EXECUTIVE SUMMARY

1991 ANNUAL ZOYSIAGRASS RESEARCH REPORT

Principle Investigator: Dr. M. C. Engelke
Technical Support: Dr. K. B. Marcum, Assistant Research Scientist
Ms. S. J. Morton, Research Assistant

Research Period: 1 November 1990 to 1 November 1991

The zoysiagrass project in its 8th year of funding. To date a total of $337,085 has been invested by the United States Golf Association in the development of zoysiagrasses which are better adapted to natural environmental conditions. 1991 marks the initiation of an extensive state wide testing program for Zoysiagrasses through the National Turfgrass Evaluation Program (NTEP). Material of 24 unique experimental and commercial cultivars were vegetatively increased by this project and distributed to 39 locations throughout the United States extending from Tangent, Oregon to Kingston, RI to Riverside, CA and West Palm Beach, FL. The USGA/TAES zoysiagrass breeding program has nine elite entries in this trial. These entries range in texture from rather broad leaved aggressive **Z. japonica's** to fine texture, highly rhizomatous **Z. matrella** types. These elite lines were selected for a combination of characters related to survival and turf quality under natural environmental conditions. Specific emphasis was placed on low water-use, competitive ability against weed invasion, recovery from injury, low fertility, and production characters. The nine entries are all vegetative. Numerous hybrids have been produced which show seed production potential and will be included in the next cycle of NTEP evaluations.

Extensive field plantings have been made in Georgia, Florida and Texas using a 'near-release' elite variety to evaluate its performance in these environments as well as to assess performance under shaded tees, and putting green conditions. All areas were solid sodded in July-August, 1991.

A cooperative project was initiated with Dr. Bob Carrow as he examines water use and fertility requirements of selected zoysiagrasses under Georgia conditions. This study in combination with performance data from the NTEP will add substantially to the understanding of varietal adaptation in other regions of the country.

The Linear Gradient Irrigation System study with 26 zoysiagrass has been terminated after 5 years of testing. The area will be excavated, fumigated and reestablished to larger plots areas of the most promising lines from the project. The future studies will enable us to evaluate the nutritional and mowing response of the new varieties under a water-gradient. To date this information is lacking. By lowering the water input, it is imperative to understand how the associated cultural practices must be altered, i.e. fertility, mowing, aerification, etc. to maximize turf performance.

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1991 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 eight 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 337,085 has been directed by the USGA/GCSAA research committee to the zoysiagrass breeding effort. The present grant provided $45,000 annually as is scheduled to terminate January 31, 1993. This report in conjunction with the INTERIM REPORT filed May 1, 1991 will address project activities for the period November 1, 1990 to November 1, 1991.

II. Technical Support Personnel

Dr. Ken B. Marcum joined the Turfgrass breeding program on June 13, 1991 as an Assistant Research Scientist. Dr. Marcum received his Ph. D. degree from the University of Hawaii under the direction of Dr. Charles Murdock. Dr. Marcum's dissertation dealt with salt glands in turfgrasses, and placed major emphasis on the Zoysia genera. Dr. Marcum is funded through the Texas Agricultural Experiment Station, however will in addition to other responsibilities spend a major portion of his research efforts on the zoysiagrass program.

Ms. Sharon J. Morton joined the turfgrass breeding program in September 1989, and since the departure of both Dr. White (November 1990) and Dr. Ruemmele (April 1991) as provided the lead support role for the program.

Mr. Robert Cunningham continues to provide part-time technical assistance for the program, and lends his expertise in vegetative propagation and greenhouse maintenance.

III. Germplasm propagation and maintenance

The 800 + accessions in the Germplasm Introduction Nursery (GPIN) are continually maintained in deepots in the greenhouse. This past year we had the opportunity to participate in the establishing the National Turfgrass Evaluation Trials for zoysiagrass. A cost of $800 per entry per year is charged for participating in this trials. This year our project entered nine selections, all designated as "DALZ" lines. The individual entries and the developer or sponsor is listed in Table 1.

Our project was responsible for propagating all grasses included in the study. Propagation and increase was initiated in early January 1991, and transplanting was completed by April 3, 1991, and with the last shipment of plant materials to cooperators by August, 1991. The

production phase resulted in development of more than 35,000 4" x 4" plugs of the 24 entries. Distribution was to more than 40 locations with distribution beginning as early as May 1, 1991. Quarantine problems were experienced with shipments into Arizona and California, however, Federal compliance procedures were followed and all shipments eventually arrived safely. See **APPENDIX A:** 1991 Zoysiagrass Distribution List and Map.

Following the NTEP increase, we developed approximately 30,000 additional plugs of 11 elite lines for shipment to the University of Georgia Station at Griffin for use in a cooperative study with Dr. Robert Carrow and the Georgia Turf Program.

On June 14, 1991, 25 NTEP zoysiagrass entries were planted at TAES-Dallas. Plot size was 6'x 6', with 36 1" plugs planted per plot, planted on 1' centers. Plots received minimal maintenance, being irrigated when needed, fertilized with up to 2 lb. N/year, and mowed at a height of 2".

As of September 25, 1991 all zoysiagrasses becoming established in the plots (Table 2) . There was no significant difference among entries as to percent survival. Percent plot coverage was similar in most of the entries, with ITR90-3, DALZ8502, and DALZ8501 being significantly slower in coverage. Texture was similar among entries, being predominately coarse, but DALZ8501, DALZ8502, DALZ8507, DALZ8508, and DALZ8516 were significantly finer.

Notes were taken periodically during the production cycle as considerable differences appeared to exist even for greenhouse propagation time. The rate of plug formation and development was significantly different. DALZ8512 and DALZ8514 developed significantly more plugs, with El Toro DALZ8507 and Sunburst running a distant second (Table 3).

A breeder stock increase field of DALZ8502 was established southwest of Houston in July 1989. Severe winter conditions during the establishment year resulted in major turf damage. The area was allowed to recover during 1990 and the first planting stock was harvested in May 1991. The initial planting was made on a moderately shaded 400 sq ft tee box at the Crenshaw & Doguet turf farm in Bastrop Texas. The tee receives heavy play in the evenings by the farm crew. The grass is well established and appears to recover from divots fairly well considering the maintenance level.

Additional harvest were made in mid-July with shipments made to Augusta, Georgia for Augusta National, to West Palm Beach Florida for Banyan Golf Club, to Summerville County (Glenrose) Texas for the Squaw Valley Golf Course and to Texas A&M Research and Extension Center - Dallas. Squaw Valley and Banyan Golf Clubs solid sodded tee boxes in moderate to heavy shade, Augusta National used on the sod on shaded bunker faces. The 1000 yards delivered to TAES-Dallas was use to construct three greens/tee boxes for future research efforts. One of the areas at TAES-Dallas was established on an 80/20 sand/peat surface for extensive evaluation as a potential putting green surface. The other two areas were established to native clay soils.

Table 1. Entries of the NTEP and their designated sponsors or developers.

NTEP Entry#	Entry	Sponsor /developer
NTEP01	TC2033	Turf Center, Inc. Spencerville, MD (D)[1]
NTEP02	QT2047	Quality Turf, Houston Texas (S)
NTEP03	CD2031	Crenshaw &Doguet Turf, Austin Texas (S)
NTEP04	TC5018	Turf Center, Inc. (D)
NTEP05	QT2004	Quality Turf (S)
NTEP06	CD259-13	Crenshaw &Doguet Turf (S)
NTEP07	Korean Common	Commercial seeded cultivar
NTEP08	JZ-1	Jacklin Seed Co, Post Falls, ID (S)
NTEP09	Meyer	Commercial variety
NTEP10	Emerald	Commercial variety
NTEP11	BELAIR	Commercial variety
NTEP12	Sunburst	Grasslyn, Inc
NTEP13	EL TORO	University of California
NTEP14	DALZ8514	Texas A&M - Dallas
NTEP15	DALZ8512	Texas A&M - Dallas
NTEP16	DALZ8516	Texas A&M - Dallas
NTEP17	DALZ8507	Texas A&M - Dallas
NTEP18	DALZ8508	Texas A&M - Dallas
NTEP19	DALZ9006	Texas A&M - Dallas
NTEP20	DALZ8502	Texas A&M - Dallas
NTEP21	DALZ8701	Texas A&M - Dallas
NTEP22	TGS-B10	Turfgrass Germplasm Services
NTEP23	TGS-W10	Turfgrass Germplasm Services
NTEP24	DALZ8501	Texas A&M - Dallas
	ITR90-3	International Turf Research, Tucson

Table 2. Turf texture (1 = fine, 2 = medium, 3 = coarse), percent turf survival, and percent turf plot coverage of NTEP zoysiagrasses, rated September 25, 1991, and planted June 4, 1991.

Entry	Texture%	Survival%	Cover%
BELAIR	2.3	97.3	84.0a[1]
EL TORO	3.0	99.0	83.3a
EMERALD	2.3	100.0	78.3a
KCOMMON	3.0	100.0	80.0a
MEYER	2.7	96.3	63.3a
SUNBURST	2.7	98.0	78.3a
DALZ8501	2.7	98.0	61.7
DALZ8502	2.3	80.7	50.0
DALZ8507	1.7a	100.0	76.7a
DALZ8508	1.7a	97.3	83.3a
DALZ8512	2.7	100.0	78.3a
DALZ8514	2.7	100.0	75.0a
DALZ8516	1.7a	99.0	76.7a
DALZ8701	2.3	100.0	82.3a
DALZ9006	3.0	97.0	78.3a
CD-2013	2.0	98.0	76.7a
CD-259-1	3.0	93.3	76.7a
GT-2004	2.0	100.0	82.7a
GT-2047	2.3	98.0	80.0a
ITR90-3	2.0	75.0	43.3
JZ1A89-1	3.0	100.0	76.7a
TC2033	2.3	94.3	76.7a
TC5018	2.3	100.0	68.3a
TGS-B10	3.0	97.0	73.3a
TGS-W10	2.7	96.3	75.0a
MSD[2]	1.2	ns	20.8

[1]Means followed by the same letter within the same column are not significantly different based on the Waller-Duncan K-ratio t test (K-ratio = 100).
[2]MSD = minimum significant difference for comparison of entry means within columns based on the Waller-Duncan K-ratio t test (K-ratio = 100).

Table 3. Plug formation of National Turfgrass Evaluation Program zoysiagrass establishment at TAES-Dallas February and March 1991.

ENTRY	Number of Fully Formed Plugs at Days after Planting 10	15	20	25	30
Belair	0.0	0.0	0.0	0.0	0.0
ElToro	0.0	1.2	3.2	5.3	5.8
Emerald	0.0	0.0	0.0	0.0	0.0
Meyer	0.0	0.0	0.0	1.3	2.5
Sunburst	0.0	0.2	1.0	2.2	3.2
DALZ8501	0.0	0.0	0.2	0.8	1.8
DALZ8502	0.0	0.0	0.0	0.0	0.0
DALZ8507	0.0	0.0	0.0	0.3	0.3
DALZ8508	0.0	0.2	0.2	0.2	0.3
DALZ8512	0.0	2.0a	5.7a	9.8a	11.8a
DALZ8514	0.0	2.7a	5.5a	10.3a	11.8a
DALZ8516	0.0	0.0	0.0	0.7	0.7
DALZ8701	0.0	0.2	0.8	3.0	4.2
DALZ9006	0.0	0.0	0.0	0.8	1.2
CD25913	0.0	0.5	0.7	1.0	1.2
2013CD	0.0	0.0	0.5	1.3	2.2
2047GT	0.0	0.0	0.0	0.0	0.0
ITR903	0.0	0.0	0.0	0.0	0.0
TC2033	0.0	0.0	0.8	1.5	1.5
TC5018	0.0	0.2	0.2	0.2	0.3
MSD entry[1]	n.s.	1.2	1.8	2.5	2.3

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

IV. FIELD EVALUATION AND PRODUCTION TRIALS

A. DALLAS FIELD TRIAL - MANAGEMENT

The mowing and fertility studies continue on the regional zoysiagrass trials. A detailed report and current data is presented in **APPENDIX B:** NITROGEN ENRICHMENT AND MOWING HEIGHT EFFECTS ON ZOYSIAGRASS PERFORMANCE.

B. LINEAR GRADIENT IRRIGATION SYSTEM

The present study involving the four species and 26 selections and cultivars of zoysiagrass will be terminated this fall. The area will be excavated and fallowed this fall and then fumigated in the spring. Plant materials of the elite and superior zoysiagrass selections will be vegetatively increased in the greenhouse this winter for establishment in late spring early summer 1992. The study areas for each of the "elite" lines will be expanded to a minimum of 3 meters wide, in contrast to the .8 meters most of the plots have been. These larger areas will permit more extensively evaluation of water use as it will relate to fertility and mowing practices. A summarization of the data to date is present in **APPENDIX C:** 1991 UPDATE ON PERFORMANCE OF ZOYSIAGRASS .....

C. TURFGRASS ROOT INVESTIGATION FACILITY

Studies on TRIF have been terminate and the data is summarized in **APPENDIX D:** TURFGRASS ROOT INVESTIGATION. The facility has served it's intended purpose of substantiating greenhouse studies concerning relative rooting growth characters. The site has been solid sodded to washed zoysiagrass sod using selection DALZ8502. Studies will be conducted on the mowing quality and greens performance of DALZ8502 as potential for use on putting greens on modified soils (TRIF) and on native soils (blackland clay).

D. ZOYSIAGRASS HYBRIDIZATION - PROGENY DEVELOPMENT

The hybridization programs continues 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. Root growth characters will become increasingly more important to extend the water reservoir to aid in avoiding drought and entering into summer dormancy. Also seed production characters continue to be evaluate especially with an eye toward finer textured more uniform plant type. 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 E:** ZOYSIAGRASS HYBRIDIZATION - PROGENY DEVELOPMENT

APPENDIX A:

Table A1. Participants in the 1991 NTEP zoysiagrass performance trials

Recipient	No. Sets	Address
Richard Autio	2	Univ. of California-Riverside 1060 Pennsylvania Riverside, CA 92521
Joel Barber	1	Oklahoma State University Dept. of Horticulture 360 Agricultural Hall Stillwater, OK 74078
Pam Borden	1	Southwest Missouri State Univ. Dept. of Agriculture Karls Hall Springfield, MO 65804
Daniel Bowman*	1	sent to Bill Rohret (see below)
A. Douglas Brede	1	Jacklin Seed Company W. 5300 Riverbend Ave. Post Falls, ID 83854
David R. Chalmers	1	Virginia Tech Dept. Crop & Soil Environ. Science 421 Smyth Hall Blacksburg, VA 24061-0403
Michael Cline	1	Green Seed Co./Genesis Group 501 N. Belvedere Dr. P.O. Box 1678 Gallatin, TN 37066
Ray Dickens	1	Auburn University 201 Funchess Hall Auburn, AL 36849
Ken Diesburg	1	Southern Illinois University Dept. of Plant and Soil Science Carbondale, IL 62901

David Doguet	1	Crenshaw-Doguet Turfgrass 609 Castle Ridge Austin, TX 78746
R.R. Duncan	2	University of Georgia Dept. of Agronomy Griffin, GA 30223-1791
John H. Dunn	2	University of Missouri 1-40 Agriculture Bldg. Columbia, MO 65211
M. C. Engelke	1	Texas A&M Research & Ext. Center 17360 Coit Road Dallas, TX 75252
Ali Harivandi	1	Univ. of California Coop. Ext. 224 W. Winton Ave, Rm 174 Hayward, CA 94544
David R. Huff	1	Dept. Crop Sci., Cook College Rutgers Univ., Lipman Hall New Brunswick, NJ 08903
Norman Hummel	1	Cornell University 20 Plant Science Bldg Ithaca, NY 14853
Dan Jones	1	Banyan Golf Course West Palm Beach, Florida
John W. King	1	University of Arkansas Dept. of Agronomy Fayetteville, AR 72701
Tony Koski	1	Colorado State University Dept. of Horticulture 101A Shepardson Bldg. Ft. Collins, CO 80523

Charles Mancino	1	Dept. of Plant Science Rm. 303, Bldg 36 (Forbes Bldg) University of Arizona Tucson, Arizona 85721
Virgil Meier	1	O.M. Scott & Sons 14310 Scottslawn Road Marysville, OH 43041
Wayne Mixson	1	O.M. Scott & Sons 1151 E. Oak St. Apopka, FL 32794-2187
Kevin Morris	2	USDA, NTEP BARC-West Bldg 001, Rm 333 Beltsville, MD 20705
Jack Murray	1	NTEP 9602 Hammock Dr. Bradenton, FL 34202
Eric Nelson	1	NK Lawn and Garden 33731 Highway 99, Box 300 Tangent, OR 97389
John Pair	1	Kansas State University 1901 E. 95th South Wichita, KS 67233
Wayne Philley	1	Mississippi State Univ. Dept. of Agronomy, Dorman Hall Mississippi State, MS 39762
AJ Powell	1/2	Agricultural Science North University of Kentucky Lexington, KY 40506
Terrance P. Riordan	1	University of Nebraska 377 Plant Science Hall Lincoln, NB 68583-0724
Bill Rohret & Robert Morris	1	Sunrise Golf Course 5500 E. Flamingo Las Vegas, NV 89122

Bridget Ruemmele	1	Dept. of Plant Science Univ. of Rhode Island Kingston, RI 02881
Tom Samples	2	Univ. of Tennessee-Knoxville Rm 3 McCord Hall Knoxville, TN 37901-1071
Ralph Sanders	1	O.M. Scott & Sons Rt. 1, Box 99, Cleveland, TX 77327
Richard Schmidt	1	Virginia Tech University Smyth Hall Blacksburg, VA 24061-0403
Tom Turner	1	University of Maryland 3120 Gracefield Road Silver Springs, MD 20904
Tom Voigt	1	University of Illinois 1201 S. Dorner Dr. Urbana, IL 61801
Ron Walden	1	Virginia Tech 1444 Diamond Springs Rd. Virginia Beach, VA 23455
Richard White	2	North Carolina State Univ. Dept. of Crop Science Raleigh, NC 27695
Lin Wu	1/2	University of California Environmental Horticulture Dept. Davis, CA 95616

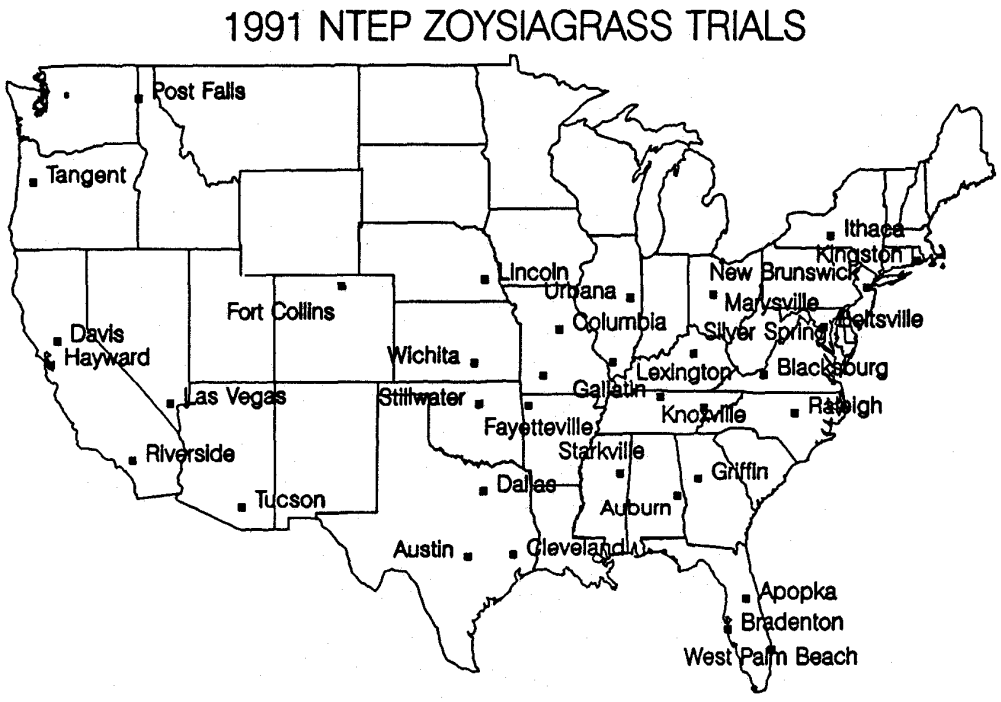

Figure A1. Test sites for the 1991 NTEP zoysiagrass trials

APPENDIX B

Nitrogen Enrichment and Mowing Height Effects on Zoysiagrass Performance

INTRODUCTION: Zoysiagrass is one of the least utilized warm season turfgrasses in the United States. This is partially due to the limited number of available cultivars, slow establishment, and relatively high cost of production in comparison to other warm season grasses. In the recent past, interest in Zoysia spp. has increased as new cultivars have emerged and the potential of several experimental selections has become apparent. Acceptance and utilization of new cultivars of zoysia also depends on development of appropriate and efficient management strategies. This work places emphasis on determining minimum and optimum requirements for producing superior turf, with particular attention given to turf quality, persistence, and thatching tendency relative to fertilization and mowing. This work places emphasis on developing and refining cultural strategies and practices that optimize turf quality and resource efficiency for existing and newly developed zoysiagrass cultivars for southern regions of the United States.

MATERIALS AND METHODS:

Turf Establishment

During the winter of 1987 to 1988, plant material was increased under greenhouse conditions to provide a 1:36 (1 m^2 sod to 36 m^2 land surface) field expansion planting ratio. The field planting material consisted of 3.8 cm plugs planted on 0.3 m centers. The field plot design is 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 include Meyer, Emerald, El Toro, Belair, Cashmere and one proprietary lines, designated TAES3372. Experimentals include DALZ8501, DALZ8502, DALZ8508, and DALZ8516. These same materials are in Regional Field Trials.

Management Experiment

The management experiment plots were overlaid on each of the established turf plots described in the previous statement. Management treatments consisting of mowing heights and nitrogen fertility levels were initiated in July 1990. Mowing treatments include heights of 0.63 and 2.54 cm., applied in strip plot fashion. 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. Nitrogen treatments were applied in a strip plot design. Data collected on the effects of management treatments included winter green color retention and turf quality.

RESULTS AND DISCUSSION - this part may need to be rewritten, for I have not compared these statements against the tables I created for this report.

GREEN COLOR RETENTION

All entries maintained green leaves under their canopies over the winter, for all treatments (Table 1). Green cover was highest (>65% green canopy cover) for DALZ8502, El Toro, and TAES3372 on December 18, 1990, and was lowest for Meyer and Belair, and TAES3477 (Cashmere) (<25% green canopy cover). Those plots mowed at 0.63 cm had 54% green canopy cover, which is significantly higher than the 45% observed of plots at 2.54 cm mow heights. DALZ8501 had 50% green cover at 3 kg N per year, but retained the 64% green cover when enriched with 1.5 kg N per year. TAES3477 lost green less rapidly when supplied 0.5 kg N per year than when supplied higher rates of nitrogen. Nitrogen enrichment did not affect the rate of green canopy loss for other entries.

Turf Quality

By mid-winter (January 24, 1991), the turf had generall entered winter dormancy and provided relatively poor turf quality for all varieties (Table 2). Emerald and experimental variety DALZ8508 retained the best appearance.

By April 25, 1991, turf quality differences among the entries increased. Half of the entries, including Meyer and DALZ8508 had acceptable turf qualities. Poor qualities were observed for DALZ8502 and TAES3372. Poor establishment was the main contributing factor to the poor rating of DALZ8502. Differences among the management treatments were not evident.

Although quality ratings were better in June and the following summer months (Table 3), relative turf quality among the varieties evaluated followed the same trends as in April. Overall, mowing treatments and enrichment levels tested did not influence turf quality of the varieties tested.

FUTURE WORK

Turf performance will continue to be monitored during 1992. Attention will focus more intently on the response of entries to differential mowing and nitrogen fertilization. Performance of entries will be based on turf quality parameters, including density, uniformity, and color, as well as fall color retention, spring greening, resistance to pests and environmental stresses, and thatching tendency.

Table B1. Winter 1990 color retention. Percent green ground cover of zoysia-grasses planted 21 June 1988 at TAES-Dallas, as influenced by nitrogen rates and mowing heights.

Mow Height Treatment	Entry	Date of green cover rating: 21 Nov.	18 Dec.	21 Nov.	18 Dec.	21 Nov.	18 Dec.
		1 lb N		3 lb N		6 lb N	
5/8"	Belair	76.7	16.7	76.7	16.7	80.0a	11.7
Reel	El Toro	82.5	68.3a	85.0	75.0	85.0a	75.0a
mow	Emerald	77.5	45.0	77.5	46.7	85.0a	56.7
	Meyer	70.0	16.7	70.0	18.3	70.0	13.3
	DALZ8501	86.7	76.7a	86.7	75.0	91.7a	63.3a
	DALZ8502	78.3	80.0a	83.3	87.5a	86.7a	78.3a
	DALZ8508	75.0	60.0	81.7	68.3	90.0a	65.0a
	DALZ8516	83.3	78.3a	86.7	73.3	91.7a	68.3a
	TAES3372	83.3	73.3a	65.0	71.7	83.3a	73.3a
	Cashmere	80.0	33.3	80.0	23.3	88.3a	21.7
	MSD entry[1]	n.s.	15.5	n.s.	6.9	14.1	19.0
Mean mow		79.3	54.8b	79.1	54.4b	85.2b	52.7b
1"	Belair	78.3a	12.3	76.7	16.7	76.7a	13.3
Rotary	El Toro	80.0a	61.7a	80.0	65.0a	80.0a	66.7a
	Emerald	77.5a	45.0	82.5	40.0	80.0a	46.7a
	Meyer	65.0	14.0	66.7	12.3	63.3	10.7
	DALZ8501	85.0a	56.7a	90.0	63.3a	90.0a	45.0
	DALZ8502	80.0a	65.0a	80.0	67.5a	81.7a	66.7a
	DALZ8508	61.7	46.7	70.0	51.7	60.0	51.7a
	DALZ8516	75.0a	66.7a	83.3	66.7a	86.7a	61.7a
	TAES3372	80.0a	58.3a	71.7	70.0a	81.7a	68.3a
	Cashmere	80.0a	30.0	71.7	25.0	83.3a	25.0
	MSD entry	15.5	15.4	n.s.	17.8	18.1	23.1
Mean mow		76.0	45.6	77.0	47.1	78.2	45.6
1"	Belair	66.7	20.0	71.7	11.3	73.3	16.7
Reel	El Toro	75.0	63.3a	82.5a	60.0a	80.0a	70.0a
	Emerald	75.0	41.7a	85.0a	43.3	85.0a	38.3
	Meyer	65.0	13.0	76.7	16.7	70.0	13.3
	DALZ8501	85.0	45.0a	90.0a	55.0a	91.7a	45.0
	DALZ8502	85.0	56.7a	88.3a	50.0a	81.7a	67.5a
	DALZ8508	68.3	53.3a	76.7	55.0a	76.7	63.3a
	DALZ8516	85.0	61.7a	90.0a	58.3a	90.0a	55.0a
	TAES3372	80.0	66.7a	75.0	63.3a	83.3a	70.0a
	Cashmere	83.3	36.7	86.7a	21.7	93.3a	16.7
	MSD entry	n.s.	29.2	8.8	19.8	15.0	22.5
Mean mow		77.0	45.8	82.1	43.2	82.5	44.8
MSD mow[2]		n.s.	5.8	n.s.	5.2	4.0	6.4

[1] MSD = minimum significant difference for comparison of entry means within based on the Waller-Duncan K-ratio t test (K-ratio = 100). Those entry means with the same letter are in the highest statistical group for that date.

[2] MSD = minimum significant difference for comparison of mow treatment means within columns on the Waller-Duncan K-ratio t test (K-ratio = 100). Those mow means with the same letter are in the highest statistical group for that date.

Table B2. Spring turf quality of zoysiagrasses planted 21 June 1988 at TAES-Dallas.
Effects of nitrogen enrichment and mowing height.

		Turf quality								
		24	25	20	24	25	20	24	25	20
Mow		Jan.	Apr.	June	Jan.	Apr.	June	Jan.	Apr.	June
Treatment	Entry		1# N			3# N			6# N	
5/8"	Belair	2.3	4.7a	6.0a	2.7a	5.0a	6.7	3.0	5.0a	7.3a
Reel	El Toro	2.7a	4.7a	6.3a	2.7a	4.7	6.7	3.0	6.0a	7.7a
	Emerald	3.3a	5.7a	6.7a	3.3a	5.0a	7.0	3.3	5.3a	6.7a
	Meyer	3.3a	5.0a	6.3a	3.0a	6.7a	7.0	3.3	6.3a	7.3a
	DALZ8501	2.0	3.0	4.7a	2.3a	3.7	5.3	2.3	3.7	6.0a
	DALZ8502	1.7	2.7	2.3	1.0	4.0	3.7	1.7	3.0	3.0
	DALZ8508	3.0a	5.3a	6.0a	3.3a	5.7a	6.7	3.7	6.3a	6.7a
	DALZ8516	2.3	3.7a	5.5a	2.3a	3.7	5.3	3.0	4.0	6.7a
	TAES3372	1.7	2.3	3.7	1.0	2.3	4.3	2.7	3.7	5.0
	Cashmere	2.3	3.7a	6.0a	3.0a	4.7	6.0	3.0	5.3a	6.7a
	MSD entry[1]	0.9	1.9	2.0	1.7	1.8	n.s.	n.s.	1.8	2.1
Mean mow		2.5	4.1	5.3	2.5	4.5	5.9	2.9	4.9	6.3
1"	Belair	2.3a	4.7a	6.0a	2.3	5.0	7.3a	3.0a	5.3a	7.3a
Rotary	El Toro	2.7a	5.0a	6.0a	2.7	4.7	7.3a	3.0a	6.0a	7.7a
	Emerald	3.3a	5.3a	6.7a	3.7a	5.3a	7.3a	3.3a	5.3a	7.0a
	Meyer	3.0a	5.3a	7.0a	3.0a	6.7a	8.0a	3.3a	6.0a	8.0a
	DALZ8501	2.0	2.7	4.0	2.0	3.3	4.7	2.0	3.3	5.3
	DALZ8502	1.7	2.7	3.3	0.7	3.0	3.7	1.0	2.0	3.3
	DALZ8508	3.0a	5.3a	5.3	3.7a	5.7a	6.0a	3.7a	6.3a	6.7a
	DALZ8516	2.0	3.3	4.3	2.0	3.7	5.0	3.0a	4.7	6.0a
	TAES3372	1.7	2.3	3.7	1.0	3.0	3.0	2.3	3.7	5.7
	Cashmere	2.3a	4.0	4.7	2.7	4.7	6.7a	3.7a	5.7	7.3a
	MSD entry[1]	1.2	0.8	1.4	0.8	1.6	1.4	1.2	1.5	2.2
Mean mow		2.4	4.1	5.1	2.4	4.5	5.9	2.8	4.8	6.4
1"	Belair	2.7	4.7a	6.0a	2.0	5.0a	6.3a	2.7	5.0a	7.0a
Reel	El Toro	2.a	5.0a	5.7a	2.7	5.0a	7.0a	3.0	6.0a	7.7a
	Emerald	3.0	5.7a	6.3a	3.3a	5.3a	7.3a	3.3	6.0a	6.3a
	Meyer	3.0	5.3a	6.3a	3.0a	6.7a	7.3a	3.0	6.3a	7.7a
	DALZ8501	2.0	2.7	4.7a	1.7	3.3	4.7	2.0	3.7	7.0a
	DALZ8502	1.3	2.7	3.0	0.3	2.7	3.7	1.3	2.7	3.7
	DALZ8508	3.0	5.3a	5.3a	3.7a	5.7a	6.3a	3.0	6.0a	6.7a
	DALZ8516	1.7	3.7	4.3a	2.0	4.3	4.7	2.7	4.7	5.7a
	TAES3372	1.3	3.0	4.7a	1.7	2.7	3.0	2.0	4.0	5.3
	Cashmere	2.0	4.0a	4.7a	2.3	5.0a	5.7a	3.3	5.7a	6.7a
	MSD entry[1]	n.s.	1.7	2.2	0.9	1.7	1.8	n.s.	2.0	2.2
Mean mow		2.3	4.2	5.1	2.3	4.6	5.6	2.6	5.0	6.4
	MSD mow[2]	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

[1] MSD = minimum significant difference for comparison of entry means within columns based on the Waller-Duncan K-ratio t test (K-ratio = 100). Those entry means with the same letter are of the highest statistical group for that date.
[2] MSD = minimum significant difference for comparison of mow treatment means within columns based on the Waller-Duncan K-ratio t test (K-ratio = 100).

Table B3. Turf quality of zoysiagrasses planted 21 June 1988 at TAES-Dallas. Effects of nitrogen enrichment and mowing height.

		Turf quality								
		1	20	7	1	20	7	1	20	7
Mow		Aug.	Sept.	Oct.	Aug.	Sept.	Oct.	Aug.	Sept.	Oct.
Treatment	Entry		1# N			3# N			6# N	
5/8"	Belair	5.7	6.3a	5.7a	6.7	7.0	7.0	6.7	6.0	6.0a
Reel	El Toro	5.0	6.3a	5.7a	6.7	7.3	6.3	6.7	6.7	6.7a
	Emerald	5.3	6.3a	5.7a	6.3	7.3	7.0	7.0	7.0	7.3a
	Meyer	5.3	6.3a	5.7a	7.0	7.3	7.0	7.0	7.0	7.0a
	DALZ8501	5.0	5.3	5.3a	6.3	6.3	6.3	6.3	5.7	6.7a
	DALZ8502	3.3	4.3	3.3	5.3	6.0	5.7	5.0	5.3	5.0
	DALZ8508	5.3	7.3a	6.0a	7.3	7.3	7.7	7.7	7.0	8.0a
	DALZ8516	5.7	7.3a	6.7a	6.0	7.0	6.7	7.3	6.7	7.7a
	TAES3372	4.0	5.7a	4.7	5.3	5.7	5.3	5.7	6.3	5.3
	Cashmere	4.7	5.3	5.0	7.0	6.3	6.7	7.0	5.7	6.3a
	MSD entry[1]	n.s.	1.9	1.5	n.s.	n.s.	n.s.	n.s.	n.s.	1.7
Mean mow		4.9	6.1	5.4	6.4b	6.8	6.6	6.6	6.3	6.6b
1"	Belair	5.7a	5.7a	5.0a	6.7a	7.0a	5.0a	6.3a	6.3a	5.3a
Rotary	El Toro	5.0a	6.3a	5.0a	6.0a	7.3a	5.0a	6.7a	6.3a	5.0a
	Emerald	4.7a	6.7a	5.3a	6.3a	7.0a	5.3a	7.0a	7.3a	5.3a
	Meyer	5.0a	7.0a	5.0a	5.7a	7.3a	5.0a	6.7a	7.0a	5.0a
	DALZ8501	4.7a	6.0a	5.0a	5.3	6.0a	5.0a	6.0a	5.7a	4.7a
	DALZ8502	3.3	3.7	3.3	4.3	5.0	4.3	4.0	4.0	3.7
	DALZ8508	5.0a	7.0a	5.0a	5.7a	7.7a	5.0a	6.7a	6.3a	5.0a
	DALZ8516	4.3a	5.7a	5.3a	5.0	6.7a	5.7a	6.0a	6.7a	5.7a
	TAES3372	3.7	5.3a	4.0	4.0	5.0	3.7	5.0	5.7a	4.0
	Cashmere	5.0a	5.7a	5.0a	6.7a	6.7a	5.3a	6.7a	6.3a	5.0a
	MSD entry	1.6	2.2	1.2	1.2	1.9	0.7	1.5	2.0	1.0
Mean mow		4.6	5.9	4.8	5.6	6.6	4.9	6.1	6.2	4.9
1"	Belair	5.0	5.7	5.0	6.3a	6.7	7.0a	6.3	6.7a	6.3a
Reel	El Toro	5.3	6.0	5.7	6.7a	7.3	6.3a	6.7	6.3a	6.7a
	Emerald	5.0	5.7	5.3	6.3a	6.7	6.3a	6.7	6.3a	7.0a
	Meyer	5.0	6.3	5.3	6.3a	6.7	6.7a	6.7	6.3a	6.7a
	DALZ8501	4.0	5.3	4.7	5.7a	5.7	5.7	6.3	5.7a	6.7a
	DALZ8502	4.3	4.3	4.0	4.7	5.0	4.7	4.7	4.0	4.7
	DALZ8508	4.7	6.0	6.3	6.0a	7.0	7.7a	.7	6.3a	7.7a
	DALZ8516	4.0	5.3	4.7	5.3a	6.0	6.7a	5.3	5.7a	6.3a
	TAES3372	3.7	5.7	4.7	4.3	5.0	4.0	5.7	5.7a	5.0
	Cashmere	5.0	5.3	5.0	6.3a	5.3	5.7	7.0	5.7a	6.7a
	MSD entry	n.s.	n.s.	n.s.	1.7	n.s.	1.5	n.s.	1.6	1.5
Mean mow		4.6	5.6	5.1	5.8	6.1	6.1	6.2	5.9	6.4b
MSD mow[2]		n.s.	n.s.	n.s.	0.5	n.s.	0.5	n.s.	n.s.	0.5

[1] MSD = minimum significant difference for comparison of entry means within columns based on the Waller-Duncan K-ratio t test (K-ratio = 100). Those entry means with the same letter are of the highest statistical group for that date.

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

Table B4. Turf quality during 1990 - 1991 of zoysiagrasses planted 21 June 1988 at TAES-Dallas, Texas.

	Turf Quality 1991					
Entry	24 Jan.	25 Apr.	20 June	1 Aug.	20 Sept.	7 Oct.
Belair	2.6	4.9	6.7a	6.1a	6.4a	5.8
El Toro	2.8	5.2	6.9a	6.1a	6.7a	5.8
Emerald	3.3a	5.4	6.8a	6.1a	6.7a	6.1a
Meyer	3.1a	6.0a	7.2a	6.1a	6.8a	5.9
DALZ8501	2.0	3.3	5.1	5.5	5.7	5.6
DALZ8502	1.2	2.8	3.3	4.3	4.6	4.3
DALZ8508	3.3a	5.7a	6.2	6.1a	6.9a	6.5a
DALZ8516	2.3	4.0	5.3	5.4	6.3a	6.1a
TAES3372	1.7	3.0	4.3	4.6	5.6	4.5
Cashmere	2.7	4.7	6.0	6.1a	5.8	5.6
MSD[1]	0.3	0.4	0.5	0.5	0.5	0.5

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

APPENDIX C

1991 Update on performance of Zoysiagrass cultivars and Elite DALZ lines under Linear Gradient Irrigation

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INTRODUCTION: Limitations on resources and societies' 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.

PROGRESS: 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 110 cm for 1989 and 1990, respectively. 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 1). Data for 1991 is through July 24, 1991. Total rainfall in 1990 was 135.6 cm., and for 1991 (through June 30) was 54.2 cm. Turf performance is measured throughout the year.

OBJECTIVES: The objectives of the winter study were to evaluate the fall color, any green color retention, and ability of the grasses to maintain a monoculture stand. Frost injury, and winter spring, and summer quality were also noted.

RESULTS:

Retention of green active growth: Seasonal turf performance differed over time, across the irrigation gradient and across varieties. The turf varieties ability to retain green active growing plant material across a moisture gradient and under stress (Table 1), and to recover from stress were significantly different. During the late summer of 1990 percent of green turf color was measured during a period of stress (September 5) and 7 days following termination of stress by rainfall (September 15). Prior to stress DALZ8512 had the highest green turf plot cover under no irrigation (Table 1). Other grasses which had good green turf cover under high and moderate irrigation, but failed to maintain adequate cover under no irrigation were Belair, Emerald, El Toro, Korean Common, Meyer, FC13521, DALZ8507, DALZ8508, DALZ8510, and DALZ8514. DALZ8522 and DALZ8523 had poor green turf coverage under all irrigations.

By September 15 (following stress) DALZ8512 still maintained highest green plot cover under all irrigations, but all grasses recovered greatly, and in particular DALZ8514. Recovery was greater under no irrigation than in moderate or high irrigation. Non-irrigated Cashmere, DALZ8503, DALZ8504, DALZ8505, DALZ8515, DALZ8522, and DALZ8523 had less than 20% green plot cover following stress, and could be considered as slow to recover.

Fall Color retention: Cashmere, Emerald, FC13521, DALZ8502, DALZ8506, DALZ8507, DALZ8508, DALZ8510, DALZ8512, DALZ8513, DALZ8515, DALZ8516, DALZ8523, and DALZ8524 had best green color on November 13 across all irrigations (Table 2). DALZ8501, DALZ8505, and DALZ8524 had equally good color at intermediate and no irrigation, but were less green under high irrigation. The poorest performers at this date were Korean Common, Meyer, DALZ8503, DALZ8504, DALZ8511, and DALZ8514. DALZ8522 received a **0** color quality rating under no irrigation, indicating that none of the planted variety was present. There were no significant differences among varieties at the November 29 sampling date. Gross fall color pigmentation is indicated for each of the lines. Several have considerable red pigmentation with possible ornamental appeal, including DALZ8503, DALZ8508, DALZ8512, and DALZ8514.

Winter and Spring Color: As of December 10, Cashmere, DALZ8501 and DALZ8502 had good color under all irrigations, while FC13521, DALZ8503, DALZ8506, DALZ8507, DALZ8508, DALZ8510, DALZ8512, DALZ8516, DALZ8517, and DALZ8524 had acceptable color under reduced irrigation only (Table 3). Lowest color ratings during winter went to Emerald, El Toro, Korean Common, Meyer, DALZ8504, DALZ8505, DALZ8511, DALZ8514, DALZ8515, DALZ8522, and DALZ8523. DALZ8502 was the only selection which maintained significant green color into February. Of those varieties and lines which lost their green canopies, gold and grey were the predominant winter colors. Golden canopies were observed for Korean Common, Meyer, DALZ8511, and DALZ8512, and grey canopies were common for Cashmere (TAES3477), DALZ8508, and DALZ8516.

As of November 29 Emerald, El Toro, FC13521, Belair, DALZ8507, and DALZ8512 had the highest green plot cover under all irrigations (Table 4). Cashmere, DALZ8501,

DALZ8502, DALZ8503, DALZ8504, DALZ8506, DALZ8508, DALZ8510, DALZ8511, DALZ8513, DALZ8514, DALZ8515, DALZ8516, and DALZ8517 had good to acceptable green cover under high and moderate irrigation, but dropped to unacceptable levels under no irrigation. Korean Common and DALZ8523 had very low green plot cover overall. El Toro, DALZ8512, and DALZ8514 had best green cover on December 10. DALZ8501, DALZ8502, DALZ8508, DALZ8516, and DALZ8517 had acceptable turf cover under high and moderate irrigation, but had lower levels under no irrigation. All varieties retained succulent stolons and some emerging green leaves beneath their canopies during this winter.

Spring green cover developed fastest for El Toro, Meyer, FC13521, DALZ8504, DALZ8506, DALZ8508, DALZ8512, DALZ8516, DALZ8517, and DALZ8524, with 70 to 90% green cover by March 29, 1991 (Table 5). DALZ8522, DALZ8523 and DALZ8513 produced only 25 to 40% green cover by this same date. The commercial varieties, Belair, El Toro, Meyer, Emerald, and Korean Common, greened up at comparable rates to each other and to most experimental lines, but were slightly slower than the top-ranked experimental lines. Plants in non-irrigated zones were slower to green up than irrigated plants. Emerald, El Toro, FC13521, Belair, DALZ8506, DALZ8507, DALZ8516, DALZ8517, and DALZ8521 were among the fastest to green up when cultured without supplemental irrigation. Experimental line DALZ8511 was among the fastest greening zoysias in the irrigated zones (GC > 80% at this mid-spring date), 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. Slowest to achieve green plot cover were Cashmere, DALZ8513, DALZ8515, DALZ8522, and DALZ8523.

Summer 1990 Turf Quality: DALZ8507 and DALZ8514 had the best quality overall on September 5 (Table 6). Both grasses also had good quality components (density, uniformity, evenness) during the winter, but color loss resulted in a loss of total turf quality. By the following spring, color was regained, along with good quality ratings. 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 and non-irrigated zones during and immediately following summer water stress.

Winter Turf Quality: During the winter turf quality was highest under all irrigations for DALZ8502 (Table 7). Turf quality was at an acceptable level under high and moderate irrigation, but dropped to an unacceptable level (<5) under no irrigation. No other grass had acceptable turf quality under any irrigation. In general, winter quality was best in high irrigation zones, and worst in non-irrigated zones.
All components of turf quality contributed to the moderate turf quality of DALZ8502, but density was primarily responsible, particularly in nonirrigated plots (Table 8). Winter color had a negative influence on turf quality of DALZ8502 on nonirrigated plots (Table 3). DALZ8522 and DALZ8523 were poor in all turf quality components. DALZ8507 and DALZ8510 had relatively high ratings for turf quality components, but had unacceptable overall quality, due to poor color (Table 3). Uniformity and density of all grasses declined

with decreasing irrigation.

Frost Injury: Frost injury became evident by November 13, 1990 (Table 9). Meyer, Emerald, FC13521, DALZ8507, DALZ8510, DALZ8511, DALZ8515, DALZ8517, and DALZ8524 were among the most injured, which contrasts greatly with DALZ8501 and DALZ8516, which showed less than 20% frost damage. All other varieties and lines tested showed at least 40% damage overall. Just two weeks later, DALZ8516 had maintained a moderate frost injury (<40% injury), while all but two of the other 25 lines had at least 60% frost damage. El Toro was the least frost damaged of the commercial varieties, yet was over 70% damaged by December 10. Frost injury was generally lower for non-irrigated plants than for plants maintained at either moderate or high irrigation levels.

Weed Cover: Since being planted in Summer 1987 & 1988, LGIS zoysiagrasses have been competing with the more aggressive neighboring LGIS zoysiagrasses, and with some of the native and naturalized North Texas flora. Varieties exhibiting the lowest overall weed cover include El Toro, DALZ8512, DALZ8507, DALZ8508, and DALZ8514 (Table 10). These are varieties which have shown excellent drought tolerance in past summers, and which have completely established turf cover. Weeds have invaded experimental lines which have not established good turf cover, such as DALZ8513, DALZ8522, and DALZ8523 (weed cover > 30% and plot green cover < 50%). Commercial varieties which exhibit higher weed cover are Korean Common and Meyer, and also have moderate turf coverage (60 to 75%). Generally, weed cover is significantly higher in the non-irrigated zone than in the highly or moderately irrigated zones evaluated for the zoysia varietal plots.

Spring Turf Quality: By spring a number of grasses had improved in overall quality, particularly at high and intermediate irrigation levels (Table 7). Under no irrigation, only Belair, Emerald, FC13521, DALZ8507, DALZ8510, DALZ8512, and DALZ8514 had relatively acceptable turf quality. DALZ8522 continued to have the poorest quality of the varieties and at all irrigation levels evaluated (quality at all irrigations = 1.58). Plants in moderately irrigated zones gained quality as spring progressed, yet non-irrigated zones were still of relatively poor quality. By May 13, Belair, DALZ8505, DALZ8507, and DALZ8514 tended to have the highest quality under no irrigation, while Cashmere, Meyer, DALZ8501, DALZ8503, DALZ8513, DALZ8515, DALZ8516, DALZ8522, and DALZ8523 had significantly lower quality (Table 12). Emerald, FC13521, DALZ8512, DALZ8517, and DALZ8524 had consistently high quality across all irrigations at this date. On June 11, Belair, Emerald, El Toro, FC13521, DALZ8507, DALZ8510, DALZ8512, and DALZ8514 had significantly better quality under no irrigation (Table 12). Emerald, EL Toro, FC13521, DALZ8507, DALZ8512, and DALZ8514 maintained good quality at intermediate irrigation. Cashmere, Korean common, DALZ8513, DALZ8522, and DALZ8523 had unacceptable quality under no, and intermediate irrigation, while Korean common, DALZ8513, and DALZ8522 had unacceptable quality across all irrigations. There was no turf present under no irrigation in DALZ8522.

Spring Turf Coverage: Total turf cover (including brown) on April 3, 1991 tended to be

highest under no supplemental irrigation in Emerald, DALZ8503, and DALZ8507, while it was lowest in Cashmere, DALZ8510, DALZ8515, and DALZ8524 (Table 11). Cashmere and DALZ8524 tended to have low total plot cover across all irrigations, while Emerald and DALZ8507 were high. In addition, Cashmere had very low green turf cover under all irrigation treatments (Table 11). DALZ8516 and DALZ8516 also had low green turf cover under low irrigation. Other grasses were statistically equivalent under no supplemental irrigation. Weed cover tended to be lowest under no irrigation in Emerald, Korean common, DALZ8503, DALZ8513, DALZ8516, and DALZ8522, while it was highest in Cashmere, DALZ8510, and DALZ8517 (Table 11).

Summer Turf Quality: On July 10, Emerald, El Toro, Korean common, DALZ8507, DALZ8510, DALZ8512, and DALZ8514 had higher than acceptable turf quality under no supplemental irrigation (Table 13). Of these, only DALZ8507 and DALZ8512 maintained acceptable quality across all irrigations. By August 28, Belair, DALZ8506, DALZ8508, and DALZ8517 had acceptable turf quality under no irrigation (Table 13). DALZ8523 had unacceptable turf quality under all irrigations. Thatch accumulated excessively in Belair, DALZ8502, DALZ8505, DALZ8511, DALZ8515, and DALZ8523 on July 10, 1991 (Table 14). In contrast, there was minimal thatch across all irrigations in Cashmere, Emerald, DALZ8507, DALZ8512, and DALZ8516.

Turf Survival, Drought Stress, and Minimum Quality Zones: The distance from the center trench (100% irrigation) was measured to transition zones where: turfgrasses failed to survive (turf cover less than 50%), turfgrasses were under drought stress (leaf blade wilt occurred), and where turfgrasses had minimum acceptable quality. On July 1, Belair, Emerald, El Toro, FC13521, DALZ8507, DALZ8510, DALZ8512, and DALZ8514 had survived to 18m from the line source (no supplemental irrigation). DALZ8513, DALZ8522, DALZ8523, and DALZ8524 were significantly poorer in survival (Table 15). Of these, DALZ8513, DALZ8522, and DALZ8524 were drought stressed close to the irrigation line source, while Belair, El Toro, Korean common, DALZ8512, DALZ8514, and DALZ8516 had significantly less drought stress (Table 15). Turf quality was maintained at significantly greater distances from the line source for Belair, Emerald, El Toro, FC13521, DALZ8507, DALZ8510, DALZ8512, and DALZ8514. On August 16 the trends in survival were similar. The trends in drought stress were also similar, though DALZ8507, DALZ8513, and DALZ8522 had improved. Turf quality was maintained at large distances from the line source (under low supplemental irrigation) in Belair, Emerald, El Toro, DALZ8507, DALZ8508, DALZ8510, DALZ8511, and DALZ8516.

FUTURE WORK: The information obtained from LGIS during 1989 and 1990 is 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 will allow identification of grasses that will persist and function acceptably with little or no supplemental irrigation.

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

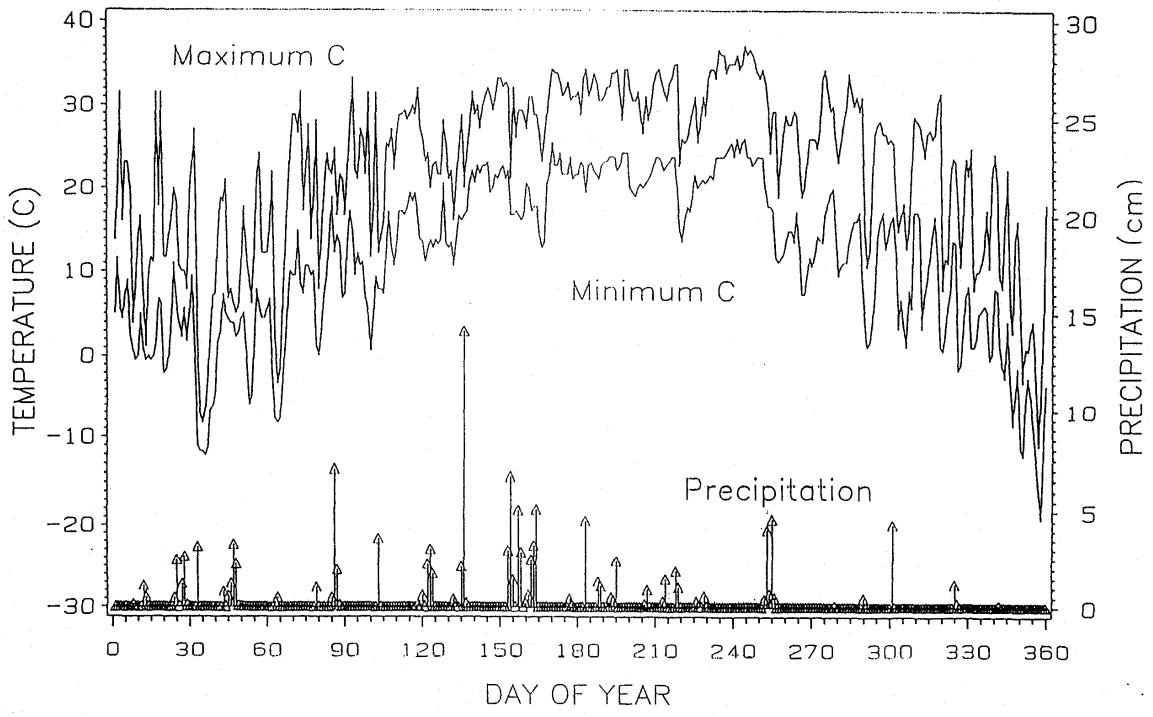

Figure 2. Temperatures and rainfall for TAES—Dallas. 1990.

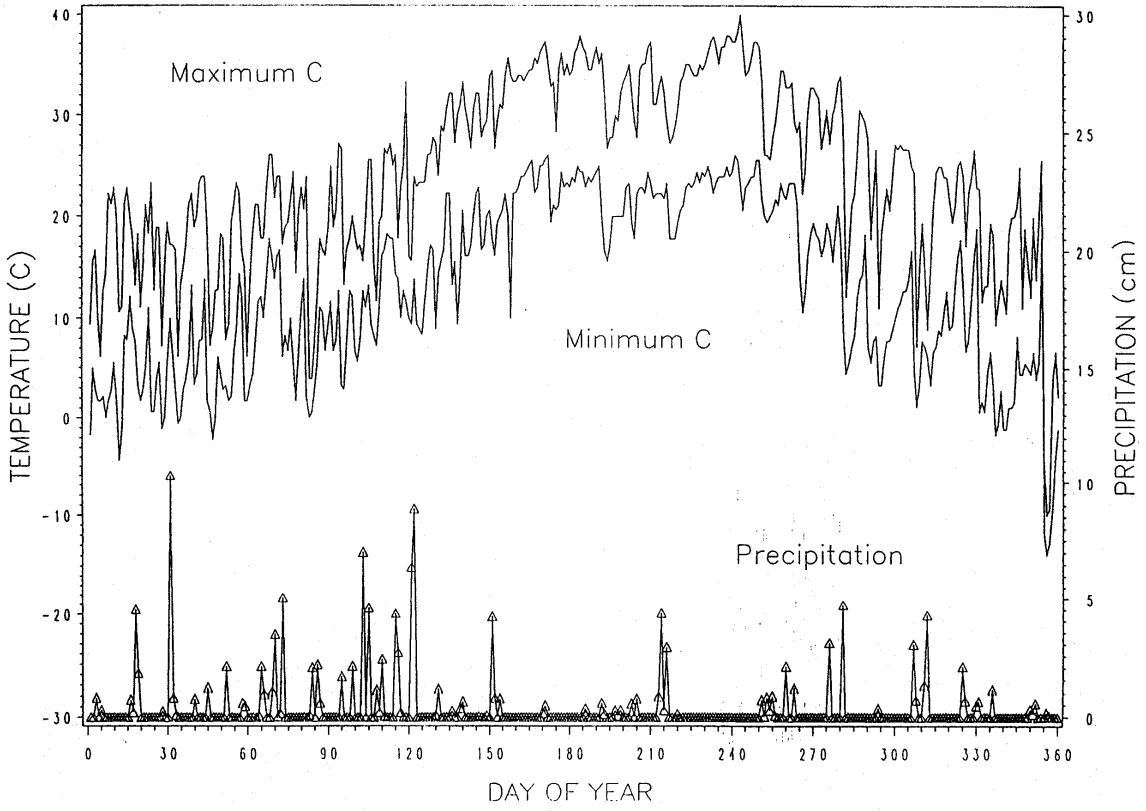

Figure 3. Temperatures and rainfall for TAES—Dallas. 1991.

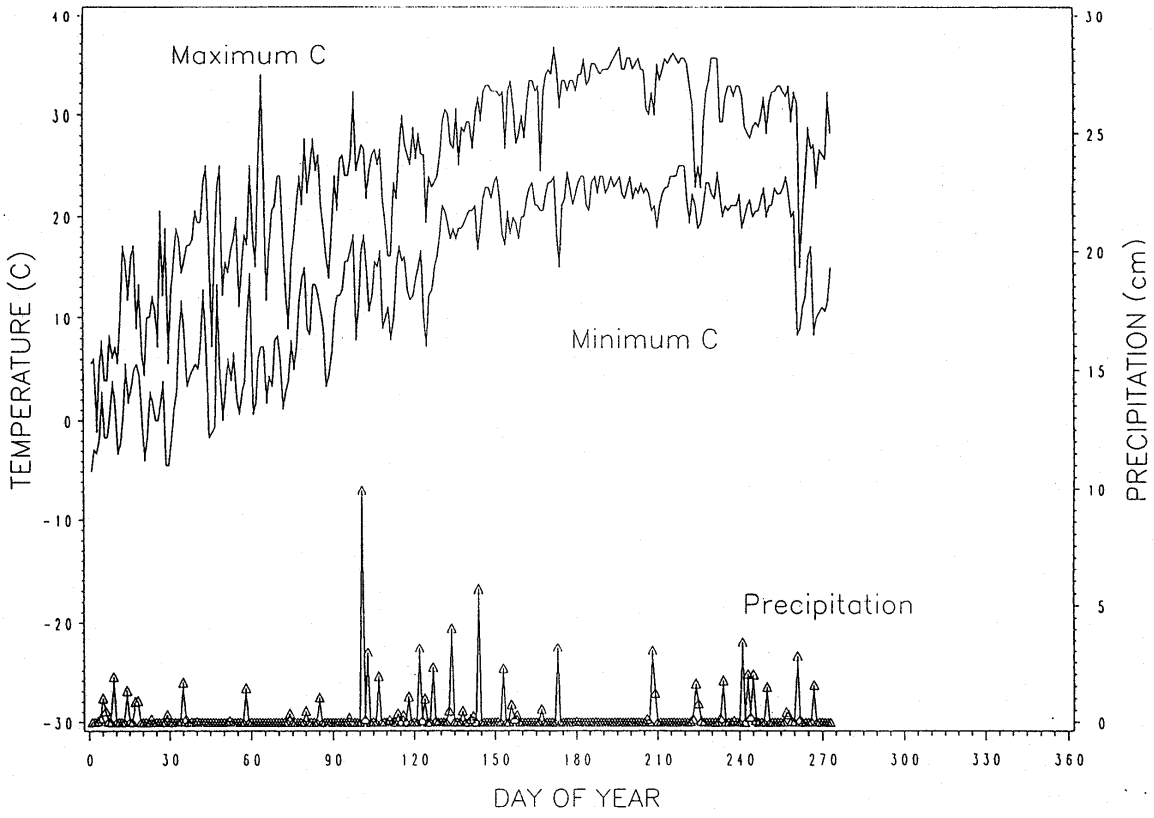

Figure 4. Irrigation distribution for LGIS at TAES—Dallas.

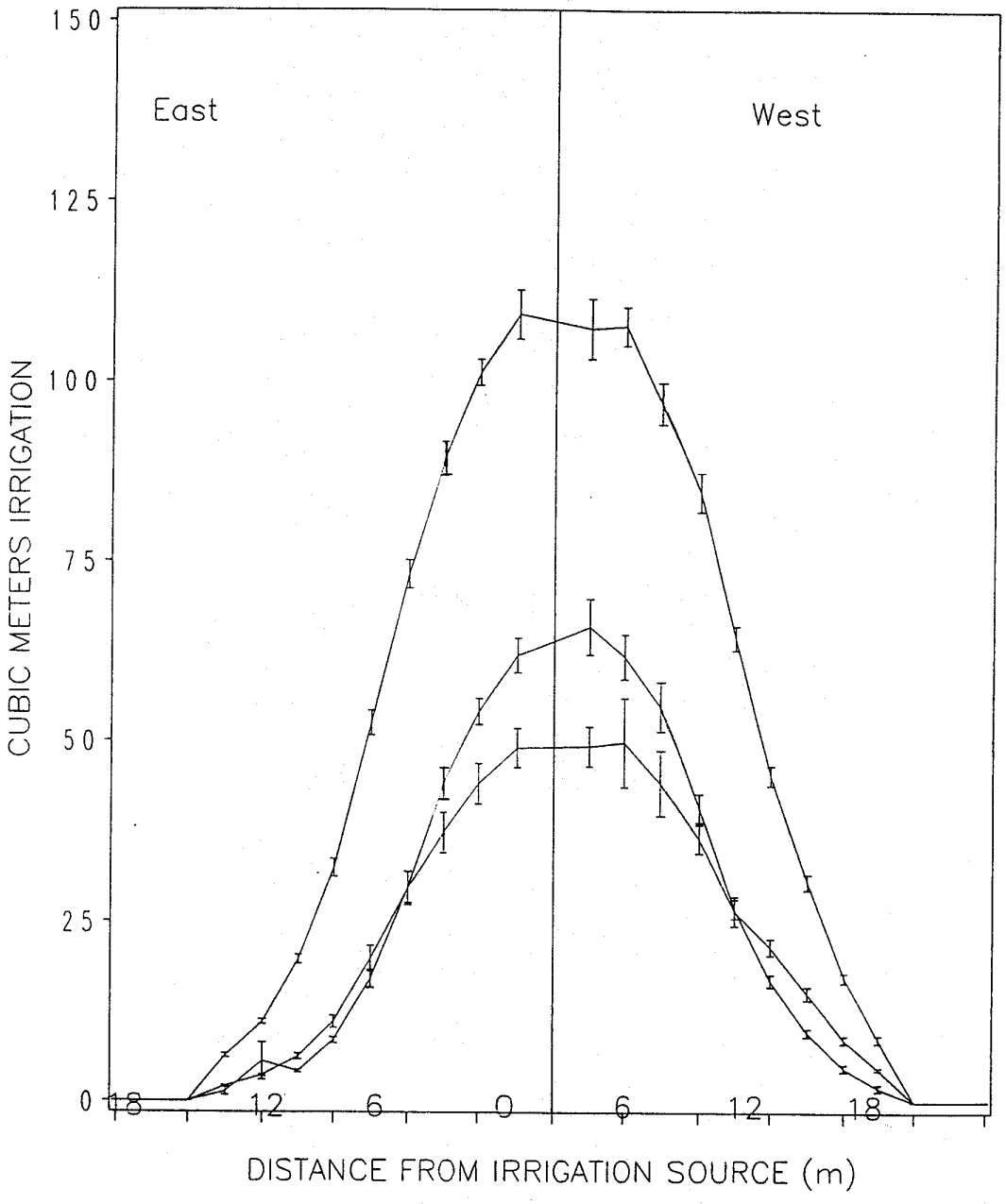

Table C1. Mean percentage green turf cover during stress (5 Sept.) and 7 days after termination of stress (15 Sept.) by rainfall for three levels of irrigation on LGIS zoysiagrasses at TAES-Dallas, Texas in 1990.

Entry	5 Sept.			15 Sept.		
	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
K. 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 C2. Fall color quality ratings (1-9 9 = darkest green and 5 = acceptable) for three levels of irrigation, and secondary color (G = green, GR = green-red, RG = red-green, and GY = green-yellow) averaged over irrigation, on LGIS zoysiagrasses at TAES, Texas in 1990.

	13 Nov.				29 Nov.			
Entry	High[1]	Inter.	None	2nd Col.	High	Inter.	None	2nd Col.
Belair	5.0	6.5	7.5	RG	5.0	5.0	6.5	RG
Cashmere	8.5	8.0	8.5	G	8.0	8.5	7.5	G
Emerald	6.5	6.5	7.0	RG	6.5	6.5	6.5	G
El Toro	6.5	6.5	5.0	RG	5.5	6.0	7.0	RG
K. common	4.0	5.0	5.5	GY	6.0	4.5	5.0	GR
Meyer	4.0	4.5	4.0	GY	5.5	5.0	5.0	G
FC13521	7.0	6.5	7.5	GR	6.5	7.0	7.5	G
DALZ8501	5.0	7.0	7.0	RG	7.0	8.0	6.5	G
DALZ8502	6.5	8.0	7.5	G	7.0	8.0	7.0	G
DALZ8503	5.5	5.5	5.0	RG	5.0	6.0	6.5	RG
DALZ8504	2.5	3.0	5.0	GY	5.5	6.0	7.5	G
DALZ8505	4.0	6.0	7.0	GR	5.5	6.5	5.5	G
DALZ8506	6.0	6.5	7.5	RG	7.0	6.5	6.5	G
DALZ8507	6.5	7.0	7.5	RG	6.0	6.0	8.0	G
DALZ8508	6.0	7.5	8.0	RG	6.0	6.5	7.5	RG
DALZ8510	6.0	7.0	7.5	RG	6.0	6.0	7.5	G
DALZ8511	4.5	3.0	4.5	RG	4.5	5.5	5.5	G
DALZ8512	6.0	6.5	7.0	RG	5.0	5.0	6.5	RG
DALZ8513	6.5	6.5	7.0	GR	6.5	6.5	7.5	G
DALZ8514	4.5	4.5	5.0	RG	6.0	5.5	6.5	RG
DALZ8515	6.5	7.5	3.0	RG	6.0	5.5	7.5	G
DALZ8516	7.0	7.5	8.0	RG	7.0	7.0	8.0	G
DALZ8517	6.5	6.5	7.0	RG	5.5	6.5	7.0	G
DALZ8522	7.0	7.0	0.0	G	6.0	4.5	7.0	G
DALZ8523	7.0	6.5	7.5	RG	4.0	3.5	4.0	GR
DALZ8524	5.5	8.0	7.5	RG	6.5	7.0	8.0	G
MSD entry[2]	2.7	2.5	2.9		ns	ns	ns	

[1]Irrigation levels of high, intermediate, and none are equivalent to 87, 29, and 0% of the irrigation volume at 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 C3. Winter color ratings (1-9 9 = darkest green and 5 = acceptable) for three levels of irrigation on LGIS zoysiagrasses at TAES, Texas in 1990-1991.

	10 Dec.			2 Feb.		
Entry	High[1]	Inter.	None	High	Inter.	None
Belair	3.0	3.3	3.8	1.5	1.5	1.0
Cashmere	6.8	7.0	7.0	1.0	1.0	1.0
Emerald	5.0	5.3	5.0	1.8	1.8	1.5
El Toro	3.5	3.0	3.8	1.8	1.5	1.0
K. common	4.0	3.5	3.0	2.0	1.8	2.0
Meyer	3.8	3.0	3.3	2.0	2.0	1.5
FC13521	5.3	5.0	6.3	1.8	1.5	1.0
DALZ8501	6.8	7.0	7.3	1.0	1.0	1.0
DALZ8502	7.3	7.3	6.0	4.0	4.0	2.0
DALZ8503	3.8	4.0	6.0	1.8	1.8	1.5
DALZ8504	3.5	4.0	4.5	2.0	1.3	1.3
DALZ8505	4.5	4.3	5.0	1.8	1.8	1.5
DALZ8506	5.5	6.3	7.0	1.5	1.5	1.3
DALZ8507	5.3	5.3	5.8	2.0	1.3	1.0
DALZ8508	4.0	3.8	6.0	1.0	1.0	1.0
DALZ8510	5.8	5.5	6.8	1.8	1.8	1.5
DALZ8511	4.3	4.3	4.8	2.0	1.8	1.8
DALZ8512	4.0	4.3	6.0	2.0	1.5	1.8
DALZ8513	5.8	5.5	6.5	1.0	1.0	1.0
DALZ8514	3.8	3.5	4.3	1.8	1.5	1.5
DALZ8515	3.5	3.8	4.0	2.0	1.8	1.0
DALZ8516	3.3	3.5	5.3	1.0	1.0	1.0
DALZ8517	4.8	5.3	6.8	1.8	1.5	1.5
DALZ8522	4.5	5.3	2.5	1.3	1.0	1.3
DALZ8523	4.5	4.8	4.5	1.0	1.0	1.0
DALZ8524	4.3	5.0	6.0	1.0	1.3	1.0
MSD entry[2]	1.5	1.4	2.2	0.4	0.6	1.1

[1]Irrigation levels of high, intermediate, and none are equivalent to 87, 29, and 0% of the irrigation volume at 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 C4. Mean percentage green turf cover during fall and winter for three levels of irrigation on LGIS zoysiagrasses at TAES, Texas in 1990-1991.

Entry	13 Nov.			29 Nov.			10 Dec.		
	High[1]	Inter.	None	High	Inter.	None	High	Inter.	None
Belair	100.0	100.0	97.5	75.5	44.5	68.5	55.3	46.0	56.5
Cashmere	100.0	95.0	42.5	76.5	89.0	23.5	18.8	18.3	3.3
Emerald	100.0	100.0	82.5	85.0	77.0	55.0	39.3	49.0	19.0
El Toro	100.0	100.0	100.0	84.5	78.5	72.0	66.5	74.3	62.3
K. common	100.0	95.5	55.0	22.5	11.0	14.5	5.8	5.8	7.5
Meyer	100.0	87.5	45.0	57.5	38.5	24.5	5.3	5.3	6.3
FC13521	100.0	100.0	77.5	67.0	67.5	52.5	30.5	36.3	23.5
DALZ8501	100.0	95.0	47.5	54.0	62.0	18.1	58.8	62.8	8.5
DALZ8502	100.0	100.0	75.0	57.0	51.0	31.0	67.8	66.5	28.0
DALZ8503	95.0	90.0	25.0	85.5	64.5	8.0	33.0	27.5	2.5
DALZ8504	95.0	92.5	35.0	71.0	49.0	7.5	14.3	25.3	5.0
DALZ8505	95.0	97.5	55.0	38.0	74.0	5.0	16.0	32.5	3.8
DALZ8506	100.0	100.0	50.0	57.5	58.5	26.5	34.3	42.3	16.3
DALZ8507	100.0	100.0	85.0	75.0	75.0	53.5	34.0	38.3	35.8
DALZ8508	92.5	100.0	52.5	79.0	77.5	35.5	58.3	64.8	12.3
DALZ8510	100.0	100.0	87.5	85.0	89.0	47.5	26.8	50.8	29.5
DALZ8511	97.5	95.0	67.5	51.5	44.5	23.0	5.8	11.5	8.8
DALZ8512	100.0	100.0	100.0	74.0	81.0	77.5	56.8	65.5	64.5
DALZ8513	100.0	100.0	92.5	47.0	56.5	5.0	12.8	17.8	17.8
DALZ8514	100.0	100.0	95.0	81.0	83.0	48.0	61.8	73.0	58.3
DALZ8515	100.0	100.0	47.5	66.5	44.5	2.0	29.5	13.5	3.8
DALZ8516	95.0	95.0	65.0	59.5	51.0	35.0	52.5	45.3	19.5
DALZ8517	100.0	100.0	60.0	68.0	75.0	14.0	40.3	63.0	8.8
DALZ8522	62.5	72.5	0.0	31.5	32.5	3.0	4.3	8.5	0.8
DALZ8523	85.0	90.0	72.5	7.5	1.0	7.5	13.5	12.0	12.8
DALZ8524	95.0	100.0	52.5	47.5	37.0	10.5	16.5	30.5	12.0
MSD entry[2]	19.9	ns	20.7	39.2	58.1	28.0	20.1	20.8	13.0

[1]Irrigation levels of high, intermediate, and none are equivalent to 87, 29, and 0% of the irrigation volume at 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 C5. Mean percentage green turf cover during spring (March 29, 1991) for three levels of irrigation on LGIS zoysiagrasses at TAES, Texas in 1990-1991.

Entry	High[1]	Inter.	None
Belair	73.8	76.3	77.5
Cashmere	51.3	47.5	25.0
Emerald	61.3	73.8	78.8
El Toro	76.3	76.3	73.8
K. common	72.5	67.5	55.0
Meyer	72.5	82.5	65.0
FC13521	82.5	85.0	76.3
DALZ8501	67.5	73.8	53.8
DALZ8502	68.8	72.5	55.0
DALZ8503	62.5	70.0	61.3
DALZ8504	65.0	81.7	60.0
DALZ8505	72.5	66.3	57.5
DALZ8506	71.3	73.8	72.5
DALZ8507	71.3	77.5	82.5
DALZ8508	89.5	83.0	73.8
DALZ8510	63.8	66.3	77.5
DALZ8511	81.3	80.0	46.3
DALZ8512	71.3	67.5	72.5
DALZ8513	37.5	26.5	37.5
DALZ8514	73.8	68.8	70.0
DALZ8515	62.5	60.0	28.8
DALZ8516	85.0	83.8	80.0
DALZ8517	66.3	65.0	66.3
DALZ8522	38.8	40.0	5.0
DALZ8523	38.8	37.5	31.3
DALZ8524	66.3	77.5	75.0
MSD entry[2]	25.2	25.0	23.2

[1]Irrigation levels of high, intermediate, and none are equivalent to 87, 29, and 0% of the irrigation volume at 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 C6. Mean zoysiagrass turf quality during stress (5 Sept.) and 7 days after termination of stress (15 Sept.) by rainfall for three levels of irrigation on LGIS at TAES-Dallas, Texas in 1990.

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

[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 C7. Winter and spring turf quality ratings (1-9 9 = highest quality and 5 = acceptable) for three levels of irrigation on LGIS zoysiagrasses at TAES, Texas in 1990-1991.

	6 Feb.			24 Apr.		
Entry	High[1]	Inter.	None	High	Inter.	None
Belair	3.8	3.8	3.3	5.0	4.8	4.8
Cashmere	4.3	3.8	3.0	4.8	4.5	1.8
Emerald	4.3	4.3	3.5	5.5	5.8	4.8
El Toro	4.0	4.0	3.5	5.3	4.8	4.5
K. common	4.5	4.0	3.5	5.0	5.3	2.5
Meyer	4.3	4.0	3.3	6.0	6.3	3.0
FC13521	4.3	3.8	3.3	5.3	5.8	4.0
DALZ8501	4.0	4.0	3.3	4.8	5.0	2.2
DALZ8502	6.0	5.8	4.5	5.8	6.3	3.8
DALZ8503	4.5	4.0	3.0	5.5	5.3	3.3
DALZ8504	4.5	3.5	3.0	5.5	6.0	2.8
DALZ8505	4.0	3.8	3.0	4.8	6.0	2.0
DALZ8506	4.0	4.0	3.3	5.5	5.5	3.8
DALZ8507	4.5	4.3	3.8	5.8	6.5	5.0
DALZ8508	4.0	3.3	3.0	6.0	6.3	3.5
DALZ8510	4.0	4.0	3.8	5.3	6.0	4.8
DALZ8511	4.5	4.0	3.5	5.8	5.8	2.8
DALZ8512	4.3	3.8	3.8	5.0	5.5	4.8
DALZ8513	3.5	3.5	3.3	4.0	3.8	2.0
DALZ8514	3.8	4.0	3.8	4.8	5.0	4.8
DALZ8515	4.3	4.0	3.0	5.3	6.0	1.3
DALZ8516	4.0	3.5	3.3	5.0	5.5	3.5
DALZ8517	4.0	4.0	3.3	5.3	6.0	3.5
DALZ8522	3.0	3.3	1.8	1.8	2.3	0.8
DALZ8523	3.5	3.3	3.5	4.3	4.3	2.3
DALZ8524	4.0	4.0	3.8	4.8	5.8	3.8
MSD entry[2]	0.7	0.8	0.9	1.0	1.1	1.1

[1]Irrigation levels of high, intermediate, and none are equivalent to 87, 29, and 0% of the irrigation volume at 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 C8. Canopy density (9 = densest, 5 = lowest acceptable density, and 0 = none of the variety is present), canopy uniformity (1 = uniform canopy, 0 = patchy canopy distribution), and canopy evenness (1 = even height, 0 = undulated canopy) at February 6, 1991 for three levels of irrigation on LGIS zoysiagrasses at TAES, Dallas.

	Density			Uniformity			Evenness		
Entry	High[1]	Inter.	None	High	Inter.	None	High	Inter.	None
Belair	4.8	4.8	4.5	0.0	0.3	0.5	0.5	0.8	0.3
Cashmere	6.0	5.5	4.3	0.5	0.0	0.0	0.8	0.3	0.8
Emerald	5.3	5.0	4.5	0.3	0.0	0.3	0.5	0.0	0.5
El Toro	4.8	4.3	4.0	0.3	0.8	0.8	0.8	1.0	0.8
K. common	5.3	4.3	3.5	0.8	0.5	0.0	0.5	0.8	0.8
Meyer	5.5	4.8	3.8	0.8	0.8	0.3	0.0	0.3	0.8
FC13521	5.3	4.5	4.0	0.8	0.5	0.5	0.3	0.5	0.8
DALZ8501	5.3	5.3	4.0	0.3	0.3	0.3	0.8	0.8	1.0
DALZ8502	6.0	5.3	5.3	0.8	0.8	0.3	1.0	0.8	0.8
DALZ8503	6.0	5.0	3.0	0.8	0.8	0.3	0.0	0.0	0.3
DALZ8504	5.5	4.5	3.5	0.8	0.8	0.0	0.3	0.0	0.5
DALZ8505	4.3	4.5	3.3	0.5	0.5	0.3	0.8	0.5	0.5
DALZ8506	5.5	5.3	3.8	0.5	0.8	0.0	0.3	0.0	1.0
DALZ8507	5.5	5.3	4.8	0.5	1.0	0.0	0.5	0.5	0.8
DALZ8508	5.0	4.8	4.0	1.0	0.3	0.0	0.0	0.3	0.5
DALZ8510	5.0	4.8	5.3	0.5	0.5	0.5	0.3	0.8	0.0
DALZ8511	5.5	4.8	3.8	0.8	1.0	0.8	0.3	0.0	0.5
DALZ8512	4.3	4.5	4.0	1.0	0.5	0.8	1.0	0.8	0.8
DALZ8513	4.8	5.0	4.8	0.5	0.3	0.0	0.3	0.5	0.3
DALZ8514	4.8	4.8	4.3	0.5	0.3	0.3	0.5	1.0	1.0
DALZ8515	5.3	5.0	3.8	0.8	0.5	0.0	0.3	0.5	0.8
DALZ8516	5.5	4.8	4.8	0.5	0.3	0.3	0.5	0.5	0.3
DALZ8517	5.0	5.0	4.0	0.8	0.8	0.0	0.3	0.5	1.0
DALZ8522	3.8	3.8	2.0	0.0	0.3	0.0	0.8	1.3	0.3
DALZ8523	4.8	4.8	4.8	0.0	0.0	0.0	0.8	0.5	0.8
DALZ8524	5.3	5.0	4.5	0.5	0.0	0.0	0.8	1.0	1.0
MSD entry[2]	1.0	ns	1.1	0.9	0.8	ns	ns	0.8	ns

[1]Irrigation levels of high, intermediate, and none are equivalent to 87, 29, and 0% of the irrigation volume at 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 C9. Percent of turf injured by frost for three levels of irrigation on LGIS zoysiagrasses at TAES, Texas in 1990-1991.

	13 Nov.			29 Nov.			10 Dec.		
Entry	High[1]	Inter.	None	High	Inter.	None	High	Inter.	None
Belair	57.5	65.0	37.5	75.0	80.0	75.0	77.5	88.3	82.5
Cashmere	90.0	85.0	47.5	85.0	77.5	77.5	97.8	95.8	92.5
Emerald	92.5	82.5	80.0	87.5	85.0	85.0	95.8	95.8	97.0
El Toro	45.0	52.5	37.5	47.5	67.5	27.5	76.3	71.3	72.5
K. common	95.0	95.0	67.5	87.5	87.5	87.5	99.0	99.3	95.8
Meyer	99.0	97.5	95.0	95.0	95.0	90.0	99.0	99.0	97.0
FC13521	85.0	85.0	80.0	85.0	87.5	85.0	95.8	95.3	95.0
DALZ8501	20.0	10.0	7.5	52.5	57.5	77.5	76.3	77.3	88.8
DALZ8502	60.0	42.5	45.0	67.5	40.0	77.5	72.5	73.8	85.0
DALZ8503	57.5	80.0	50.0	90.0	90.0	87.5	89.3	90.8	96.8
DALZ8504	90.0	60.0	30.0	92.5	90.0	87.5	98.0	96.5	91.3
DALZ8505	87.5	90.0	42.5	85.0	87.5	72.5	96.5	93.3	88.8
DALZ8506	85.0	80.0	45.0	85.0	87.5	85.0	97.3	94.0	93.3
DALZ8507	85.0	82.5	85.0	87.5	90.0	72.5	96.0	95.8	94.0
DALZ8508	80.0	70.0	25.0	82.5	75.0	70.0	71.0	78.8	94.8
DALZ8510	87.5	85.0	87.5	87.5	82.5	80.0	97.5	92.5	93.3
DALZ8511	92.5	95.0	75.0	92.5	87.5	92.5	97.8	96.3	93.5
DALZ8512	40.0	82.5	45.0	80.0	77.5	75.0	83.8	87.5	81.3
DALZ8513	70.0	82.5	45.0	77.5	80.0	35.0	96.0	94.5	93.3
DALZ8514	40.0	45.0	47.5	67.5	57.5	60.0	66.3	63.8	70.0
DALZ8515	90.0	95.0	75.0	90.0	92.6	85.0	96.5	96.8	70.8
DALZ8516	20.0	17.5	12.5	35.0	30.0	32.5	65.0	72.5	73.3
DALZ8517	87.5	77.5	80.0	87.5	80.0	75.0	92.3	90.0	91.3
DALZ8522	87.5	37.5	0.0	92.5	80.0	65.0	97.5	97.5	48.5
DALZ8523	80.0	85.0	40.0	35.0	35.0	35.0	70.0	70.8	69.5
DALZ8524	90.0	72.5	85.0	90.0	87.5	87.5	97.8	96.0	91.3
MSD entry[2]	46.2	36.7	57.5	29.9	26.3	36.8	22.3	21.5	44.2

[1]Irrigation levels of high, intermediate, and none are equivalent to 87, 29, and 0% of the irrigation volume at 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 C10. Percentage of the plot that is weed cover (not of the variety planted) for March 29, 1991 on LGIS zoysiagrasses at TAES, Texas.

Entry	High[1]	Inter.	None
Belair	6.8	15.5	13.8
Cashmere	10.5	13.5	38.8
Emerald	22.3	12.5	11.8
El Toro	8.3	7.5	10.3
K. common	8.5	31.3	37.5
Meyer	15.8	18.5	31.3
FC13521	16.3	15.0	21.3
DALZ8501	12.5	14.3	36.3
DALZ8502	14.8	18.8	30.0
DALZ8503	12.5	18.3	48.8
DALZ8504	9.6	23.3	52.5
DALZ8505	21.0	15.5	61.3
DALZ8506	18.8	12.3	32.5
DALZ8507	9.3	7.3	12.3
DALZ8508	8.3	7.8	15.5
DALZ8510	7.5	6.3	19.3
DALZ8511	6.5	13.0	24.3
DALZ8512	6.5	5.5	15.8
DALZ8513	40.0	26.3	41.3
DALZ8514	10.8	8.5	13.0
DALZ8515	16.8	36.3	53.8
DALZ8516	16.8	18.5	22.5
DALZ8517	9.0	8.0	40.0
DALZ8522	32.5	31.3	31.3
DALZ8523	41.3	58.8	46.3
DALZ8524	27.5	25.5	27.3
MSD entry[2]	22.4	23.3	22.0

[1]Irrigation levels of high, intermediate, and none are equivalent to 87, 29, and 0% of the irrigation volume at 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 C11. Mean percentage total turf cover, mean percentage green turf cover, and mean percentage weed cover during April 3, 1991 for three levels of irrigation on LGIS zoysiagrasses at TAES, Texas.

Entry	Total Turf Cover			Green Turf Cover			Weed Cover		
	High[1]	Inter.	None	High	Inter.	None	High	Inter.	None
Belair	62.5	82.5	69.0	85.0	85.0	75.0	30.0	15.0	25.0
Cashmere	25.0	37.5	42.5	25.0	30.0	3.0	65.0	57.5	45.0
Emerald	87.5	91.5	88.0	55.0	60.0	70.0	7.5	8.5	11.0
El Toro	86.5	77.5	50.0	75.0	75.0	70.0	12.0	22.5	37.5
K. common	65.0	70.0	78.5	77.5	75.0	82.5	27.5	25.0	15.0
Meyer	66.5	82.5	62.5	55.0	82.5	55.0	20.0	17.5	28.5
FC13521	82.5	82.5	72.5	75.0	77.5	82.5	9.5	15.0	20.0
DALZ8501	81.5	75.0	42.5	57.5	57.5	55.0	16.0	25.0	42.5
DALZ8502	15.0	85.0	76.0	25.0	75.0	75.0	52.5	15.0	20.0
DALZ8503	70.0	85.0	85.0	70.0	90.0	87.5	14.0	12.5	12.5
DALZ8504	55.0	75.0	76.5	72.5	80.0	77.5	27.5	22.5	22.5
DALZ8505	84.0	84.0	70.0	75.0	85.0	40.0	7.5	16.0	20.0
DALZ8506	71.5	69.0	46.0	70.0	72.5	35.0	20.0	23.5	22.5
DALZ8507	81.5	89.0	84.0	77.5	82.5	80.0	12.5	6.0	12.5
DALZ8508	79.0	87.5	40.0	77.5	78.0	47.5	13.5	11.0	25.0
DALZ8510	70.0	55.0	17.5	70.0	80.0	45.0	22.5	42.5	75.0
DALZ8511	51.5	92.5	47.5	60.0	82.5	65.0	42.5	7.5	46.5
DALZ8512	71.0	72.5	65.0	80.0	85.0	80.0	22.5	26.0	32.5
DALZ8513	52.5	75.0	81.0	77.5	85.0	80.0	35.0	25.0	12.5
DALZ8514	57.5	81.5	67.5	60.0	75.0	65.0	31.0	16.0	25.0
DALZ8515	50.0	40.0	25.0	25.0	25.0	35.0	40.0	42.5	25.0
DALZ8516	89.0	94.0	62.5	62.5	60.0	22.5	5.0	6.0	17.5
DALZ8517	80.0	48.5	22.5	75.0	72.5	35.0	15.0	47.5	62.5
DALZ8522	89.0	91.0	79.5	82.5	77.5	67.5	8.5	4.0	15.5
DALZ8523	66.0	78.5	67.5	90.0	93.5	84.0	27.5	15.0	20.0
DALZ8524	21.0	43.5	52.5	37.5	52.5	57.5	47.5	47.5	21.0
MSD entry[2]	56.7	ns	ns	ns	42.2	55.0	ns	ns	ns

[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 18m 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 C12. Turfgrass quality (9 = optimum, 5 = minimum acceptable) on May 13, and June 11, 1991, for three levels of irrigation on LGIS zoysiagrasses at TAES-Dallas, Texas.

	May 13			June 11		
Entry	High[1]	Inter.	None	High	Inter.	None
Belair	4.3	5.5	6.3	6.3	6.0	6.3
Cashmere	4.8	4.3	2.5	6.3	5.5	1.3
Emerald	5.3	6.3	5.0	5.8	7.3	7.0
El Toro	4.0	5.5	5.3	6.8	6.8	7.3
K. common	2.3	5.8	4.5	4.8	5.8	3.0
Meyer	4.8	5.5	3.0	5.5	6.3	3.0
FC13521	4.8	6.0	5.3	5.5	7.3	6.8
DALZ8501	4.3	5.3	3.3	5.0	6.3	2.0
DALZ8502	3.5	5.3	4.8	5.3	5.8	5.0
DALZ8503	3.0	5.0	3.8	5.8	7.0	2.8
DALZ8504	4.0	5.8	5.3	5.8	6.5	3.3
DALZ8505	4.5	5.5	5.5	5.3	6.3	3.5
DALZ8506	2.8	6.0	5.0	5.5	7.5	5.0
DALZ8507	4.8	6.0	5.5	6.5	7.5	7.3
DALZ8508	2.5	5.0	5.0	6.2	6.8	3.8
DALZ8510	3.8	5.5	4.8	6.3	7.0	7.0
DALZ8511	3.8	5.5	4.3	6.0	6.3	2.3
DALZ8512	5.5	6.3	4.8	6.0	6.8	6.3
DALZ8513	3.8	4.3	3.8	4.5	4.5	3.0
DALZ8514	5.8	5.5	5.8	6.0	6.3	6.5
DALZ8515	5.0	5.5	3.0	5.0	6.0	2.3
DALZ8516	4.0	5.0	4.0	5.3	6.0	4.0
DALZ8517	4.8	6.3	5.0	6.0	6.0	5.5
DALZ8522	3.5	4.0	2.3	2.0	4.0	0.0
DALZ8523	4.3	5.5	3.3	4.8	5.0	2.8
DALZ8524	4.5	6.0	5.0	4.5	6.0	4.0
MSD[2]	ns	ns	2.1	0.9	1.3	1.6

[1]Irrigation levels of high, intermediate, and none are equivalent to 87, 29, and 0% of the irrigation volume at the line source, or 1.5, 9, and 18m from 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 C13. Turfgrass quality (9 = optimum, 5 = minimum acceptable) on July 10, and August 28, 1991, for three levels of irrigation on LGIS zoysiagrasses at TAES-Dallas, Texas.

Entry	July 10			August 28		
	High[1]	Inter.	None	High	Inter.	None
Belair	4.5	3.0	3.0	5.5	5.3	5.0
Cashmere	3.0	5.0	.	6.0	5.8	3.5
Emerald	.	4.0	7.0	5.7	6.3	4.0
El Toro	6.0	.	6.0	6.5	5.5	4.0
K. common	2.0	2.0	6.0	5.2	5.3	3.5
Meyer	4.0	4.0	2.0	4.2	5.3	3.3
FC13521	3.0	4.0	2.0	6.2	6.5	3.8
DALZ8501	7.0	6.0	3.5	5.0	6.0	3.8
DALZ8502	4.0	2.5	3.0	5.8	6.3	4.5
DALZ8503	3.0	3.0	2.5	7.0	6.5	2.0
DALZ8504	2.0	2.0	2.0	5.0	6.0	3.0
DALZ8505	4.0	4.0	5.0	6.5	6.0	3.5
DALZ8506	6.0	4.0	3.0	4.8	6.5	5.3
DALZ8507	6.0	6.0	6.0	7.0	5.8	3.8
DALZ8508	6.0	6.0	3.5	5.5	6.5	5.0
DALZ8510	5.0	4.0	7.0	6.8	6.0	3.5
DALZ8511	5.0	3.0	2.5	5.3	6.0	3.8
DALZ8512	6.0	6.0	7.5	5.3	5.5	4.5
DALZ8513	6.0	3.0	2.0	5.3	6.3	3.8
DALZ8514	3.0	4.0	6.0	6.8	5.8	2.8
DALZ8515	7.0	2.0	2.0	5.5	5.8	2.0
DALZ8516	4.5	5.0	4.5	6.0	6.3	3.8
DALZ8517	4.0	3.5	4.5	5.0	6.0	5.3
DALZ8522	3.5	6.5	4.0	4.0	5.0	3.3
DALZ8523	6.0	4.0	2.0	4.8	4.3	2.3
DALZ8524	4.5	4.5	5.0	5.8	6.0	2.5
MSD[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 at the line source, or 1.5, 9, and 18m from 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 C14. Mean percentage thatch during July 10, 1991 for three levels of irrigation on LGIS zoysiagrasses at TAES, Texas.

Entry	High[1]	Inter.	None
Belair	35	65	60
Cashmere	40	30	0
Emerald	7	30	10
El Toro	20	.	20
K. common	80	80	30
Meyer	20	70	70
FC13521	50	50	70
DALZ8501	25	25	60
DALZ8502	55	75	75
DALZ8503	70	35	70
DALZ8504	75	50	80
DALZ8505	70	70	50
DALZ8506	30	50	60
DALZ8507	30	20	20
DALZ8508	25	25	50
DALZ8510	40	50	30
DALZ8511	35	60	75
DALZ8512	20	20	15
DALZ8513	30	50	50
DALZ8514	60	40	20
DALZ8515	20	50	80
DALZ8516	30	25	25
DALZ8517	25	10	40
DALZ8522	10	25	40
DALZ8523	30	60	80
DALZ8524	40	55	40
MSD entry[2]	ns	ns	ns

[1]Irrigation levels of high, intermediate, and none are equivalent to 87, 29, and 0% of the irrigation volume at the line source, or 1.5, 9, and 18m 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 C15. Distance from irrigation line source (m) at which: turfgrass no longer survives (Survival), turfgrass wilts (Wilt), and turfgrass color quality drops below acceptable levels (Quality), during July 1, and August 16, 1991, on LGIS zoysiagrasses at TAES-Dallas, Texas.

	July 1			August 16		
Entry	Survival	Wilt	Quality	Survival	Wilt	Quality
Belair	18.0	18.0	16.9	17.6	17.6	13.1
Cashmere	13.5	9.8	11.6	16.9	13.1	15.0
Emerald	18.0	8.0	16.1	18.0	14.3	15.8
El Toro	18.0	17.3	17.3	18.0	18.0	16.1
K. common	16.1	13.9	12.4	16.5	15.0	15.4
Meyer	14.6	13.1	12.8	17.6	11.3	13.1
FC13521	18.0	7.9	16.1	12.0	12.0	12.0
DALZ8501	13.9	7.9	10.5	15.0	15.0	13.1
DALZ8502	16.1	4.9	12.8	16.5	16.1	14.3
DALZ8503	15.0	12.0	12.8	17.6	12.8	14.6
DALZ8504	14.6	12.8	12.0	16.9	16.9	14.6
DALZ8505	13.5	12.0	11.6	17.3	16.1	13.9
DALZ8506	17.3	7.1	12.0	17.3	16.1	14.6
DALZ8507	18.0	7.9	15.8	18.0	17.3	15.0
DALZ8508	17.3	8.6	13.1	17.6	15.4	15.0
DALZ8510	18.0	6.4	16.1	15.8	15.8	13.1
DALZ8511	16.5	10.5	13.1	18.0	9.8	13.9
DALZ8512	18.0	18.0	18.0	12.4	12.4	9.8
DALZ8513	9.0	7.9	6.4	17.3	15.4	13.5
DALZ8514	18.0	18.0	17.6	11.3	6.8	9.8
DALZ8515	14.6	8.6	11.3	12.4	12.8	8.6
DALZ8516	15.8	13.9	13.9	16.5	15.0	14.3
DALZ8517	15.4	6.4	12.4	15.4	13.9	12.4
DALZ8522	5.3	2.6	4.1	16.1	16.1	13.9
DALZ8523	12.0	10.9	9.8	16.9	13.1	14.6
DALZ8524	12.0	2.6	9.8	13.1	12.0	10.1
MSD[2]	3.3	3.1	2.7	ns	ns	ns

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

APPENDIX D

TURFGRASS ROOT INVESTIGATION

INTRODUCTION: The Turfgrass Root Investigation Facility (TRIF) is being used to assess turfgrass rooting characteristics in the field. The goal is to develop turfgrasses having greater root extension, which are capable of mining the subsurface moisture supply to provide superior persistence during drought periods. A greenhouse root screening technique using flexible plastic tubes is currently underway which will allow a confirmation of TRIF field data. Both TRIF and the greenhouse experiments will allow a comparative assessment of relative root distributions within the soil profile.

OBJECTIVES: Determine rooting characteristics of zoysiagrass germplasm and the relationship between root characters and drought resistance. Additionally, other characteristics are being determined, including relative shoot ground coverage and turfgrass quality.

PROGRESS: On August 10, 1990 six commercial cultivars and 44 experimental lines of zoysiagrass, were planted in separate randomized complete block designs on TRIF. All entries were planted as 56 x 56 cm sod pieces, and replicated three times. The plants were uniformly fertilized with 0.5 kg N are^{-1} with a slow release (24-4-11: N, P_2O_5, K_2O) fertilizer.

Most of the entries had established at least 75% turf cover by the end of fall. All entries, except DALZ8701, retained green stolons through the winter. By March 21, 1991, all the commercial varieties and forty of the experimental lines had greened up. Midwest and Meyer greened up the fastest of the commercial entries, while TAES3357, TAES3358, TAES3359, TAES3360, TAES3364, and DALZ8518 were the first experimental lines to green up (Table 2). DALZ8522, DALZ8523, DALZ8701, and TAES3361 were the slowest to green up, not producing green leaves in the early spring.

Total percentage of turf cover throughout the spring and summer was best in DALZ8505, DALZ8506, DALZ8512, DALZ9002, DALZ9004, TAES3357, TAES3358, TAES3359, TAES3360, TAES3364, and TAES3366, while it was worst in TAES3361, TAES3372, and DALZ8701 (Table 1). The percentage of green turf cover followed the same trend (Table 2). The commercial were intermediate in turf coverage, except for FC13521, which was poor. Most entries maintained low percentages of weed cover (Table 3). Only TAES3365, TAES3368, TAES3477, DALZ8502, DALZ8504, DALZ8508, DALZ8516, DALZ8520, DALZ8522, and DALZ8701 had 10% or greater weed cover. In all cases, this corresponded with low total turfgrass coverage (Table 1).

Turfgrass quality was determined during the summer of 1991 (Table 3). TAES3357, TAES3358, TAES3360, TAES3364, and DALZ8511 had the best quality, while El Toro, Meyer, TAES3356, TAES3359, TAES3363, TAES3366, DALZ8504, DALZ8506, DALZ8512,

DALZ8515, and DALZ8518 maintained turf quality above the minimum acceptable rating of 5.

Soil core samples (5 cm x 76 cm deep) were taken from TRIF entries on August 21 and 22 by replication, and stored at 5 C. Components of root distribution are currently being analyzed, including root length, root number and volume at 10 cm increments of each root system.

FUTURE WORK: A greenhouse flexible root-tube experiment was planted from September 16 - 18, 1991, by replication. Twenty-five zoysiagrasses and 22 buffalograsses were included in the planting. Data will be taken on rate of root elongation, relative root number and mass per 10 cm segment root depth, and rate of shoot growth. Data will be compared to that taken from TRIF to substantiate results.

Table D1. Percent total (live and dead) turfgrass cover on zoysiagrasses planted to TRIF.

Entry	Observation Date				PS[1]
	March 21	May 15	June 10	August 15	
Belair	81.7	86.7a	70.0	86.7a	2
El Toro	91.7a[2]	88.3a	71.7	94.0a	3
Emerald	73.3	90.0a	58.3	92.3a	2
FC13521	63.3	86.7a	58.3	60.0	1
Meyer	83.3	91.7a	80.0a	93.3a	3
Midwest	58.3	75.0	66.7	85.0a	1
TAES3356	91.7a	91.7a	71.7	90.0a	3
TAES3357	97.0a	96.0a	85.0a	98.3a	4
TAES3358	94.3a	94.3a	86.7a	99.0a	4
TAES3359	93.3a	93.3a	80.0a	98.0a	4
TAES3360	90.0a	95.0a	83.3a	98.0a	4
TAES3361	80.0	95.0a	11.7	28.3	1
TAES3362	87.3a	93.3a	61.7	95.0a	3
TAES3363	80.0	88.3a	73.3a	91.3a	3
TAES3364	95.7a	97.0a	81.7a	98.3a	4
TAES3365	80.0	91.7a	26.7	41.7	1
TAES3366	88.3a	88.3a	73.3a	94.3a	4
TAES3367	80.0	93.3a	38.3	58.3	1
TAES3368	81.7	81.7a	8.3	20.0	1
TAES3372	70.0	71.7	46.7	66.7	0
TAES3477	75.0	86.7a	15.0	48.3	1
DALZ8501	81.7	85.0a	26.7	55.0	1
DALZ8502	73.3	81.7a	9.3	30.0	1
DALZ8503	83.3	93.3a	78.3a	91.0a	3
DALZ8504	68.3	85.0a	35.0	50.0	1
DALZ8505	88.3a	90.0a	76.7a	90.3a	4
DALZ8506	86.7a	88.3a	73.3a	91.7a	4
DALZ8507	88.3a	90.0a	66.7	86.7a	3
DALZ8508	60.0	83.3a	23.3	51.7	1
DALZ8510	81.7	93.3a	63.3	85.0a	2
DALZ8511	81.7	93.3a	76.7a	97.0a	3
DALZ8512	96.3a	94.0a	80.0a	97.0a	4
DALZ8513	93.3a	95.0a	33.3	80.0a	3
DALZ8514	90.0a	91.7a	80.0a	91.0a	4
DALZ8515	85.0	94.0a	78.3a	96.0a	3
DALZ8516	55.0	88.3a	31.7	55.0	1
DALZ8517	86.7a	95.0a	51.7	85.0a	3
DALZ8518	83.3	89.3a	78.3a	97.0a	3
DALZ8519	71.7	78.3	71.7	67.7	0
DALZ8520	53.3	53.3	66.7	86.0a	1
DALZ8522	94.0a	76.7	23.3	50.0	1
DALZ8523	85.0	84.3a	15.0	41.7	1
DALZ8524	66.7	83.3a	31.7	76.7	1
DALZ8701	66.7	76.7	8.3	31.7	0
DALZ9001	41.7	50.0	58.3	73.3	0
DALZ9002	95.0a	91.7a	73.3a	95.0a	4
DALZ9003	46.7	68.3	60.0	80.0a	1
DALZ9004	86.7a	90.0a	76.7a	94.3a	4
MSD entry[3]	11.8	16.9	14.1	19.6	

[1]PS = Phenotypic Stability, the number of times an entry received superior ratings on the Waller-Duncan k-ratio t test (k-ratio=100).
[2]Means followed by the same letter within a column are not significantly different based on the Waller-Duncan k-ratio t test.
[3]MSD = minimum significant difference for comparison of entry means within columns based on the Waller-Duncan k-ratio t test.

Table D2. Percent green turfgrass cover on zoysiagrasses planted to TRIF.

Entry	Observation Date			PS[1]
	March 21	May 15	August 15	
Belair	50.0[2]	80.0a	86.7a	2
El Toro	36.6	80.0a	86.3a	2
Emerald	60.0	81.7a	83.3a	2
FC13521	33.3	66.7	48.3	0
Meyer	70.0	95.0a	85.0a	2
Midwest	76.6a	81.7a	75.0	2
TAES3356	40.0	86.7a	80.0a	2
TAES3357	80.0a	94.3a	96.0a	3
TAES3358	81.6a	94.3a	98.3a	3
TAES3359	78.3a	93.3a	96.0a	3
TAES3360	55.0a	93.3a	96.0a	3
TAES3361	0.0	11.7	21.7	0
TAES3362	40.0	80.0a	86.7a	2
TAES3363	60.0	88.3a	88.0a	2
TAES3364	73.3a	95.3a	95.7a	3
TAES3365	1.0	25.0	30.0	0
TAES3366	61.6	83.3a	87.7a	2
TAES3367	19.0	46.7	51.7	0
TAES3368	1.0	7.3	16.7	0
TAES3372	31.6	66.7	55.0	0
TAES3477	6.6	21.7	31.7	0
DALZ8501	5.0	41.7	43.3	0
DALZ8502	3.0	5.0	13.3	0
DALZ8503	55.0	91.7	82.0a	1
DALZ8504	28.3	56.7	40.0	0
DALZ8505	66.6	86.7a	84.3a	2
DALZ8506	51.6	90.0a	85.0a	2
DALZ8507	48.3	96.7a	78.3	1
DALZ8508	36.6	45.0	40.0	0
DALZ8510	45.0	81.7a	74.0	1
DALZ8511	70.0	95.0a	93.7a	2
DALZ8512	60.0	92.3a	93.3a	2
DALZ8513	5.6	43.3	66.7	0
DALZ8514	56.6	90.0a	80.7a	2
DALZ8515	55.0	95.7a	90.0a	2
DALZ8516	31.6	35.0	45.0	0
DALZ8517	43.3	60.0	75.0	0
DALZ8518	71.6a	92.7a	91.7a	3
DALZ8519	51.6	90.0a	58.3	1
DALZ8520	61.6	90.0a	75.0	1
DALZ8522	0.0	26.7	38.3	0
DALZ8523	0.0	15.0	33.3	0
DALZ8524	38.3	70.0	61.7	0
DALZ8701	0.0	4.3	21.7	0
DALZ9001	43.3	90.0a	60.0	1
DALZ9002	43.3	81.7a	85.0a	2
DALZ9003	53.3	88.3a	68.3	1
DALZ9004	40.0	86.7a	88.3a	2
MSD entry[3]	10.5	16.6	18.7	

[1]PS = Phenotypic Stability, the number of times an entry received superior ratings on the Waller-Duncan k-ratio t test (k-ratio=100).
[2]Means followed by the same letter within a column are not significantly different based on the Waller-Duncan k-ratio t test.
[3]MSD = minimum significant difference for comparison of entry means within columns based on the Waller-Duncan k-ratio t test.

Table D3. Percent weed cover, rated June 10, 1991, and turfgrass quality (5 is minimum acceptable turf), rated on August 15 on zoysiagrasses planted to TRIF.

Entry	% Weed Cover	Turf Quality
Belair	1.6a[1]	4.0
El Toro	6.6a	5.3
Emerald	7.3a	4.7
FC13521	8.3a	3.0
Meyer	1.6a	5.0
Midwest	2.3a	4.3
TAES3356	5.0a	5.0
TAES3357	0.7a	7.0a
TAES3358	0.0a	7.7a
TAES3359	0.0a	6.0
TAES3360	0.0a	7.0a
TAES3361	6.6a	1.7
TAES3362	4.3a	4.7
TAES3363	6.6a	5.7
TAES3364	3.3a	6.7a
TAES3365	12.6	2.7
TAES3366	3.3a	5.0
TAES3367	8.3a	3.7
TAES3368	13.3	1.7
TAES3372	3.3a	3.0
TAES3477	16.0	2.0
DALZ8501	9.3	1.3
DALZ8502	10.3	4.7
DALZ8503	5.0a	2.7
DALZ8504	20.0	5.3
DALZ8505	3.3a	4.3
DALZ8506	6.6a	5.3
DALZ8507	8.3a	3.0
DALZ8508	15.0	3.3
DALZ8510	6.6a	4.0
DALZ8511	4.0a	6.3a
DALZ8512	0.6a	5.7
DALZ8513	9.3	3.7
DALZ8514	0.0a	4.3
DALZ8515	6.0a	5.3
MSD entry[2]	11.0	1.5

[1]Means followed by the same letter within a column are not significantly different based on the Waller-Duncan k-ratio t test.
[2]MSD = minimum significant difference for comparison of entry means within columns based on the Waller-Duncan k-ratio t test.

Table D3 (cont). Percent weed cover, rated June 10, 1991, and turfgrass quality (5 is minimum acceptable turf), rated on August 15 on zoysiagrasses planted to TRIF.

Entry	% Weed Cover	Turf Quality
DALZ8516	13.3	3.0
DALZ8517	5.0a	4.0
DALZ8518	4.3a	6.0
DALZ8519	0.0a	3.3
DALZ8520	10.6	4.0
DALZ8522	16.6	3.0
DALZ8523	5.0a	2.3
DALZ8524	7.3a	3.7
DALZ8701	11.6	1.7
DALZ9001	6.6a	3.0
DALZ9002	2.6a	5.0
DALZ9003	8.3a	4.0
DALZ9004	3.3a	5.0
MSD entry[2]	11.0	1.5

[1]Means followed by the same letter within a column are not significantly different based on the Waller-Duncan k-ratio t test.
[2]MSD = minimum significant difference for comparison of entry means within columns based on the Waller-Duncan k-ratio t test.

APPENDIX E

ZOYSIAGRASS HYBRIDIZATION - PROGENY DEVELOPMENT

INTRODUCTION: Morphological, floral, and seed production characters have been recorded on accessions from China, Japan, Korea, and the Philippines. Cultivar development to this stage, relative to the Oriental collection, has emphasized selection from these original accessions. Seed has been harvested from open pollinations and germinated to yield a number of progeny populations. Continued hybridization and progeny evaluations are necessary to enhance cultivar development and to combine desirable morphological and agronomic characters identified in selected parents.

JUSTIFICATION: Although seed production capacity is a key goal, hybridizations attempting to combine desirable turf characteristics are also needed. The present population includes genotypes with fine leaf texture, dark green color, vigorous growth habit, and disease resistance/tolerance.

OBJECTIVES:

1. Use self, crossed, and open pollinations to obtain seed for progeny evaluations of zoysiagrasses with desirable turf morphological and physiological characteristics.

2. Advance progeny through multiple cycles of selection to combine superior turf performance characters with or without high seed production potential.

PROGRESS: Progeny evaluation is underway for selected accessions. A space planting was established August 1, 1989, by placing 822 1-inch plugs on 3 foot centers. Plants were generated from 3 seed sources of Zoysia sinica acquired from China, as well as seed produced from the Texas A&M-Dallas breeding program. The latter group included progeny which were generated from 9 high seed-producing genotypes and 4 elite DALZ selections. Although the Z. sinica seed lots resulted in most plants with a medium-coarse texture and light green color, extremes in variability were noted. Survival, spread, color, and texture ratings were recorded,and the best plants were selected in 1990 for advanced testing.

More than 1500 progeny were generated for a second space planting. Of these progeny, 976 were planted on 3 ft. centers from July through September, 1990. These progeny were produced from open, self, and cross pollinations of advanced TAES lines and commercial varieties. Included in this planting was a parent-progeny space planting to compare phenotypic and growth factors in a replicated trial. For each parent there were 16 progeny evaluated.

Ratings taken on these plots during 1991 included spring greenup percentages, turf color, green percent plot cover, turf texture, and turf quality. Progeny from Belair, El Toro, DALZ8511, and DALZ8512 achieved more rapid spring greenup than other progenies (Table 1). DALZ8523 had no green leaves present by March 24, 1991. FC13521 and DALZ8515 progeny had the highest turf quality, best color, and best plot coverage as of

October 4, 1991 (Table 2). Both were ranked medium in texture. Good quality was also noted in progeny from Belair, El Toro, Emerald, DALZ8511, DALZ8512, DALZ8514, and DALZ8515.

A third planting in October 1990 included 88 accessions from the zoysiagrass collection in Beltsville, MD. Each accession was replicated 3 times, with each 36 ft^2 plot started from a 9 in^2 plug. Plants were evaluated during the spring of 1991 for percent green turf plot coverage, color, and turf quality. There was little difference in color or quality among progenies, except that TAES3361 and TAES3581 were poorer than the rest. Overall ratings were best in El Toro, TAES3356, TAES3363, and TAES3366 progenies, due to superior plot coverage.

FUTURE WORK:
when flowering, accessions selected for desirable turf characteristics will continue to be isolated for self and/or cross pollinations. Previous floral induction attempts were of limited success, but will be used whenever natural flowering diminishes. Progeny will continue to be assessed for flowering habit, morphology, and quality attributes.

Table E1. Zoysiagrass progeny evaluation for spring greenup percentages, rated from February 2 to March 24, 1991 for zoysiagrasses planted in July, 1990.

	Rating Date					
Entry	Feb.2	Feb.20	Feb.24	Mar.10	Mar.17	Mar.24
BELAIR	1	2	4	7	8	11
CASHMERE	0	0	0	1	1	2
EL TORO	2	5	9	14	15	20
DALZ8501	0	0	1	1	1	2
DALZ8502	0	0	1	1	1	2
DALZ8511	1	2	5	9	9	11
DALZ8512	2	4	8	12	15	19
DALZ8513	0	0	0	0	1	2
DALZ8514	0	1	3	4	5	7
DALZ8616	0	0	1	2	3	5
DALZ8523	0	0	0	0	0	0
MSD[1]	2	3	2	6	7	9

[1]MSD = minimum significant difference for comparison of means within columns based on the Waller-Duncan k-ratio t test (k-ratio = 100), rounded to the nearest whole number.

Table E2. Zoysiagrass progeny evaluation, rated October, 1991 for color (1-9), green plot cover (1-9), texture (1-5, 1=coarse, 5=fine), and quality (1-9), planted July - September, 1990.

Entry	Color	Cover	Texture	Quality	PS[1]
BELAIR	3.3a	3.7	1.6a	2.7a	3
CASHMERE	2.8	2.9	1.9a	2.4	1
EL TORO	3.3a	3.1	1.5a	2.6a	3
EMERALD	3.7a	3.2	2.0a	2.7a	3
FC13521	4.4a	7.0a	2.7a	4.6a	4
DALZ8501	2.1	1.7	1.5a	1.6	1
DALZ8502	2.1	2.0	1.2a	1.6	1
DALZ8503	2.6	2.2	0.8	2.0	0
DALZ8507	1.8	0.8	1.5a	1.0	1
DALZ8508	1.0	0.6	1.0	0.8	0
DALZ8510	3.0	1.5	1.5a	1.5	1
DALZ8511	5.6a	6.0a	2.5a	4.5a	4
DALZ8512	3.8a	4.4	1.8a	2.9a	3
DALZ8513	2.6	2.1	1.4a	1.9	1
DALZ8514	3.3a	3.1	1.6a	2.6a	3
DALZ8515	4.0a	5.2a	2.0a	3.6a	4
DALZ8516	1.9	1.6	1.0	1.2	0
DALZ8522	0.0	0.0	0.0	0.0	0
DALZ8523	2.6	3.5	1.6a	2.5	1
DALZ8524	0.7	0.7	0.2	0.6	0
DALZ8701	0.0	0.0	0.0	0.0	0
MSD[2]	2.4	2.5	1.5	1.9	

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

Table E3. Zoysiagrass progeny evaluation, rated spring, 1991 for % total plot cover (CVR), turf color (COLOR 1-9, 9 = best), and turf quality (TQ 1-9, 9 = best), planted October, 1990.

ENTRY	CVR	COLOR	TQ	PS[1]	ENTRY	CVR	COLOR	TQ	PS
BELAIR	18.5	6.5a	6.5a	2	T3494	20.0	5.0a	5.0a	2
ELTORO	81.7a	6.3a	6.3a	3	T3495	31.7	6.3a	6.3a	2
EMERALD	6.7	4.7a	5.3a	2	T3496	16.0	5.7a	5.7a	2
MEYER	12.3	5.3a	6.0a	2	T3497	9.3	5.3a	5.0a	2
Z8501[2]	2.3	3.3a	3.3a	2	T3498	13.7	5.3a	5.7a	2
Z8502	3.3	3.3a	3.3a	2	T3499	20.0	6.0a	5.3a	2
Z8701	11.0	4.3a	4.7a	2	T3500	10.0	4.3a	4.3a	2
T3356[3]	73.3a	4.7a	5.7a	3	T3501	13.7	5.0a	5.7a	2
T3357	46.7	3.3a	3.7a	2	T3502	14.0	5.7a	6.3a	2
T3358	41.7	5.0a	6.3a	2	T3503	11.7	3.3a	3.7a	2
T3359	53.3	5.3a	6.0a	2	T3504	10.0	3.3a	3.7a	2
T3360	26.7	5.0a	5.7a	2	T3505	11.7	3.7a	3.7a	2
T3361	2.7	1.7	2.0		T3506	20.0	5.3a	6.0a	2
T3362	16.0	4.0a	4.3a	2	T3507	4.0	5.3a	4.7a	2
T3363	66.7a	6.0a	6.7a	3	T3508	30.0	5.0a	5.0a	2
T3364	36.7	4.0a	5.0a	2	T3509	21.7	5.7a	5.7a	2
T3365	8.3	5.0a	4.7a	2	T3510	12.3	5.3a	5.7a	2
T3366	75.0a	4.7a	5.3a	3	T3511	18.3	5.0a	6.0a	2
T3367	11.0	2.7a	3.3a	2	T3512	8.3	5.3a	5.0a	2
T3368	0.0	0.0	0.0	0	T3513	21.7	5.3a	5.3a	2
T3483	21.7	3.0a	3.3a	2	T3514	18.3	5.3a	6.0a	2
T3484	16.7	5.3a	5.7a	2	T3515	6.7	5.3a	5.0a	2
T3485	11.0	5.7a	5.3a	2	T3516	25.0	5.3a	5.0a	2
T3486	7.7	3.3a	3.0a	2	T3517	21.7	4.0a	6.0a	2
T3487	19.0	4.7a	5.0a	2	T3518	13.3	3.3a	4.0a	2
T3488	19.3	5.7a	5.3a	2	T3519	17.0	5.0a	5.3a	2
T3489	40.0	5.7a	6.3a	2	T3520	41.7	6.3a	7.0a	2
T3490	15.0	6.3a	6.7a	2	T3521	58.8	5.0a	5.5a	2
T3491	14.7	4.3a	5.0a	2	T3522	35.0	5.7a	5.3a	2
T3492	31.7	5.3a	5.0a	2	T3523	21.7	3.0a	3.0a	2
T3493	10.0	3.3a	3.3a	2	T3524	40.0	4.3a	4.7a	2
MSD[4]	22.9	5.0	4.4		MSD	22.9	5.0	4.4	

[1]PS = phenotypic stability, the number of times an entry received superior ratings based on the Waller-Duncan k-ratio t test.
[2]Z - D = abbreviation for DALZ lines.
[3]T - T = abbreviation for TAES lines.
[4]MSD = minimum significant difference for comparison of entry means within columns based on the Waller-Duncan k-ratio t test (K-ratio = 100).

Table E3 (cont). Zoysiagrass progeny evaluation, rated spring, 1991 for % total plot cover (CVR), turf color (COLOR 1-9, 9 = best), and turf quality (TQ 1-9, 9 = best), planted October, 1990.

ENTRY	CVR	COLOR	TQ	PS[1]	ENTRY	CVR	COLOR	TQ	PS
T3525	18.3	3.0a	3.3a	2	T3557	10.7	5.3a	5.3a	2
T3526	23.3	2.7a	3.3a	2	T3558	35.7	6.3a	6.3a	2
T3527	16.0	4.0a	3.7a	2	T3559	33.3	5.7a	6.0a	2
T3528	35.0	5.3a	5.3a	2	T3560	16.7	6.3a	6.3a	2
T3529	46.7	6.0a	6.3a	2	T3561	11.0	4.7a	4.0a	2
T3530	25.0	5.0a	5.0a	2	T3563	34.3	5.7a	5.3a	2
T3531	27.5	5.5a	6.0a	2	T3564	38.3	5.7a	6.0a	2
T3532	28.3	5.7a	5.3a	2	T3565	21.7	5.3a	5.0a	2
T3533	8.7	5.0a	5.0a	2	T3566	73.3	5.7a	6.3a	2
T3534	36.7	5.7a	5.3a	2	T3567	29.0	5.7a	6.3a	2
T3535	29.0	5.0a	5.3a	2	T3569	35.0	5.7a	6.7a	2
T3536	20.3	6.3a	6.0a	2	T3570	45.0	5.3a	5.7a	2
T3537	10.7	3.7a	3.3a	2	T3571	21.7	3.3a	3.3a	2
T3538	41.7	5.0a	5.3a	2	T3572	3.7	4.0a	4.3a	2
T3539	5.7	4.3a	4.7a	2	T3573	0.0	0.0	0.0	0
T3540	4.0	4.0a	4.3a	2	T3574	11.3	6.3a	6.0a	2
T3541	9.3	5.3a	5.7a	2	T3575	38.3	5.3a	5.7a	2
T3542	9.0	5.0a	5.3a	2	T3576	21.7	5.3a	5.7a	2
T3543	31.7	4.3a	5.3a	2	T3577	26.7	5.7a	6.0a	2
T3544	25.0	5.5a	5.0a	2	T3578	23.3	4.3a	4.7a	2
T3545	8.0	5.7a	5.7a	2	T3579	13.3	3.0a	3.3a	2
T3547	15.0	6.7a	6.0a	2	T3580	6.3	6.0a	5.7a	2
T3548	29.3	5.7a	5.7a	2	T3581	11.7	1.7	1.7	0
T3549	7.7	3.7a	4.0a	2	T3582	2.0	3.7a	3.7a	2
T3550	25.0	5.5a	6.0a	2	T3583	35.0	5.7a	6.0a	2
T3551	31.7	4.0a	5.0a	2	T3584	4.7	3.0a	3.3a	2
T3552	12.7	6.0a	6.3a	2	T3585	5.0	5.3a	5.3a	2
T3553	31.7	5.0a	4.7a	2	T3586	13.3	4.7a	5.7a	2
T3554	46.7	4.7a	5.3a	2	T3587	2.3	3.3a	3.3a	2
T3555	53.3	5.7a	6.3a	2	T3588	24.3	5.7a	6.0a	2
T3556	28.3	4.7a	4.7a	2	T4394	30.0	4.0a	4.0a	2
MSD[2]	22.9	5.0	4.4		MSD	22.9	5.0	4.4	

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