1992

ANNUAL PROGRESS REPORT

concerning

BREEDING AND DEVELOPMENT OF ZOYSIAGRASS

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1992 ANNUAL RESEARCH REPORT
ZOYSIAGRASS BREEDING AND DEVELOPMENT

1992 RESEARCH REPORT
BREEDING AND DEVELOPMENT OF ZOYSIAGRASS

EXECUTIVE SUMMARY

Principle Investigator: Dr. M. C. Engelke
Co-Investigators: Dr. K. B. Marcum
Technical Support: Ms. Sharon Morton

Research Period: 1 November 1991 through 1 November 1992.

The zoysiagrass project in its 9th year of funding. To date a total of $382,085 has been invested by the United States Golf Association in the development of zoysiagrasses which are better adapted to natural environmental conditions. The Zoysiagrass NTEP trials were initiated in 1991 at nearly 40 locations throughout the US. We have completed studies on the root-growth characters of all entries, and have initiated shade studies under natural tree canopy, open-irrigated turf quality evaluation trials, and greenhouse based salinity tolerance trials. Considerable variability exist among entries for root growth characters, with preliminary information suggesting similar variation exist for salinity tolerance. Only limited information has been returned from NTEP trials at this time (establishment year), with additional valuable information anticipated beginning in 1993 through 1995. Cooperative research projects in Georgia, California (2 locations), and Missouri substantiate the adaptability of several of the DALZ lines to a broad range of environmental conditions.

Several zoysiagrass putting greens were built this past summer with the 'minute-elite" selection, including at two golf courses - Firewheel Municipal Golf Course, Garland Texas, and Banyan Golf Club - West Palm Beach Florida. In addition, two greens were built at TAES-Dallas during 1991/1992 seasons. Briefly, the #1 hole of the Lakes Course at Firewheel Golf Course - Garland, Texas was solid sodded on June 10 and opened for play on July 15, 1992. The soil profile is a USGA green, which was frequently top-dressed, verticut and mowed at 5/32 throughout the summer 1992. In September, the green was overseeded to a bentgrass-Poa trivilias-fine fescue mix with good establishment results. The green will be covered by geotextile during anticipated cold periods during the winter of 1992/93. The Banyan green was planted as a nursery green and will be maintained under greens conditions in 1993. One of the TAES-Dallas zoysia greens was sodded on a deep sand (3 meters) and was maintained at 1/8" throughout the summer. The green was split into four sections for management studies to included the use of geotextile covering/and overseeding to determine the survivability and hardiness in the Dallas Area. Stimpmeter ratings generally ranged between 6.7 and 8.2. The second TAES-Dallas green was constructed on native soil (Houston Black Clay) and is being maintained at 3/16", with only minimal cultural inputs. Cultural practices of concern to be addressed in future studies includes, cold-hardiness, transition from overseeding, fertility and irrigation needs, traffic tolerance, and general turf quality.

The Linear Gradient Irrigation System study was reestablished with 12 elite experimental zoysiagrasses using a combination of solid sodding, plugging and sprigging to determine the rate of establishment under a moisture gradient. Comparative performance will simultaneously be made on moisture performance with selected bermudagrasses, buffalograsses, St. Augustinegrass and Tall Fescue.

Breeder blocks were established in July, 1992 for four elite zoysiagrass lines which will be submitted for release to the industry during 1993. The four varieties were selected specifically for turf performance under low water use requirements. Three of the four selections have water requirements comparable to 'Prairie' buffalograss. In addition selection was made based on persistence of turf quality under minimal maintenance, and for potential use under low light, and high traffic conditions. Emphasis in selecting these four also ranged from behavior at mowing heights ranging from 1/8" to infrequent mowing at 3 to 4 inches, cold hardiness, heat tolerance, rate of recovery from injury (divots), and general overall turf performance.

1992 Annual Zoysiagrass Research Report

M.C. Engelke, K.B. Marcum, 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. To date $382,085 has been directed by the USGA/GCSAA research committee to the zoysiagrass breeding effort. The present grant provided $45,000 annually. This report will address project activities for the period November 1, 1991 through November 1, 1992.

II. Technical Support Personnel

Dr. Kenneth B. Marcum (Assistant Research Scientist) joined the Turfgrass breeding program on June 13, 1991. Dr. Marcum is funded through the Texas Agricultural Experiment Station. Dr. Marcum's responsibilities focus on physiology and development of zoysiagrass, with emphasis on screening for root development and salinity tolerance. Dr. Marcum devotes approximately 80% of his time to the zoysiagrass breeding program.

Ms. Sharon J. Morton (Research Associate) joined the turfgrass breeding program in September 1989, and has provided a lead support role in the field screening of zoysiagrasses developed in the program. Approximately 80% of Ms. Morton's time is spent on the zoysia project.

Mr. Julian Acosta and Ms. Laurie Bornstein provide part-time technical assistance for Ms. Morton, each contributing their expertise in field evaluation, vegetative propagation, and greenhouse maintenance. Each contributes approximately 80% of their time to the zoysia program.

Mr. Charles Dayton provides part-time technical assistance for Dr. Marcum. Approximately 90% of his time is spent on the zoysia program.

III. A. GREENHOUSE AND LABORATORY PROGRESS

1. GERMPLASM MAINTENANCE

The 800 + 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 by Jack Murray.

2. ROOT DEVELOPMENT

The use of flexible plastic root tubes in the glasshouse has proven to be an efficient screening technique for zoysiagrasses. Rooting of zoysiagrasses are being investigated as related to drought tolerance. Rooting characters (rooting depth, and root numbers and weight in the lower root profile) have been found to be strongly associated with drought tolerance in the field, as observed in the Linear Gradient Irrigation study. The screening technique is described in **APPENDIX A: Turfgrass Root Investigation.**

3. ZOYSIAGRASS SALINITY TOLERANCE MECHANISMS

INTRODUCTION: 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.

OBJECTIVES: 1) Determine relative salt tolerances within the zoysiagrasses, bermudagrasses, and creeping bentgrasses. 2) Determine the relative importance of the salt tolerance mechanisms a)shoot Na^+ exclusion due to salt gland activity, and b)increased root growth in 5 species of zoysiagrass (*Zoysia japonica, Z. matrella, Z. macrostachya, Z. sinica*, and *Z. tenuifolia*). 3) Determine ultrastructural differences of salt glands among 5 zoysiagrass species.

PROGRESS: Greenhouse hydroponics salinity experiments are underway on 60 zoysiagrasses, including a number collected from around the Orient as well as those included in the 1991 NTEP trial. Also two separate salinity trials, including germplasm from the 1992 bermudagrass NTEP trial and the 1990 creeping bentgrass NTEP trial are currently underway. Data is being taken on survival under salt stress.

Salt glands are being investigated as the mechanism of tolerance in the zoysiagrasses. Differences in activities (salt secreted per unit leaf weight) are being measured using atomic absorption spectrometry, as well as size, density (number of glands per unit leaf area) and appearance of salt glands on the leaves by scanning electron microscopy.

In addition, differences in the internal ultrastructure of the salt glands of 5 *Zoysia* species present in this study will be observed using transmission electron microscopy. The species under study are *Zoysia japonica, Z. matrella, Z. macrostachya, Z. sinica*, and *Z. tenuifolia*. The objective of the study is to determine any species differences in salt gland anatomy which might relate to species level differences in salt excretion, and salinity tolerance, by the zoysiagrasses. Samples have been embedded and are ready for sectioning and microscopic examination.

4. SOD WEBWORM RESISTANCE

The tropical sod webworm *Herpetogramma phaeopteralis* Guenee is an important pest of zoysiagrass in the southern United States. In recent years, this sod webworm has extended its range northward to Atlanta and Dallas and now is well established in more of the region where zoysiagrass is cultivated. Host resistance to the tropical sod webworm (TSW) has been documented in cultivars of bermudagrass and St. Augustinegrass. These host resistant cultivars have been used successfully as a means of insect control.

Yet, considerable work in the development of pest resistant turf cultivars is needed to meet the environmental quality and safety demands of the future. The purpose of this research was to evaluate genotypes and cultivars of zoysiagrass for resistance to the tropical sod webworm. The report is in **APPENDIX B: Zoysiagrass Resistance to Tropical Sod Webworm.**

5. ZOYSIAGRASS MITE RESISTANCE

The zoysiagrass mite (*Eriophyes zoysiae*, Baker, Kono, and O'Neill) is host specific to zoysiagrass and causes extensive growth reduction by producing a leaf curl and failure of the leaf tip to unfold on susceptible genotypes. Greenhouse screening trials were made to delineate potential resistance among zoysiagrass cultivars and genotypes to the zoysiagrass mite. The results are presented in **APPENDIX C: Zoysiagrass Resistance to Zoysiagrass Mite.**

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 places 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. Data is presented on turf quality and color in **APPENDIX B: Nitrogen Fertilization and Mowing Height Effects on Zoysiagrass Performance.**

2. LINEAR GRADIENT IRRIGATION SYSTEM

The information obtained from LGIS during 1989, 1990, and 1991 was invaluable to the objectives of the turfgrass breeding program at TAES-Dallas. These data demonstrate the utility of LGIS for determining water requirements of experimental and commercially available germplasm under field conditions. With long-term use, LGIS has allowed identification of grasses that will persist and function acceptably with little or no supplemental irrigation. A summarization of the data for the previous LGIS study are presented in **APPENDIX D: Summarization of Zoysiagrass Performance under Linear Gradient Irrigation.**

The study involving 26 zoysiagrass selections and cultivars was terminated March 1992. The area was fallowed, then fumigated. A new set of zoysiagrasses were planted to LGIS during August 1992, which included 6 elite experimental zoysiagrasses (DALZ8501, DALZ8502, DALZ8507, DALZ8510, DALZ8512, and DALZ8514) and 3 cultivars (El Toro, Emerald, and Meyer). Three entries in the previous LGIS study were able to expand beyond their plot boundaries in the non-irrigated zones of the linear irrigation gradient. These 3 entries, DALZ8507, DALZ8512, and DALZ8514, were planted using a combination of prerooted plugs, cut plugs, and solid sodding, to determine rates of establishment under moisture gradient. All other entries were plugged at a 1:12 planting ratio. The study design is a randomized complete block, with 2 replications on either side of the line irrigation source, for a total of 4 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.

3. SHADE TOLERANCE TRIALS

A zoysiagrass shade tolerance trial was planted September 1992. The trial was a randomized complete block design with 3 replications of each of the 25 NTEP zoysiagrasses, which includes 10 Dallas elite lines. Entries were planted on 0.3 m centers in 0.6 m x 0.6 m plots. Entries will be evaluated for spread, overall turf quality, and the individual components of turf quality.

4. NATIONAL TURFGRASS EVALUATION PROGRAM (NTEP)
Evaluation of the performance of zoysiagrasses in the 1991 NTEP trial continues. A detailed report and current data is presented in **APPENDIX E: Update on the 1991 Zoysiagrass NTEP Trial.**

5. REGIONAL FIELD TRIALS
Regional field trials are useful to define areas of adaptation of improved zoysiagrass selections in comparison to commercially available cultivars. Regional trial data has been obtained from a number of regions, including California, Arizona, Nevada, Texas, Oklahoma, and Missouri, as presented in **APPENDIX F: Regional Field Trials.**

6. DALZ8502 GREEN
Stimp readings on the DALZ8502 green began September 9, 1992. On September 24, 1992, half of the DALZ8502 green was overseeded with annual ryegrass. Stimp readings on the overseeded area began October 8. **Figure 1** illustrates the change in stimp with time and changes in mowing height.

Nightly application of an insulating frost blanket was begun October 15. The cover veiled half of the green in such a manner that half of the overseeded area and half of the nonseeded area was covered. Stimp readings for the four treatment areas will begin November 2.

III. C. ZOYSIAGRASS HYBRIDIZATION

1. ORIENTAL ZOYSIAGRASS COLLECTION

The oriental zoysiagrass collection continues to undergo field evaluation, with emphasis on flower production, and drought and traffic tolerance. Irrigation to the field planting of oriental zoysiagrasses was discontinued in December 1991, but trafficking was continued. A summarization of the data is presented in **APPENDIX G: Zoysiagrass Hybridization - Oriental Collection.**

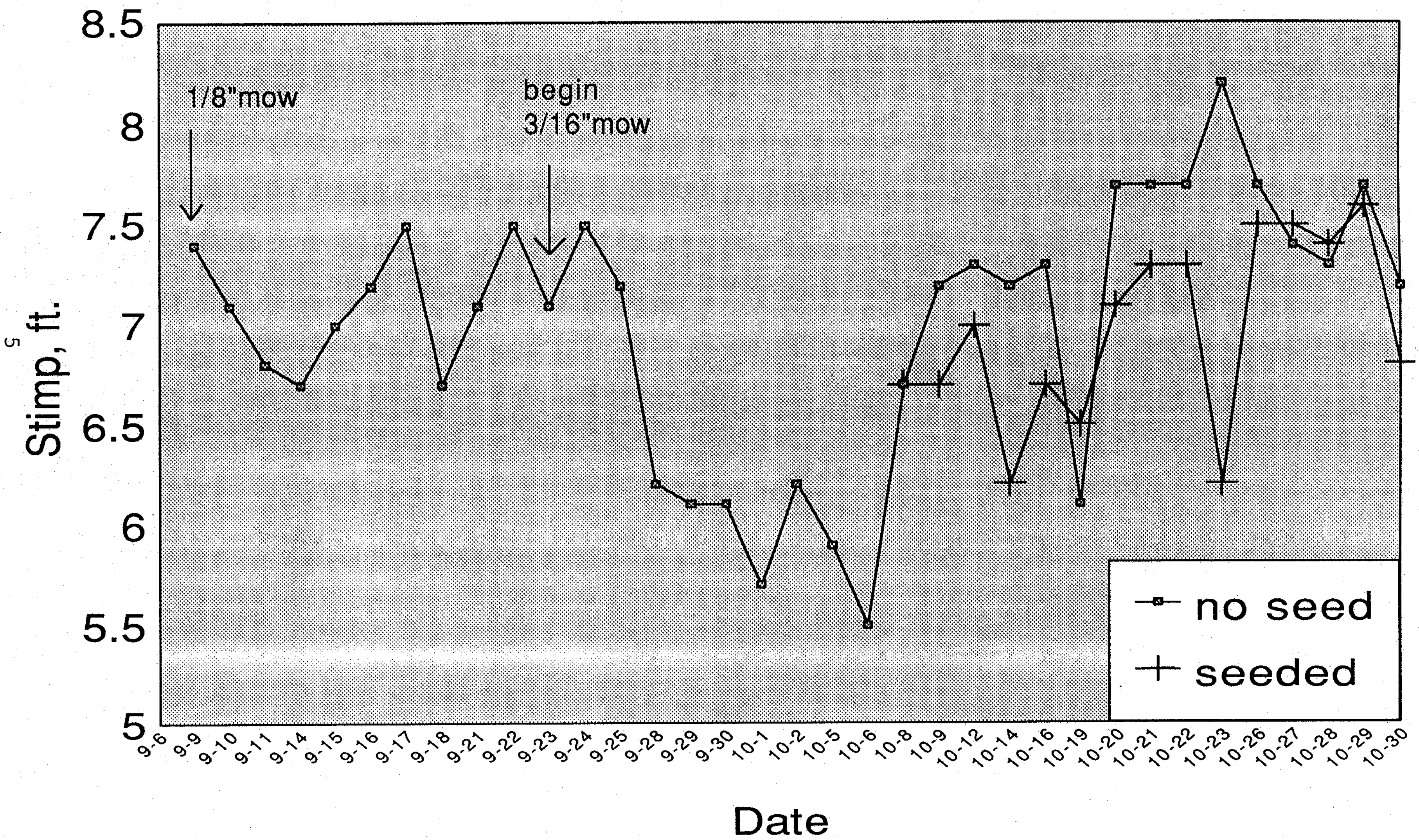
2. PROGENY DEVELOPMENT

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 H: Zoysiagrass Hybridization - Progeny Development.**

3. INCREASE PLANTINGS AT TAES-DALLAS

Breeder fields of each DALZ8502, DALZ8507, DALZ8512, and DALZ8514, were planted July 1992. Each breeder field was 15000 sq ft, to which 250 sq ft of each, except DALZ8502, were planted with a 1:60 planting ratio. A 1:30 planting ratio was planted of DALZ8502. All were planted as 4x4 inch plugs.

Figure 1. Zoysiagrass Stimp Ratings
Fall 1992



APPENDIX A

Turfgrass Root Investigation

Root extension to lower soil depths and root branching are important drought avoidance mechanisms, allowing roots to extend to soil zones where plant available moisture exists. The use of flexible tubes to assess root growth in the greenhouse is a technique for efficiently screening large numbers of plant materials. The technique has advantages over the field in that root extension can be monitored nondestructively through time.

OBJECTIVES: Determine the rooting characteristics (depth of rooting, root mass, root branching) within various soil depths of zoysiagrass germplasm. Rooting characteristics are then related to drought tolerance as determined in the field.

PROGRESS: In fall 1991, all zoysiagrass entries included in the 1991 NTEP trial were planted to individual clear plastic flexible tubes in a glasshouse (see Table A1). Flexible tubes were filled with silica sand of uniform particle size distribution with a constant amount of Osmocote 14-14-14 uniformly mixed into the rooting profile, and were inserted into opaque PVC pipe, and suspended in racks tilted 30 degrees from vertical. Irrigation was applied with a mist system three times daily until termination of the study. Root extension was determined weekly by marking maximum root depth on the flexible tube face. Root systems of entries were harvested by replication when one entry reached the bottom of the flexible tubes. Root systems of the entries were assessed for maximum and third maximum root length, root number and weight at 10 cm increments, root extension rate, and total leaf dry weight. After termination of the study, a second study was planted in spring 1992. Results were correlated, so are reported as an average of the two experiments.

Grasses having the greatest root extension to lower soil depths were Meyer, Emerald, Belair, El Toro, DALZ8514, DALZ8512, DALZ8516, TC-2033, TC-5018, GT-2004, and GT-2047 (Table A1). Grasses having the greatest number of roots in the lower profile (greater or equal to 30 cm) were Meyer, Emerald, Belair, DALZ8514, DALZ8512, DALZ8516, DALZ9006, TC-2033, TGS-W10, GT-2047, AND ITR90-3 (Table A2). Greatest total root mass and root mass in lower sections occurred in Meyer, Emerald, El Toro, DALZ8514, DALZ8512, DALZ8516, TC-2033, TC-5018, and GT-2047 (Table A3). When all root parameters are taken into account, the best grasses appear to be Meyer, Emerald, El Toro, DALZ8512, DALZ8514, DALZ8516, TC-2033, and GT-2047.

Fifty percent of the NTEP entries are coarse in texture. However, the majority of the grasses with superior root growth were coarse in texture, with exception being Emerald (fine), and DALZ8516 and TC2033 (medium). Shoot growth rate tended to follow the same trend as root growth (Table A4). Greatest shoot growth occurred in Meyer, El Toro, Sunburst, Korean Common, DALZ8512, DALZ8514, CD-2013, GT-2004, TC-2033, and TC-5018. These grasses are predominately coarse in texture.

Twelve of the NTEP zoysiagrasses were also included in a linear gradient irrigation field experiment to determine drought tolerance over a three year period. Within the group of twelve grasses included in the field experiment, superior root extension rate and root branching at lower soil depths in the root tubes was strongly associated with drought survival in the field. Drought tolerant grasses were El Toro, Emerald, Belair, DALZ8512, DALZ8514, and DALZ8507.

Table A1. Root lengths (in mm) of third longest and longest root of NTEP zoysiagrasses. Leaf blade texture is listed as C = coarse, M = medium, F = fine.

Entry	NTEP#	Texture	Third	Longest	PS[2]
TC-2033	1	M	266	340a	1
GT-2047	2	C	353a	409a	2
CD-2013	3	M	240	307	0
TC-5018	4	C	308a	389a	2
GT-2004	5	MF	275a	333a	2
CD-259-13	6	C	269a	372a	2
KOREAN	7	C	211	283	0
JZ-1	8	C	232	317	0
MEYER	9	MC	287a	378a	2
EMERALD	10	F	300a	359a	2
BELAIR	11	C	249	342a	1
SUNBURST	12	C	163	243	0
ELTORO	13	C	308a	403a	2
DALZ8514	14	C	275a	360a	2
DALZ8512	15	C	317a	391a	2
DALZ8516	16	M	284a	328a	2
DALZ8507	17	F	192	318	0
DALZ8508	18	MF	127	175	0
DALZ9006	19	F	146	208	0
DALZ8502	20	F	197	295	0
DALZ8701	21	MF	180	207	0
TGS-B10	22	C	270a	325	1
TGS-W10	23	C	262	316	0
DALZ8501	24	MF	132	190	0
ITR90-3	25	M	171	268	0
MSD[1]			85	83	

[1]MSD = Minimum significant difference for comparison of entry means within columns based on the Waller-Duncan k ratio t test where k=100.

[2]PS = Phenotypic stability, the number of times an entry received superior ratings based on the Waller-Duncan k ratio t test.

Table A2. Mean numbers of roots per 10 cm vertical root section for NTEP zoysiagrasses.

	Root numbers per vertical section						
Entry	0	10	20	30	40	50	PS[2]
TC-2033	31.6a	12.2a	6.3	2.2	3.0a	0.4a	4
GT-2047	25.7	19.3a	13.5a	9.9a	4.8a	1.1a	5
CD-2013	25.4	14.3a	6.8	2.2	0.5	0.0	1
TC-5018	32.2a	19.4a	9.8a	5.0	1.2	0.1	3
GT-2004	29.3	19.2a	9.2a	2.2	0.3	0.0	2
CD-259-13	17.3	14.8a	8.1a	3.3	0.9	0.0	2
KOREAN	27.0	17.5a	9.6a	2.1	0.2	0.0	2
JZ-1	21.7	9.4	4.8	3.1	1.8	0.1	0
MEYER	32.9a	18.3a	9.3a	4.1	1.2	0.3a	4
EMERALD	35.0a	16.8a	8.8a	5.7	0.7	0.0	3
BELAIR	18.7	13.1a	13.3a	7.8a	2.6a	0.0	4
SUNBURST	16.9	8.4	4.4	1.0	0.0	0.0	0
ELTORO	19.2	11.3a	10.7a	6.2a	2.1a	0.1	4
DALZ8514	23.3	11.0	8.4a	4.5	3.3a	0.2	2
DALZ8512	26.2	17.6a	12.7a	8.6a	1.8	0.1	3
DALZ8516	35.1a	15.5a	6.8	5.5	1.5	0.5a	3
DALZ8507	23.6	8.1	4.3	2.3	0.1	0.1	0
DALZ8508	17.9	6.6	0.4	0.0	0.0	0.0	0
DALZ9006	17.0	7.6	2.7	1.3	0.6	0.1	0
DALZ8502	45.0a	15.9a	5.5	1.3	0.0	0.0	2
DALZ8701	34.8a	8.2	2.8	1.3	0.4	0.0	1
TGS-B10	17.8	13.0a	11.5a	3.3	0.8	0.0	2
TGS-W10	25.9	13.6a	11.3a	5.3	2.2a	0.0	3
DALZ8501	20.3	7.1	1.8	0.3	0.1	0.0	0
ITR90-3	17.7	9.8	2.9	3.0	0.4	0.1	0
MSD[1]	13.5	8.4	6.2	4.0	2.8	0.8	

MSD[1] = Minimum significant difference for comparison of entry means within columns based on the Waller-Duncan k ratio t test where k=100.
PS[2] = Phenotypic stability, the number of times an entry received superior ratings based on the Waller-Duncan k ratio t test.

Table A3. Mean weight of roots per 10 cm vertical root section for NTEP zoysiagrasses.

	Root mass (mg) per vertical section							
Entry	0-10	10-20	20-30	30-40	40-50	50-60	Total mass	PS[2]
TC-2033	240a	90	51	21	10a	3	424a	3
GT-2047	173	120a	79a	55a	20a	3	471a	5
CD-2013	181	94	37	12	0	0	326	0
TC-5018	289a	154a	77a	33a	5	5	571a	5
GT-2004	199	103a	48	14	0	0	368	1
CD-259-13	195	122a	59a	14	4	0	401	2
KOREAN	132	82	39	12	0	0	281	0
JZ-1	140	62	24	11	5	1	270	0
MEYER	210a	109a	58a	26	7a	5	434a	5
EMERALD	262a	106a	61a	30	2	0	471a	4
BELAIR	126	95	71a	33a	5	0	345	2
SUNBURST	125	34	14	2	0	0	185	0
ELTORO	207a	130a	88a	39a	9a	2	483a	6
DALZ8514	238a	106a	56a	40a	16a	3	509a	6
DALZ8512	227a	121a	86a	52a	10a	4	516a	6
DALZ8516	235a	88	48	25	7a	7	444a	3
DALZ8507	176	56	31	13	1	6	297	0
DALZ8508	129	39	2	0	0	0	173	0
DALZ9006	103	37	15	7	2	3	187	0
DALZ8502	186	62	19	3	0	0	273	0
DALZ8701	116	36	20	9	7a	0	249	1
TGS-B10	134	90	40	11	1	0	285	0
TGS-W10	192	89	47	20	3	0	360	0
DALZ8501	113	32	5	1	0	0	157	0
ITR90-3	89	30	19	7	2	3	155	0
MSD[1]	87	57	34	23	13	ns	150	

[1]MSD = Minimum significant difference for comparison of entry means within columns based on the Waller-Duncan k ratio t test where k=100.
[2]PS = Phenotypic stability, the number of times an entry received superior ratings based on the Waller-Duncan k ratio t test.

Table A4. Shoot clipping dry weights for NTEP zoysiagrasses.

Entry	Wt.(mg)
TC-2033	477a
GT-2047	485a
CD-2013	488a
TC-5018	555a
GT-2004	586a
CD-259-13	300
KOREAN	319a
JZ-1	271
MEYER	466a
EMERALD	241
BELAIR	286
SUNBURST	497a
ELTORO	391a
DALZ8514	452a
DALZ8512	406a
DALZ8516	174
DALZ8507	244
DALZ8508	192
DALZ9006	180
DALZ8502	176
DALZ8701	247
TGS-B10	299
TGS-W10	279
DALZ8501	251
ITR90-3	157
MSD[1]	266

[1]MSD = Minimum significant difference for comparison of entry means within columns based on the Waller-Duncan k ratio t test where k=100.

APPENDIX B

Zoysiagrass Resistance to the Tropical Sod Webworm (*Herpetogramma phaeopteralis*)

Development of pest resistant cultivars has been widely neglected in turfgrass, compared to emphasis on aesthetic traits. The turfgrass industry has relied extensively on pesticides for control of the major insect and mite pests in turf. This has suppressed the development of alternate control strategies including host resistant cultivars, and has led to the development of resistance to pesticides as insect and mite populations exposed to continual pesticide applications have developed the capacity to detoxify or otherwise tolerate these toxicants. Host resistant cultivars, however, have been used successfully as a means of insect control. Host resistance to the tropical sod webworm (TSW) has been documented in bermudagrass and St. Augustinegrass cultivars. The purpose of this research was to evaluate genotypes and cultivars of zoysiagrass for resistance to the TSW. This work was performed in collaboration with Dr. James Reinert.

MATERIALS AND METHODS

Zoysiagrass genotypes (Tables B1 and B2)were grown in 18-cell trays with each cell measuring 7.5x7.5 cm and 4 cm deep. For Experiment 1, the 7.5x7.5 cm plants of each genotype were randomly assigned to cells in each tray within 10 replicated trays. Five trays were placed each in two separate screen cages framed with PVC pipe ca 60 cm tall and large enough to contain the five trays. Ninety TSW adults from a greenhouse colony wee introduced into one caged set of 5 trays while the plants in the other cage were exposed to a natural infestation before they were caged. Larval damage per genotype was evaluated 27 days after first exposure to oviposition by the moths. A rating scale of 1 = extensive, nearly complete defoliation, and 9 = little or no sod webworm injury was used.

A second experiment was set up in the laboratory using 9 cm plastic petri dishes as larvae feeding chambers. Each dish was provided with two water saturated 7-cm filter paper discs. Each dish within each of the 5 replicates of 14 dishes was labeled with a coded number for the genotypes in Table B2, and provided with a small amount (ca 3 g) of the respective zoysiagrass entry. Three neonate larvae were then randomly selected and placed on the grass in each dish and dishes were arranged in a randomized complete block design on the laboratory bench. Water was added to the filter paper daily to keep it saturated to maintain the grass cuttings, and grass was added or replaced throughout the experiment so that turgid fresh gras was always available to the developing larvae.

Larvae were weighed 15 days after introduction, which was 3 days before the first of several individuals pupated. Survival and days as larvae to pupation were recorded for each larvae.

Data were analyzed using the General Linear Model procedure and mean separated by Waller-Duncan k-ratio t test (α = 0.05) (SAS Institute 1985).

RESULTS AND DISCUSSION

Zoysiagrass damage ratings differed (α = 0.05) among selections (Table B1). Least feeding damage was apparent on DALZ8501 and DALZ8507. Additionally, JZ-1 was not significantly different from the two least preferred genotypes. Accordingly, near complete defoliation was observed on Meyer, DALZ8516, and TC2033.

When neonate larvae were established and allowed to develop on each zoysiagrass,a similar response was found. The most rapid larval development occurred on DALZ8516, DALZ8502, and Meyer with highest larval survival and least days to pupation (before 20 days). Larvae developed slowest, with the least weight gain on Korean Common, El Toro, DALZ8507, and DALZ8501. Pupation on these four grasses also took the longest (mean >27 days). Two larvae on DALZ8507 fed for 37 and 39 days before the first larvae died and the latter pupated. Lowest survival occurred on DALZ8507, DALZ8501, Emerald, and Korean Common, which corresponded to the least damage observed in Experiment 1.

Genotypes with resistance to the TSW have been identified. Resistance in the form of larval mortality and an extended developmental period were documented. Slowed larval development has an added benefit of increased mortality due to natural predation since the larvae would be exposed longer to their natural enemies.

Table B1. Evaluation of zoysiagrass genotypes for resistance to tropical sod webworm (N = 10)[1].

Zoysiagrass genotype	Visual[2,3] Damage
DALZ8501	7.4 a
DALZ8507	7.3 a
JZ-1	6.6 ab
Emerald	5.8 bc
DALZ8508	5.8 bc
DALZ8512	5.3 bc
DALZ8701	5.2 c
CD259-13	5.2 c
TC5018	5.0 c
DALZ8502	4.8 c
Sunburst	4.8 c
DALZ9006	4.7 c
CD2031	4.6 c
DALZ8514	3.2 d
Belair	3.1 d
El Toro	2.3 de
TC2033	1.3 e
DALZ8516	1.2 e
Meyer	1.1 e

[1] Only 5 replicates were evaluated for Sunburst and DALZ8514.

[2] Worm damage ratings 1 = Near complete defoliation, 9 = No feeding damage.

[3] Means in a column followed by the same letter are not significantly different by Waller-Duncan K-ratio T test (k = 100) (P = 0.05).

Table B2. Resistance to tropical sod webworm in zoysiagrass: survival, larval weight, and days to pupation.

	Larval		Pupation	
Zoysiagrass genotype	alive (n)[1]	wt.[2] (mg)	alive (n)[3]	days[4]
Korean Common	8	6.3 a[5]	7	29.6 a
El Toro	12	6.9 a	10	27.5 abc
DALZ8507	9	7.2 ab	6	29.0 ab
DALZ8501	9	7.5 ab	9	27.1 bcd
DALZ8514	11	10.0 abc	10	25.8 cde
DALZ8508	13	10.7 abc	12	24.8 de
JZ-1	13	14.2 abc	12	24.3 ef
Belair	13	15.0 bc	13	23.6 ef
DALZ9006	13	15.1 bc	11	24.2 ef
DAlZ8512	13	15.6 c	11	24.3 ef
Emerald	9	17.1 c	9	22.6 f
Meyer	14	36.4 d	14	19.4 g
DALZ8502	13	37.5 d	13	19.7 g
DALZ8516	15	41.0 d	15	19.1 g

[1] Number of surviving 15-day-old larvae.
[2] Mean larval weight taken after 15 days of feeding.
[3] Number surving to pupatation.
[4] Mean number of days to pupation.
[5] Means in a column followed by the same letter are not significantly different by Waller-Duncan K-ratio T test (k = 100) (P = 0.05).

APPENDIX C

Zoysiagrass Resistance to the Zoysiagrass Mite, *Eriophyes zoysiae*

The zoysiagrass mite (*Eriophyes zoysiae*, Baker,Kono, and O'Neill) is host specific to zoysiagrass and causes extensive growth reduction by producing a leaf curl and failure of the leaf tip to unfold on susceptible genotypes. It was first described on zoysiagrass accessions introduced into the United States in 1982 from Korea and Japan. They reported mites and injury from five species of *Zoysia*. This mite is now established in Maryland, Texas, and Florida, where the plant materials have been used in genetic improvement programs.

All stages of the mite are found on unexpanded leaves, on the leaf sheath and collar, and in the spike and glume. New leaf tips and occasionally culms are twisted and caught in the partially unrolled older leaves resulting in a characteristic terminal arch or 'buggy whip' symptom. In heavy infestations, the entire leaf margin is rolled and most of the leaf is chlorotic.

The present research was initiated to delineate potential resistance among zoysiagrass genotypes and cultivars to the zoysiagrass mite. Greenhouse observations of zoysiagrass genotypes, and previous work with other insect and mite pests of zoysiagrass suggest a high potential for resistance to this mite. The work was a joint effort with Dr. James Reinert.

MATERIALS AND METHODS

Eighteen of the 1991 NTEP zoysiagrass series (Table C1) were grown in 18-cell trays with each cell measuring 7.5x7.5 cm and 4 cm deep. One 7.5x7.5 cm plant of each genotype was randomly assigned to each cell in each of the 18 replicate trays; however, cells 8 and 11 in each tray were reserved for plants of either CD259-13 or JZ-1. These two entries were heavily infested with mites before the test and were placed in theses locations to serve as inoculum for the experiment. By placing infested plant material in these locations, all plants within a replicate were immediately adjacent to an infested plant to allow for easy spread of the mites.

On 24 February, 1992, the 18 replicate trays were randomly arranged within a screen cage framed with PVC pipe ca 60 cm tall and large enough to contain the experiment. The cage was provided prevent interaction from other zoysiagrass pests. Plants were watered daily and plants were inspected and trimmed as needed throughout the experiment to avoid cross contamination among the genotypes.

Preliminary evaluations were made on 11 April 1992. Since the mite infestations were very irregular across the replicates, an additional source of inoculum was added. Single rows of heavily infested plants of Sunburst were placed between the replicate trays. Additionally, a fan was placed at one end of the experiment to provide a gentle breeze across the test area. Since eriophyid mites are known to disperse in the wind, this method provided an ideal inoculation method for the dispersion from infested plants to the test plant.

The experiment was evaluated for zoysiagrass mite infestation on 3 and 24 April 1992 by closely examining each plant and counting the number of leaves with leaf roll or hooked leaf tip symptoms. Since the actual number of leaves per plant varied significantly due to genotype differences, counts of greater than 10 were recorded as 10 for the analysis.

Data were subjected to analysis by ANOVA and genotype means were separated by Waller-Duncan k-ratio t test (α = 0.05). Data were transformed by LOG(N+0.5) before analysis, but untransformed means are presented here.

RESULTS AND DISCUSSION

Significant difference in susceptibility to the zoysiagrass mite existed among the zoysiagrass genotypes evaluated. Data taken on 3 and 24 April and combined dates analysis (Table C1) show DALZ9006, DALZ8516, DALZ8508, and Emerald are highly resistant to the zoysiagrass mite. Only 3,2,6, and 6, respective of the 18 replicate plants showed infestation for these four resistant genotypes. DALZ8501, DALZ8512, DALZ8514, TC2033, and El Toro exhibited moderate resistance to the mite with mean levels (combined dates) of 2.0 to 5.8 infested leaves per plant. Additionally, these genotypes ranged from 13 to 15 infested plants among the 18 replicates. The cultivars Meyer and Belair were among the most susceptible with all plants infested and an average of greater than 15 and 18 infested leaves per plant, respectively.

Additional zoysiagrass genotypes were evaluated during the test period. Tray plants of Korean Common, Sunburst, TGS-B10, TGS-W10, ITR90-3, and QT2049 exhibited moderate to very heavy levels of mite infestation.

Zoysiagrass genotypes have been identified that are highly resistant to the zoysiagrass mite. DALZ8501 which exhibited moderate resistance to this mite, also shows resistance to the tropical sod webworm. Genotypes like DALZ8501 with combined resistance to several pests should play an important role in the overall integrated pest management system for turfgrass. As new cultivars with pest resistance are developed, we will be able to reduce our dependence upon pesticides to maintain turfs of the future.

Table C1. Mean ± SE number and mite infested leaves per zoysiagrass plant (n = 18).

	Leaves with symptoms/plant[+±]		
Genotype	4/3/92	4/24/92	Combined Dates
DALZ9006[§]	0.2 ±0.6 a	0.2 ±0.6 a	0.2 ±0.5 a
DALZ8516	1.8 ±1.9 d	0.3 ±1.0 ab	1.0 ±1.6 b
DALZ8508	0.7 ±0.8 b	0.6 ±0.9 ab	0.6 ±0.9 b
Emerald	1.3 ±1.9 bc	0.9 ±1.9 b	1.1 ±1.9 b
DALZ8501	1.4 ±1.2 cd	2.6 ±2.5 c	2.0 ±2.1 c
DALZ8512	5.4 ±2.6 ef	2.3 ±1.7 c	3.9 ±2.7 d
El Toro	5.6 ±3.1 ef	2.8 ±3.1 c	4.2 ±3.3 d
DALZ8514	7.5 ±2.7 fg	4.0 ±3.6 cd	5.8 ±3.6 e
TC2033	4.4 ±2.8 e	4.3 ±3.8 d	4.4 ±3.3 d
CD2031	7.6 ±3.6 gh	7.9 ±3.0 e	7.8 ±3.3 f
DALZ8502	7.8 ±2.4 gh	9.4 ±1.4 ef	8.6 ±2.1 g
DALZ8701	9.3 ±2.1 h	9.4 ±1.7 ef	9.4 ±1.8 g
DALZ8507	9.1 ±2.4 h	9.8 ±0.7 ef	9.5 ±1.8 g
Meyer	9.9 ±0.5 h	9.9 ±0.2 ef	9.9 ±0.4 g
Belair	10.0 ±0.0 h	9.9 ±0.5 f	9.9 ±0.3 g
JZ-1	10.0 ±0.0 h	9.9 ±0.2 f	10.0 ±0.2 g
TC5018	9.8 ±0.9 h	10.0 ±0.0 f	9.9 ±0.7 g
CD259-13	10.0 ±0.0 h	10.0 ±0.0 f	10.0 ±0.0 g

[+] Number of mite infested leaves per plant (>10 = 10). Infested recognized as rolled leaf or hooked leaf tip.

[±] Data transformed using LOG(N+0.5) for analysis. Means in a column followed by the same letter are not significantly different by Waller-Duncan K-ratio T test (k = 100) (P = 0.05).

[§] DALZ represents Texas A&M University, Dallas, TX; TC represents Turf Center, Inc., Spencerville, MD; CD represents Crenshaw & Doguet Turf Farm, Austin, TX; and JZ represents Jacklin Seed Co., Post Falls, ID.

APPENDIX D

Nitrogen Fertilization and Mowing Height 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 places 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.

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. Nitrogen treatments consist of 0.12, 0.37 and 0.75 Kg N are^{-1} applied April, May, July, and September for total yearly amounts of 0.5, 1.5, and 3 Kg N are^{-1}, respectively. The plots were verticut on April 1, 1992. Data collected on the effects of management treatments included winter green color retention, spring greenup 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:
Spring Greenup
The zoysias never went completely dormant during the winter of 1991-92. The upper canopy lost color, but green actively growing leaves were present in the understory. Generally, there was no overall interaction between fertilizer level and mowing height treatments.

By April 25, the effects of the fertilizer levels were being expressed, where the 1#N plots were significantly greener than the higher nitrogen level plots, irrespective of mow treatment (Table D1). As supported by the entry mean separations and the phenotypic stability index, two experimentals, DALZ8508 and DALZ8516, and the cultivars El Toro, Emerald, and Meyer were the fastest to green up. Slower green up was observed in DALZ8501, Taes3372, Belair, Cashmere, primarily in the 6# N plots.

Winter Color Retention
Plots treated with 1#N generally retained green cover longer than other fertilizer levels (Table D2). Mowing height had no significant effect on the overall community. Entries were significantly different from one another only for the 3# rate under 1" reel mower. Here, DALZ8502, DALZ8508, DALZ8516, TAES3372, Cashmere and El Toro maintained superior winter green color.

Spring Turf Quality
Turf quality generally declined with the April reading, due to verticutting three weeks prior (Table D3). Generally the plots regained acceptable turf quality by May. Among the experimentals, the best turf quality was observed of DALZ8508 in all treatment plots. It had good quality before the verticut and quickly regained quality afterwards for all treatment combinations. Meyer and Emerald had the best quality of the commercially available cultivars in all treatment combinations.

Summer Turf Quality

Turf quality was best for DALZ8508, El Toro, Emerald, and Meyer across all treatments (Table D4). There was generally no effect of mowing, but fertility did effect turf quality, causing an increase with increasing applied nitrogen. There was little difference among turfgrasses in quality at the low nitrogen rate, but differences became apparent at higher rates.

Winter Turf Quality

Winter 1991-92 was mild, and contributed to the higher than normal turf quality scores during January (Table D5). Quality had declined during the early winter. There was no significant effect of the treatments on the winter quality of the zoysias tested.

FUTURE WORK: Turf performance will continue to be monitored during 1992. Attention will continue to focus on the response of entries to differential mowing and nitrogen fertilization. Performance of entries will again be evaluated on turf quality parameters, including density, uniformity, color quality, fall color retention, and spring greening. Additional study will include resistance to pests and environmental stresses, and thatching tendency.

Table D1. 1992 Spring green up of zoysiagrasses planted at TAES-Dallas. Effects of nitrogen enrichment and mowing height.

Mow Treatment	Entry	3 Mar. (1# N)	27 Mar. (1# N)	25 Apr. (1# N)	3 Mar. (3# N)	27 Mar. (3# N)	25 Apr. (3# N)	3 Mar. (6# N)	27 Mar. (6# N)	25 Apr. (6# N)	PS[1]
		Green cover									
5/8" Reel	Dalz8501	28.3	35.0	92.3a	20.0	33.3	70.0	8.3	36.7	66.7a	2
	Dalz8502	58.7a	35.0	63.3	28.3	48.3	71.7	8.7	35.0	56.7	1
	Dalz8508	28.3	53.3a	90.0a	36.7	55.0	83.3	21.7	46.7	58.3	2
	Dalz8516	41.7a	61.7a	90.0a	36.7	51.7	75.0	25.0	35.0	48.3	3
	Taes3372	15.0	33.3	56.7	18.3	40.0	61.7	11.7	30.0	45.0	0
	Belair	10.0	45.0	80.0a	16.7	45.0	65.0	5.7	41.7	53.3	1
	Cashmere	25.0	33.3	85.0a	11.7	30.0	80.0	13.7	28.3	53.3	1
	El Toro	21.7	36.7	83.3a	23.3	41.7	80.7	33.3	43.3	75.0a	2
	Emerald	16.7	36.7	90.0a	16.0	45.0	91.0	26.7	51.7	66.7a	2
	Meyer	23.3	51.7a	93.3a	20.0	53.3	93.3	18.3	60.0	91.7a	3
	MSD entry[2]	23.6	16.3	20.0	n.s.	n.s.	n.s.	n.s.	n.s.	29.9	
	Mean mow	26.9	42.2	82.4	22.8	44.3	77.2	17.3	40.8	61.5	
	MSD fert[3]	7.3	n.s.	5.9							
1" Rotary	Dalz8501	30.0	33.3	90.0a	16.7	33.3	78.3	9.3	28.3	63.3	1
	Dalz8502	27.0	38.3a	61.7	20.3	40.0a	73.3	30.0a	36.7	66.7	3
	Dalz8508	28.3	45.0a	90.0a	33.3	50.0a	86.7a	41.7a	50.0a	80.0	6
	Dalz8516	31.7	48.3a	86.7a	33.3	45.0a	73.3	28.3a	50.0a	73.3	5
	Taes3372	11.7	30.0	56.7	23.3	36.7	50.0	18.3	30.0	51.7	0
	Belair	12.7	45.0a	75.0a	13.3	41.7a	65.0	5.0	38.3	58.3	3
	Cashmere	25.0	28.3	85.0a	10.0	28.3	81.7a	3.0	26.7	61.7	2
	El Toro	18.3	38.3a	85.0a	25.0	43.3a	83.3a	28.3a	43.3a	80.0	6
	Emerald	19.3	36.7a	86.7a	27.3	45.0a	88.3a	23.3a	46.7a	70.0	6
	Meyer	25.0	51.7a	93.3a	26.7	53.3a	95.0a	30.0a	60.0a	92.3	6
	MSD entry	n.s.	15.4	18.8	n.s.	11.7	16.5	20.2	20.5	n.s.	
	Mean mow	22.9	39.5	81.0	22.9	41.7	77.5	21.7	41.0	69.7	
	MSD fert	n.s.	n.s.	5.8							
1" Reel	Dalz8501	16.7	35.0	86.7	15.0	31.7	68.3	5.7	31.7	70.0a	1
	Dalz8502	30.0	40.0	75.0	26.7	40.0a	68.3	30.0a	35.0	60.0	2
	Dalz8508	26.7	43.3	86.7	31.7	48.3a	81.7	23.3a	46.7a	63.3	3
	Dalz8516	25.0	46.7	78.3	23.3	46.7a	60.0	16.7a	43.3	45.0	2
	Taes3372	13.3	31.7	53.3	13.3	30.0	53.3	8.3	33.3	41.7	0
	Belair	5.7	40.0	80.0	6.7	43.3a	68.3	6.7	38.3	55.0	1
	Cashmere	16.7	28.3	85.0	7.7	25.0	66.7	2.3	28.3	55.0	0
	El Toro	21.7	40.0	85.0	26.7	43.3a	76.7	28.3a	46.7a	75.0a	4
	Emerald	22.7	38.3	76.7	25.0	43.3a	83.3	7.3	46.7a	65.0a	3
	Meyer	15.0	51.7	93.3	13.3	53.3a	86.7	16.7a	60.0a	80.0a	4
	MSD entry	n.s.	n.s.	n.s.	n.s.	14.6	n.s.	14.1	15.2	15.6	
	Mean mow	19.3	39.5	80.0	18.9	40.5	71.3	14.5	41.0	61.0	
	MSD fert	4.4	n.s.	5.4							
	MSD mow[4]	n.s.	2.5	n.s.	n.s.	2.8	3.7	5.6	n.s.	4.9	

[1]PS = phenotypic stability, which is the number of times an entry is ranked in the most desirable statistical group.
[2]MSD entry = minimum significant difference between entry means for comparisons within columns based on the Waller-Duncan K-ratio t test (K-ratio = 100).
[3]MSD fert = minimum significant difference between fertilizer treatment means for comparisons within date columns and mow treatment rows based on the Waller-Duncan K-ratio t test (K-ratio = 100).
[4]MSD mow = minimum significant difference between mow treatment means for comparisons within date and fertilizer treatment columns based on the Waller-Duncan K-ratio t test (K-ratio = 100).

Table D2. Green color retention, as percentage of turf cover which is green cover, as noted on November 18, 1991. Effects of nitrogen enrichment and mowing height.

Mow Treatment	Entry	1# N	3# N	6# N	MSD fert[1]
		Green cover			
5/8" Reel	Dalz8501	30.0	13.3	7.7	
	Dalz8502	33.3	25.0	15.0	
	Dalz8508	21.7	15.0	12.7	
	Dalz8516	30.0	25.0	20.7	
	Taes3372	30.0	21.7	20.0	
	Belair	19.3	11.7	13.7	
	Cashmere	14.0	14.0	3.7	
	El Toro	26.7	12.3	15.7	
	Emerald	16.0	18.3	13.3	
	Meyer	20.0	12.3	11.7	
	MSD entry[2]	n.s.	n.s.	n.s.	
Mean mow		24.1	16.9	13.4	3.4
1" Rotary	Dalz8501	23.3	10.7	10.0	
	Dalz8502	36.7	21.7	18.3	
	Dalz8508	19.0	9.3	11.7	
	Dalz8516	30.0	25.0	16.7	
	Taes3372	21.7	16.7	18.3	
	Belair	20.0	11.0	11.7	
	Cashmere	14.0	10.7	3.7	
	El Toro	20.0	13.0	13.3	
	Emerald	16.7	9.0	9.3	
	Meyer	14	10.7	11.3	
	MSD entry	n.s.	n.s.	n.s.	
Mean mow		21.5	13.8	12.4	3.1
1" Reel	Dalz8501	18.3	4.3	3.7	
	Dalz8502	30.0	13.3a	15.0	
	Dalz8508	23.3	15.0a	15.0	
	Dalz8516	23.3	20.0a	11.7	
	Taes3372	20.0	20.0a	15.0	
	Belair	21.7	9.3	12.7	
	Cashmere	13.3	11.7a	4.3	
	El Toro	21.7	9.7a	14.0	
	Emerald	16.7	8.3	7.0	
	Meyer	20.0	6.0	7.7	
	MSD entry	n.s.	11.4	n.s.	
Mean mow		20.8	11.8	10.6	3.1
MSD mow[3]		n.s.	3.0	n.s.	

[1]MSD fert = minimum significant difference for comparison of fertilizer treatments within date columns and mow treatment rows based on the Waller-Duncan K-ratio t test (K-ratio = 100).
[2]MSD entry = minimum significant difference for comparison of entry means within columns based on the Waller-Duncan K-ratio t test (K-ratio = 100).
[3]MSD mow = minimum significant difference for comparison of mowing treatments within date and fertilizer treatment columns based on the Waller-Duncan K-ratio t test (K-ratio = 100).

Table D3. Spring 1992 turf quality for zoysiagrasses planted at TAES-Dallas. Effect of nitrogen enrichment and mowing height.

Mow Treatment	Entry	27 Mar.	25 Apr.	27 May	27 Mar.	25 Apr.	27 May	27 Mar.	25 Apr.	27 May	PS[1]
			1# N			3# N			6# N		
		Green cover									
5/8" Reel	Dalz8501	4.7	5.3a	5.0	5.0	3.7	4.7	5.0a	3.0	4.0	2
	Dalz8502	3.7	3.0	3.3	5.0	4.0	4.7	4.3	2.7	4.7	0
	Dalz8508	5.3	5.3a	6.3a	5.7	4.7	7.7a	5.3a	3.0	4.7	4
	Dalz8516	5.3	5.0a	5.0	5.3	4.3	4.3	5.0a	2.7	3.0	2
	Taes3372	4.0	3.3	3.0	4.7	3.3	4.0	4.7	2.7	2.3	0
	Belair	5.3	4.0	4.3	5.0	3.0	3.3	5.0a	2.7	3.0	1
	Cashmere	5.0	4.7a	4.7	5.0	4.3	6.0a	5.3a	2.7	4.3	3
	El Toro	5.0	4.7a	5.0	5.3	4.3	5.7a	5.7a	4.0a	4.7	4
	Emerald	4.7	5.3a	4.3	5.0	5.3	5.7a	5.3a	3.7a	5.7a	5
	Meyer	5.3	5.7a	6.7a	5.3	5.3	6.7a	6.0a	4.7a	7.0a	6
	MSD entry[2]	n.s.	1.4	1.1	n.s.	n.s.	2.7	1.0	1.1	1.9	
Mean mow		4.8	4.6	4.8	5.1	4.2	5.3	5.2	3.2	4.3	
MSD fert[3]		0.3	0.4	0.6							
1" Rotary	Dalz8501	4.7	5.0a	5.0	5.0	4.0	5.0	4.7	3.3	3.7	1
	Dalz8502	3.3	3.3	3.3	4.3	4.0	4.0	3.7	3.7a	4.7	1
	Dalz8508	5.0	5.0a	6.7a	5.0	5.3a	7.0a	5.3a	4.3a	6.0a	7
	Dalz8516	5.0	5.3a	4.3	5.0	3.7	4.0	5.3a	3.7a	3.7	3
	Taes3372	4.0	3.0	3.3	4.3	2.7	3.0	5.0a	2.7	2.7	1
	Belair	4.7	4.3a	3.7	5.0	3.7	3.7	5.0a	3.0	3.0	2
	Cashmere	5.0	4.7a	5.0	5.0	4.7a	6.0a	5.7a	3.3	4.0	4
	El Toro	4.7	4.7a	5.0	5.0	4.0	6.3a	5.0a	4.0a	5.7a	5
	Emerald	4.7	5.0a	4.7	5.3	5.0a	6.0a	5.3a	4.0a	5.0a	6
	Meyer	5.0	5.0a	6.7a	5.7	5.0a	7.0a	6.0a	5.3a	7.0a	7
	MSD entry	n.s.	1.3	1.0	n.s.	0.8	1.8	1.3	1.7	2.1	
Mean mow		4.6	4.5	4.8	5.0	4.2	5.2	5.1	3.7	4.5	
MSD fert	0.3	0.4	n.s.								
1" Reel	Dalz8501	4.7	4.7	4.3	4.7	3.7	4.3	4.7	3.7	4.0a	1
	Dalz8502	4.7	4.0	3.3	4.0	4.0	4.7	4.7	3.0	4.0a	1
	Dalz8508	5.0	5.0	6.3	5.0a	4.3	7.3a	5.3	3.0	6.0a	3
	Dalz8516	4.3	4.0	4.0	4.7	3.3	3.7	4.7	2.7	3.3	0
	Taes3372	4.3	3.3	3.3	4.3	2.7	2.3	5.0	2.3	2.0	0
	Belair	5.0	4.3	4.3	5.0a	3.3	3.3	5.0	2.7	2.3	1
	Cashmere	5.0	4.7	5.0	5.0a	3.7	5.7a	5.7	3.0	4.7a	3
	El Toro	4.7	4.7	5.0	5.0a	4.0	6.0a	5.3	3.3	5.0a	3
	Emerald	4.7	5.0	4.3	5.3a	4.7	6.3a	5.7	3.3	5.0a	3
	Meyer	5.0	5.7	6.0	5.7a	4.7	7.0a	6.0	4.0	6.3a	3
	MSD entry	n.s.	n.s.	n.s.	0.9	n.s.	2.4	n.s.	n.s.	2.3	
Mean mow		4.7	4.5	4.6	4.9	3.8	5.1	5.2	3.1	4.3	
MSD fert	0.3	0.3	n.s.								
MSD mow[4]		n.s.	n.s.	n.s.	n.s.	0.4	n.s.	n.s.	0.3	n.s.	

[1]PS = phenotypic stability, which is the number of times an entry is ranked in the statistically highest group.
[2]MSD entry = minimum significant difference for comparison of entry means within date columns based on Waller-Duncan K-ratio t test (K-ratio = 100).
[3]MSD fert = minimum significant difference for comparison of fertilizer treatment means within date columns and mow treatment rows based on Waller-Duncan K-ratio t test (K-ratio = 100).
[4]MSD mow = minimum significant difference for comparison of mow height treatment means within date and fertilizer treatment columns based on Waller-Duncan K-ratio t test (K-ratio = 100).

Table D4. 1992 Summer turf quality. Effects of nitrogen enrichment and mowing height.

Mow Treatment	Entry	24 June (1# N)	31 July (1# N)	26 Aug. (1# N)	24 June (3# N)	31 July (3# N)	26 Aug. (3# N)	24 June (6# N)	31 July (6# N)	26 Aug. (6# N)	PS[1]
		Turf Quality									
5/8" Reel	Dalz8501	5.3	4.7	4.7	5.0	5.3	5.0a	5.0	5.7	6.3	1
	Dalz8502	5.3	4.0	3.3	6.7	5.0	6.3a	7.0a	6.3	5.3	2
	Dalz8508	7.3	4.7	6.3	9.0a	6.3	7.0a	7.0a	5.7	7.0	3
	Dalz8516	5.7	5.0	5.7	5.3	4.7	5.0a	3.3	3.7	5.3	1
	Taes3372	4.3	4.7	4.3	4.7	5.7	3.0	3.3	4.3	4.0	0
	Belair	5.0	5.0	4.3	5.3	5.3	6.0a	5.0	4.3	5.7	1
	Cashmere	7.3	4.7	5.3	8.3a	6.3	7.3a	8.7a	7.0	6.7	3
	El Toro	6.7	5.0	6.0	7.0a	6.3	7.0a	7.3a	7.0	7.7	3
	Emerald	6.7	3.7	4.0	8.0a	4.7	4.7a	8.0a	5.3	5.3	3
	Meyer	7.7	5.7	7.3	7.7a	6.0	7.7a	7.7a	6.7	7.7	3
	MSD entry[2]	n.s.	n.s.	n.s.	2.1	n.s.	3.6	2.6	n.s.	n.s.	
1" Rotary	Dalz8501	6.0	4.0	4.0	6.3	4.0	4.7	5.7	3.7	6.0a	1
	Dalz8502	6.7	3.3	4.0	6.3	4.3	4.0	6.7a	4.3	5.0	1
	Dalz8508	7.3	2.7	5.0a	8.3a	3.7	5.7a	7.7a	4.0	7.3a	5
	Dalz8516	5.3	4.3	4.7a	5.3	4.3	3.7	5.7	4.3	7.0a	2
	Taes3372	4.7	4.7	3.7	5.0	4.0	2.0	3.7	3.7	3.7	0
	Belair	4.7	3.7	4.0	5.3	4.7	6.0a	5.0	3.7	5.7a	2
	Cashmere	7.3	4.0	5.7a	8.7a	4.3	6.3a	8.7a	4.0	7.7a	5
	El Toro	6.3	5.0	6.0a	7.0a	5.0	7.0a	7.3a	6.0	7.7a	5
	Emerald	6.3	3.7	4.7a	8.0a	3.7	5.3a	7.7a	4.3	4.7	4
	Meyer	7.0	4.3	7.0a	8.3a	4.0	7.7a	7.7a	4.3	7.7a	5
	MSD entry	n.s.	n.s.	2.5	2.2	n.s.	2.5	2.6	n.s.	2.7	
1" Reel	Dalz8501	5.3	4.3	4.0	5.3	4.7	5.0a	6.3a	5.3	7.7a	3
	Dalz8502	6.7	4.7	4.0	7.0a	4.7	3.7	6.3a	5.3	6.3a	3
	Dalz8508	7.0	4.7	6.3	8.3a	6.0a	6.7a	7.7a	6.7a	7.0a	6
	Dalz8516	5.7	4.3	3.3	4.3	3.7	3.3	4.7	3.3	3.0	0
	Taes3372	5.7	3.7	4.7	5.0	4.0	3.0	5.0	3.7	2.7	0
	Belair	5.0	4.3	4.7	4.3	4.7	5.0a	4.7	5.3	5.0a	2
	Cashmere	7.0	5.3	5.3	8.0a	7.0a	8.0a	8.3a	7.3a	7.3a	6
	El Toro	5.3	5.0	6.7	7.0a	7.0a	6.3a	6.7a	7.7a	6.7a	6
	Emerald	5.0	4.7	5.0	7.7a	6.0a	6.0a	7.7a	5.0	5.3a	5
	Meyer	5.0	6.0	6.7	7.7a	6.3a	8.0a	7.7a	6.3a	8.0a	6
	MSD entry	n.s.	n.s.	n.s.	1.7	2.1	3.7	2.2	2.2	4.0	
MSD fert[3]		0.5	0.5	0.5							
MSD mow[4]		n.s.	n.s.	n.s.							

[1]PS = Phenotypic stability, which is the number of times an entry is ranked in the most desirable statistical group.
[2]MSD = Minimum significant difference for comparison of entry means within columns based on the Waller-Duncan k-ratio t test (k-ratio = 100).
[3]MSD = Minimum significant difference for comparison of fertilizer treatments within date columns and mow treatment rows based on the Waller-Duncan k-ratio t test (k-ratio = 100).
[4]MSD = Minimum significant difference for comparison of mowing treatments within date and fertilizer treatment columns based on the Waller-Duncan k-ratio t test (k-ratio = 100).

Table D5. Turf quality for winter 1991. Effects of nitrogen enrichment and mowing height.

Mow Treatment	Entry	18 Nov. 1# N	22 Jan. 1# N	18 Nov. 3# N	22 Jan. 3# N	18 Nov. 6# N	22 Jan. 6# N	PS[1]
		Green cover						
5/8" Reel	Belair	2.0	5.0a	2.0	5.0	2.7a	5.0	2
	Dalz8501	1.7	5.0a	2.0	5.0	1.7	5.0	1
	Dalz8502	2.0	3.7	2.0	4.3	1.3	4.3	0
	Dalz8508	2.7	5.0a	3.0	5.0	3.0a	5.0	2
	Dalz8516	2.0	5.0a	2.3	5.0	2.7a	5.0	2
	El Toro	2.7	5.0a	2.0	5.0	2.0	5.0	1
	Emerald	2.7	5.0a	3.0	5.0	2.7a	5.0	2
	Meyer	2.7	5.0a	2.7	5.0	2.7a	5.0	2
	Taes3372	1.7	3.7	2.0	4.3	2.0	5.0	0
	Cashmere	2.0	4.3a	2.7	5.0	2.4a	5.0	2
	MSD entry[2]	n.s.	1.1	n.s.	n.s.	0.9	n.s.	
	Mean mow	2.2	4.7	2.4	4.9	2.3	4.9	
	MSD fert[3]	n.s.	n.s.					
1" Rotary	Belair	2.0	4.3a	2.0	5.0a	2.7a	5.0	3
	Dalz8501	2.0	4.7a	1.7	5.0a	1.3	4.3	1
	Dalz8502	1.3	3.3	1.0	4.0	1.0	4.3	0
	Dalz8508	2.7	5.0a	2.0	5.0a	2.3a	5.0	3
	Dalz8516	2.3	4.3a	1.7	5.0a	2.3a	5.0	3
	Eltoro	2.3	5.0a	2.3	5.0a	2.3a	5.0	3
	Emerald	2.7	4.7a	2.3	5.0a	2.3a	5.0	3
	Meyer	2.3	5.0a	2.7	5.0a	2.0a	5.0	3
	Taes3372	2.0	3.7	1.7	4.3	2.0a	4.3	1
	Cashmere	2.0	4.3a	2.0	5.0a	1.7a	5.0	3
	MSD entry	n.s.	0.9	n.s.	0.3	1.2	n.s.	
	Mean mow	2.2	4.4	1.9	4.8	2.0	4.8	
	MSD fert	n.s.	0.2					
1" Reel	Belair	2.0	5.0	2.0	5.0	2.0	5.0	0
	Dalz8501	2.0	4.3	2.3a	4.7	1.7	4.7	1
	Dalz8502	1.7	4.0	1.3	4.3	1.0	4.0	0
	Dalz8508	2.0	5.0	3.0a	5.0	2.3	5.0	1
	Dalz8516	1.7	4.0	1.7	5.0	2.3	5.0	0
	Eltoro	2.3	5.0	2.0	5.0	2.0	5.0	0
	Emerald	2.0	4.7	3.0a	5.0	2.3	5.0	1
	Meyer	2.3	5.0	2.3a	5.0	2.0	5.0	1
	Taes3372	1.7	4.7	1.7	4.0	1.7	5.0	0
	Cashmere	2.3	4.7	2.0	5.0	2.3	5.0	0
	MSD entry	n.s.	n.s.	0.7	n.s.	n.s.	n.s.	
	Mean mow	2.0	4.6	2.1	4.8	2.0	4.9	
	MSD fert	n.s.	n.s.					
	MSD mow[4]	n.s.	n.s.	0.3	n.s.	0.3	n.s.	

[1]PS = Phenotypic stability, which is the number of times an entry is ranked in the most desirable statistical group.
[2]MSD = Minimum significant difference for comparison of entry means within columns based on the Waller-Duncan K-ratio t test (K-ratio = 100).
[3]MSD = Minimum significant difference for comparison of fertilizer treatments within date columns and mow treatment rows based on the Waller-Duncan K-ratio t test (K-ratio = 100).
[4]MSD = Minimum significant difference for comparison of mowing treatments within date and fertilizer treatment columns based on the Waller-Duncan K-ratio t test (K-ratio = 100).

APPENDIX E

Summarization of Zoysiagrass performance under Linear Gradient Irrigation

Limitations on resources and society's concern for the environment dictate that future turfgrass cultivars have high tolerance to pests and environmental stresses. They must produce acceptable to high aesthetic and functional turf quality with minimum cultural inputs. The development and utilization of turfgrass cultivars with superior drought resistance continues to be one of the greatest needs of the turfgrass industry and demands high priority. The linear gradient irrigation system (LGIS) at TAES-Dallas was developed specifically to evaluate water requirements of newly developed turfgrasses under field conditions. More specifically, to: 1) determine the minimum amount of supplemental irrigation required to maintain turf for soil and water conservation and stabilization, and 2) determine the minimum amount of water required for acceptable turf performance. Numerous opportunities arise to also address other performance characters.

The objective of the study was to evaluate the quality of selected zoysiagrasses throughout each year for three years. During the three summers, the study included determination of the amount of irrigation water required to prevent stress, maintain acceptable turf quality, and to maintain a persistent turf cover. The study also evaluated spring green up, green color retention in the fall, and ability of the grasses to maintain a monoculture stand.

MATERIALS AND METHODS

A total of 26 different zoysiagrasses were planted to LGIS during 1987. A randomized complete block with four replications, two on either side of the line irrigation source, were used. Plots were 1.5 m wide by 20 m perpendicular to the line irrigation source and were planted as sprigs using a 1:35 planting ratio. The area received uniform fertilization and irrigation as needed in 1987 and 1988 to prevent stress and to encourage full turf coverage, which was achieved by fall 1988. The experimental area receives a yearly total of 0.98 kg N are^{-1} and is maintained at a 2.54 cm mowing height.

Gradient irrigation was initiated mid-July 1989 and is continual regardless of season, to create a moisture stress gradient and to determine the volume of irrigation required to maintain ground cover, prevent drought stress, maintain acceptable turf quality, and maintain at least 50% green turf ground cover. Average annual rainfall for Dallas, Texas is about 71 cm, but was 124 and 136 cm for 1989 and 1990, respectively (Figures E1 and E2). Total rainfall for 1991, through September 30, was 77.7 cm (Figure E3). Water distribution for the gradient was determined by measuring irrigation water collected in rain gauges positioned at 1.5 m increments from the line irrigation source (Figure E4). Least squares non-linear regression of irrigation volume against distance from the line source was used to predict irrigation distribution along the gradient (Figure E4). Irrigation water volume in 1990 exceeded that to 1989 or 1991 because the study period was extended and rainfall was lower in the summer of 1990. The summer of 1991 was unusually wet, with twice as many days with rainfall as in 1989 or 1990. Turf performance is measured throughout the year.

RESULTS AND DISCUSSION

Drought Tolerance and Recovery .
The distance from the center trench (supplemental irrigation at 120% evapotranspiration) was measured to transition zones where: turfgrasses failed to survive (green turf cover less than 50%), turfgrasses were under drought stress (leaf blade wilt occurred), and where turfgrasses had minimum acceptable quality (TQ=5.0). The distance was translated by least squares non-linear regression into the water required to maintain turf cover, prevent stress, and maintain acceptable turf quality, respectively.

Stress prevention
Those entries which required low volumes of water to prevent stress, measured as the minimum irrigation level at which leaf rolling was prevented, include Belair, El Toro, DALZ8512, and DALZ8514, all of which required less than 250mm irrigation to prevent leaf rolling, an indicator of leaf wilt (Table E1). Significantly larger volumes of water was required to prevent stress in commercial cultivar FC13521, and in two experimental lines, DALZ8522, and DALZ8524.

Acceptable Turf Cover
Belair, El Toro, DALZ8507, DALZ8510, DALZ8512, and DALZ8514 required the least water to maintain at least 50% green turf cover (Table E1). As noted in Table 4, these entries expanded their boundaries in the non-irrigated zones, and thus showed potential for establishment in minimally irrigated regions. DALZ8513, DALZ8522, DALZ8523, and DALZ8524 were significantly poorer survivors in the non-irrigated zones of the irrigation gradient, and required the most supplemental irrigation to maintain green turf cover (Tables E1 and E2). On average the zoysias tested required about 525mm supplemental irrigation to maintain at least 50% green turf cover in Dallas.

Acceptable Turf Quality
Turf quality maintenance required the most water, as it involves preserving good color levels, good turf cover, and good canopy densities, qualities which diminish as the grasses are progressively stressed along the linear irrigation gradient (Table E1). Among the entries tested, all required at least 500mm of irrigation to maintain acceptable turf quality (TQ = 5.0). Significantly less irrigation was required for turf quality maintenance of Belair, El Toro, Emerald, FC13521, DALZ8507, DALZ8510, DALZ8512, DALZ8514, and DALZ8524 than for other entries. This group was diverse, with representatives from all zoysiagrass textural categories. Significantly more water was required to maintain acceptable turf quality for Cashmere, Korean Common, Meyer, DALZ8501, DALZ8511 and DALZ8522. DALZ8502, DALZ8516, and DALZ8523 required moderate levels of supplemental irrigation to maintain acceptable turf quality.

Recovery
During and after drought, mean green turf ground cover of textural classes decreased in the order of long wide>short narrow=long narrow>short wide in zones of intermediate and no irrigation (Tables E1 and E2). Percent green turf ground cover doubled for all entries within 7 days after termination of stress. Notable recovery was observed for DALZ8507, DALZ8512, DALZ8514, Emerald, and El Toro. Several of the DALZ lines have remarkable potential to recover from drought stress.

Turf Survival
Turf cover and weed cover changed very little during the 3 years of the gradient study in the high and intermediate irrigation zones of the gradient (Tables E3 and E4). During the same era of the study, significant changes in turf cover and weed cover did arise in the non-irrigated sectors of the gradient. In this zone, significant loss of turf cover developed in the plots of DALZ8515 and DALZ8522. Yet, of particular importance, several of the zoysiagrasses expanded beyond their plot boundaries in the non-irrigated region of the gradient. Most distinguished among these are El Toro, DALZ8507, DALZ8512, and DALZ8514, three of which were among the entries which consistently required the least supplemental irrigation to maintain turf cover, maintain turf quality, remain free of leaf wilt. Entries which maintained high turf cover and low weed cover in the non-irrigated zones include the above four, plus DALZ8502, DALZ8508, DALZ8510, FC13521, and Belair.

Turf Quality
For both years of evaluation, there was no improvement in turf quality following stress (Table E5). Belair, DALZ8507, DALZ8512, and DALZ8514 had the best quality overall on September 5, 1990. There was no improvement in turf quality following stress, except for moderate improvement in zones receiving no irrigation. Only DALZ8507 had acceptable (TQ > 5) turf quality in moderately irrigated zones during and immediately following summer water stress.

As the 1991 drought period was a cooler, and less dry than in 1990 (Figures E3 and E4), more varieties maintained good quality during the stressful period. On July 10, during drought stress, Emerald, El Toro, Korean Common, DALZ8507, DALZ8510, DALZ8512, and DALZ8514 had higher than acceptable turf quality under no supplemental irrigation (Table E2). Of these, only DALZ8507 and DALZ8512 maintained acceptable quality across all irrigations. By August 28, after drought stress, Belair, DALZ8506, DALZ8508, and DALZ8517 had acceptable turf quality under no irrigation (Table E2). DALZ8523 had unacceptable turf quality under all irrigations. By 1991, thatch had accumulated excessively in Belair, DALZ8502, DALZ8505, DALZ8511, DALZ8515, and DALZ8523 (data not shown).

Net Radiation

Generally, net radiation decreased as irrigation decreased (Tables E6, E7, E8). This was as expected, because net radiation is a measure of photosynthetic activity of the tissues, and as moisture becomes more limiting, photosynthesis should decline. The net radiometer measures the difference between incident light onto the tissues and reflected light from the tissues. One expects the difference to be larger when the plants are absorbing more photic energy. Entries were not significantly different within an irrigation zone. Net radiation and canopy temperature, along with climatic data, are used to calculate a crop water stress index (CWSI), which will be calculated for these zoysiagrasses in the near future.

Canopy Temperature

Canopy temperature correlates negatively with increasing transpiration of plants, in which transpiration ceases as stomates close and leaves roll. For the zoysiagrasses tested on LGIS, canopy temperatures increased, indicating increased stress, as supplemental irrigation approached zero (Tables E9, E10, E11). Differences among entries were detected especially during 1990. Entries with the lowest canopy temperatures in the non-irrigated zones included Belair, El Toro, DALZ8512, and DALZ8516.

General Performance

Fall Color retention

Fifteen of the entries had good fall color by December 10, 1990, and only five had such on December 6, 1989 (Table E12). The differences are probably related to the climatic conditions during the respective autumns (Figures E1 and E2). Overall, five entries, DALZ8501, DALZ8502, DALZ8513, DALZ8522, and Emerald, consistently held good green color later into the year than other entries. The lowest color ratings, at these late fall dates, were observed for El Toro, DALZ8514, and DALZ8504. During the fall, as the zoysiagrasses lose their chlorophyll, many varieties and lines were observed to produce red anthocyanin pigmentation (Table E12). Strong producers of red pigmentation in the fall were Belair, El Toro, DALZ8503, DALZ8508, DALZ8512, DALZ8514, and DALZ8523. When the entries lost their green canopies, gold and grey were the predominant winter colors. Golden canopies (data not presented) were observed for Korean Common, Meyer, DALZ8511, and DALZ8512, and grey canopies were common for Cashmere, DALZ8508, and DALZ8516 (Table E12).

Spring Turf Coverage

Spring cover was slow to appear during the spring of 1989 (Table E13). By April 1, the maximum green cover was 50%, and several entries had less than 10% green cover. In 1990, spring green cover developed fastest for Korean Common, Meyer,and DALZ8511, with about 75% green cover by March 30. Whereas, in 1991, by April 3, El Toro, Meyer, FC13521, DALZ8504, DALZ8506, DALZ8508, DALZ8511, DALZ8516, DALZ8517, and DALZ8524, had 70 to 90% green cover. Those entries which were slowest to produce green cover in all 3 years includes Cashmere, DALZ8501, DALZ8513, DALZ8522, and DALZ8523, with less than 25% average green cover.

In all years, plants in non-irrigated zones were slower to green up than irrigated plants (data not presented). In 1990, Emerald, El Toro, FC13521, Belair, DALZ8506, DALZ8507, DALZ8516, DALZ8517, and DALZ8521 were among the fastest to green up when cultured without supplemental irrigation (Morton, et al.).

Experimental line DALZ8511 was among the fastest greening zoysias in the irrigated zones (GC ≈ 80% on April 3), and was one of six zoysiagrass lines which in the non-irrigated zone had green up rates at least 1.6 times slower than when irrigated. Among all entries, Meyer and DALZ8511 were consistently fastest to green.

Turf Quality - Autumn and Winter
All turf quality components considered during the active growing season were used in turf quality evaluations during the autumn and winter. During the winter of 1990-91, good turf quality occurred at all irrigation levels for DALZ8502 as late as February 1991 (Table E14). In the preceding autumn of 1991, good quality turf was maintained for all entries in irrigated zones. However, in non-irrigated areas, 8 entries maintained good turf quality. These include Belair, El Toro, Emerald, and FC13521, and DALZ8507, DALZ8510, DALZ8512, and DALZ8514.

Turf Quality - Spring
As noted in late April, spring turf quality was consistently high each year for DALZ8507, at all irrigation levels (Table E15). Other zoysiagrasses which had good spring turf quality were DALZ8511, Emerald, and Meyer. These four entries are representatives of the finer textured zoysiagrasses. Five entries which had consistently poor spring turf quality include Cashmere, DALZ8501, DALZ8513, DALZ8522, and DALZ8523.

Flowering
With respect to turf quality, culm production is undesirable. During 1989, flowering by most zoysiagrass entries declined as irrigation was reduced. Eight entries showed no change in the level of culm production with respect to irrigation level (USGA Progress Report, Nov. 1989).

During 1990, the fall culm production was minimal, with only seven entries producing culms. Of these, five entries had reduced culm levels in increasingly non-irrigated zones of the gradient (data not shown).

REFERENCE

1. Morton, S.J., M. C. Engelke, R. H. White, K.B. Marcum. 1992. 1991 Update on performance of Zoysiagrass cultivars and Elite DALZ lines under Linear Gradient Irrigation. Texas Turfgrass Research-1991. Texas Agric. Exp. Sta. PR-4890.

Figure 1. Temperatures and rainfall for TAES—Dallas, 1989.

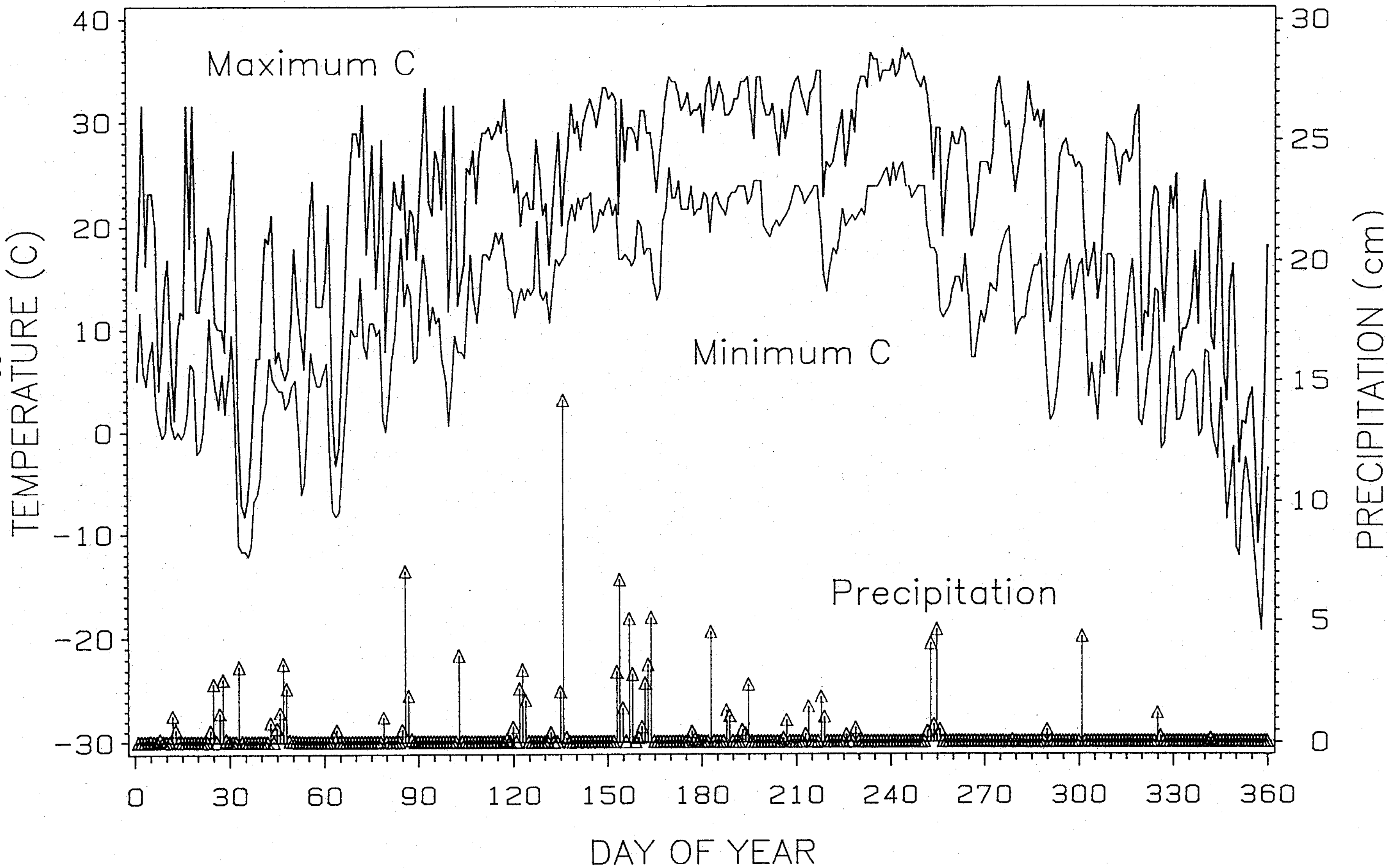


Figure 2. Temperatures and rainfall for TAES–Dallas. 1990.

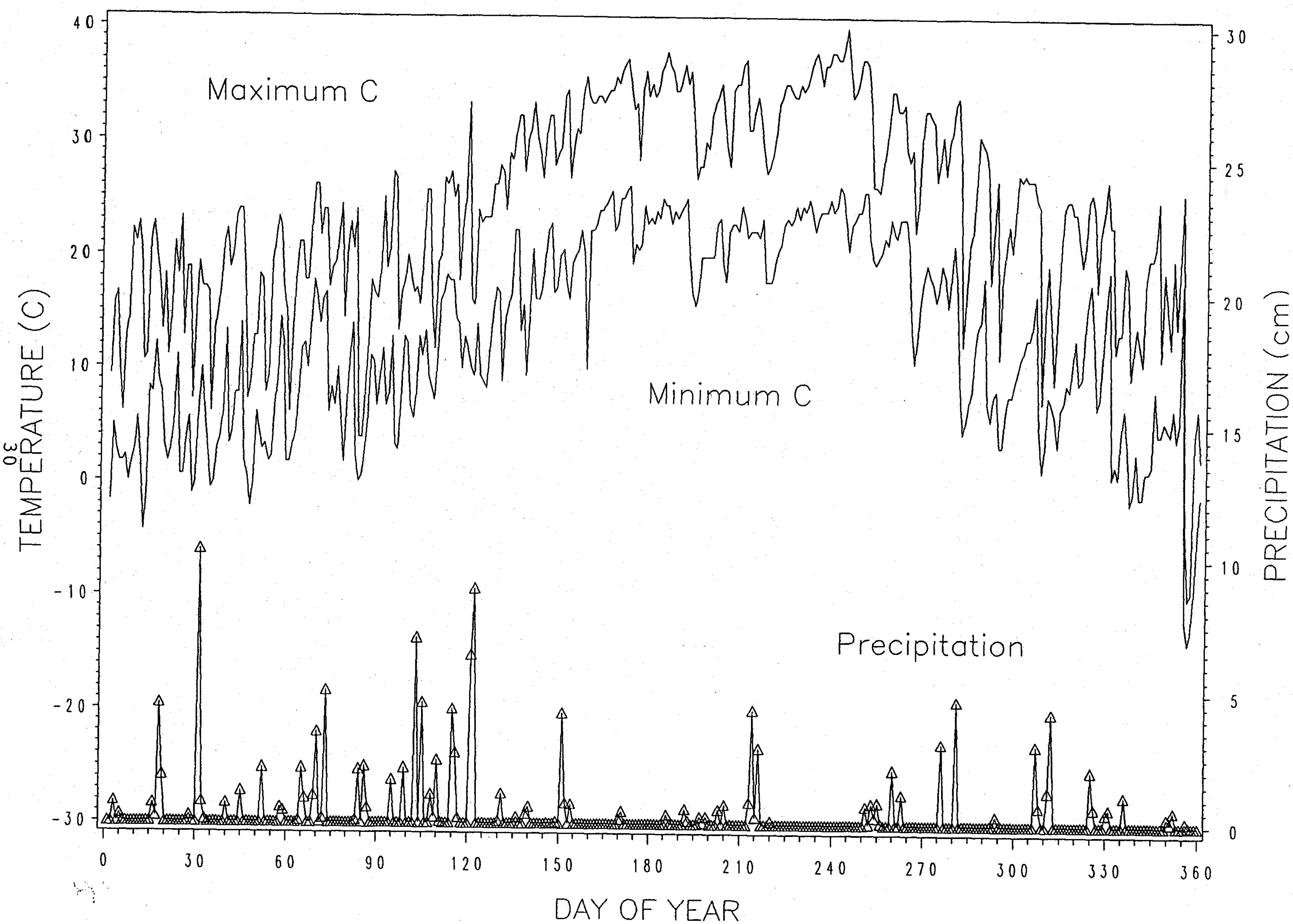


Figure 3. Temperatures and rainfall for TAES—Dallas. 1991.

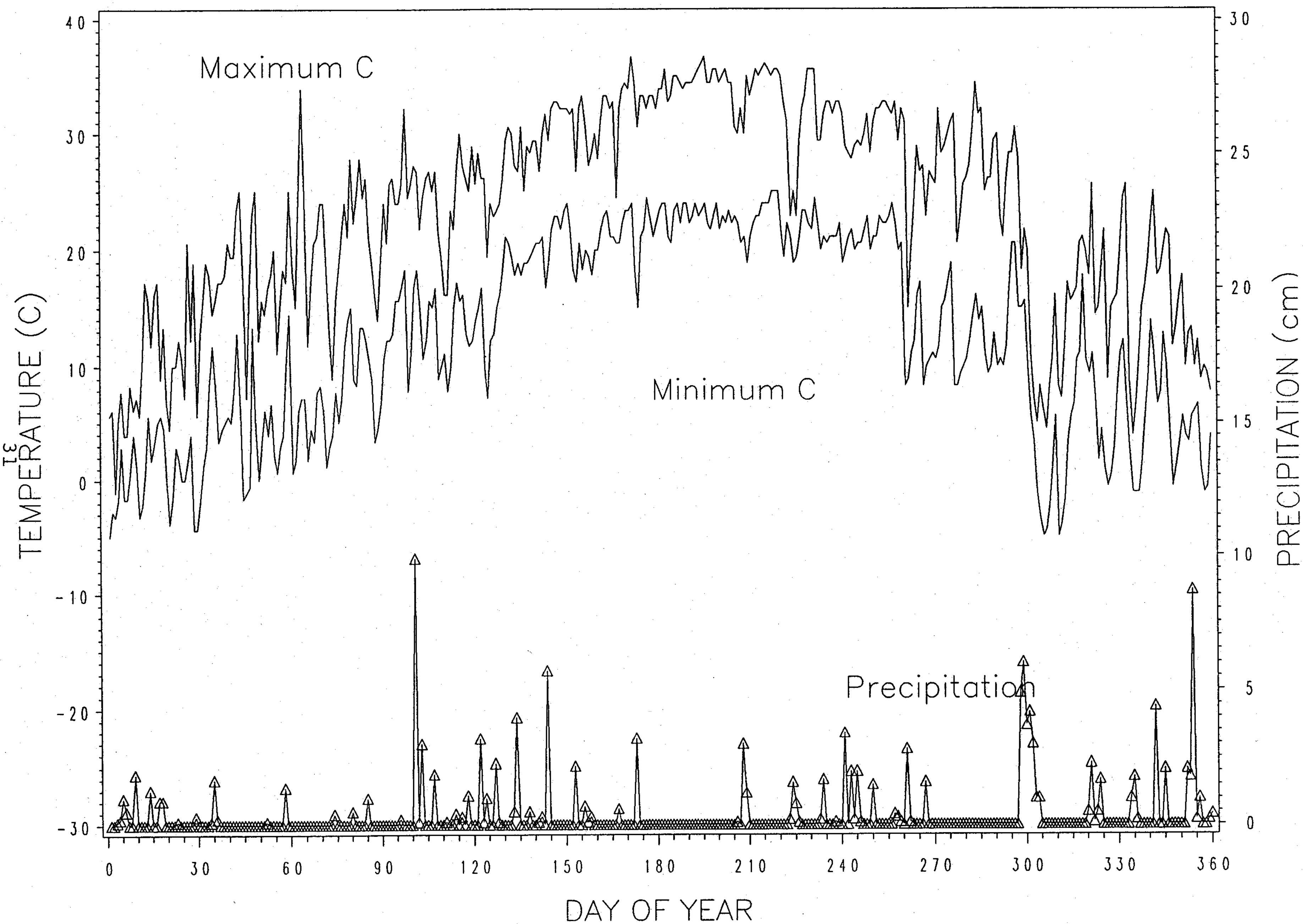


Figure 4. Irrigation distribution for the Linear Gradient Irrigation System at TAES-Dallas during 1989, 1990, and January through September 1991. Means plus standard errors at plotted east and west of the line irrigation source, respectively.

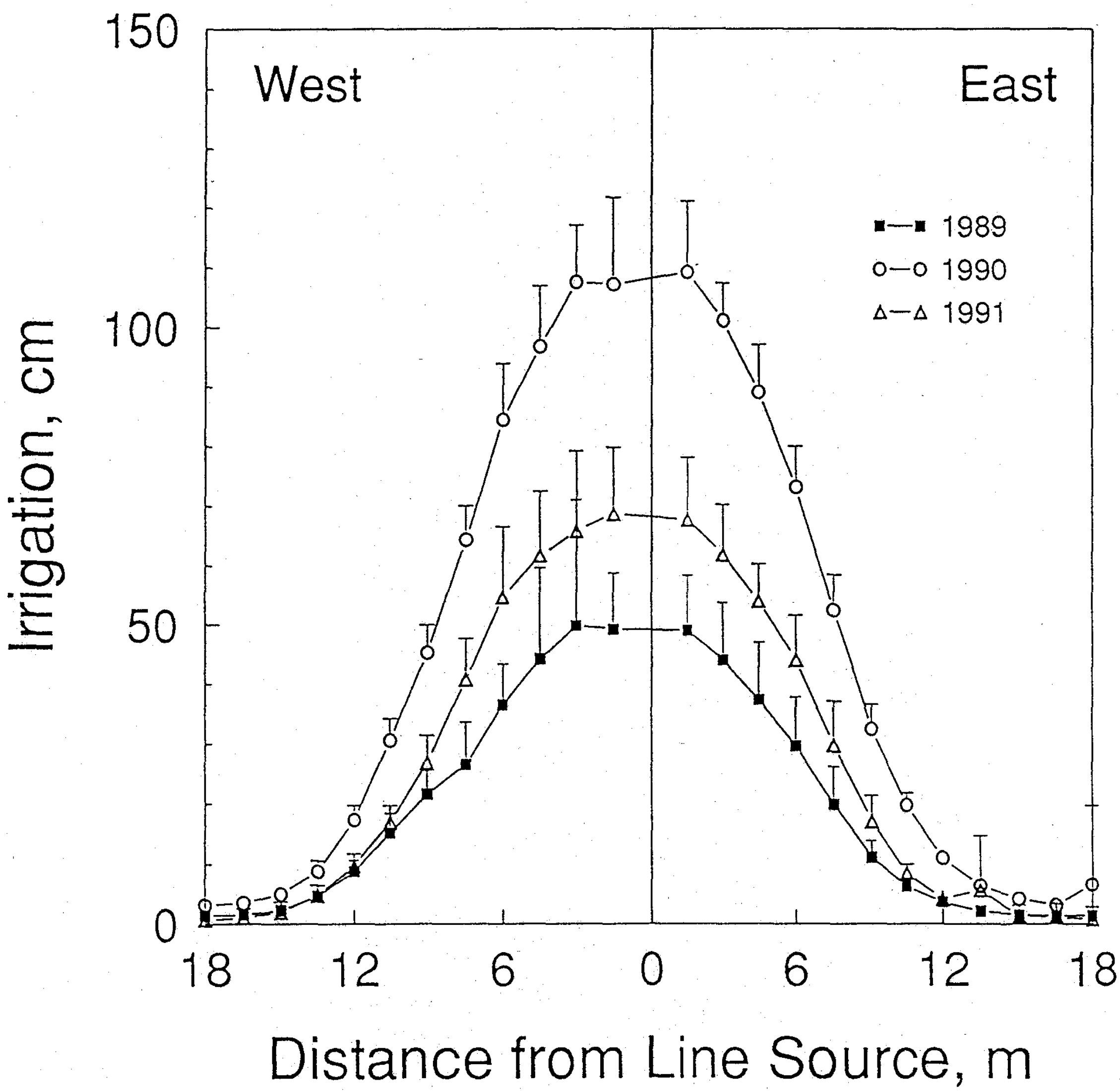


Table E1. Supplemental irrigation required to prevent stress, maintain turf quality of 5, and to maintain green turf cover for zoysiagrasses planted to LGIS at TAES-Dallas. Averages are for the three years of the Linear Gradient study.

		1989 to 1991 Mean			
Entry	Textural Class[1]	Prevent Stress	Minimum 50% GTC	Minimum TQ of 5	PS[2]
Belair	2	113a	339a	526a	3
Cashmere	1	390	673	721	-
El Toro	4	149a	397a	523a	3
Emerald	1	437	478	564a	1
FC13521	3	458	478	575a	1
Korean Common	4	244a	542	746	1
Meyer	3	282	589	695	-
DALZ8501	1	474	612	744	-
DALZ8502	1	488	553	625	-
DALZ8503	3	305	546	711	-
DALZ8504	3	326	627	732	-
DALZ8505	3	262	670	757	-
DALZ8506	2	431	486	747	-
DALZ8507	2	360	456a	573a	2
DALZ8508	3	408	481	741	-
DALZ8510	2	388	467a	515a	2
DALZ8511	3	299	492	693	-
DALZ8512	4	93a	325a	500a	3
DALZ8513	3	273	621	719	-
DALZ8514	4	132a	443a	519a	3
DALZ8515	2	427	569	759	-
DALZ8516	4	286	524	631	-
DALZ8517	2	455	551	746	-
DALZ8522	3	677	654	659	-
DALZ8523	3	361	579	643	-
DALZ8524	1	551	606	601a	2
MSD entry[3]		187	146	103	

[1]Textural Classes are based on leaf shape. 1=short narrow, 2=long narrow, 3=short wide, and 4=long wide.
[2] PS = phenotypic stability, which is the frequency with which an entry occurs in the top statistical group.
[3]MSD entry = minimum significant difference for comparison of entry means within columns based on the Waller-Duncan K-ratio t test (K-ratio = 100).

Table E2. Mean percentage green turf cover during stress (5 Sept.) and 7 days after termination of stress (15 Sept.) by rainfall for three levels of irrigation on LGIS zoysiagrasses at TAES-Dallas, Texas in 1990.

	5 Sept.			15 Sept.		
Entry	High[1]	Inter.	None	High	Inter.	None
Belair	93	87	36	93	85	70
Cashmere	78	48	8	83	52	10
Emerald	95	82	20	95	84	66
El Toro	93	90	35	95	90	77
Korean Common	96	76	13	96	78	39
Meyer	96	73	13	95	80	40
FC13521	95	78	16	93	81	52
DALZ8501	89	64	16	89	64	19
DALZ8502	90	74	20	90	81	41
DALZ8503	96	67	8	96	69	14
DALZ8504	91	54	7	94	64	17
DALZ8505	89	66	5	94	66	13
DALZ8506	94	67	18	95	74	33
DALZ8507	96	82	25	97	87	67
DALZ8508	95	76	17	96	80	35
DALZ8510	96	76	21	95	81	58
DALZ8511	96	68	15	93	72	27
DALZ8512	92	89	45	94	93	80
DALZ8513	83	67	21	82	70	45
DALZ8514	94	88	35	94	92	78
DALZ8515	94	65	9	94	68	13
DALZ8516	90	73	22	91	76	41
DALZ8517	94	70	10	95	80	30
DALZ8522	25	6	1	25	13	2
DALZ8523	56	31	11	49	34	18
DALZ8524	84	68	23	85	74	29
MSD[2]	6	15	5	6	14	7

[1]Irrigation levels of high, intermediate, and none are equivalent to 87, 29, and 0% of the irrigation volume applied at the line source, respectively.

[2]Minimum significant difference for comparison of entry means within columns based on the Waller-Duncan K ratio test where K=100.

Table E3. Change in turf cover through time of zoysiagrasses planted to LGIS at TAES-Dallas.

Entry	High[1]			MSD	Intermediate			MSD	Low			MSD
	1990	1991	1992	Year[2]	1990	1991	1992	Year	1990	1991	1992	Year
Belair	45.0	87.5	94.3	27.5	60.0	78.3	85.8	n.s.	52.5	80.0	83.9	n.s.
Cashmere	87.5	86.3	91.5	n.s.	90.0	82.0	80.3	n.s.	77.5	41.3	50.4	n.s.
El Toro	80.0	87.8	93.4	n.s.	80.0	88.8	90.1	n.s.	67.5	83.5	92.7	17.1
Emerald	92.5	85.8	89.5	n.s.	85.0	86.3	89.9	n.s.	77.5	79.5	88.2	n.s.
FC13521	80.0	78.5	90.4	n.s.	85.0	82.0	89.4	n.s.	72.5	70.5	81.1	n.s.
Korean Common	80.0	87.5	88.3	n.s.	65.0	65.0	82.8	n.s.	12.5	41.3	50.6	28.8
Meyer	47.5	88.8	87.8	n.s.	40.0	80.8	86.8	31.9	27.5	55.0	41.3	n.s.
DALZ8501	75.0	79.5	90.6	n.s.	85.0	82.5	83.8	n.s.	60.0	33.8	48.5	n.s.
DALZ8502	40.0	81.5	84.5	n.s.	42.5	80.0	80.8	n.s.	37.5	61.3	61.9	n.s.
DALZ8503	80.0	84.8	91.1	n.s.	75.0	80.5	90.8	n.s.	67.5	23.8	50.7	n.s.
DALZ8504	90.0	88.8	90.4	n.s.	87.5	76.5	83.6	n.s.	65.0	28.8	71.7	21.1
DALZ8505	89.5	67.5	65.3	n.s.	82.0	86.3	55.9	n.s.	89.0	18.8	52.5	43.6
DALZ8506	90.0	79.3	87.4	n.s.	95.0	86.8	81.5	n.s.	77.5	55.0	67.4	n.s.
DALZ8507	82.5	88.8	91.6	n.s.	62.5	91.5	94.0	20.7	47.5	80.3	88.3	22.4
DALZ8508	94.0	90.0	92.4	n.s.	90.0	91.0	90.5	n.s.	67.5	58.8	80.1	18.7
DALZ8510	95.0	90.0	96.5	n.s.	87.5	93.0	89.6	n.s.	79.0	73.0	82.5	n.s.
DALZ8511	92.5	90.5	93.8	n.s.	90.0	85.0	90.6	n.s.	65.0	48.8	68.1	n.s
DALZ8512	92.5	88.3	95.8	n.s.	90.0	89.8	92.5	n.s.	40.0	79.8	87.0	18.3
DALZ8513	77.5	56.3	84.0	n.s.	75.0	59.3	78.8	n.s.	32.5	38.8	52.4	n.s.
DALZ8514	92.5	85.5	94.5	n.s.	94.0	88.3	89.1	n.s.	52.5	79.5	89.0	16.8
DALZ8515	87.0	79.3	84.9	n.s.	92.0	61.8	65.0	n.s.	87.5	20.5	28.8	34.9
DALZ8516	87.5	77.3	89.5	11.6	87.5	79.0	69.4	n.s.	57.5	63.0	72.7	n.s.
DALZ8517	89.5	89.0	90.4	n.s.	92.0	89.8	82.9	n.s.	45.0	48.8	67.7	n.s.
DALZ8522	94.5	38.8	48.1	36.3	67.5	49.3	43.1	n.s.	60.0	7.5	4.6	13.4
DALZ8523	89.5	52.5	68.4	n.s.	72.5	33.0	59.4	n.s.	62.5	36.3	36.6	n.s.
DALZ8524	92.5	68.8	75.9	n.s.	82.5	72.8	74.1	n.s.	65.0	50.0	62.7	n.s.
MSD entry[3]	n.s.	22.4	13.4		n.s.	27.1	16.9		n.s.	25.2	16.0	

[1]Irrigation levels of high, intermediate, and none are equivalent to 87, 29, and 0% of the irrigation volume applied at the line source, respectively.
[2]MSD year = minimum significant difference for comparison of entry-year means within date columns, based on the Waller-Duncan k-ratio t test (k-ratio = 100).
[3]MSD entry = minimum significant difference for comparison of entry means within columns, based on the Waller-Duncan k-ratio t test (k-ratio = 100).

Table E4. Average annual weed cover, as percentage of plot area, per irrigation level in 1990 through 1992 in zoysiagrass plots planted in LGIS at TAES-Dallas.

	1990				1991				1992				
Entry	high	inter	none	msd[1]	high	inter	none	msd	high	inter	none	msd	PS[2]
Belair	5.1a	10.0a	8.1a	ns	14.6a	11.5a	10.6a	ns	5.5a	16.0a	5.0a	7.2	9
DALZ8501	11.6a	15.9a	19.4a	ns	18.8a	9.6a	33.8	10.1	12.8a	13.8a	49.3	16.2	7
DALZ8502	13.1a	18.8a	21.3a	ns	23.6	17.1a	25.6a	ns	13.5a	19.0a	31.1	ns	8
DALZ8503	6.1a	12.4a	16.3a	5.1	21.9a	14.3a	51.9	16.0	14.3a	12.0a	63.1	22.3	7
DALZ8504	9.5a	18.0a	20.5a	ns	19.8a	15.0a	45.0	14.1	6.5a	14.0a	29.2	9.3	7
DALZ8505	30.4	32.5	43.1	ns	25.5	15.9a	46.3	23.0	34.5	29.5a	46.3	ns	2
DALZ8506	22.8	14.6a	17.0a	ns	18.1a	10.5a	30.0	8.7	10.8a	10.8a	38.3	17.9	6
DALZ8507	13.8a	9.0a	7.0a	ns	10.3a	10.0a	8.4a	ns	10.0a	4.0a	9.8a	ns	9
DALZ8508	9.1a	7.0a	7.1a	ns	14.4a	7.4a	19.6a	ns	8.8a	9.0a	18.0	8.7	8
DALZ8510	8.3a	9.5a	10.9a	ns	10.3a	4.9a	12.8a	ns	5.0a	4.0a	12.8a	6.3	9
DALZ8511	5.4a	19.3a	21.3a	ns	17.6a	10.3a	29.1	ns	8.0a	8.8a	33.1	ns	7
DALZ8512	5.4a	5.9a	7.4a	ns	6.0a	4.8a	10.6a	ns	4.3a	6.0a	12.3a	ns	9
DALZ8513	26.5	30.1	37.6	ns	31.9	17.5a	38.8	ns	11.8a	13.0a	34.0	10.3	3
DALZ8514	6.8a	6.8a	8.6a	ns	14.1a	12.3a	15.3a	ns	5.8a	11.0a	7.1a	ns	9
DALZ8515	16.9a	36.9	35.6	ns	22.1a	25.9	58.8	18.8	22.8a	33.8a	78.2	28.1	4
DALZ8516	12.9a	12.9a	11.4a	ns	24.0	19.9a	28.1	ns	8.3a	41.3	28.1	ns	5
DALZ8517	11.0a	16.9a	20.6a	ns	15.1a	11.5a	40.0	12.8	9.5a	7.3a	28.0	10.9	7
DALZ8522	49.1	82.5	91.9	28.6	36.9	36.9	58.1	ns	36.3	40.0	73.3	28.5	-
DALZ8523	36.9	60.0	55.0	ns	36.9	42.5	37.5	ns	52.0	53.8	49.7	ns	-
DALZ8524	16.1a	27.8a	26.4	ns	36.9	24.0	37.8	ns	19.5a	20.5a	30.4	ns	4
El Toro	4.0a	5.0a	3.1a	ns	9.8a	6.9a	10.1a	ns	8.0a	9.3a	3.3a	ns	9
Emerald	6.9a	13.4a	11.6a	ns	22.3a	16.3a	13.4a	ns	15.0a	10.8a	14.4a	ns	9
FC13521	16.3a	14.6a	10.4a	ns	21.3a	12.8a	18.8a	ns	9.0a	8.3a	16.3	ns	8
Korean Common	7.1a	23.8	20.0a	14.0	21.1a	21.9	34.4	ns	8.5a	14.5a	49.0	15.6	5
Meyer	7.5a	11.0a	12.3a	ns	11.9a	19.9a	34.3	16.6	17.0a	8.0a	57.5	26.9	7
Cashmere	27.1	28.3	40.6	ns	10.3a	12.6a	44.4	15.6	14.5a	21.8a	66.6	23.1	4
MSD entry[3]	17.4	18.4	19.0	.	17.5	16.3	16.5	.	26.2	30.7	12.1	.	
Mean[4]	14.8	20.9	22.5	4.5	19.9	15.8	30.5	3.2	14.3	16.9	34.0	5.0	

[1] MSD gauge = minimum significant difference between gauges per entry per year or per the entire population per year. Based on Waller-Duncan k-ratio t test, where k=100.

[2] PS = phenotypic stability, which is the frequency with which an entry occurs in the top statistical group.

[3] MSD entry = minimum significant difference between entries within a column, based on Waller-Duncan k-ratio t test, where k=100. The letters identify those entries within the lowest weed cover group.

[4] Mean = mean weed cover per column.

Table E5. Mean zoysiagrass turf quality during stress (5 Sept., 1990, July 10, 1991) and after termination of stress (15 Sept., 1990, 16 Aug., 1991) by rainfall for three levels of irrigation on LGIS at TAES-Dallas, Texas.

	1990						1991					
	Sept. 5			Sept. 15			July 10			August 28		
Entry	High[1]	Inter	None	High	Inter	None	High	Inter	None	High	Inter	None
Belair	4.6	4.1	2.2a	4.5	4.1	3.2	4.5	3.0	3.0	5.5	5.3	5.0
Cashmere	2.6	1.9	1.0	2.7	2.1	1.0	3.0	5.0	.	6.0	5.8	3.5
Emerald	5.4	4.0	1.8	5.3	4.0	2.7	.	4.0	7.0	5.7	6.3	4.0
El Toro	5.3	4.3a	2.1	5.2	4.4	3.6	6.0	.	6.0	6.5	5.5	4.0
Korean Common	5.5	3.2	1.4	5.0	3.4	2.0	2.0	2.0	6.0	5.2	5.3	3.5
Meyer	5.8	3.8	1.7	5.7	4.1	2.1	4.0	4.0	2.0	4.2	5.3	3.3
FC13521	5.3	4.4a	1.8	5.5	3.9	2.1	3.0	4.0	2.0	6.2	6.5	3.8
DALZ8501	3.9	2.9	1.1	3.7	2.9	1.5	7.0	6.0	3.5	5.0	6.0	3.8
DALZ8502	4.7	4.1	1.5	4.9	4.0	1.9	4.0	2.5	3.0	5.8	6.3	4.5
DALZ8503	5.7	3.8	1.1	5.5	3.6	1.3	3.0	3.0	2.5	7.0	6.5	2.0
DALZ8504	4.7	2.8	1.0	4.8	3.2	1.3	2.0	2.0	2.0	5.0	6.0	3.0
DALZ8505	4.8	3.5	1.0	4.4	3.4	1.2	4.0	4.0	5.0	6.5	6.0	3.5
DALZ8506	5.4	4.2a	1.6	5.9a	4.0	1.8	6.0	4.0	3.0	4.8	6.5	5.3
DALZ8507	6.6a	5.0a	2.2a	6.4a	5.4a	2.9	6.0	6.0	6.0	7.0	5.8	3.8
DALZ8508	5.7	4.0	1.5	5.8a	3.9	2.0	6.0	6.0	3.5	5.5	6.5	5.0
DALZ8510	6.0	4.9a	1.9	5.7	4.5	2.9	5.0	4.0	7.0	6.8	6.0	3.5
DALZ8511	5.6	3.4	1.6	5.6	3.4	1.9	5.0	3.0	2.5	5.3	6.0	3.8
DALZ8512	5.0	4.4	2.4a	5.0	4.9a	3.9a	6.0	6.0	7.5	5.3	5.5	4.5
DALZ8513	3.3	2.7	1.4	2.9	2.6	1.8	6.0	3.0	2.0	5.3	6.3	3.8
DALZ8514	5.2	4.5a	2.3a	5.0	4.5	3.4	3.0	4.0	6.0	6.8	5.8	2.8
DALZ8515	5.4	3.4	1.0	5.2	3.5	1.4	7.0	2.0	2.0	5.5	5.8	2.0
DALZ8516	3.8	2.9	1.3	3.9	3.1	2.0	4.5	5.0	4.5	6.0	6.3	3.8
DALZ8517	5.1	3.4	1.3	5.1	3.8	1.8	4.0	3.5	4.5	5.0	6.0	5.3
DALZ8522	1.3	1.0	1.0	1.4	1.2	1.0	3.5	6.5	4.0	4.0	5.0	3.3
DALZ8523	2.6	1.9	1.3	2.0	1.9	1.4	6.0	4.0	2.0	4.8	4.3	2.3
DALZ8524	3.1	2.9	1.1	2.7	2.7	1.7	4.5	4.5	5.0	5.8	6.0	2.5
MSD entry[2]	0.6	0.8	0.2	0.6	0.7	0.2	ns	ns	ns	ns	ns	ns

[1]Irrigation levels of high, intermediate, and none are equivalent to 87, 29, and 0% of the irrigation volume applied at the line source, respectively.

[2]Minimum significant difference for comparison of entry means within columns based on the Waller-Duncan K ratio test where K=100.

Table E6. Net radiation in 1989 of zoysiagrasses planted in LGIS.

Entry	3	6	9	12	15	18
	Distance from center trench, m					
Belair	501.3	508.5	510.3	448.0	468.0	458.0
Cashmere	500.8	513.0	509.3	493.5	473.3	460.8
El Toro	507.3	507.8	505.5	496.5	489.0	486.8
Emerald	507.8	514.0	513.0	506.5	493.3	488.8
FC13521	479.0	459.3	400.8	428.5	457.0	460.8
Korean Common	455.8	489.5	507.5	504.8	497.0	491.0
Meyer	519.5	528.0	526.5	517.8	501.3	492.3
DALZ8501	540.8	554.0	555.5	548.3	536.8	511.0
DALZ8502	478.3	504.5	514.5	510.0	498.8	496.0
DALZ8503	438.5	440.8	439.5	425.0	414.0	406.3
DALZ8504	494.5	509.5	522.5	513.5	493.5	426.8
DALZ8505	525.8	534.3	532.5	523.5	513.3	505.0
DALZ8506	475.3	473.0	452.5	400.8	384.3	391.8
DALZ8507	441.0	418.5	405.3	424.3	450.3	460.8
DALZ8508	514.3	526.3	525.5	488.8	444.5	420.5
DALZ8510	483.8	467.3	456.3	440.0	427.5	418.0
DALZ8511	536.8	541.8	541.5	529.8	518.5	512.0
DALZ8512	429.3	477.8	488.5	485.3	475.3	470.0
DALZ8513	492.0	501.0	501.8	496.3	483.0	478.8
DALZ8514	487.3	486.8	487.0	482.5	472.8	469.8
DALZ8515	518.5	523.3	521.0	510.0	498.3	496.3
DALZ8516	443.8	440.5	459.3	436.3	414.3	413.0
DALZ8517	500.8	497.5	491.5	487.3	479.8	461.0
DALZ8522	513.8	531.0	531.8	528.3	515.3	511.5
DALZ8523	517.8	517.8	517.0	510.5	501.0	494.8
DALZ8524	530.0	535.5	534.5	528.5	518.0	509.5
MSD entry[1]	ns	ns	ns	ns	ns	ns

[1]MSD entry = minimum significant difference between entry means for comparison within irrigation level, based on Waller-Duncan k-ratio t test, where k-ratio=100.

Table E7. Net radiation in 1990 of zoysiagrasses planted in LGIS.

Entry	3	6	9	12	15	18
	Distance from center trench, m					
Belair	573.0	568.8	558.3	548.8	538.4	538.8
Cashmere	580.8	588.9	585.4	567.1	550.4	533.4
El Toro	579.9	582.3	583.6	582.5	565.4	553.7
Emerald	577.6	587.0	589.6	588.2	578.0	572.5
FC13521	573.8	584.6	587.5	576.6	567.7	560.8
Korean Common	563.2	569.5	574.3	582.2	573.7	560.4
Meyer	575.5	586.3	590.9	583.3	561.9	539.3
DALZ8501	584.7	578.5	577.9	576.2	567.4	554.1
DALZ8502	597.3	601.6	602.4	596.1	583.6	576.6
DALZ8503	567.8	578.9	585.8	585.2	577.9	567.7
DALZ8504	585.0	591.4	599.1	595.0	583.4	573.0
DALZ8505	566.2	566.8	566.3	574.6	574.9	564.6
DALZ8506	591.0	599.9	599.7	596.2	584.7	574.2
DALZ8507	593.0	599.5	600.0	594.6	583.4	572.5
DALZ8508	582.1	589.9	593.8	585.5	567.9	556.0
DALZ8510	582.6	587.5	587.6	582.8	579.8	566.4
DALZ8511	589.5	596.6	593.9	581.5	562.8	556.6
DALZ8512	574.4	577.3	578.8	578.5	574.7	569.4
DALZ8513	584.5	593.0	594.7	586.4	573.4	568.5
DALZ8514	571.9	578.6	583.6	582.4	576.0	564.6
DALZ8515	574.1	592.4	585.2	573.6	564.4	567.2
DALZ8516	570.7	582.1	588.6	585.1	574.1	567.2
DALZ8517	581.6	578.0	581.0	575.7	567.6	563.4
DALZ8522	587.8	588.3	581.7	583.2	578.2	577.3
DALZ8523	585.0	594.8	590.2	587.6	577.1	577.3
DALZ8524	590.0	594.6	590.4	580.7	568.5	565.0
MSD entry[1]	ns	ns	ns	ns	ns	ns

[1] MSD entry = minimum significant difference between entry means for comparison within irrigation level, based on Waller-Duncan k-ratio t test, where k-ratio=100.

Table E8. Net radiation in 1991 of zoysiagrasses planted in LGIS.

Entry	3	6	9	12	15	18
	Distance from center trench, m					
Belair	416.3	363.0	353.3	341.5	369.3	387.8
Cashmere	410.8	425.3	408.5	383.3	411.8	423.5
El Toro	466.8	454.5	445.3	438.8	434.5	434.5
Emerald	490.7	466.5	482.0	458.0	434.3	414.8
FC13521	445.0	451.5	436.3	418.3	402.3	408.5
KCommon	447.3	453.0	450.3	432.8	425.0	422.5
Meyer	461.3	453.3	434.8	438.0	436.3	431.3
DALZ8501	438.3	473.5	443.5	432.3	428.8	442.0
DALZ8502	482.8	481.8	475.0	459.0	443.5	436.3
DALZ8503	328.5	326.5	321.8	335.0	345.0	345.3
DALZ8504	409.0	429.8	447.3	455.3	461.5	463.8
DALZ8505	467.8	463.3	455.8	448.8	440.0	431.5
DALZ8506	446.8	442.5	414.3	402.8	406.8	410.0
DALZ8507	460.5	465.5	459.0	439.5	419.3	408.3
DALZ8508	354.5	338.3	329.8	336.0	344.8	370.5
DALZ8510	467.5	461.5	449.5	445.5	440.0	439.8
DALZ8511	388.8	378.8	372.0	368.8	407.5	419.8
DALZ8512	475.0	468.5	464.3	452.0	414.8	343.0
DALZ8513	458.8	456.0	444.3	433.8	433.8	437.3
DALZ8514	441.0	440.5	431.0	410.3	402.0	402.3
DALZ8515	427.3	419.3	408.5	399.5	391.5	390.3
DALZ8516	452.8	448.5	444.8	445.8	436.8	426.0
DALZ8517	466.3	454.8	439.3	427.0	419.8	418.8
DALZ8522	489.0	477.0	457.8	444.3	443.5	465.0
DALZ8523	457.0	455.0	446.5	435.0	431.8	427.8
DALZ8524	474.0	478.3	471.8	460.5	447.5	445.5
MSD entry[1]	ns	ns	ns	ns	ns	ns

[1] MSD entry = minimum significant difference between entry means for comparison within irrigation level, based on Waller-Duncan k-ratio t test, where k-ratio=100.

Table E9. Canopy temperatures in 1989 of zoysiagrasses planted in LGIS.

Entry	3	6	9	12	15	18
	Distance from center trench, m					
Belair	39.1	38.1	38.5	41.4	43.3	44.9
Cashmere	36.3	36.4	36.5	45.2	49.7	49.8
El Toro	38.4	38.0	38.8	43.4	46.2	46.2
Emerald	37.5	37.2	38.3	43.0	46.1	47.0
FC13521	38.0	37.5	37.2	42.0	44.9	45.8
Korean Common	36.9	37.6	38.4	44.9	47.3	49.2
Meyer	38.3	38.4	38.3	44.6	47.7	47.8
DALZ8501	39.1	38.8	39.1	45.4	46.4	47.1
DALZ8502	36.7	36.9	37.3	44.5	47.2	47.5
DALZ8503	37.0	36.7	38.1	45.4	47.7	47.6
DALZ8504	38.7	38.6	41.3	50.8	51.8	50.2
DALZ8505	37.4	37.9	39.3	46.2	46.9	49.3
DALZ8506	37.5	37.8	38.1	42.2	44.5	45.9
DALZ8507	36.7	36.7	38.0	43.5	44.7	46.4
DALZ8508	37.3	37.2	38.2	44.7	47.1	47.8
DALZ8510	37.2	36.6	37.2	43.3	44.4	44.9
DALZ8511	38.0	38.4	39.0	45.5	48.8	48.5
DALZ8512	36.7	37.8	38.2	42.0	43.7	44.9
DALZ8513	37.0	37.2	37.1	41.5	43.7	44.3
DALZ8514	38.2	38.2	38.5	41.5	44.1	44.9
DALZ8515	38.8	39.4	40.7	46.3	46.8	47.5
DALZ8516	35.4	35.7	36.0	42.5	44.4	44.8
DALZ8517	38.1	37.2	38.2	46.8	48.3	48.3
DALZ8522	40.0	38.7	38.4	44.0	45.2	46.6
DALZ8523	39.4	38.9	38.3	42.2	45.2	44.8
DALZ8524	38.0	38.7	39.0	44.2	48.0	48.6
MSD entry[1]	ns	3.7	4.5	ns	ns	ns

[1] MSD entry = minimum significant difference between entry means for comparison within irrigation level, based on Waller-Duncan k-ratio t test, where k=100.

Table E10. Canopy temperatures in 1990 of zoysiagrasses planted in LGIS.

Entry	3	6	9	12	15	18
	Distance from center trench, m					
Belair	38.2a	38.3	38.9a	42.8	45.0	46.2
Cashmere	39.0a	38.9a	40.7a	46.7a	49.4a	45.9
El Toro	37.7	38.0	39.3	43.5	45.7	46.6
Emerald	38.4a	38.5	39.5	43.9	47.0	47.1
FC13521	37.9	38.7	40.4a	43.7	46.9	47.2
Korean Common	37.4	37.4	38.7	44.5	47.4	47.4
Meyer	38.1a	38.4	40.1a	45.7a	48.3a	48.9a
DALZ8501	37.7	37.6	39.8a	45.5	47.3	48.7a
DALZ8502	37.4	37.1	39.0	44.0	47.0	48.4a
DALZ8503	38.1a	38.6	41.0a	46.1a	47.7a	48.8a
DALZ8504	37.9	38.4	40.7a	46.0a	46.7	48.4a
DALZ8505	36.3	36.8	38.9	44.1	45.7	46.7
DALZ8506	37.5	39.1a	40.7a	45.5	47.5a	49.3a
DALZ8507	38.0	39.4a	40.5a	45.6	48.1a	47.6a
DALZ8508	37.7	38.3	40.0a	47.1a	48.4a	49.4a
DALZ8510	38.2a	39.1a	40.9a	44.7	47.8a	47.6a
DALZ8511	38.2a	38.5	40.4a	45.5	47.9a	46.8
DALZ8512	37.9	38.2	39.4	43.1	45.1	45.6
DALZ8513	37.3	37.6	39.1	44.1	45.8	47.6a
DALZ8514	38.1a	38.9a	40.3a	43.7	46.1	46.7
DALZ8515	38.6a	39.2a	41.6a	45.7a	48.3a	49.4a
DALZ8516	37.8	38.1	39.7a	44.0	47.4	48.0a
DALZ8517	38.9a	39.5a	41.4a	47.1a	50.3a	50.0a
DALZ8522	38.9a	39.1a	39.6	45.6	49.0a	50.1a
DALZ8523	38.0	37.6	38.8	43.5	46.5	47.1
DALZ8524	38.7a	40.0a	41.1a	44.7	48.2a	48.4a
MSD entry[1]	1.3	1.2	2.3	2.3	2.9	3.0

[1] MSD entry = minimum significant difference between entry means for comparison within irrigation level, based on Waller-Duncan k-ratio t test, where k=100.

Table E11. Canopy temperatures in 1991 of zoysiagrasses planted in LGIS.

Entry	3	6	9	12	15	18
	Distance from center trench, m					
Belair	37.7	36.9	38.5	42.4	46.1	47.1
Cashmere	35.3	35.8	36.6	43.4	46.8	45.8
El Toro	37.1	37.4	40.5	45.1	49.3	49.3
Emerald	37.3	37.7	40.5	46.1	49.9	49.8
FC13521	37.3	38.2	42.0	46.0	47.7	48.1
Korean Common	38.0	37.2	41.2	44.3	48.7	47.4
Meyer	37.5	37.3	39.7	45.4	45.2	47.4
DALZ8501	37.2	38.5	41.4	43.2	46.3	45.9
DALZ8502	37.5	37.5	41.6	44.8	48.7	49.2
DALZ8503	37.4	37.4	39.9	41.5	42.3	44.1
DALZ8504	37.7	37.4	42.9	43.3	45.9	46.8
DALZ8505	38.4	39.6	42.3	47.3	44.6	46.2
DALZ8506	38.3	39.2	44.0	44.9	48.1	46.8
DALZ8507	37.3	37.4	40.1	45.7	47.6	47.5
DALZ8508	36.3	36.0	40.0	43.6	46.6	45.9
DALZ8510	38.9	38.6	42.4	46.9	50.0	49.7
DALZ8511	36.8	36.6	38.6	43.4	46.2	45.3
DALZ8512	38.5	37.7	39.7	43.7	45.4	44.8
DALZ8513	37.3	37.2	40.5	45.2	46.7	48.6
DALZ8514	37.7	37.3	40.5	45.0	48.0	48.3
DALZ8515	39.7	39.1	43.9	45.7	48.2	46.2
DALZ8516	36.5	36.0	39.7	44.2	46.5	48.1
DALZ8517	38.0	38.3	41.3	46.3	47.8	48.2
DALZ8522	35.3	35.2	37.5	43.7	45.5	43.0
DALZ8523	36.9	37.0	39.5	43.4	46.4	43.7
DALZ8524	37.6	38.7	41.1	43.9	48.2	47.4
MSD entry[1]	ns	ns	ns	ns	ns	ns

[1] MSD entry = minimum significant difference between entry means for comparison within irrigation level, based on Waller-Duncan k-ratio t test, where k=100.

Table E12. Autumn and winter color quality of zoysiagrasses planted in LGIS at TAES-Dallas. Presence of red leaf color.

	Autumn				Winter							
	Nov23 1989	Nov13 1990			Dec10 1990			Jan28 1991				2° Fall
Entry	High[1]	High	Inter	None	high	Inter	None	High	Inter	None	PS[2]	Color
Belair	2.8	5.0	6.5a	7.5a	3.0	3.3	3.8	1.5	1.5	1.0	2	R
Cashmere	2.8	8.5a	8.0a	8.5a	6.8a	7.0a	7.0a	1.0	1.0	1.0	6	G
DALZ8501	7.8a	5.0	7.0a	7.0a	6.8a	7.0a	7.3a	1.0	1.0	1.0	6	R
DALZ8502	7.0	6.5a	8.0a	7.5a	7.3a	7.3a	6.0a	4.0a	4.0a	2.0	8	G
DALZ8503	2.5	5.5	5.5a	5.0	3.8	4.0	6.0a	1.8	1.8	1.5	2	R
DALZ8504	3.0	2.5	3.0	5.0	3.5	4.0	4.5	2.0	1.3	1.3	-	G
DALZ8505	4.3	4.0	6.0a	7.0a	4.5	4.3	5.0	1.8	1.8	1.5	2	G
DALZ8506	5.5	6.0a	6.5a	7.5a	5.5	6.3a	7.0a	1.5	1.5	1.3	5	R
DALZ8507	4.8	6.5a	7.0a	7.5a	5.3	5.3	5.8a	2.0	1.3	1.0	4	R
DALZ8508	2.8	6.0a	7.5a	8.0a	4.0	3.8	6.0a	1.0	1.0	1.0	4	R
DALZ8510	4.8	6.0a	7.0a	7.5a	5.8a	5.5	6.8a	1.8	1.8	1.5	5	R
DALZ8511	5.0	4.5	3.0	4.5	4.3	4.3	4.8	2.0	1.8	1.8	-	R
DALZ8512	4.0	6.0a	6.5a	7.0a	4.0	4.3	6.0a	2.0	1.5	1.8	4	R
DALZ8513	6.8	6.5a	6.5a	7.0a	5.8a	5.5	6.5a	1.0	1.0	1.0	5	R
DALZ8514	2.5	4.5	4.5	5.0	3.8	3.5	4.3	1.8	1.5	1.5	-	R
DALZ8515	2.5	6.5a	7.5a	3.0	3.5	3.8	4.0	2.0	1.8	1.0	2	R
DALZ8516	3.5	7.0a	7.5a	8.0a	3.3	3.5	5.3a	1.0	1.0	1.0	4	R
DALZ8517	3.8	6.5a	6.5a	7.0	4.8	5.3	6.8a	1.8	1.5	1.5	3	R
DALZ8522	4.8	7.0a	7.0a	.	4.5	5.3	2.5	1.3	1.0	1.3	2	G
DALZ8523	4.0	7.0a	6.5a	7.5a	4.5	4.8	4.5	1.0	1.0	1.0	3	R
DALZ8524	3.0	5.5	8.0a	7.5a	4.3	5.0	6.0a	1.0	1.3	1.0	3	R
El Toro	2.5	6.5a	6.5a	5.0	3.5	3.0	3.8	1.8	1.5	1.0	2	R
Emerald	5.8	6.5a	6.5a	7.0a	5.0	5.3	5.0	1.8	1.8	1.5	3	R
FC13521	5.5	7.0a	6.5a	7.5a	5.3	5.0	6.3a	1.8	1.5	1.0	4	R
Korean Common	2.3	4.0	5.0	5.5	4.0	3.5	3.0	2.0	1.8	2.0	-	R
Meyer	4.8	4.0	4.5	4.0	3.8	3.0	3.3	2.0	2.0	1.5	-	G
MSD entry[3]	0.7	2.7	2.5	2.9	1.5	1.4	2.2	0.4	0.6	ns		
Mean	4.2	5.8	6.3	6.3	4.5	4.7	5.3	1.7	1.5	1.3		

[1] Irrigation levels of high, intermediate, and none are equivalent to 87, 29, and 0% of the irrigation volume at the line source, or a distance of 1.5, 9, and 18 m from the line source, respectively.

[2] PS = phenotypic stability, which is the frequency with which an entry occurs in the top statistical group.

[3] MSD entry = minimum significant difference for comparison of entry means within columns, based on Waller-Duncan k-ratio t test (k-ratio=100).

Table E13. Spring greenup, as spring green cover, of zoysiagrasses planted to LGIS at TAES-Dallas.

Entry	1989 1 April	1990 30 March	1991 3 April	PS[1]
Belair	20.0	47.5	81.3a	1
Cashmere	5.0	1.0	32.5	-
El Toro	15.0	20.0	78.8a	1
Emerald	40.0	27.5	71.3	-
FC13521	37.5	8.8	82.5a	1
Korean Common	10.0	77.5a	72.5	1
Meyer	13.3	77.5a	81.3a	2
DALZ8501	8.3	1.5	65.0	-
DALZ8502	10.0	2.5	70.0	-
DALZ8503	12.5	53.3	67.5	-
DALZ8504	7.0	52.5	67.5	-
DALZ8505	6.7	62.5	68.8	-
DALZ8506	27.5	25.0	71.3	-
DALZ8507	12.5	25.0	71.3	-
DALZ8508	7.0	8.8	90.8a	1
DALZ8510	10.0	20.0	66.3	-
DALZ8511	25.3	75.0a	78.8a	2
DALZ8512	17.5	17.5	71.3	-
DALZ8513	7.5	1.0	42.5	-
DALZ8514	50.0	25.8	73.8	-
DALZ8515	10.0	42.5	62.5	-
DALZ8516	12.5	35.0	90.0a	1
DALZ8517	7.5	22.5	81.3a	1
DALZ8522	7.5	0.5	25.0	-
DALZ8523	40.0	2.8	38.8	-
DALZ8524	41.7	5.0	70.0	-
MSD entry[2]	n.s.	13.4	14.1	

[1] PS = phenotypic stability, which is the frequency with which an entry occurs in the top statistical group.

[2]MSD entry = minimum significant difference for comparison of entry means within columns based on the Waller-Duncan K-ratio t test (K-ratio = 100).

Table E14. Winter and autumn turf quality of zoysiagrasses planted in LGIS at TAES-Dallas.

	February 1991			October 1991		
Entry	High[1]	Inter.	None	High	Inter.	None
Belair	3.8	3.8	3.3	6.3a	6.0a	6.3a
Cashmere	4.3	3.8	3.0	5.3	5.8	4.0
DALZ8501	4.0	4.0	3.3	7.0a	6.0a	3.3
DALZ8502	6.0a	5.8a	4.5a	5.0	5.3	4.0
DALZ8503	4.5	4.0	3.0	6.0a	5.5	3.5
DALZ8504	4.5	3.5	3.0	6.3a	5.8	4.0
DALZ8505	4.0	3.8	3.0	6.3a	5.8	4.3
DALZ8506	4.0	4.0	3.3	6.5a	6.8a	4.3
DALZ8507	4.5	4.3	3.8a	6.7a	6.5a	6.0a
DALZ8508	4.0	3.3	3.0	4.8	5.5	4.0
DALZ8510	4.0	4.0	3.8a	6.8a	6.8a	6.0a
DALZ8511	4.5	4.0	3.5	6.8a	6.0a	3.8
DALZ8512	4.3	3.8	3.8a	6.8a	6.8a	6.5a
DALZ8513	3.5	3.5	3.3	6.3a	5.8	4.0
DALZ8514	3.8	4.0	3.8a	6.5a	6.5a	6.0a
DALZ8515	4.3	4.0	3.0	6.0a	5.3	2.8
DALZ8516	4.0	3.5	3.3	5.0	4.5	4.5
DALZ8517	4.0	4.0	3.3	5.8a	5.0	4.3
DALZ8522	3.0	3.3	1.8	4.0	4.0	1.5
DALZ8523	3.5	3.3	3.5	5.8a	5.3	4.3
DALZ8524	4.0	4.0	3.8a	5.3a	5.3	4.0
El Toro	4.0	4.0	3.5	6.3a	6.5a	6.3a
Emerald	4.3	4.3	3.5	5.8a	5.8	6.0a
FC13521	4.3	3.8	3.3	6.5a	7.0a	6.0a
Korean Common	4.5	4.0	3.5	5.5a	5.8	4.5
Meyer	4.3	4.0	3.3	6.5a	6.0a	4.0
MSD entry[2]	0.7	0.8	0.9	2.0	1.2	1.2

[1] Irrigation level of high, intermediate, and none represent 87, 29, and 0% of the irrigation volume at the line source, or a distance of 1.5, 9, and 18 m from the line source, respectively.

[2] MSD entry = minimum significant difference for comparison of entry means within columns, based on the Waller-Duncan k-ratio t test (k-ratio = 100).

Table E15. Spring turf quality of zoysiagrasses planted in LGIS at TAES-Dallas during 1989 through 1991.

Entry	1989 High[1]	1990 High	1990 Inter	1990 None	1991 High	1991 Inter	1991 None	PS[2]
Belair	4.8	4.0	4.8	3.3	4.3	5.5	6.3	1
Cashmere	4.0	1.0	1.0	1.5	4.8	4.3	2.5	-
DALZ8501	4.3	2.0	1.7	1.5	4.3	5.3	3.3	-
DALZ8502	5.0	2.0	2.7	2.2	3.5	5.3	4.8	1
DALZ8503	6.0	5.0	4.7	2.8	3.0	5.0	3.8	2
DALZ8504	5.0	4.3	4.3	2.2	4.0	5.8	5.3	1
DALZ8505	4.0	3.5	4.3	2.2	4.5	5.5	5.5	1
DALZ8506	5.8	4.0	4.7	3.3	2.8	6.0	5.0	1
DALZ8507	6.5	5.0	5.0	4.9	4.8	6.0	5.5	5
DALZ8508	6.3	4.3	3.3	2.7	2.5	5.0	5.0	1
DALZ8510	6.3	4.8	5.0	3.4	3.8	5.5	4.8	2
DALZ8511	5.8	5.9	4.7	4.7	3.8	5.5	4.3	3
DALZ8512	5.8	3.8	3.3	3.8	5.5	6.3	4.8	1
DALZ8513	3.3	1.0	1.0	1.0	3.8	4.3	3.8	-
DALZ8514	5.5	4.3	4.0	3.2	5.8	5.5	5.8	1
DALZ8515	4.5	5.3	4.3	3.1	5.0	5.5	3.0	1
DALZ8516	4.0	3.8	4.0	2.8	4.0	5.0	4.0	1
DALZ8517	6.3	4.0	4.0	3.2	4.8	6.3	5.0	2
DALZ8522	2.0	2.0	1.0	1.0	3.5	4.0	2.3	-
DALZ8523	3.0	1.5	1.3	1.0	4.3	5.5	3.3	-
DALZ8524	5.5	3.5	2.7	3.5	4.5	6.0	5.0	1
El Toro	5.8	3.8	3.7	3.5	4.0	5.5	5.3	1
Emerald	5.8	5.5	6.2	4.0	5.3	6.3	5.0	3
FC13521	6.8	3.5	3.3	3.2	4.8	6.0	5.3	2
Korean Common	4.5	5.0	4.0	3.8	2.3	5.8	4.5	2
Meyer	5.5	6.3	6.0	4.8	4.8	5.5	3.0	3
MSD entry[3]	0.4	1.3	1.3	0.6	ns	ns	2.3	
MEAN[4]	5.1	3.8	3.8	2.9	4.1	5.5	4.4	

[1] Irrigation level of high, intermediate, none represent 87, 29, and 0% of the irrigation volume at the line source, or a distance of 1.5, 9 and 18 m from the line source, respectively.

[2] PS = phenotypic stability, which is the frequency with which an entry occurs in the top statistical group.

[3] MSD 3yr = minimum significant difference for comparison of the 3 year average turf quality between irrigation levels, based on the Waller-Duncan k-ratio t test (k-ratio = 100).

[4] MSD entry = minimum significant difference for comparison of entries within columns, based on the Waller-Duncan k-ration t test (k-ratio = 100).

APPENDIX F

Update on the 1991 Zoysiagrass NTEP Trial

Establishment of the 1991 NTEP zoysiagrass trial encountered some obstacles, yet was essentially achieved by late summer 1992. Most plots were 75% filled, and those which had less turf cover should be complete by early summer 1993 (Table F1). Among the fastest to fill were CD259-13, DALZ8502, DALZ8507, DALZ8512, DALZ8514, DALZ9006, El Toro, GT2047, Korean Common, Sunburst, and TC5018. With the exception of DALZ8502, DALZ8507, and DALZ906, most of these are coarse textured zoysiagrasses.

One problem with establishment was bermudagrass contamination. Previously the site had been a bermudagrass trial, the tissue of which persisted during most of the growing season. Acclaim (fenoxyprop) was applied repeatedly, and eventually most of the bermudagrass was controlled. By late summer the zoysiagrasses were prevalent in their respective plots. Acclaim will be used continuously throughout the study to suppress the bermudagrass.

Spring green up of the zoysiagrasses started with DALZ8502, on February 24, with 10% green ground cover (Table F2). Most entries had at least 33% green ground cover by March 26. The fastest to complete green up were CD259-13, DALZ8512, DALZ8514, Emerald, GT2004, JZ1A89-1, Korean Common, Sunburst, TC5018, TGS-B10 and TGS-W10. Slowest to green up was DALZ8701, which had only 10% green cover by April 8.

Turf quality, which includes color, canopy density, turf cover, leaf texture, uniformity of distribution, evenness of stand, and green ground cover (inversely thatchiness), was affected by roundup injury during the early spring. Roundup was applied during the winter, during warm season turf dormancy, to eliminate tall fescue contamination. Those entries most affected by the roundup included Belair, DALZ8512, DALZ8514, DALZ8516, DALZ8701, and El Toro (Table F3). As evidenced by the presence of green cover in all entries on November 22 and February 24 (Table F2), these entries in particular were not dormant enough when the roundup was applied in the late winter. This injury is reflected in the turf quality ratings in the early spring (Table F4). Turf quality ratings indicate that recovery was complete by July.

Consistently, the highest quality ratings were observed for DALZ8502, Emerald, GT2004, TC2003 (Table F4). Most entries had acceptable turf quality during the summer, while those entries with poor quality by late summer were Belair and TGS-W10.

Table F1. Turf cover in 1992, as percentage of plot area that has turf cover, of NTEP zoysiagrasses at TAES-Dallas.

Entry	27 Mar	15 June	23 July	26 Aug	19 Oct	PS[1]
Belair	28.3	63.3	35.0	36.7	60.0	2
CD2013	27.7	57.7	38.3	38.3a	65.0	3
CD259-13	33.3a	78.3	63.3a	68.3a	80.0	4
DALZ8501	31.7a	61.7	28.3	35.0	51.7	3
DALZ8502	26.7	75.0	41.7	63.3a	75.0	3
DALZ8507	28.3	82.7	50.0	51.7a	75.0	3
DALZ8508	28.3	70.0	33.3	35.0	56.7	2
DALZ8512	40.0a	94.3	90.0a	76.7a	70.0	5
DALZ8514	40.0a	91.0	68.3a	80.0a	78.3	5
DALZ8516	26.7	56.7	21.7	31.7	46.7	2
DALZ8701	28.3	80.0	30.0	48.3a	75.0	3
DALZ9006	31.7a	88.3	38.3	60.0a	78.3	4
El Toro	36.7a	93.3	88.3a	86.7a	71.7	5
Emerald	30.0a	90.0	56.7	65.0a	73.3	4
GT2004	26.7	65.0	46.7	61.7a	71.7	3
GT2047	36.7a	70.0	64.7a	63.3a	71.7	5
ITR90-3	20.0	56.7	21.7	30.7	53.3	2
JZ1A89-1	31.0a	70.0	61.7a	56.7a	58.3	5
Korean Common	31.7a	70.0	80.0a	68.3a	51.7	5
Meyer	21.7	76.7	38.3	55.0a	70.0	3
Sunburst	28.3	90.0	89.7a	46.7a	58.3	4
TC2033	31.7a	88.3	51.7	56.7a	58.3	4
TC5018	31.7a	83.3	80.0a	75.0a	75.0	3
TGS-B10*	30.0a	78.3	48.3	61.7a	71.7	4
TGS-W10*	30.0a	65.0	43.3	41.7a	43.3	4
MSD entry[2]	11.2	ns	31.1	48.4	ns	

[1] PS = phenotypic stability, which is the frequency of occurrence of an entry in the top statistical group.

[2] MSD entry = minimum significant difference for comparison between entry means within columns, based on Waller-Duncan k-ratio t test, where k-ratio = 100.

Table F2. Spring green up, as percent green ground cover, of 1991 NTEP zoysiagrasses planted at TAES-Dallas during 1992.

Entry	22 Nov	24 Feb	26 Mar	8 Apr	PS[1]
Belair	2.0	4.3	46.7a	60.0	1
CD2013	3.0a	4.3	50.0a	53.3	2
CD259-13	2.3	3.7	58.3a	71.7a	2
DALZ8501	1.3	2.7	23.3	33.3	-
DALZ8502	4.0a	10.0a	41.7a	35.0	3
DALZ8507	3.3a	4.3	46.7a	48.3	2
DALZ8508	2.0	4.3	35.0	36.7	-
DALZ8512	2.7	4.3	45.0a	66.7a	2
DALZ8514	2.0	3.7	43.3a	71.7a	2
DALZ8516	3.3a	8.3a	46.7a	41.7	3
DALZ8701	2.3	2.3	10.0	10.0	-
DALZ9006	2.7	6.0	48.3a	41.7	1
El Toro	2.7	4.3	43.3a	61.7	1
Emerald	3.0a	5.0	70.0a	66.7a	3
GT2004	3.0a	3.0	50.0a	55.0	2
GT2047	2.0	3.0	65.0a	85.0a	2
ITR90-3	2.0	4.0	58.3a	46.7	1
JZ1A89-1	2.0	2.7	45.0a	68.3a	2
Korean Common	1.7	2.7	51.7a	75.0a	2
Meyer	3.0a	4.3	53.3a	50.0	2
Sunburst	2.7	3.7	60.0a	78.3a	2
TC2033	2.3	4.3	46.7a	56.7	1
TC5018	3.0a	3.7	51.7a	70.0a	3
TGS-B10*	2.0	3.7	65.0a	70.0a	2
TGS-W10*	3.0a	3.7	68.3a	82.7a	3
MSD entry[2]	1.1	1.8	28.8	21.0	

[1] PS = phenotypic stability, which is the frequency of occurrence of an entry in the top statistical group.

[2] MSD entry = minimum significant difference between entry means for comparison within columns, based on Waller-Duncan k-ratio t test, where k-ratio = 100.

Table F3. Roundup injury noted March 26, 1992 for 1991 NTEP zoysiagrasses planted at TAES-Dallas.

Entry	26 March
Belair	58.3a
CD2019	22.7
CD259-13	16.0
DALZ8501	45.0
DALZ8502	9.3
DALZ8507	35.0
DALZ8508	32.3
DALZ8512	51.7a
DALZ8514	55.0a
DALZ8516	55.0a
DALZ8701	88.3a
DALZ9006	19.3
El Toro	58.3a
Emerald	17.3
GT2004	26.7
GT2047	11.7
ITR90-3	23.3
JZ1A89-1	36.7
Korean Common	41.7
Meyer	31.7
Sunburst	11.7
TC2033	46.7
TC5018	43.3
TGS-B10*	31.0
TGS-W10*	7.3
MSD entry[1]	41.0

[1] MSD entry = minimum significant difference between entry means for comparison within columns, based on Waller-Duncan k-ratio t test, where k-ratio = 100.

Table F4. Turf quality of NTEP zoysiagrasses in Dallas, Texas. Rating scale is 0 to 9, where 9 is best and 5 is the lowest acceptable quality.

	1991	1992						
	22	27	12	15	23	26	26	19
Entry	Nov	Mar	May	June	July	Aug	Sep	Oct
Belair	2.0	2.7a	5.3a	4.3	3.7a	6.3a	4.3	5.7
CD2013	2.7a	2.7a	5.0	4.7	4.0a	5.0	5.0	6.3a
CD259-13	2.0	3.0a	6.0a	5.3	5.7a	5.3	4.3	6.3a
DALZ8501	2.3	1.7	5.0	4.0	2.7	4.3	3.7	7.3a
DALZ8502	3.3a	3.7a	3.7	4.3	4.0a	5.7a	3.7	7.7a
DALZ8507	3.0a	3.0a	5.3a	5.7	4.7a	4.3	4.3	6.0a
DALZ8508	2.3	2.7a	5.5a	5.0	3.3	5.0	4.7	6.7a
DALZ8512	2.7a	2.7a	6.3a	6.3	6.7a	5.0	4.7	6.0a
DALZ8514	2.3	2.7a	6.7a	6.3	5.7a	4.3	4.7	7.0a
DALZ8516	2.3	2.3a	3.0	4.0	2.3	6.7a	4.3	6.7a
DALZ8701	3.0a	1.0	3.0	4.3	4.3a	4.0	4.0	6.3a
DALZ9006	2.7a	3.0a	5.7a	5.7	4.3a	5.3	5.0	7.3a
El Toro	2.3	2.7a	6.3a	6.7	6.0a	5.3	5.0	6.3a
Emerald	2.7a	3.3a	6.0a	5.3	5.0a	6.7a	6.0	7.3a
GT2004	2.7a	3.0a	5.3a	4.0	4.3a	6.0a	4.7	7.0a
GT2047	2.0	3.7a	6.0a	4.7	5.3a	6.0a	4.3	6.7a
ITR90-3	1.7	2.0	4.0	4.3	2.3	5.3	4.3	6.0a
JZ1A89-1	2.0	3.0a	5.3a	4.0	5.0a	5.3	4.3	7.0a
Korean Common	2.0	2.7a	5.0	4.3	5.3a	5.3	4.7	6.3a
Meyer	2.3	3.0a	5.3a	4.7	4.0a	6.3a	5.0	7.0a
Sunburst	2.0	3.3a	6.3a	5.0	6.3a	4.0	4.7	6.0a
TC2033	2.7a	3.0a	6.0a	6.0	4.7a	5.7a	4.7	6.7a
TC5018	2.0	3.0a	5.3a	5.7	6.0a	5.3	4.7	6.3a
TGS-B10*	2.0	2.7a	6.0a	5.3	4.7a	6.0a	5.0	6.3a
TGS-W10*	2.0	3.3a	4.0	4.0	4.0a	5.7a	3.7	4.7
MSD entry[1]	0.9	1.6	1.5	ns	3.2	1.3	ns	1.9

[1] MSD entry = minimum significant difference for comparison of entry means within columns, based on Waller-Duncan k-ratio t test, where k-ratio = 100.

APPENDIX G

Regional Field Trials

INTRODUCTION: Regional field trials are useful to define areas of adaptation of improved zoysiagrass selections in comparison to commercially available cultivars.

OBJECTIVE: Develop a base of information on performance of both experimental accessions and established cultivars of zoysiagrasses under various environmental conditions and management practices.

PROGRESS: Regional trial results have been recently received from Dr. Dennis Martin of the Oklahoma State University, Dr. Victor Gibeault of the University of California-Riverside, Dr. Charles Mancino of the University of Arizona, Dr. John Dunn of the University of Missouri, Dr. David Bowman of the University of Nevada-Reno, and Mr. Stephen Brown of Quality Turfgrass,.

Data from Dr. Gibeault is presented in Tables G1-G3. Dr. Gibeault's description of the experiment and data collection follows. "The 24 sq. ft. plots were established on July 18, 1989 by hand planting six plugs into each plot, with each treatment replicated three times. After initial cover, the plots were mowed regularly at 3/4 inch with a reel mower, fertilized at a rate of 1/2 lb. N per 1000 sq. ft per month, and irrigated according to reference ET X 0.6 adjusted for C.U. The study was conducted by Richard Autio".

"Data in the tables were taken from August 1991 to July 1992. Turf quality scores were taken monthly, rated on a scale from 1 - 9 with 9 being best. Color ratings were taken from December 1991 to March 1992, and scalping was rated in September and October 1991, and again in June and July 1992. Low turf scores in the fall of 1991 of DALZ8501 and DALZ8502 was due to scalping. The higher UCR turf scores in the winter reflect the color retention of these grasses. DALZ8502 and DALZ8507 provided the best color retention of the Dallas grasses. The May 1992 drastic reduction in turf score for DALZ8507 was due to scalping."

The Arizona zoysiagrass regional trial included 8 grasses (see Tables G4-G7). Data was collected from May 15, 1991 to January 14, 1992 on percent dormancy, color, density, percent green cover, and quality.

During the spring and fall of 1991 DALZ8508, 8516, and 8502 had higher percent dormancy than did the other zoysias (Table G4). By December there were no differences in dormancy. During the summer better color was found in Belair, El Toro, Emerald, Meyer, and DALZ8508 (Table G5). During the winter the best color was noted in DALZ8508, DALZ8516, DALZ8502, and Emerald. Throughout the summer of 91 green turf cover and density was inferior in DALZ8502 (Table G6 and G7).

Data from Dr. Martin are summarized in Tables G8 and G9. The grasses tested were those of the National Turf Evaluation trial. Dr. Martin's description of the plots follows. "The zoysiagrasses were established at the Turfgrass Research Center in early May of 1992. The trial is still in the establishment phase because of the naturally slow growth of the materials. Initial data on rate of cover, color, and texture have been recorded this summer."

"Since placing the trial on a slope was unavoidable, the plots have been staggered to reduce erosion. The plot size is 6 X 10 feet with 9" alleys. Plugs were planted on 1 foot centers in sterilized soil on May 6 and 7 1992."

"The maintenance program during the establishment phase has been 0.5 lbs. N per 1000 sq. ft. every 2 and 1/2 weeks, and mowing at 1.5" with a bagger. Metolachlor (Pennant) and bentazon (Basagran) were used for control of broadleaves, annual grasses and yellow nutsedge. Glyphosate (Roundup) was used periodically on the alleys. Invading bermudagrass was dug out by hand. Irrigation was applied as needed to promote growth, while unusually heavy rains kept us busy trying to hold the soil in place until the turfgrass varieties filled in the plots. Maintenance during the mature turf phase of the trial will include 3 lbs. N per 1000 sq. ft. per year, mowing at 3/4 inch, and reduced irrigation."

Belair, Meyer, Korean common, Emerald, Sunburst, DALZ8516, DALZ8508, DALZ8514, DALZ9006, DALZ8502, TC5018, TGS-B10, TC2033, GT2004, TGS-W10, and JZ-1 were in the top statistical group for color (Table G8). DALZ8508, DALZ9006, DALZ8502, DALZ8501, DALZ8701 and Emerald were finest in texture. During July and August the greatest turf cover was found in El Toro, TGS-B10, DALZ8514, TC5018, CD259-13 and DALZ8507 (Table G9).

Data from the University of Missouri regional trial was furnished by Dr. John Dunn. Dr. Dunn described the experiment and results as follows. "Cultivars and experimental zoysiagrass entries were planted in small plots on June 12, 1989 by placing 5.1 cm plugs on 0.31 m centers in bare silt loam soil. Phosphorus and K levels were high according to U. of Missouri soil tests; pH of the soil was 6.2. N was applied at a yearly rate of 98 kg ha^{-1}. Plots were irrigated as needed to prevent severe stress, except when turf was intentionally not irrigated to check tolerance to short term drought. Mowing was at least once a week at 1.89 cm (2.54 cm in fall). Weeds were controlled by hand and chemically."

"DALZ entries were slow to greenup in spring with the exception of 8514 which was not significantly different from Meyer (Table G11). All DALZ entries gave good to excellent turfgrass quality from early July to late september, except during a one month period of drought stress (Table G10). Turf was not irrigated during the period of limited rainfall August 5 to September 1, in order to evaluate tolerance (resistance to wilting) of entries to short term drought stress. DALZ8514 was among the most drought tolerant of the entries while DALZ8508 was the least tolerant entry."

Data from Dr. Bowman is shown in Table G12. No statistical analysis was possible, but it appears that DALZ8502 and DALZ8701 did not survive the harsh winter of 1991 in Reno. Turf cover was also fairly low in DALZ8503 and DALZ8510.

A trial of the 25 zoysiagrasses included in the National Turfgrass Evaluation Program was also run at Quality Turfgrass sod farm. Notes were taken on turf quality August 24, 1992 (Table G13). There were no significant differences among grasses.

Table G1. Turfgrass quality (1=worst, 9=best) of zoysiagrasses from the University of California at Riverside, established July 18, 1989.

	Date of Observation								
Grass	9/91	10/91	11/91	12/91	1/92	5/92	6/92	7/92	PS[2]
El Toro	7.0a	7.0a	5.3a	4.0	4.0	7.0a	7.0a	6.0a	6
Emerald	6.0	4.6	3.6	3.6	3.1	6.9a	7.4a	6.0a	3
Belair	6.0	6.0a	3.6	3.6	3.3	6.0a	6.0	5.0	2
Meyer	6.7a	6.7a	4.6	4.0	3.6	5.7a	5.6	4.6	3
DALZ8501	6.0	4.3	3.3	3.0	3.3	6.0a	6.0	6.7a	2
DALZ8502	6.0	5.0	4.3	4.6	4.6	5.0	5.3	4.3	0
DALZ8507	6.3	6.3a	5.0	4.6	4.3	4.3	4.3	4.7	1
DALZ8512	6.3	6.0a	4.3	4.0	4.0	6.3a	6.3	6.3a	3
DALZ8514	6.3	6.3a	5.3a	4.0	4.0	6.7a	6.7a	6.3a	5
DALZ8701	6.3	6.3a	5.0	3.6	3.6	5.0	5.0	6.7a	2
UCR-Z88-1	7.0a	7.0a	5.3a	5.6a	4.0	7.0a	7.0a	6.7a	7
UCR-Z88-5	7.0a	6.7a	6.3a	5.3a	5.3a	6.0a	6.0	6.0a	7
UCR-Z88-8	6.7a	6.7a	6.0a	6.0a	5.6a	6.6a	6.7a	7.0a	8
UCR-Z88-9	7.3a	7.3a	6.0a	5.0a	4.0	6.0a	6.0	6.3a	6
UCR-Z88-14	7.0a	7.0a	7.0a	6.0a	6.0a	7.0a	8.0a	6.7a	8
LSD[1]	0.69	1.47	1.74	1.17	1.33	1.46	1.62	1.40	

[1]Means followed by the same letter are not statistically different at the 5% level of significance.
[2]PS = phenotypic stability, the number of times an entry received superior ratings based on least significant differences (LSD).

Table G2. Turfgrass color (1=worst, 9=best) of zoysiagrasses from the University of California at Riverside, established July 18, 1989.

	Date of Observation				
Grass	12/91	1/92	2/92	3/92	PS[2]
El Toro	2.0	1.0	1.0	7.0a	1
Emerald	2.2	1.1	2.1	6.5a	1
Belair	1.0	1.0	1.0	5.7	0
Meyer	1.0	1.0	1.0	6.7a	1
DALZ8501	3.6	3.3	4.7a	6.0	1
DALZ8502	3.6	5.1	4.7a	6.0	1
DALZ8507	4.6	2.3	4.7a	5.7	1
DALZ8512	1.6	1.0	1.0	5.7	0
DALZ8514	2.0	1.0	1.0	6.3a	1
DALZ8701	2.6	2.7	4.7a	5.7	1
UCR-Z88-1	5.3a	4.3	3.7	5.7	1
UCR-Z88-5	5.3a	5.0	3.7	6.0	1
UCR-Z88-8	6.3a	6.0a	5.3a	6.0	3
UCR-Z88-9	5.0	2.0	2.0	6.7a	1
UCR-Z88-14	6.3a	5.3a	5.0a	6.3a	4
LSD[1]	1.27	0.78	1.21	0.82	

[1]Means followed by the same letter are not statistically different at the 5% level of significance.
[2]PS = phenotypic stability, the number of times an entry received superior ratings based on least significant differences (LSD).

Table G3. Turfgrass scalping ratings (1=worst, 9=no scalping) of zoysiagrasses from the University of California at Riverside, established July 18, 1989.

Grass	Date of Observation 9/91	10/91	6/92	7/92	PS[2]
El Toro	9.0a	9.0a	9.0a	8.3a	4
Emerald	8.0	4.4	8.3a	6.3	1
Belair	9.0a	9.0a	9.0a	9.0a	4
Meyer	9.0a	9.0a	9.0a	6.0	3
DALZ8501	6.0	4.3	8.0a	3.7	1
DALZ8502	6.7	4.6	6.0	4.7	0
DALZ8507	9.0a	7.3a	4.6	5.3	2
DALZ8512	9.0a	9.0a	9.0a	8.7a	4
DALZ8514	9.0a	9.0a	9.0a	8.3a	4
DALZ8701	9.0a	8.0a	7.3a	8.3a	4
UCR-Z88-1	9.0a	9.0a	9.0a	9.0a	4
UCR-Z88-5	9.0a	9.0a	9.0a	8.3a	4
UCR-Z88-8	9.0a	9.0a	9.0a	9.0a	4
UCR-Z88-9	9.0a	9.0a	9.0a	8.7a	4
UCR-Z88-14	9.0a	9.0a	9.0a	8.7a	4
LSD[1]	0.52	1.88	1.78	2.41	

[1]Means followed by the same letter are not statistically different at the 5% level of significance.
[2]PS = phenotypic stability, the number of times an entry received superior ratings based on least significant differences (LSD).

Table G4. Percent dormancy (0 - 100%) of zoysiagrasses in the regional trial at the University of Arizona.

Entry	Date of observation 5/15/91	11/13/91	12/20/91	1/14/92	PS[1]
DALZ8508	13a	13a	77	93	1
DALZ8516	27a	3a	77	97	1
DALZ8502	63	3a	73	87	2
DALZ8501	73	53a	83	97	2
Belair	13a	73	90	100	2
Meyer	13a	43a	87	100	1
El Toro	47a	20a	67a	93	0
Emerald	20a	7a	73	90	1
LSD[2]	11	20	14	ns	

[1]Phenotypic stability = number of times an entry is in the top significance group.
[2]Least significant difference among means within a column at the 5% level of probability.

Table G5. Color (1 - 9, 6 = minimum acceptable) of grasses in the regional trial at the University of Arizona.

	Date of observation					
Entry	6/13/91	7/17/91	8/13/91	10/16/91	11/13/91	PS[1]
DALZ8508	5.8a	6.7a	6.5	7.3a	6.2a	4
DALZ8516	5.2	4.3	6.5	6.3	6.7a	1
DALZ8502	5.2	6.8a	7.0	7.8a	7.3a	3
DALZ8501	5.0	6.5a	6.3	7.3a	3.3	2
Belair	6.5a	6.7a	6.3	7.3a	2.7	3
Meyer	6.0a	6.7a	6.8	7.2a	4.2	3
El Toro	5.7a	6.8a	7.2	7.3a	5.5	3
Emerald	5.5a	6.8a	7.0	7.7a	6.7a	4
LSD[2]	0.7	0.7	ns	0.8	1.1	

[1]Phenotypic stability = number of times an entry is in the top significance group.
[2]Least significant difference among means within a column at the 5% level of probability.

Table G6. Green turf cover (1 to 9, 6 = acceptable) of zoysiagrasses in the regional trial at the University of Arizona.

	Date of observation			
Entry	6/13/91	7/17/91	8/13/91	PS[1]
DALZ8508	7.3a	7.5a	7.7a	3
DALZ8516	5.2	4.3	5.0	0
DALZ8502	7.2a	7.7a	7.5a	3
DALZ8501	6.5a	7.3a	7.3a	3
Belair	7.0a	7.2a	7.3a	3
Meyer	7.7a	7.3a	7.7a	3
El Toro	7.8a	8.0a	8.0a	3
Emerald	7.8a	7.7a	8.0a	3
LSD[2]	1.2	0.7	0.5	

[1]Phenotypic stability = number of times an entry is in the top significance group.
[2]Least significant difference among means within a column at the 5% level of probability.

Table G7. Turf density (1 to 9, 6 = acceptable) of zoysiagrasses in the regional trial at the University of Arizona.

Entry	6/13/91	7/17/91	8/13/91	PS[1]
		Date of observation		
DALZ8508	7.3a	7.5a	7.7a	3
DALZ8516	5.5	5.3	5.0	0
DALZ8502	7.2a	7.7a	7.7a	3
DALZ8501	6.3a	7.2a	7.5a	3
Belair	7.2a	7.2a	7.3a	3
Meyer	7.5a	7.3a	7.3a	3
El Toro	7.8a	8.0a	7.8a	3
Emerald	7.7a	7.5a	7.7a	3
LSD[2]	1.2	0.6	0.4	

[1]Phenotypic stability = number of times an entry is in the top significance group.
[2]Least significant difference among means within a column at the 5% level of probability.

Table G8. Turfgrass color and texture ratings for the Oklahoma State University zoysiagrass NTEP trial established May, 1992.

Entry	Aug 28 Color	July 17 Texture	PS[2]
TC-2033	7.7a	6.7	1
GT-2047	7.0	5.0	0
CD-2013	7.0	6.3	0
TC-5018	7.7a	5.0	1
GT-2004	7.3a	7.0	1
CD-259-13	7.0	5.0	0
KOREAN COMMON	7.7a	5.0	1
JZ-1	7.3a	5.0	1
MEYER	8.0a	6.3	1
EMERALD	7.7a	8.0a	2
BELAIR	8.0a	5.0	1
SUNBURST	7.3a	5.0	1
ELTORO	7.0	5.0	0
DALZ8514	7.7a	5.0	1
DALZ8512	7.0	5.0	0
DALZ8516	8.0a	6.7	1
DALZ8507	7.0	7.0	0
DALZ8508	7.7a	8.0a	2
DALZ9006	7.3a	8.0a	2
DALZ8502	7.3a	8.0a	2
DALZ8701	7.0	8.0a	1
TGS-B10	7.7a	5.0	1
TGS-W10	7.3a	5.7	1
DALZ8501	7.0	7.7a	1
LSD[1]	0.70	0.6	

[1]Means followed by the same letter are not statistically different at the 5% level of significance based on LSD.
[2]PS = phenotypic stability, the number of times an entry received superior ratings based on least significant differences (LSD).

Table G9. Turfgrass percent cover ratings for the Oklahoma State University zoysiagrass NTEP trial established May, 1992.

Entry	July 17	Aug. 3	Aug. 17	PS[2]
TC-2033	51.7	55.0	53.3	0
GT-2047	55.0	53.3	58.3	0
CD-2013	50.0	51.7	56.7	0
TC-5018	53.3	58.3a	65.0a	2
GT-2004	51.7	51.7	53.3	0
CD-259-13	53.3	58.3a	60.0a	2
KOREAN COMMON	55.0	55.0	61.7a	1
JZ-1	55.0	60.3a	58.3	1
MEYER	51.7	51.7	53.3	0
EMERALD	50.0	53.3	53.3	0
BELAIR	53.3	55.0	55.0	0
SUNBURST	51.7	55.0	58.3	0
ELTORO	58.3a	61.7a	66.7a	3
DALZ8514	56.7a	60.0a	63.3a	3
DALZ8512	51.7	56.7	61.7a	1
DALZ8516	50.0	50.0	55.0	0
DALZ8507	51.7	58.7a	60.0a	2
DALZ8508	51.7	51.7	51.7	0
DALZ9006	51.7	53.3	55.0	0
DALZ8502	50.0	50.0	50.0	0
DALZ8701	50.0	50.0	55.0	0
TGS-B10	58.3a	58.3a	60.0a	3
TGS-W10	55.0	56.7	60.0a	1
DALZ8501	50.0	50.0	55.0	0
LSD[1]	3.26	7.68	6.70	

[1]Means followed by the same letter are not statistically different at the 5% level of significance.
[2]PS = phenotypic stability, the number of times an entry received superior ratings based on least significant differences (LSD).

Table G10. Quality of 9 zoysiagrass cultivars and experimentals (1 to 9, 6 = acceptable) in the regional trial planted May 28, 1989 at the University of Missouri.

	Date of observation			
Entry	6/1/92	7/9/92	8/12/92	9/23/92
Belair	3.7	5.0	6.0	5.7
El Toro	4.3	6.7	6.7	7.7
Emerald	6.7	7.7	6.3	7.3
Meyer	5.0	5.0	7.0	5.7
DALZ?	7.3	5.0	7.3	6.7
DALZ8507	6.0	8.0	7.7	7.3
DALZ8508	6.0	8.0	7.3	7.7
DALZ8512	5.0	7.0	6.3	7.0
DALZ8514	5.7	7.0	6.3	6.0
LSD[1]	1.6	0.9	ns	1.1

[1]Least significant difference among means within a column at the 5% level of probability.

Table G11. Spring greenup (April 28, 1992, 9 = best) and drought stress (August 25, 1992, 9 = most) of 9 zoysiagrass cultivars and experimentals (1 to 9, 6 = acceptable) planted May 28, 1989 at the University of Missouri.

Entry	Greenup	Drought Stress
Belair	4.3	2.7
El Toro	2.0	1.3
Emerald	3.7	3.3
Meyer	5.0	4.0
DALZ?	5.0	6.0
DALZ8507	2.7	4.7
DALZ8508	2.7	6.3
DALZ8512	2.7	2.3
DALZ8514	4.0	1.7
LSD[1]	1.4	1.1

[1]Least significant difference among means within a column at the 5% level of probability.

Table G12. Turfgrass survival and cover, as a percent, for the University of Nevada-Reno zoysiagrass regional trial established July 1, 1990.

Entry	May 24, 91 Survival	June 3, 92 Cover
DALZ8502	0	0
DALZ8503	100	35
DALZ8505	88	90
DALZ8506	100	70
DALZ8507	100	60
DALZ8508	100	60
DALZ8510	62	40
DALZ8514	93	75
DALZ8701	0	0
El Toro	100	90
Emerald	100	80
Meyer	100	90

Table G13. Turfgrass quality ratings (1 - 9, 9 = best) for the Quality Turfgrass sodfarm zoysiagrass regional trial, rated August 24, 1992.

Entry	Quality
TC-2033	7.3*
GT-2047	5.3
CD-2013	5.7
TC-5018	7.7
GT-2004	4.7
CD-259-13	6.7
KOREAN COMMON	6.0
JZ-1	7.3
MEYER	8.7
EMERALD	7.3
BELAIR	6.7
SUNBURST	7.3
ELTORO	5.7
DALZ8514	6.3
DALZ8512	5.3
DALZ8516	5.0
DALZ8507	7.7
DALZ8508	6.7
DALZ9006	7.7
DALZ8502	5.0
DALZ8701	5.7
TGS-B10	6.3
TGS-W10	7.0
DALZ8501	6.7
ITR90-3	5.0

*Treatment means are not significantly different at the 5% level of probability.

APPENDIX H

Zoysiagrass hybridization - Oriental Collection

1. **Oriental Zoysia Collection** - Flower Production

Flowering notes were continued on the oriental zoysia collection. On April 24, 15% of entries had ratings $\geq$7.0, the minimum rating for desired levels of culm production.

From the field-planted oriental collection, 23 coarse-textured and 8 finer-textured zoysiagrasses were selected for their culm production and vegetative turf characteristics and planted into 2 polycross nurseries. El Toro, Meyer, Belair, DALZ8512, and DALZ8514 were added to the set of coarse textured selections, and Cashmere and Emerald were added to the set of finer textured selections for the final polycross nursery plans. Six reps were planted in the finer-textured nursery, and two reps in the coarser textured nursery. On September 8, 1992, all were planted on 4 ft centers in their respective nurseries as plugs, which had been taken from the field with a 4" cup cutter.

Seed were collected from those zoysiagrasses selected for the polycross nurseries. Seed will be germinated and the plants will undergo further progeny testing.

2. **Oriental Zoysia Collection** - Traffic Tolerance

The field planting of the oriental zoysiagrass collection was the site of the wear study. 598 zoysiagrass entries were tested for their wear tolerance. Trafficking began during summer 1991 and has continued thrice weekly through to the present. Irrigation was discontinued to the plots during the winter of 91-92.

Notes on wear injury response gave consideration to factors of compaction, necrosis, chlorosis, shredding, or any non-healthy condition of the turf. Wear injury was measured as percent of plot that was injured in each worn and unworn plots. The difference between the two treatments was determined as the level of wear response. A green cover note during spring 1992 was taken to measure effect of wear on spring green up.

GLM was performed to test for significant differences in wear injury between entries. When $P>F \leq 0.05$, Duncan-Waller mean separation was performed to determine the statistically lowest wear group. When $P>F >0.05$, t tests were run to determine the number of entries in which injury was not significantly different from the control.

During the spring, trafficking injury was not as severe as when noted in late summer, as indicated by the increase in value of the most frequent wear level (Table H1). By the fall, and after summer's drought period had begun to challenge the less drought tolerant, the range of wear among the entries varied from 25 to 90 percent injury. This wide range showed that much genetic diversity in wear tolerance existed in the zoysiagrasses, and was part of the turf character criteria used to select zoysiagrasses for polycross nurseries and for further study of vegetative zoysiagrass turf.

On March 2, 1992, green cover was noted on 75% of entries, for effect of wear on spring green up. Spring green up was not significantly different among entries. The difference in green cover between worn and non worn plots (gc-gw) ranged from 42.5 to -40.0, which means that some worn plots (8% of entries) had more green cover than their corresponding control plots. It is possible that the trafficking enhanced dormant tissue degradation during early spring, which could result in new tissue growth being more noticeable. One might conclude that wear may not affect spring green up of the zoysiagrasses. Most (70%) entries had between 8 and 24% more green cover in the control plots than in the worn. For the whole population, green cover on the worn plots was significantly different from that of the control plots. When analyzed individually, only 23 entries had significantly different green up rates between worn and control plots.

Table H1. Wear responses of oriental zoysiagrasses.

Notedate	Minimum Average Wear[1]	Maximum Average Wear	Most Frequent Wear Level	Percent in Lowest Wear Group	Maximum of Lowest Wear Group[2]
Dec. 9, 1991	2	35	16.5	97	25
Jan. 31, 1992	11	65	32	91	43
Mar. 2, 1992	0	70	21	100	ns
May 6, 1992	15	77	45	100	ns
92279	25	90	72	100	ns

[1] Wear per entry = injury in worn plots less injury in control plots.

[2] Lowest wear group = statistical group with significantly less wear than other entries, based on GLM ($\alpha = 0.05$).

APPENDIX I

Zoysiagrass Hybridization - Progeny Development

1. Progeny Space Plantings

Progeny evaluations continued on the 1990 space planting, and began on a 1992 space planting. For the 1990 space planting, notes taken during 1991 and 1992 included turf cover, leaf texture, canopy density, turf quality, color quality, and culm production. A portion of this planting included a parent-progeny planting, for determination of heritability of traits. Analysis of the data for this part of the space planting indicated that measurements of heritable traits should be performed during the first year, or the developmental period of the plants. Past that point, competition and other environmental factors influence the phenotype of a plant. A broad-sense heritability index is included in the tables (Tables I1 and I2). For the traits noted, all showed some degree of heritability, with turf cover having the highest heritability index for the zoysiagrass population tested. For both 1991 and 1992 data, turf cover data generated high heritability indices (0.46 and 0.50, respectively), such that an inference that the ability to spread rapidly can be made.

Progeny in the parent progeny planting were not significantly different from each other for the traits noted in 1991. In 1992, culm production in DALZ8502, DALZ8513, Cashmere, Belair was high, and the finest leaf texture was observed of DALZ8502.

Progeny in the 1990 space planting, including the parent progeny heritability test planting, will be evaluated another year. Rankings for the 1991 and 1992 data indicate several entries, of all leaf texture types, which have consistently high turf quality ratings.

A progeny space planting nursery was started April 1992. Notes taken 4 months after planting the nursery included spread (as stolon length, in cm), turf quality, leaf texture, canopy density, color quality (Table I3). Analysis of the progeny indicate that TAES3362, TAES3365, DALZ8512, and DALZ8701 spread quickly, and that many of the progeny have good overall turf quality (includes density, color, texture). This trend in overall quality is reflected in the individual quality components measured. In spring 1993, four replications of female parents will be planted with the progeny in this 1992 space planting nursery, and the progeny cut back to comparable dimensions, to allow a parent progeny heritability test in this planting. Developmental characteristics of the grasses will be monitored.

Table I1. Parent-progeny regression and mean separation of characters noted in 1991 for progeny and their respective female parents. For each parent-progeny set, n=4 and n=16 for the parent and progeny populations, respectively.

Female	Color Quality		Turf Quality		Turf Cover		Leaf Texture	
Parent	Parent	Progeny	Parent	Progeny	Parent	Progeny	Parent	Progeny
DALZ8501	4.5	3.6	3.0	2.8	2.0	2.9	2.0	2.6
DALZ8502	4.8	4.4	4.3	3.6	4.5	3.3	2.8	2.8
DALZ8511	4.8	4.3	4.3	3.0	5.8	4.3	2.8	2.1
DALZ8512	5.0	3.6	4.5	3.3	6.8	5.2	2.3	2.2
DALZ8513	3.5	3.8	2.8	3.3	3.0	3.6	2.3	1.8
DALZ8514	4.8	4.7	3.5	3.6	5.3	4.2	2.0	2.4
DALZ8516	5.0	4.4	3.5	3.5	5.5	4.4	3.3	3.1
DALZ8523	6.0	4.1	5.0	3.0	6.0	3.7	2.5	1.9
Belair	5.3	4.9	4.3	7.9	7.0	4.9	3.7	2.5
Cashmere	5.3	3.1	3.5	2.3	3.5	2.3	3.5	2.0
El Toro	2.5	4.2	2.5	3.6	5.5	5.3	1.5	2.3
MSD entry[1]	ns	ns	ns	ns	ns	ns	ns	ns
C.V.	45.7	59.4	44.0	144.3	51.7	70.7	59.2	68.5
h^{2*}	0.18		0.14		0.46		0.46	

[1] MSD entry = minimum significant difference between entry means for comparison within variable columns, based on Waller-Duncan k-ratio t test, where k=100.
* h^2 = broad-sense heritability, as determined from parent progeny regression.

Table I2. Parent-progeny regression and mean separation of characters noted in 1992 for progeny and their respective female parents. For each parent-progeny set, n=4 and n=16 for the parent and progeny populations, respectively.

Female	Canopy Density		Culm Production		Turf Quality		Turf Cover		Leaf Texture	
Parent	Parent	Progeny	Parent	Progeny	Parent	Progeny	Parent	Progeny	Parent	Progeny
DALZ8501	4.0	3.8	2.0	2.3a	4.3	4.3	67.5	74.0	2.0	2.3
DALZ8502	4.0	5.0	3.5	4.1a	4.0	5.1	61.3	73.9	2.3	3.6a
DALZ8511	5.8	4.3	2.3	3.1a	6.3	4.6	96.5	79.0	2.0	2.3
DALZ8512	3.5	3.9	1.3	2.9a	3.8	4.1	78.0	79.1	1.8	1.9
DALZ8513	4.3	3.9	5.0	4.0a	4.3	4.1	80.0	57.7	3.0	2.4
DALZ8514	3.0	4.4	1.3	2.6a	3.8	4.9	72.5	88.1	2.0	2.3
DALZ8516	4.8	4.6	1.8	2.6a	5.0	4.9	85.5	72.6	2.5	2.2
DALZ8523	5.3	4.1	3.5	2.0	4.8	4.3	87.5	79.1	2.5	2.3
Belair	4.5	4.5	3.3	2.4a	5.3	4.5	69.8	81.2	2.8	2.1
Cashmere	4.0	4.4	2.5	2.9a	4.0	4.7	70.0	77.4	2.3	2.7
El Toro	3.5	3.6	2.0	1.9	4.3	4.1	78.8	81.4	2.0	2.1
MSD entry[1]	ns	ns	ns	1.8	ns	ns	ns	ns	ns	0.7
C.V.	33.4	32.6	67.4	73.6	33.3	32.4	34.1	32.7	50.2	39.5
h^{2*}	0.24		0.36		0.12		0.50		0.31	

[1] MSD entry = minimum significant difference between entry means for comparison within variable columns, based on Waller-Duncan k-ratio t test, where k=100.
* h^2 = broad-sense heritability, as determined from parent progeny regression.

Table I3. Parent and progeny characteristics of 1992 space planting. Parent information is based on sample size of n=1 per female parent, and for progeny information sample size, n, ranges from 1 to 30 progeny per female parent.

Female	Stolon Length, cm		Turf Quality		Color Quality		Canopy Density		Leaf Texture	
Parent	Parent	Progeny	Parent	Progeny	Parent	Progeny	Parent	Progeny	Parent	Progeny
TAES3356	7	4.4	7	5.2a	7	6.4a	6	5.0a	1	1.4
TAES3357	3	3.6	7	4.4	8	4.7a	7	4.1	1	0.9
TAES3359	7	2.5	7	4.8a	7	5.8a	6	4.7a	1	0.8
TAES3360	7	6.9	8	5.5a	8	6.8a	8	5.5a	1	1.3
TAES3361	7	6.6	5	6.1a	5	7.1a	5	6.2a	3	2.5
TAES3362	7	8.6a	6	6.6a	7	7.1a	6	6.3a	1	1.7
TAES3364	2	6.6	3	5.6a	2	6.5a	3	5.6a	1	1.9
TAES3365	1	13.6a	5	5.6a	6	6.0a	5	5.8a	3	3.0
TAES3366	6	3.0	8	5.0a	8	5.0	7	5.7a	1	1.0
TAES3372	6	5.5	5	5.2a	6	5.8	6	5.3a	1	2.5
DALZ8501	5	4.1	6	4.8a	7	5.4	7	5.2a	2	3.2
DALZ8502	2	1.6	7	3.3	7	3.6	9	3.2	4	3.1
DALZ8503	5	2.9	5	3.4	7	4.1	6	3.8	2	1.7
DALZ8504	2	5.0	4	6.0a	4	5.7a	4	5.7a	1	1.7
DALZ8505	2	5.0	5	6.0a	7	6.5a	6	5.5a	1	2.5
DALZ8506	1	3.4	5	6.7a	7	7.6a	7	6.4a	2	1.3
DALZ8507	9	2.0	5	5.0a	6	7.0a	2	6.5a	4	3.0
DALZ8508	3	4.9	5	5.4a	6	5.6	6	5.7a	4	1.9
DALZ8510	12	8.0	6	6.3a	7	7.0a	5	6.0a	2	2.4
DALZ8511	2	5.3	5	4.4	7	5.1	5	4.6a	1	1.8
DALZ8512	15	8.8a	8	5.4a	7	6.1a	7	5.8a	1	2.0
DALZ8513	8	7.6	7	6.5a	7	7.1a	7	6.3a	2	2.1
DALZ8514	11	4.7	7	6.4a	7	7.4a	7	6.5a	1	2.2
DALZ8515	1	3.0	3	5.8a	3	7.3a	4	6.0a	2	1.8
DALZ8517	1	5.3	5	5.5a	6	7.3a	6	5.7a	4	3.0
DALZ8522	2	6.8	6	5.8a	7	7.2a	7	6.2a	3	1.2
DALZ8523	10	6.4	4	5.1a	5	5.8a	5	5.1a	3	1.6
DALZ8524	7	4.9	6	5.1a	6	6.3a	7	5.8a	4	2.4
DALZ8701	11	8.5a	7	5.0a	7	6.0a	6	5.5a	4	3.5
DALZ9002	24	3.8	6	4.3	6	5.8a	5	4.0	1	1.0
Belair	6	6.0	6	5.5a	7	6.6a	6	5.8a	1	1.5
Emerald	3	6.0	7	5.8a	7	6.5a	7	5.8a	2	2.0
Meyer	12	5.5	8	4.1	8	5.6	8	4.1	3	2.3
Midwest	7	7.8	7	5.8a	8	6.3a	7	5.8a	1	1.0
MSD entry[1]	.	5.3	.	1.9	.	1.8	.	1.9	.	

[1] MSD entry = minimum significant difference between entry means for comparison within columns, based on Duncan-Waller k-ratio t test, where k=100.

2. 1990 Zoysia Germplasm Introduction Nursery (GPIN)

The zoysiagrass GPIN included four commercial cultivars, three DALZ lines, and 66 accessions. Establishment (as turf cover), canopy density, culm production, leaf texture, and overall turf quality were noted for the entries during 1992.

Leaf textures were ranked as coarse, medium, and fine bladed types, for which El Toro, Meyer, and Emerald are respective examples. Eleven entries had coarse textures, and 17 had fine textures (Table I4).

Zoysiagrasses with fastest spread were medium- to coarse-textured, which included nineteen accessions and El Toro (Table I4). Among the fine- textured types, four of the accessions showed promise as moderately fast spreaders. Only three accessions, TAES3368, TAES3573, and TAES3581, did not survive.

Canopy density, or the proximity of leaves within a given area, was high for two thirds of the entries (Table I4). The remaining 22 entries had open canopies, among which all leaf texture types were represented.

Flowering occurred from April through October. One entry, TAES3360, had outstanding culm production during April (Table I4). Other entries produced superior numbers of culms later during the growing season. These include TAES3555, TAES3538, TAES3564, TAES3362, TAES3359, TAES3514, and TAES3364 (data not presented). Seed collected from these eight entries will be germinated and propagated for further testing and crossing.

Spring quality of the zoysiagrasses was high for most entries (Table I5). As summer progressed and irrigation was only enough to maintain survival, drought stress became evident as leaves began to roll. Consequently, turf quality scores diminished. Entries which had acceptable summer (July) turf quality included Meyer, DALZ8501, and 33 of the accessions.

In August 1992, twenty-two entries, including 20 of the accessions, were selected for their vegetative turf quality characteristics and for potential drought stress tolerance.

3. Accession increases

Some of the 20 accessions selected from the zoysia GPIN will be increased during the winter for field increase planting in the spring. These accessions were selected primarily for their vegetative turf qualities, although culm production was an important feature of eight entries.

Table 14. Spring 1992 turf characteristics for 1990 zoysiagrass GPIN. Turf cover, Canopy density, culm production (culm level) are rated on scales of 0 to 9, in which 9 is the best score, 5 is the minimum acceptable score, and 0 indicates absence of tissue. Leaf textures are ranked as fine (F, narrow blades), medium (M, medium to wide short blades), and coarse (C, wide long blades). Culm ratings were noted in April 1992.

Entry	Turf Cover	Canopy Density	Culm Level	Leaf Texture	Entry	Turf Cover	Canopy Density	Culm Level	Leaf Texture	Entry	Turf Cover	Canopy Density	Culm Level	Leaf Texture
Belair	4.3	6.3a	0.0	M	TAES3507	2.3	5.0a	1.7	F	TAES3549	2.0	2.7	0.0	M
El Toro	9.0a	6.3a	4.3	C	TAES3508	5.3	5.3a	0.3	M	TAES3550	5.0	4.7a	0.0	M
Emerald	3.7	7.0a	0.3	F	TAES3509	5.0	6.0a	0.0	M	TAES3551	5.0	4.3a	0.0	M
Meyer	4.3	7.7a	0.0	M	TAES3510	5.7	7.0a	0.0	M	TAES3552	4.0	6.0a	0.0	M
TAES3356	8.7a	6.3a	0.3	M	TAES3511	4.7	5.3a	0.0	M	TAES3553	4.3	4.3a	0.0	M
TAES3357	5.7	4.3a	0.0	M	TAES3512	2.7	4.0	0.0	M	TAES3554	6.0	5.3a	0.0	M
TAES3358	7.3a	6.7a	0.0	M	TAES3513	4.3	5.3a	0.0	M	TAES3555	7.7a	6.7a	3.0	M
TAES3359	7.7a	6.7a	2.0	M	TAES3514	4.0	6.3a	1.0	M	TAES3556	5.7	5.3a	0.3	M
TAES3360	6.3a	5.0a	6.3a	M	TAES3515	3.3	4.3a	0.0	M	TAES3557	4.3	5.3a	0.3	M
TAES3361	1.3	2.3	0.0	M	TAES3516	5.0	4.3a	0.0	M	TAES3558	6.0	6.3a	2.3	M
TAES3362	4.7	5.3a	2.3	M	TAES3517	5.0	5.3a	0.0	M	TAES3559	7.0a	6.3a	0.0	M
TAES3363	8.7a	6.3a	0.0	M	TAES3518	2.3	3.3	0.0	M	TAES3560	4.3	5.7a	0.3	M
TAES3364	7.7a	6.7a	4.7	M	TAES3519	4.7	6.0a	0.0	M	TAES3561	2.7	3.7	0.0	M
TAES3365	2.7	4.7a	3.3	F	TAES3520	7.3a	7.0a	0.0	M	TAES3563	4.7	5.0a	0.3	M
TAES3366	8.3a	6.3a	2.0	M	TAES3521	6.0	4.0	0.0	C	TAES3564	7.3a	6.7a	3.0	M
TAES3367	3.0	4.3a	4.7	M	TAES3522	4.7	4.3a	0.0	M	TAES3565	4.7	4.7a	0.0	M
TAES3368	0.0	0.0	0.0	M	TAES3523	3.3	3.0	0.0	M	TAES3566	8.3a	6.3a	2.0	M
TAES3483	3.3	2.7	0.0	C	TAES3524	6.0	6.0a	0.0	M	TAES3567	5.3	5.3a	0.0	M
TAES3484	5.0	5.7a	0.0	C	TAES3525	4.0	3.0	0.0	M	TAES3569	6.3a	5.7a	0.0	M
TAES3485	3.7	5.0a	0.0	M	TAES3526	3.7	3.0	0.0	M	TAES3570	7.7a	5.7a	0.0	M
TAES3486	2.7	3.3	0.0	M	TAES3527	3.0	3.7	0.0	M	TAES3571	4.0	3.0	0.0	C
TAES3487	4.3	6.7a	0.0	F	TAES3528	5.0	4.7a	0.0	C	TAES3572	2.7	4.7a	0.0	F
TAES3488	3.7	4.3a	0.0	C	TAES3529	7.3a	6.7a	1.7	M	TAES3573	0.0	0.0	0.0	M
TAES3489	7.3a	7.3a	0.0	M	TAES3530	5.0	5.3a	0.0	M	TAES3574	4.0	7.7a	0.0	F
TAES3490	4.7	7.0a	0.0	M	TAES3531	5.0	5.3a	0.0	C	TAES3575	7.0a	6.3a	2.0	M
TAES3491	3.7	4.7a	1.0	M	TAES3532	5.0	5.7a	0.0	M	TAES3576	4.3	6.0a	0.0	M
TAES3492	5.0	5.0a	0.0	M	TAES3533	2.3	4.0	0.3	M	TAES3577	4.3	4.3a	0.0	M
TAES3493	3.3	4.0	0.3	M	TAES3534	5.7	5.7a	0.0	M	TAES3578	4.3	4.3a	1.3	M
TAES3494	4.0	4.7a	0.3	M	TAES3535	5.3	5.3a	0.3	M	TAES3579	5.7	6.3a	0.0	M
TAES3495	5.7	5.7a	0.0	C	TAES3536	5.7	6.0a	0.7	M	TAES3580	3.7	6.3a	0.0	F
TAES3496	4.3	5.0a	0.0	M	TAES3537	2.7	2.7	0.0	M	TAES3581	0.0	0.0	0.0	-
TAES3497	3.3	5.0a	0.0	M	TAES3538	7.3a	6.3a	0.0	M	TAES3582	1.3	3.7	0.0	F
TAES3498	4.7	6.0a	0.0	M	TAES3539	2.3	4.3a	0.0	M	TAES3583	6.7a	5.7a	0.0	M
TAES3499	5.3	5.7a	0.0	M	TAES3540	2.0	4.7a	1.7	M	TAES3584	3.0	3.7	0.0	F
TAES3500	3.3	3.0	0.0	M	TAES3541	4.3	6.3a	0.0	M	TAES3585	4.3	7.0a	0.0	F
TAES3501	4.0	5.0a	0.3	M	TAES3542	4.3	5.3a	0.0	M	TAES3586	4.3	7.0a	0.0	F
TAES3502	4.7	7.7a	0.0	M	TAES3543	5.0	5.0a	0.0	M	TAES3587	1.7	4.7a	0.0	F
TAES3503	2.3	3.7	0.3	M	TAES3544	4.0	4.7a	0.3	M	TAES3588	5.7	7.0a	0.0	F
TAES3504	2.7	4.3a	0.3	M	TAES3545	3.7	5.3a	0.0	M	DALZ8501	1.7	4.7a	2.3	F
TAES3505	2.7	3.0	0.0	M	TAES3547	3.3	4.3a	0.0	C	DALZ8502	2.0	4.7a	3.7	F
TAES3506	4.7	5.7a	0.0	M	TAES3548	5.0	5.0a	0.3	C	DALZ8701	1.7	1.7	1.3	F
										MSD entry[1]	2.9	3.4	1.4	

[1] MSD entry = minimum significant difference between entry means for comparison within columns, based on Waller-Duncan k-ratio t test, where k-ratio = 100.

Table 15. Spring and summer 1992 turf quality for 1990 zoysiagrass GPIN.

Entry	Spring Quality	Summer Quality	Entry	Spring Quality	Summer Quality	Entry	Spring Quality	Summer Quality
Belair	6.0a	3.7	TAES3507	5.3a	3.7	TAES3549	6.3a	3.7
El Toro	7.0a	3.7	TAES3508	6.3a	4.3a	TAES3550	4.3a	4.0
Emerald	.	1.7	TAES3509	6.7a	3.7	TAES3551	5.7a	4.0
Meyer	7.3a	4.3a	TAES3510	5.0a	3.0	TAES3552	5.0a	4.0
TAES3356	6.7a	4.3a	TAES3511	7.0a	4.3a	TAES3553	4.0a	2.3
TAES3357	6.3a	4.7a	TAES3512	3.7a	2.7	TAES3554	6.0a	3.7
TAES3358	7.0a	4.0a	TAES3513	5.3a	4.0	TAES3555	7.3a	4.7a
TAES3359	6.7a	4.0a	TAES3514	6.3a	4.3a	TAES3556	6.3a	4.0
TAES3360	6.3a	5.0a	TAES3515	6.0a	4.7a	TAES3557	6.3a	4.3a
TAES3361	5.0a	3.0	TAES3516	6.0a	3.3	TAES3558	5.0a	2.7
TAES3362	6.0a	4.7a	TAES3517	6.7a	4.3a	TAES3559	7.7a	4.0
TAES3363	7.3a	4.0	TAES3518	4.3a	2.7	TAES3560	6.7a	4.0
TAES3364	7.0a	4.0	TAES3519	6.7a	4.0	TAES3561	4.0a	2.7
TAES3365	4.7a	5.7a	TAES3520	6.7a	4.3a	TAES3563	6.7a	3.7
TAES3366	6.3a	4.0	TAES3521	5.0a	3.7	TAES3564	7.7a	4.3a
TAES3367	6.3a	4.3a	TAES3522	5.3a	4.0	TAES3565	5.3a	4.0
TAES3368	4.0a	4.7a	TAES3523	4.7a	4.0	TAES3566	7.7a	4.3a
TAES3483	4.3a	2.7	TAES3524	5.3a	4.0	TAES3567	5.0a	3.3
TAES3484	5.7a	4.0	TAES3525	3.7a	3.3	TAES3569	7.0a	4.0
TAES3485	1.7	1.7	TAES3526	4.0a	2.7	TAES3570	7.0a	4.0
TAES3486	4.3a	2.7	TAES3527	7.3a	5.0a	TAES3571	6.3a	4.0
TAES3487	6.7a	4.0	TAES3528	6.7a	4.7a	TAES3572	6.7a	4.3a
TAES3488	5.0a	3.7	TAES3529	7.3a	4.3a	TAES3573	0.0	0.0
TAES3489	6.0a	4.0	TAES3530	6.7a	4.0	TAES3574	6.0a	4.3
TAES3490	6.7a	4.0	TAES3531	5.7a	4.0	TAES3575	6.3a	3.7
TAES3491	5.3a	4.3a	TAES3532	4.3a	2.7	TAES3576	5.3a	3.7
TAES3492	6.0a	4.0	TAES3533	3.0	2.7	TAES3577	6.3a	4.0
TAES3493	4.0a	2.3	TAES3534	4.7a	4.0	TAES3578	2.3	1.3
TAES3494	5.0a	4.0	TAES3535	5.7a	4.0	TAES3579	7.3a	4.0
TAES3495	5.3a	4.3a	TAES3536	3.7a	2.7	TAES3580	6.3a	3.7
TAES3496	4.3a	2.7	TAES3537	4.3a	2.7	TAES3581	1.7	1.3
TAES3497	4.7a	4.7a	TAES3538	7.3a	5.0a	TAES3582	3.7a	3.7
TAES3498	6.3a	4.7a	TAES3539	7.3a	4.0	TAES3583	6.7a	4.3a
TAES3499	5.3a	3.7	TAES3540	2.3	1.3	TAES3584	4.0a	3.0
TAES3500	2.0	1.7	TAES3541	6.3a	3.0	TAES3585	7.3a	5.0a
TAES3501	6.0a	4.0	TAES3542	6.3a	4.0	TAES3586	6.7a	4.7a
TAES3502	6.7a	3.7	TAES3543	6.0a	4.0	TAES3587	3.7a	2.7
TAES3503	3.7a	3.0	TAES3544	6.0a	4.0	TAES3588	7.0a	4.3a
TAES3504	6.7a	4.7a	TAES3545	4.7a	3.0	DALZ8501	5.3a	5.3a
TAES3505	5.7a	3.7	TAES3547	6.0a	4.0	DALZ8502	5.0a	4.0
TAES3506	4.7a	2.7	TAES3548	6.3a	4.0	DALZ8701	1.3	1.3
						MSD entry[1]	4.4	1.7

[1] MSD entry = minimum significant difference between entry means for comparison within columns, based on Waller-Duncan k-ratio t test, where k-ratio = 100.