantly vegetatively propagated species. However, vegetative tissue has generally more contaminants than seed. In our experiments, only 25% or less tissue were clean after standard sterilization processes. To overcome this problem, we incubate clean tissues (crowns) in hormone-free media that allow tissues to regenerate plants. After the plants grow enough and produce sufficient number of tillers, crowns

will be harvested from them and used for callus induction study.

Through her research, Dr. Yamamoto will be able to provide important information about methods of zoysia tissue culture and potentials for genetic engineering in the genus.

Electrophoretic Identification of Zoysiagrasses

Dr. Yamamoto conducted electrophoresis to provide genetic "finger prints" of six DALZ lines (8501, 8502, 8507, 8512, 8514, and 8516), and four commercial cultivars (Belair, El Toro, Emerald, and Meyer). According to the isoenzyme banding patterns of phosphoglucose isomerase (PGI), all 10 lines/cultivars were clearly identified. Triosephosphate isomerase (TPI) is another enzyme system that is effective for identifying cool-season species; however, TPI banding patterns of zoysiagrasses showed little morphological variation. Except DALZ8501 and DALZ8507 (*Z. matrella*), all other lines/cultivars (six *Z. japonica*; one *Z. matrella*; and one hybrid between *Z. japonica* and *Z. tenuifolia*) showed the same TPI isoenzyme banding patterns; hence, species discrimination was not possible by TPI.

One of our zoysiagrass breeding objectives is, for example, transferring tropical sod webworm resistant characteristics in DALZ8501 to susceptible line, DALZ8502. For this purpose, we are intensively working with these two lines, which are morphologically very similar. To maintain genetic purity during research and to examine F1 and backcrossed progeny, we use electrophoresis technique as a quick and practical tool.

Field Evaluation and Production Trials

Shade Tolerance

Shade Tolerance of the 1991 NTEP trial

The performance of the 1991 NTEP zoysiagrasses tested under shade conditions has entered the third year of evaluation. The focus remains on the ability to persist and spread, green color retention, density, and overall turf quality. During this research period (Nov. 1994 to Nov. 1995), seven DALZ lines were ranked in the top nine cultivars/lines for overall turf quality (Table E6). In addition, according to the accumulative turf performance index (TPI) for past 3 years, these seven lines were ranked in the top nine cultivars/lines (Table E8). The detailed results are shown in Appendix E.

Compaction and shading effects on DALZ8502 green

Among zoysiagrasses, which are relatively tolerant to shade and/or traffic (Cockerham, et al., 1994), DALZ8502 is one of the most tolerant lines to shade. To evaluate the potential use of DALZ8502 as a playing surface for domed stadiums, we conducted studies simulating the dome conditions by limiting light intensity and providing compaction.

In May 1995, a DALZ8502 green (20 by 20 ft) established in a polyhouse was covered by shades. The green was divided into 16 plots (5 by 5 ft), and each plot was covered with

one of four shade treatments: no shade cloth (0%), 47% shade cloth, 73% shade cloth, and 95% shade cloth. The experimental design was balanced RCBD with three replications. The green was periodically rolled to simulate athletic traffic compaction. Under 47 and 73% shaded conditions, DALZ8502 performed better than or as well as under 0% shaded conditions, suggesting potential use of DALZ8502 as a "dorm cultivar." The results are shown in Appendix F.

To confirm the results, we have been conducting the same experiment under field conditions since 22 Aug. 1995. The green is mowed at 1" once/wk, compacted (rolled) once/wk, and irrigated as needed. Several quality notes are taken.

U. C. - Riverside Trial

DALZ8502 sod was distributed to Univ. of California - Riverside in Mar. 1995 for inclusion in the indoor sports facility turf evaluation trials. The trials are conducted by Mr. Steve Cockerham and are financed by interested parties in the projected Phoenix Dome Stadium for baseball.

National Turfgrass Evaluation Program (NTEP)

Locally, the 1991 planting of the NTEP trial was severely contaminated with bermudagrass. Therefore, the 1991 NTEP trial was replanted on 2 Aug. 1994. Except for notes pertaining to disease incidence and insect infestation, the 1991 planting of the trial was abandoned. Evaluation continues, however, on the 1993 planting. Performance of the 1991 NTEP entries is shown in Appendix G.

Fairways

In May 1993, DALZ8507 and DALZ8512 fairways (total 7200 ft^2) were established by planting plugs at a 1:200 (tissue area:ground area) ratio. Prior to planting, the soil in half of each fairway was treated with hydrozone polyacrylamide moisture retention material to retard desiccation. The fairways are reel mowed at 5/8", fertilized at 0.5 lb N/1000 ft^2 /mo., and irrigated as needed.

During winter dormancy, weed invasion was minimum, and fairways were nicely greened up in spring. To evaluate and demonstrate the versatility of these zoysiagrasses, half of each fairway is currently mowed at 4". The discrepancy in mowing height is designed to address turf performance under high-cut conditions as in horse-race tracks (see "*Racetrack* in Other Field Trials" section).

DALZ8502 Greens

Winter green-cover effects on spring green-up

A DALZ8502 green at TAES-Dallas was covered throughout the winter when ambient temperatures dropped below 40°F. Due to a calm winter of 1994-95, difference in spring green-up between the covered- and uncovered-area was not as prominent as in previous years. The green will be covered in 1995-96 winter, and covering effects on spring green-up will be examined.

Cool-season species overseeding effects on zoysia green

Three cool-season species, creeping bentgrass 'Cato,' rough bluegrass 'Laser,'

and perennial ryegrass 'Rebel II,' were overseeded on 21 Sept., 1995. Seeding rates were 1, 2, and 5 lb/1000 ft^2 for bentgrass, bluegrass, and ryegrass, respectively. Half of the green was pre-aerified using Star Tines to examine mechanical-cultivation effects on overseeding. Overseeding effects on zoysia green quality in the following spring will be examined.

Chipping greens and home lawn

Additional greens have been maintained at other locations. Chipping greens are currently maintained at Colonial Country Club and at Alvarmar Country Club in Lawrence, Kansas.

Three home greens, which were established to allow private residents to test the potential for use in such situations, have been maintained as well. One green was built on a sand-modified root zone. DALZ8502 sod was harvested, washed thoroughly and laid, followed by extensive top dressing with sand root zone mix. The other greens were solid sodded on native soil sites. Plantings was conducted in late Aug. 1994. To date, reports are positive.

Other Field Trials

Pascal High School

On 3 Apr. 1995, DALZ8514 was plugged onto a soccer field at Pascal High School in Fort Worth, TX. The planting rate was 250 yds of sod per acre. A portion of the field (approx. 9000 ft^2) was hydro-sprigged for comparing establishment methods. The field is used as a typical high-school athletic field. Turf performance as a playing surface will be evaluated.

Racetrack

In Apr. 1995, DALZ8514 and DALZ8512 were planted to simulate a horse practice track. The area was established by plugging at a 250 yds/acre planting rate. Establishment rate and turf performance will be evaluated to examine the potential use of the zoysiagrasses as racetrack turfs, and to determine the optimum mowing height.

Zoysiagrass Development and Increase

Polycross Nurseries

Two polycross nurseries are maintained and examined for speed of spread, texture, flowering, and seed production. These characteristics are evaluated under normal environmental conditions so that cultivars with desirable combinations of traits can be identified. The nurseries are maintained with minimum irrigation to prevent wilting, and fertilized at 0.5 lb N/1000 ft^2, twice per year. The nurseries are not regularly mowed. In June 1995, we harvested relatively high seed-production plots. Those mother lines are: TAES3484; TAES3503; TAES3510; TAES3519; TAES3531; TAES3534; TAES3536; TAES3538; TAES3540; TAES3554; TAES3555; TAES3564; TAES3575; and Meyer. The progeny will be used for further zoysia developing programs.

Breeder and Foundation Fields

Breeder-Class Fields

Four breeder fields, DALZ8502, DALZ8507, DALZ8512, and DALZ8514 (15,000 ft^2 each), were planted in July 1992,

and DALZ9006 was planted in June 1994. The fields are carefully managed to prevent any pests and contaminations. The fields are fertilized at 1 lb N/1000 ft^2 per month, and regularly mowed, rolled, and irrigated. The mowing heights are 3/8" for DALZ8502, 5/8" for DALZ8507 and DALZ9006, and 1½" for DALZ8512 and DALZ8514.

Each of breeder fields, except DALZ9006, was harvested at least once, suggesting excellent sod production. In comparison with a commercial cultivar 'Meyer,' which requires 15 to 24 months per harvest cycle, substantial improvement in productivity was realized for DALZ8502, DALZ8512, and DALZ8514. Since DALZ8502 is not highly tolerant to winter coldness, part of the field was covered during 1994-95 winter. Under the cover, plants maintained a substantial green cover; hence, we could harvest covered-DALZ8502 sod much earlier than uncovered-area.

Foundation-class Fields

Foundation fields of DALZ8507, DALZ8512 and DALZ8514 were planted in June, 1994. These fields are fertilized at 3 lb N/1000 ft^2 per year, and mowed, rolled, and irrigated as need. The fields are carefully managed to be pest free. DALZ8512 and DALZ8514 are the quickest to establish, and sod was ready for harvest in the mid-summer 1995. DALZ8507 is slower to establish than the other lines, but it could be harvested by the end of summer 1995.

Experimental Design and Statistics

Dr. M. C. Engelke presented a paper to the American Society of Agronomy introducing a turf performance index (TPI). Simply stated, the TPI is the number of times a particular turfgrass was rated in the top statistical grouping. The TPI has several advantages over merely ranking the cultivars (a practice which can be highly misleading and which has been misconstrued on many occasions):

1. Visual ratings are highly subjective and can vary with the skill, experience, knowledge or personal taste of the person conducting the evaluation. Ratings can also vary with the mental and emotional state of the same evaluator from date to date. The TPI, however, is a dimension less measure based on an entries' performance relative to the other entries in the trial, thus removing variation due to subjective differences in observer ratings. Such variation can confound real differences in turf performance and render statistical inference impossible.

2. A TPI can be accumulated over any desired set of evaluations. For example, a TPI can be calculated for a particular rating in a particular trial (e.g., turf quality ratings of the 1991 NTEP zoysiagrass trial at TAES-Dallas) or a TPI could be calculated for an entire trial (e. g., the whole NTEP trial, nationally). An accumulative TPI can also be calculated for a particular year, a period of years, or particular types of trials (e.g., irrigation trials).

3. The mean can be severely skewed by only one or two extreme values. When an entry performs very poorly or extremely well at one location relative to the other locations, the mean can become a misleading statistic. Thus, rankings based on means can substantially over- or underestimate the true

performance and/or range of adaptation for any particular cultivar. The TPI is nonparametric and unaffected by extreme values. Thus, TPI provides accurate insight regarding the true performance *consistency* of turfgrass cultivars.

We calculate TPI for each trial conducted at TAES-Dallas, as well as accumulative TPI over all trials. The accumulative TPI data for 1991 NTEP zoysiagrass trial (data from NTEP 1992 and 1993), and all known trials (Dallas, Regional, and NTEP) in which DALZ lines were included are shown in Appendix H.

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APPENDICES

Appendix A

VITA

Ikuko Yamamoto

Education:

Pennsylvania State University, University Park, PA.
Department of Agronomy (Ph.D.), December 1994.
Thesis title: Solid Matrix Turfgrass Seed Priming Effects on Imbibition, Germination, Emergence, Growth Rate, and Post-Storage Viability.

Pennsylvania State University, University Park, PA.
Department of Agronomy (M.S.), May 1990.
Thesis title: *Agrostis* Cultivar Identification and Penncross Characterization by Electrophoresis.

Obihiro University, Obihiro, Japan.
Department of Grassland Sciences (B.Ag.)
Thesis title: Effects of Late Fall Seeding on the Following Spring Stand Establishment of Cool-Season Turfgrasses.

Publication and Conference Participation:

"Electrophoretic Identification of Cross-Pollinated Bentgrass Species and Cultivars," Crop Sci. 34: 792-98 (1994).

"Electrophoretic Identification of Cross-Pollinated Bentgrass Species and Cultivars," at Northeastern Branch Meeting, American Society of Agronomy, 1993 (third-place award graduate student contest).

"Seed Priming: Concept and Effects on Turfgrasses," at Golf Turf Conference, Penn State Univ., 1991.

"Electrophoresis: A Laboratory Cultivar Identification Method," at Golf Turf Conference, Penn State Univ., 1989.

Special Skills and License:

*Bilingual (Japanese / English)
*Instructional Development Program in College Teaching Certificate
*High School Teacher's License in Science and Agriculture (certified by the Japanese Department of Education)

Research Experience:	Research Assistant, Valentine Turfgrass Research Center, Department of Agronomy, Penn State Univ., 1987 - 1994.
Field Work:	*Designed, established, and managed cool-season species experimental field. *Conducted field plot experiments. *Evaluated experimental cultivars.
Electrophoresis:	*Developed starch gel electrophoresis techniques for cross-pollinated cultivar identification. *Developed technique to apply newly released rapid-automated electrophoresis system (Phast System) for cultivar identification. *Identified genetic purity of 'Penncross' to discriminate from "bogus" Penncross cultivars (evidence used in a law suit). *Completed a laboratory manual on electrophoresis procedure.
Seed Analysis:	*Designed and operated seed vigor, germination, emergence, and deterioration tests. *Applied near infrared spectroscopy analysis (NIRS) for seed moisture determination. *Used video capture monitoring system for seed size measurement.
Other Responsibilities:	*Designed and managed greenhouse, growth chamber, and germination chamber research. *Conducted statistical analysis on data.
Activities and Honors:	American Society of Agronomy Crop Science Society of America Gamma Sigma Delta (Honor Society of Agriculture) Pennsylvania Turfgrass Council Graduate Merit Award (twice) Appointed member of advisory committee for Strategic Planning, Office of International Students, Penn State Univ., 1991. Secretary of Japanese Student Association, Penn State Univ., 1990 - 1992.

Appendix B
Rhizoctonia Blight on Inoculated Zoysiagrasses

Zoysiagrass (Zoysia spp.)
Rhizoctonia blight (Rhizoctonia solani)

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RHIZOCTONIA BLIGHT ON INOCULATED ZOYSIAGRASSES. 1993. Eighteen experimental and six commercial zoysiagrasses were examined for resistance to Rhizoctonia blight in inoculation studies. Plugs of each of the established Zoysiagrass plots, measuring 36 cm^2, were placed in plastic trays using a randomized complete block design with six replications. Inoculum of R. solani (R-64) obtained as mycelial discs from the periphery of a 3-day old potato dextrose agar culture, was placed on the foliar canopy of each of the turfgrass plugs. The inoculated plugs were misted daily to maintain a moisture saturated environment for optimum foliar blighting over a 7-day period. Each of six plastic trays containing a complete block of the inoculated zoysiagrass cultivars were covered with a clear plastic lid and maintained in a lighted (50 fc; 10 $uE \cdot sec^{-1} \cdot m^2$) walk-in growth chamber maintained at 28 C. Test plants were evaluated for disease susceptibility after 7 days using a visual rating of percent blight. Observations were also made to determine the recuperative ability of each cultivar following a 7-day inoculation period. Recuperative growth was assessed 30 days after inoculation using a recovery grouping based on three categories (1-3 best) evaluating shoot density and leaf color.

Rhizoctonia blight susceptibility differed significantly among the genotypes in the study. Meyer, a coarse textured turfgrass, demonstrated the least foliar blighting of all the genotypes in the study. Among the narrow leafed zoysiagrass cultivars (class 1 and 3) DALZ9006 showed the lowest percentage of disease activity although not significantly lower than DALZ8507 and DALZ8502, which also demonsurated a high degree of disease resistance. The fine textured commercial variety Emerald was more susceptible than DALZ9006. Belair and Korean Common were highly susceptible to Rhizoctonia foliar blighting. There were no significant differences in disease susceptibility among the four textural classes used in the study.

Cultivar	Textural Class[1]	Mean % Infection[2]	Mean Recovery[3]
CD2013	3	100 a	1.0 a
Korean	4	77.8 b	1.9 b
DALZ8512	4	76.7 bc	2.0 bc
DALZ8701	3	73.0 bcd	2.5 def
Sunburst	4	70.0 bcd	2.3 cde
Belair	4	67.5 bcd	1.3 a
GT2047	4	64.1 bcd	2.2 bcd
JZ1A89-1	4	60.8 cd	2.3 cde
GT2004	3	57.5 cde	2.2 bcd
DALZ8501	1	55.8 def	2.3 cde
CD259-13	4	53.3 defg	2.2 bcd
TC5018	4	42.5 efgh	2.3 cde
TGS-W10	4	38.3 efgh	2.2 bcd
El Toro	4	37.5 ghi	2.7 efg
Emerald	3	36.2 ghi	2.3 cde
DALZ8514	4	35.0 hi	2.5 def
TGS-B10	4	34.2 hi	2.0 bc
DALZ8508	2	32.5 hij	2.8 fg
DALZ8516	2	30.0 hij	2.8 fg
TC2033	3	29.2 hij	2.7 efg
DALZ8502	1	26.7 hijk	3.0 g
DALZ8507	3	20.0 ijk	2.3 cde
DALZ9006	3	15.8 jk	2.5 def
Meyer	2	10.8 k	3.0 g

[1] Textural class of zoysiagrass: 1= short, narrow leaves; 2=short, wide leaves; 3=long, narrow leaves; 4=long, wide leaves.

[2] Mean foliar blight percentages. Means followed by the same letter are not significantly different. Waller-Duncan multiple comparison procedure P= .05.

[3] Cultivar recovery from disease and regrowth of leaf canopy in a greenhouse. 1=poorest recovery, 3=best.

Appendix C
Pythium Blight on Inoculated Zoysiagrasses

ZOYSIAGRASS (Zoysia spp.)
Pythium blight (Pythium aphanidermatum)

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PYTHIUM BLIGHT OF INOCULATED ZOYSIAGRASSES. 1988. Thirty-six experimental and four commercial zoysiagrasses were examined for resistance to Pythium foliar blight. Four soil core samples of each of the 40 zoysiagrasses were transferred into individual plastic cups (8 cm dia) and maintained on a greenhouse bench one month prior to inoculation with Pythium aphanidermuatum. Genotypes TAES3356 and TAES3368 were hybrid zoysias selected for drought resistance and low fertility requirements while Meyer, Emerald, El Toro, Belair and FC13521 were commercially available varieties. After one mon in the greenhouse, the grasses were placed randomly in plastic vegetable crispers and each inoculated with two agar discs containing two turfgrass isolates of P. aphanidermatum known to cause severe foliar blighting. Each of the cups containing the inoculated test grasses were covered with snap-on clear plastic lids with four aeration holes and maintained in a walk-in growth chamber where daily misting, temperature (27 C) and light conditions 24 hr (200 fc) favored Pythium blight infection over a seven day period.

Results of inoculations after seven days demonstrated good Pythium blight resistance among the germplasm lines and commercial varieties studied. The disease resistance of the zoysiagrasses was indicated by the large number of genotypes (18) with less than 10% foliar blighting. Only four of the germplasm lines were damaged more than 50%. The commercial varieties Meyer and Emerald were numerically more resistant to Pythium blight than El Toro, Belair and FC 13521 which also ranked among the more resistant cultivars in the study. The germplam lines TAES3357, TAES3365, TAES3356, TAES3364, TAES3358, DALZ8508, and DALZ8517 ranked among the most resistant of experimental zoysiagrasses used in the study.

Zoysiagrass Cultivar	Foliar Blight Mean %		Zoysiagrass Cultivar	Foliar Blight Mean %	
TAES3357	1.4	a	DALZ8513	12.0	abcd
TAES3365	1.9	ab	DALZ8506	12.5	abcd
TAES3356	2.0	ab	BELAIR	15.5	abcd
TAES3364	4.0	abc	TAES3359	16.3	abcd
TAES3358	4.2	abc	TAES3360	16.3	abcd
DALZ8508	4.6	abc	DALZ8515	16.5	abcd
DALZ8517	4.8	abc	DALZ8507	17.5	abcde
TAES3367	5.0	abc	FC 13521	21.2	abcde
MEYER	6.3	abcd	DALZ8502	26.7	bcde
TAES3372	6.3	abcd	TAES3361	28.3	bcde
EMERALD	6.5	abcd	DALZ8504	30.0	def
DALZ8514	6.5	abcd	DALZ8505	30.0	def
DALZ8511	7.3	abcd	DALZ8503	30.5	def
TAES3363	7.3	abcd	DALZ8501	30.7	def
TAES3366	7.3	abcd	TAES3362	31.3	def
DALZ8523	8.3	abcd	DALZ8510	40.5	ef
DALZ8512	9.7	abcd	DALZ8522	52.3	fg
DALZ8701	11.3	abcd	TAES3368	68.3	gh
EL TORO	11.3	abcd	DALZ8524	73.8	hi
DALZ8516	12.0	abcd	TAES3477	93.8	i

* Data represents a mean of four replications
** Means followed by a common letter are not significantly different (DMRT, P=0.05)

Appendix D
Sclerotinia Dollar Spot Incidence on Zoysiagrasses

ZOYSIAGRASS (Zoysia spp.)
Sclerotinia dollar spot (Sclerotinia homeocarpa)

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SCLEROTINIA DOLLAR SPOT INCIDENCE ON ZOYSIAGRASS. 1987-88. The incidence and severity of naturally occurring symptoms of Sclerotinia dollar spot was determined on field planting blocks of experimental and commercial germmplasm lines of zoysiagrass. Field observations of disease symptoms were made on zoysiagrass cultural study blocks at TAMU-Dallas during the months of Oct or Nov in 1987 and 1988. Observations of disease severity were made on three replicate cultural blocks with randomized plantings of the commercial and experimental zoysiagrasses.

The incidence of dollar spot symptoms was greatest on the variety Emerald and the experimental germplasm line TAES3477. Dollar spot symptoms were also noted on the experimental gerplasm DALZ8502 both years and during one of the two years on DALZ8508 and DALZ8501. During 1988, two hybrid zoysiagrasses, TAES3372 and TAES3477, were added to the cultural blocks. Although TAES3372 did not demonstrate disease symptoms, the hybrid TAES3477 was severely damaged.

Zoysiagrasses with fine leaf textures and a high leaf density were generally more dollar spot susceptible than turfgrasses with a coarse leaf texture and low leaf density in the foliar canopy. The experimental variety DALZ8516 with a fine leaf texture and high leaf density was an exception, however, with no dollar spot disease symptoms observed during the two year study.

Variety or Germplasm	Leaf Texture Class	Leaf Density Rating [1]	Plot % Infection [2] Oct 1987	Nov 1988 [3]
Belair	Coarse	3.2	0.0 a	0.0 a
El Toro	Coarse	4.2	0.0 a	0.0 a
Meyer	Medium	3.0	0.0 a	0.0 a
TAES3372	Medium	2.3	-	0.0 a
Emerald	Fine	3.3	28.0 b	19.3 ab
DALZ8516	~~Fine~~ Coarse	6.3	0.0 a	0.0 a
DALZ8501	Fine	3.5	0.0 a	5.3 a
DALZ8502	Fine	6.2	4.0 a	4.0 a
DALZ8508	Fine	3.5	3.5 a	0.0 a
TAES3477	Fine	5.0	-	30.0 b

[1] Mean Sept. leaf density ratings for1988 and 1989 (1-9, 9=most dense)
[2] Percent diseased leaf canopy 17 Oct 1987 and 12 Nov 1988
[3] Means followed by a commn letter are not significantly different (DMRT P = 0.05)

Appendix E
Performance of the 1991 NTEP Zoysiagrasses Under Shade

Table E1. Turf cover (percentage of plot area covered with turf) of the 1991 NTEP zoysiagrass trial planted under 90% shade at TAES-Dallas.

Entry	1994 1 Dec	1995 9 Jan	16 May	11 July	3 Aug	7 Sep	TPI[1]
	---------- % ----------						
DALZ8502	70.0a[2]	73.3a	66.7a	85.0a	78.3a	83.3a	6
DALZ8507	55.0a	68.3a	61.7a	83.3a	78.3a	76.7a	6
DALZ8510	51.7a	58.3a	60.0a	75.0a	66.7a	63.3a	6
DALZ8516	61.7a	58.3a	58.3a	80.0a	78.0a	75.0a	6
DALZ9006	56.7a	53.3a	53.3a	78.3a	70.0a	60.0a	6
TC2033	56.7a	68.0a	70.0a	83.3a	86.7a	71.7a	6
DALZ8508	46.7	44.3	56.7a	73.3a	71.7a	65.0a	4
DALZ8512	53.3a	56.7a	55.0a	68.3a	58.3	31.7	4
DALZ8514	50.0a	55.0a	50.a	66.7a	48.3	31.7	4
El Toro	53.3a	53.3a	55.0a	60.0a	50.0	40.0	4
Emerald	43.3	51.7a	53.3a	68.3a	60.0	55.0a	4
CD2013	35.0	33.3	48.3a	58.3a	58.3	55.0a	3
DALZ8701	40.0	50.0a	33.3	56.7	43.3	41.7	1
TC5018	35.0	33.3	43.3	56.7	56.7	50.0a	1
Belair	25.0	25.0	31.7	45.0	50.0	35.0	0
CD259-13	13.3	10.0	18.3	21.7	18.3	16.7	0
DALZ8501	35.0	38.3	33.3	51.7	43.3	35.0	0
GT2004	18.7	11.7	25.0	31.7	26.7	26.7	0
GT2047	18.3	21.7	25.0	26.7	26.7	20.0	0
ITR90-3	21.7	20.0	20.0	26.7	28.3	20.0	0
JZ-1#A89[3]	16.7	15.0	23.3	28.3	23.3	8.3	0
K. Common[3]	21.7	21.7	25.0	30.0	23.3	10.0	0
Meyer	18.3	15.0	23.3	23.3	23.3	16.7	0
Sunburst	46.7	40.0	40.0	50.0	43.3	31.7	0
TGS-B10[3]	30.0	23.3	43.3	55.0	35.0	30.0	0
TGS-W10[3]	31.7	33.3	40.0	51.7	43.3	35.0	0
MSD[4]	0.2	0.3	0.3	0.3	0.3	0.4	

[1] TPI = turf performance index, which is the number of times an entry occurred in the top statistical group.
[2] Means were back-transformed to the original scale, but tests were made on the angular transformed means.
[3] Seeded entry.
[4] MSD is the minimum significant difference between entry means within columns, based on the Duncan-Waller *k*-ratio *t* test (*k*-ratio = 100) on the transformed data. Means in the top statistical group are indicated by 'a.'

Table E2. Green cover (percentage of the turf that is green) of the 1991 NTEP zoysiagrass trial planted under 90% shade at TAES-Dallas.

Entry	1994 1 Dec	1995 9 Jan	10 Feb	6 Apr	11 July	3 Aug	7 Sep	TPI[1]
	---------- % ----------							
DALZ8502	70.0a[2]	66.7a	73.3a	68.3a	89.7a	91.3a	78.3a	7
DALZ8516	83.3a	66.7a	66.7a	80.0a	97.7a	99.0a	85.0a	7
DALZ8512	63.3a	43.3a	40.0	63.3a	73.3	89.7a	76.7a	5
DALZ8508	63.3a	22.3	23.3	65.0a	83.3	86.7a	75.0a	4
DALZ8510	58.3a	40.0a	43.3	63.3a	66.7	76.7	76.7a	4
DALZ8514	71.7a	36.7	30.0	63.3a	66.7	83.3a	75.0a	4
DALZ9006	65.0a	33.3	43.3	71.7a	78.3	81.7a	76.7a	4
El Toro	61.7a	26.7	23.3	66.7a	70.0	88.0a	73.3a	4
DALZ8501	60.0a	53.3a	50.0	50.0	76.7	75.0	70.0a	3
DALZ8507	58.3a	38.3	33.3	66.7a	60.0	75.0	76.7a	3
DALZ8701	53.3	53.3a	43.3	55.0	76.7	81.7a	68.3a	3
Sunburst	40.0	0.0	0.0	68.3a	63.3	89.7a	75.0a	3
TC2033	53.3	23.3	20.0	70.0a	86.7	86.7a	81.7a	3
Belair	13.3	0.0	0.0	50.0	76.7	85.0a	76.7a	2
Emerald	50.0	18.3	23.3	66.7a	68.3	71.7	76.7a	2
GT2004	31.7	0.0	0.0	50.0	73.3	84.7a	83.3a	2
ITR90-3	13.3	0.0	0.0	40.0	63.3	85.0a	73.3a	2
JZ-1#A89[3]	16.7	0.0	0.0	26.7	65.0	89.7a	75.0a	2
K. Common[3]	21.7	0.0	0.0	53.3	58.3	91.3a	51.7a	2
Meyer	13.3	0.0	0.0	40.0	53.3	83.0a	51.7a	2
TC5018	40.0	6.7	0.0	56.7	66.7	85.0a	76.7a	2
TGS-B10[3]	16.7	0.0	0.0	46.7	66.7	89.7a	78.3a	2
TGS-W10[3]	28.3	0.0	0.0	55.0	58.3	81.3a	73.3a	2
CD2013	36.7	0.0	0.0	50.0	66.7	76.7	75.0a	1
GT2047	0.0	0.0	0.0	19.7	48.3	71.7	73.3a	1
CD259-13	16.7	10.0	6.7	51.7	68.3	76.7	29.3	0
MSD[4]	0.3	0.3	0.2	0.2	0.2	0.3	0.5	

[1] TPI = turf performance index, which is the number of times an entry occurred in the top statistical group.
[2] Means were back-transformed to the original scale, but tests were made on the angular transformed means.
[3] Seeded entry.
[4] MSD is the minimum significant difference between entry means within columns, based on the Duncan-Waller *k*-ratio *t* test (*k*-ratio = 100) on the transformed data. Means in the top statistical group are indicated by 'a.'

Table E3. Density[1] of the 1991 NTEP zoysiagrass trial planted under 90% shade at TAES-Dallas.

Entry	1994 1 Dec	1995 16 May	1995 11 July	TPI[2]
DALZ8502	7.7a	7.7a	8.0a	3
TC2033	6.0a	6.3a	6.7a	3
DALZ8501	7.0a	6.3a	6.3	2
DALZ8507	6.7a	6.0	7.0a	2
DALZ8508	6.3a	6.3a	5.7	2
DALZ8516	7.0a	6.0	7.3a	2
DALZ9006	5.7a	6.2a	6.0	2
Emerald	6.0a	6.7a	6.3	2
DALZ8510	6.0a	6.0	6.3	1
DALZ8701	6.3a	6.0	6.3	1
Belair	2.3	3.0	3.7	0
CD2013	5.0	4.3	4.7	0
CD259-13	1.7	3.7	2.7	0
DALZ8512	4.3	4.7	5.0	0
DALZ8514	3.0	4.7	5.0	0
El Toro	4.0	3.7	3.7	0
GT2004	3.0	3.0	3.3	0
GT2047	1.7	3.7	2.7	0
ITR90-3	3.0	2.7	2.3	0
JZ-1#A89[3]	1.7	2.3	2.3	0
K. Common[3]	2.3	2.7	2.3	0
Meyer	2.3	3.3	2.3	0
Sunburst	3.7	4.0	3.7	0
TC5018	4.0	4.3	3.7	0
TGS-B10[3]	1.3	3.7	3.7	0
TGS-W10[3]	2.7	3.3	4.0	0
MSD[4]	2.1	1.5	1.6	

[1] Density 1-9, where 9 = best and 1 = poorest.
[2] TPI = turf performance index, which is the number of times an entry occurred in the top statistical group.
[3] Seeded entry.
[4] MSD is the minimum significant difference between entry means within columns, based on the Duncan-Waller *k*-ratio *t* test (*k*-ratio = 100). Means in the top statistical group are indicated by 'a.'

Table E4. Texture[1] of the 1991 NTEP zoysiagrass trial planted under 90% shade at TAES-Dallas.

Entry	1995 16 May	TPI[2]
DALZ8502	8.0a	1
DALZ8508	7.0a	1
DALZ9006	7.0a	1
Emerald	7.0a	1
DALZ8507	6.8	0
TC2033	6.2	0
DALZ8501	6.5	0
DALZ8701	6.0	0
DALZ8510	5.7	0
GT2004	5.7	0
CD2013	5.3	0
DALZ8516	5.3	0
Sunburst	5.0	0
CD259-13	4.7	0
ITR90-3	4.7	0
Meyer	4.7	0
TC5018	4.3	0
TGS-W10[3]	4.3	0
DALZ8512	4.0	0
DALZ8514	4.0	0
El Toro	4.0	0
GT2047	4.0	0
TGS-B10[3]	4.0	0
Belair	3.7	0
JZ-1#A89[3]	3.3	0
K. Common[3]	2.7	0
MSD[4]	1.2	

1 Texture 1-9, where 9 = best and 1 = poorest.

2 TPI = turf performance index, which is the number of times an entry occurred in the top statistical group.

3 Seeded entry.

4 MSD is the minimum significant difference between entry means within columns, based on the Duncan-Waller *k*-ratio *t* test (*k*-ratio = 100). Means in the top statistical group are indicated by 'a.'

Table E5. Color Quality[1] of the 1991 NTEP zoysiagrass trial planted under 90% shade at TAES-Dallas.

Entry	1995 11 July	TPI[2]
DALZ8516	7.7a	1
DALZ8502	7.0a	1
DALZ9006	5.7	0
DALZ8508	5.3	0
DALZ8701	5.3	0
TC2033	5.3	0
Belair	5.0	0
DALZ8510	5.0	0
ITR90-3	5.0	0
CD2013	4.7	0
Emerald	4.7	0
DALZ8501	4.7	0
DALZ8507	4.7	0
DALZ8512	4.7	0
DALZ8514	4.7	0
TC5018	4.7	0
El Toro	4.0	0
GT2004	4.0	0
Meyer	4.0	0
Sunburst	4.0	0
CD259-13	3.7	0
K. Common[3]	3.7	0
TGS-B10[3]	3.7	0
TGS-W10[3]	3.7	0
JZ-1#A89[3]	3.3	0
GT2047	2.7	0
MSD[4]	1.2	

1 Color quality 1-9, where 9 = best and 1 = poorest.

2 TPI = turf performance index, which is the number of times an entry occurred in the top statistical group.

3 Seeded entry.

4 MSD is the minimum significant difference between entry means within columns, based on the Duncan-Waller *k*-ratio *t* test (*k*-ratio = 100). Means in the top statistical group are indicated by 'a.'

Table E6. Turf quality[1] of the 1991 NTEP zoysiagrass trial planted under 90% shade at TAES-Dallas.

Entry	1994 1 Dec	1995 9 Jan	10 Feb	9 Mar	6 Apr	16 May
DALZ8502	6.0a	5.3a	5.7a	5.0a	5.5a	6.3a
DALZ8507	5.3a	4.7a	5.0a	4.7a	5.0a	5.7a
DALZ8516	5.3a	4.7a	5.7a	5.7a	5.8a	6.0a
TC2033	5.3a	4.0a	5.0a	4.3a	5.7a	6.7a
DALZ8508	4.7a	3.7	4.7a	4.3a	4.5a	5.7a
Emerald	4.7a	4.0a	4.3a	4.0	4.3a	5.0a
DALZ8512	4.7a	4.0a	4.7a	4.3a	4.7a	5.7a
DALZ8510	4.2	3.7	4.7a	4.7a	4.7a	5.3a
DALZ9006	5.0a	3.7	4.3a	3.7	3.0	5.7a
DALZ8514	4.3	3.7	4.3a	4.3a	4.3a	5.7a
El Toro	4.3	3.7	4.3a	4.3a	4.3a	5.3a
TC5018	3.5	2.7	3.7	3.3	4.0	5.0a
DALZ8701	3.3	3.3	4.3a	3.7	3.0	4.3
CD2013	3.8	2.7	3.0	3.3	4.0	4.3
Belair	2.0	1.7	2.3	2.0	2.7	3.3
CD259-13	1.3	1.0	1.7	1.7	2.0	2.3
DALZ8501	2.5	3.0	4.0	4.0	3.3	3.7
GT2004	1.7	1.0	2.0	2.0	2.3	3.0
GT2047	1.3	1.3	2.0	1.7	2.0	3.0
ITR90-3	1.7	1.0	1.7	1.3	1.7	2.7
JZ-1#A89[2]	1.5	1.0	1.3	1.3	2.0	3.0
K. Common[2]	2.2	1.7	2.0	1.7	3.0	2.0
Meyer	1.5	1.0	1.3	1.7	1.3	2.3
Sunburst	4.0	2.7	3.0	3.0	4.2	4.7
TGS-B10[2]	2.7	1.3	1.7	2.0	3.0	3.7
TGS-W10[2]	3.7	2.3	2.7	2.7	3.7	4.0
MSD[3]	1.6	1.6	1.5	1.6	1.6	1.7

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Table E6 --- Cont.

Entry	1995 1 June	11 July	3 Aug	7 Sep	TPI[4]
DALZ8502	5.7a	6.3a	5.8a	6.3a	10
DALZ8507	6.0a	6.0a	6.0a	5.8a	10
DALZ8516	5.7a	6.7a	6.2a	6.3a	10
TC2033	6.0a	6.5a	6.8a	5.7a	10
DALZ8508	5.3a	5.7a	5.2	4.8a	8
Emerald	5.0a	5.3a	4.8	5.0a	8
DALZ8512	5.3a	5.0a	4.3	3.5	8
DALZ8510	5.0a	5.5a	5.2	5.3a	7
DALZ9006	5.3a	5.7a	5.7a	4.8a	7
DALZ8514	4.3	4.5	4.0	3.3	4
El Toro	4.3	3.5	4.3	3.8	4
TC5018	4.7a	4.7	4.7	4.0	2
DALZ8701	3.7	4.7	4.0	3.7	1
CD2013	5.0a	4.3	4.3	4.0	1
Belair	3.7	3.3	4.2	3.3	0
CD259-13	2.3	2.3	2.3	2.3	0
DALZ8501	4.3	3.7	4.0	3.3	0
GT2004	3.3	2.7	3.0	3.0	0
GT2047	3.0	2.3	2.7	2.7	0
ITR90-3	3.0	3.0	3.0	2.3	0
JZ-1#A89[2]	3.0	2.3	2.3	2.0	0
K. Common[2]	3.3	3.3	2.3	1.7	0
Meyer	2.3	2.3	2.7	2.3	0
Sunburst	4.3	4.3	4.0	2.8	0
TGS-B10[2]	4.0	3.7	3.3	3.2	0
TGS-W10[2]	4.0	3.3	4.0	3.5	0
MSD[3]	1.5	1.7	1.4	2.3	

[1] Turf quality 1-9, where 9 = best, 1 = poorest, and 5 is the minimum acceptable level.
[2] Seeded entry.
[3] MSD is the minimum significant difference between entry means within columns, based on the Duncan-Waller *k*-ratio *t* test (*k*-ratio = 100). Means in the top statistical group are indicated by 'a.'
[4] TPI = turf performance index, which is the number of times an entry occurred in the top statistical group.

Table E7. Summary of observations of the 1991 NTEP zoysiagrass shade trial at TAES-Dallas.

	1992	1993	1994	1995	Total
Turf Cover	1	6	6	5	18
Green Color Retention / greenup	1	6	4	6	17
Color Qualtiy	1	0	0	1	2
Density	0	0	1	2	3
Texture	0	0	0	1	1
Overall Turf Quality	0	6	6	9	21
Total Observations	3	18	17	24	62

Table E8. Accumulative turf performance index of the 1991 NTEP zoysiagrass trial planted under 90% shade at TAES-Dallas during 1992 to 1995.

Entry	Accumu. TPI	% of Max.[1]	Rank
DALZ8516	60	96.8	1
DALZ8502	59	95.2	2
TC2033	52	83.9	3
DALZ9006	51	82.3	4.5
DALZ8508	51	82.3	4.5
DALZ8510	50	80.6	6
Emerald	48	77.4	7
DALZ8507	47	75.8	8
DALZ8512	46	74.2	9
DALZ8514	42	67.7	10
El Toro	36	58.1	11
DALZ8701	33	53.2	12
CD2013	29	46.8	13
TGS-W10[2]	27	43.5	14
DALZ8501	26	41.9	15.5
TC5018	26	41.9	15.5
Sunburst	25	40.3	17
ITR90-3	21	33.9	18
K. Common[2]	19	30.6	19
Belair	18	29.0	21
Meyer	18	29.0	21
TGS-B10[2]	18	29.0	21
GT2047	16	25.8	23
JZ-1#A89[2]	15	24.2	24
GT2004	12	19.4	25
CD259-13	11	17.7	26

[1] Accumulative TPI divided by max. possible TPI (= total no. of observations in Table E7).
[2] Seeded entry.

Appendix F
Performance of DALZ8502 Green Under Shade

Table F1. Turf performance of DALZ8502 under four levels of shade.

Shade Level (%)	25 May	1 Jun	6 Jul	17 Jul	Mean
			Turf quality[1]		
0	7.3ns[2]	7.0b	6.8a	6.5a	6.9a
47	7.5	7.5ab	7.0a	7.3a	7.3a
73	7.3	8.0a	6.8a	7.3a	7.3a
95	7.0	7.3ab	4.8b	3.0b	5.5b
			Color quality[1]		
0	6.5c	6.5b	6.5a	6.0a	6.4bc
47	7.3ab	7.8a	7.3a	7.1a	7.3ab
73	7.8a	8.5a	7.3a	7.3a	7.7a
95	7.0bc	7.8a	4.0b	3.0b	5.4c
			Uniformity[1]		
0	6.0ns	7.8a	7.3a	8.0a	7.3a
47	6.0	7.5ab	7.0a	7.5a	7.0a
73	5.5	7.5ab	7.3a	7.0a	6.8a
95	5.3	6.3b	5.0b	3.5b	5.0b
			Density[1]		
0	-	7.0a	8.0a	8.0a	7.7a
47	-	6.8a	7.3b	7.5ab	7.2ab
73	-	6.3a	6.3c	7.0b	6.5b
95	-	4.5b	4.5d	2.5c	3.8c
			Vertical growth[1]		
0	-	2.0a	2.0a	2.0a	2.0a
47	-	4.3b	5.0b	4.8b	4.7b
73	-	5.0b	6.8c	6.8c	6.2c
95	-	8.0c	7.0c	7.3c	7.4d
			% green cover		
0	-	-	83.5a	78.5a	81.0a
47	-	-	81.0a	92.3a	86.6a
73	-	-	81.3a	96.0a	88.6a
95	-	-	38.8b	26.3b	32.5b

[1] Rating scale 1-9, where 9 = best and 1 = poorest.

[2] Means in the top statistical group are indicated by 'a' based on the Duncan-Waller *k*-ratio *t* test (*k*-ratio = 100); ns = not significant.

Appendix G
Update to the 1991 National Turfgrass Evaluation Program (NTEP) Zoysiagrass Trial at TAES-Dallas

Table G1. Color quality[1] of the 1991 NTEP zoysiagrass trial at TAES-Dallas (Aug. 1993 planted).

	1994					1995		
Entry	4 Nov	15 Nov	2 Dec	12 Dec	20 Dec	3 Jan	4 Jul	TPI[2]
DALZ8502	8.0a	8.0a	8.0a	8.0a	7.7a	8.0a	8.0a	7
DALZ8516	8.7a	8.5a	8.7a	7.0a	6.0a	7.3a	8.7a	7
DALZ9006	8.0a	8.0a	8.0a	7.3a	7.2a	7.3a	8.0a	7
DALZ8507	7.3a	7.7a	7.0a	7.0a	6.5a	7.0a	7.7	6
DALZ8508	8.0a	8.0a	8.0a	7.7a	7.5a	7.0a	7.3	6
Emerald	8.0a	8.0a	8.0a	8.0a	7.3a	6.7a	7.3	6
DALZ8501	7.3a	7.0	7.0a	7.0a	6.5a	6.3	7.3	4
TC2033	7.7a	6.8	7.0a	7.0a	6.5a	4.7	6.7	4
DALZ8512	7.0a	7.0	6.7	7.3a	6.2a	5.7	5.7	3
DALZ8514	7.0a	7.0	6.0	7.0a	6.0a	6.3	5.7	3
GT2004	7.7a	7.2	6.7	6.3a	6.3a	5.0	6.7	3
Belair	6.3	7.2	6.3	7.0a	6.2a	6.0	6.0	2
DALZ8701	8.0a	7.7a	7.3	4.7	1.0	1.0	6.3	2
CD2013	6.0	6.2	6.3	5.3	5.8a	3.0	6.7	1
CD259-13	6.3	5.7	3.0	1.0	1.0	1.0	6.7	0
El Toro	6.7	6.5	6.0	5.7	4.7	4.3	5.7	0
GT2047	4.7	4.0	1.0	1.0	1.0	1.0	6.3	0
ITR90-3	4.0	5.3	4.3	3.7	2.7	1.0	7.3	0
JZ-1#A89-1[3]	5.7	4.7	0.7	1.0	1.0	1.0	5.7	0
K. Common[3]	6.3	6.0	3.7	3.0	2.7	2.7	5.7	0
Meyer	5.7	4.7	2.0	1.0	1.0	1.0	6.0	0
Sunburst	6.0	6.2	5.7	6.0	4.0	1.0	6.3	0
TC5018	5.7	5.3	2.0	1.7	1.0	1.0	6.0	0
TGS-B10[3]	5.7	5.0	1.3	1.0	1.0	1.0	6.0	0
TGS-W10[3]	6.3	5.0	2.7	1.0	1.3	1.0	6.0	0
MSD[4]	1.7	1.0	1.8	1.8	1.8	1.5	0.9	

[1] Color quality 1 - 9, where 9 = darkest and 1 = lightest.

[2] TPI is the turf performance index, or the number of times an entry was rated in the top statistical group.

[3] Seeded entry

[4] MSD is the minimum significant difference between entry means based on the Waller-Duncan *k*-ratio *t*-test (*k*-ratio = 100). Means in the top statistical group are indicated by an 'a.'

Table G2. Winter green color retention, spring green up, and summer green cover of the 1991 NTEP zoysiagrass trial at TAES-Dallas (Aug. 1993 planted).

Entry	1994 4 Nov	2 Dec	12 Dec	20 Dec	1995 3 Jan	10 Feb	Winter TPI[1]
	--------- % green color retention[2] --------						
DALZ8516	88.7a[3]	86.0a	71.3a	63.3a	46.7a	16.7	5
DALZ9006	78.3	88.3a	68.3a	53.3a	46.7a	11.7	4
DALZ8502	96.0a	93.0a	80.0a	76.7a	65.0a	28.3a	6
DALZ8507	86.7a	85.0a	68.3a	66.7a	63.3a	0.0	5
DALZ8508	92.3a	83.3a	68.3a	65.0a	50.0a	13.3	5
Emerald	86.7a	87.7a	76.7a	75.0a	66.7a	21.7a	6
TC2033	73.3	85.0a	60.0a	60.0a	53.3a	1.7	4
DALZ8512	76.7	76.7a	65.0a	66.7a	36.7	0.0	3
GT2004	78.3	70.0	56.7a	65.0a	58.3a	0.0	3
Belair	76.7	76.7a	56.7a	53.3a	46.7a	0.0	4
DALZ8501	81.7	75.0a	65.0a	68.3a	63.3a	5.0	4
DALZ8514	78.3	68.3	63.3a	60.0a	46.7a	0.0	3
CD259-13	58.3	16.7	0.0	0.0	0.0	0.0	0
Sunburst	71.7	53.3	46.7	43.3	0.0	0.0	0
GT2047	33.3	3.3	0.0	0.0	0.0	0.0	0
K. Common[4]	58.3	23.3	16.7	16.7	7.5	0.0	0
Meyer	48.3	20.0	0.0	0.0	0.0	0.0	0
CD2013	71.7	56.7	50.0	48.3	26.7	0.0	0
El Toro	75.0	63.3	50.0	43.3	26.7	0.0	0
ITR90-3	66.7	33.3	20.0	21.7	0.0	0.0	0
JZ-1#A89-1[4]	56.7	6.7	0.0	0.0	0.0	0.0	0
TGS-W10[4]	55.0	21.7	0.0	3.3	0.0	0.0	0
TGS-B10[4]	56.7	8.3	0.0	0.0	0.0	0.0	0
TC5018	53.3	18.3	8.3	0.0	0.0	0.0	0
DALZ8701	75.0	56.7	18.3	0.0	0.0	0.0	0
MSD[5]	0.2	0.3	0.3	0.8	0.2	0.1	

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Table G2 --- Cont.

Entry	1995 8 Mar	27 Mar	3 Apr	17 Apr	Spring TPI[1]	1 Jun	4 July	Summer TPI[1]	Total TPI[1]
	---------- % green up[6] ----------					-- % green cover[7] --			
DALZ8516	40.0a[3]	81.7a	75.0a	94.3	3	99.0a	99.0a	2	10
DALZ9006	31.7a	83.3a	76.7a	93.3	3	97.7a	97.7a	2	9
DALZ8502	36.7a	60.0	51.7	75.0	1	91.7	94.7a	1	8
DALZ8507	6.7	70.0a	63.3	85.0	1	99.0a	97.7a	2	8
DALZ8508	35.0a	76.7a	65.0	90.0	2	94.7a	86.7	1	8
Emerald	25.0a	73.3a	70.0	81.0	2	91.3	88.3	0	8
TC2033	13.3	78.3a	73.3a	91.3	2	94.7a	94.7a	2	8
DALZ8512	3.3	76.7a	73.3a	86.3	2	99.0a	96.0a	2	7
GT2004	3.3	80.0a	75.0a	94.7	2	93.0a	93.3a	2	7
Belair	1.7	63.3	65.0	90.0	0	94.7a	93.0a	2	6
DALZ8501	15.0	78.3a	65.0	81.7	1	97.7a	90.0	1	6
DALZ8514	1.7	65.0	65.0	85.0	0	96.0a	93.0a	2	5
CD259-13	3.3	83.3a	73.3a	95.7	2	97.7a	94.3a	2	4
Sunburst	3.3	75.0a	75.0a	96.3	2	99.0a	97.7a	2	4
GT2047	1.7	88.3a	89.3a	99.0	2	90.0	99.0a	1	3
K. Common[4]	5.0	75.0a	71.7	86.3	1	99.0a	96.3a	2	3
Meyer	5.0	76.7a	71.7	93.0	1	96.3a	93.3a	2	3
CD2013	0.0	63.3	60.0	82.3	0	92.7a	95.0a	2	2
El Toro	0.0	66.7	70.0	88.3	0	94.7a	96.0a	2	2
ITR90-3	5.0	65.0	60.0	74.3	0	94.7a	91.7a	2	2
JZ-1#A89-1[4]	0.0	70.0a	70.0	94.3	1	88.0	96.0a	1	2
TGS-W10[4]	3.3	60.0	53.3	84.7	0	99.0a	94.3a	2	2
TGS-B10[4]	3.3	65.0	73.3a	89.3	1	86.7	94.7a	1	2
TC5018	0.0	66.7	70.0	96.0	0	85.0	94.7a	1	1
DALZ8701	0.0	23.3	23.3	43.3	0	81.7	88.3	0	0
MSD[5]	0.2	0.3	0.2	0.2		0.2	0.2		

[1] TPI is the turf performance index, which is the number of times an entry occurred in the top statistical group.
[2] Winter green color retention = percentage of turf that remains green.
[3] Means were back-transformed to the original scale, but tests were made on the angular transformed means.
[4] Seeded entry.
[5] MSD is the minimum significant difference between entry means within columns, based on the Duncan-Waller *k*-ratio *t* test (*k*-ratio = 100) on the transformed data. Means in the top statistical group are indicated by 'a.'
[6] Spring green up = percentage of turf that turns to green.
[7] Green cover = percentage of turf that is green.

Table G3. Density[1] of the 1991 NTEP zoysiagrass trial planted under 90% shade at TAES-Dallas.

Entry	1995 20 Apr	4 July	TPI[2]
DALZ8502	8.0a	9.0a	2
DALZ9006	8.7a	8.3a	2
DALZ8501	8.2a	7.7	1
DALZ8507	8.0a	7.7	1
DALZ8508	7.7a	8.0	1
DALZ8516	7.7a	8.0	1
Emerald	7.7a	8.0	1
GT2004	7.8a	6.7	1
GT2047	7.7a	6.3	1
Meyer	7.7a	7.0	1
TC2033	8.0a	8.0	1
TC5018	7.7a	6.0	1
Belair	6.3	6.7	0
CD2013	6.3	6.7	0
CD259-13	6.7	6.7	0
DALZ8512	7.3	6.7	0
DALZ8514	7.3	6.3	0
DALZ8701	5.7	7.0	0
El Toro	7.0	6.0	0
ITR90-3	5.3	6.3	0
JZ-1#A89[3]	5.7	3.7	0
K. Common[3]	6.5	5.3	0
Sunburst	7.3	7.0	0
TGS-B10[3]	6.0	5.7	0
TGS-W10[3]	5.3	6.0	0
MSD[4]	1.3	0.8	

1 Density 1-9, where 9 = best and 1 = poorest.

2 TPI = turf performance index, which is the number of times an entry occurred in the top statistical group.

3 Seeded entry.

4 MSD is the minimum significant difference between entry means within columns, based on the Duncan-Waller *k*-ratio *t* test (*k*-ratio = 100). Means in the top statistical group are indicated by 'a.'

Table G4. Texture[1] of the 1991 NTEP zoysiagrass trial planted under 90% shade at TAES-Dallas.

Entry	1995 4 July	TPI[2]
DALZ8502	9.0a	1
DALZ8508	8.7a	1
DALZ9006	8.3a	1
Emerald	8.3a	1
DALZ8501	8.0	0
DALZ8507	8.0	0
DALZ8701	8.0	0
CD2013	7.7	0
GT2004	7.7	0
TC2033	7.3	0
DALZ8516	6.7	0
CD259-13	6.0	0
DALZ8512	6.0	0
DALZ8514	6.0	0
ITR90-3	6.0	0
Belair	5.7	0
Meyer	5.3	0
Sunburst	5.3	0
El Toro	5.0	0
GT2047	5.0	0
K. Common[3]	4.3	0
TC5018	3.7	0
TGS-W10[3]	3.7	0
TGS-B10[3]	3.0	0
JZ-1#A89[3]	2.3	0
MSD[4]	1.0	

1 Texture 1-9, where 9 = best and 1 = poorest.

2 TPI = turf performance index, which is the number of times an entry occurred in the top statistical group.

3 Seeded entry.

4 MSD is the minimum significant difference between entry means within columns, based on the Duncan-Waller *k*-ratio *t* test (*k*-ratio = 100). Means in the top statistical group are indicated by 'a.'

Table G5. Turf quality[1] of the 1991 NTEP zoysiagrass trial at TAES-Dallas (Aug. 1993 planted).

Entry	1994 4 Nov	15 Nov	2 Dec	12 Dec	20 Dec	1995 3 Jan	10 Feb	8 Mar	3 Apr
TC2033	8.0a	7.7a	8.0a	8.0a	7.5a	7.7a	7.0a	7.5a	7.0a
DALZ9006	7.3a	7.3a	8.0a	7.3a	7.2a	6.7	6.8a	6.7a	6.7a
DALZ8501	7.7a	7.5a	7.7a	7.7a	7.2a	7.7a	7.2a	7.2a	7.0a
DALZ8512	7.7a	7.8a	7.7a	7.3a	7.0a	7.3a	7.0a	7.0a	6.5a
DALZ8507	8.0a	8.0a	8.0a	7.7a	7.3a	8.0a	7.0a	7.2a	6.3
GT2004	8.0a	7.5a	7.7a	7.7a	7.3a	7.3a	7.0a	7.0a	7.0a
Belair	7.3a	7.5a	7.3a	7.0a	7.0a	7.3a	7.0a	6.7a	6.3
Sunburst	7.0	7.2a	7.0	7.0a	7.0a	6.0	7.0a	7.0a	7.0a
DALZ8502	7.0	7.2a	7.7a	7.3a	7.2a	6.3	6.2a	6.2	6.2
DALZ8514	7.0	7.7a	7.3a	7.0a	7.0a	7.0a	7.0a	7.0a	6.2
El Toro	7.7a	7.5a	7.7a	7.0a	6.7	6.7	7.0a	7.0a	6.2
DALZ8508	7.0	6.8	7.7a	6.7	6.5	5.7	6.2a	6.0	6.0
Emerald	7.0	7.0	7.3a	7.3a	7.0a	6.3	6.5a	6.3	6.0
K. Common[2]	6.7	6.5	6.3	6.3	6.2	6.0	6.5a	6.7a	6.7a
CD259-13	6.3	5.8	5.7	5.3	5.8	5.0	6.0a	6.2	6.3
CD2013	7.0	6.7	7.0	7.0a	7.2a	6.7	7.0a	6.5a	5.7
Meyer	6.3	6.0	6.0	6.0	6.3	6.0	7.0a	7.0a	6.7a
TC5018	7.0	6.8	6.7	6.3	6.2	5.7	7.0a	7.0a	6.5a
GT2047	6.3	6.0	6.3	6.0	6.0	6.0	7.0a	7.0a	7.3a
JZ-1#A89-1[2]	6.3	6.2	6.0	6.0	6.2	6.0	7.0a	7.0a	6.5a
TGS-B10[2]	6.0	6.0	5.7	5.7	5.7	5.3	6.7a	6.3	6.5a
DALZ8516	6.7	6.7	6.3	5.7	5.7	4.7	4.7	5.0	6.0
TGS-W10[2]	5.7	5.7	6.0	5.0	5.3	5.0	6.3a	5.8	5.5
DALZ8701	7.0	7.0	6.7	6.3	5.2	5.0	6.8a	6.0	4.7
ITR90-3	5.7	5.7	5.3	3.0	4.8	4.7	5.3	5.0	5.0
MSD[3]	0.9	0.9	0.7	1.2	0.7	1.1	1.2	1.1	0.9

Cont. on next page.

Table G5 --- Cont.

Entry	1995 15 May	1 June	4 July	3 Aug	5 Sep	TPI[4]
TC2033	8.3a	7.8a	7.3a	7.3a	7.5a	14
DALZ9006	8.3a	7.7a	8.0a	8.2a	8.0a	13
DALZ8501	7.8a	7.2a	6.7	8.0a	7.5a	13
DALZ8512	7.3a	7.0a	6.0	7.5a	6.7	12
DALZ8507	8.0a	8.0a	7.0	7.5a	6.7	11
GT2004	8.2a	7.0a	6.0	7.0	6.3	11
Belair	7.0a	7.3a	6.0	7.0	6.2	10
Sunburst	7.0a	7.7a	6.7	7.3a	7.2a	10
DALZ8502	7.0a	6.7a	6.7	8.3a	7.0a	9
DALZ8514	7.3a	7.0a	6.0	6.7	6.0	9
El Toro	7.0a	6.3a	5.7	7.0	6.7	8
DALZ8508	7.2a	6.8a	7.2a	7.5a	6.8a	7
Emerald	6.7a	7.0a	6.3	6.7	5.8	6
K. Common[2]	7.0a	7.0a	5.3	7.3a	6.2	6
CD259-13	7.0a	6.3a	6.3	7.3a	7.0a	5
CD2013	7.0a	4.3	6.3	6.7	6.0	5
Meyer	7.0a	7.0a	6.7	6.2	6.0	5
TC5018	7.0a	6.7a	6.3	6.7	6.2	5
GT2047	4.7	7.0a	6.5	7.2	6.3	4
JZ-1#A89-1[2]	5.7	6.5a	5.3	6.5	5.7	4
TGS-B10[2]	6.3a	6.7a	5.7	6.3	6.2	4
DALZ8516	5.3	5.7	5.7	8.0a	7.3a	2
TGS-W10[2]	5.3	6.3a	5.7	6.0	6.2	2
DALZ8701	4.0	5.3	4.3	6.7	5.5	1
ITR90-3	4.7	5.7	4.7	5.7	5.5	0
MSD[3]	2.0	1.9	1.0	1.1	1.2	

[1] Turf quality ratings 1 - 9, where 9 = best, 1 = poorest, and 5 is the minimum acceptable turf quality.
[2] Seeded entry.
[3] MSD is the minimum significant difference between entry means based on the Waller-Duncan *k*-ratio *t*-test (*k*-ratio = 100). Means in the top statistical group are indicated by an 'a.'
[4] TPI is the turf performance index, or the number of times an entry was rated in the top statistical group. The average is not included in the TPI.

Table G6. Summary of observations of the 1991 NTEP zoysiagrass trial at TAES-Dallas (Aug. 1993 planted).

	1993	1994	1995	Total
Color Qualtiy	0	8	2	10
Green Color Retention	2	7	2	11
Spring Greenup	0	2	3	5
Green Cover	0	0	2	2
Turf Cover	2	4	0	6
Density	0	2	2	4
Texture	0	2	1	3
Culm Density	0	1	0	1
Overall Turf Quality	0	11	9	20
Total Observations	4	37	21	62

Table G7. Accumulative turf performance indices of the 1991 NTEP zoysiagrass trial at TAES-Dallas (Aug. 1993 planted) during 1993 to 1995.

Entry	Accumu. TPI	% of Max.[1]	Rank
DALZ9006	49	79.0	1
TC2033	44	71.0	2
DALZ8502	43	69.4	3
DALZ8501	40	64.5	4.5
DALZ8507	40	64.5	4.5
Emerald	39	62.9	6
GT2004	38	61.3	7
DALZ8508	37	59.7	8
DALZ8512	37	59.7	9
DALZ8516	36	58.1	10
Belair	35	56.5	11
DALZ8514	33	53.2	12
Sunburst	28	45.2	13
Meyer	25	40.3	14
El Toro	24	38.7	15
CD2013	22	35.5	16
GT2047	21	33.9	17.5
TC5018	21	33.9	17.5
K. Common[2]	18	29.0	19
CD259-13	17	27.4	20.5
TGS-B10[2]	17	27.4	20.5
DALZ8701	15	24.2	22
JZ-1#A89-1[2]	15	24.2	23
TGS-W10[2]	14	22.6	24
ITR90-3	11	17.7	25

[1] Accumulative TPI divided by max. possible TPI (= total no. of observations in Table G6).
[2] Seeded entry.

Appendix H
Accumulative Turf Performance Indices for the 1991 NTEP National Trial and for all Dallas, Regional and National Trials Combined

Table H1. Accumulative turf performance index for the 1991 NTEP zoysiagrass trials. Data from 1992 and 1993. Maximum possible TPI = 246.

Entry	Total TPI	% of Maximum
DALZ8507	141	57.3
Emerald	134	54.5
El Toro	133	54.1
DALZ8508	129	52.4
DALZ8512	129	52.4
Sunburst	128	52.0
TC2033	128	52.0
GT2004	125	50.8
DALZ9006	123	50.0
DALZ8514	122	49.6
CD2013	120	48.8
TC5018	118	48.0
CD259-13	93	37.8
DALZ8502	92	37.4
GT2047	92	37.4
Meyer	83	33.7
Belair	79	32.1
DALZ8516	79	32.1
K. Common[1]	69	28.0
TGS-B10[1]	69	28.0
TGS-W10[1]	69	28.0
DALZ8501	65	26.4
DALZ8701	65	26.4
JZ-1#A89-1[1]	65	26.4

[1] Seeded entry.

Table H2. Accumulative turf performance indices including data from all trials (Dallas, regional and national) in which DALZ lines were included. Data includes everything prior to 1 January 1995.

Entry	Total TPI	Maximum Possible	% of Max
El Toro	811	1178	68.8
Emerald	769	1173	65.6
DALZ8512	511	793	64.4
DALZ8514	484	782	61.9
TC2033	234	394	59.4
DALZ8507	452	769	58.8
DALZ8508	681	1128	60.4
Meyer	645	1190	54.2
DALZ8502	666	1204	55.3
DALZ8516	611	1135	53.8
TC5018	212	394	53.8
CD2013	212	398	53.3
GT2004	200	387	51.7
Belair	619	1203	51.5
DALZ9006	222	433	51.3
DALZ8501	568	1201	47.3
GT2047	185	392	47.2
CD259-13	168	398	42.2
TGS-W10[1]	149	387	38.5
TGS-B10[1]	148	386	38.2
K. Common [1]	236	620	38.1
DALZ8701	200	568	35.2
JZ-1#A89-1[1]	134	389	34.4

[1] Seeded entry.

Appendix I
Distribution of Zoysiagrass from TAES-Dallas from 1992 to 1995

Location Address	Date	Variety	Amount	Intended Use
Mr. David Stone Honors Course 9601 Lee Highway Ooltewah, TN 37363	6-1-92	DALZ8507 DALZ8508 DALZ8512 DALZ8514 MEYER	18 3" x 3" plugs each	Regional trial
Mr.Jeff Froke 26700 Rancho San Carlos Rd Carmel, CA 93923 Ph:(408)626-8200	6-1-92	DALZ8507	54 trays, 18 3" x 3" plugs each	Irrigation study Coordinated by Mike Kenna
Mr Jim Snow Golf House Liberty Corner Road Far Hills,NJ 07931	6-1-92	DALZ8507	5 trays, 18 3" x 3" plugs each	Coordinated by Jim Snow
Dr. Kimberly S. Erusha Golf House Liberty Corner Road Far Hills,NJ 07931	6-1-92	DALZ8507	4 trays, 18 2" x 2" plugs each	
Mr.Gary Joseph Country Place Carrollton, TX	6-11-92	DALZ8502	2 pallets	Tee box
Mr. Tim Taylor Richland Country Club One Club Dr. Nashville , TN 37215 Ph:(615)370-0060 Fax:(615)371-8452	7-20-92	DALZ8507 DALZ8512 DALZ8514 MEYER EL TORO	2 trays each, 18 3" x 3" plugs each tray	Golf-course nursery; evaluation of drought, cold and disease resistance
Mr. Paul Latshaw Wilmington Country Club 4825 Kennett Pike Rt.52 Wilmington, DE 19807 Ph:(302)655-2905	7-20-92	DALZ8507 DALZ8512 DALZ8514 MEYER EL TORO	2 trays each, 18 3" x 3" plugs each tray	Fairway evaluation

Location Address	Date	Variety	Amount	Intended Use
Mr. Don Parsons Old Ranch Country Club 3901 Lampson Ave. Seal Beach, CA 90740 Ph:(310)431-6213	9-14-92	DALZ8501 DALZ8502 DALZ8507 DALZ8508 DALZ8510 DALZ8512 DALZ8514 DALZ8516 DALZ8701 DALZ9006 MEYER EMERALD	1 tray each variety, 18 3" x 3" plugs each tray (8511 & 8514 2" x 2" plugs)	Regional trial
Mr. Stan Brauen Washington State Univ. Res. and Ext. Ctr. 7612 Pioneer Way East Puyallup, WA 98371-4998 Ph:(206)840-4500	9-14-92	DALZ8507 DALZ8510 DALZ8512 DALZ8514	1 tray each, 18 3" x 3" plugs each tray	Field evaluation
Mr. Frank Wicker Vineyard Knolls 1129 Dealy Lane NAPA, CA 94559 Ph:(714)457-9464	4-12-93	DALZ8502 DALZ8507	11 trays DALZ8502 10' x10' thin layer DALZ8507	Field evaluation
Mr. John Pair KSU Horticulture Research Center 1901 East 95th South Wichita, KS 67233	4-22-93	DALZ8507 DALZ8512	65 yds sod each	Oversseding and shade tolerance studies
Dr. Hisao Fukuoka Prof. of Genetics & Plant Breeding Dean, Faculty of Agriculture Kyushu Tokai University Choyo, Aso, Kumamoto 869-14 JAPAN	6-14-93	DALZ8502 DALZ8507 DALZ8512 DALZ8514 MEYER EMERALD BELAIR	One bag of sprigs each	field trials Japan
Steven Sorrell Collentaon River Plantation 5 COllenton River Drive Hilton Head, SC 29910	6-14-93	DALZ8502	12 trays; 18 3" x 3" plugs each tray	

Location Address	Date	Variety	Amount	Intended Use
Dr. Charles Peacock Dept. of Crop Science 1126 Williams Hall N. C. State Univ. Raleigh, NC 27695 Ph:(919)515-7615	7-14-93	DALZ8502	80 flats	Experiment green
Mr. Don Holly 3220 S. Jupiter Garland, TX 75041	7-20-93	DALZ8507 DALZ8512	30 yds each	Landscape research
Mr. Reed Yenny Mesa Verde Country Club 3000 Clubhouse Road Costa Mesa, CA 92626 Ph (shop):(714)549-396 Ph (club):(714)549-0377	8-5-93	DALZ8501 DALZ8502 DALZ8507 DALZ8508 DALZ8510 DALZ8512 DALZ8514 DALZ8516 DALZ9006 EL TORO	150 plugs each	Field evaluation in cooperation with Paul Vermuelen
Mr. Tom Werner Colonial Country Club Fort Worth, TX	9-30-93	DALZ8502	6,000 ft^2	Chipping green tee box
Mr. Ron Nolf Vista Valley Country Club 29354 Vista Valley Drive Vista, CA 92028	2-10-94	DALZ8502 DALZ9006 MEYER	4' x 4' sod strips	Wear tolerance, heat tolerance, disease resistenc
Mr. Don Parsons Old Ranch Country Club Lampson Ave. Seal Beach, CA 90701	3-10-94	DALZ8502 DALZ9006 MEYER	5' x 5' sod strips	Field evaluation wear and disease resistence)
Mr. Reed Yenny Mesa Verde Country Club 3000 Clubhouse Road Costa Mesa, CA	3-11-94	DALZ8501 DALZ8502 DALZ8507 DALZ8508 DALZ8510 DALZ8512 DALZ8514 DALZ8516 DALZ9006 EL TORO	600 plugs each	Fairway evaluation

Location Address	Date	Variety	Amount	Intended Use
Dr. Andrew Patterson Dept. of Crop & Soil Sci. Rm 434, Heep Center College Staton, TX 77843-2424	1-18-94	DALZ8507 DALZ8502	9 2' x2' plugs each	DNA
Mr. Jerry Fine City Pointe Golf Center Dallas, TX	2-17-94	DALZ8512	2,000 ft^2	Wear and compaction stud
Mr. John Foster West Coast Turf P.O. Box 4563 Palm Desert, CA 92261	4-26-94	DALZ8502 DALZ9006	5 trays	Field evaluation
Mr. Dan Pierson Wilmington Country Club 4825 Kennett Pike Greenville, DE 19807	4-26-94	DALZ8507 DALZ8512 DALZ8514	50 yds sod each	Field evaluation Fairway
Mr. Paul Latshaw Congressional Country Club 8500 River Road Bethdsda, MD 20817- 2026	4-26-94	DALZ8507 DALZ8512 DALZ8514	50 yds sod each	Field evaluation Fairway
Mr. Paul Latshaw, Jr. Marion Country Club 6265 Hughes Road Prospect, OH 43342-9602	4-26-94	DALZ8507 DALZ8512 DALZ8514	50 yds sod each	Field evaluation Fairway
Mr. Doug Petersan Baltimore Country Club 11700 Jennifer Road Timonium, MD 21093	4-26-94	DALZ8507 DALZ8512 DALZ8514	50 yds sod each	Field evaluation Fairway
Mr. Cary Tegtmeyer Topeka C.C. 2700 Buchanan Topeka, KS 66611 Ph:(913)354-8350	5-6-94	DALZ8507 DALZ8512 DALZ8514	50 yds sod each	Fairway

Location Address	Date	Variety	Amount	Intended Use
Mr. Tom Van de Walle Bellerive C. C. 12925 Ladue Rd. St. Louis, MO 63141 Ph:(314)275-9458 Fax:(314)434-2088	5-6-94	DALZ8507 DALZ8512 DALZ8514	50 yds sod each	Fairway
Mr. Dick Stentz Alvamar C.C. 2021 Crossgate Drive Lawrence, KS 66047 Ph:(913)843-6303 Fax:(913)843-34901	5-6-94	DALZ8502 DALZ8507 DALZ8512 DALZ8514	= 250 yds = 50 yds = 50 yds = 50 yds	Tee box green Fairway
Mr. Tim Burch Norwood Hills C.C. 5565 Lucas and Hunt Road St. Louis, Missouri 63121 Ph:(314)522-3552 Fax:(314)521-0792	5-6-94	DALZ8502 DALZ8507 DALZ8512 DALZ8514	50 yds each	DALZ8502 - Tee box DALZ8507 - Fairway DALZ8512 - Rough DALZ8514 - Tee box / Fairway
Mr. Chris Rather Buffalo Creek 624 Country Club Drive Heath, TX 75087 P.O. Box 910 Rockwall, TX 75087 Ph or Fax:(214)771-8989	5-6-94	DALZ8512 DALZ8514	100 yds each	Tee box and fairway
Mr. Mark Price Northwood Country Club 6524 Alpha Road Dallas, TX 75240 Ph:(214)239-1366 Ph:(214)239-8077	5-24-94	DALZ8502 DALZ8514	= 50 yds = 250 yds	DALZ8514 - Bunker face DALZ8502 - Tee boxes
Mr. Jim Gwynn Northwest 10726 E. Northwest Hwy Dallas , TX 75238 Ph(offoce):(214)348-3693 Ph(home):(214)328-6429 Ph(mobile):(214)532-9194	6-16-94	DALZ8502	50 yds sod	Field evaluation
Dr. M.C. Engelke 4005 Parker Road Parker, TX	7-7-94	DALZ8507 DALZ8512 DALZ8514	= 50 yds = 130 yds = 80 yds	Residential planting

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Location Address	Date	Variety	Amount	Intended Use
Mr. John Cooper Denton County Extension Agent-Hort For: St. Andrews Presbyterian Ch. Corner of Oak & Bolivar St., Denton, TX	7-7-94	DALZ8507 DALZ8512 DALZ8514	= 50 yds = 100 yds = 100 ft^2	Demonstration
John Foster West Coast Turf 41025 Burr St. Bermuda Dunes, CA 92201	7-8-94	DALZ8502 DALZ9006	36 plugs each	
Dr. Richard White Texas A&M Univ.- Turf Agronomy Road-Turf Field Lab College Station, TX	7-7-94	DALZ8512 DALZ8514	70 yds each	Field evaluation drought resistance
Mr. Blake Borough Firewheel Golf Course 600 E. Blackburn Garland, TX	7-29-94	DALZ8502	620 ft^2	Tee box evaluation
Mr. Alan Houdeck Preston Trails	8-3-94	DALZ8502	140 yds	Field evaluation Shade tee box
Mr.D.Armstrong/ Mr.David Hollander Golf Resources Inc. 6000 N. O'Connor Blvd. Ste. 106 Irving, TX 75039 Grass located: Willams Golf Ranch Rt. 1 Box 13375 Winnsboro, TX 75494 (903)860-2222	8-14-94	DALZ8502 DALZ8514	100 ft^2 each	Field evaluation - tee surface in shaded area
Mr. Jim May 2119 Meadowlake Court Arlington, TX 76013	8-17-94	DALZ8502	30 yds sod	Field evaluation Home Green

Location Address	Date	Variety	Amount	Intended Use
Dr. M.C. Engelke 4005 E. Parker Rd. Dallas, TX Ph: (214)516-8873	8-17-94	DALZ8502	150 yds	Residential planting Home Green
Mr. Craig Boyer 6907 Mill Falls Dallas, TX 75248 Ph: (214) 980-1644 or (214) 783-2004	8-17-94	DALZ8502	75 yds	Home Green
Mr. Tom Werner Colonial Country Club 3735 Country Club Circle Fort Worth, TX 76109 Ph:(817)927-4255	8-15-94	DALZ8507 DALZ8512 DALZ8514	= 50 yds = 50 yds = 100 yds	Field evaluation
Mr. Jim Latham - USGA 111 Hill Terrace White Bluff Subdivision Whitney, TX Ph-Work(414)242-8742 Ph-Home(414)352-4451	8-30-94	DALZ8507 DALZ8512 DALZ8514	100 yds each	Home lawn
Mr. Makato Yaneshita Toyo Green Limited Japan Turfgrass Inc. 3-6-2 Akanehama, Narashino-shi, Chiba, 275 JAPAN Ph:0474-54-8741	9-12-94 carried over by plane	DALZ8502 DALZ8507 DALZ8512 DALZ8514 DALZ9006	2 3' x3' plugs each	
Mr. David Denley Lochinvar Country Club 2000 Farrell Rd Houston, TX 77073 Ph:(713)821-2878	9-12-94 and 9-16-94	DALZ8502 (two shipments)	100 ft^2 and 150 ft^2	Tee box
Neil Noble Environmental Turfgrass Systems 500 Ala Moana Blvd. Honolulu, Hawaii 96813	10-11-94	DALZ8507 DALZ8512 DALZ8514 DALZ9006	2 trays, 2 ft^2 each	

Location Address	Date	Variety	Amount	Intended Use
Steve Cockerham Univ. of California- Riverside Supt. of Ag. Operations 1060 Martin Luther King Blvd. Riverside, CA 92307	3-15-95	DALZ8502	2 pallets	
John Smartz	6-26-95	DALZ8507 DALZ8512 DALZ8514	100 yds each	
Santa Anita Race Track C/O John Foster West Coast Turf 41025 Burr Street Bermuda Dunes, CA 92201	7-14-95	DALZ8512 DALZ8514	450sq.ft. 450sq.ft.	
Bill Baker Riviera C.C. 1250 Capri Drive Pacific Palisades, CA 90272	7-14-95	DALZ8502	2 pallets 450sq.ft each	
Ernie Pacheco/Jim Porter Redhill C.C. 8358 Red Hill Country Club Drive Rancho Cuca Monga, CA 91730	7-14-95	DALZ8502 DALZ8507 DALZ8512 DALZ8514	2 pallets 2 pallets 2 pallets 1 pallets	
Scott McColgan/Dave Carollo SouthHills C.C. 2655 S. Citrus West Covina, CA 91791	7-14-95	DALZ8502 DALZ8507 DALZ8512 DALZ8514	2 pallets 2 pallets 2 pallets 1 pallet	
Bill Baker Riviera C.C. 1250 Capri Drive Pacific Palisades, CA 90272	7-24-95	DALZ8512 DALZ8514		

Location Address	Date	Variety	Amount	Intended Use
Andy Coz Golfcrest CC Pearland, TX	7-31-95	DLAS8502	450 ft^2	
Scott Johnson Colonial CC Fort Worth	7-31-95	DALZ8502	900 ft^2	
Jergen Gramkow Southland Sod 2599 East Hueneme Oxnard, CA 93030	7-31-95	DALZ8501 DALZ8502 DALZ8507 DALZ8512 DALZ8514 DALZ9006 DALZ8510	1 tray of each of 18- 3"x3" plugs	
Dr Paul Sebesta Univ. of California Desert Research and Extension Center 1004 East Holton Road El Centro, CA 92243	7-31-95	DALZ8501 DALZ8502 DALZ8507 DALZ8512 DALZ8514 DALZ9006 DALZ8510	1 tray of each of 18- 3"x3" plugs	
Pat Gradoville Cypress Golf Club 4921 Katella Avenue Los Alamitos ,CA 90720	7-31-95	DALZ8501 DALZ8502 DALZ8507 DALZ8512 DALZ8514 DALZ9006 DALZ8510	1 tray of each of 18- 3"x3" plugs	
Craig Wilger Union Carbide 2317 Windham Road South. Charleston, West Virginia. 25303	8-4-95	DALZ8512 DALZ8514	2 trays each	
Glenn Moore Cedar Creek 18392 Country Club Dr Hemp, Texas 75143	8-8-95	DALZ8502	900 ft^2	tee shaded

Location Address	Date	Variety	Amount	Intended Use
Hank Haney Golf Ranch 4101 Custer Rd McKinney Texas 75070	8-7-95	DALZ8502	450 ft^2	tee
Davis Creech/John Walters Stephen F. Austin Univ. 1800 Wilson Drive PO box 13000 Nacogdoches, TX 75962	8-11-95	DALZ8501 DALZ8502 DALZ8507 DALZ8512 DALZ8514 DALZ9006	1 tray each line	
John Walters and David Creech SFA Univ. POBox 13000 Nacadoches, TX 75962	8-11-95	DALZ8501, 8502, 8507, 8510, 8512, 8514, 9006, Meyer,Eltor	1 tray each	research
Gene R.Taylor II Lawn PRO Inc 3900 Freedom Way Hubert, NC 28539	8-14-95	DALZ8507 DALZ8512 DALZ8514	50 sq.yards each	
Jorg Hentschel/ Russ Gruber Brickman Group Long Grove Road Long Grove, IL 60047	8-15-95	DALZ8507 DALZ8512 DALZ8514	8 yds each	
Mark Price Northwood C.C. Alpha Road Dallas, TX 75252	8-23-95	DALZ8512	8 yards	
Dan Wegan Squaw Creek C.C. HCR 51 BOX 46 Glenrose, TX 76043	9-6-95	DALZ8502	3 pallets	
Jim Taylor Hatsuho International C.C. Guam	9-11-95	DALZ8501 DALZ8502 DALZ8507 DALZ8512 DALZ8514 DALZ9006	1 tray each	

Robbie Robinson 3409 Rambling Way Plano, TX Ph: (214) 605-1300	9-18-95	DALZ8507	450 ft^2 (1 pallet)

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