1993
ANNUAL PROGRESS REPORT
concerning
BREEDING AND DEVELOPMENT OF ZOYSIAGRASS

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BREEDING AND DEVELOPMENT OF ZOYSIAGRASS

EXECUTIVE SUMMARY

Principal Investigator: Dr. M.C. Engelke
Co-Investigator: Ms. S.J. Morton

Research Period: 1 November 1992 through 1 November 1993.

Marking the ninth year of this USGA sponsored research project over $440,000 has been directed to this project. First year results of the NTEP zoysiagrass trials include nine TAES/USGA entries. DALZ8507, a fine-textured, cold hardy *Zoysia matrella*, topped the trials, with DALZ8512 and DALZ8514, in the top 25%.

Breeder fields of DALZ8502, DALZ8507, DALZ8512 and DALZ8514 (15,000 ft^2 (0.139 ha) each) were planted in July 1992. All four fields were fully established by midsummer 1993. These fields will serve as: 1) planting stock for foundation production, once approved for release, and 2) source material for more extensive field evaluation studies.

The DALZ8502 greens at TAES-Dallas continue to perform well. One is on sand and the other is in clay soil. Overseeding in 1992 on part of the sand green and tee box revealed severe damage to the zoysia and will not be recommended in the future. Under agreement with Colonial Country Club, we have established a 4500-ft^2 (0.04 ha) chipping green and a 1500-ft^2 (0.01 ha) shaded tee box to continue a field evaluation of DALZ8502. Rapid regrowth in the area harvested for the sod used in these green and tee box marks the extensive rhizome system of this fine-textured *Z. matrella* variety.

The Linear Gradient Irrigation System (LGIS) has been reestablished with 12 *Zoysia* experimentals, three bermudagrasses, a buffalograss, a St. Augustinegrass, and a Texas bluegrass to provide extensive inter- and intraspecies water-use/cultural input comparisons. Of targeted interest is the influence of fertility levels across the moisture gradient on turfgrass performance. Each experimental unit will be mowed at its 'optimum' height.

Release documents are being prepared for DALZ8507, DALZ8512, and DALZ8514.

1993 Annual Zoysiagrass Research Report

M.C. Engelke and S.J. Morton

I. INTRODUCTION

The zoysiagrass breeding and development program is in its ninth year of funding through the United States Golf Association. The cooperative effort between the Texas Agricultural Experiment Station and USGA to develop improved zoysiagrasses for the golf and turf industry was initiated in May 1984. Through January 1993, a total of $382,045 over eight years was dedicated to Zoysiagrass Breeding and Development. In February 1993, contracts were renegotiated with annual funding set at $60,000 with an annual 5% inflation factor included for renewal. This report will address project activities for the period November 1, 1992 through November 1, 1993.

II. Technical Support Personnel

Ms. Sharon J. Morton (Research Associate) joined the turfgrass breeding program in September 1989. Ms. Morton has provided a lead support role in the field screening of zoysiagrasses developed in the program. Approximately 60% of Ms. Morton's time is spent on the zoysiagrass project.

Mr. Charles Dayton provided full-time technical assistance to Ms. Morton from January through September 1993. Mr. Dayton has since taken a position at Colonial Country Club Golf Course. Approximately 90% of his time was spent on the zoysiagrass program.

Mr. John Deaton provides part-time technical assistance to Ms. Morton. Approximately 80% of Mr. Deaton's time is spent on the zoysiagrass project.

III. A. GREENHOUSE AND LABORATORY PROGRESS

1. GERMPLASM MAINTENANCE

The 900+ accessions in the Germplasm Introduction Nursery are continually maintained in deepots in the greenhouse. This past year we increased the collection, with the addition of zoysiagrasses collected in Japan and China. In cooperation with the USDA, seed from the new zoysiagrasses is being tested for future release from quarantine. The project serves as a quarantine facility for new introductions of zoysiagrass which have been obtained from Japan (1992) and China (1993). New regulations restrict the movement of vegetative material into the immediate program, however, controlled hybridization and seed harvest enables us to utilize the germplasm in a timely manner.

Two presentations will be made on the germplasm collection, maintenance, and evaluation of the zoysiagrasses at the Agronomy Society of America meetings in November 1993. Work on isolation of salinity, heat, and drought tolerance genes is being conducted in conjunction with Mr. Yaneshita, a Research Scientist with Japan Turfgrass Company and University of California at Davis. The work will be initiated in November 1993.

2. ZOYSIAGRASS SALINITY TOLERANCE MECHANISMS

There is an increasing need for salt tolerant turfgrasses. Increased restrictions on the use of potable water for irrigation of turfgrasses places greater emphasis on the use of alternate water sources such as recycled or effluent waters. Progress on zoysiagrass salinity tolerance screening trials is presented in **Appendix A : Salinity Tolerances of Selected Zoysiagrass Genotypes** (published in Texas Turfgrass Research

Report - 1993).

3. FALL ARMYWORM RESISTANCE
In collaboration with Dr. James Reinert (Director, TAES-Dallas), zoysiagrass genotypes in the 1991 NTEP trial are being evaluated for their potential resistance to the Fall Armyworm. In a preliminary experiment, three levels of resistance in the zoysiagrasses were observed, with several genotypes expressing total resistance.

III. B. FIELD EVALUATION AND PRODUCTION TRIALS

1. DALLAS FIELD TRIAL - MANAGEMENT

Zoysiagrass (*Zoysia* spp. L.) is one of the least utilized warm season turfgrasses in the United States, due in part to slow establishment, lack of seeded cultivars, and relatively high cost of production in comparison to other warm season grasses. However, its inherent characters of having comparatively low water and nutritional requirements makes this grass a strong candidate for use in an environmentally conscious urban industry. Acceptance and utilization of zoysiagrasses depends in part on development of appropriate and efficient management strategies. This work has placed emphasis on determining minimum and optimum fertilization and mowing requirements of existing and newly developed zoysiagrass cultivars, with particular attention given to turf quality, persistence, and thatching tendency. The results in past years indicated no difference in performance between mowing heights for the zoysiagrass lines tested. Thus, mowing height treatments were discontinued in April 1993, to obtain a better picture of the response of the selected zoysiagrasses to three nitrogen levels. Data on turf quality, color, and spring green up through April, 1993, are presented in **APPENDIX B: Nitrogen Fertilization Effects on Zoysiagrass Performance.**

2. LINEAR GRADIENT IRRIGATION SYSTEM

A new set of zoysiagrasses was planted to LGIS during August 1992, which included six elite experimental zoysiagrasses (DALZ8501, DALZ8502, DALZ8507, DALZ8510, DALZ8512, and DALZ8514) and three cultivars (El Toro, Emerald, and Meyer). The study design is a randomized complete block, with two replications on either side of the line irrigation source, for a total of four replications. All plots are 4 m wide by 20 m perpendicular to the line irrigation source. The larger plot sizes will allow more extensive evaluation of water use and its relation to fertility and mowing practices. Net radiation and canopy temperature measurements will begin in May 1994. All entries, except DALZ8507, DALZ8512, and DALZ8514, were plugged at a 1:12 planting ratio. Turf establishment of the nine zoysiagrasses is presented in Table 1.

In the previous LGIS study, DALZ8507, DALZ8512, and DALZ8514 expanded beyond their plot boundaries in the non-irrigated zones of the linear irrigation gradient. In the current study, these three entries were planted using a combination of prerooted plugs, cut plugs, and solid sodding, to determine rates of establishment. A study on the establishment of these three zoysiagrasses is presented in **Appendix C: Vegetative Establishment of Selected Zoysiagrass Lines** (published in Texas Turfgrass Research Report - 1993).

Table 1. Turf establishment of zoysiagrasses planted to LGIS at TAES-Dallas.

	Percent turf cover[1]	
	1993	
Entry	31May	22June
DALZ8501	54	55
DALZ8502	72a	81a
DALZ8507	77a	79a
DALZ8510	33	57
DALZ8512	69a	87a
DALZ8514	78a	83a
El Toro	78a	83a
Emerald	33	34
Meyer	42	48
MSD entry	15	14

[1] Percent turf cover is an estimate of the percentage of the plot area with turf cover.
[2] MSD entry = minimum significant difference between entry means within a column, based on the Waller-Duncan k-ratio t test (k-ratio = 100).

3. SHADE TOLERANCE TRIALS
Shade tolerances of the 1991 NTEP zoysiagrasses are being evaluated at TAES-Dallas. In previous zoysiagrass shade tolerance trials, the grasses were evaluated only during their first growing season. The current study was designed for evaluation of the grasses over a three year growth period. Entries will be evaluated for spread, overall turf quality, and the individual components of turf quality. Results for the first year of the study are presented in **Appendix D: Shade Tolerance of NTEP zoysiagrasses** (published in Texas Turfgrass Research Report - 1993).

4. NATIONAL TURFGRASS EVALUATION PROGRAM (NTEP)
Evaluation of the performance of zoysiagrasses in the 1991 NTEP trial continues. Because of the persistence of bermudagrass contamination in the initial planting site, a second planting of the 1991 NTEP zoysiagrass trial was initiated in July 1993. A detailed report and current data on the initial planting are presented in **APPENDIX E: Update on the 1991 Zoysiagrass NTEP Trial** (published in NTEP Committee Report. 1992 (3), USDA, Beltsville, MD; also in Texas Turfgrass Research Report - 1993).

5. REGIONAL FIELD TRIALS
Regional field trials are useful to define areas of adaptation of improved zoysiagrass selections in comparison to commercially available cultivars. A list of regional trial sites is presented in **APPENDIX F: Regional Field Trials.**

6. DALZ8502 GREEN
The DALZ elite line, DALZ8502, has shown promise for use as a putting green. During the winter of 1992-3, a study evaluating the effect of overseeding and application of a thermal cover on green color retention and stimp was performed. Results are presented in **Appendix G: Greens Quality Zoysiagrass: Evaluation of ball speed and various winter treatments** (published in Texas Turfgrass Research Report - 1993). During the 1993-4 winter, a cover will be applied to half of the green to evaluate cover retention, and traffic will be imposed in both covered and uncovered areas. Overseeding will not be performed again, because the resulting injury to the zoysiagrass was severe last winter.

The DALZ8502 green established in June 1992, at Firewheel Golf Course, Richardson, Texas, was overseeded in October 1992, using a blend of 50% Creeping Bentgrass, 25% Fine Fescue, and 25% Poa trivialis, similar to the TAES-Dallas green. During the winter, the zoysiagrass was under relatively heavy play and received management optimal for a winter overseeding, and failed to recover from the overseeding in the spring of 1993. Similar results occurred on shaded tee box areas. Based on this experience, overseeding is not recommended on DALZ8502 under greens or tee box conditions.

The DALZ8502 green established at Banyan Golf Club, West Palm Beach, Florida, was abandoned. However the rough and fairway plantings under heavy shade continue to do well.

7. DALZ8502 TRAFFIC TOLERANCE
DALZ8502 zoysiagrass has potential for use in highly trafficked areas, such as tee boxes and athletic fields. The study was designed to evaluate the wear response, as green cover, density, and turf quality, of DALZ8502 to a foot traffic stimulator. The results of study are presented in **Appendix H: Traffic Tolerance of DALZ8502 Zoysiagrass.**

III. C. ZOYSIAGRASS HYBRIDIZATION

1. ORIENTAL ZOYSIAGRASS COLLECTION
The oriental zoysiagrass collection continues to undergo field evaluation, with emphasis on traffic tolerance. Wear during the winter and spring was noted as the turf cover loss by the oriental zoysiagrasses (Wear

= turf cover of the unworn plots less turf cover of the worn plots). There are 598 oriental zoysia entries in 829 plots. Overall, turf cover (tc) in the unworn plots (mean tc=69%) was significantly more than in the worn plots (mean tc=54%) (P>T is 0.0001). Overall there was a 5% turf cover loss by the zoysiagrasses when worn three times each week. The most frequent wear level was 4%, which was observed of 45% of all entries. Fewer than 10% of entries had more than 75% wear.

Irrigation to the field planting of oriental zoysiagrasses was discontinued in December 1991, and reinstated May 1993, for brown patch induction. Trafficking continued through September 1993. A final note on spread will be made before half of each plot is removed with a sod harvester. Regrowth will be evaluated, as a measure of rhizome development by each line.

2. INCREASE PLANTINGS AT TAES-DALLAS

Breeder fields of each DALZ8502, DALZ8507, DALZ8512, and DALZ8514, were planted July 1992. These elite lines of zoysiagrass were selected as superior in turf quality, sod strength, drought and salinity tolerance, root development, cold tolerance tests, and have ranked highest at the majority of test sites for the 1991 NTEP trial. Each breeder field was 15,000 ft^2 (0.13 ha), and except for DALZ8502, were planted with a 1:60 tissue area to land area planting ratio. A 1:30 planting ratio was planted of DALZ8502. 49 kg/ha is applied each month, and biweekly application of Roundup herbicide on the weeds are made. All were completely filled by July, 1993. Sod from each was harvested during September, 1993, for planting as collars around bentgrass greens. Within a month after harvest, DALZ8502, DALZ8512, and DALZ8514 have nearly refilled. DALZ8507 has some regrowth, but much less than in the others.

A fairway of each DALZ8507 and DALZ8512, alongside 'Prairie' buffalograss, were planted May 1993. Each 7200 ft^2 (0.06 ha) fairway was planted as plugs at a 1:200 planting ratio. The soil in half of each fairway was amended with Hydrozone polyacrylamide moisture retention material prior to planting. The fairway leads to DALZ8502 green on native soil. As of October 20, 1993, DALZ8512 was 70% covered, DALZ8507 was 45% covered, and 'Prairie' was 95% covered. A preemergent phytotoxicity trial was performed during the second through fourth week after planting. The results of the trial are presented in **Appendix I: Preemergent phytotoxicity in zoysiagrass.**

3. PROGENY DEVELOPMENT

The hybridization programs continue with major emphasis on inter-crossing parental lines with superior performance characters when grown under natural environmental conditions. Concerns are still targeted to cold hardiness, especially among the finer textured types which generally are considered winter tender, i.e. DALZ8502. Seed production characters continue to be evaluated especially with an objective of developing finer-textured more uniform plant types. Presently the primary advances in seeded types will most likely be restricted to the coarser textured *Z. japonica* as they have the potential for larger and more profuse floral development. Most of the finer textured species, i.e. *Z. matrella* and *Z. tenuifolia* types, lack sufficient seed head development to obtain sufficient seed to warrant developing a seeded type. Regardless, work continues and is further summarized in **APPENDIX J: Zoysiagrass Hybridization - Progeny Development.**

APPENDIX A

Salinity Tolerances of Selected Bermudagrass and Zoysiagrass Genotypes

K.B. Marcum, M.C. Engelke, S.J. Morton, and C. Dayton

Introduction

Soil salinity can be a problem in the turf industry in semi-arid and arid regions of the country. Generally, irrigation waters contain some salts, and a problem occurs when the added salt accumulates to a concentration that is harmful to the grass, either by direct injury to the plant or by damage to the soil structure through salt crust formation, poor aeration, and waterlogging of the soil (Oster and Rhoades, 1985; Salisbury and Ross, 1985).

The accumulation rate depends on the quantity of salt applied in the irrigation water and the rate at which salt is removed by leaching. High temperatures, high winds, and frequent brief sprinklings increase the ratio of evaporation to leaching, thus increasing the rate of soil salt accumulation. Soil salt accumulation rates are also high where recycled and effluent waters are used for irrigation (Odum, 1971; Oster and Rhoades, 1985; Salisbury and Ross, 1985).

Irrigation water is often the effluent from wastewater treatment plants, and depending on the facilities of a municipality have different water qualities. Most municipalities have, at minimum, secondary treatment facilities, which remove sediments and biologicals (Crook, 1985). These waters generally have a high salt load, which is reduced, but not eliminated, by tertiary treatment. Secondary effluents have salt levels up to 400 ppm, whereas tertiary waters have salt levels between 100 and 200 ppm. Sodium and chloride are the most common salt ions in treated waters, of which both can be toxic to plants in high concentrations (Moore and Moore, 1976; Asano, et al., 1985).

Solutions to the salinity problem include use of salt tolerant turfgrasses, aeration of the soil, soil leaching with less saline waters, or chemical treatment with calcium sulfate or sulfuric acid. Less frequent, yet thorough, irrigation and good soil drainage are essential to allow movement of water and dissolved salts through the root zone (Oster and Rhoades, 1985). The turfgrass breeding program at TAES-Dallas, in conjunction with USGA goals of reducing environmental impact in the golf course industry, has focused on development of salt tolerant grasses. As part of this effort, a study was performed to evaluate the salinity tolerance of selected lines of zoysiagrass (*Zoysia* spp.).

Materials and Methods

The study contained five *Zoysia* species, which were represented by six commercially available cultivars and 53 accessions, including germplasm collected from Asia. Zoysiagrass cultivars included 'Belair', 'El Toro', 'Emerald', 'Korean Common', 'Meyer', and 'Sunburst'.

Each entry was vegetatively propagated from rhizomes in crystalline silica blasting sand in 4 cm diameter x 13 cm deep 'Conetainers[1]', with modified screen-covered bases. Plants were maintained with weekly applications of 12 kg N/ ha as 20-20-20 Peters nutrient solution, supplemented with 1.2 kg Fe/ha Fe-chelate ("Sprint 330", Ciba-Geigy), until transferred to the salinity tanks.

Each salinity tank included a hydroponics system composed of covered 52 L

[1] 'Conetainers' are a product of Stuewe and Sons, Inc.

rectangular container containing 1/3 strength modified Hoagland #2 solution (Hoagland and Arnon, 1950). Constant aeration of solutions was provided by bubbling air through 15.25 cm airstones placed in the bottom of each tank. Nutrient solution was replaced every 10 days. Conetainers were placed into 4 cm diameter holes in the lids of the tanks such that the bases were immersed 4 cm into the nutrient solution. Each tank supported one replication of each grass, allowing a split plot design, with salinity the main effect and genotype the sub effect. Two experimental runs, each with three replications and one control, were completed for the zoysiagrass study.

Starting October 8, 1992, 1575 ppm NaCl was added each day for the 12 weeks of the study. Zoysiagrasses were placed into recovery after the peak salinity level was reached. A control tank, containing nonsaline Hoagland #2 solution, was set up for each grass to establish baseline growth information, from which injury and production measurements could be compared.

Percent injury of shoots was noted through time, and is presented as the relative % of dead tissue for an entry in relation to the control. Recovery was noted as the presence of green tissue 2 weeks after being placed in regular nutrient solution.

Data between experimental runs were significantly correlated, and were combined for presentation. Analysis of variance procedure was performed on the data to test for significant differences between entries, with a Waller-Duncan k-ratio t test used to separate entry means at the 0.05 significance level (SAS, 1987).

Results and Discussion

Percent injury is presented as the average over all rating dates (Table A1). *Z. macrostachya*, *Z. japonica* and *Z. matrella* had entries at all salinity tolerance levels. The bulk of *Z. matrella* and *Z. sinica* entries were the largest segment of the most salt tolerant group, which included entries with injury ratings $\leq$ 40%. *Z. matrella* entries collected from the Philippines and Taiwan (P9, P2, P47, T38) were more tolerant than those collected from Korea or Japan (entries beginning with K or J). Two experimentally developed lines, QT2004 and CD2013, and a Korean accession, K254, were among the *Z. matrella* entries in the most salt sensitive group (injury $\geq$ 50%). *Z. japonica* entries constituted the majority of the most salt sensitive group. However, J239, an accession collected from Japan, and a cultivar, 'El Toro', were *Z. japonica* entries rated in the most salt tolerant group.

J207, a *Z. tenuifolia* collected from Japan, was moderately salt tolerant (41 to 49% injury), as well as the *Z. japonica* x *Z.tenuifolia* hybrid, 'Emerald', each with 43% and 42% injury, respectively. The four *Z. korenia* spp. were also closely grouped, also in the moderate tolerance range, indicating their genetic relatedness.

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Table A1. Average percent shoot salt injury (average of 20 rating dates) of 59 zoysiagrass entries.

Entry	Source[1]	Species[2]	%Injury[3]
P9	TAES1509	matr.	32a
DALZ8502	NTEP20	matr.	33ab
DALZ8501	NTEP24	matr.	33ab
T38	TAES1567	matr.	33ab
T16	TAES1562	macro.	33ab
T14	TAES1560	macro.	33ab
P47	TAES1541	matr.	33abc
P2	TAES1502	matr.	33abc
DALZ8701	NTEP21	matr.	35abcd
DALZ8508 (K227)	NTEP18	matr.	37abcde
P58	TAES1550	sin.	37abcde
P49	TAES1542	sin.	37abcde
El Toro	NTEP13	jap.	38abcde
J239	TAES2004	jap.	38abcde
P50	TAES1543	sin.	39abcdef
T4	TAES1554	sin.	40abcdefg
DALZ9006	NTEP19	matr.	41abcdefgh
K227	TAES2219	matr.	41abcdefgh
K12	TAES2077	matr.	41abcdefgh
K245	TAES2238	jap.	41abcdefgh
Emerald	NTEP10	jap.xten.	42abcdefgh
DALZ8507	NTEP17	matr.	42abcdefgh
TC2033	NTEP01	matr.	42abcdefgh
K103	TAES2143	kor.	42abcdefgh
QT2047	NTEP02	jap.	42abcdefgh
K260	TAES2236	kor.	43abcdefghi
K98	TAES2138	kor.	43 bcdefghi
J207	TAES2043	ten.	43 bcdefghi
T44	TAES1569	sin.	45 cdefghi
J222	TAES2054	matr.	45 j defghi
K99	TAES2139	kor.	46 j efghi
T21	TAES1565	macro.	46 jk efghi
DALZ8512	NTEP15	jap.	46 jk efghi
DALZ8514	NTEP14	jap.	46 jk efghi
J225	TAES1999	matr.	47 jk efghi
K246	TAES2230	macro.	49 jk fghi
J3-2	TAES1674	jap.	49 jk fghi
Belair	NTEP11	jap.	50 jk fghi
DALZ8516	NTEP16	jap.	50 jklm ghi
Sunburst	NTEP12	jap.	52 jklm hi
QT2004	NTEP05	matr.	54 jklm i
J87-2	TAES3485	jap.	56 jklmn
ITR90-3	TAES	jap.	56 jklmn
K248	TAES2233	macro.	57 jklmn
TC5018	NTEP04	jap.	57 klmn
Meyer	NTEP09	jap.	58 lmn
CD2013	NTEP03	matr.	59 lmn
CD259-13	NTEP06	jap.	60 lmno
K254	TAES2232	matr.	61 mno
JS10-3	TAES1613	jap.	66 nop
TGS-W10	NTEP23	jap.	66 nop
K241	TAES3547	jap.	71 opq
JS23	TAES1663	jap.	73 pq
J94-5	TAES1835	jap.	73 pq
TGS-B10	NTEP22	jap.	73 pq
K157	TAES2180	jap.	74 pq
Korean Common	NTEP07	jap.	76 pq
JZ-1	NTEP08	jap.	79 q
K162	TAES2184	jap.	81 q

[1] NTEP - National Turfgrass Evaluation Program. TAES - Texas Agricultural Experiment Station Accession.
[2] Species identity is sometimes an estimate (jap. - *Z. japonica*, matr. - *Z. matrella*, macro. - *Z. macrostachya*, sin. - *Z. sinica*, kor. - *Z. korenia*, ten. - *Z. tenuifolia*).
[3] Means with the same letter were not significantly different, based on the Waller-Duncan k-ratio t test (k-ratio = 100).

APPENDIX B

NITROGEN FERTILIZATION EFFECTS ON ZOYSIAGRASS PERFORMANCE

Zoysiagrass (*Zoysia* spp. L.) is one of the least utilized warm season turfgrasses in the United States, due in part to slow establishment, lack of seeded cultivars, and relatively high cost of production in comparison to other warm season grasses. However, its inherent characters of having comparatively low water and nutritional requirements makes this grass a strong candidate for use in an environmentally conscious urban industry. Acceptance and utilization of zoysiagrasses depends in part on development of appropriate and efficient management strategies. This work has placed emphasis on determining minimum and optimum fertilization and mowing requirements of existing and newly developed zoysiagrass cultivars, with particular attention given to turf quality and persistence.

MATERIALS AND METHODS

During 1988, plots were planted to zoysiagrasses using 3.8 cm plugs planted on 0.3 m centers. The field plot design was a randomized complete block, consisting of three replications of 10 entries. Plot size is 5.79 m by 4.27 m. Cultivars in this management trial are Meyer, Emerald, El Toro, Belair, Cashmere, and one proprietary line, designated TAES3372. Experimental entries are DALZ8501, DALZ8502, DALZ8508, and DALZ8516. These same materials are in regional field trials throughout the Southern United States. Management treatments, initiated in July, 1990, were overlaid as strip plots onto each grass plot. Mowing treatments consist of two rotary mow heights of 0.63 (5/8") and 2.54 cm (1"), and one 0.63 cm reel mow cut. Mowing treatments were discontinued April 1, 1993. Nitrogen treatments consist of 0.12, 0.37, and 0.75 kg N/are applied April, May, July, and September for total yearly amounts of 0.5, 1.5, and 3 kg N/are, respectively.

Data collected on the effects of management treatments included winter green color retention, spring green up, color, and turf quality. Statistical analysis was by standard ANOVA procedures, with comparison between means through Waller-Duncan k-ratio t test (k-ratio = 100) for analyses significant at the alpha = 0.05 level.

RESULTS AND DISCUSSION

There were no interactions between mowing height, nitrogen level, and entry. This allowed for univariate analysis in the comparison of entries within each treatment type and within each treatment combination. Significant differences between entries occurred for color and green cover, but differences between the turf quality of the entries occurred in only a few nitrogen-mow combinations. There were no significant differences between the mow levels, between the nitrogen levels, nor between the 9 mow-nitrogen combinations, whether compared for individual entries nor for the total zoysiagrass community.

On January 25, 1993, significant differences in color occurred between entries within many of the mow and nitrogen combinations (Table B1). Over all combinations, El Toro had the best winter color of the commercial entries, and DALZ8501, DALZ8502, DALZ8516, and TAES3372 had the best winter color of the experimental entries (all had TPI = 9). El Toro was not significantly different from the best experimental zoysias. DALZ8508 consistently had poorer winter color than all other zoysiagrass entries. By April 13, DALZ8508 and all four of the cultivars had the best color quality of the entries tested, without respect to nitrogen or mow level.

Over all mow-nitrogen combinations, DALZ8502 and DALZ8516 maintained at least 10 percent green cover during the winter months of January through March (Table B2). The early part of the winter of 1992-3 was milder and wetter than average for TAES-Dallas, but was closer to average temperatures by February, 1993. Evidence of this late cold was documented in the green cover on March 17, in which none of the zoysiagrasses had more than 20 percent green cover. The zoysiagrasses had not completely greened up by April 13, when most had about 70% green cover (data not shown).

Although ratings were less than five, primarily because of the lack of green color, turf quality during the winter months was acceptable for all zoysiagrass entries (Table B3). Ratings should not have been less than five, because other components, such as turf cover, density, texture, evenness, and uniformity, were above minimum acceptable levels and did not change significantly when the grass became dormant. With these considerations, it was observed that the spring turf quality of the zoysiagrasses was not significantly different between entries for most mow-nitrogen combinations. But differences between the zoysiagrasses were detected when the treatments were examined separately, especially by the March note (Tables B4 and B5). In January and February, turf quality did not differ greatly between the zoysias, but as the grasses were greening up in March, turf quality for DALZ8516 was superior to the other nine entries in all treatments.

Turf quality ratings taken on April 13 reflected the presence of green tissue (Table B6). Among the highest rated were El Toro, Meyer, DALZ8508, and DALZ8502. The highest rating was 7.6. The weakest turf quality was observed in DALZ8501, which had a mean rating of 5.9.

Because of the lack of response of the grasses to the different mowing treatments, the mowing treatments were discontinued on April 1, 1993. The fertilizer treatments will be continued, along with rating of overall turf quality and its components. The effect of fertilizer level on hatching tendency will also be evaluated.

Table B1. Color on January 25, 1993 for zoysiagrasses managed under three mow heights and three nitrogen levels.

Mow Treatment	Entry	25 January 1#N	2#N	3#N	TPI[1]	Total TPI
5/8" Reel	Belair	2.0	2.3a	2.0	1	
	DALZ8501	2.3a	2.3a	2.3a	3	
	DALZ8502	3.0a	3.0a	3.0a	3	
	DALZ8508	1.3	1.3	1.3	-	
	DALZ8516	3.0a	3.0a	3.0a	3	
	Cashmere	2.3a	1.7	1.7	1	
	El Toro	3.0a	3.0a	3.0a	3	
	Emerald	2.7a	2.7a	2.3a	3	
	Meyer	2.0	2.0a	2.0	1	
	TAES3372	3.0a	2.3a	2.7a	3	
	MSD entry[1]	0.9	1.0	0.9		
1" Rotary	Belair	2.0	2.0	2.0	-	
	DALZ8501	3.0a	3.0a	3.0a	3	
	DALZ8502	3.0a	3.0a	3.0a	3	
	DALZ8508	1.3	1.3	1.3	-	
	DALZ8516	3.0a	3.0a	3.0a	3	
	Cashmere	2.0	1.7	2.0	-	
	El Toro	3.0a	3.0a	3.0a	3	
	Emerald	2.7a	2.3	2.7a	2	
	Meyer	2.0	2.0	2.0	-	
	TAES3372	3.0a	3.0a	3.0a	3	
	MSD entry	0.7	0.5	0.7		
1" Reel	Belair	2.3a	2.3a	2.3a	3	4
	DALZ8501	3.0a	3.0a	2.3a	3	9
	DALZ8502	3.0a	2.7a	3.0a	3	9
	DALZ8508	1.3	1.3	1.3	-	-
	DALZ8516	3.0a	3.0a	3.0a	3	9
	Cashmere	2.0	1.7	1.7	-	1
	El Toro	3.0a	3.0a	2.7a	3	9
	Emerald	2.3a	2.7a	2.3a	3	8
	Meyer	2.0	2.0	2.0a	1	2
	TAES3372	3.0a	3.0a	3.0a	3	9
	MSD entry	0.8	0.7	1.0		

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

[2] MSD entry = minimum significant difference between entry means within a column and mow treatment, based on the Waller-Duncan k-ratio t test (k-ratio = 100). Means in the top statistical group are indicated by 'a'.

Table B2. Spring green cover for zoysiagrasses managed under 3 mow heights and 3 nitrogen levels.

Mow Treatment	Entry	25 Jan	25 Feb	17 Mar	25 Jan	25 Feb	17 Mar	25 Jan	25 Feb	17 Mar
			1#N/yr			3#N/yr			6#N/yr	
5/8"	Belair	0	0	3	2	0	3	0	0	4
Reel	DALZ8501	13a	10a	2	13a	7	3	10	4	2
	DALZ8502	28a	15a	14a	23a	8	10	10	7a	6
	DALZ8508	0	3	8	0	3	10	0	3	12
	DALZ8516	15a	20a	18a	17a	18a	13	8	15a	15
	Cashmere	2	3	0	0	2	0	0	2	0
	El Toro	5	1	3	5	1	3	5	1	3
	Emerald	4	1	4	3	1	6	2	1	5
	Meyer	0	0	3	0	0	3	0	0	4
	TAES3372	4	1	3	2	0	3	5	0	2
	MSD entry	17	11	9	15	11	ns	ns	10	ns
1"	Belair	0	0	3	0	0	2	0	0	3
Rotary	DALZ8501	15	7	2	13	7	1	12	6a	2
	DALZ8502	35a	22a	17a	18	13a	15a	27a	15a	11
	DALZ8508	0	4	8	0	4	8a	0	5	10
	DALZ8516	13	17a	17a	15	15a	3a	8	13a	15
	Cashmere	2	2	0	0	4	0	2	2	0
	El Toro	4	1	3	5	1	3	5	1	3
	Emerald	2	1	4	2	1	4	3	1	4
	Meyer	0	0	4	0	0	4	0	0	3
	TAES3372	7	3	3	6	2	3	7	2	3
	MSD entry	14	9	8	ns	8	8	14	11	ns
1"	Belair	2	0	4	2	0	4	2	0	4
Reel	DALZ8501	15a	10a	2	15	9a	2	8	10	2
	DALZ8502	23a	15a	12a	12	10a	12a	27a	15a	13a
	DALZ8508	0	3	8a	0	3	7a	0	3	7a
	DALZ8516	13a	17a	15a	13	17a	12a	12	17a	15a
	Cashmere	2	2	0	0	3	0	0	2	0
	El Toro	4	1	3	4	1	2	3	1	2
	Emerald	2	1	3	3	1	5a	2	2	4
	Meyer	0	0	3	0	0	3	0	0	3
	TAES3372	7a	4	3	6	3	3	7	3	3
	MSD entry	17	12	10	ns	11	7	11	10	9

[1] MSD entry = minimum significant difference between entry means within a column and mow treatment, based on the Waller-Duncan k-ratio t test (k-ratio = 100).

Table B3. Spring turf quality for zoysiagrasses managed under 3 mow heights and 3 nitrogen levels.

Mow Treatment	Entry	25 Jan (1#N/yr)	25 Feb (1#N/yr)	17 Mar (1#N/yr)	25 Jan (3#N/yr)	25 Feb (3#N/yr)	17 Mar (3#N/yr)	25 Jan (6#N/yr)	25 Feb (6#N/yr)	17 Mar (6#N/yr)	TPI[1]	Total TPI
5/8"	Belair	3.7	3.7	4.0	3.7	3.3	4.0	3.7	3.3	3.7	8	
Reel	DALZ8501	4.0	4.0	4.0	3.7	4.0	4.3	4.0	4.0	4.0	8	
	DALZ8502	3.3	3.3	4.3	3.7	3.7	4.3	3.3	3.3	4.0	8	
	DALZ8508	4.0	4.0	4.3	4.0	4.0	4.3	4.0	4.0	4.3	8	
	DALZ8516	4.0	3.7	5.0a	3.7	3.7	4.7	3.7	3.7	4.7	9	
	Cashmere	3.7	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	8	
	El Toro	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	8	
	Emerald	3.7	4.0	4.0	3.7	4.0	4.0	3.3	4.0	4.0	8	
	Meyer	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	8	
	TAES3372	4.0	3.7	4.0	4.0	3.7	4.0	3.7	3.7	4.0	8	
	MSD entry[1]	ns	ns	0.5	ns	ns	ns	ns	ns	ns		
1"	Belair	3.3	3.3	3.7	3.7	3.7	4.0	3.0	3.0	3.7	7	
Rotary	DALZ8501	4.0	4.0	4.0	3.7	4.0	4.0	3.7a	4.0	4.0	7	
	DALZ8502	4.0	4.0	4.7	3.7	4.0	4.7a	3.7a	3.7	4.3	9	
	DALZ8508	4.0	4.0	4.3	4.0	4.0	4.3	4.0a	4.0	4.3	8	
	DALZ8516	3.3	4.0	4.7	3.7	3.3	5.0a	4.0a	4.0	4.7	9	
	Cashmere	3.7	4.0	4.0	4.0	4.0	4.0	4.0a	4.0	4.0	8	
	El Toro	4.0	4.0	4.0	4.0	4.0	4.0	4.0a	4.0	4.0	8	
	Emerald	3.7	4.0	4.0	3.7	4.0	4.0	3.3a	4.0	4.0	8	
	Meyer	3.0	4.0	4.0	4.0	4.0	4.0	4.0a	4.0	4.0	8	
	TAES3372	3.7	3.3	3.7	3.7	3.7	3.7	2.7	3.7	4.0	7	
	MSD entry	ns	ns	ns	ns	ns	0.6	0.9	ns	ns		
1"	Belair	3.7	3.7	3.7	3.7	3.7	4.0	3.3	3.3	3.7	8	23
Reel	DALZ8501	4.0	4.0	4.0	3.7	3.7	4.0	3.7	4.0	4.0	8	24
	DALZ8502	3.7	4.0	4.3	4.0	3.3	4.7a	4.0	4.0	4.7	9	26
	DALZ8508	4.0	4.0	4.3	4.0	4.0	4.3a	4.0	4.0	4.3	9	25
	DALZ8516	3.7	3.7	4.7	3.3	3.3	4.7a	3.3	3.7	4.7	9	27
	Cashmere	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	8	24
	El Toro	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	8	24
	Emerald	3.3	4.0	4.0	3.7	4.0	4.0	3.3	3.7	4.0	8	24
	Meyer	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	8	24
	TAES3372	3.7	3.7	3.7	3.3	3.3	4.0	3.3	3.3	4.0	8	23
	MSD entry	ns	ns	ns	ns	ns	0.7	ns	ns	ns		

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

[2] MSD entry = minimum significant difference between entry means within a column and mow treatment, based on the Waller-Duncan k-ratio t test (k-ratio = 100). Means in the top statistical group are indicated by 'a'.

Table B4. Spring turf quality for zoysiagrasses managed under 3 nitrogen levels.

	25 Jan	25 Feb	17 Mar	25 Jan	25 Feb	17 Mar	25 Jan	25 Feb	17 Mar	
Entry	1#N/yr			3#N/yr			6#N/yr			TPI[1]
Belair	3.6	3.6	3.8	3.7	3.6a	4.0	3.3	3.2	3.7	3
DALZ8501	4.0	4.0a	4.0	3.7	3.9a	4.1	3.8a	4.0a	4.0	6
DALZ8502	3.7	3.8a	4.4	3.8	3.7a	4.6a	3.7a	3.7a	4.3	7
DALZ8508	4.0	4.0a	4.3	4.0	4.0a	4.3	4.0a	4.0a	4.3	6
DALZ8516	3.7	3.8a	4.8a	3.6	3.4	4.8a	3.7a	3.8a	4.7a	8
Cashmere	3.8	4.0a	4.0	4.0	4.0a	4.0	4.0a	4.0a	4.0	6
El Toro	4.0	4.0a	4.0	4.0	4.0a	4.0	4.0a	4.0a	4.0	6
Emerald	3.6	4.0a	4.0	3.7	4.0a	4.0	3.3	3.9a	4.0	5
Meyer	3.7	4.0a	4.0	4.0	4.0a	4.0	4.0a	4.0a	4.0	6
TAES3372	3.8	3.6	3.8	3.7	3.6a	3.9	3.2	3.6a	4.0	4
MSD entry[2]	ns	0.4	0.3	ns	0.5	0.3	0.5	0.6	0.3	

[1] TPI = turf performance index, which is the number of times an entry occurred in the top statistical group.
[2] MSD entry = minimum significant difference between entry means within a column and mow treatment, based on the Waller-Duncan k-ratio t test (k-ratio = 100).

Table B5. Spring turf quality for zoysiagrasses managed under 3 mow heights.

	25 Jan	25 Feb	17 Mar	25 Jan	25 Feb	17 Mar	25 Jan	25 Feb	17 Mar	
Entry	5/8" Reel			1" Rotary			1" Reel			TPI[1]
Belair	3.7	3.4	3.9	3.3	3.3	3.8	3.6	3.6	3.8	3
DALZ8501	3.9	4.0	4.1	3.8	4.0	4.0	3.8	3.9	4.0	6
DALZ8502	3.4	3.4	4.2	3.8	3.9	4.6	3.9	3.8	4.6	6
DALZ8508	4.0	4.0	4.3	4.0	4.0	4.3	4.0	4.0	4.3	6
DALZ8516	3.8	3.7	4.8	3.7	3.8	4.8	3.4	3.6	4.7	8
Cashmere	3.9	4.0	4.0	3.9	4.0	4.0	4.0	4.0	4.0	6
El Toro	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	6
Emerald	3.6	4.0	4.0	3.6	4.0	4.0	3.4	3.9	4.0	5
Meyer	4.0	4.0	4.0	3.7	4.0	4.0	4.0	4.0	4.0	6
TAES3372	3.9	3.7	4.0	3.3	3.6	3.8	3.4	3.4	3.9	4
MSD entry[2]	0.5	0.4	0.3	ns	0.5	0.3	0.4	0.5	0.3	

[1] TPI = turf performance index, which is the number of times an entry occurred in the top statistical group.
[2] MSD entry = minimum significant difference between entry means within a column and mow treatment, based on the Waller-Duncan k-ratio t test (k-ratio = 100).

Table B6. Spring turf quality of zoysiagrasses planted in management trial at TAES-Dallas.

Entry	13Apr
Belair	6.3a
DALZ8501	5.9
DALZ8502	7.2a
DALZ8508	7.3a
DALZ8516	6.7a
El Toro	7.6a
Emerald	6.6a
Meyer	7.4a
TAES3372	6.9a
TAES3477	6.8a
MSD entry[1]	1.2

[1] MSD entry = minimum significant difference between entry means within a column and mow treatment, based on the Waller-Duncan k-ratio t test (k-ratio = 100).

APPENDIX C

Vegetative Establishment of Three *Zoysia* Genotypes

S.J. Morton and M.C. Engelke.

Introduction

Zoysiagrass is generally solid sodded because it has a slow growth rate. However, solid sodding is an expensive method, because of the longer time of investment before crop harvest. Ruemmele, et al. (1993) reported that plugged zoysiagrass may require two or more years to fill the planted area. To overcome this problem the TAES-Dallas zoysiagrass breeding program has made selections to obtain faster spreading zoysiagrasses with superior turf performance. The objective of the study was to evaluate plugging methods for the establishment of three zoysiagrass genotypes, DALZ8507, DALZ8512, and DALZ8514. These lines have known drought tolerance, and once rooted, DALZ8512 and DALZ8514 are capable of growth in the Dallas climate and soil (Morton, et al., 1992; White, et al., 1993).

Materials and Methods

The zoysiagrasses were planted mid-August, 1992. A randomized complete block design, with four replications was used. Each genotype was planted by three methods: solid sodding, pre-rooted plugs, and cut plugs. Plugs were planted at a 1:30 tissue area: land area planting ratio. The solid sodded area of the DALZ8514 was planted at a 1:15 planting ratio, because sod stock was insufficient.

Plugs and sod were rolled after planting. Plants were watered every 2 days during the first 2 weeks, then watered weekly to prevent stress. Fertilizer, as NH_4NO_3 (34-0-0), was applied during the growing season as six monthly applications, each of 49 kg N/ha, for a total of 294 kg N/ha per year. Plantings were mowed at 5.0 cm.

Turf cover establishment was noted monthly as the visual estimate of the percentage of the plot area with turf ground cover. An ANOVA was employed to detect significant differences between treatment means and between entry means. When the ANOVA indicated the occurrence of a significant difference between the means at the alpha = 0.05 level, a Waller-Duncan k-ratio t test was used to separate means (SAS, 1987).

Results and Discussion

On April 29, 1993, which was after complete green up of the zoysiagrasses, percent turf cover in the sodded plots was less than expected (90 to 100%), probably from winter kill (Table C1). The same percentage winter kill probably occurred in the plugged plots. Consequently, turf cover development for the sodded plots is included in the results.

For DALZ8507 and DALZ8512, prerooted plug plantings and solid sodded plots were at least 80% filled by June 22, 1993, 10 months after planting. The DALZ8514 treatment containing the 1:30 planting ratio filled at the same rate as the treatment planted at the 1:15 ratio and had at least 80% turf cover on June 22, 1993. These findings suggest that using a higher planting ratio of prerooted plugs or solid sodding might not enhance overall coverage rate of these *Zoysia* genotypes when planted in North Central Texas in August.

Cut plugs of DALZ8507 and DALZ8512 were significantly slower to produce cover than prerooted plugs. Cut plugs of DALZ8514 were also slower growers than the prerooted plugs, yet not significantly slower. By June 22, 1993, at least 67% turf cover existed in all cut plug treatments for all genotypes. Overall, genotypes had approximately the same establishment rate within each treatment.

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Table C1. Turf cover establishment, noted monthly as percentage of plot area with turf, by experimental zoysiagrasses when planted by three planting methods.

Entry	Treatment	Percent Turf Cover 29Apr	31May	22Jun
DALZ8507	Cut plugs	38c[1]	55b	68[ns]
	Prerooted plugs	56b	85a	82
	Solid sod	78a	90a	88
	Mean entry	57	77	79
DALZ8512	Cut plugs	43c	41c	77b
	Prerooted plugs	59b	73b	91a
	Solid sod	76a	92a	92a
	Mean entry	59	69	87
DALZ8514	Cut plugs	39b	78[ns]	76[ns]
	Prerooted plugs	52a	79	91
	Solid sod	53a	75	82
	Mean entry	48	78	83
	MSD entry[2]	4	8	ns

[1] Treatment means within a entry category that are followed by the same letter were not significantly different, based on the Waller-Duncan k-ratio t-test (k-ratio = 100). ns = no significant difference occurred between treatment means.
[2] MSD entry = minimum significant difference between entry means within columns, based on Waller-Duncan k-ratio t test (k-ratio = 100). ns = no significant difference occurred between entry means.

APPENDIX D

Performance of Three Warm-Season Turfgrass Genera Cultured in Shade III. *Zoysia* spp.

S.J. Morton and M.C. Engelke

Introduction

In previous work it had been observed that some *Zoysia* genotypes have excellent shade tolerance (Morton, et al., 1991). It was the objective of this study to continue the evaluation of the turf performance of 25 *Zoysia* genotypes when maintained under shade.

Materials and Methods

The 1991 National Turfgrass Evaluation Program (NTEP) zoysiagrass series was planted into a live-oak shaded site at TAES-Dallas on September 1, 1992. The trial had 25 entries, including six commercial varieties, and one proprietary experimental accession, ITR90-3. Four of the entries, JZ-1#A89, Korean Common, TGS-B10, and TGS-W10, were seeded types, which were germinated and propagated into plugs before field planting. A randomized complete block with three replications was used. Each entry was planted into 0.6 m x 0.6 m plots at a 1:16 tissue area: land area planting ratio. Plots were maintained under 90% shade, mowed at 5.0 cm, and irrigated weekly to prevent water stress. Incident light was measured under the canopy and in direct sunlight with a pyranometer (Li-Cor 170 photometer). Shade was calculated as the percentage of direct sunlight that occurred under canopy. Two applications of fertilizer were applied, as NH_4NO_3 (34-0-0), at 24.5 kg N/ha each, for a total of 49 kg N/ha per year.

Entries were evaluated for their ability to spread, maintain green turf cover, and their overall turf quality. The ability to spread was estimated monthly as the percentage of the plot area with turf cover. The persistence of green turf cover was estimated monthly as the percentage of the turf cover that was green. Overall turf quality encompassed components of canopy density, color quality, turf cover, uniformity of appearance, and leaf texture. Turf quality and color quality were each rated on a scale of 1 to 9, where 9 was the best turf quality or darkest green color, and 5 was the minimum acceptable turf quality or green color, respectively (Hickey and Engelke, 1984). Evaluations of fall color retention, as the percentage of the turf that retained green turf cover, were started on November 9, 1992.

Data were analyzed by ANOVA. When significant differences among entry means occurred (alpha = 0.05), a Waller-Duncan mean separation test was performed to determine statistical separations among groups (SAS Institute, 1985)).

Results and Discussion

On August 3, 1993, color quality ratings $\geq$ 5.0 were observed for half of the entries (Table D1). 'Emerald,' 'El Toro,' and 'Belair' had the darkest green colors among commercial entries. Eight of the ten DALZ lines, and TC2033 and ITR90-3 had the darkest green colors among the experimental lines. However, none of the entries had ratings greater than 7.0, on a scale of 0 to 9, where 9 was the darkest green turf. DALZ8507, QT2047, and CD2013 had the poorest green color in the shade (ratings < 4.3). Among commercial varieties, 'Korean Common' and 'Meyer' had the poorest color (ratings = 4.7) when cultivated in the shade.

During May and June, 1993, when rainfall was above normal and incident light higher due to the lower solar angle, green cover was 70% or more for most zoysiagrass entries (Table D2). As the trees began to shade the grasses more, and rainfall ceased, green cover was lost, and at different rates for the entries. DALZ8502, DALZ8508, DALZ8510, DALZ8514, DALZ8516, and 'Emerald' were slow to lose green cover and had good color quality on August 3. DALZ8507, CD2013, CD259-13, QT2004, JZ-1#A89, TGS-B10 (experimental entries), and 'Korean Common' lost the most green turf cover over the summer.

Turf cover doubled for all entries eleven months after planting (Table D3). There were no significant differences among the entries during establishment in the shade. All plots had about 45% turf cover by August 3, 1993.

The highest turf quality ratings overall were during June (Table D4). DALZ8502, DALZ8510, DALZ8514, DALZ8516, and 'Emerald' maintained good turf quality into August. All other entries that had good turf quality in June, had turf quality ratings < 5.0 in August. 'Belair', CD259-13, DALZ8507, and QT2004 consistently had the poorest turf quality when maintained in shade.

Future work will investigate the perennial performance of these shade-grown zoysiagrasses. Performance characteristics to be monitored will include overall turf quality and turf quality components of canopy density, color quality, turf cover development, and the ability to maintain green turf cover.

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Table D1. Color quality on August 3, 1993, for zoysiagrasses of the 1991 NTEP planted in 90% shade at TAES-Dallas.

Entry	Color Quality[1] 3Aug
Emerald[2]	6.3a[3]
DALZ8502	6.0ab
DALZ8514	6.0ab
DALZ8510	5.7abc
DALZ8512	5.7abc
DALZ8516	5.7abc
DALZ8701	5.7abc
Belair	5.3abcd
DALZ8501	5.3abcd
DALZ8508	5.3abcd
El Toro	5.3abcd
ITR90-3	5.3abcd
TC2033	5.3abcd
DALZ9006	5.0 bcde
Sunburst	5.0 bcde
TC5018	5.0 bcde
TGS-W10*	5.0 bcde
CD259-13	4.7 cde
QT2004	4.7 cde
Korean Common*	4.7 cde
Meyer	4.7 cde
TGS-B10*	4.7 cde
JZ-1#A89*	4.3 de
CD2013	4.0 ef
QT2047	4.0 ef
DALZ8507	3.3 f

[1] Color quality was estimated on a scale of 1 to 9, where 9 was the darkest green color, and 5 was the minimum acceptable green color.
[2] CD = Crenshaw & Doguet Turf Farm; DALZ = Texas A&M Univ. at Dallas; ITR = Innovative Turfgrass Research; JZ = Jacklin Seed Co.; QT = Quality Turf; TC = Turf Center, Inc.; TGS = TG Services, Inc.
[3] Means with the same letter within a column were not significantly different, based on the Waller-Duncan k-ratio t test (k-ratio = 100).
*Seeded entries.

Table D2. Green turf cover, as the percentage of turf ground cover that is green, for zoysiagrasses of the 1991 NTEP planted in 90% shade at TAES-Dallas.

	Percent green turf cover					
	1992	1993				
Entry	9Nov	7May	8Jun	9Jul	3Aug	TPI[1]
Emerald	70a	67	89	68a	67a	5
DALZ8514	80a	88	95	77a	63a	5
DALZ8502	80a	81	95	77a	62a	5
DALZ8508	77a	88	92	73a	60a	5
DALZ8510	77a	88	95	75a	57a	5
DALZ8516	75a	80	92	65a	57a	5
DALZ8701	80a	88	71	63a	52	4
TC2033	70a	77	89	62a	50	4
DALZ8501	78a	90	87	62a	45	4
ITR90-3	58	68	83	58	53a	3
El Toro	55	70	64	67a	52	3
TGS-W10*	50	75	89	65a	52	3
DALZ8512	72a	83	75	58	52	3
Meyer	53	77	82	62a	45	3
DALZ9006	70a	76	88	60	45	3
Sunburst	70a	89	69	55	42	3
CD2013	77a	88	86	53	37	3
DALZ8507	67a	67	88	47	28	3
TC5018	58	78	83	57	52	2
Belair	52	68	69	53	47	2
Korean Common*	50	93	87	55	40	2
TGS-B10*	53	85	77	50	40	2
QT2047	32	73	43	45	40	2
QT2004	55	69	82	55	38	2
JZ-1#A89*	58	80	59	52	38	2
CD259-13	28	47	38	42	38	2
MSD entry[2]	16	ns	ns	16	14	

[1] TPI = turf performance index, which is the number of times an entry occurred in the top statisical group.
[2] MSD entry = minimum significant difference between entry means for comparison within columns, which is based on the Waller-Duncan k-ratio t test (k-ratio = 100). ns = no significant difference occurred between entry means within a column. Means in the top statistical group are indicated by 'a'.
*Seeded entries.

Table D3. Turf cover, as the percentage of the plot with turf ground cover, for zoysiagrasses of the 1991 NTEP planted in 90% shade at TAES-Dallas.

	Percent turf cover				
	1992	1993			
Entry	9Nov	7May	8Jun	9Jul	3Aug
Belair	20[1]	30	33	47	45
CD2013	23	31	33	48	45
CD259-13	20	30	25	45	42
DALZ8501	22	30	32	50	47
DALZ8502	22	30	35	52	47
DALZ8507	20	30	33	52	45
DALZ8508	20	30	28	50	45
DALZ8510	21	31	28	55	47
DALZ8512	25	33	35	55	48
DALZ8514	20	28	30	50	43
DALZ8516	27	34	37	53	47
DALZ8701	27	33	28	58	48
DALZ9006	23	33	35	58	50
El Toro	20	30	27	55	47
Emerald	20	30	30	50	43
QT2004	20	30	27	48	45
QT2047	23	32	28	48	42
ITR90-3	22	30	32	53	47
JZ-1#A89*	20	29	30	50	45
Korean Common*	22	30	30	48	43
Meyer	18	29	28	47	43
Sunburst	23	32	33	52	45
TC2033	25	31	30	50	45
TC5018	20	30	28	48	43
TGS-B10*	22	33	30	48	45
TGS-W10*	22	30	30	50	47

[1] No significant differences between entry means occurred for any note date, based on the Waller-Duncan k-ratio t test (k-ratio = 100).
*Seeded entries.

Table D4. Turf quality for zoysiagrasses of the 1991 NTEP planted in 90% shade at TAES-Dallas.

	Turf quality[1]				
	1993				
Entry	7May	8Jun	9Jul	3Aug	TPI[2]
DALZ8502	5.3a	8.3a	6.3a	6.0a	4
Emerald	4.7a	8.0a	6.0a	6.0a	4
DALZ8514	6.0a	7.7a	6.7a	5.3a	4
DALZ8510	5.0a	7.3a	6.3a	5.0a	4
DALZ8516	6.0a	7.3a	5.7a	5.0a	4
DALZ8508	5.0a	7.3a	6.0a	4.7	3
TGS-W10*	5.0a	7.3a	5.7a	4.7	3
DALZ8501	6.3a	7.3a	5.7a	4.3	3
DALZ9006	4.7a	7.3a	5.3a	4.3	3
DALZ8512	5.3a	6.7	6.0a	4.7	2
El Toro	4.7a	6.7	6.0a	4.7	2
TC5018	4.7a	7.0	5.7a	4.7	2
ITR90-3	3.7	7.3a	5.3a	4.7	2
TC2033	5.3a	7.0	5.3a	4.7	2
DALZ8701	6.0a	7.0	6.0a	4.3	2
Sunburst	5.7a	6.7	5.3a	4.0	2
Korean Common*	5.0a	7.0	5.3a	3.3	2
TGS-B10*	5.3a	6.3	5.3a	3.3	2
Meyer	4.3	7.0	5.3a	4.0	1
QT2047	4.7a	6.3	4.7	3.7	1
CD2013	5.0a	7.0	5.0	3.3	1
JZ-1#A89*	4.3	6.3	5.3a	3.3	1
Belair	4.3	7.0	4.7	4.3	-
CD259-13	3.0	6.3	4.7	3.7	-
QT2004	4.3	7.0	5.0	3.7	-
DALZ8507	4.0	7.0	4.7	3.0	-
MSD entry[3]	1.8	1.0	1.4	1.3	

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

APPENDIX E

1993 Update to the 1991 National Turfgrass Evaluation Program (NTEP) Zoysiagrass trial at TAES-Dallas.

S.J. Morton and M.C. Engelke

Introduction

Zoysia has a wide range of adaptations among its genotypes, including drought and salinity tolerance (Morton, et al., 1992, White, et al., 1993, Marcum, et al., 1993). These attributes contribute to the potential of some of its genotypes as a low maintenance turf. Currently, *Zoysia* is less frequently cultivated than other warm-season grasses, but is being utilized more as water supplied for irrigation becomes more scarce and saline. Much breeding effort has focused on developing tolerant grasses with good turf quality characteristics. In line with objectives of the National Turfgrass Evaluation Program (NTEP), the study was designed to evaluate turf performance of 25 *Zoysia* genotypes at TAES-Dallas.

Materials and Methods

Twenty four NTEP entries plus one TAES-Dallas accession were planted in native blackland prairie soil at TAES-Dallas on June 14, 1991. The experiment was a randomized complete block design with three replications. All entries were planted as plugs at a 1:48 planting ratio into 1.83 m x 1.83 m plots. Seeded entries were germinated and grown into plugs prior to field planting. The experiment was watered as needed to prevent water stress, and was maintained at a 5.0 cm mowing height. Three 49 kg N/ha applications of NH_4NO_3 (34-0-0) were applied, for a total fertilizer level of 147 kg N/ha per year.

Turf performance was evaluated by considering the separate components of turf quality (canopy density, color quality, turf cover, leaf texture, and uniformity of stand) and as well as the overall turf quality of the zoysiagrasses. Density, color quality, and overall turf quality were each rated on a scale of 0 to 9, in which 9 represented the best level of the character, and 5 represented the minimum acceptable level (Hickey and Engelke, 1984). Uniformity of stand included uniformity in color, density, and turf cover distribution, and was rated on a scale of 1 to 3, in which 3 was 90 to 100% uniform for all three characters, and 2 represented 50 to 89% uniformity. Turf cover was estimated as the percentage of the plot area with turf ground cover. Green cover was estimated as the percentage of the turf ground cover that was green.

An ANOVA was used to test for significant differences among entry means. When a significant difference between entry means occurred, a Waller-Duncan k-ratio t-test was performed to separate entry means (alpha = 0.05). (SAS, 1987).

Results and Discussion

Color Quality
In February, 1993, 'Emerald', 'Meyer', 'Korean Common', 'Sunburst', all commercial entries available, and eight experimental entries had a golden dormant color ($3.0 \leq$ color quality ≤ 4.3) (Table E1). All entries with ratings less than 3.0 were grey when dormant. DALZ8502, TC5018, QT2047 had green color present, and earned ratings ≥ 4.7.

By April 29, all entries had color ratings ≥ 4.7, and had minimum acceptable color. Differences in color existed among the entries, but the variability between reps was high, thus there was no statistical difference between color ratings. Variability resulted from differences in green-up among the reps. On May 31, 1993, 'Emerald', 'Meyer', and 'Belair' were the highest rated commercially available entries, and DALZ8502, DALZ8516, TGS-W10, CD259-13, TC2033 were among the darkest green experimental entries.

Spring Green Up
Complete plot green up was earlier in 1993 than in 1992, (Table E2). This earlier green up was documented by the March 31, 1993 ratings, in which all but one entry, DALZ8501, had at least two-thirds of the plots with green cover. By comparison, on April 8, 1992, only half of the entries had two-thirds green cover.

In both years, DALZ8502 maintained some green cover during the winter. By late March all entries had begun the green-up process. Fifteen entries were in the group with the most green turf cover both years during March. However, only DALZ8512, DALZ8514, 'Emerald', QT2047, and TC5018 were in the top group during April for both years. The slowest group to green up in both years included DALZ8501, DALZ8508, and Korean Common.

Fall Green Cover Retention
On November, 1992, DALZ8502, DALZ9006, and 'Emerald' retained $\geq$ 67% green turf cover (Table E2). In contrast, thirteen entries, including 'Korean Common', QT2047, TGS-B10, and DALZ8514, already had less than 45% green cover.

Turf Cover Establishment
In July 1992, one year after planting, DALZ8512, 'Sunburst', 'El Toro', TC5018, 'Korean Common', DALZ8514, QT2047, CD259-13, and JZ#1A89-1, had at least 60% turf cover (Table E3). DALZ8516, ITR90-3, and DALZ8501 were among the slowest to establish full plot cover.

Turf Quality
Overall turf quality as measured by the turf performance index (TPI) was consistently greatest for both years for TC2033, DALZ8502, DALZ9006, QT2004, QT2047, and DALZ8507 (Table E4). 'Emerald', 'Meyer', and 'El Toro' were consistently the best among the commercial entries. Highest ratings in 1992 for all entries were observed during summer months. The poorest overall performance was observed for the experimental lines DALZ8501, ITR90-3, and TGS-W10. The worst performing commercial entry was 'Korean Common'.

References Cited

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Table E1. Color quality during 1993 for 1991 NTEP zoysiagrasses planted at TAES-Dallas.

Entry	Color quality[1] 1993 24Feb	29Apr	31May	TPI[2]
DALZ8502[3]	6.0a	7.3	8.0a	3
DALZ8516	2.7	6.7	8.3a	2
Emerald	3.3	7.0	8.0a	2
Meyer	4.3	7.0	7.3a	2
TGS-W10*	3.3	7.0	7.3a	2
Belair	2.3	7.3	7.0a	2
CD259-13	3.3	6.3	7.0a	2
TC5018	4.7a	7.0	6.7	2
TGS-B10*	3.0	7.0	6.7	2
QT2047	5.0a	6.0	6.7	2
DALZ8512	1.3	6.3	5.7	2
DALZ9006	3.0	7.7	8.0	1
TC2033	3.0	6.7	7.7a	1
DALZ8508	2.3	6.3	7.7a	1
QT2004	2.7	5.3	6.7	1
ITR90-3	3.0	6.3	6.3	1
CD2013	2.7	5.3	6.3	1
DALZ8514	1.7	7.0	6.0	1
El Toro	1.7	7.0	6.0	1
DALZ8701	3.0	6.0	6.0	1
Korean Common*	3.3	5.7	6.0	1
Sunburst	3.3	6.3	5.7	1
JZ#1A89-1*	3.0	6.3	5.7	1
DALZ8507	2.0	6.3	5.7	1
DALZ8501	2.3	4.7	5.3	1
MSD entry[4]	1.4	n.s.	1.5	

[1] Color quality was rated on a scale of 1 to 9, where 9 was the darkest green color, and 5 was the minimum acceptable green color.
[2] TPI = turf performance index, which is the number of times an entry occurred in the top statistical group.
[3] CD = Crenshaw & Doguet Turf Farm; DALZ = Texas A&M Univ. at Dallas; ITR = Innovative Turfgrass Research; JZ = Jacklin Seed Co.; QT = Quality Turf; TC = Turf Center, Inc.; TGS = TG Services, Inc.
[4] MSD entry = minimum significant difference between entry means, based on Waller-Duncan k-ratio t test (k-ratio=100).
* Seeded entries.

Table E2. Spring green up and fall green cover retention, as percentage of the turf ground cover that was green, during 1992 and 1993 for 1991 NTEP zoysiagrasses planted at TAES-Dallas.

	Percent green turf cover								
	1992				1993				
Entry	24Feb	26Mar	8Apr	13Nov	20Jan	24Feb	31Mar	29Apr	TPI[1]
DALZ8502	10a	42a	35	82a	52a	48a	93a	93a	7
Emerald	5	70a	67a	67a	22	11	87a	86a	5
DALZ8516	8a	47a	42	62	28	23	87a	92a	4
DALZ9006	6	48a	42	67a	18	14	87a	88a	4
QT2047	3	65a	85a	30	0	1	77a	88a	4
TC5018	4	52a	70a	33	0	2	77a	83a	4
DALZ8512	4	45a	67a	38	1	4	78a	83a	4
DALZ8514	4	43a	72a	35	0	3	78a	82a	4
El Toro	4	43a	62	43	1	3	80a	88a	3
Meyer	4	53a	50	47	5	6	85a	87a	3
QT2004	3	50a	55	53	3	4	80a	83a	3
TC2033	4	47a	57	52	7	7	82a	80a	3
JZ#1A89-1*	3	45a	68a	43	0	1	72	80a	3
Sunburst	4	60a	78a	37	0	2	73	79a	3
CD259-13	4	58a	72a	33	0	1	72	78a	3
TGS-W10*	4	68a	83a	47	2	6	83a	76	3
TGS-B10*	4	65a	70a	30	0	2	80a	72	3
DALZ8701	2	10	10	48	18	14	77a	87a	2
ITR90-3	4	58a	47	45	0	4	70	87a	2
DALZ8507	4	47a	48	38	4	5	70	84a	2
CD2013	4	50a	53	47	1	4	73	83a	2
Korean Common*	3	52a	75a	28	1	0	75	72	2
Belair	4	47a	60	33	2	5	78a	70	2
DALZ8501	3	23	33	58	10	9	63	82a	1
DALZ8508	4	35	37	53	5	6	80a	72	1
MSD entry[2]	2	29	21	17	10	5	18	16	

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

[2] MSD entry = minimum significant difference between entry means, which is based on the Waller-Duncan k-ratio t test (k-ratio = 100).

* Seeded entries.

Table E3. Turf cover, as the percentage of the plot with turf, during 1992 for 1991 NTEP zoysiagrasses planted at TAES-Dallas.

	Turf cover			
	1992			
Entry	27Mar	15Jun	23Jul	TPI[1]
DALZ8512	40a	94	90a	3
Sunburst	28	90	90a	2
El Toro	36a	93	88a	3
TC5018	32a	83	80a	3
Korean Common*	32a	70	80a	3
DALZ8514	40a	91	68a	3
QT2047	37a	70	65a	3
CD259-13	33a	78	63a	3
JZ#1A89-1*	31a	70	62a	3
Emerald	30a	90	57	2
TC2033	32a	88	52	2
DALZ8507	28	83	50	1
TGS-B10*	30a	78	48	2
QT2004	27	65	47	1
TGS-W10*	30a	65	43	2
DALZ8502	27	75	42	1
DALZ9006	31a	88	38	2
Meyer	22	77	38	1
CD2013	28	58	38	1
Belair	28	63	35	1
DALZ8508	28	70	33	1
DALZ8701	28	80	30	1
DALZ8501	31a	62	28	2
DALZ8516	27	57	22	1
ITR90-3	20	57	22	1
MSD entry[2]	11	ns	31	

[1] TPI = turf performance index, which is the number of times in which an entry occurred in the top statistical group.
[2] MSD entry = minimum significant difference between entry means, which is based on the Waller-Duncan k-ratio t test (k-ratio = 100).
* Seeded entries.

Table E4. Mean turf quality during 1992 and 1993 for 1991 NTEP zoysiagrasses planted at TAES-Dallas.

	Turf quality[1]														
	1991	1992								1993					
Entry	22 Nov	27 Mar	12 May	14 Jun	23 Jul	26 Aug	26 Sep	23 Nov	9 Dec	20 Jan	24 Feb	31 Mar	29 Apr	31 May	TPI[2]
Emerald	2.7a	3.3a	6.0a	5.3	5.0a	6.7a	6.0	3.3	3.7a	4.0	4.0a	5.7	6.3	6.7	14
TC2033	2.7a	3.0a	6.0a	6.0	4.7a	5.7a	4.7	3.3	3.7a	4.0	4.0a	5.0	6.3	6.7	14
DALZ8502	3.3a	3.7a	3.7	4.3	4.0a	5.7a	3.7	3.0	3.0a	3.3	5.3a	6.0	6.7	7.7	13
DALZ9006	2.7a	3.0a	5.7a	5.7	4.3a	5.3	5.0	3.7	3.3a	4.0	4.0a	5.3	6.7	6.7	13
Meyer	2.3	3.0a	5.3a	4.7	4.0a	6.3a	5.0	3.3	3.3a	4.0	3.7a	5.0	6.3	6.3	13
QT2004	2.7a	3.0a	5.3a	4.0	4.3a	6.0a	4.7	3.3	3.3a	4.0	3.3	4.0	5.0	6.3	13
QT2047	2.0	3.7a	6.0a	4.7	5.3a	6.0a	4.3	3.7	3.7a	4.3	4.3a	5.0	6.0	6.0	13
DALZ8507	3.0a	3.0a	5.3a	5.7	4.7a	4.3	4.3	3.3	3.7a	3.7	3.7a	4.7	5.3	4.7	13
DALZ8514	2.3	2.7a	6.7a	6.3	5.7a	4.3	4.7	3.7	4.0a	4.0	3.7a	5.7	6.3	5.3	12
TGS-B10*	2.0	2.7a	6.0a	5.3	4.7a	6.0a	5.0	3.3	3.7a	4.0	3.0	4.3	5.3	5.3	12
CD259-13	2.0	3.0a	6.0a	5.3	5.7a	5.3	4.3	3.7	4.0a	4.0	4.3a	4.7	6.0	5.0	12
DALZ8512	2.7a	2.7a	6.3a	6.3	6.7a	5.0	4.7	3.3	4.0a	4.0	2.3	5.3	6.0	4.7	12
Belair	2.0	2.7a	5.3a	4.3	3.7a	6.3a	4.3	3.0	3.3a	3.7	3.0	4.3	4.7	4.3	12
TC5018	2.0	3.0a	5.3a	5.7	6.0a	5.3	4.7	3.3	4.0a	4.0	3.3	5.0	7.0	6.7	11
El Toro	2.3	2.7a	6.3a	6.7	6.0a	5.3	5.0	3.7	4.0a	4.0	2.7	5.7	6.0	6.0	11
JZ#1A89-1*	2.0	3.0a	5.3a	4.0	5.0a	5.3	4.3	3.3	4.0a	3.7	2.7	4.7	5.7	5.3	11
DALZ8508	2.3	2.7a	5.5a	5.0	3.3	5.0	4.7	3.3	3.3a	3.7	4.0a	5.3	5.0	5.3	11
Sunburst	2.0	3.3a	6.3a	5.0	6.3a	4.0	4.7	3.7	4.0a	3.7	2.3	4.3	5.3	5.0	11
CD2013	2.7a	2.7a	5.0	4.7	4.0a	5.0	5.0	3.3	3.7a	4.0	3.3	4.7	5.7	4.0	11
DALZ8516	2.3	2.3a	3.0	4.0	2.3	6.7a	4.3	3.3	3.0a	3.7	3.3	5.3	5.0	5.3	10
Korean Common*	2.0	2.7a	5.0	4.3	5.3a	5.3	4.7	3.0	3.3a	4.0	2.0	4.0	4.3	5.0	10
DALZ8701	3.0a	1.0	3.0	4.3	4.3a	4.0	4.0	2.7	3.0a	3.7	3.3	4.3	5.0	4.3	10
TGS-W10*	2.0	3.3a	4.0	4.0	4.0a	5.7a	3.7	2.7	2.7	3.0	2.0	4.3	4.7	4.3	10
DALZ8501	2.3	1.7	5.0	4.0	2.7	4.3	3.7	3.3	3.3a	4.0	3.0	4.3	4.7	3.7	10
ITR90-3	1.7	2.0	4.0	4.3	2.3	5.3	4.3	3.3	3.0a	3.3	2.7	4.7	4.7	3.0	8
MSD entry[3]	0.9	1.6	1.5	ns	3.2	1.3	ns	ns	1.2	ns	2.0	ns	ns	ns	

[1] Turf quality was rated on a scale of 1 to 9, where 9 represented the best turf quality, and 5 was the minimum acceptable turf quality.
[2] TPI = turf performance index, which was the number of times an entry occurred in the top statistical group.
[3] MSD entry = minimum significant difference between entry means, which is based on the Waller-Duncan k-ratio t test (k-ratio = 100).

APPENDIX F

Regional Trials

New regional trials were planted at the sites listed in Table 1 during 1992 and 1993. Evaluations of establishment and overall performance will be monitored. Dr. Mike Kenna is monitoring the DALZ8507 at Rancho San Carlos. Tim Taylor reported the zoysiagrasses at the Richland Course are filling nicely. He will be sending some data on general appearance and disease problems. David Stone has promised some data for us to analyze. Dr. Charles Peacock indicated that the DALZ8502 green at the Colleton River Plantation is filling quickly, and will be in peak condition in spring. The plots at the Old Ranch Country Club in Seal Beach, CA have completely filled, and their performance will be monitored during the upcoming year.

Data was submitted by John Dunn from a regional trial at University of Missouri at Columbia. Color ratings in October, 1992, ranged from 5.7 to 6.7 for all entries except Belair, which had significantly poorer color (4.3) (Table F2). By May, 1993, all but DALZ8507 and Emerald had color ratings greater than 5.0 (Table F3). Color ratings ranged from 5.0 to 7.0. El Toro, DALZ8512, and Z. matrella were significantly greener than DALZ8507 and Emerald.

DALZ8507 had the best overall turf quality during summer 1993 (TPI = 4) (Table F4). Belair, DALZ8514, and Meyer had the lowest quality ratings overall, although all had ratings greater than 5.3.

The following zoysiagrasses are in quarantine in Hawaii under the name of Southern Turf Nurseries: DALZ8501, DALZ8507, DALZ8508, DALZ8512, DALZ8514, DALZ8516, DALZ8701, DALZ9006.

Table F1. Sites of zoysiagrass regional trials planted during 1992 and 1993.

Date Sent	Contact	Site	City	Entries	Purpose
6/1/92	Jeff Froke	Rancho San Carlos	Carmel, CA	DALZ8507	Irrigation Trial
6/1/92	David Stone	Honors Course	Ooltewah, TN	DALZ8507	Field trial
				DALZ8508	
				DALZ8512	
				DALZ8514	
7/20/92	Tim Taylor	Richland Country Club	Nashville, TN	DALZ8507	Field trial
				DALZ8512	
				DALZ8514	
9/14/92	Don Parsons	Old Ranch Country Club	Seal Beach, CA	DALZ8501	Field trial
				DALZ8502	
				DALZ8507	
				DALZ8508	
				DALZ8510	
				DALZ8512	
				DALZ8514	
				DALZ8516	
				DALZ8701	
				DALZ9006	
9/14/92	Stan Brauen	Washington State Univ.	Pullayup, WA	DALZ8507	Field trial
				DALZ8510	
				DALZ8512	
				DALZ8514	
4/12/93	Frank Wicker	USGA, Vineyard Knolls	Napa, CA	DALZ8502	Demo plots
				DALZ8507	
6/14/93	Charles Peacock	Colleton River Plantation c/o NCSU	Hilton Head, SC Raleigh, NC	DALZ8502	Green
7/1/93	Ray Smith	Ciba-Geigy Research	College Station, TX	DALZ8501	Chemical studies
8/2/93	Reed Yenny	Mesa Verde Country Club	Costa Mesa, CA	DALZ8501	Field trial
				DALZ8502	
				DALZ8507	
				DALZ8508	
				DALZ8510	
				DALZ8512	
				DALZ8514	
				DALZ8516	
				DALZ9006	
93	Tom Diamond	Colonial Country Club	Fort Worth, TX	DALZ8502	4500 ft^2 Chipping green 1500 ft^2 Tee Box

Table F2. Color during 1992 for Missouri zoysiagrass regional trial.

Entry	Oct
Belair	4.3
DALZ8507	6.0a
DALZ8508	5.7a
DALZ8512	6.7a
DALZ8514	6.0a
El Toro	6.3a
Emerald	6.0a
Z. matrella	6.7a
Meyer	6.0a
LSD entry[1]	1.1

[1] LSD entry = least significant difference between entry means, based on Fisher's LSD (alpha = 0.05). Means in the top statistical group are indicated by 'a'.

Table F3. Spring green up in 1993 for Missouri zoysiagrass regional trial.

Entry	May
Belair	5.7a
DALZ8507	4.0
DALZ8508	5.0a
DALZ8512	6.7a
DALZ8514	6.0a
El Toro	7.0a
Emerald	4.0
Z. matrella	6.7a
Meyer	6.0a
LSD entry[1]	2.1

[1] LSD entry = least significant difference between entry means, based on Fisher's LSD (alpha = 0.05). Means in the top statistical group are indicated by 'a'.

Table F4. Turf quality during 1993 for Missouri zoysiagrass regional trial.

Entry	June	July	Aug	Sept	TPI[1]
Belair	5.3	5.7	5.8	6.0	1
DALZ8507	7.0	7.2a	7.3a	7.5a	4
DALZ8508	6.0	7.5a	7.2a	7.0	3
DALZ8512	6.2	7.3a	6.3	6.5	2
DALZ8514	6.3	6.8	6.5	6.3	1
El Toro	7.2	7.2a	6.7	6.5	2
Emerald	6.2	7.3a	8.0a	7.3	3
Z. matrella	6.2	6.5	7.5a	8.2a	3
Meyer	6.2	5.8	5.7	6.7	1
LSD entry[2]	ns	0.6	1.2	0.7	

[1] TPI = turf performance index, which is the number of times an entry occurred in the top statistical group.
[2] LSD entry = least significant difference between entry means, based on Fisher's LSD (alpha = 0.05). Means in the top statistical group are indicated by 'a'.

APPENDIX G

Zoysiagrass for Greens: Evaluation of Over-wintering Requirements and Putting Speed

M.C. Engelke, S.J. Morton, and R. Cunningham

Introduction

The need to decrease cultural inputs on golf course greens has become an important issue in recent years. Bentgrass greens have the most desirable play characteristics of grasses currently in use. During the summer months bentgrasses usually requiring high water and pesticide inputs when planted on golf courses in the southern United States. Bermudagrass greens have poor winter color retention, and are often overseeded in the fall to enhance the percentage green turf cover and playability during the winter. The genus *Zoysia* includes genotypes which have good green color retention in the fall, and have the heat and drought tolerance that is characteristic of many warm-season turf grasses. The objective of this study was to evaluate the overwintering requirements and the effects of overwintering procedures on the putting speed of an experimental *Zoysia* genotype. The genotype selected, DALZ8502, has shown a greens quality growth habit and has the prolonged green color retention that is desired.

Material & Methods

The DALZ8502 zoysiagrass was solid sodded onto a modified sand base on June 10, 1992, at the turf facility at TAMU-REC-Dallas. The grass was irrigated daily and allowed to establish. After the sod had rooted, the grass was maintained at 5 mm mowing height, and daily irrigation was continued. After establishment and prior to March, 1993, 24.5 kg N/ha was applied monthly. Beginning in March, 1993, 24.5 kg N/ha was applied every two months.

Half of the green was overseeded with a mixture of bentgrass (*Agrostis* spp.), rough bluegrass (*Poa trivialis*) and fine fescue (*Festuca rubra*) on October 7, 1992 (seeding rate was 269 kg/ha (5.5 lb/1000 ft^2); the blend was 50% bent: 25% bluegrass: 25% fescue; percentage was based on seed count). A woven thermal blanket was applied to half of the green whenever air temperature dropped below 40° F for protection from frost. One-half of the seeded area and one-half of the nonseeded area were covered. The green was thus divided into four sections, one with no seed and no cover, one with no seed but with cover, one with seed but no cover, and one with seed and cover.

Stimp measurements were taken as a measure of the putting speed of the green. Stimp is the distance which a golf ball rolls after release from a stimpmeter held at a height to release the ball. Weekly readings were taken from September 9, 1992, to June 30, 1993. Four stimp readings were taken in each of the four sections of the green.

The amount of green turf cover was noted during the winter months and during the removal of the cool-season grasses. Green turf cover was estimated as the percentage of the turf ground cover that was green. Four sub-samples were taken per treatment section of the green.

Means were calculated for each treatment section. Comparative statistics are not appropriate for the data, as this is only one replication. All statements regarding comparisons between the treatments should be taken with caution. Repetitions across years will be required to make substantive claims.

Results and Discussion

Putting Speed

There were no differences in stimp readings between the overseeded and only zoysiagrass areas from October 7, 1992, through January 20, 1993. However, differences among the four quadrants were observed from January 20, through June 30, 1993 (Figure G1). During the spring, the non-seeded areas had a higher stimp than the seeded areas. As summer progressed stimp on the seeded half was higher overall, the presence of the cover slowed the stimp.

Green Turf Cover

Green cover was different among the four quadrants (Table G1). During the winter (January 1 through March 7), the seeded, covered area had the most green cover and the unseeded, uncovered area consistently had the lowest percentage of green cover. From January to March, the unseeded, covered area had 50 to 85% green cover. This was less green cover than in the seeded areas (86 to 97%), but was more green cover than the uncovered, unseeded area (41 to 74%). Thus, it can be inferred that application of the thermal blanket is sufficient to maintain green playable cover during winter.

Future work will continue monitoring of the playability and overwintering requirement of this warm-season greens quality turf.

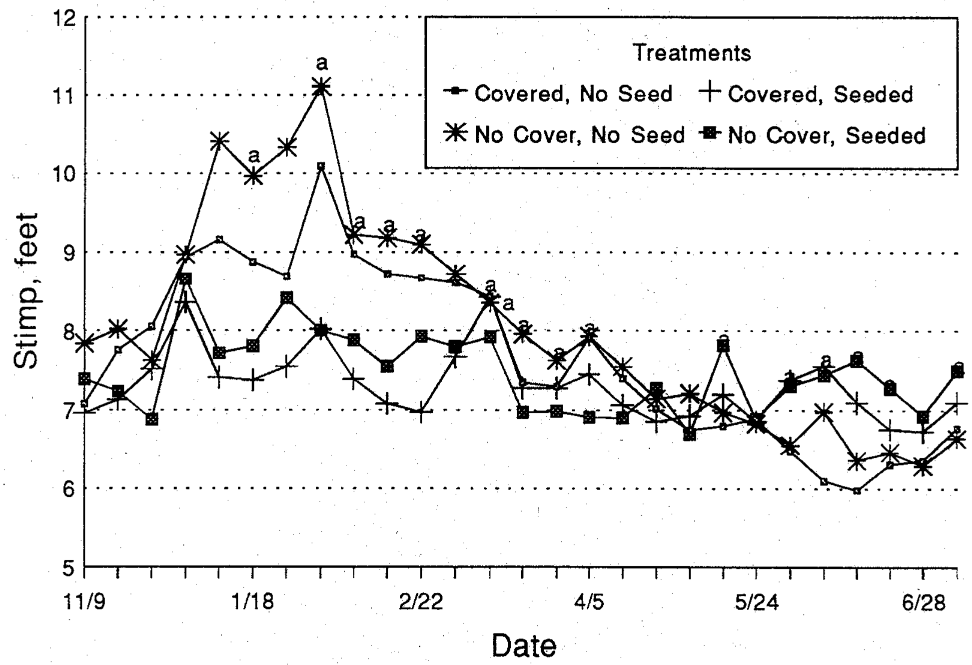
Table G1. Green cover of DALZ8502 zoysia green at TAES-Dallas.

	Percent Green Cover							
	1992						1993	
Treatment	2Nov	9Nov	23Nov	7Dec	16Dec	30Dec	5Jan	13Jan
No seed, no cover	94	94	91	92	88	78	52	66
No seed, with cover	95	95	96a	94	93a	93a	84	82
Seeded, no cover	97a	96a	96a	95a	93a	93a	93a	91a
Seeded, with cover	98a	97a	98a	97a	96a	96a	94a	94a
MSD treatment[1]	2	1	2	2	3	6	5	4

	1993							
Treatment	19Jan	25Jan	1Feb	8Feb	25Feb	10Mar	16Mar	30Mar
No seed, no cover	63	48	46	41	41	43	44	74
No seed, with cover	85	71	75	50	61	45	48	83
Seeded, no cover	93a	93a	91a	88a	86a	94a	86	95a
Seeded, with cover	95a	95a	94a	92a	93a	95a	93a	97a
MSD treatment	5	3	6	4	11	4	6	4

[1] MSD treatment = minimum significant difference between treatment means within a date column, based on Waller-Duncan k-ratio t test (k-ratio = 100). Means in the top statistical group are indicated by 'a'.

Figure 1. DALZ8502 Zoysiagrass Green Stimp Readings



Significant differences among treatment means on a given date are indicated by 'a'

APPENDIX H

DALZ8502 TRAFFIC TOLERANCE

DALZ8502 zoysiagrass has promise as a low maintenance, athletic turf. In previous studies it has demonstrated a rapid recovery to injury, such as in golf tee boxes. This study examined the degree of wear required to lower density, turf cover, green cover, and turf quality of DALZ8502 zoysiagrass.

MATERIALS AND METHODS

Established DALZ8502 was trafficked three times weekly, at four wear levels. Levels were high, medium, low, and none, which refer to 3, 2, 1, and 0 passes with a water-filled power-driven, pegged roller with a downward force of 0.73 kg/cm^2 (about the force of a 1240 lb person). The traffic machine simulated wear and compaction expected from heavy foot traffic. The study was a randomized complete block design, with three replications. Plots were 1.83 m x 3.05 m, and were maintained with 98 kg N/ha/year. Plots were mowed at 2.54 cm, and irrigated as needed to prevent water stress in the control (no wear) plots.

Responses were noted as percent injury, percent turf cover, percent green cover, density and turf quality. Percent injury is a combination of the percentage of the turf cover that is injured tissue, the percentage of exposed soil in the plot, the compression of the turf, and the density. Percent turf cover is the percentage of the plot with turf cover, while percent green cover refers to the percentage of the turf cover that is green healthy tissue. Turf quality includes color, density, uniformity, turf cover, and green cover.

Data were evaluated by ANOVA, and when a significant F ratio occurred, Duncan-Waller k-ratio t test was performed to separate treatment means.

RESULTS AND DISCUSSION

Injury
Generally, injury was more severe on high and medium wear plots than on low or control plots (Table H1). However, in August and September, injury in medium wear plots was the same as that in the control and low wear plots. This improved response in late summer may reflect more active growth, and probable recovery, of zoysiagrass during this warmer part of the year in Dallas.

Components of injury
Factors that describe the injury responses of the turfgrasses include turf cover, green cover, and density. In DALZ8502 zoysiagrass, the primary component contributing to the injury observed was green cover (Table H2). Changes in green cover are of the same magnitude and generally mimic the injury response. Turf cover and density remained fairly constant across treatments, and through time. For most dates, small, yet significant, losses in turf cover were observed in the medium and high wear treatments (Tables H3 and H4). Generally, at least 85% turf cover was maintained in all treated plots.

Effect on turf quality
Wear did affect turf quality, as noted by the significantly better turf quality in the low and no wear treatments as compared with the medium and high wear treatments (Table H5). As noted above, turf cover and density were maintained in all treatments. Yet, green cover was lost, and contributed to the loss in turf quality in the medium and high wear plots. Evenness and uniformity were not measured individually, and probably contributed to the loss in turf quality.

Continual wear applications and subsequent injury response notes will allow better evaluation of the durability of DALZ8502 to simulated traffic.

Table H1. Percent injury during 1993, as percentage of turf cover that is injured, for DALZ8502 treated with four wear intensities at TAES-Dallas.

	Percent Injury						
	1993						
Treatment[1]	25Feb	15Apr	21May	14Jun	20Aug	20Sep	Avg
High	8	23	38a	38	22	38	28
Medium	8	13	47	32	10a	25a	22
Low	5	4	30a	3a	8a	15a	11a
None	0	0a	17a	0a	2a	6a	4a
MSD treatment[2]	ns	4	26	17	8	24	8

[1] High, Medium, Low, and None treatments refer to 9, 6, 3, and 0 passes with traffic machine each week, respectively.
[2] MSD treatment = minimum significant difference between treatment means within a column, based on the Waller-Duncan k-ratio t test (k-ratio = 100).

Table H2. Percent green cover during 1993, as percentage of the turf cover with green tissue, for DALZ8502 trafficked at four wear levels at TAES-Dallas.

	Percent Green Cover					
	1993					
Treatment[1]	25Feb	15Apr	21May	14Jun	20Aug	20Sep
High	33	17	45	87	87	63
Medium	37	31	53a	89	94a	70
Low	40	38a	67a	93a	94a	83a
None	38	53a	72a	95a	97a	91a
MSD treatment[2]	ns	22	20	3	5	16

[1] High, Medium, Low, and None treatments refer to 9, 6, 3, and 0 passes with traffic machine each week, respectively.
[2] TPI = turf performance index, which is the number of times a treatment was ranked in the top statistical group.
[3] MSD treatment = minimum significant difference between treatment means within a column, based on the Waller-Duncan k-ratio t test (k-ratio = 100).

Table H3. Percentage of plot area with turf cover during 1993 for DALZ8502 treated with four wear intensities at TAES-Dallas.

	Percent Turf Cover						
	1993						
Treatment[1]	25Feb	15Apr	21May	14Jun	20Aug	20Sep	Avg
High	100	94	93	85	96	96	94
Medium	100	94	93	87	98	98	95
Low	100	97	98a	93a	99a	99a	98a
None	100	97	99a	95a	100a	99a	99a
MSD treatment[2]	ns	ns	5	5	2	1	2

[1] High, Medium, Low, and None treatments refer to 9, 6, 3, and 0 passes with traffic machine each week, respectively.
[2] MSD treatment = minimum significant difference between treatment means within a column, based on the Waller-Duncan k-ratio t test (k-ratio = 100).

Table H4. Density during 1993 for DALZ8502 plots treated with four wear intensities at TAES-Dallas.

	Density[1]						
	1993						
Treatment[2]	25Feb	15Apr	21May	14Jun	20Aug	20Sep	Avg
High	8.0	8.3	7.3	3.3	7.7	6.7	6.9
Medium	8.0	8.0	7.3	3.3	8.0	7.3a	7.0
Low	8.0	8.3	7.7	4.3a	8.3	7.7a	7.4
None	8.0	8.7	7.3	4.7a	8.0	8.0a	7.4
MSD treatment[3]	ns	ns	ns	1.0	ns	0.8	ns

[1] Density is the density of the canopy of the turf, where 9 is the most dense, and 5 is the minimum acceptable density, and has about 50% air space in the canopy.
[2] High, Medium, Low, and None treatments refer to 9, 6, 3, and 0 passes with traffic machine each week, respectively.
[3] MSD treatment = minimum significant difference between treatment means within a column, based on the Waller-Duncan k-ratio t test (k-ratio = 100).

Table H5. Turf quality during 1993 for DALZ8502 treated with four wear intensities at TAES-Dallas.

	Turf Quality[1]						
	1993						
Treatment[2]	25Feb	15Apr	21May	14Jun	20Aug	20Sep	Avg
High	5.0	7.7	5.0	7.0a	8.0	6.7	6.6a
Medium	4.7	8.0	4.0	6.7	8.0	7.0	6.4
Low	5.0	8.3	6.3	8.0a	8.3	7.7a	7.3a
None	5.0	8.7	7.0	8.0a	9.0a	8.3a	7.7a
MSD treatment[3]	ns	ns	ns	1.0	0.6	0.7	1.2

[1] Turf quality is rated on a scale of 1 to 9, where 9 is the best turf quality, and 5 is the minimum acceptable turf quality.
[2] High, Medium, Low, and None treatments refer to 9, 6, 3, and 0 passes with traffic machine each week, respectively.
[3] MSD treatment = minimum significant difference between treatment means within a column, based on the Waller-Duncan k-ratio t test (k-ratio = 100).

APPENDIX I

ZOYSIAGRASS HYBRIDIZATION - INCREASES - FAIRWAY PHYTOTOXICITY TRIAL

Among the zoysiagrasses developed at TAES-Dallas, and under consideration for release, DALZ8507 and DALZ8512 are two with excellent potential for use in golf course fairways. The study examined the phytotoxicity response of these zoysiagrasses to common preemergent herbicides, which might be used in establishment of these grasses in fairways.

MATERIALS AND METHODS

Each 0.67 ha fairway was planted on May 20, 1993, as plugs, at a 1:9 planting ratio. Before planting, the soil in half of each planting was modified with a polyacrylamide soil moisture enhancer (Hydrozone). In the half not treated with the polyacrylamide, the phytotoxicity test was performed. Each phytotoxicity study was a randomized complete block design, with three replications. Plots were 1.83 m x 3.05 m. Herbicides were applied on June 4, 1993 as indicated on label directions, and are listed in Table I1.

On June 21 and July 28, 1993, injury was estimated as the percentage of turf cover with injured tissue. Injury was calculated as the difference between the injury in the treatment plot of a grass less the average injury for the grass in the control treatment. Data were analyzed by ANOVA, and when a significant F ratio occurred, Duncan-Waller k-ratio t test was performed to separate treatment means. A student's t test was used to compare responses between the zoysiagrasses.

RESULTS AND DISCUSSION

No significant differences in response was observed between herbicide treatments of DALZ8507 (Table I2). However, on July 21 injury was less than on June 28, which indicated that recovery of the grass had occurred. On July 21, 1993, significantly more injury was noted on the Simtrol and Surflan treated DALZ8512. All other herbicides effected a significantly lower level of injury in DALZ8512.

In general, DALZ8507 was injured more severely than DALZ8512 by the preemergent herbicides used in this test. Overall, the average injury of DALZ8507 was 11% (means range from 1 to 28%) and for DALZ8512 was 5% (means range from 0 to 15%) (alpha = 0.02). One can infer that DALZ8507, a *Zoysia matrella*, is more sensitive to these preemergent herbicides than DALZ8512, a *Zoysia japonica*.

Table I1. Herbicides applied in zoysiagrass preemergent phytotoxicity trial.

Tradename	Chemical	Rate #a.i./A
Simtrol	Simazine	2.00
Ronstar	Oxadiazon	3.00
Surflan	Oryzalin	2.00
Dimension	Dithiopyr	0.25
Pennant	Metolachlor	4.00
Balan	Benefin	1.50

Table I2. Percent injury, as percentage of the turf cover with injured tissue, of DALZ8507 and DALZ8512 in herbicide phytotoxicity trial 1993.

		Percent Injury	
		1993	
Zoysia line	Herbicide	28Jun	21Jul
DALZ8507	Simtrol	10.3	5.0
	Ronstar	16.7	6.7
	Surflan	28.3	12.2
	Dimension	13.3	1.1
	Pennant	15.0	4.4
	Balan	18.3	5.6
	MSD treatment[1]	ns	ns
DALZ8512	Simtrol	10.0	8.3
	Ronstar	3.3	0.0a
	Surflan	15.0	8.3
	Dimension	3.3	0.0a
	Pennant	0.0	3.3a
	Balan	6.7	5.0a
	MSD treatment	ns	6.7

[1] MSD treatment = minimum significant difference among treatment means within a column, based on the Waller-Duncan k-ratio t test (k-ratio = 50).

APPENDIX J

ZOYSIAGRASS HYBRIDIZATION - PROGENY DEVELOPMENT

1. Progeny Space Plantings

Parent-Progeny Heritability Study

A parent-progeny heritability study was planted August 27, 1993 at TAES-Dallas. The study was a randomized complete block of parent-progeny cells, with four replications. Each cell had a completely random arrangement of one parent with four of its progeny. Twenty-one parent-progeny relationships will be evaluated. Parents include nine TAES accessions, 11 DALZ lines, and the cultivar, 'Belair'.

Rate of spread, cold hardiness, flowering characteristics, color, leaf texture will be rated during the 3 years of the trial.

2. Polycross Nurseries

Two polycross nurseries were planted in September, 1992. The first polycross nursery contains six replications of 10 *Z. matrella* type parents. The second has two replications of 28 *Z. japonica* type parents. Each polycross is set up as a randomized complete block design. Parents were selected primarily for culm production, but overall turf quality, rate of spread, wear tolerance, and cold hardiness were also important selection criteria. Each polycross nursery is sheltered from external zoysia pollen by a wind screen of sorghum or wheat (seasonal). Parents will continue to be evaluated for the above traits. Seed will be collected and progeny turf performance evaluated.

3. Zoysia Germplasm Introduction Nursery (GPIN) Evaluations

1990 GPIN

In 1990, 116 TAES accessions, four commercial cultivars, and three DALZ lines were planted in a randomized complete block, with three replications. Each plot was planted with a single plug on 1.83 m centers. These zoysiagrasses have been irrigated as needed to prevent water stress, and mowed at 5 cm. Two 49 kg N/ha applications of 34-0-0 ammonium nitrate are made each year.

All plots of TAES3368, TAES3573, and TAES3581 have died during the 2 1/2 years of the field study and will not be included in the following discussion. However, they are listed in the tables and have ratings of zero for all parameters.

87% of entries had color ratings greater than 4.7 on April 30, and 90% of entries had color ratings greater than 4.3 on May 14 (Table J1). The top color rating for both dates was 8.3, observed of TAES3586 and Emerald. The poorest was observed on 30 April for DALZ8701 (color = 2.0).

By November 10, 1992, TAES3549 had the greatest loss of green cover, with only 18% remaining (Table J2). Overall, only 16% of entries had lost at least 57% green cover by November 10. Generally, this group of zoysiagrasses has good color retention in mid-autumn, as percent green cover ranged from 82% to 18%, and half of the entries having between 60 and 80% green cover.

Most zoysiagrasses had at least 50% green cover by April 30, 1993, with the highest rating of 95% green cover (Table J2). Green cover was lost by 25% of entries as the summer drought set in. Yet, more than half of the entries maintained at least 50% green cover during the early summer. DALZ8502 had 93% green cover on June 8, which was the highest value on this date.

Over 50% of the entries in this GPIN earned TPI = 6, and 33% earned TPI = 5, for turf quality (Table J3). Generally, ratings during November, 1992, were minimally acceptable or less, and was primarily related to green color loss. The zoysiagrasses tested had the best quality ratings during late spring and early summer in 1993.

1993 GPIN

Eighty-six zoysiagrasses were planted in a TAES accession trial on August 27, 1993 at TAES-Dallas. Included were 75 TAES accessions, seven DALZ lines, and four commercially available cultivars, consisting of Belair, El Toro, Emerald, and Meyer. The study includes three replications, as part of a randomized complete block experimental design.

Entries will be evaluated for spread, culm production, seed production, winter hardiness, and turf quality, including the components of color, density, uniformity, texture, and evenness. Winter color retention and spring green up will also be evaluated during the three years of the study.

In addition, a space planting of 149 progeny (110 F1 and 39 F2) was planted August 27, 1993. Most are progeny from outcrossing of 29 mothers. Nine progeny are from selfed mothers. The study is not replicated. Progeny will be screened for spread, culm production, and turf quality during the next three years.

Table J1. Color of zoysiagrasses during spring 1993 for 1990 GPIN at TAES-Dallas.

Entry	1993	
	30Apr	14May
TAES3315	7.0a	7.0a
TAES3356	6.7a	7.3a
TAES3357	4.0	5.0a
TAES3358	5.7a	6.7a
TAES3359	7.0a	7.3a
TAES3360	7.0a	7.3a
TAES3361	2.3	2.7
TAES3362	6.0a	7.0a
TAES3363	7.0a	8.0a
TAES3364	7.0a	7.7a
TAES3365	7.7a	7.0a
TAES3366	5.7a	6.3a
TAES3367	3.3	4.3a
TAES3368	0.0	0.0
TAES3483	3.7	4.0
TAES3484	6.7a	6.3a
TAES3485	7.0a	7.0a
TAES3486	4.3	4.3a
TAES3487	7.7a	7.3a
TAES3488	6.0a	5.7a
TAES3489	6.7a	7.0a
TAES3490	7.7a	7.3a
TAES3491	5.3a	6.0a
TAES3492	6.7a	6.0a
TAES3493	3.7	4.0
TAES3494	6.0a	6.7a
TAES3495	6.3a	6.3a
TAES3496	6.3a	6.7a
TAES3497	7.0a	7.7a
TAES3498	7.0a	7.0a
TAES3499	6.3a	6.7a
TAES3500	4.0	4.3a
TAES3501	6.0a	6.0a
TAES3502	7.3a	7.7a
TAES3503	4.3	3.7
TAES3504	5.3a	5.3a
TAES3505	4.7a	4.3a
TAES3506	5.3a	5.3a
TAES3507	7.3a	7.0a
TAES3508	6.7a	6.7a
TAES3509	6.7a	6.0a
TAES3510	7.0a	7.3a
TAES3511	7.0a	7.3a
TAES3512	5.3a	6.0a
TAES3513	7.0a	7.0a
TAES3514	7.3a	6.7a
TAES3515	7.0a	6.5a
TAES3516	6.3a	6.7a
TAES3517	6.0a	6.0a
TAES3518	3.7	3.7
TAES3519	6.7a	7.3a
TAES3520	7.0a	7.0a
TAES3521	4.7a	5.7a
TAES3522	7.0a	7.3a
TAES3523	3.7	3.3
TAES3524	6.0a	7.0a
TAES3525	6.7a	6.7a
TAES3526	3.7	4.0
TAES3527	5.0a	5.0a
TAES3528	6.0a	6.0a
TAES3529	6.7a	7.3a
TAES3530	6.0a	6.0a
TAES3531	5.7a	6.0a
TAES3532	6.0a	6.0a
TAES3533	6.7a	5.7a
TAES3534	4.0	4.3a
TAES3535	6.0a	5.7a
TAES3536	5.7a	6.0a
TAES3537	4.0	4.0
TAES3538	7.0a	7.0a
TAES3539	4.7a	5.0a
TAES3540	4.7a	4.3a
TAES3541	6.7a	7.0a
TAES3542	6.7a	6.3a
TAES3543	5.3a	6.0a
TAES3544	6.0a	6.0a
TAES3545	5.3a	6.0a
TAES3547	6.3a	7.0a
TAES3548	6.0a	5.7a
TAES3549	4.3	4.7a
TAES3550	5.3a	5.0a
TAES3551	6.0a	5.7a
TAES3552	6.7a	6.7a
TAES3553	6.3a	6.0a
TAES3554	5.3a	6.3a
TAES3555	7.0a	7.0a
TAES3556	7.0a	6.7a
TAES3557	6.0a	6.0a
TAES3558	7.0a	7.0a
TAES3559	4.7a	3.7
TAES3560	5.7a	6.0a
TAES3561	3.7	3.7
TAES3563	6.0a	6.0a
TAES3564	7.0a	7.7a
TAES3565	6.3a	6.3a
TAES3566	6.3a	7.0a
TAES3567	6.0a	6.0a
TAES3569	6.3a	7.0a
TAES3570	7.0a	7.3a
TAES3571	4.7a	4.0
TAES3572	5.7a	5.3a
TAES3573	0.0	0.0
TAES3574	8.0a	8.0a
TAES3575	6.7a	7.7a
TAES3576	4.7a	6.0a
TAES3577	6.0a	6.3a
TAES3578	5.0a	4.7a
TAES3579	7.3a	7.0a
TAES3580	7.7a	8.0a
TAES3581	0.0	0.0
TAES3582	5.7a	5.3a
TAES3583	6.3a	6.0a
TAES3584	5.0a	5.3a
TAES3585	7.7a	7.3a
TAES3586	8.3a	8.3a
TAES3587	5.0a	5.3a
TAES3588	8.0a	8.0a
Belair	7.3a	6.7a
El Toro	6.7a	8.0a
Emerald	8.3a	8.0a
Meyer	8.0a	7.3a
DALZ8501	5.3a	5.0a
DALZ8502	8.3a	8.0a
DALZ8701	2.0	2.3
MSD entry	3.9	4.1

[1] MSD entry = minimum significant difference between entry means within a column, based on the Waller-Duncan k-ratio t test (k-ratio = 100).

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Table J2. 1992 winter color retention and 1993 spring green up, measured as percent green cover, for zoysiagrasses in 1990 GPIN at TAES-Dallas.

Entry	1992 10Nov	1993 30Apr	1993 8Jun	Entry	1992 10Nov	1993 30Apr	1993 8Jun	Entry	1992 10Nov	1993 30Apr	1993 8Jun
TAES3315	60a	90a	72a	TAES3511	63a	88a	82a	TAES3554	67a	88a	76a
TAES3356	73a	89a	89a	TAES3512	72a	87a	79a	TAES3555	42	83a	83a
TAES3357	43a	58a	57a	TAES3513	70a	91a	83a	TAES3556	68a	90a	77a
TAES3358	73a	93a	85a	TAES3514	52a	68a	78a	TAES3557	67a	84a	79a
TAES3359	62a	90a	85a	TAES3515	50a	91a	79a	TAES3558	38	86a	82a
TAES3360	73a	89a	88a	TAES3516	57a	59a	55a	TAES3559	67a	83a	80a
TAES3361	28	28	28	TAES3517	72a	81a	78a	TAES3560	65a	89a	74a
TAES3362	78a	88a	88a	TAES3518	43a	57a	85a	TAES3561	45a	60a	42a
TAES3363	73a	93a	87a	TAES3519	65a	86a	84a	TAES3563	72a	58a	85a
TAES3364	82a	90a	88a	TAES3520	55a	88a	75a	TAES3564	38	85a	77a
TAES3365	77a	87a	87a	TAES3521	60a	88a	77a	TAES3565	65a	90a	81a
TAES3366	72a	86a	86a	TAES3522	53a	90a	62a	TAES3566	43a	88a	83a
TAES3367	48a	55a	58a	TAES3523	37	59a	52a	TAES3567	53a	89a	70a
TAES3368	0	0	0	TAES3524	57a	89a	84a	TAES3569	50a	90a	79a
TAES3483	45a	58a	50a	TAES3525	73a	82a	81a	TAES3570	43a	66a	67a
TAES3484	57a	88a	73a	TAES3526	33	58a	51a	TAES3571	40	58a	79a
TAES3485	70a	89a	83a	TAES3527	45a	59a	54a	TAES3572	50a	58a	59a
TAES3486	45a	54a	48a	TAES3528	62a	90a	78a	TAES3573	0	0	32
TAES3487	68a	91a	85a	TAES3529	53a	88a	85a	TAES3574	77a	91a	85a
TAES3488	68a	88a	79a	TAES3530	68a	93a	83a	TAES3575	43a	87a	82a
TAES3489	47a	83a	78a	TAES3531	57a	91a	74a	TAES3576	72a	88a	78a
TAES3490	57a	87a	82a	TAES3532	58a	86a	60a	TAES3577	60a	88a	82a
TAES3491	53a	78a	73a	TAES3533	65a	92a	81a	TAES3578	42	61a	52a
TAES3492	73a	87a	77a	TAES3534	63a	90a	81a	TAES3579	72a	90a	81a
TAES3493	43a	59a	53a	TAES3535	62a	91a	74a	TAES3580	60a	87a	84a
TAES3494	53a	91a	82a	TAES3536	58a	83a	75a	TAES3581	0	0	0
TAES3495	55a	90a	80a	TAES3537	33	58a	45a	TAES3582	50a	59a	58a
TAES3496	63a	87a	81a	TAES3538	48a	80a	79a	TAES3583	45a	87a	77a
TAES3497	72a	88a	78a	TAES3539	47a	58a	57a	TAES3584	43a	62a	55a
TAES3498	63a	91a	80a	TAES3540	55a	50a	52a	TAES3585	73a	90a	85a
TAES3499	50a	87a	53a	TAES3541	62a	85a	75a	TAES3586	77a	89a	86a
TAES3500	40	61a	54a	TAES3542	62a	86a	78a	TAES3587	32	37	58a
TAES3501	55a	85a	74a	TAES3543	68a	87a	69a	TAES3588	75a	95a	86a
TAES3502	65a	88a	85a	TAES3544	73a	82a	74a	BELAIR	65a	79a	80a
TAES3503	48a	57a	55a	TAES3545	63a	84a	68a	ELTORO	67a	90a	85a
TAES3504	37	58a	56a	TAES3547	58a	88a	76a	EMERALD	78a	66a	83a
TAES3505	37	58a	53a	TAES3548	57a	85a	46a	MEYER	65a	91a	85a
TAES3506	53a	90a	79a	TAES3549	18	40a	43a	DALZ8501	40	60a	57a
TAES3507	42	77a	70a	TAES3550	63a	89a	60a	DALZ8502	50a	63a	93a
TAES3508	68a	82a	79a	TAES3551	57a	82a	73a	DALZ8701	20	29	22
TAES3509	67a	90a	77a	TAES3552	65a	93a	84a				
TAES3510	72a	90a	84a	TAES3553	72a	82a	77a	MSD entry	39	57	56

[1] MSD entry = minimum significant difference difference between entry means within a column, based on the Waller-Duncan k-ratio t test (k-ratio = 100).

Table J3. Turf quality from November 10, 1992 through August 10, 1993 for zoysiagrasses in 1990 GPIN at TAES-Dallas.

Entry	1992 10Nov	1993 30Apr	1993 14May	1993 8Jun	1993 12Jul	1993 10Aug	TPI[1]
TAES3315	4a	7a	7a	5a	5a	4	5
TAES3356	5a	7a	7a	7a	8a	7a	6
TAES3357	3a	4a	5a	5a	5	5	4
TAES3358	5a	6a	7a	8a	8a	7a	6
TAES3359	4a	7a	6a	7a	8a	7a	6
TAES3360	5a	8a	7a	8a	6a	7a	6
TAES3361	2	2	2	2	2	3	–
TAES3362	5a	6a	7a	8a	7a	7a	6
TAES3363	5a	7a	8a	8a	7a	7a	6
TAES3364	5a	7a	7a	8a	7a	8a	6
TAES3365	5a	7a	6a	7a	7a	7a	6
TAES3366	5a	6a	6a	7a	6a	7a	6
TAES3367	3a	5a	4a	5a	5	5a	5
TAES3368	0	0	0	0	0	0	–
TAES3483	3a	4	4	3	3	3	1
TAES3484	4a	6a	6a	5a	5	6a	5
TAES3485	4a	6a	6a	6a	4	3	4
TAES3486	2a	4	4	4	3	3	1
TAES3487	4a	8a	7a	7a	5a	5	5
TAES3488	4a	6a	6a	6a	5a	6a	6
TAES3489	4a	7a	7a	7a	6a	6a	6
TAES3490	3a	8a	7a	7a	5a	4	5
TAES3491	3a	5a	5a	4a	2	4	4
TAES3492	4a	6a	6a	6a	6a	6a	6
TAES3493	3a	4a	4	4a	4	4	3
TAES3494	3a	6a	6a	7a	6a	5a	6
TAES3495	4a	7a	6a	6a	6a	7a	6
TAES3496	4a	6a	6a	6a	6a	6a	6
TAES3497	3a	6a	6a	6a	4	3	4
TAES3498	5a	7a	7a	7a	6a	6a	6
TAES3499	3a	6a	6a	4a	3	3	4
TAES3500	3a	4a	4	4a	3	4	3
TAES3501	3a	6a	6a	6a	6a	6a	6
TAES3502	4a	8a	7a	7a	6a	6a	6
TAES3503	3a	5a	4a	5a	5a	5	5
TAES3504	2a	5a	4a	4a	4	5	4
TAES3505	2a	4	4	4	3	4	1
TAES3506	3a	6a	6a	6a	5a	5a	6
TAES3507	2a	6a	6a	4	2	3	3
TAES3508	3a	6a	6a	6a	5a	6a	6
TAES3509	4a	6a	6a	7a	5a	6a	6
TAES3510	5a	7a	7a	8a	6a	6a	6
TAES3511	4a	7a	7a	7a	6a	5a	6
TAES3512	5a	6a	6a	6a	5	6a	5
TAES3513	4a	7a	7a	5a	6a	5a	6
TAES3514	4a	6a	6a	4a	4	3	4
TAES3515	4a	7a	5a	5a	4	4	4
TAES3516	4a	6a	5a	6a	4	5a	5
TAES3517	4a	6a	6a	6a	5	6a	5
TAES3518	3a	4	4	6a	4	4	2
TAES3519	4a	7a	7a	7a	6a	6a	6
TAES3520	4a	7a	7a	6a	6a	6a	6
TAES3521	4a	6a	6a	6a	5a	6a	6
TAES3522	3a	6a	5a	4a	4	2	4
TAES3523	2a	4	4	3	3	4	1
TAES3524	3a	7a	7a	7a	6a	6a	6
TAES3525	4a	6a	6a	6a	6a	6a	6
TAES3526	2	4	4	3	2	3	–
TAES3527	3a	5a	4a	4a	4	5a	5
TAES3528	4a	6a	6a	6a	5a	6a	6
TAES3529	4a	6a	7a	7a	6a	7a	6
TAES3530	4a	7a	7a	7a	6a	7a	6
TAES3531	4a	6a	6a	6a	6a	6a	6
TAES3532	3a	6a	6a	5a	4	5a	5
TAES3533	4a	7a	6a	7a	5a	6a	6
TAES3534	4a	6a	6a	6a	6a	6a	6
TAES3535	4a	6a	6a	6a	5a	5	5
TAES3536	4a	6a	6a	6a	5	4	4
TAES3537	2	4	4	4	2	2	–
TAES3538	4a	6a	6a	7a	7a	7a	6
TAES3539	3a	5a	5a	5a	4	4	4
TAES3540	4a	4a	4	3	3	4	2
TAES3541	4a	7a	6a	6a	5	4	4
TAES3542	4a	6a	6a	5a	5a	6a	6
TAES3543	4a	6a	5a	5a	5a	6a	6
TAES3544	4a	7a	5a	5a	5a	5	5
TAES3545	4a	6a	6a	5a	5	4	4
TAES3547	3a	6a	6a	5a	4	6a	5
TAES3548	4a	6a	5a	5a	5a	6a	6
TAES3549	2	3	4	3	1	2	–
TAES3550	4a	6a	6a	5a	4	6a	5
TAES3551	3a	6a	5a	5a	4	5a	5
TAES3552	4a	7a	7a	6a	5a	5a	6
TAES3553	4a	5a	5a	5a	6a	5	5
TAES3554	4a	6a	6a	6	5a	6a	5
TAES3555	3a	7a	6a	7	6a	7a	5
TAES3556	4a	6a	6a	7	6a	5a	5
TAES3557	4a	6a	6a	6	6a	5a	5
TAES3558	3a	7a	7a	7	6a	6a	5
TAES3559	5a	6a	6a	6	6a	7a	5
TAES3560	4a	6a	6a	6	5a	6a	5
TAES3561	3a	4a	4	4	3	4	2
TAES3563	4a	7a	6a	6	6a	5a	5
TAES3564	3a	6a	7a	6	6a	7a	5
TAES3565	4a	7a	6a	6	6a	5	4
TAES3566	4a	6a	6a	7	6a	6a	5
TAES3567	4a	6a	6a	5	5a	6a	5
TAES3569	4a	6a	6a	6	6a	6a	5
TAES3570	4a	6a	6a	6	4	5a	4
TAES3571	2a	4	4	4	4	4	1
TAES3572	3a	5a	5a	5	5	5a	4
TAES3573	0	0	0	2	0	1	–
TAES3574	5a	8a	7a	7a	6a	7a	6
TAES3575	3a	7a	7a	7a	6a	6a	6
TAES3576	4a	7a	6a	6a	5	6a	5
TAES3577	4a	6a	6a	7a	5a	6a	6
TAES3578	3a	5a	5a	5a	4	3	4
TAES3579	4a	7a	7a	7a	6a	5a	6
TAES3580	3a	8a	7a	6a	4	3	4
TAES3581	0	0	0	0	0	1	–
TAES3582	3a	5a	5a	5a	4	5a	5
TAES3583	3a	6a	6a	5a	6a	6a	6
TAES3584	3a	5a	5a	5a	3	3	4
TAES3585	5a	8a	7a	8a	6a	5a	6
TAES3586	5a	8a	8a	7a	7a	6a	6
TAES3587	2	5a	4	4	2	2	1
TAES3588	5a	8a	8a	8a	7a	8a	6
Belair	4a	7a	6a	5a	5	6a	5
El Toro	5a	7a	7a	7a	7a	7a	6
Emerald	5a	8a	8a	7a	5a	6a	6
Meyer	4a	8a	7a	8a	7a	7a	6
DALZ8501	2a	5a	4	5a	3	3	3
DALZ8502	3a	8a	7a	7a	5	6a	5
DALZ8701	1	2a	2	2	1	2	1
MSD entry	3	4	4	4	3	3	

[1] TPI = turf performance index, which is the number of times an entry occurred in the top statistical group.
[2] MSD entry = minimum significant difference difference between entry means within a column, based on the Waller-Duncan k-ratio t test (k-ratio = 100). Entries in the top statistical group are indicated by 'a'.