SIXTH
ANNUAL PROGRESS REPORT

concerning

BREEDING AND DEVELOPMENT OF ZOYSIAGRASS

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Index

BREEDING AND DEVELOPMENT OF ZOYSIAGRASS

EXECUTIVE SUMMARY

SIXTH ANNUAL ZOYSIA PROGRESS REPORT
ZOYSIAGRASS BREEDING AND DEVELOPMENT

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Dr. Bridget A. Ruemmele, Post Doctoral Research Associate

Research Period: 1 November 1988 to 1 November 1989

A major redirection within the zoysiagrass program occurred in 1989 with the addition of Dr. Richard H. White, as Assistant Research Scientist specializing in turfgrass physiology, and Dr. Bridget Ruemmele in turfgrass breeding. The combined efforts of the group have been directed specifically to the assessment of germplasm relative to stress tolerance mechanisms and the specific hybridization of selected accessions in order to study the relative heritabilities of such traits and to combine multiple desirable traits into new varieties.

Maintenance of the zoysiagrass germplasm nurseries will receive considerable attention these next few years due to the reduction in turfgrass research efforts on the part of the United States Department of Agriculture. The Oriental zoysiagrass collection will be consolidated and eventually entered into the Plant Introduction System. Vegetative maintenance and production of these accessions, as well as newly developed cultivars, has become streamlined and more expedient with the use of thin-layer sod production techniques developed here.

Numerous elite accessions of zoysiagrasses have been evaluated for water-use requirements under field conditions using the Linear Gradient Irrigation System (LGIS). A parallel set of accessions are also being evaluated for growth response under the Turfgrass Root Investigation Facility (TRIF) as well as under heavy natural shade. The combined testing facilities suggest considerable genetic variability exist within the elite accessions (DALZ lines) as well as the Oriental collection. Of greatest promise is the variation noted for water-use, canopy temperature, growth response, growth habit, texture and turf quality. Regional trials suggest good variability exist among the lines under evaluation for cold hardiness, rate of spread, texture and turf quality.

Regional field trials have been established in several locations including Missouri, Illinois, Arizona, California, Oklahoma and Florida as well as several locations in Texas. Electrophoresis has been completed on 23 DALZ lines by Dr. Lin Wu, University of California - Davis.

DALZ8501 and DALZ8502 have been identified for their superior regrowth and recovery ability due to highly rhizomatous growth characters. DALZ8502 has potential for use in the deep south for putting greens. It retains an excellent winter growth characteristic, has been identified as a low water-user, and has a relatively low nutritional requirement. Additional testing will be initiated for its potential use on the putting surface. Foundation production fields of both DALZ8501 (1.0 acres at TAES-Dallas) and DALZ8502 (1.7 acres in Bay City, Texas) were planted in the spring of 1989.

Numerous selections have been identified in the Oriental Collection for turf quality, color retention, greenup, drought hardiness, seed production potential, and numerous desirable agronomic traits. Considering the cold susceptibility of DALZ8501, and DALZ8502, it will be necessary to concentrate on identifying and developing accessions with considerably more winter hardiness.

SIXTH ANNUAL ZOYSIAGRASS REPORT 1989

M. C. Engelke, R. H. White, B. A. Ruemmele

I. INTRODUCTION

The Zoysiagrass Breeding and Development program is entering its seventh 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 $247,085 has been directed by the USGA/GCSAA research to the zoysiagrass breeding program. The annual grant of $40,000 was increased to $45,000 in 1989. In order for the program to continue at the level it is presently operating, additional funding will be necessary in the near future. This is the sixth annual report to be submitted and will address project activities especially for the period November 1, 1988 through November 1, 1989.

II. TECHNICAL SUPPORT PERSONNEL

A major adjustment in personnel occurred on the zoysiagrass breeding program in 1989.

Ms. Melinda Quick, former Research Assistant, resigned her position with the zoysiagrass program, was married and moved to Michigan.

Dr. Bridget Ruemmele (Vita Appendix A) was employed January 1989 as Post-Doctoral Research Associate on the Turfgrass Breeding Program. Dr. Ruemmele completed her Ph. D. under the direction of Dr. Don White and Dr. Pete Ascher at the University of Minnesota in January 1989. Dr. Ruemmele has joined the staff as Turfgrass Breeder and has responsibilities for working with several species including tall fescue, St. Augustinegrass, buffalograss and zoysiagrass. Funding for Dr. Ruemmele's position is provided in its entirety by Texas Agricultural Experiment Station. Approximately 60% of her time is directed to the zoysiagrass breeding program, with specific emphasis being directed to germplasm development.

Mr. Robert Cunningham provides part-time technical assistance for Dr. Ruemmele and is funded entirely from contracts with numerous chemical companies for product evaluation.

Dr. Richard H. White (Vita Appendix A) joined the Turf Breeding Staff at TAES-Dallas effective 1 May 1989 as an Assistant Research Scientist. Formerly an Assistant Professor at Cook College, Rutgers University, Dr. White received his Ph. D. under Dr. Richard Schmidt, Virginia Polytechnical Institute, in Turfgrass Physiology, and his Master's degree under Dr. Ray Dickens, Auburn University, Alabama. Dr. White's responsibilities center on the physiological development of zoysiagrass germplasm with special emphasis on drought resistance and water use characters. Approximately 80% of Dr. White's time is spent on the zoysiagrass breeding program.

Ms. Sharon Morton has joined the zoysiagrass breeding program effective 1 September 1989, under the supervision of Dr. White's efforts. Ms. Morton (Vita Appendix A) has a master's degree in Biology from Texas Christian University. She was pursuing her Ph.D. degree in Botany at Miami of Ohio prior to moving to the Dallas area. Ms. Morton's position is funded entirely from contracts with numerous chemical companies for product evaluation.

III. IMPLEMENTATION

A. GREENHOUSE STUDIES

1. GERMPLASM MAINTENANCE

The *Zoysia* spp. germplasm of over 800 unique accessions continues to be maintained in Deepots in the greenhouse to insure individual integrity. Individual plants have been maintained and held in this high density arrangement under greenhouse conditions since 1983. Less than 1% cross pegging (contamination) occurs between pots. This high density arrangement increases space efficiency by approximately 50% over terra-cotta pots of similar size. This procedure simultaneously provides a fixed position for ease of cataloging and a significant reduction in risk of germplasm contamination. Repotting occurs every 3-4 years and is scheduled for the winter of 1989/90.

In October 1988, Mr. J. J. Murray, USDA, ARS, Beltsville, Maryland retired due to medical reasons and in February 1989 his position was officially closed. To date, none of the zoysiagrass germplasm collected in 1982 has been entered into the United States Department of Agriculture Plant Introduction(PI) System. A preproposal has been submitted to the USDA Germplasm Crop Advisory Committee for Grasses to support a research project developing a CORE collection of zoysia from the Oriental Collection to be included in the PI system (Appendix B). Tentative approval of the proposal has been made. A full proposal will be developed and submitted by January 1990. In addition, a cooperative proposal is being developed between TAES-Dallas and the USDA PI Center - Griffin, Georgia for the short-term (3-5 years) maintenance of the germplasm collection until necessary facilities can be constructed at Griffin, Georgia where the CORE collection will ultimately be maintained.

An additional 150 plants were obtained from J. J. Murray's collection in November 1988 for inclusion in the current breeding program. Additional efforts will be made over the next few months to insure the critical genetic diversity available in the United States is included or represented in the CORE collection.

2. GERMPLASM PROPAGATION

a. DEVELOP TECHNIQUES FOR RAPID VEGETATIVE PRODUCTION.

INTRODUCTION: Advanced stages of variety testing require an adequate supply of planting stock of each experimental accession. Previously, limited quantities of stock were provided to cooperators, which required further increase prior to planting. This additional step of further increasing plant material prior to field planting has resulted in 1) fewer willing cooperators due to limited greenhouse space and labor required for increase, and 2) frequent contamination between accessions or loss of identity.

We have initiated studies to develop techniques which will accelerate vegetative propagation of numerous individual accessions while maintaining genetic integrity. Such steps are necessary to support extensive regional testing by providing adequate material for making direct field plantings.

Consideration is also given to developing an alternate production system (APS) which may be applicable to commercial production. Some turfgrasses, especially of the genus Zoysia, are slow to establish even under the best of field conditions. A production system which is more expedient would permit producers to predict future sales more accurately, thereby increasing efficiency and reducing capital risk. Such a system must be economically feasible, while providing a high quality product in a timely fashion, and must be flexible enough to blend with a variable market. Storage systems to maintain mature APS sod would also improve the capacity of suppliers to meet market demands (see next section). Several commercial chemical companies have provided limited funding to evaluate the influence of chemical amendments (nutritional and biostimulants) on production time under APS.

Sod production, using an alternate production system consisting of a thin layer (approximately 1/2" thick) of selected medium supplemented with nutrients, may provide a production technique which can be more readily responsive to seasonal markets and has a shorter production time than conventional sod production. This should result in higher economic efficiency with lower financial risk.

OBJECTIVE: Develop alternate methods of turfgrass propagation which will accelerate production time, maintain genetic integrity of planting stock and possibly have commercial appeal. Investigations include production time, shelf life and establishment ease.

PROGRESS: Several media and media amendments have been evaluated for potential use in vegetative production of plants grown on plastic with minimal soil and/or soilless media. Initial experiments used sand and rice hulls alone or in combination with either peat moss or water absorbing polymers. Generally, pure sand or pure rice hulls were inadequate in promoting growth when compared to using them in combination with peat and/or vermiculite. Water-absorbing polymers reduced the amount of time to reach complete coverage of a plot area, as well as reducing the water stress during peak stress periods. However, due to their relatively high cost, it may be difficult to judge their feasibility for large scale production.

The most recent experiment (Figure 1) included 5 media and 13 media amendments using DALZ8502 plant material. The media included: grass clippings, 50% grass clippings with 50% sand, rice hulls, composted rice hulls, and a peatlite mix (Fafard brand). Media amendments included rates of 1/2, 1, or 2 pounds N per 1000 square feet using fertilizers with ratios of 10-2-6, 5-10-3, 10-10-10, 18-46-0 and 1-0-1. The latter amendment is derived from a certain type of seaweed and is actually recommended for its water-holding capacity, rather than the fertility component.

The response invoked by the supplemental nutritional source significantly influenced growth performance and also differed among growth media (Table 1). Comparing percent cover on all five media at the 2 lb. N rate, peatlite was superior to composted rice hulls and rice hulls after 12 weeks. Rice hulls, composted rice hulls, and grass:sand media were similar in responses, although growth rates were variable among media amendments. The grass medium decomposed at a steady rate throughout the duration of the experiment, consistently ranking at the bottom of all ratings for each media amendment, and would not be recommended for use alone. There were exceptions, however, where plant growth was rapid enough to form a mat prior to major grass decomposition. In combination with rice hulls, decomposing grass clippings may be an inexpensive alternative to other media, with the additional benefit of being lightweight for shipping. These results indicate interactions between nutrient sources and media, which will require further consideration in interpretation of results.

FUTURE WORK: Additional greenhouses will be constructed in 1989/90 to accommodate germplasm maintenance and production studies, and to support selection of plant materials for superior establishment characters.

b. INCREASING SHELF-LIFE OF VEGETATIVELY PRODUCED TURFGRASS

INTRODUCTION: Successful development of an APS for turfgrasses must be coupled with procedures for extending the 'shelf-life' of the product. Production of turfgrasses using systems which drastically restrict root extension dramatically increases long term maintenance cost. All moisture, nutrition and physical support must be provided in an atypical fashion. If the production cycle is out of sequence with the normal field planting/establishment cycle, it is necessary to preserve the product with maximum viability at minimal maintenance cost.

OBJECTIVE: Evaluate the shelf-life of zoysiagrasses grown on APS (thin-layer) and placed in cool storage at 4 °C with no supplemental light, moisture or nutrients.

PROGRESS: In late January 1989, APS-produced sod of DALZ8502 and an advanced St. Augustinegrass selection were subjected to cold storage to determine the feasibility of long term storage. Twenty 12 inch x 18 inch sections were cut from each 5 month old sod pad. Half of each piece was treated with an anti-transparent (Folicote (R)) and the other half was left untreated. The sod pieces were then stacked, bagged, and placed in cold storage at 4 °C (39 °F). The sod received no additional light, fertilizer or water until being removed from storage beginning 3 weeks later. A single piece of sod for each species was removed from storage on a weekly basis. The sod pad was placed on a 24-cell tray containing composted rice hulls.

Initial results indicate 95+% survivability of DALZ8502 is probable after a 14-week cold storage treatment. However, root initiation is slower for longer cold storage exposure. The St. Augustinegrass suffered considerably more chilling damage after 9 weeks in storage. The 'Folicote' treatments appeared to have no effect on either grass, regardless of treatment time.

The final four sections of each species were still in cold storage as of September (30 weeks). One piece of each species was removed at that time. No recovery has been observed on the St. Augustinegrass. Green tissue present on the zoysiagrass sample upon removal from the cooler rapidly discolored and died. However, new tissue emerged within a few days, indicating that crown tissue survived and was able to initiate vegetative growth after 7 months without supplemental light, moisture, or nutrients. The remaining 3 sections of zoysiagrass will be removed at monthly intervals.

Another experiment was initiated 14 September 1989 to examine cold storage survival and regrowth of the same zoysiagrass over an 18 month period. Sod samples produced by the aforementioned alternate production system will be removed at biweekly intervals for survival and regrowth assessment.

FUTURE WORK: This study will continue until all sod has been taken from cold storage and evaluated for survival and regrowth. This experiment will be terminated earlier than 18 months if total necrosis is indicated in prior samples.

Storing sod in this thin-layer format has distinct advantages in being more compact, and lighter in weight compared to maintaining extensive field plots or expensive greenhouse operations. The thin-layer format is immediately ready for transport, even across country. Where cold storage facilities are not available, APS sod can be 1) marketed directly for immediate planting as a solid "rug", or 2) transferred immediately to trays for additional growth, rooting and eventual marketing as plugs. Trays containing plugs are likewise an effective means of extending the shelf-life of the product while maintaining the marketability and quality of the product.

B. FIELD EVALUATION AND PRODUCTION TRIALS:

1. DALLAS FIELD TRIAL - MANAGEMENT

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 started to increase as new cultivars have emerged and the potential of several experimental selections has become apparent. The acceptance and utilization of new cultivars of zoysia is also dependent on the development of appropriate and efficient management strategies. Emphasis must be placed on determining the minimum and optimum requirements for producing superior turf, with particular attention given to turf quality, persistence, and thatching tendency relative to fertilization and mowing.

OBJECTIVES: Develop and refine cultural strategies and practices that optimize turf quality and resource efficiency for existing and newly developed zoysiagrass cultivars for the southern regions of the United States.

PROGRESS: During the winter of 1987 to 1988, plant material was increased under greenhouse conditions to accommodate a 1:36 (1 sq. ft. of sod to 36 sq. ft. land surface) field expansion planting ratio. The field planting material consisted of 1.5" plugs planted on 1 foot centers. The field plot design is a randomized complete block, consisting of three replications of 10 varieties. Plot size is 5.79 m by 4.27 m (19 ft. by 14 ft.). The cultivars in this management trial include Meyer, Emerald, El Toro, Belair, and two proprietary lines, designated TAES3372 and TAES3477. Experimentals include DALZ8501, DALZ8502, DALZ8508, and DALZ8516. These same materials are in Regional Field Trials.

Evaluation of the establishment rates of entries was initiated 15 days after planting and will continue until all entries are fully covered. TAES3477 and El Toro established significantly faster from plugs than other entries. About 16 weeks after planting, TAES3477 and El Toro were about 95% covered. Meyer, DALZ8501, and DALZ8508 were about 65% covered and all other entries were less than 50% covered (Table 2).

DALZ8501 and DALZ8502 had significantly more green plot area on 23 November 1988 than all other entries except TAES3372 and TAES3477 (Table 3). TAES3372 had significantly more green plot area than all other entries except Emerald. Meyer and Belair had only 25 to 30% green coverage in late November. Appreciable growth ceased in November 1988, although full winter dormancy did not occur until February 1989 following 4 inches of ice and 114 hours of sub-zero temperatures in the Dallas area.

El Toro had the highest and DALZ8502 the least plot coverage approximately 1 year after planting (Table 3). Turf density was above average for all entries 1 year after planting except for TAES3372, DALZ8501, DALZ8502, and DALZ8516. TAES3477 and El Toro were the most uniform entries and Belair and TAES3372 the least uniform.

Greenup was noted in some plots by the end of February, however, a second ice storm in early March killed all visible green leaves. All plots had visible green leaves by 20 March 1989 and greenup notes were reinitiated, although late spring frosts greatly delayed spring greening during 1989. Emerald, Meyer, and DALZ8508 greened more rapidly and appeared less susceptible to late frosts than other entries (Table 4).

TAES3477, DALZ8501, DALZ8502, and DALZ8516 appear to suffer more winter damage and greened more slowly than other entries. These occurrences may be related to their late color retention in the fall. This relationship needs further investigation.

FUTURE WORK: Routine evaluation of all entries will continue during 1989 and 1990. Management treatments have been delayed because of an early fall and will be imposed during spring 1990. Initial determinations of entry response to treatment variables will begin at that time. Management treatments will center on fertilization and mowing height frequency. Performance of entries will be based on turf density, uniformity, color, fall color retention, spring greening, resistance to pests and environmental stresses, and thatching tendency.

2. LINEAR GRADIENT IRRIGATION SYSTEM

INTRODUCTION: The 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. Approximately 50% of municipal water supplies are used for maintaining urban Texas landscapes during moisture stress periods.

The linear gradient irrigation system (LGIS) at TAES-Dallas was developed specifically to evaluate water requirements of newly developed turfgrasses under actual field conditions. Meteorological data and plant responses are being used to determine minimum irrigation levels required by major turfgrass species in an attempt to substantially reduce supplemental irrigation requirements. The performance of newly developed turfgrasses is being evaluated with a full gradient of supplemental irrigation to determine the minimum amount of water required to sustain a turf that will persist and stabilize the soil and the minimum amount of water required to maintain actively growing turf with acceptable quality. Additionally, LGIS will facilitate the determination of mechanisms responsible for superior drought resistance under field conditions.

Characterizations of these grasses as to drought resistance in contrasting environments will allow identification of morphological and physiological characters which favor excellent performance under adverse environments and to identify stable genetic markers easily utilized in the selection process. Such characterizations will aid turfgrass breeders in choosing parental germplasm and in developing breeding objectives. The development and implementation of techniques to rapidly identify stress tolerant germplasm will accelerate the development and release of drought resistant turfgrass cultivars and is essential for a well defined results-oriented breeding program.

OBJECTIVE: The primary objective of this project is to develop new turfgrasses which will significantly reduce (by 50 to 75%) the amount of water required to maintain quality turf.

PROGRESS: Construction of the LGIS system was initiated in the Spring of 1986 with only the four major grasses for the water management section being established by fall 1986. This section includes plots which are each 3.7 m by 20 m and are perpendicular to the center trench. The cultivars in this section include Falcon tall fescue, Meyer zoysiagrass, Texturf 10 bermudagrass, and Raleigh St. Augustinegrass.

Grasses were established in a second section for varietal evaluations during 1987 and 1988. A total of 25 different zoysiagrasses were selected and increased for inclusion in LGIS experimental turfgrass trials and planted in 1987. This includes 19 DALZ zoysiagrass lines representing the elite selections and products of the turf breeding program thus far, plus 6 commercial cultivars. The zoysiagrass varietal evaluation trials and the water management studies are discussed separately.

a. VARIETAL EVALUATION TRIALS

The field design is a randomized complete block with two replications on either side of the line irrigation source for a total of four replications. Each experimental grass plot measures 1.5 m by 20 m, is perpendicular to the center trench, and covers approximately 20 m^2 (325 ft^2). Plots were planted with a 1:35 planting ratio. Fertilizer to provide 0.5 kg N are^{-1} per growing month was supplied during establishment.

Spreading of all experimental grasses was evaluated periodically by estimating coverage, color, spring greenup and overall turf quality. Estimates of coverage for the zoysiagrasses were initiated within 6 weeks of planting (Table 5). By September 1987, considerable variation in rate of coverage was noted among commercial and experimental lines. Of the commercial entries, El Toro, Korean Common and Meyer were similar in coverage (44.4%, 43.5%, and 36%, respectively). Notably, Korean Common was established from seed, whereas all other entries were vegetatively established.

Although further testing is essential, the initial performance of some of the DALZ lines shows considerable promise. By comparison DALZ8502, DALZ8507, and DALZ8512 were statistically similar in coverage to El Toro, Meyer, and Korean Common. Of particular interest is DALZ8502, a fine-leaved Z. matrella type, which will typically spread slower. DALZ8502 was selected for its excellent rhizome production and recovery characteristics. It appears that the initial establishment rate among the experimental lines may also be competitive with commercial cultivars. During 1988, all entries were 65 to 95% covered. Many of the DALZ lines were similar in coverage to commercial cultivars during July 1988 (Table 5). Particularly notable among the experimental lines are DALZ8512, DALZ8504, DALZ8511, DALZ8502, DALZ8517, and DALZ8516.

The rate of spring greenup was also highly variable among varieties. DALZ8516, DALZ8508, and DALZ8503 were the fastest to greenup and similar only to Korean Common by April 1989 (Table 5). Many of the other DALZ lines greenup similar to commercial varieties; however, some lines, such as DALZ8522 and

DALZ8523 greenup more slowly. Turf quality of the DALZ lines, in general, was good and most plots were established well enough for the stress cycle during 1989.

During 1989, the gradient was imposed beginning mid-July to create stress and to allow determination of: 1) water use requirements of these grasses, 2) supplemental irrigation required to keep the grasses alive, and 3) minimum amount of supplemental irrigation required to maintain acceptable turf quality. Rainfall during the first three quarters of 1989 was exceptionally high for north central Texas, with about 114 cm at TAES-Dallas. Average yearly rainfall for Dallas is about 71 cm. A 4 cm rain occurred on 7 August and was the last significant precipitation event until the gradient was temporarily terminated during the week of 10 September 1989 by 10 cm of natural rainfall. This relatively short term drought (32 days), however, did allow a full gradient and striking differences to occur among commercially available and experimental grasses.

Supplemental irrigation was monitored throughout the gradient during the 1989 season and water distribution was determined at 1.5 meter increments from the line source (Figure 2). The minimum supplemental irrigation required to keep the grasses alive and actively growing was then determined from least squares non-linear regression of irrigation distribution against distance from the line source and visual estimates of turf wilt and survival at 1.5 meter increments from the line source. Periodically during the gradient, canopy temperatures and net incident radiation were measured at 1.5 meter increments, and wind speed, air temperature, and relative humidity were monitored, and will be used to calculate water stress indices for individual grasses.

The irrigation gradient had a marked effect on turf performance (Figure 3) and on floral production (Table 6). For all plots, floral production decreased as stress levels increased. Striking differences occurred in expression of drought stress symptoms among the zoysiagrasses (Table 7; Figure 4). The first symptoms of stress were evident on 1 August 1989 but were interrupted by rainfall on 7 August. Beginning 22 August the position (1-12) from the line source of irrigation (position 1) where initial stress occurred was noted. Progressive stress response was evaluated every 2 to 5 days until significant fall rains occurred on 11 September 1989. DALZ8512, and DALZ8514 showed remarkable drought resistance characteristics throughout the stress period as compared to commercially available cultivars such as Meyer, FC13521, and Emerald. Of the commercial lines, El Toro and Belair were superior in performance to Meyer, but showed a higher degree of stress than DALZ8512 or DALZ8514. All five of these varieties are Zoysia japonica. Z. japonica typically have an open canopy with relatively broad leaves. Even after natural rainfall interrupted the gradient, stress was still evident on some plots 1 October (Table 7).

The superior drought resistance of DALZ8512 and DALZ8514 is demonstrated by the amount of supplemental irrigation required to sustain live, green turf of these experimentals compared to commercial cultivars (Table 8). Emerald and Meyer required about 7.6 cm (about 81,000 gallons per acre) of supplemental irrigation during the first 8 months of 1989 to sustain live green turf (Table 8). In contrast, DALZ8512 and DALZ8514, required only about 0.9 and 1.3 cm (about 9,500 and 14,000 gallons per acre), respectively, of supplemental irrigation during the same period. Thus, over 60,000 gallons per acre (GPA) less supplemental irrigation water was required by DALZ8512 and DALZ8514 than Emerald and Meyer. Compared to El Toro, a product of California breeding efforts and selected for superior drought resistance, DALZ8514 required over 30,000 GPA less water to sustain live, green, actively growing turf.

b. WATER MANAGEMENT STUDIES - MAJOR SPECIES

Cooperative project with Dr. Garald Horst, El Paso, and Dr. J. B. Beard, College Station.

Results from physiology studies at TAES-Dallas are preliminary at present and studies need additional stress cycles to fully develop baseline information or water use. Extensive information was collected during 1989 and will require additional time for data organization and interpretation with regard to plant water stress indices. However, notable information was obtained during 1989 in relation to water requirements of turfgrasses commonly grown in north central Texas. The irrigation gradient had a marked effect on performance of the grasses in this section of LGIS (Figure 5.) Raleigh St. Augustinegrass required no supplemental irrigation during 1989 to sustain live, actively growing turf (Table 9). Texturf 10 bermudagrass was intermediate in water requirement of the four turfgrasses tested and needed about 50,000 GPA of supplemental irrigation during 1989 to sustain live, green turf. Meyer zoysiagrass and Falcon tall fescue were similar in reaction to drought stress and had similar supplemental irrigation requirements.

The grasses on LGIS are maintained with about 1 kg N are^{-1} $year^{-1}$. We have observed that over time this may be an insufficient amount for some of the grasses being evaluated. This is particularly true for Raleigh St. Augustinegrass and Texturf 10 bermudagrass. A general decline in overall turf quality has occurred for these grasses and appears to be due to nitrogen deficiency (data not shown). Steps may be required in the near future to correct this deficiency for long term use of the test area. These observations also point to a basic need for evaluation of turfgrasses under a range of N fertility programs.

FUTURE WORK: The information obtained from LGIS during 1989 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 both experimental and commercially available germplasm under field conditions and selection of water conserving turfgrasses. With long term use, LGIS will allow the identification of those grasses that will persist and function acceptably with little or no supplemental irrigation in North Central Texas. However, the information obtained is only a start toward the development of grasses with superior drought resistance. Presently, a tremendous need exists to gain a definitive understanding of the mechanisms involved in turfgrass drought resistance. The data from LGIS will allow the identification of superior germplasm under natural field conditions and provide experimental material with which to explore specific physiological and morphological characters that contribute to superior drought resistance. Such knowledge is vital to rapid breeding progress and cultivar development, as well as to our overall basic understanding of drought survival.

3. SHADE TOLERANCE TRIALS

INTRODUCTION: Zoysiagrasses are intermediate among warm season grasses in their ability to persist under heavily shaded conditions. Determination of light requirements for newly developed cultivars and experimental selections is essential to defining utilization guidelines.

OBJECTIVE: Identify the relative shade tolerance of commercial and elite experimental varieties of zoysiagrass.

PROGRESS: In cooperation with the city of Richardson, Texas, Parks and Recreation Department, a shade evaluation trial was established in mid-July, 1988 and again in mid-May 1989. The planting site is under low light conditions (only 15 to 20% of full sunlight) caused by dense shade from live oaks and cedar elms. Elite DALZ selections along with five commercial varieties, including Meyer, Emerald, El Toro, FC13521, and Belair, a proprietary line designated TAES3372, and TAES3477 were planted as 10 cm plugs on 0.6 m centers using a replicated randomized complete block design. Data was collected periodically on rate of spread, color, and density of stand.

In 1988, after 11 weeks under heavy shade, differences were evident for density, spread, and color. Several entries decreased in density over time, such as Meyer, El Toro, and DALZ8512. Other entries, such as DALZ8502, DALZ8514, DALZ8517, DALZ8524, and DALZ8701, showed improvement in density over the same time period. DALZ8516, a highly stoloniferous, low growing selection, and DALZ8510 had the best rate of spread, closely followed by DALZ8507, DALZ8515, and DALZ8508. DALZ8502 maintained excellent density once established, but spread weakly. The grasses were rated successfully for the last time on 30 September 1988 just before an event that had over 100,000 people in attendance, totally eliminated the experimental plots. At that time, turf canopy density, a sensitive indicator of shade tolerance, ranged from a low of 2.0 for DALZ8505 to 8.0 for DALZ8502 (Table 10). Although the density range was extreme, there was not a significant difference among entries.

In 1989, about 1 month after planting, differences were noted in turf quality among entries. DALZ8502, DALZ8508, and DALZ8516 had the best and DALZ8524 the worst overall turf quality. An evaluation on 26 September was the final evaluation during 1989 before traffic and wear from the annual event with crowds in excess of 100,000 eliminated the experimental plots. Evaluations of turf density have provided a good indication of shade tolerance of the zoysiagrasses during 1989. During late September 1989, significant differences were noted in density (Table 10). DALZ8523, DALZ8517, and DALZ8502 had the highest and Meyer, Belair, DALZ8505, and DALZ8506 the lowest density.

Based on average density at the last observation dates for 1988 and 1989, DALZ8502, DALZ8517, DALZ8523 are capable of maintaining acceptable density under shade and rank high in shade tolerance for the zoysiagrasses (Table 10). El Toro, FC13521, DALZ8516, DALZ8514, DALZ8524, and DALZ8507 are intermediate in shade adaptation. Belair, Emerald, and Meyer are ranked low in shade tolerance along with many of the DALZ lines.

FUTURE WORK: Future work will continue to explore the relative shade tolerance of zoysiagrasses. Because of problems associated with maintenance of experimental plots off station, another area will be sought for continued evaluation of experimental and commercially available zoysiagrasses.

4. TURFGRASS ROOT INVESTIGATION

INTRODUCTION: Attention is being directed to developing turfgrasses with greater root extension. Such root systems are capable of mining the subsurface moisture supply to provide superior persistence during prolonged periods of moisture stress. The turfgrass root investigation facility (TRIF) was designed to permit field assessment of root characteristics. TRIF will allow a comparative assessment of relative root distribution within the soil profile, and to confirm greenhouse screening procedures for root distribution.

OBJECTIVES: Determine rooting characteristics of zoysiagrass germplasm and the relationship between root characters and drought resistance. Additionally, other characteristics contributing to drought resistance, such as dehydration tolerance and turgor maintenance, will be determined.

PROGRESS: On 18 May 1989, commercial cultivars and experimental selections of zoysiagrass, buffalograss, centipedegrass, and St. Augustinegrass were planted in separate randomized complete block designs. All entries are replicated four times, except centipedegrass, which is replicated three times. All material was planted as 10 cm^2 plugs. The plants are uniformly fertilized with 0.5 kg N are^{-1} with a slow release 24-4-11 fertilizer every 2 weeks. The grasses are being evaluated for turf quality, rate of spread, density, and color. The root distribution densities of these grasses are being determined.

Turf color of DALZ8501, DALZ8506, DALZ8512, DALZ8524, TAES3362, and TAES3365 is good on this sand growing-medium (Table 11). Meyer, Belair, TAES3477, and DALZ8701 are poor in color ratings in the initial phases of this study. Rapid spread has occurred in DALZ8505, DALZ8512, DALZ8514, TAES3356, TAES3357, and TAES3363. Emerald, Meyer, DALZ8502, and DALZ8524 have been slow to spread (Table 11). The buffalograsses under evaluation in pure sand performed poorly.

Inflorescence counts and approximate culm heights were recorded 10 August, 1989 for all zoysiagrasses on TRIF (Table 12). Flowering and culm height varied significantly, with DALZ8523 and DALZ8513 producing the most inflorescences. DALZ8512 produced the longest culms.

FUTURE WORK: Root distribution will be periodically monitored during subsequent years of this study. Moisture stress will be imposed during the second and third years of the study to determine moisture stress tolerance of the entries and the relationship of root density distribution to drought resistance. Other characteristics, such as leaf firing, turgor maintenance, and tissue dehydration tolerance, will also be ascertained. We should also be able to determine which species can be accurately evaluated in this environment.

5. REGIONAL FIELD TRIALS:

INTRODUCTION: Regional field trials are utilized to define the area of adaptation and utility of improved zoysiagrasses in comparison to commercially available cultivars.

OBJECTIVE: Develop a base of information on the performance of these varieties under different environmental conditions and under various management practices.

PROGRESS: During the fall/spring of 1986/87, four elite experimental selections (DALZ8501, DALZ8502, DALZ8508, and DALZ8516) and four commercially available varieties (Meyer, Emerald, El Toro, and Belair) were provided to numerous research programs throughout the United States for extensive REGIONAL FIELD TRIALS. A list of cooperators, site locations, and trial types is specified in the 1987 annual report. Additional data from these sites was included in the 1988 annual report.

Specific locations cooperating in the Regional Zoysia Trial since 1986/1987 include:

1) University of Missouri in cooperation with Drs. John Dunn and Dave Miner;

2) Southern Illinois University - Carbondale in cooperation with Dr. Ken Deesberg (previously with Dr. Anna Marie Pennucci;

3) Oklahoma State University in cooperation with Drs. Mike Kenna and Joel Barber;

4) University of Arizona in cooperation with Drs. Charles Mancino and Dave Kopec;

5) University of California - Davis in cooperation with Mr. Ali Harivandi with field plantings and Dr. Lin Wu, with electrophoresis studies.

Two additional sites were established between November 1988 and May 1989:

6) Banyan Golf Course, FL., under the direction of Dan Jones; and

7) Palmetto Golf Club, FL, under the direction of Alan Wietzel (see May, 1989 Appendix).

Both provided space for management studies involving mowing and fertilization practices. These Regional Field Study site accessions were amended and abbreviated for the specific nature of the study. They included DALZ8501, DALZ8502, DALZ8508, DALZ8701, TAES3477 and Emerald.

8) Dr. Victor Gibeault, from the University of California - Riverside was added as a cooperator in May, 1989.

In addition to the same set of grasses distributed earlier, Drs. Gibeault and Dunn also received the additional DALZ accessions 8507, 8512, 8514, and 8701 during the same time period.

Regional trial results have recently been received from Drs. Lin Wu, UC-Davis; Charles Mancino, U of AZ; Ali Harivandi, UC-Santa Clara Field Station; and John Dunn, U of MO. Dr. Wu completed electrophoretic analysis of 12 of the original DALZ selections (Figure 6).

Dr. Harivandi's reports are summarized in Tables 13 and 14. DALZ8508 appears to have the best overall performance at the Santa Clara Station, although the other DALZ selections rank in the upper group for several ratings.

Dr. Mancino's reports from the U of AZ are included in Tables 15-17. Superior ground coverage has been noted for all DALZ selections. Other DALZ selections also rank high for color, density and texture ratings.

The report from Dr. Dunn is included in the form received (Appendix C). The 1987 planting succumbed, except for DALZ8508, of which 2 reps are doing well. The 1989 planting has not yet reached complete plot coverage, but several DALZ selections are reported favorably for spread.

6. ORIENTAL COLLECTION - FIELD PERFORMANCE

INTRODUCTION: Oriental zoysiagrass accessions have been maintained in replicated field trials since 1984, These plants have been evaluated for leaf type, growth rate, plant color, anthesis, onset and rate of spring greenup, canopy temperature, and sod regrowth potential. Field evaluation studies will continue to broaden the base of information available on these germplasm resources.

OBJECTIVE: Evaluate for spring greenup, flowering habit, and seed production potential. Following seed harvest, assess traffic tolerance.

PROGRESS: Spring and early summer evaluations included a greenup assessment, stage of floral development, degree of flowering, height of inflorescence, and anther and stigma color. In general, anthesis was asynchronous, with seed production and culm heights highly variable. Seed was collected from selected plants with high seed production and/or desirable turf traits.

FUTURE WORK: Traffic studies will be continued through 1990. Plants identified as having high seed production potential under field conditions will be entered into seed production trials and isolated crossing blocks in the spring of 1990.

7. FOUNDATION PLANTINGS AND REGROWTH POTENTIAL - DALZ LINES

INTRODUCTION: Zoysiagrasses are generally slow to establish and lack recuperative potential. These characteristics limit the use of zoysiagrasses to turf areas where long growing seasons exist and where rapid recuperative ability is not a requirement.

Zoysiagrasses that possess desirable turf characteristics with rapid establishment and recuperative abilities are needed. Such zoysiagrasses would greatly improve availability of sod, and increase their use on golf course tees and fairways and other intensively trafficked turfgrass areas. Additionally, experimentals nearing release must be increased through foundation field plantings. Such plantings provide additional information about the sod production potential of zoysiagrasses.

OBJECTIVE: Determine regrowth potential and suitability of zoysiagrasses for commercial sod production.

PROGRESS: Three-year-old replicated trials of several commercial cultivars and experimental selections of zoysiagrasses were harvested in 1987 with a sod cutter, irrigated, fertilized, and allowed to regrow to determine their recuperative rates and production characteristics. Recovery was determined by making actual counts of the number of individual growing points per unit area. This information was previously reported.

DALZ8501 sod from field breeder stock was clean-cut harvested on 25 May 1989, and used to establish foundation production at TAES-Dallas. The area from which the sod was harvested was evaluated to determine tiller production rate and rate of regrowth from rhizomes. The number of tillers in a randomly selected area was counted during the 50 days after harvest. Coverage (0 to 100%) was estimated visually from 0 to 86 days after sod harvest to determine the time required for reestablishment of a complete sod. Ten to 20 randomly selected areas were evaluated on each observation date. These evaluations were used as an estimation of regrowth potential of DALZ8501. Linear regression was utilized to determine the relationships between tillers/dm^2 with days after harvest, and percent coverage with days after harvest.

In 1989, the relationship between tillers/dm^2 with days after harvest, and percent coverage with days after harvest were linear (Figure 7). Coverage of DALZ8501 averaged almost 60% at 49 days after harvest with about 90 tillers/dm^2. The predicted time required for 100% coverage, based on rate of regrowth during the first 49 days, was approximately 74 days. Nearly 100% coverage was obtained in 86 days. Thus, the time required for the sod to be harvested a second time is considerably less than for existing cultivars. The rapid regrowth potential of this experimental zoysiagrass indicates promise for sod production and use on intensively trafficked turf areas.

Foundation production of DALZ8501 is currently at about 1.0 acres, with plans to double the acreage in 1990. Aerial photographs of the DALZ8501 foundation field planted on 25 May 1989 demonstrate a good rate of coverage (Figure 8). DALZ8502 was planted to 1.7 acres of foundation production in 1989. These fields will be ready for initial harvest in the spring of 1990.

C. ZOYSIAGRASS HYBRIDIZATION

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 pollinated hybridizations and have been germinated to yield several 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.

1. DEVELOPING A SEEDED ZOYSIAGRASS

JUSTIFICATION: Zoysiagrass cultivars are predominantly distributed vegetatively due to their relatively poor seed production and strong seed dormancy. Earlier studies on zoysiagrass seed germination indicated that factors promoting dormancy increased during seed development and maturation. Seed harvested for germination prior to full maturation may be a viable means of avoiding seed dormancy complications. Simplification of seed germination and selection for enhanced seed production capabilities would increase the potential for developing a seed-produced cultivar. Additionally, hybridizations attempting to combine desirable turf characteristics are needed. The present population includes genotypes with fine leaf texture, dark green color, vigorous growth habit, and disease resistance/tolerance.

OBJECTIVES:

1. Identify plants within the zoysiagrass germplasm introduction nursery which have high seed production potential.

2. Use single-cross and polycross matings to combine zoysiagrasses with high seed production potential and desirable turf quality.

3. Advance progeny through multiple cycles of selection to combine superior turf performance characters with high seed production potential.

PROGRESS: Several accessions have been identified for high seed production capability and/or desirable turf traits. Data relating to morphological characters have been analyzed and summarized. Progeny evaluation is underway for selected accessions. A space planting was established 1 August, 1989 by placing 822 1-inch plugs on 3 foot centers.

Additionally, plants were generated from three seed sources of Zoysia sinica acquired from China, as well as seed produced by 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 have been recorded to date.

FUTURE WORK: When available, accessions selected for seed production and/or desirable turf characteristics will be used for self and/or cross pollinations (Figure 9). Pollination attempts from one diallel currently in progress are noted in Table 18. Progeny will be evaluated for seed production and/or turf characteristics from successful pollinations and seed germinations. Flowering habit, seed production potential and obvious agronomic attributes will be assessed throughout 1990.

2. STRESS TOLERANCE IN ZOYSIAGRASS HYBRIDIZATION PROGRAM

JUSTIFICATION: Major progress is being made at Dallas in defining minimum levels of supplemental irrigation required for turfgrass maintenance utilizing a line source irrigation system (LGIS). Meteorological data and plant responses are being used to determine minimum irrigation levels required by major turfgrass species and elite zoysiagrass experimentals in an attempt to substantially reduce supplemental irrigation requirements.

Although significant progress has been made in understanding turfgrass water use and irrigation requirements, less attention has been given to understanding the heritability of biological characters associated with drought resistance in grasses used for turf purposes. The degree to which turfgrasses adapt physiologically to water deficits and high temperatures has received almost no attention in published technical literature.

Numerous accessions of zoysiagrass designated as DALZ lines are being evaluated for water requirements and tolerance to stress in general. Considerable variability exists among these lines for 1) quantity of supplemental irrigation needed to sustain active growing turf, 2) leaf texture, 3) leaf orientation, 4) density of stand, and 5) general turf quality. Information on the heritability of such traits and the role of these traits in adaptation and performance under stress is not available.

OBJECTIVES:

1. Determine the relationship of specific water relations characters to morphological characters and to drought resistance to ascertain the feasibility of utilizing morphological characters as stabile genetic markers to rapidly select for drought resistant germplasm.
2. Determine the heritability of such characters for utilization in a turfgrass breeding program emphasizing superior drought resistance and water use efficiency.

PROGRESS: Linear Gradient Irrigation System (LGIS) field facilities at Dallas permit a gradient application of water onto established, replicated turf plots. LGIS was utilized during 1989 to determine the drought resistance and water use characteristics of elite zoysiagrasses and commercial varieties. Superior experimental zoysiagrasses were identified and selected for an intensive hybridization program. Plants have been established for diallel crossing to assess heritability of stress tolerance.

FUTURE: The Turfgrass Root Investigation Facility established at Dallas was planted during May 1989 to replicated plots of zoysiagrasses common to LGIS. This will allow determination of subsurface plant characteristics such as root mass, root distribution, root number, and root extension rate, that may contribute to superior drought resistance. Greenhouse studies are also in progress to determine the feasibility of screening for specific physiological drought tolerance characters.

Specific water relations characteristics will be measured for grasses planted to TRIF and LGIS to quantify drought resistance of selected genotypes. Parameters to be measured include osmotic potential, water potential, and relative water content. Correlations among these characters and performance under moisture deficits will be used to ascertain mechanisms of drought resistance such as osmotic adjustment, tissue elasticity regulation, and apoplastic water fraction adaptation. The relationship of water relations characteristics to morphological characters and drought stress symptoms will be ascertained from the data collected to determine morphological markers that will allow rapid selection of superior germplasm.

The aerial morphological characteristics of these grasses, such as leaf width, leaf extension rate, leaf surface characteristics, and leaf rolling and leaf firing during moisture deficits, will be determined. A knowledge of the drought resistance, morphological characters, and physiological adaptation of these grasses to moisture deficits will allow the identification of mechanisms which favor excellent performance under adverse environments and identification of stabile genetic markers easily utilized in the selection process.

Diallel seed production and progeny evaluation will be utilized to determine the heritability of desirable characteristics and a breeding scheme which will make optimal progress toward species improvement. The development and implementation of greenhouse techniques to rapidly identify stress tolerant germplasm will accelerate the development and release of drought resistant turfgrass cultivars.

LIST OF FIGURES

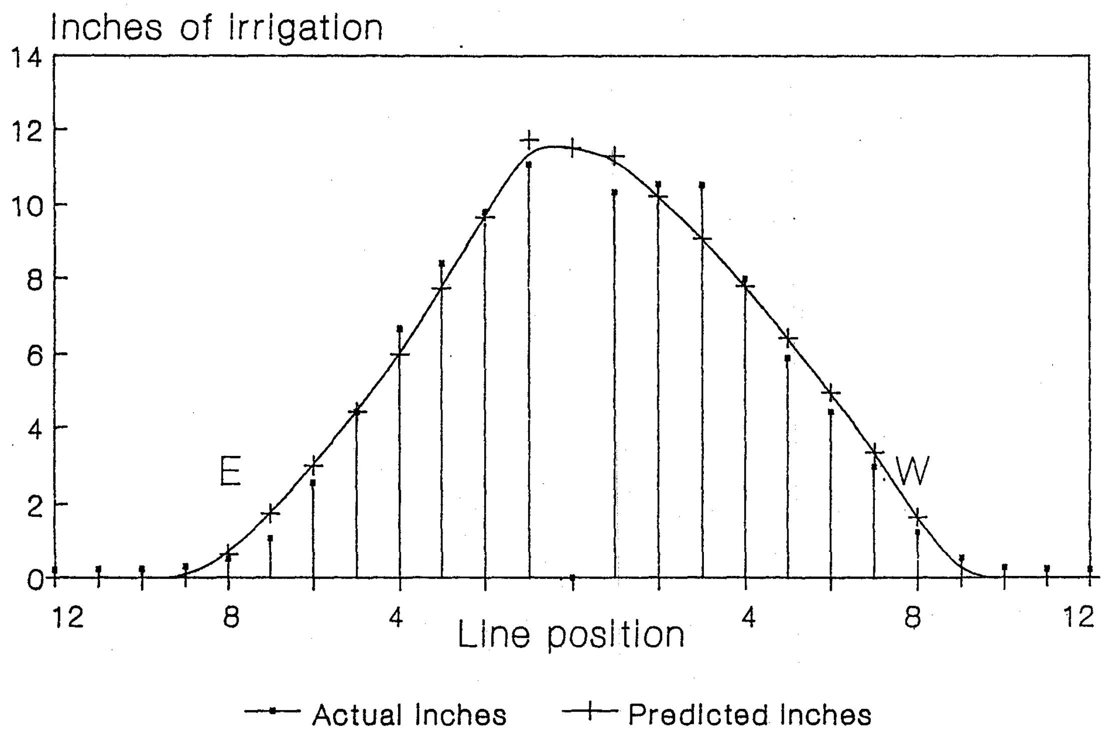

Figure 2. Supplemental irrigation distribution for the Linear Gradient Irrigation System at TAES-Dallas during 1989 as of 1 September 1989.

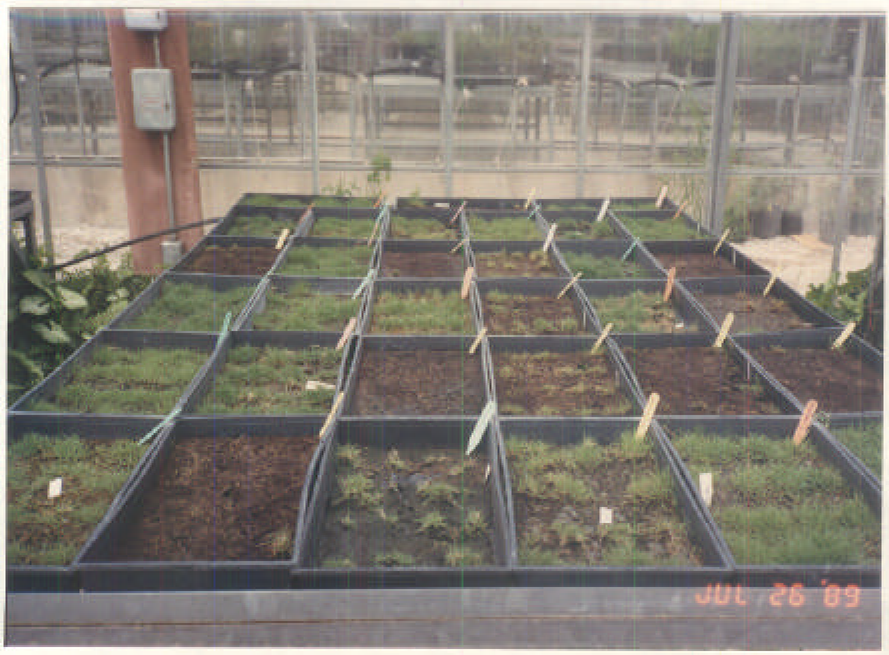

Figure 1. Configuration of flats on 1 of 8 benches included in the alternate production system experiment.

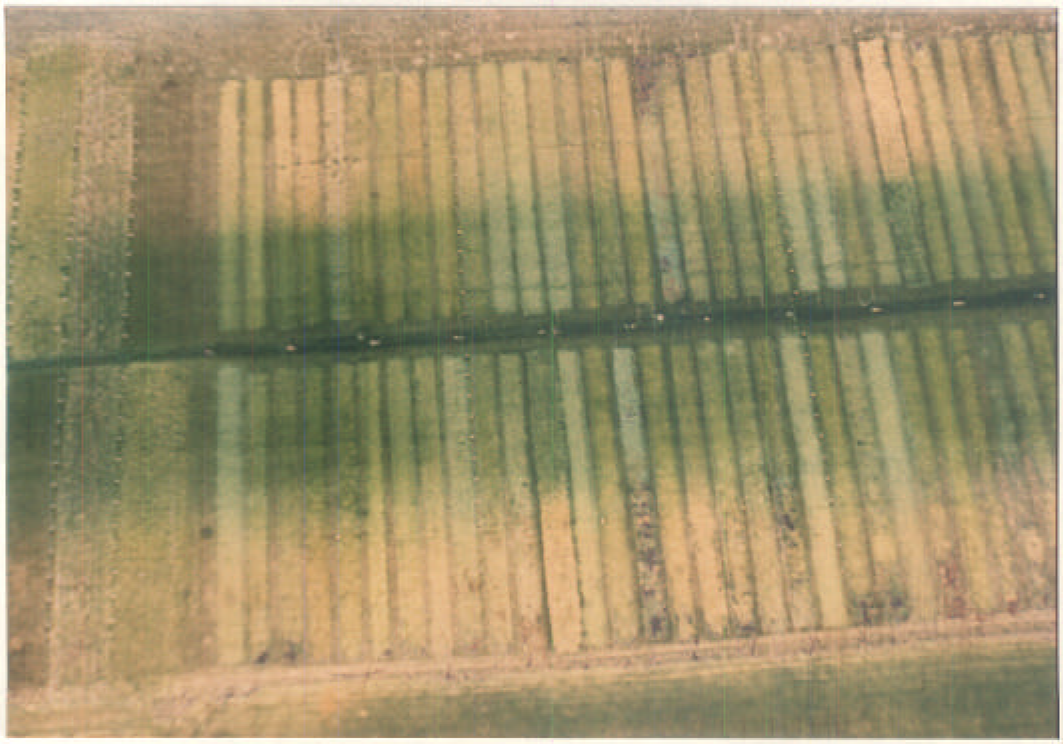

Figure 3. Photograph of the zoysiagrass experimentals on the Linear Gradient Irrigation System at TAES-Dallas on 6 September 1989.

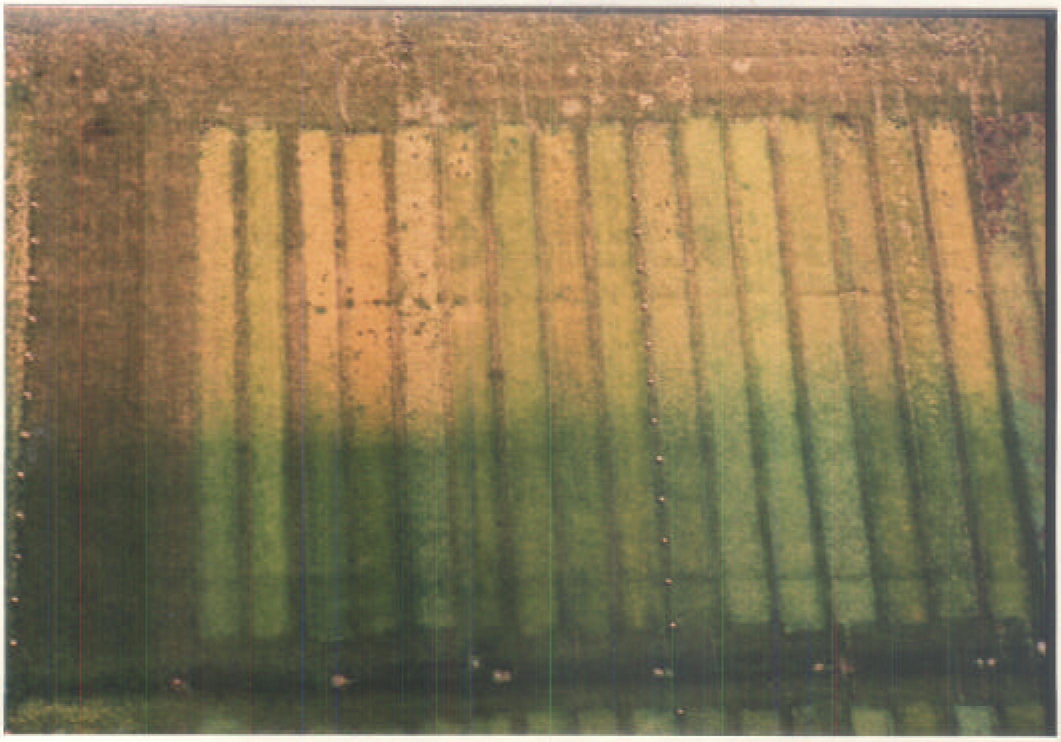

Figure 4. Photograph of zoysiagrass experimentals on the Linear Gradient Irrigation System at TAES-Dallas in late-August 1989 showing variation in response to stress.

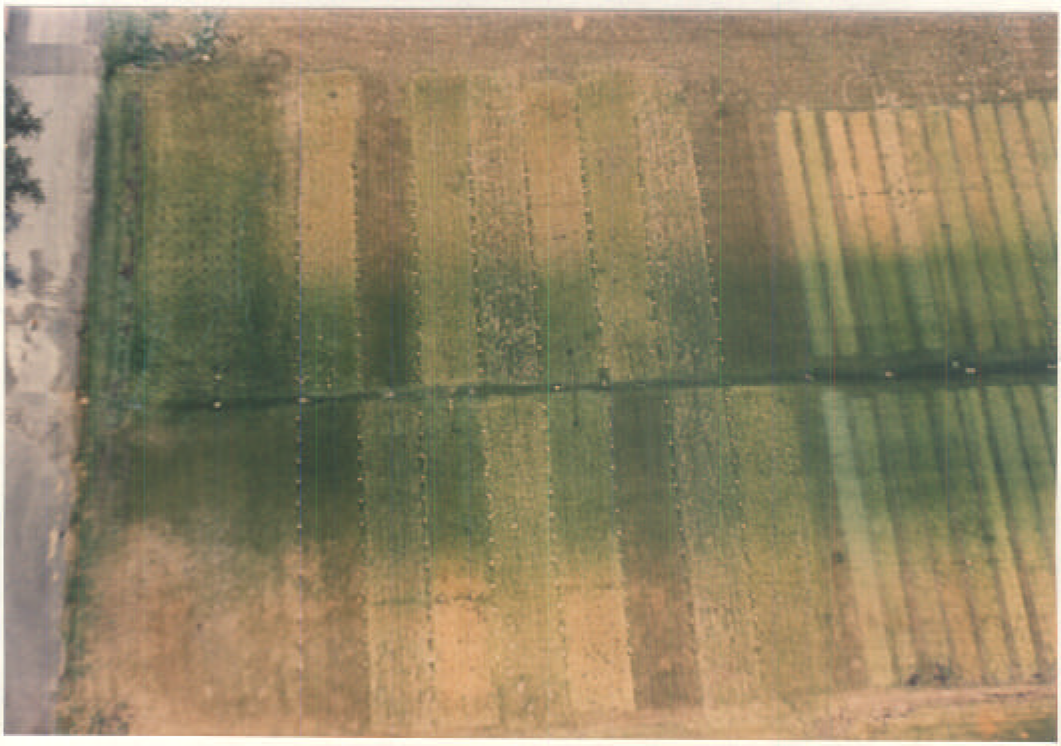

Figure 5. Photograph of the physiology study area on the Linear Gradient Irrigation System at TAES-Dallas during late-August 1989.

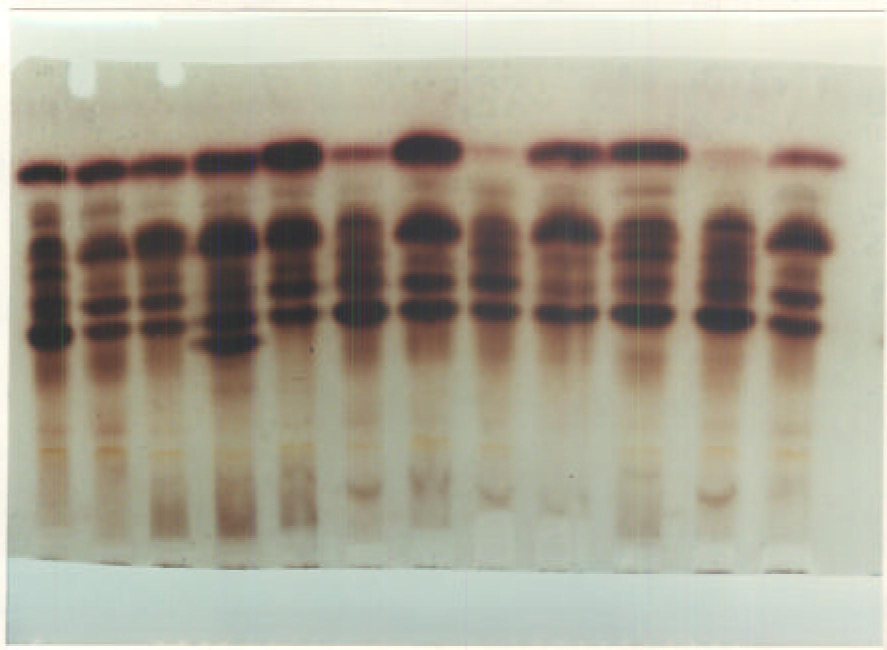

Figure 6. Distinguishing electrophoretic patterns of (l to r) DALZ8512, DALZ8513, DALZ8514, DALZ8515, DALZ8516, DALZ8517, DALZ8518, DALZ8519, DALZ8520, DALZ8522, DALZ8523, and DALZ8524. Electrophoresis was conducted by Dr. Lin Wu, UC-Davis.

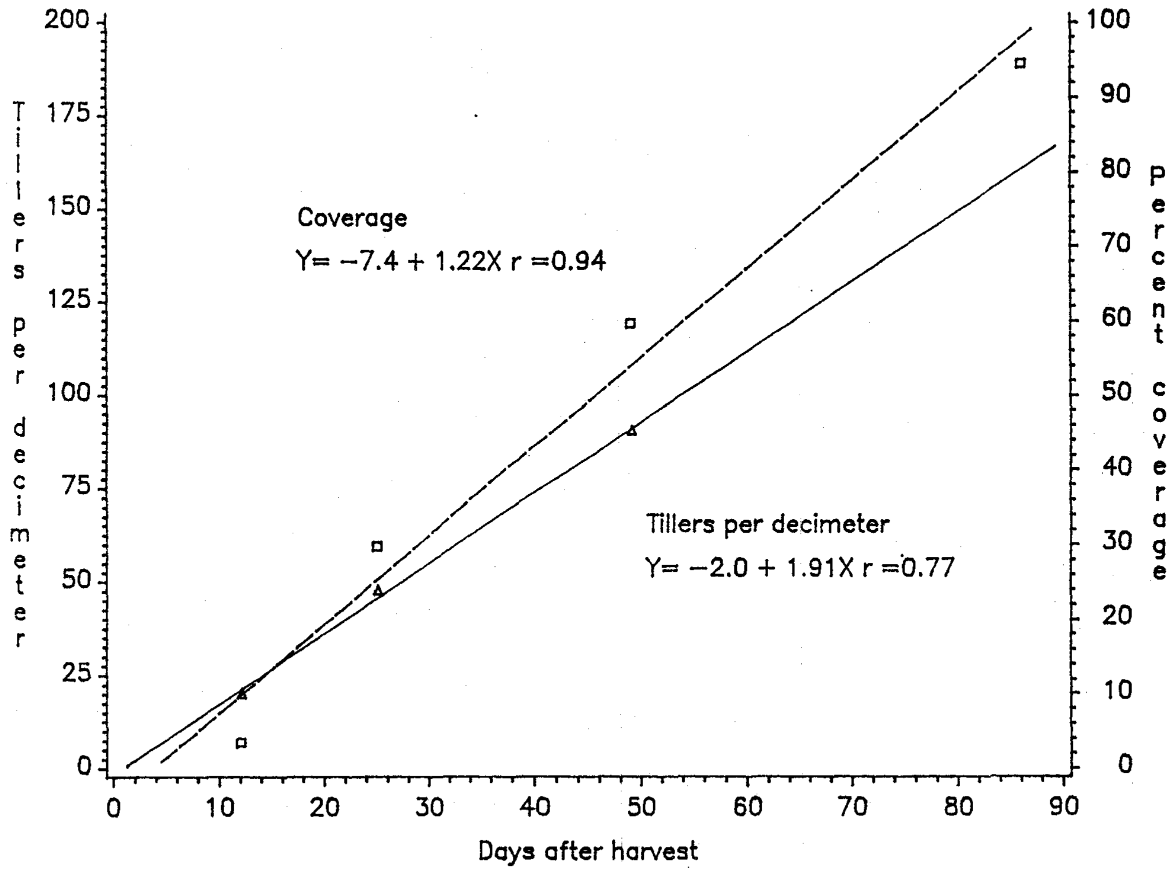

Figure 7. Tiller production and coverage of DALZ8501 after clean cutting of sod for the establishment of a foundation production field at TAES-Dallas on 25 May 1989. Symbols represent the means of 12 to 25 observations.

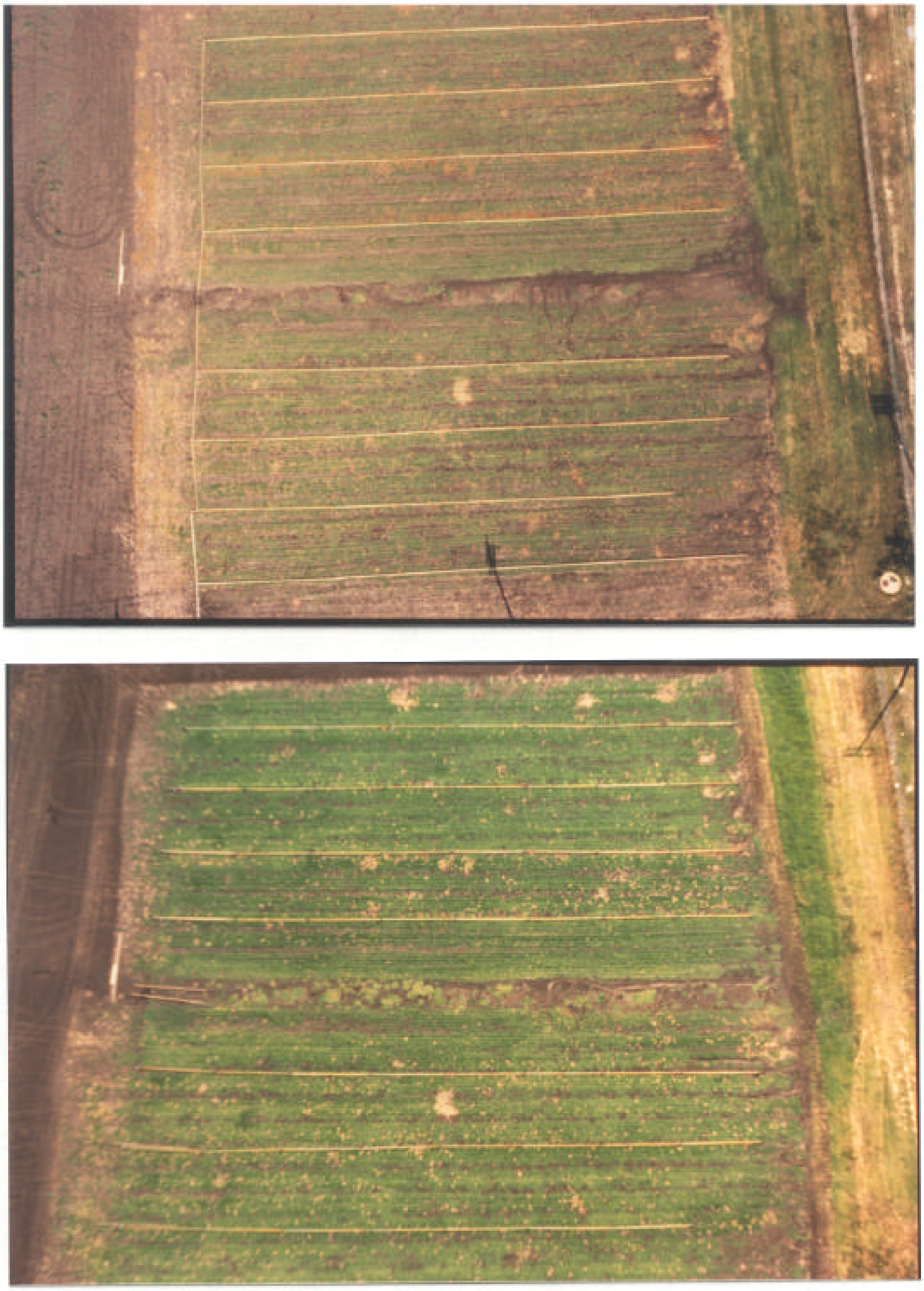

Figure 8. Aerial photographs of DALZ8501 in foundation production. Upper photograph taken 14 August and lower photograph taken 6 September 1989. Date of establishment was 25 May 1989.

Figure 9. *Inflorescences* bagged prior to stigma emergence. Covered culms are subjected to self or cross pollination after stigmas emerge, but prior to anther dehiscence.

LIST OF TABLES

Table 1. Comparison of media at 2 pounds nitrogen per thousand square feet per month using percent coverage ratings.

		Medium[1]				
Week	Treatment Amendment	G	G:S	R	C	P
1	Restart	1.75	2.00	5.00	5.00	6.25
	Restore	1.50	2.50	4.25	6.25	4.25
	10-10-10	2.50	2.75	5.00	7.50	4.25
	Sand-aid	4.00	4.25	5.00	4.25	3.50
	Control	2.00	4.25	4.25	5.50	4.25
3	Restart	2.25	3.50	6.00	6.00	11.75
	Restore	3.50	5.25	7.50	8.50	10.00
	10-10-10	3.75	4.75	6.25	10.50	8.50
	Sand-aid	1.75	3.50	5.50	3.50	3.50
	Control	1.75	6.00	5.00	5.50	6.75
6	Restart	8.00	23.75	35.00	26.25	41.25
	Restore	13.75	31.75	36.25	37.50	45.00
	10-10-10	15.25	26.25	26.25	41.25	50.00
	Sand-aid	1.00	2.50	13.00	1.75	3.50
	Control	6.00	30.00	13.75	10.00	13.00
9	Restart	22.50	65.00	75.00	66.25	76.25
	Restore	36.25	66.25	83.75	73.75	87.50
	10-10-10	26.25	71.25	57.50	73.75	.85.00
	Sand-aid	1.00	2.00	20.00	1.50	4.75
	Control	20.00	27.25	25.00	25.00	25.00
12	Restart	32.50	83.75	89.75	76.25	86.75
	Restore	51.25	78.75	93.50	81.25	95.25
	10-10-10	37.50	85.00	76.25	88.00	95.00
	Sand-aid	1.00	0.75	15.00	1.00	4.50
	Control	27.50	55.00	25.00	25.00	22.50
15	Restart	56.25	97.00	98.00	88.00	92.50
	Restore	76.25	93.50	98.25	94.75	100.00
	10-10-10	68.75	98.50	93.00	96.00	99.75
	Sand-aid	1.75	0.75	17.50	0.75	7.75
	Control	45.00	67.50	30.00	23.75	23.75

[1]G = grass clippings, G:S = 1 part grass clippings : 1 part sand, R = rice hulls, C = composted rice hulls, P = peatlite mix.

Table 2. Establishment rate of cultivars and experimental selections of zoysiagrasses planted 21 June 1988 at TAES-Dallas.

Entry	Weeks after planting 2	8	12	16	Ave.	Phenotypic stability
		- % Cover		-		
Emerald	5.0	13.3	21.7	41.7	20.4	
Meyer	5.0	16.7	33.3	65.0	30.0	
El Toro	5.0	23.3	51.7	92.7a	43.2	1
Belair	5.0	11.7	21.7	46.7	21.3	
DALZ8501	5.0	11.7	23.3	65.0	26.3	
DALZ8502	5.0	11.7	18.3	30.0	16.3	
DALZ8508	5.0	10.0	25.0	63.3	25.8	
DALZ8516	5.0	10.0	15.0	20.0	12.5	
TAES3372	5.0	11.7	25.0	45.0	21.7	
TAES3477	9.0a	36.7a	70.0a	95.7a	52.8	4

Means followed by "a" are in the highest statistical rating group according to Waller-Duncan K ratio t test. Phenotypic stability is the frequency of occurrence in the highest rating group.

Table 3. Fall 1988 percent green plot coverage, and percent cover, density, and uniformity approximately 1 year after establishment of zoysiagrass cultivars and selections.

Entry	23 Nov 88 % green	6 June 1989 % cover	Density	Uniformity
Emerald	52	90	5.7	5.3
Meyer	28	93	5.3	5.7
El Toro	43	96	6.7	6.0
Belair	25	83	5.0	4.7
DALZ8501	75	77	4.0	3.7
DALZ8502	92	55	3.7	2.7
DALZ8508	50	93	5.0	5.0
DALZ8516	42	58	3.7	3.0
TAES3372	67	73	4.0	3.7
TAES3477	65	92	5.7	6.0
LSD	15	12	1.6	1.2

LSD, Least significant difference at the 5% level of probability for comparison of means within columns. Density and uniformity are based on 1 = least dense and least uniform and 9 = most dense and uniform.

Table 4. Spring greening during 1989 of zoysiagrass cultivars and experimental selections planted 21 June 1988 at TAES-Dallas.

Entry	Date of Rating 15 Mar	20 Mar	28 Mar	5 Apr.	20 Apr.	Phenotypic stability
	- % Green tissue -					
Emerald	38.3a*	65.3a	76.7a	88.3a	93.3a	5
Meyer	32.5a	60.0a	65.0a	80.0a	96.3a	5
El Toro	29.2a	55.8a	58.3	78.3	86.7	4
Belair	26.7a	57.5a	53.3	83.3a	93.3a	4
DALZ8501	7.5	24.2	15.0	36.7	45.0	0
DALZ8502	3.3	8.3	6.7	10.0	16.7	0
DALZ8508	38.3	61.7a	76.7a	80.0a	90.0a	5
DALZ8516	10.8	27.5	21.7	35.7	53.3	0
TAES3372	5.0a	51.7	63.3a	48.7	76.7	2
TAES3477	9.0	21.3	10.0	30.0a	45.0	0

*Means followed by "a" are in the highest statistical rating group according to Waller-Duncan K ratio t test. Phenotypic stability is the frequency of occurrence in the highest rating group.

Table 5. Percent coverage, greenup, and quality of zoysiagrass cultivars and selections planted during 1987 on LGIS at TAES-Dallas and evaluated during 1988 and 1989.

Entry	% Coverage Sept. 87	% Green-up July 88	Quality April 89	Quality May 89
MEYER	36.0a*	94.9a	47.5	5.5
EMERALD	22.0	89.9a	50.0	5.8a
EL TORO	44.4a	88.3a	48.8	5.8a
BELAIR	16.2	73.1	48.8	4.8
FC13521	17.8	80.7	50.0	6.8a
KOREAN COMMON	43.5a	95.4a	60.0a	4.5
DALZ8501	30.3	82.9	28.8	4.3
DALZ8502	32.5a	89.6a	32.5	5.0
DALZ8503	25.1	81.3	53.8a	6.0a
DALZ8504	26.9	93.5a	45.0	5.0
DALZ8505	14.5	66.4	47.5	4.0
DALZ8506	26.2	74.0	46.3	5.8 a
DALZ8507	35.5a	84.0	47.5	6.5 a
DALZ8508	20.7	79.2	57.5a	6.3a
DALZ8510	24.8	79.7	50.0	6.3 a
DALZ8511	30.2	91.6a	45.0	5.8 a
DALZ8512	33.3a	94.2a	47.5	5.8 a
DALZ8513	29.5	78.8	13.8	3.3
DALZ8514	27.6	80.2	43.8	5.5
DALZ8515	10.9	69.8	43.8	4.5
DALZ8516	24.6	87.9a	58.8a	4.0
DALZ8517	24.6	89.0a	32.5	6.3 a
DALZ8522	9.5	41.5	0.0	2.0
DALZ8523	20.7	76.7	12.5	3.0
DALZ8524	19.4	79.0	45.0	5.5

*Means within a column followed by the same letter are not different at the 5% level of probability based on Waller-Duncan multiple comparison procedure (K=100). Greenup ratings are percentage of green plot area and quality ratings are 1 to 9 where 9 = best.

Table 6. Flower rating recorded 1 October, 1989 for zoysiagrass cultivars and selections planted during 1987 on LGIS at TAES-Dallas.

	Position from center trench												
Entry	1	2	3	4	5	6	7	8	9	10	11	12	Average
Meyer	1.25 g-i*	1.00 ij	1.00 gh	1.00 jk	1.00 h	1.00 ef	1.00 h	1.00 fg	1.00 g	1.00 f	1.00 ef	1.00 fg	1.02 h
Emerald	1.75 g-i	1.50 ij	1.50 f-h	1.00 jk	1.00 h	1.00 ef	1.00 h	1.00 fg	1.00 g	1.00 f	1.00 ef	1.00 fg	1.15 gh
El Toro	6.00 b-d	6.00 cd	5.75 b	5.50 d-f	5.25 de	5.00 b	4.75 c-e	4.50 cd	3.75 de	3.50 bc	4.00ab	3.75 ab	4.81 bcd
Belair	5.50 c-e	5.00 de	5.25 b	4.75 e-g	4.75 e	5.00 b	3.50 ef	3.50 de	2.75 ef	2.75 cd	2.50 cd	2.50 c-e	3.98 d
FC13521	2.50 f-h	2.25 g-i	1.75 f-h	2.00 i-k	1.50 gh	2.00 de	1.50 gh	1.00 fg	1.00 g	1.00 f	1.00 ef	1.00 fg	1.54 f-h
Korean Common	1.00 hi	1.00 ij	1.00 gh	1.00 jk	1.00 h	1.00 ef	1.00 h	1.00 fg	1.00 g	1.00 g	1.00 ef	1.00 fg	1.00 h
DALZ8501	7.50 ab	7.50 ab	7.25 a	7.25 a-c	7.00 a-c	6.00 b	5.50 cd	4.00 cd	2.75 ef	2.75 cd	3.00 bc	2.25 de	5.23 b
DALZ8502	7.00 a-c	7.00 a-c	7.25 a	6.50 b-d	6.50 b-d	5.75 b	4.50 de	2.25 ef	1.00 g	1.00 f	1.00 ef	1.00 fg	4.23 cd
DALZ8503	4.00 ef	3.50 fg	3.50 de	3.00 hi	3.00 f	2.25 d	2.00 gh	1.50 fg	1.25 g	1.25 ef	1.00 ef	1.00 fg	2.27 ef
DALZ8504	1.00 hi	1.00 ij	1.00 gh	1.00 jk	1.00 h	1.00 ef	1.00 h	1.00 fg	1.00 g	1.00 f	1.00 ef	1.00 fg	1.00 h
DALZ8505	0.75 i	0.75 j	0.75 h	0.75 k	0.75 h	0.75 f	0.75 h	0.75 g	0.75 g	0.75 f	0.75 ef	0.75 fg	0.75 h
DALZ8506	1.75 g-i	1.50 ij	1.25 gh	1.50 jk	1.25 h	1.00 ef	1.00 h	1.00 fg	1.00 g	1.00 f	1.00 ef	1.00 fg	1.19 gh
DALZ8507	4.00 ef	3.25 f-h	2.50 ef	3.00 hi	2.00 f-h	1.50 d-f	1.25 h	1.25 fg	1.00 g	1.00 f	1.00 ef	1.00 fg	1.90 e-g
DALZ8508	1.50 g-i	1.25 ij	1.00 gh	1.00 jk	1.00 h	1.00 ef	1.00 h	1.00 fg	1.00 g	1.00 f	1.00 ef	1.00 fg	1.06 gh
DALZ8510	2.75 gh	2.00 h-j	2.00 fg	2.25 ij	2.00 f-h	1.50 d-f	1.25 h	1.00 fg	1.00 g	1.00 f	1.00 ef	1.00 fg	1.56 f-h
DALZ8511	2.00 g-i	1.75 ij	1.50 f-h	1.50 jk	1.50 gh	1.50 d-f	1.25 h	1.25 fg	1.25 g	1.25 ef	1.25 ef	1.00 fg	1.42 f-h
DALZ8512	6.25 b-d	6.50 bc	6.00 b	5.50 d-f	5.75 c-e	6.00 b	5.75 cd	5.25 bc	4.50 cd	1.25 ef	4.25 a	4.00 ab	5.31 b
DALZ8513	8.00 a	8.00 a	8.00 a	7.50 ab	7.50 ab	7.25 a	7.25 ab	6.25 ab	5.75 ab	5.25 a	4.25 a	4.25 a	6.60 a
DALZ8514	6.50 a-d	6.25 b-d	5.75 b	6.00 c-e	5.75 c-e	5.25 b	4.75 c-e	3.75 d	3.75 de	3.50 bc	3.50 a-c	3.25 a-d	4.83 b-d
DALZ8515	1.25 g-i	1.00 ij	1.00 gh	1.00 jk	1.00 h	1.00 ef	1.00 h	1.00 fg	1.00 g	1.00 f	1.00 ef	1.00 fg	1.02 h
DALZ8516	7.00 a-c	7.00 a-c	7.25 a	7.00 a-c	7.00 a-c	7.50 a	6.00 bc	3.75 d	2.50 f	2.25 de	1.75 de	1.5 ef	5.04 bc
DALZ8517	2.00 g-i	1.25 ij	1.25 gh	1.00 jk	1.00 h	1.00 ef	1.00 h	1.00 fg	1.00 g	1.00 f	1.00 ef	1.00 fg	1.13 gh
DALZ8522	4.00 ef	4.25 ef	4.00 cd	4.00 gh	4.50 e	3.75 c	2.75 fg	1.25 fg	1.25 g	1.00 f	0.25 f	0.25 g	2.60 e
DALZ8523	8.00 a	8.00 a	8.00 a	8.00 a	7.75 ab	7.75 a	7.25 ab	7.25 a	6.50 a	4.25 ab	3.25 a-c	3.00 b-c	6.58 a
DALZ8524	5.25 cd	4.50 ef	5.00 bc	4.50 fg	2.75 fg	2.00 de	1.25 h	1.00 fg	1.00 g	1.00 f	1.00 ef	1.00 fg	2.52 e
TAES3477	8.00 a	8.00 a	8.00 a	8.00 a	8.00 a	8.00 a	7.50 a	6.25 ab	5.25 bc	4.25 ab	4.25 a	3.50 a-c	6.58 a
MSD	1.55	1.35	1.24	1.34	1.30	1.17	1.32	1.82	1.02	1.24	1.16	1.19	0.87

*Means within a column followed by the same letter are not different at the 5% level of probability based on Waller-Duncan multiple comparison procedure (K=100). Each position = 1.5 m section betweeen rain gauge of that number and the next higher number, e.g. section 1 = area between rain gauges 1 and 2.

Table 7. Line position on the Linear Gradient Irrigation System of live, actively growing turf of zoysiagrass cultivars and selections at TAES-Dallas during 1989.

	Date of visual rating							
Entry	22 Aug.	24 Aug.	27 Aug.	28 Aug.	1 Sept.	6 Sept.	Ave.	1 Oct.
BELAIR	11.50*	11.25	8.83	10.50	7.69	8.53	9.79	11.44 ab
EL TORO	10.38	12.50	10.13	11.50	7.63	8.38	9.91	11.56 a
EMERALD	9.00	8.25	7.81	7.75	6.63	7.84	8.02	6.50 c-f
FC13521	8.13	7.00	7.28	7.25	6.19	7.28	7.32	8.25 b-e
KOREAN COMMON	8.25	7.25	7.25	7.19	6.38	7.16	7.36	5.75 c-f
MEYER	7.50	7.00	7.13	6.88	6.56	6.94	7.06	6.44 c-f
DALZ8501	8.13	7.75	7.56	7.63	6.75	7.38	7.59	6.88 c-f
DALZ8502	7.75	7.75	7.69	7.13	6.50	6.88	7.29	9.00 a-c
DALZ8503	7.75	7.00	7.35	7.19	6.88	7.38	7.33	6.25 c-f
DALZ8504	6.00	7.25	7.13	7.00	6.19	6.91	6.67	5.88 c-f
DALZ8505	8.00	5.25	7.10	7.06	6.63	7.13	7.04	4.25 fg
DALZ8506	7.13	6.67	7.38	6.88	6.38	7.16	7.00	7.19 c-f
DALZ8507	7.50	7.50	8.00	7.13	6.31	7.06	7.26	5.69 d-f
DALZ8508	7.50	7.75	7.56	7.44	6.88	7.50	7.45	6.38 c-f
DALZ8510	9.25	7.75	7.94	6.81	6.69	7.28	7.78	6.19 c-f
DALZ8511	9.25	7.50	7.65	7.25	6.81	7.38	7.81	6.00 c-f
DALZ8512	13.00	13.00	12.50	13.00	9.44	8.94	11.48	11.19 ab
DALZ8513	10.13	11.50	10.58	10.44	7.44	7.84	9.49	11.25 ab
DALZ8514	12.88	12.00	10.88	12.25	8.63	9.50	11.06	11.06 ab
DALZ8515	6.38	7.00	7.06	7.00	6.06	7.59	6.88	5.19 ef
DALZ8516	7.50	7.75	7.75	8.00	6.69	7.56	7.54	8.62 a-d
DALZ8517	7.25	7.50	7.50	7.00	6.19	7.18	7.13	6.75 c-f
DALZ8522	7.38	-	7.19	2.25	-	4.42	4.14	1.50 g
DALZ8523	11.13	6.25	7.69	6.25	7.13	7.06	7.96	7.75 c-e
DALZ8524	7.63	6.80	7.44	6.50	6.25	7.13	7.05	9.00 a-c
TAES3477	8.25	7.75	7.13	7.50	7.19	7.59	7.70	6.88 c-f
MSD 5%	2.41	1.85	1.50	2.11	0.89	1.43	0.85	3.25

*Values are the average of four replications and represent the line position on the Linear Gradient Irrigation System where moisture stress was evident. The higher the value, the greater the distance from the irrigation source and therefore received the least amount of irrigation. MSD is the minimum significant difference at the 5% level of probability for comparison of means within columns based on the Waller-Duncan K ratio test where K=100.

Table 8. Line position of live, actively growing turf on 1 Sept. 1989 and the total irrigation plus rainfall, supplemental irrigation, and gallons per acre (GPA) of supplemental irrigation required to sustain live, actively growing turf of zoysiagrass cultivars and selections planted on the Linear Gradient Irrigation System at TAES-Dallas.

ENTRY	Line* position	Irrigation plus rainfall	Irrigation applied	Irrigation amount
		-cm-	-cm-	GPA
BELAIR	7.69	92.6	3.7	39453
EL TORO	7.63	92.8	3.9	41982
EMERALD	6.63	96.5	7.6	81334
FC13521	6.19	98.1	9.2	98738
KOREAN COMMON	6.38	97.3	8.4	90327
MEYER	6.56	96.5	7.6	81088
DALZ8501	6.75	95.8	6.9	73971
DALZ8502	6.50	96.8	7.9	84840
DALZ8503	6.88	95.3	6.4	68265
DALZ8504	6.19	98.1	9.2	98142
DALZ8505	6.63	96.3	7.4	79450
DALZ8506	6.38	97.2	8.3	89263
DALZ8507	6.31	97.4	8.5	91359
DALZ8508	6.88	95.4	6.5	9342
DALZ8510	6.69	96.1	7.2	76459
DALZ8511	6.81	95.7	6.8	72287
DALZ8512	9.44	90.2	0.9	9469
DALZ8513	7.44	93.4	4.5	47813
DALZ8514	8.63	89.8	1.3	14087
DALZ8515	6.06	98.5	9.6	102878
DALZ8516	6.69	96.2	7.3	78151
DALZ8517	6.19	98.0	9.1	97546
DALZ8523	7.13	94.6	5.7	60819
DALZ8524	6.25	97.7	8.8	94537
TAES3477	7.19	94.3	5.4	58239
MSD 5%	0.97	2.9	2.9	31022

*Values are the average of four replications and represent the line position on the Linear Gradient Irrigation System where moisture stress was evident. The higher the value, the greater the distance from the irrigation source and therefore received the least amount of irrigation. MSD is the minimum significant difference at the 5% level of probability for comparison of means within columns based on the Waller-Duncan K ratio test where K=100.

Table 9. Line position of live, actively growing turf and the total irrigation plus rainfall, supplemental irrigation, and gallons per acre (GPA) of supplemental irrigation as of 8 September 1989 required to sustain live, actively growing turf of commercial turfgrasses planted on the Linear Gradient Irrigation System at TAES-Dallas.

	Line position*							
ENTRY	9 Aug.	18 Aug.	25 Aug.	1 Sept.	8 Sept.	Irr. plus rainfall	Irr. applied	Irr. amount
						-cm-	-cm-	GPA
FALCON	10.0	8.8	7.0	6.5	6.3	95.7	6.8	72662
MEYER	9.3	8.8	7.3	6.5	6.3	95.7	6.8	72662
RALEIGH	12.0	12.0	11.8	11.3	10.8	88.9	0	0
TEXTURF	12.0	12.0	11.8	10.0	7.3	92.7	3.8	40774
MSD	0.4	0.8	0.8	0.9	1.0	2.3	2.3	18349

*Values are the average of four replications and represent the line position on the Linear Gradient Irrigation System where moisture stress was evident. The higher the value, the greater the distance from the irrigation source and therefore received the least amount of irrigation. MSD is the minimum significant difference at the 5% level of probability for comparison of means within columns based on the Waller-Duncan K ratio test where K=100.

Table 10. Turf density of zoysiagrass cultivars and experimentals evaluated for two years at Cottonwood Park in Richardson, Texas, under dense shade.

Entry	Density Rating 30 Sept. 1988	Density Rating 26 Sept. 1989	Average
DALZ8502	8.0	4.3	6.2
DALZ8517	7.0	4.7	5.8
DALZ8523	5.7	5.3	5.5
DALZ8516	6.3	2.0	4.2
DALZ8514	6.0	2.3	4.2
DALZ8524	5.0	3.0	4.0
DALZ8507	4.3	3.7	4.0
DALZ8701	5.3	2.3	3.8
DALZ8508	5.0	2.0	3.5
DALZ8503	4.3	2.7	3.5
DALZ8501	3.0	4.0	3.5
DALZ8515	5.0	1.3	3.2
DALZ8512	3.3	2.7	3.0
DALZ8511	4.7	1.3	3.0
DALZ8513	2.7	2.7	2.7
DALZ8510	3.3	2.0	2.7
TAES3477	-	5.0	5.0*
DALZ8506	3.0	1.7	2.3
DALZ8504	2.7	2.0	2.3
DALZ8522	2.3	2.0	2.2
DALZ8505	2.0	1.7	1.8
TAES3372	-	2.3	2.3*
BELAIR	5.0	1.3	3.2
EL TORO	5.0	3.3	4.2
EMERALD	4.0	2.7	3.3
FC13521	5.3	3.0	4.2
MEYER	4.3	1.7	3.0
MSD 5%	NS	3.5	3.1

MSD 5% is the minimum significant difference for comparison of means within columns based on the Waller-Duncan multiple comparison test (K =100). *One years' data only.

Table 11. Color and length of the second longest stolon during 1989 of zoysiagrass experimentals and cultivars planted to TRIF on 18 May 1989.

	Color			Stolon length		
Entry	23 June	14 August	28 Sept.	23 June	14 August	28 Sept.
					- cm -	
BELAIR	7.5	5.5	1.3	5.5	10.3	13.3
EL TORO	6.8	5.0	4.8	4.5	12.3	18.5
EMERALD	6.8	6.0	4.3	4.0	6.3	9.3
FC13521	5.8	6.8	4.8	4.0	6.3	12.8
MEYER	5.3	4.0	1.3	4.0	6.8	9.8
DALZ8501	5.5	6.0	5.3	4.3	7.8	11.0
DALZ8502	5.3	4.3	3.7	5.3	6.7	7.7
DALZ8503	5.8	4.8	3.5	4.8	9.3	13.8
DALZ8504	5.8	5.5	3.0	6.5	16.0	19.5
DALZ8505	5.5	4.7	3.0	5.0	16.3	25.5
DALZ8506	5.0	5.0	5.3	4.3	7.0	13.5
DALZ8507	6.0	6.0	3.5	5.0	10.5	14.0
DALZ8508	7.3	5.8	4.5	5.5	9.5	14.0
DALZ8510	5.8	4.0	3.3	4.5	10.3	14.3
DALZ8511	6.8	5.3	3.0	4.3	8.5	14.8
DALZ8512	6.8	6.0	5.3	5.0	15.3	25.3
DALZ8513	5.0	3.5	3.8	5.0	12.5	18.3
DALZ8514	6.8	5.8	4.3	5.8	15.8	22.8
DALZ8515	5.5	4.0	3.5	4.5	7.3	10.3
DALZ8516	7.5	6.8	4.8	5.0	7.0	10.5
DALZ8517	5.8	4.5	3.0	4.5	6.8	11.5
DALZ8522	6.0	3.8	2.8	4.0	8.5	11.8
DALZ8523	6.5	4.5	4.0	4.5	8.8	11.0
DALZ8524	6.3	7.8	6.0	4.8	6.0	9.3
DALZ8701	4.8	3.0	2.0	4.5	8.3	11.8
TAES3356	6.3	5.5	4.0	5.3	14.8	20.3
TAES3357	6.0	4.8	3.3	5.0	16.5	24.0
TAES3358	5.0	4.5	4.0	4.5	12.5	16.8
TAES3359	6.0	5.0	4.5	5.5	12.3	20.5
TAES3360	6.3	5.8	5.5	4.3	7.8	12.5
TAES3361	6.0	5.0	3.8	4.5	9.0	10.5
TAES3362	6.8	7.0	5.8	4.3	7.8	11.5
TAES3363	7.0	6.0	5.3	6.0	15.3	23.0
TAES3364	5.5	6.8	4.5	5.3	12.0	19.0
TAES3365	7.0	7.0	5.0	4.3	7.5	13.3
TAES3366	7.0	5.5	3.8	5.5	14.8	20.8
TAES3367	5.5	5.8	4.5	4.3	12.8	16.3
TAES3372	5.3	4.2	3.8	5.3	11.8	11.5
TAES3477	5.5	5.5	3.0	5.3	11.5	20.0
MSD 5%	1.6	1.9	2.1	2.0	4.3	6.2

MSD 5% is the minimum significant difference for comparison of means within columns based on the Waller-Duncan multiple comparison test (K =100).

Table 12. Flowering notes recorded 10 August 1989 for zoysiagrass cultivars and selections planted 18 May 1989 on TRIF.

Entry	Inflorescence count	Culm height (inches)
Meyer	8.50 g-k	2.25 c-i
Emerald	5.00 h-k	1.00 i-k
El Toro	16.50 f-h	3.88 ab
Belair	0.50 jk	1.00 i-k
FC13521	0.25 k	0.50 jk
DALZ8501	19.25 fg	2.00 d-j
DALZ8502	1.00 jk	0.50 jk
DALZ8503	5.00 h-k	2.25 c-i
DALZ8504	0.50 jk	1.50 g-k
DALZ8505	2.50 i-k	3.00 a-g
DALZ8506	1.50 jk	0.50 jk
DALZ8507	0.00 k	0.00 k
DALZ8508	1.50 jk	0.62 jk
DALZ8510	0.25 k	0.50 jk
DALZ8511	6.25 h-k	2.38 b-i
DALZ8512	8.50 g-k	4.50 a
DALZ8513	45.75 bc	2.75 b-h
DALZ8514	12.25 f-j	3.50 a-d
DALZ8515	13.75 f-i	2.75 b-h
DALZ8516	2.50 i-k	1.25 h-k
DALZ8517	0.75 jk	1.12 i-k
DALZ8522	32.00 de	2.25 c-i
DALZ8523	100.00 a	2.00 d-j
DALZ8524	6.75 h-k	1.25 h-k
DALZ8701	37.75 cd	2.00 d-j
TAES3356	11.50 g-k	3.75 a-c
TAES3357	7.25 h-k	2.75 b-h
TAES3358	3.25 i-k	2.75 b-h
TAES3359	2.25 i-k	3.50 a-d
TAES3360	23.50 ef	3.25 a-e
TAES3361	47.00 bc	2.50 b-i
TAES3362	47.00 bc	2.75 b-h
TAES3363	2.00 i-k	3.25 a-e
TAES3364	8.50 g-k	3.12 a-f
TAES3365	38.00 cd	1.75 e-j
TAES3366	3.75 i-k	3.00 a-g
TAES3367	54.00 b	3.00 a-g
TAES3372	0.25 k	1.00 i-k
TAES3477	37.75 cd	1.62 f-j

*Means within a column followed by the same letter are not different at the 5% level of probability based on Waller-Duncan multiple comparison procedure (K=100).

Table 13. Quality, color, texture, and density notes for the University of California Santa Clara Field Station zoysiagrass regional trial established 6/23/87 or 8/26/87.

	Quality				Color		Density	Texture
Entry	05/04/89	07/19/89	08/22/89	09/26/89	05/04/89	07/19/89	07/19/89	07/19/89
DALZ8501	4.67bc	5.00de	4.67ef	5.33d	6.00c	6.00cd	8.33ab	7.00c
DALZ8502	7.00a	6.67c	6.67abc	6.33bc	7.00bc	7.33ab	7.67bc	8.33a
DALZ8508	7.00a	8.00a	7.33a	8.00a	7.00bc	7.33ab	9.00a	7.33bc
DALZ8516	7.33a	7.67ab	7.00ab	7.00b	9.00a	8.00b	9.00a	5.33d
CV A	3.67cd	3.00f	3.33g	3.33f	7.33b	5.33d	4.67e	3.33e
CV B	7.00a	7.00bc	7.33a	7.00b	7.33b	7.00abc	7.00cd	5.67d
CV C	7.00a	6.67c	5.33de	5.67cd	6.33bc	6.67bc	9.00a	4.00e
CV D	6.67a	7.00bc	7.33a	7.00b	7.33b	7.33ab	8.33ab	8.00ab
CV E	3.00d	4.33e	4.33f	4.33e	6.67bc	6.67bc	4.67e	2.00f
CV F	3.67cd	5.00de	5.33de	4.00ef	6.67bc	6.67bc	5.00e	2.00f
CV G	5.33b	5.00de	6.33bc	5.67cd	6.67bc	6.67bc	6.33d	5.67d
CV H	6.67a	5.67d	6.00cd	5.67cd	7.00bc	6.00cd	7.67bc	4.00e
MSD*	1.19	0.89	0.85	0.71	1.06	1.09	0.93	0.99

* MSD = Minimum Significant Difference at the 5% level. Means within a column followed by the same letter are not different at the 5% level of probability based on Waller-Duncan multiple comparison procedure (K=100). Quality, color, texture, and density ratings = 1-9, with 9 = highest quality, darkest green, finest texture, and most density, respectively. Phenotypic stability is the frequency of occurrence in the highest rating group. CV A-H are commercial cultivars or varieties.

Table 14. Living ground cover percentage notes for the University of California Santa Clara Field Station zoysiagrass regional trial established 6/23/87 or 8/26/87.

Entry	Living Ground Cover Percentage 05/04/89	07/19/89	Phenotypic* Stability
DALZ8501	68.33ef	75.00d	0
DALZ8502	76.67cde	94.67ab	1
DALZ8508	95.00ab	99.00a	2
DALZ8516	83.33bcd	97.67ab	1
CV A	56.67fg	68.33d	0
CV B	80.00cde	93.00ab	1
CV C	99.00a	99.33a	2
CV D	70.00def	88.33bc	0
CV E	53.33g	88.33bc	0
CV F	70.00def	94.33ab	1
CV G	80.00cde	78.33cd	0
CV H	88.33abc	97.67ab	2
MSD*	13.43	10.13	

* Minimum Significant Difference (MSD) = 5% level. Means within a column followed by the same letter are not different at the 5% level of probability based on Waller-Duncan multiple comparison procedure (K=100). Quality, color, texture, and density ratings = 1-9, with 9 = highest quality, darkest green, finest texture, and most density, respectively. Phenotypic stability is the frequency of occurrence in the highest rating group. CV A-H are commercial cultivars or varieties.

Table 15. Quality notes for the University of Arizona zoysiagrass regional trial, Tucson, AZ; established 1987.

Entry	Quality - 1989 May	Jun	Sep	Oct	Phenotypic Stability
DALZ8501	2.25b	4.50b	6.75a	7.00ab	2
DALZ8502	4.50a	6.00a	7.50a	7.33a	4
DALZ8508	5.25a	6.75a	4.75b	6.27b	2
DALZ8516	5.00a	6.25a	6.50a	7.00ab	4
BELAIR	4.75a	4.25b	5.00b	6.27b	1
EL TORO	5.50a	6.25a	7.25a	7.33a	4
EMERALD	5.25a	6.00a	7.25a	7.00ab	4
MEYER	5.50a	6.00a	6.75a	7.17ab	4
MSD*	1.33	0.91	1.40	1.02	

* MSD = Minimum Significant Difference at the 5% level. Means within a column followed by the same letter are not different at the 5% level of probability based on Waller-Duncan multiple comparison procedure (K= 100). Quality ratings = 1-9, with 1 = very poor, 6 = acceptable, 9 = excellent. Phenotypic stability is the frequency of occurrence in the highest rating group.

Table 16. Color notes for the University of Arizona zoysiagrass regional trial, Tucson, AZ; established 1987.

	Color - 1989					
Entry	Mar	May	Jun	Sep	Oct	Phenotypic Stability
DALZ8501	1.67b	5.75a	5.75c	7.00ab	6.67ab	3
DALZ8502	2.00ab	6.25a	6.50ab	7.50a	7.50a	5
DALZ8508	2.00ab	5.75a	6.75a	5.25c	6.83ab	4
DALZ8516	2.00ab	6.75a	6.75a	6.50abc	7.17a	5
BELAIR	3.00a	6.25a	5.00d	5.75bc	6.17b	2
EL TORO	1.67b	6.00a	6.00bc	7.50a	7.17a	3
EMERALD	2.33ab	6.75a	6.75a	7.25ab	7.00ab	5
MEYER	3.00a	6.50a	6.25abc	6.25abc	7.00ab	5
MSD*	1.01	1.42	0.65	1.60	0.89	

* MSD = Minimum Significant Difference at the 5% level. Means within a column followed by the same letter are not different at the 5% level of probability based on Waller-Duncan multiple comparison procedure (K=100). Color ratings = 1-9, with 1 = brown, 6 = acceptable and 9 = dark green. Phenotypic stability is the frequency of occurrence in the highest rating group.

Table 17. Percent winter kill, ground cover, iron chlorosis and chlorosis ratings for the University of Arizona zoysiagrass regional trial, Tucson, AZ; established 1987.

	Percent Winter Kill	Ground Cover			Iron Chlorosis	Chlorosis	
Entry	May	May	Jun	Sep	Jun	Oct	Phenotypic Stability
DALZ8501	10.00a	90.00a	4.00c	7.50a	8.00b	7.50a	4
DALZ8502	27.50b	87.50a	5.75ab	8.00a	9.00a	7.50a	5
DALZ8508	12.50ab	90.00a	6.75a	3.75b	8.50ab	6.67ab	5
DALZ8516	5.00a	85.00a	5.50b	6.75a	9.00a	7.17ab	5
BELAIR	5.00a	35.00b	4.00c	4.75b	4.50a	6.00b	2
EL TORO	5.00a	90.00a	6.50ab	7.50a	7.00a	7.83a	6
EMERALD	10.00ab	85.00a	6.00ab	7.00a	8.50ab	7.33a	6
MEYER	10.00a	77.50a	6.25ab	7.50a	8.00b	7.17ab	5
MSD*	16.94	25.60	0.65	1.77	0.87	1.21	

* MSD = Minimum Significant Difference at the 5% level. Means within a column followed by the same letter are not different at the 5% level of probability based on Waller-Duncan multiple comparison procedure (K=100). Winter kill and May ground cover ratings = percentages. June and September ground cover = 1-9, with 1= bare, 6 = acceptable, and 9 = complete. Both chlorosis ratings = 1-9, with 1 = very yellow, 6 = acceptable, and 9 = no yellow. Phenotypic stability is the frequency of occurrence in the highest rating group.

Table 18. DIALLEL OF COMPLETED POLLINATION ISOLATIONS.

F/M	8501	8502	8503	8506	8507	8508	8513	8514	8515	8516	8517	8520	8523	8524	8701	BK7	BL	CS	ET	EM	MY
DALZ8501	5	8	2	2		2			2	2				4					1	4	
DALZ8502	8	10				1														1	
DALZ8503			17																	1	
DALZ8506				17																	
DALZ8507	4	4	1	1		3	1	1						3			1	2		3	1
DALZ8508	2					26											1			2	1
DALZ8513							2													1	
DALZ8514	1	1																			
DALZ8515	2								10												3
DALZ8516										7											
DALZ8517	3	2				1						1		3						2	1
DALZ8520	2	2							1				1	1						2	
DALZ8523																					
DALZ8524	2												20				1				2
DALZ8701																					
BK7																					
BELAIR														1			9				1
CASHMERE	3	3	1	1		3	1							3			2	6		3	
EMERALD	6	2	1	1		2			1			1		2			1			17	1
EL TORO																					
MEYER									5					1			1				7

APPENDIX A

VITA

BRIDGET A. RUEMMELE
Post Doctoral Research Associate
Texas A&M University Research and Extension Center
Dallas, Texas 75252

PROFESSIONAL OBJECTIVE

I desire an industry or academic teaching, fundamental and/or applied research, and/or extension position involving horticulture and/or agronomy.

EDUCATION

Ph.D., 1989 - U. of Minnesota, Horticulture Major. GPA: 4.00
M.S., 1984 - U. of Minnesota, Horticulture Major. GPA: 4.00
B.S., 1980 - U. of Wisconsin-River Falls, Horticulture Major. GPA: 4.00

RESEARCH AND SKILLS

Warm and cool season turfgrass breeding and management; reproductive biology in Poa annua L.; laboratory, greenhouse, and field experiences including scanning and transmission electron microscopy, genetics (including incompatibility), breeding methods, cytological methods, tissue culture, pesticide and growth regulator application and evaluation, use of IBM equipment for word processing and data analysis and interpretation, SAS, turf equipment operation and maintenance.

EMPLOYMENT RECORD

POST-DOCTORAL RESEARCH ASSOCIATE
Texas A&M University Research and Extension Center - Dallas; 1/89 - present. Involved with warm and cool season turfgrass breeding, genetics, management. Species include zoysiagrass, buffalograss, tall fescue, St. Augustinegrass, centipedegrass. Supervise program in project leader's absence.

GRADUATE RESEARCH ASSISTANT
U. Of Minnesota; 3/81 - 12/88. Studied feasibility of using scanning electron microscopy to examine turfgrass anatomy. Assisted with genetic and breeding program for improvement of Poa annua L. Assisted other project activities and supervised technical assistants.

TEACHING ASSISTANT
U. of Minnesota; 3/81 - 6/81; 1/88 - 3/88. Involved with laboratory and lecture preparation and teaching of undergraduate students in introductory turfgrass science and plant propagation courses.

STUDENT ASSISTANT, TEACHING AND CLERICAL
U. of Wisconsin-River Falls; 9/78 - 5/80. Assisted in laboratory preparation, teaching and grading of an introductory soils course. Performed clerical duties including typing, filing, and proofreading.

PROFESSIONAL MEMBERSHIPS

American Society of Agronomy; American Society of Horticultural Science; Crop Science Society of America; Alpha Zeta; Gamma Sigma Delta; Phi Kappa Phi; Pi Alpha Xi.

PUBLICATIONS

Taxonomy of zoysia. 1989. B. A. Ruemmele*, M. C. Engelke, and M. R. Quick. Crop Science Society of America Meeting. Las Vegas, Nevada. (abstract)

Effect of protracted cold treatments on excised Poa annua L. and Poa supina Schrad. stolons. 1988. D. B. White, B. A. Ruemmele*, and P. D. Ascher. Crop Science Society of America Meeting. Anaheim, California. (abstract)

Separation of Poa annua L. and Poa supina Schrad. biotypes by isozyme electrophoresis. 1988. S. A. Berman*, D. B. White, and B. A. Ruemmele. Crop Science Society of America Meeting. Anaheim, California. (abstract)

Variability in reproductive biology among Poa annua L. biotypes: incongruity and compatibility analyses. 1988. B. A. Ruemmele*, D. B. White, and P. D. Ascher. Crop Science Society of America Meeting. Anaheim, California. (abstract)

The influence of mefluidide on vegetative suppression and seedhead inhibition of Poa annua L. and Poa supina Schrad. 1988. Bridget A. Ruemmele*, Donald B. White, and Peter D. Ascher. American Society of Horticultural Science Meeting. East Lansing, Michigan (abstract)

Reproductive biology in Poa annua L.: seed set analysis. 1987. B. A. Ruemmele*, D. B. White, and P. D. Ascher. Crop Science Society of America Meeting. Atlanta, Georgia. (abstract)

Factors affecting seed set from detached Poa spp. inflorescences. 1987. P. D. Ascher, B. A. Ruemmele*, and D. B. White. Crop Science Society of America Meeting. Atlanta, Georgia. (abstract)

Some scanning electron microscopy (SEM) applications in turfgrass research. 1987. D. B. White* and B. A. Ruemmele. Crop Science Society of America Meeting. Atlanta, Georgia. (abstract)

Cold storage effects on survival and regrowth of excised Poa annua and Poa supina stolons. 1987. Bridget A. Ruemmele*, Donald B. White, and Peter D. Ascher. American Society of Horticultural Science Meeting. Orlando, Florida. (abstract)

Techniques for investigating self compatibility and self incompatibility in Poa annua L. and Poa supina Schrad. 1986. B. A. Ruemmele*, D. B. White, and P. D. Ascher. Crop Science Society of America Meeting. New Orleans, Louisiana. (abstract)

Variation in domestic and exotic Poa annua L. and Poa supina Schrad. germplasm sources. 1986. D. B. White*, B. A. Ruemmele, and P. D. Ascher. Crop Science Society of America Meeting. New Orleans, Louisiana. (abstract)

Genetic control of self-incompatibility in grasses: a re-evaluation. 1985. N. O. Anderson, B. E. Liedl, P. H. Velguth, R. Merrill, S. Berman, B. A. Ruemmele, and P. D. Ascher. Stadler Genetics Symposium. Columbia, Missouri. (abstract)

Growing potatoes in Minnesota. 1985. B. A. Ruemmele. Dial U Teletip. University of Minnesota Horticultural Extension Service.

Growing onions in Minnesota. 1984. B. A. Ruemmele. Dial U Teletip. University of Minnesota Horticultural Extension Service.

VITA

Richard H. White
Assistant Research Scientist
Texas A&M University Research and Extension Center
Dallas, Texas 75252

EDUCATION:

B.S. 1979, Auburn University, Agronomy
M.S. 1982, Auburn University, Agronomy
Ph.D. 1985, VPI and State University, Agronomy

EMPLOYMENT:

Assistant Research Scientist, Texas A&M University Research Center, Dallas, TX 75252, 1989-present.
Assistant Research Professor, Soils and Crops Department, Rutgers University-Cook College, New Brunswick, NJ 08903, 1985-1989.
Research Associate, Department of Plant Physiology and Pathology, VPI and State University, Blacksburg, VA 24061, 1985.
Graduate Research Assistant, Department of Agronomy, VPI and State University, Blacksburg, VA 24061, 1982-1984.
Graduate Research Assistant, Department of Agronomy and Soils, Auburn University, Auburn, AL 36849, 1979-1982.
Self-employed, Turfgrass Establishment and Management, Home Lawns, 1974-1976.

PUBLICATIONS:

White, R. H., and R. E. Schmidt. 1989. Fall performance and post-dormancy growth of Midiron bermudagrass in response to nitrogen, iron, and benzyladenine. J. Am. Soc. Hortic. Sci. (In press).
White, R. H. 1989. Water relations of tall fescue as influenced by Acremonium endophyte. Agron. Abstr. American Society of Agronomy, Madison, WI. p. 167.
White, R. H., and R. E. Schmidt. 1989. Bermudagrass response to chilling temperatures as influenced by iron and benzyladenine. Crop Sci. 29:768-773.
Funk, C. R., R. H. White, and R. F. Bara. 1989. Registration of 'Pinnacle' perennial ryegrass. Crop Sci. 29:(In press).
White, R. H., P. Stefany, and M. Comeau. 1988. Pre- and poststress temperature influence perennial ryegrass in vitro heat tolerance. HortScience 23:1047-1050.
White, R. H., and R. E. Schmidt. 1988. CO2 exchange of Tifgreen bermudagrass exposed to chilling temperatures as influenced by iron and benzyladenine. J. Am. Soc. Hortic. Sci. 113:423-428.
White, R. H. 1988. The Northeast - A research review. Park Maintenance and Grounds Management 32:8-11.
White, R. H. 1988. Improving sod rooting for installation success. Grounds Maintenance 23:28, 40-41.
White, R. H., and M. Comeau. 1987. Tall fescue leaf gas exchange and water relations as influenced by endophytic fungi. Agron. Abstr. American Society of Agronomy, Madison, WI. p. 140.
White, R. H. 1987. Why Aerify? Rutgers Turfgrass Proceedings Vol. 18:25-32.
Schmidt, R. E., R. H. White, and S. W. Bingham. 1986. Technique to measure rooting of sods grown in small containers.Agron. J. 78:212-216.
Clarke, B. B., and R. H. White. 1986. Evaluation of nitrogen fertility and fungicide timing for the control of sclerotinia dollar spot on bentgrass. Rutgers Turfgrass Proceedings Vol. 17:107-114.
Schmidt, R. E., and R. H. White. 1985. Cytokinin and iron influence on desiccated zoysiagrass. Agron Abstr. American Society of Agronomy, Madison, WI. p. 121.
White, R. H., and R. E. Schmidt. 1985. Carbon dioxide exchange rate of bermudagrass under chilling stress in response to iron fertilization. Agron. Abstr. American Society of Agronomy, Madison, WI. p. 122.
Schmidt, R. E., and R. H. White, and S. W. Bingham. 1984. Technique to measure turfgrass root growth efficiently in laboratory and greenhouse. Agron. Abstr. American Society of Agronomy, Madison, WI. p. 154.
White, R. H., and Ray Dickens. 1984. Thatch accumulation in bermudagrass as influenced by cultural practices. Agron. J. 76:19-22.
White, R. H., and Ray Dickens. 1984. Plant-parasitic nematode populations in bermudagrass as influenced by cultural practices. Agron. J. 76: 41-43.
Schmidt, R. E., and R. H. White. 1984. Rooting enhancement of transplanted Poa pratensis L. sod. Agron. Abstr. American Society of Agronomy, Madison, WI. p. 154.

White, R. H., and R. E. Schmidt. 1983. Update on sod installation research. Proc. 23rd Virginia Turfgrass Conf. p. 80-83.

Dickens, Ray, R. White, D. Turner, and K. Miller. 1982. Several perennial ryegrasses look good for putting greens. Highlights of Agric. Res. 29(2). Alabama Agric. Exp. Station, Auburn, AL.

White, R. H., and Ray Dickens. 1981. Cultural practices control thatch in bermudagrass golf greens. Highlights of Agric. Res. 28(3). Alabama Agric. Exp. Station, Auburn, AL.

White, R. H., and Ray Dickens. 1981. Thatch accumulation as affected by cultural practices and bermudagrass cultivar. Agron. Abstr. American Society of Agronomy, Madison, WI. p. 129.

White, R. H., and Ray Dickens. 1980. Nematode populations in bermudagrass as affected by cultivar and management. Agron. Abstr. American Society of Agronomy, Madison, WI. p. 120.

HONORS:

Sigma Xi, The National Research Honor Society - 1988
Phi Sigma, National Biological Honor Society - 1984
Teaching Scholarship, Department of Agronomy and Soils, Auburn University - 1980.
Instructional Scholarship, Department of Agronomy, VPI and State University - 1983, 1984, 1985.

MEMBERSHIP IN PROFESSIONAL AND HONORARY SOCIETIES:

American Society of Agronomy-Crop Science Society of America:

1979-present	Member
1988	Session Chair, "Effects of Culture on Turfgrass Stress"
1988-present	Division C-5 Symposium Committee
1989	Division C-5 Symposium Committee, "Fate of Nutrients and Pesticides Applied to Turf"

Northeast Regional Cooperative Turfgrass Research Committee:

1985-1989	Member
1988	Chairman

New Jersey Turfgrass Association:

1985-1989	Agronomic Advisor
1985-1989	Associate Editor - GreenWorld,
1985-1989	Editor, Rutgers Turfgrass Proceedings.

Northeastern Weed Science Society

1985-1989	Member

Golf Course Superintendents Association of NJ

1985-present	Honorary Member

VITA

Sharon J. Morton
Research Assistant
Texas A&M University Research and Extension Center
Dallas, Texas 75252

EDUCATION:

B. S. 1979, Oklahoma University, Botany
M. S. 1982, Texas Christian University, Biology

EMPLOYMENT:

Research Assistant, Texas A&M University Research Center, Dallas, TX 75252, 1989-present.
Doctoral and Teaching Fellow, Botany, Miami University of Ohio, Oxford, Ohio 45056, 1983-1987.
Teaching Assistant, Biology Department, Texas Christian University, Fort Worth, Texas 76129 1979-1982.

RESEARCH EXPERIENCE:

Doctoral Research: Tissue localization of flavonoids, and enzymes related to their biosynthesis of Sorghum bicolor Moench.

Master's Research: Structure and function in an old-field plant community in the western crosstimbers of Texas.

PUBLICATION:

Fawley, M. W., S. J. Morton, K. D. Stewart, and K. R. Mattox. 1987. Evidence for a common evolutionary origin of light harvesting fucozanthin chlorophyll a/c - protein complexes of Pavlova gyrans (Prymnesiophyceae) and Phaeodactylum tricornutum (Bacillariophyceae). J. Phycol. 23(2):377-381.

APPENDIX B

PREPROPOSAL

October 15, 1989

Submitted to the Crop Advisory Committee-Grasses
for review and recommendation

ESTABLISHING A CORE COLLECTION OF ZOYSIA SPP.

M. C. Engelke
Associate Professor
Texas A&M Research & Extension Center-Dallas

PURPOSE:

The United States Golf Association, the United States Department of Agriculture, Agricultural Research Service (USDA-ARS), and Texas Agricultural Experiment Station (TAES) funded an extended plant collection trip for zoysiagrass germplasm in the Pacific Rim countries including Japan, South Korea, Taiwan, and the Philippines in 1982. These germplasm have been in field (Beltsville and Dallas) and greenhouse (Dallas) nurseries since 1982. Considerable information has been assembled at each location on morphological and agronomic traits on most of the germplasm. None of this information has been consolidated. No germplasm has been entered into the USDA Plant Introduction (PI) system, either. The loss of the USDA position (J. J. Murray) having curator and/or germplasm maintenance responsibility with ARS, Beltsville Agricultural Research Center (BARC) in January 1989 has resulted in the potential loss of information and germplasm being held at that location. It is the intent of this proposal to consolidate the information into a reasonable data base, and classify the information using the latest techniques and procedures to identify a CORE of germplasm which would ultimately be entered into the PI System.

OBJECTIVES:

1) Consolidate the information on the agronomic, morphological and biochemical performance characters of the zoysiagrass collection that has been previously assembled independently by the two zoysiagrass research programs (ARS, BARC and TAES-Dallas). Collect and assess additional characters as needed.
2) Statistically assess the genetic diversity of the germplasm based on this available information using statistical and numerical taxonomic procedures.
3) Identify a "core" of genotypes (phenotypes) consisting of approximately 10% of the original collection which will represent at least 90-95% of the genetic diversity available. The germplasm resources present in the zoysiagrass collection will be used to mathematically test the theory on "CORE COLLECTIONS" which should aid in developing a model for other plant species.
4) Establish maintenance procedures for long term preservation of vegetative germplasm resources of the Zoysia spp.

JUSTIFICATION AND BACKGROUND:

Considerable germplasm of the Zoysia spp. presently exist at two locations in the United States (USDA, BARC and Texas A&M-Dallas) as a result of a 1982 plant exploration trip made in Japan, South Korea, Taiwan and the Philippines. The trip, jointly funded by the USDA Agricultural Research Service, Texas A&M Agricultural Experiment Station, and the United States Golf Association resulted in acquiring approximately 800 accessions of the genus Zoysia. This trip was made by J. J. Murray (formerly USDA, ARS now retired) and M. C. Engelke (Texas A&M).

Following a lengthy quarantine, a major portion of the collection was duplicated and sent to Texas in February 1983. The total collection has grown to approximately 1000 accessions through additional materials sent from Korea since 1982 in cooperation with the late Dr. Do Yi (Dewey) Yeam. Dr. Yeam, a major Foreign cooperator on this project, was killed in an automobile accident in 1987.

Considerable field and greenhouse data have been assembled over the past 7 years by both Engelke and Murray. To date, none of this information has been made available to the general public. None of the plant material has been entered into the PI System, and only limited, if any, germplasm has been distributed. There have been numerous calls for the germplasm.

The two collections were being maintained independently. The Beltsville collection was being maintained primarily under field conditions with several of the less winter-hardy accessions also grown under greenhouse conditions. The TAES-Dallas collection has been maintained in its entirety in both the field and the greenhouse. The greenhouse collection is maintained in Deepots. Plants are repotted approximately every 3 years in order to maintain genetic purity and to relieve strain from being pot bound.

PROCEDURES:

Mr. J. J. Murray has retired from the USDA, ARS, and has moved from the Beltsville, MD area. His professional position has been closed-out by the Agency with no plans to reinstate. Presently little, if any, attention is being directed to maintenance of the Maryland collection, with records maintained in dormant files. It is imperative that specific attention be given to the permanent maintenance of the raw data files and records of Mr. Murray. This information is essential, in combination with data from the zoysia collection in Texas, to accurately assess the genetic diversity. It is proposed that the information would be assembled, analyzed using routine statistical procedures such as Analysis of Variance (ANOVA), CoVariant Analysis (COVANOVA) as well as Cluster Analysis (SAS procedures), Principle Component Analysis and other recognized statistical procedures to aid in identifying the degree of genetic diversity. It is further intended that Mr. Murray would be retained on a limited basis to aid in expeditious interpretation and entry of data into a compatible computer base. This, of course, is contingent on Mr. Murray's willingness and ability to participate, which presently appears quite positive. Also, I have had extensive conversations with a numerical taxonomist presently located at a small private University in North Texas. He has expressed an interest in working with us to aid in identification and classification of these germplasm, using conventional and sophisticated laboratory procedures.

Utilizing such procedures, and interaction with both Murray and the Taxonomist, should allow us to identify individual plants for inclusion in a CORE COLLECTION, which should represent at least 90-95% of the genetic diversity of the entire collection.

Such information would be useful in reducing the number of vegetative clones being permanently maintained in the PI system. Maintenance of vegetative material is quite expensive in time needed to periodically transfer material due to root binding and decline of material maintained in pots. Also, it is expensive in the space and facilities required to maintain materials which are subject to environmental extremes. Many of the zoysias are tropical in origin and lack winterhardiness to survive under field conditions in Beltsville, Maryland or even in North Texas. By reducing the physical number of plants which must be maintained as a CORE COLLECTION, we can better insure maintenance of the collection, and above all else preservation of germplasm that is so critical to the future of the species and the turf industry.

APPENDIX C

TEXAS A&M UNIVERSITY
RESEARCH AND EXTENSION CENTER AT DALLAS

THE TEXAS AGRICULTURAL EXPERIMENT STATION
17360 COIT ROAD DALLAS, TEXAS 75252
PHONE (214) 231-5362

rev 2/89

MEMORANDUM OF AGREEMENT

TO: DR. Victor Gibeault

FROM: M. C. Engelke, Turfgrass Breeder and Geneticist
Texas Agricultural Experiment Station - Dallas

SUBJECT: TRANSFER AND TESTING OF PLANT MATERIAL

PLANT SPECIES: Zoysia spp.

Description and quantity of material released:

Experimental Designation	Quantity & Type Material
DALZ8501; DALZ8507; DALZ8701 DALZ8502; DALZ8512; DALZ8514	2 flats apiece (~22"×11" per flat) = total 12 flats

Commercially Available Cultivars	
Belair Meyer El Toro Emerald	2 flats apiece (~22"×11") = total 8 flats

PURPOSE OF RELEASE: description of proposed testing procedure(s) or objectives, i.e. field evaluation, disease assessment, etc.

· field evaluation

Modifications to Purpose:

Location of Planting:

Riverside, California

OTHER: Plant material may not be released to a third party and may not be used for any purpose other than the original specific request without the expressed written permission from M. C. Engelke, and/or Texas Agricultural Experiment Station. Information concerning performance of plant materials designated above as experimentals will not be made public, in written or verbal form without prior written permission from M. C. Engelke, and/or Texas Agricultural Experiment Station.

RELEASED BY: Bridget Ruemmele (Rep of Turf Breeding Program) 5-23-89 Date

RECEIVED BY: Victor A. Gibeault (Name of Requesting Cooperator or Rep) 6-1-89 Date

TEXAS A&M UNIVERSITY

RESEARCH AND EXTENSION CENTER AT DALLAS

THE TEXAS AGRICULTURAL EXPERIMENT STATION
17360 COIT ROAD DALLAS, TEXAS 75252
PHONE (214) 231-5362

rev 2/89

MEMORANDUM OF AGREEMENT

TO: DR. JOHN DUNN

FROM: M. C. Engelke, Turfgrass Breeder and Geneticist
Texas Agricultural Experiment Station - Dallas

SUBJECT: TRANSFER AND TESTING OF PLANT MATERIAL

PLANT SPECIES: Zoysia spp.

Description and quantity of material released:

Experimental Designation	Quantity & Type Material
DALZ 8507; DALZ 8512 DALZ 8514; DALZ 8701 DALZ8508;	1 ~22" x 11" flat of each

Commercially Available Cultivars

—

PURPOSE OF RELEASE: description of proposed testing procedure(s) or objectives, i.e. field evaluation, disease assessment, etc.

field evaluation

Modifications to Purpose:

Location of Planting:

Columbia, Missouri

OTHER: Plant material may not be released to a third party and may not be used for any purpose other than the original specific request without the expressed written permission from M. C. Engelke, and/or Texas Agricultural Experiment Station. Information concerning performance of plant materials designated above as experimentals will not be made public, in written or verbal form without prior written permission from M. C. Engelke, and/or Texas Agricultural Experiment Station.

RELEASED BY: Bridget Ruemmele (Rep of Turf Breeding Program) 5-30-89 Date

RECEIVED BY: J. Dunn (Name of Requesting Cooperator or Rep) 6/5/89 Date

TEXAS A&M UNIVERSITY

RESEARCH AND EXTENSION CENTER AT DALLAS

THE TEXAS AGRICULTURAL EXPERIMENT STATION
17360 COIT ROAD DALLAS, TEXAS 75252
PHONE (214) 231-5362

rev 2/89

MEMORANDUM OF AGREEMENT

TO: Sunset Hills Golf Club

FROM: M. C. Engelke, Turfgrass Breeder and Geneticist
Texas Agricultural Experiment Station - Dallas

SUBJECT: TRANSFER AND TESTING OF PLANT MATERIAL

PLANT SPECIES: Zoysia sp.

Description and quantity of material released:

Experimental Designation				Quantity & Type Material — all materials are 2" plugs; 2 of each
DALZ 8504	DALZ 8507	DALZ 8511	DALZ 8502	
DALZ 8505	DALZ 8508	DALZ 8512	DALZ 8503	
DALZ 8506	DALZ 8509	DALZ 8513	DALZ 8514	
	DALZ 8510	DALZ 8501	DALZ 8515	(see other side)

Commercially Available Cultivars

Belair Midwest FC 13521
El Toro Meyer
Cashmere Emerald

PURPOSE OF RELEASE: description of proposed testing procedure(s) or objectives, i.e. field evaluation, disease assessment, etc.

field evaluation - not for public release

Modifications to Purpose:

Location of Planting:

Sunset Hills Golf Club, Edwardsville, Ill.

OTHER: Plant material may not be released to a third party and may not be used for any purpose other than the original specific request without the expressed written permission from M. C. Engelke, and/or Texas Agricultural Experiment Station. Information concerning performance of plant materials designated above as experimentals will not be made public, in written or verbal form without prior written permission from M. C. Engelke, and/or Texas Agricultural Experiment Station.

RELEASED BY: M C Engelke (Rep of Turf Breeding Program) 6/3/89 Date

RECEIVED BY: ______________________ (Name of Requesting Cooperator or Rep) ________ Date

TEXAS A&M UNIVERSITY
RESEARCH AND EXTENSION CENTER AT DALLAS

THE TEXAS AGRICULTURAL EXPERIMENT STATION
17360 COIT ROAD DALLAS, TEXAS 75252
PHONE (214) 231-5362

rev 2/89

MEMORANDUM OF AGREEMENT

TO: David Doguet, Quality Turf, B-4 Corp.

FROM: M. C. Engelke, Turfgrass Breeder and Geneticist
Texas Agricultural Experiment Station - Dallas

SUBJECT: TRANSFER AND TESTING OF PLANT MATERIAL

PLANT SPECIES: Zoysia matrella

Description and quantity of material released:

Experimental Designation	Quantity & Type Material
7/6 DALZ 8502	160 sq.ft.
7/13 DALZ8502	30 yds

Commercially Available Cultivars

PURPOSE OF RELEASE: description of proposed testing procedure(s) or objectives, i.e. field evaluation, disease assessment, etc.

Foundation production in Lone City

Modifications to Purpose: to increase to 1.7 acres Foundation grade production

Location of Planting:
Quality Turf ~~Lone~~ Looper Farm, Lone City, Texas

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RELEASED BY: M C Engelke 7/13/89
(Rep of Turf Breeding Program) Date

RECEIVED BY: David Doguet 7-13-89
(Name of Requesting Cooperator or Rep) Date

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rev 2/89

MEMORANDUM OF AGREEMENT

TO: DR. Dan Bowman

FROM: M. C. Engelke, Turfgrass Breeder and Geneticist
Texas Agricultural Experiment Station - Dallas

SUBJECT: TRANSFER AND TESTING OF PLANT MATERIAL

PLANT SPECIES: Zoysia spp. (matrella & japonica)

Description and quantity of material released:

Experimental Designation — Quantity & Type Material

DALZ8501 DALZ8502 DALZ8503 DALZ8504 DALZ8505 DALZ8506 DALZ8507 DALZ8508 DALZ8509 DALZ8510 DALZ8511 DALZ8512 DALZ8513 DALZ8514 DALZ8515 DALZ8516 DALZ8517 DALZ8518 DALZ8519 DALZ8520 DALZ85222 DALZ8523 DALZ8524 DALZ8701

1 square ft. sod piece

Commercially Available Cultivars

Emerald
Meyer
Belair

PURPOSE OF RELEASE: description of proposed testing procedure(s) or objectives, i.e. field evaluation, disease assessment, etc.
salt resistance screening, followed by nitrogen uptake and metabolism analysis of salt resistant/tolerant vs. salt sensitive accessions; field evaluation - beginning 1990

Modifications to Purpose:

Location of Planting:
University of Nevada-Reno
- greenhouse & field

OTHER: Plant material may not be released to a third party and may not be used for any purpose other than the original specific request without the expressed written permission from M. C. Engelke, and/or Texas Agricultural Experiment Station. Information concerning performance of plant materials designated above as experimentals will not be made public, in written or verbal form without prior written permission from M. C. Engelke, and/or Texas Agricultural Experiment Station.

RELEASED BY: Bridget Ruemmele — August 14, 1989
(Rep of Turf Breeding Program) — Date

RECEIVED BY: [signature] — Aug 25 1989
(Name of Requesting Cooperator or Rep) — Date

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rev 2/89

MEMORANDUM OF AGREEMENT

TO: MR. WILLIAM BENGEYFIELD

FROM: M. C. Engelke, Turfgrass Breeder and Geneticist
Texas Agricultural Experiment Station - Dallas

SUBJECT: TRANSFER AND TESTING OF PLANT MATERIAL

PLANT SPECIES: Zoysia

Description and quantity of material released:

Experimental Designation	Quantity & Type Material
DALZ8501	1 sod piece

Commercially Available Cultivars

PURPOSE OF RELEASE: description of proposed testing procedure(s) or objectives, i.e. field evaluation, disease assessment, etc.

Visual assessment -- please discard after assessment

I did so! WHB

Modifications to Purpose:

Location of Planting:

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RELEASED BY: Bridget Ruemmele (Rep of Turf Breeding Program) 8-17-89 Date

RECEIVED BY: Bill Bengeyfield (Name of Requesting Cooperator or Rep) 8-18-89 Date

w/ Thanks! There was great, ...

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rev 2/89

MEMORANDUM OF AGREEMENT

TO: Dr. David Huff

FROM: M. C. Engelke, Turfgrass Breeder and Geneticist
Texas Agricultural Experiment Station - Dallas

SUBJECT: TRANSFER AND TESTING OF PLANT MATERIAL

PLANT SPECIES: Zoysia spp. - zoysiagrasses

Description and quantity of material released:

Experimental Designation		Quantity & Type Material
DALZ8501	DALZ8507	5 sq. ft. of each
DALZ8502	DALZ8701	

Commercially Available Cultivars

PURPOSE OF RELEASE: description of proposed testing procedure(s) or objectives, i.e. field evaluation, disease assessment, etc.

Demonstration and evaluation of performance on golf course

Modifications to Purpose:

Location of Planting:

Driving Range on Ben Crenshaw golf course at Barton Creek

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RELEASED BY: MC Engelke 9/3/89
(Rep of Turf Breeding Program) Date

RECEIVED BY: Tommy Thurmond 9/13/89
(Name of Requesting Cooperator or Rep) Date

1989 Zoysiagrass Evaluation, Columbia, MO

1989 Planting

Procedure: Entries were planted in 4' x 8' plots on June 6, 1989, by placing approximate 1 inch diameter sprig clusters on 1 foot centers. Turf was topdressed with urea (45-0-0) using rates of ½ to 1 lb N at 3-4 week intervals during the growing season for an average seasonal total of 2½ lb N. Turf was irrigated as needed to prevent drought stress. Mowing was done when necessary but at least once/week with a rotary mower to maintain turf at 1 inch. Dacthal was applied to the test area at the time of establishment to prevent crabgrass infestations. No other chemicals were broadcast during the growing season. However, glyphosate was used to edge plots as needed.

Soil at the turf site is a Mexico silt loam (Udallic Ochraqualf) with a pH of approximately 6.2. A complete fertilizer was tilled into the soil prior to planting to insure an initial, high level of major nutrients.

Average temperatures during the establishment period June through September were as follows:

Month	Av. Temperature, °F	
	Min.	Max.
June	59	80
July	66	86
Aug	64	83
September	53	74

Progress: Several entries have almost covered their respective plot areas after approximately 3 months (see Table). For example, coverage by Dal 8512 and 8514 was 95-96% on September 6, compared with about 57% for Meyer zoysiagrass. Additional observations on fall color, winter hardiness, and quality will be forthcoming next year as the study progresses.

Percent cover of selected zoysiagrass entries aproximately three months after planting on 6/6/89. Columbia, Mo.

Entry	Cover, 9/16/89 (%)
Dal 8512	96
Dal 8514	95
Dal 8507	84
El Toro	81
Matrella	62
Dal 8701	57
Meyer	57
Belair	57
Dal 8508	43
Emerald	40

1987 Planting

Formal observations were discontinued in early summer, 1988, because of extensive 1987-88 winterkill of experimental Dal entries. However, small patches of Dal 8508 survived in 2 of 3 replications and now occupy 100% of their intended plot areas in those 2 reps. Quality of the 2 surviving plots was excellent during summer, 1989.