SIXTH MID-YEAR

PROGRESS REPORT

concerning

PHYSIOLOGICAL INVESTIGATIONS

in

DEVELOPING WATER CONSERVING MINIMAL MAINTENANCE TURFGRASSES AND CULTURAL SYSTEMS

Submitted by:

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I. EXECUTIVE SUMMARY

This report represents the status report for the sixth mid-year of intensive research activity devoted to developing water conserving, minimal maintenance turfgrasses and cultural systems. The current status of the research objectives and individual studies under each of the original seven research objectives are summarized in the following table.

Research Objective	Total Studies	Studies Completed: Scientific Papers Published	Studies Completed: TAES Progress Reports Published	Studies Completed: Scientific Papers in Preparation	Studies in Progress*	Studies That Can Be Complete With An Additional Year of Funding	Studies On Hold
A. Minimal Water Use Rate	15	4	6	9	4 (3)	2	-
B. Enhanced Rooting/ Water Absorption	20	--	4	4	12 (8)	4	2
C. Improved Drought Resistance	9	1	3	3	1	1	3
D. Basis of Minimal Maintenance Turfgrass	4	--	1	2	1	--	2
E. Improved Water Stress Hardiness	2	--	--	1	1	--	1
F. Wear Tolerance	2	--	2	--	--	--	--
G. Heat Tolerance	--	--	--	--	--	--	--

*Studies that will be completed by February, 1990 in parenthesis.

A detailed review of the projected completion date for each of the on-going studies was conducted in February of 1989. The primary objective was to identify those projects which could definitely be completed by February of 1990 versus those which would require a longer time frame in which to accomplish. The primary concern being to identify those projects which could be fully completed and publishable by February of 1990 in case funding for the project is ceased. As shown in the above summary table, a decision was made to set eight studies on hold and to place all our labor and resources on those projects which could be completed within the upcoming year. A flow diagram of the physiology research operations (March, 1989-April, 1990) is shown in the Appendix. A lab handout accompanies the flow diagram.

Key studies which are projected to be completed during 1989 include the following:

A-11 - Influence of cutting height and nitrogen-potassium nutritional levels on evapotranspiration rates of turfgrasses.
A-14 - Comparative evapotranspiration rates of the New Mexico State bermudagrass selections.
A-15 - Influence of a dull mower blade on evapotranspiration rates and leaf-canopy morphology.
B-17 - Determine the effects of nitrogen and temperature on seasonal carbohydrate partitioning between the roots and shoots of grasses, especially as related to the physiological basis for minimal maintenance turfgrasses.
B-18 - Determine if the carbon movement associated with spring root decline (SRD) can be altered by applications of plant growth regulators and hormones.
B-19 - Determine the effect of water stress on root hair density and viability.
B-20 - Assess root hair density, size, and viability among field-grown, warm-season turfgrasses.

Reasonably good progress has been made in all of these areas. The studies involving genetic rooting potential, root hair viability and density, and carbohydrate partitioning are very labor intensive and thus time consuming. Undoubtedly this is one of the reasons very few attempts have been made to investigate these critical dimensions of water conserving, minimal maintenance turfgrasses.

Considerable time and funds have been invested in the development of techniques for studying root hair density and viability, dehydration tolerance mechanisms related to the rate of stomatal closure/wax formation, and the carbohydrate partitioning mechanism that controls the low nitrogen requirement in turfgrasses. One additional year's funding in the order of $56,000 would allow the completion of four key research needs.

1. Determine the effects of key turfgrass cultural practices and root zone physical/chemical properties on turfgrass root hair density and viability.

2. Establish the specific effects of cutting height and nitrogen-potassium nutritional interactions on dehydration avoidance and drought resistance of turfgrasses under field conditions.

3. Provide definitive data on the relative interspecies dehydration tolerance, a major component of drought resistance, and the allied roles of rate of stomatal closure and wax formation. This would complete our understanding of the major components of drought resistance (see table on following page). For turfgrass breeding programs, it will serve as the basis to establish specific priorities in selecting plant components that will contribute the most to drought resistance.

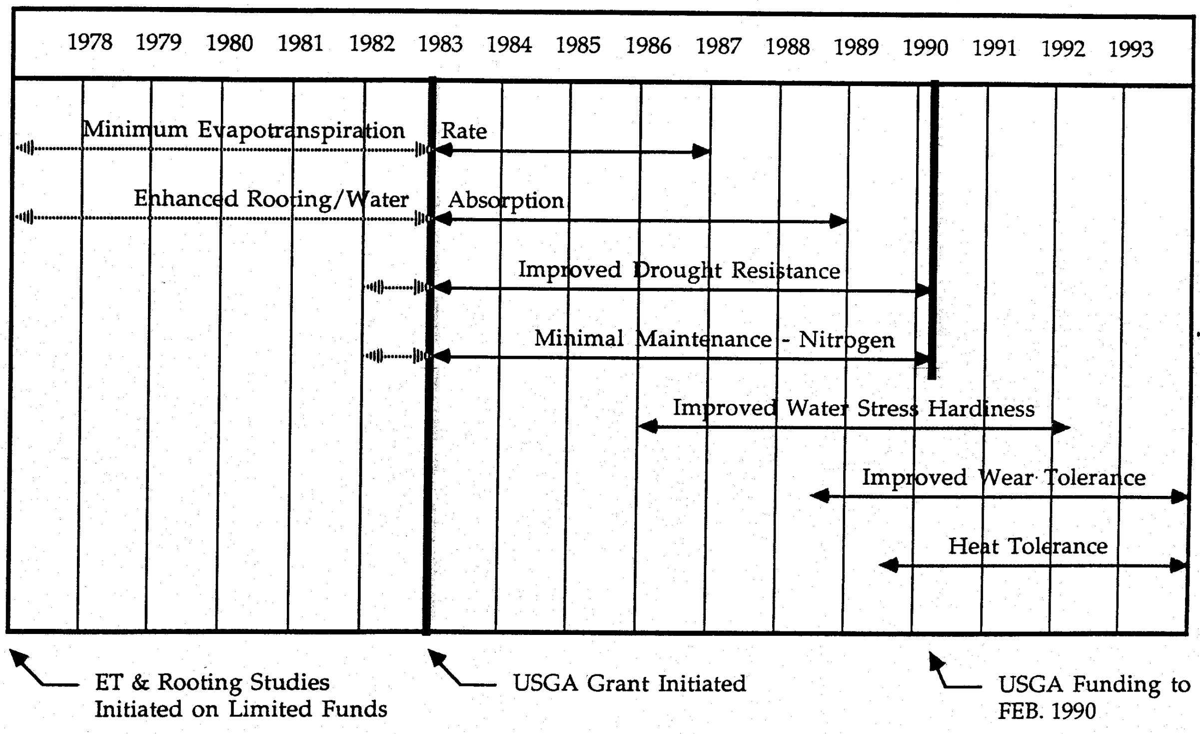
4. Investigate the hormonal (internal plant growth regulator) control involved in the uniform partitioning of carbohydrates between the shoots and roots, which this project has identified as critical in turfgrasses having a low nitrogen requirement. A key dimension is the potential for identification of a plant growth regulator that can be applied externally to turfgrasses to reduce their nitrogen requirement.

SUMMARY OF COMPARATIVE TRAITS CONTRIBUTING TO DROUGHT RESISTANCE IN WARM-SEASON TURFGRASSES TEXAS A&M UNIVERSITY

			Dehydration Avoidance Components				
Turfgrass Species	Drought Resistance	Dehydration Avoidance	Low ET	Early Stomatal Closure	Extensive Rooting	Extensive Root Hairs	Dehydration Tolerance
Bermudagrass - Group I	++++	++++	++++	+++	++++	++++	-?
Bermudagrass - Group II	+++	++	+++	?	+++	++	-?
St. Augustinegrass - Group I	++++	++++	--	?	+++	++	+++?
Seashore Paspalum - Group I	+++	++++	+	-	+	++	++
Zoysiagrass	-	-	+	+++	---	-	--
Centipedegrass	--	+	++	-	--	-	---
St. Augustinegrass - Group III	---	-	--	---	+	?	+?
Seashore Paspalum - Group III	-	--	?	?	?	?	?
Buffalograss	++++	----	+++	?	---	-	++++*

*Escape by strong dormancy mechanism.

SCHEDULE OF RESEARCH OBJECTIVES: FOR THE DEVELOPMENT OF WATER CONSERVING, MINIMAL MAINTENANCE TURFGRASSES AND CULTURAL PRACTICES



(April, 1989 - J. B. BEARD)

II. IMPLEMENTATION

A. Organization

The research staff organizational structure is shown on page 6. Although each individual has assigned areas of research responsibility, there must be and is much interactive cooperation among the group. As project leader I am very proud of the research staff that has been assembled. They are very dedicated to this project of developing water conserving, minimal maintenance turfgrasses. Each has a specific unique technical expertise that allows us to conduct a diverse range of in-depth pioneering type studies. The names of individuals assisting in each study area are listed following the objective statement.

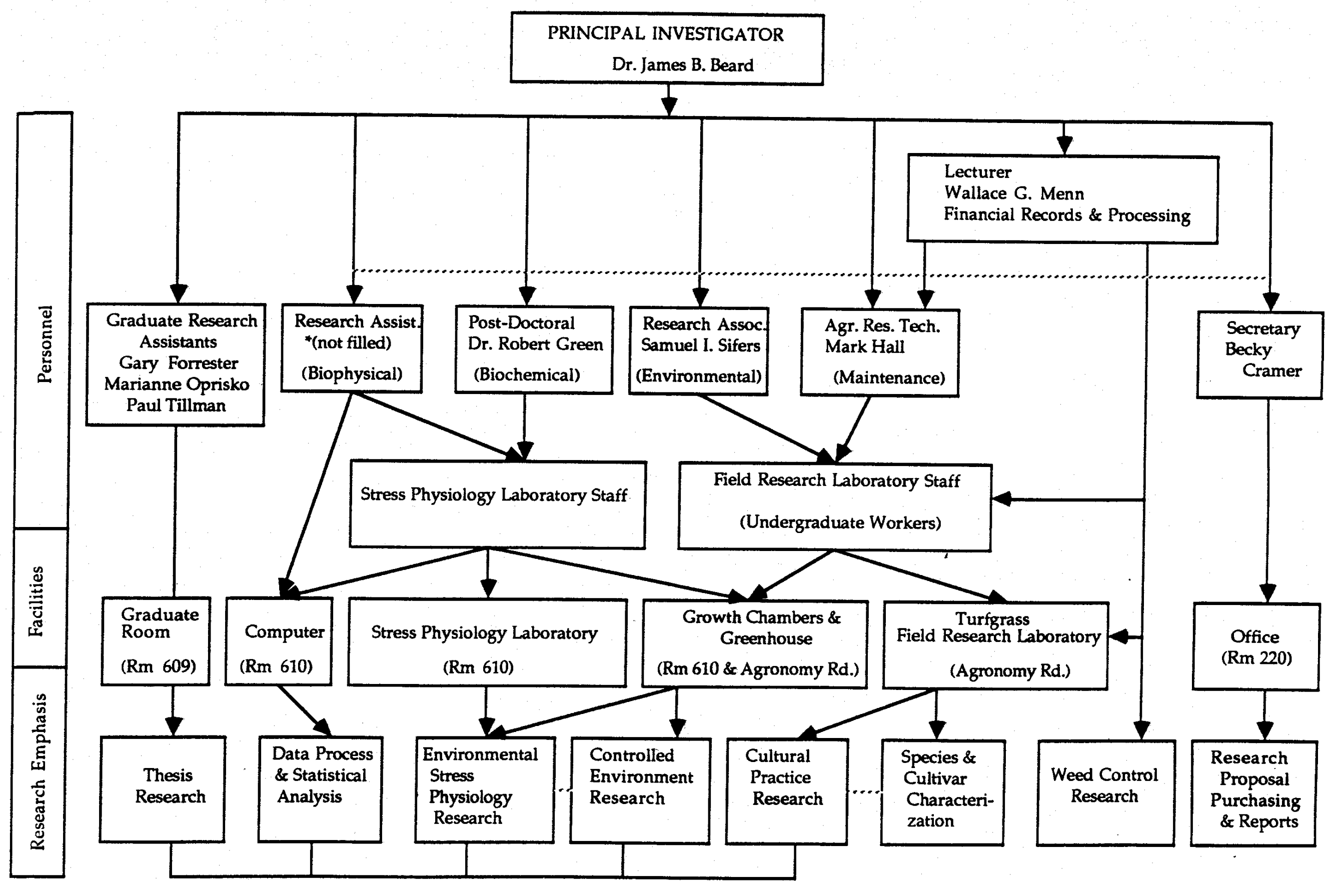
B. Personnel

No changes in personnel since the latest report.

C. Facilities Development

The status of our physical facilities to pursue the key research objectives outlined in this project is good. As originally planned, the relative percentage of our experiments involving greenhouse and laboratory activities has been increasing while the field dimension of our experimental activities has been decreasing. This trend will continue for the first five research thrust areas. However, with the initiation of wear stress studies and at a future date the heat hardiness studies, this will cause an increase in field activities during the initial 2 to 3 years to develop the turf tolerance characterizations needed under typical field conditions. These latter studies will not be undertaken if funding for the full ten years is not available.

Turfgrass Research Project Organizational Structure, Texas A&M University, College Station, Texas



(May ,1989 - J. B. BEARD)

* Position not filled due to funding deficiencies

TEXAS A&M UNIVERSITY
TURFGRASS RESEARCH FACILITIES

A. Turfgrass Stress Physiology Lab:

The 2,100 square feet complex includes a biochemistry volatiles lab, physical stress lab, isotope room, histology room, and dark room which have capabilities in carbohydrate, protein, lipid, and enzyme analyses. Equipment includes gas chromatography, open system for differential analysis of CO_2 exchange, disc gel and SDS electrophoresis, thin layer chromatography, column chromatography, spectrophotometers, refrigerated centrifuge, $carbon^{14}$ isotope facilities, spectral radiometer, potentiometers, hygrometers, thermocouple psychrometers, porometers, etc.

B. Plant Growth and Stress Chambers:

Four high-light controlled environment plant growth chambers.
Programmed low temperature and chill stress chamber.
Heat and drought stress simulation chamber.

C. Greenhouse:

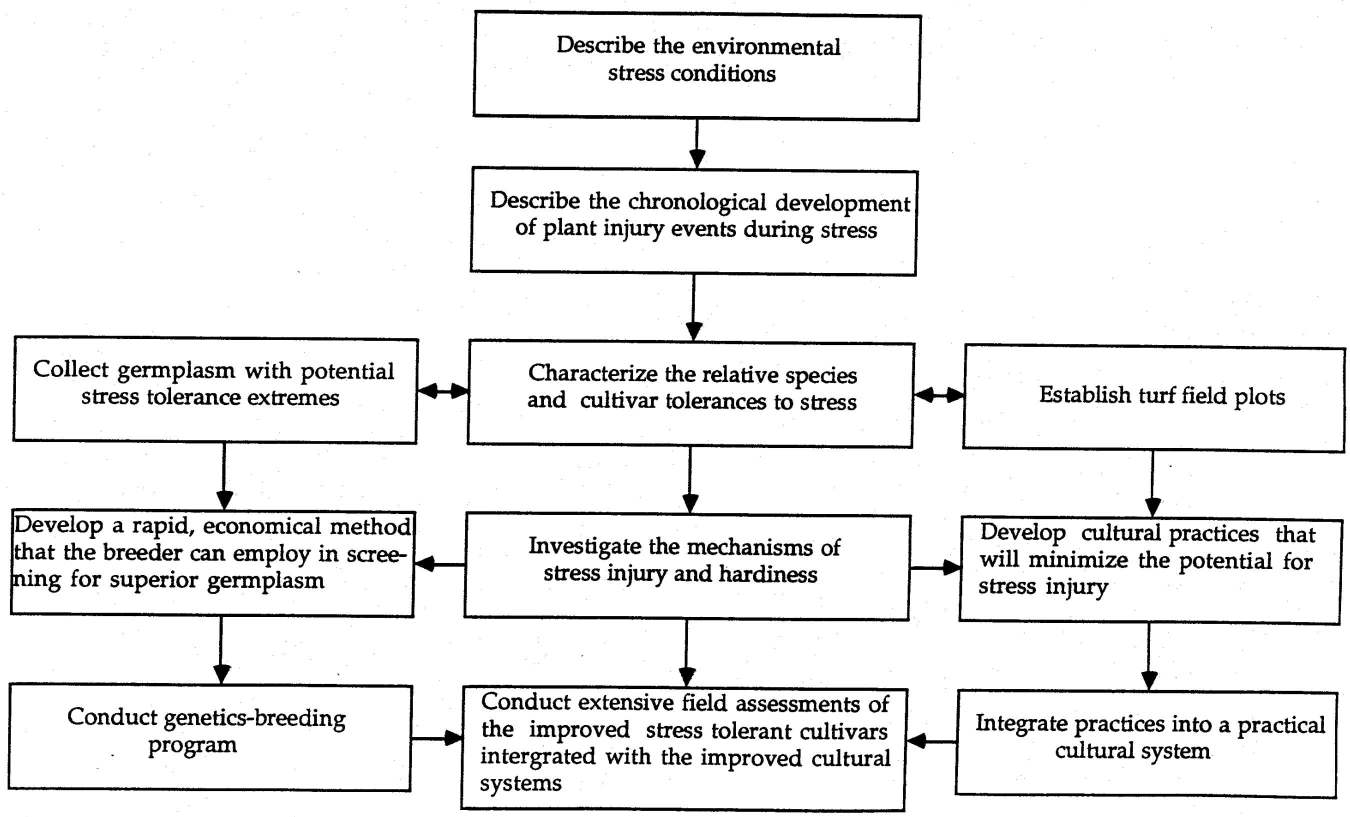
Have 1,600 square feet underglass with evaporative cooling and programmed mist irrigation which is comprised of a warm-season grass house, a cool-season grass house, and an isolation room with mist chamber; plus headhouse support facilities.

D. Turfgrass Field Laboratory:

Consists of 14 acres of turf plots including 4 acres with a sand modified root zone, 55,000 square feet of 'green' type turf plots, 65,000 square feet of tree shaded turf plots, a linear gradient irrigation area, and a microclimate monitoring system. The plots are irrigated with a fully automatic, valve in head pop-up system with master and satellite control units.

A 5,000 square foot Field Lab Building is composed of a diagnostic lab, microclimate-irrigation control center, growth room, equipment service and teaching shop, and a representative selection of turfgrass maintenance equipment.

AN ENVIRONMENTAL STRESS PHYSIOLOGY - GENETICS MODEL TO IMPROVE STRESS TOLERANCE IN TURFGRASSES



III. MID-YEAR STATUS REPORT OF ONGOING RESEARCH CONDUCTED DURING THE SIXTH YEAR

This section summarizes ongoing research that has been conducted during the past six months and/or is planned for the upcoming year. Research that has been completed and is currently in the report/scientific article preparation stage is summarized in Section V. The summary of ongoing investigations for the five major research thrusts is as follows.

A. Minimal Water Use Rates - Eleven studies have been completed, four studies are continuing.

B. Enhanced Rooting/Water Absorption - Six studies have been completed, ten studies are continuing, one is waiting for available space, three studies are on hold, and one study has been added.

C. Improved Drought Resistance - Four studies are completed, one study is continuing, four studies are on hold.

D. Mechanistic Basis of Minimum Maintenance Turfgrasses - Two studies are completed, one study is continuing, and two are on hold.

E. Improved Water Stress Hardiness - This is a new research thrust initiated in 1986 that was part of the overall master plan. One study has been completed and one is on hold.

A. OBJECTIVES FOR MINIMAL WATER USE RATE: RESEARCH STATUS AND RESULTS

This major research thrust relates primarily to the development of low evapotranspiration (water use) rates for turfs that are normally irrigated, thereby, contributing to water conservation. Also, the development of turfgrasses and cultural systems possessing reduced evapotranspiration rates will contribute one dimension to a drought avoidance strategy that is a component of drought resistance.

A-11 Investigate more critically the influences of cutting heights and nitrogen/potassium nutritional levels on turfgrass evapotranspiration rates. Initiated in 1985. S. Sifers, W. Menn, and M. Hall.

Status - Cultural treatments were continued on the Tifway bermudagrass turf along with visual ratings begun during late 1985. Cultural treatments included three cutting heights of 0.5, 1.0, and 1.5 inches, three nitrogen nutritional levels of 0.5, 1.0, and 1.5 pounds per 1,000 square feet per growing month, and three potassium levels of 0.5, 1.0, and 1.5 pounds per 1,000 square feet per growing month. These cultural treatments are combined in all possible combinations in three replications. The experimental site is a modified sand root zone with a subsurface drainage system. Specific water use rate measurements using the water balance method with mini-lysimeters were planned for 1989. Upon completion of these studies a drought resistance investigation is scheduled. These studies have been delayed due to decreased funding. This project needs one more year of funding. (Improved Cultural Systems)

A-13 Determine the comparative evapotranspiration (ET) rates for six centipedegrass cultivars. Initiated in 1986. S. Sifers, M. Hall, and C. Atkins.

Status - The third year of field studies have been completed and analyzed. The controlled environment simulation chamber studies will be completed with 1989 funding. (Intraspecies Comparison and Breeding Markers)

A-14 Determine the comparative evapotranspiration (ET) rates for six bermudagrass cultivars submitted for testing by Dr. Arden Baltensperger, New Mexico State University, in a cognitive effort. The cultivars are Arizona Common, Tifgreen, Texturf 10, NM S-4, NM 30, and NuMex Sahara. S. Sifers, M. Hall, R. Green, and C. Atkins.

Status - The six cultivars have been received and planted in mini-lysimeters. Field studies and environmental simulator studies will be conducted in 1989 to assess the comparative evapotranspiration rates. This project will be completed with 1989 funding. (Intraspecies Comparison)

A-15 Determine the effect of a dull mower blade on evapotranspiration rate and several leaf and canopy morphological characteristics of St. Augustinegrass and bermudagrass. Initiated in 1988. R. Green, C. Atkins, and M. Hall.

Status - Two grass species, Raleigh St. Augustinegrass and Santa Ana bermudagrass, were established in minilysimeters and grown under greenhouse conditions. Following establishment, there will be two mowing treatments: sharp mower blade and dull mower blade. Measurements will be made periodically of ET rate, vertical leaf extension rate, and leaf/canopy characteristics. ET rate measurements will be made in the environmental simulation chamber. Initial studies will be completed by February, 1990. (Improved Cultural Systems)

B. OBJECTIVES FOR ENHANCED ROOTING/WATER ABSORPTION: RESEARCH STATUS AND RESULTS

Development of an enhanced rooting capability will allow the turfgrass plant to absorb moisture from a greater portion of the soil profile. The relationship of rooting to the rate of moisture withdrawal must be quantified. Delineation of the rooting dimensions will contribute to both a reduced water use rate and to the avoidance dimension of drought resistance. Thus, these rooting investigations interface closely with two of the other concurrent research objectives, A and C.

B-4 Conduct exploratory studies of turfgrass root enhancing agents. Initiated in 1984. S. Sifers.

Status - This study uses 30 cm long mini-root columns with a clear plastic viewing strip to allow detailed observation of the root system. Use of these columns allows us to conduct non-destructive assessments. Turfs were subjected to temperatures of 65°F (18°C), 75°F (24°C), 85°F (30°C), and 95°F (35°C) during the heat stress phase.

Preliminary data indicate that the iron and the seaweed extract do not enhance bentgrass root survival at high sustained temperatures, but that vitamin B_1, sucrose, a mixture of these, and oxamide did show promise as root enhancing agents. Shoot die back at the high temperatures without accompanying root die back may be attributed to the high light intensity and lower humidity conditions of the chamber, but this phenomena needs further investigation. This study has been delayed due to limited space in environmental chambers and will require one more year of funding to be completed. (Mechanistic and Cultural Studies)

B-5 Determine the cause of spring root decline (SRD) of warm-season turfgrasses as well as methods to minimize its potentially negative effects (see B-16 for carbohydrate analysis and B-18 for the use of PGR's in preventing SRD). Initiated in 1984, with the biochemical studies initiated in 1986. S. Sifers, R. Green, W. Richie, F. Gonzalez, and G. Forrester.

Status - The third phase of experiments involves two studies for determining the fate of radioactive carbon in St. Augustinegrass and bermudagrass labeled prior to shoot dormancy and then induced into greenup under either SRD or non SRD conditions; plants were harvested during dormancy, early root decline, maximum root decline, early root regeneration and late root regeneration. In these experiments the amount of radioactive carbon will be determined in three carbohydrate components (sugars, starch, and structural carbohydrate) in five tissue structures (leaf, bud, stem, upper 10 cm roots, and lower 10 cm roots). Both experiments are completed and the tissues are being analyzed. The latter requires 16 months of continuous work. (Mechanistic Study)

B-6 Assess the interspecific rooting potentials of twelve major cool-season turfgrasses under non-limiting moisture conditions. Initiated in 1985. S. Sifers.

Status - This study is planted. It will be completed with 1989 funding. (Interspecies Comparisons)

B-7 Assess the interspecific rooting potentials of twelve major cool-season turfgrass species under heat stress and non-limiting moisture conditions. Initiated in 1984. S. Sifers.

Status - This project will need one more year of funding to be completed. (Interspecies Comparisons)

B-10 Assess the intraspecific rooting potentials of 24 bermudagrass cultivars under non-limiting moisture conditions. Initiated in 1986. S. Sifers.

Status - One harvest has been completed and analyzed. The second set has been harvested and is being analyzed. Progress is satisfactory and this study should be completed in 1989. (Intraspecies Comparisons)

B-11 Assess the intraspecific rooting potentials of 11 zoysiagrass cultivars under non-limiting moisture conditions. To be initiated in 1987. S. Sifers.

Status - The 11 zoysiagrass cultivars have been planted. This project requires one more year of funding. (Intraspecies Comparisons)

B-12 Assess the intraspecific rooting potentials of 11 St. Augustinegrass cultivars under non-limiting moisture conditions. To be initiated in 1987. S. Sifers.

Status - The St. Augustinegrasses have been planted. This project requires one more year of funding. (Intraspecies Comparisons)

B-13 Assess root hair location, density, size, and viability among 13 cool-season turfgrasses under non-limiting moisture conditions. Initiated in 1987. R. Green.

Status - Root Hair Study I was initiated February, 1987 and harvested in June, 1987. The intact root systems have been fixed and are being stored in jars containing ethanol under refrigeration. Analysis will be initiated when labor and time are available. (Mechanistic Study)

B-15 Determine the root hair viability among the major warm-season and cool-season turfgrasses. Initiated in 1987. R. Green and M. Oprisko.

Status - A successful technique for determining root hair viability via Evan's blue has been confirmed. Studies continue to define how long roots can be stored prior to analysis with Evan's blue and secondly, comparing the absence or presence of a root hair nucleus with whether the root hair is functional or nonfunctional according to Evan's blue. Other studies involve the testing of Evan's blue as a whole root vital stain. Studies confirming root hair viability among the major warm-season turfgrasses are on hold. (Mechanistic Study)

B-16 Carbohydrate analysis of warm-season turfgrasses from the actively growing phase through shoot dormancy to shoot greenup phase. Initiated 1987. R. Green, B. Richie, F. Gonzalez, and G. Forrester.

Status - A reliable, consistent methodology for the determination of sugars (glucose + fructose + sucrose), starch, and structural carbohydrate (residual) has been developed and successfully tested on warm-season perennial grasses. this analysis procedure will be used in B-5, B-17, and possibly B-18.

B-17 Determine the effect of nitrogen and temperature on seasonal carbohydrate partitioning between the roots and shoots of a perennial grass. Initiated in 1988. G. Forrester. This study also applied to Objective D - Mechanisms of Minimal Maintenance Turfgrass.

Status - The first objective of this study is to determine the partitioning of total nonstructural carbohydrates during a complete season of growth, from actively growing state through dormancy and back to an actively growing state, under three different levels of N fertilization and two differing temperature regimes. This study is being conducted in PVC columns, previously described in B-5.

Along with the above controlled environmental growth studies, plugs have been harvested monthly from the Texas A&M University Turfgrass Field Lab and are being analyzed for sugars and starches in 5 separate plant parts (root, stem, bud, leaf and remaining tissue). Both studies will be completed in the Fall of 1989.

B-18 Determine if the carbon movement associated with spring root decline (SRD) can be altered by applications of plant growth regulators and hormones. Initiated in 1988. R. Green, G. Forrester, F. Gonzalez, and B. Richie.

Status - Recently obtained data from study B-5 indicate that during maximum spring root decline more radioactive labeled C (carbohydrate) has left the verdure and root sections in SRD St. Augustinegrass plants than non-SRD St. Augustinegrass plants. If drastic movements of carbohydrate out of root and verdure sections during fast greenup can be slowed, then it may be possible to prevent SRD. Some plant growth regulators have been shown to alter radioactive labeled C movement, with subsequent higher levels in the root system. The first phase of this experiment involves surveying several PGR's and hormones for their ability to redirect radioactive C movement with subsequent higher levels in root and verdure sections. The second phase of this project involves the testing of the selected PGR for its ability to prevent SRD, confirmed visually and by radioactive C movement. The turfgrass species chosen for this project is St. Augustinegrass, because of the larger leaves and roots. Six-inch pots of St. Augustinegrass turfs have been established for the first phase. The first phase will be conducted in the Fall of 1989 through the Spring of 1990.

B-19 Determine the effect of moisture stress on root hair density and viability in warm-season turfgrasses. Initiated in 1989. R. Green and M. Oprisko.

Status - The first study will be conducted in the Summer of 1989. It will involve growing warm-season turfgrasses in Dee pots containing sand under greenhouse conditions. Progressive drought will be induced with a subsequent return to nonlimiting moisture conditions. Periodically, plants will be harvested and characterized for root hair population and viability. (Mechanistic Study)

B-20 Assess root hair density, size, and viability among field-grown, warm-season turfgrasses. Initiated in 1989. R. Green and M. Oprisko.

There is a need to confirm data of B-8 with field-grown turfgrasses. The first phase of this study, describing root hair density and size among the warm-season turfgrasses will be started in the Summer of 1989.

C. OBJECTIVES FOR IMPROVED DROUGHT RESISTANCE: RESEARCH STATUS AND RESULTS

Following the onset of soil drought, a grass plant exhibits leaf rolling, firing of the outer lower leaves, eventually a cessation of growth, and finally total browning of the aboveground shoot tissues. At this point, it is defined as being in a state of dormancy. Once rainfall occurs, most perennial turfgrasses have varying degrees of ability to reinitiate new shoot growth, depending on the particular species and duration of drought stress. **Drought resistance** is broadly defined as the ability of a plant to survive an extended soil drought. Note that a turfgrass that has a low water use rate is not necessarily drought resistant. These are two entirely different physiological parameters.

An important component of drought resistance is termed **dehydration avoidance**. It encompasses such characteristics as a reduced evapotranspiration rate and deeper rooting which, respectively, slows the rate of water loss from the shoots and increases the ability to absorb moisture from a greater portion of the soil profile. As a result, the point at which a plant enters dormancy is delayed and, therefore, the potential period of time when a plant is subjected to severe moisture stress during dormancy is shortened. Thus, it can be seen that Objective A, concerning Minimal Water Use Rates, and Objective B, concerning Enhanced Rooting/Water Absorption, will provide information concerning two key dimensions of dehydration avoidance.

C-4 Assess the relationship between rooting characteristics and drought resistance of twelve major warm-season perennial turfgrasses. Initiated in 1984. S. Sifers and K. Kim.

Status - The initial study under non-limiting soil moisture conditions was completed during the winter of 1985 in the greenhouse and the data were analyzed in relation to dehydration avoidance. A Doctoral Thesis covering the data was mailed to each USGA Research Committee member.

The rooting potential of the same grasses when under water stress needs to be investigated in PVC root columns in the greenhouse. The study is planned for the Fall of 1989. Needs one more year of funding. (Mechanistic Study)

C-7 Assess the relationship between rooting characteristics and drought resistance of 12 major cool-season turfgrasses. S. Sifers.

Status - Study on hold. Can be completed with one more year of funding. (Mechanistic Study)

C-8 Assessment of dehydration tolerance studies using PEG and Manitol techniques on bermudagrass and St. Augustinegrass. R. Green and M. Oprisko.

Status - Study on hold. (Mechanistic Study)

C-9 Dehydration avoidance studies involving assessments of the rate of stomatal closure and wax formation using scanning electron microscope techniques on bermudagrass and St. Augustinegrass. R. Green and M. Oprisko.

Status - Study on hold. (Mechanistic Study)

D. OBJECTIVES FOR MECHANISTIC BASIS OF MINIMAL MAINTENANCE TURFGRASS: RESEARCH STATUS AND RESULTS

A basic premise of this overall research project thrust is that those turfgrasses which have greater water conservation characteristics also will possess characteristics contributing to turfgrasses that, from an overall standpoint, can be described as minimal maintenance types. Minimal maintenance implies the least possible resource requirements in terms of water and nutrients, plus low maintenance inputs such as labor, energy, and pesticides. One of the first priorities in investigations concerning minimal maintenance turfgrasses is to determine the morphological, anatomical, and physiological factors associated with a species possessing minimal maintenance traits. These traits can then be utilized by turfgrass breeders to provide a more sound basis for selecting minimal maintenance turfgrasses.

D-2 Assess the morphological, anatomical, and physiological plant characteristics associated with adaptation to low nitrogen requirements and their relationship to the drought resistance and recuperative potential of bermudagrasses. Initiated in the spring of 1986. S. Sifers.

Status - A preliminary field study has been completed in conjunction with objective C-5. Leaf extension rate, internode length, root mass relative to shoot mass, and visual quality were the parameters being measured and observed. The preliminary study was combined with objective C-5 which was beneficial. However, a separate study will now be required to allow plant nitrogen depletion and stress to occur before the drought and recuperation events.

A more detailed study is underway. Turfs of Tifway, Santa Ana, Texturf 10, A-22, Midway, and Centennial bermudagrass have been planted in 30 cm plastic pots. This selection of genotypes was based on field drought resistance data accumulated over the last four years. Two cultivars were selected from each of the relative classifications of high, medium, and low for leaf firing and shoot recovery. This study is on hold. (Mechanistic Study)

D-3 Investigate the morphological, anatomical, and physiological plant parameters associated with minimal maintenance characteristics of zoysiagrass cultivars. Initiated in 1986. S. Sifers.

Status - A greenhouse study is underway. Root observation columns have been planted with Meyer, Emerald, and El Toro zoysiagrasses in the greenhouse. These cultivars were selected because they possess leaf width differentials from narrow to broad plus a variety of rooting characteristics. This study is a duplication of objective D-1, except the target species is zoysiagrass rather than bermudagrass. Studies can be completed with one more year of funding. (Intraspecies Comparison and Mechanistic Study)

D-4 Investigate mechanisms associated with the adaptation of bermudagrass and zoysiagrass cultivars to regimes of low nitrogen availability that permit cultivars to adapt to a minimum maintenance environment. Initiated in 1986. S. Sifers.

Status - This study has been placed on hold due to higher priority studies and lack of available manpower. (Mechanistic Study)

E. OBJECTIVES FOR IMPROVED WATER STRESS HARDINESS: RESEARCH STATUS AND RESULTS

Objective C is devoted to improve drought resistance from the aspect of dehydration avoidance and those external plant characteristics contributing to a low water use rate, enhanced rooting,and survival through dormant structures during extended periods of water stress. In contrast, Objective E addresses the dimension of **dehydration tolerance**. This involves those internal plant characteristics that enable certain plant tissues to survive the water stress once the dehydration avoidance phase is terminated and the plant enters severe internal tissue moisture stress. Such dimensions as osmotic regulation, inherent internal tissue hardiness and plasticity, cellular structure, and certain physiological dimensions, such as proline/ABA synthesis need to be investigated in relation to dehydration tolerance.

E-2 Investigate the cellular structure of warm-season turfgrass species and associated changes that occur during water stress, and characterize the possible relationship to the drought tolerance mechanism.

Status - This study was designed to investigate the inter- and/or intracellular structure of warm-season turfgrass species before and after water stress. The initial study was supposed to be conducted during the summer of 1986 in a controlled environmental growth chamber. However, due to the busy schedule at the Electron Microscopy Center located at the Texas A&M University, this could not be conducted. This study is on hold because Dr. Kim's poistion was not filled due to financial limitations. (Mechanistic Study)

IV. SIXTH MID-YEAR STATUS REPORT OF COMPLETED RESEARCH BEING PREPARED FOR PUBLICATION

The major research objectives and associated individual studies that are currently being written and submitted for publication in scientific journals are summarized in this section. A research project is really not fully completed until it has been written and published in both a scientific and a trade journal. The process includes (a) drafting and multiple revisions of a manuscript; (b) internal departmental review by three colleagues; (c) submission to the Texas Agricultural Experiment Station for a final review and assignment of a TAES manuscript number; (d) submission to the USGA Research Committee for review and approval; and (e) submission to the appropriate scientific journal where it is then reviewed by three peers in the field. Then following any revisions suggested by the reviewers, it is published in the scientific journal. Normally, this process requires from 8 to 18 months, depending on the extent of revisions suggested by the reviewers.

Major emphasis is being placed on manuscript preparation. Currently, this research project has in the publication phase the following.

A. Minimal Water Use Rate - 8 publications

B. Enhanced Rooting/Water Absorption - 4 publications

C. Improved Drought Resistance - 2 publications

D. Basis of Minimal Maintenance Turfgrass - 2 publications

E. Improved Water Stress Hardiness - 1 publication

A. MINIMAL WATER USE RATE: RESEARCH COMPLETED AND PUBLICATION STATUS

A-3 Compare the stomatal characteristics, densities, and distribution among ten major warm-season and twelve major cool-season turfgrasses under controlled environment growth chamber conditions. Initiated in 1983. D. Casnoff and R. Green.

Status - The warm-season turfgrass interspecies study was completed in 1985, and the scientific paper has been written and will be presented at the Sixth International Turfgrass Research Conference and also appear in the Proceedings. (Species Comparisons and Mechanistic Study)

A-5 Determine the comparative potential evapotranspiration rates of twelve major cool-season turfgrasses. Initiated in 1983. S. Griggs and R. Green.

Status - A detailed series of experiments was completed in the water/heat stress environmental simulator in 1986. The draft of a scientific paper has been submitted to HortScience. (Species Comparisons)

A-6 Determine the potential for using turfgrass leaf growth inhibitors in water conservation. Initiated in 1983. K. Kim and R. Green.

Status - The greenhouse research involving two studies was completed in 1987. The scientific paper has been submitted to HortScience. (Improved Cultural Systems)

A-7 Compare the influences of cutting height and nitrogen rate on the evapotranspiration rates of eleven major warm-season turfgrasses. Initiated in 1983. K. Kim and S. Sifers.

Status - Field studies over two years were completed in 1986. A scientific paper has been written and submitted to the Texas Agricultural Experiment Station for review. Revisions are now in process. (Improved Cultural Systems)

A-8 Determine the comparative genetic variability in evapotranspiration rates of 24 bermudagrass cultivars under non-limiting moisture conditions. Initiated in 1984. S. Sifers and K. Kim.

Status - A three-year study was completed in 1987, and the results were processed and analyzed. A scientific paper has been drafted and submitted for departmental review. Revisions are now in process. (Intraspecies Comparisons)

A-9 Assess the validity and relative accuracy of visual estimates of evapotranspiration rates using the canopy resistance - leaf extension concepts on mowed bermudagrass and zoysiagrass cultivars. Initiated in 1984. S. Sifers, G. Horst, and M. Engelke.

Status - A two-year study has been completed for mowed bermudagrass and zoysiagrass cultivars. Visual rankings for 24 bermudagrasses and 11 zoysiagrasses have been statistically compared to actual evapotranspiration rates. All data are now processed, and detailed statistical analyses were conducted by G. Horst. The scientific paper is being prepared with the research from objectives A-9 and A-12 being combined into one paper. (Breeding Markers)

A-10 Determine the comparative evapotranspiration rates for eleven zoysiagrasses that have a diverse array of canopy densities, leaf orientations, and leaf extension rates. Initiated in 1985. S. Sifers, R. Green, and C. Atkins.

Status - A manuscript is currently being written for HortScience. (Intraspecies Comparisons)

A-12 Assess the validity and relative accuracy of visual estimates of evapotranspiration on unmowed bermudagrass turfs using the high canopy resistance - low leaf area concept as it would be applied in a turfgrass breeding program. Initiated in 1985. S. Sifers, M. Engelke, and G. Horst.

Status - Greenhouse and field studies were completed assessing 24 unmowed bermudagrass cultivars grown in mini-lysimeters in 1987. Three evaluators, Dr.'s Beard, Engelke, and Horst, visually estimated the evapotranspiration rates across three replications of each turf cultivar. These assessments were compared statistically to the actual evapotranspiration rates by G. Horst. A scientific paper is being prepared by the collaborators. See A-9. (Breeding Markers)

B. ENHANCED ROOTING/WATER ABSORPTION: RESEARCH COMPLETED AND PUBLICATION STATUS

B-2 Assess the interspecific rooting potentials of 11 major warm-season turfgrasses under non-limiting moisture conditions. Initiated in 1984. D. Casnoff and S. Sifers.

Status - Research was completed in 1985, which included two greenhouse studies using the root-column facility. The scientific paper has been written, approved by the USGA Research Committee, and submitted to Agronomy Journal for publication. It is entitled "Assessment of the Interspecific Rooting Potentials of Eleven Warm-Season Perennial Turfgrasses under Non-limiting Moisture Conditions". (Species Comparisons)

B-5 Determine the cause of spring root decline (SRD) of warm-season turfgrasses as well as methods to minimize its potentially negative effects. Initiated in 1984 with the biochemical studies initiated in 1986. S. Sifers, R. Green, and W. Richie.

Status - Carbohydrate movement was found to be associated with SRD in St. Augustinegrass. This finding involved two replicated studies to determine the fate of radioactive carbon in St. Augustinegrass leaf, crown, and root tissue labeled prior to shoot dormancy and then induced into greenup under either SRD or non-SRD conditions. A manuscript of this work is in advanced preparation. (Mechanistic Study)

B-8 Assess root hair location, density, size, and viability among 13 warm-season turfgrasses under non-limiting moisture conditions. Initiated in 1985. R. Green and M. Oprisko.

Status - Root hair studies I, II, III, and IV are completed and the data analyzed. A manuscript covering this work will be submitted for Departmental review shortly. (Species Comparisons and Mechanistic Study)

B-15 Determine the root hair viability among the major warm-season and cool-season turfgrasses. Initiated in 1987. R. Green and M. Oprisko.

Status - A draft of a scientific paper covering the first phase of this project has been written and submitted to Crop Science. A draft of a second scientific paper is being prepared for Stain Technology.

C. IMPROVED DROUGHT RESISTANCE: RESEARCH COMPLETED AND PUBLICATION STATUS

C-3 Characterize the morphological, anatomical, and physiological plant parameters associated with the drought resistance (i.e., recuperative ability) of eleven major warm-season turfgrass species following subjection to severe drought stress. Initiated in 1984. K. Kim.

Status - Three sets of preliminary studies were completed in both the field and greenhouse in 1984, followed by an extensive field study in 1985 and 1986. Shoot recovery was the primary response used in assessing the attributes related to drought resistance. Since drought resistance is the combination of dehydration avoidance and dehydration tolerance, the relative importance of factors contributing to drought resistance was investigated and assessed in relation to the results from dehydration avoidance study C-2. A more detailed physiological and anatomical investigation was conducted during the fall and winter of 1987. A paper has been drafted and is now in the revision phase. (Mechanistic Study)

C-5 Characterize the comparative drought resistances of the major warm-season turfgrass cultivars including 24 bermudagrasses, 6 zoysiagrasses, 6 centipedegrasses, and 5 St. Augustinegrasses. Initiated in 1985. S. Sifers and K. Kim, and J. Walker.

Status - Three years of field studies on a newly constructed modified sand root zone were completed, and the data were analyzed and summarized. In the third year of the study, new experimental selections were added to the field plot. They included 3 bermudagrasses from New Mexico State University; 3 cool-season turfgrasses (Kentucky 31 tall fescue, Adelphi Kentucky bluegrass, Pennfine perennial ryegrass) from the University of Nebraska; and 3 St. Augustinegrasses, 2 buffalograsses, and 4 zoysiagrasses from the Texas Agricultural Experiment Station at Dallas. A paper is in advanced editing for Departmental review. (Intraspecies Comparisons)

D. MECHANISTIC BASIS OF MINIMAL MAINTENANCE TURFGRASS: RESEARCH COMPLETED AND PUBLICATION STATUS

D-1 Investigate the morphological, anatomical, and physiological plant parameters associated with minimal maintenance-low nitrogen stress tolerance characteristics of bermudagrass cultivars. Initiated in 1984. S. Sifers.

Status - Both field and greenhouse studies were completed in 1986, including analyses of tissue fractions for nitrogen content. The data analyses are also completed. A Masters Thesis has been published and a copy mailed to each USGA Research Committee member. A draft of a scientific paper is in review. (Intraspecies Comparisons and Mechanistic Study)

D-5 Investigate the nitrogen economy of 10 warm-season turfgrasses by ^{15}N-isotope and N-balance methodology. Initiated in 1987. R. Green.

Status - Analysis is completed and a manuscript will be written later this year. (Mechanistic Study)

E. OBJECTIVES FOR IMPROVED WATER STRESS HARDINESS: RESEARCH COMPLETED AND PUBLICATION STATUS

E-1 Characterize the physiological changes occurring in the turfgrass leaf during water stress to determine possible dehydration tolerance (hardiness) mechanisms of the major warm-season turfgrasses. Initiated in 1985. K. Kim.

Status - An initial study was conducted during the winter of 1985 in a controlled environmental growth chamber with three species, followed by a greenhouse study with eleven turfgrasses. Leaf firing, shoot recovery and tissue proline content were examined. Data were collected, analyzed and interpreted in relation to the dehydration tolerance level of each grass. A proline investigation also was conducted in the field in the summer of 1986 to confirm the results from the previous studies. A research paper is now in review. (Mechanistic Study)

V. BUDGET STATUS

Cost containment has continued to be a high priority during the past 6 months.

VI. PUBLICATIONS

The scientific publication activity has been summarized in Section IV. In addition to the technical research papers being drafted, oral reports and published abstracts of research supported by the USGA were presented at the American Society of Agronomy Meetings in December of 1988, in Anaheim, California. They are as follows:

A. ABSTRACTS PUBLISHED IN 1988:

1. The effects of flurprimidol and mefluidide on ET, leaf growth and quality of St. Augustinegrass grown at two soil moisture levels. R. L. Green, K. S. Kim, and J. B. Beard. 1988 Agronomy Abstracts, p. 151.

2. An assessment of vital and mortal stains for research of root hair viability of 12 warm-season perennial grasses. M. J. Oprisko, J. B. Beard, and R. L. Green. 1988 Agronomy Abstracts, p. 154.

B. PAPERS TO BE PRESENTED:

1. Turfgrass water stress: drought resistance components, physiological mechanisms, and species-genotype diversity. J. B. Beard. Invited Plenary Paper. VI International Turfgrass Research Conference. Tokyo, Japan. August, 1989.

2. Leaf blade stomatal densities of ten warm-season perennial grasses and their evapotranspiration rates. D. M. Casnoff, R. L. Green, and J. B. Beard. VI International Turfgrass Research Conference. Tokyo, Japan. August, 1989.

3. Contribution of root hairs to total root length in warm-season turfgrasses. R. L. Green, M. J. Oprisko, and J. B. Beard. American Society of Agronomy Meetings. Las Vegas, Nevada. October, 1989.

4. Use of Evan's Blue as a vital stain for root hairs. M. J. Oprisko, R. L. Green, and J. B. Beard. American Society of Agronomy Meetings. Las Vegas, Nevada. October, 1989.

5. Comparative intraspecies and interspecies dehydration resistance of six major warm-season turfgrass species. S. I. Sifers and J. B. Beard. American Society of Agronomy Meetings. Las Vegas, Nevada. October, 1989.

6. Seasonal photosynthate partitioning in St. Augustinegrass as influenced by nitrogen and temperature. G. Forrester, J. B. Beard, and R. L. Green. American Society of Agronomy Meetings. Las Vegas, Nevada. October, 1989.

B. TAES PROGRESS REPORTS PUBLISHED:

Progress reports of research supported by the United States Golf Association were released to the public via Texas Turfgrass Research which is published annually by the Texas Agricultural Experiment Station. They are as follows:

1. "Comparative Evapotranspiration Rates of Thirteen Turfgrasses Grown Under Both Non-Limiting Soil Moisture and Progressive Water Stress Conditions" by K. S. Kim, J. B. Beard, L. L. Smith, and M. Ganz. Texas Turfgrass Research - 1983. p. 39.

2. "Spring Root Decline Induction Studies" by S. I. Sifers and J. B. Beard. Texas Turfgrass Research - 1984. pp. 8-14.

3. "The Effects of Nitrogen Fertility Level and Mowing Height on the Evapotranspiration Rates of Nine Turfgrasses" by K. S. Kim and J. B. Beard. Texas Turfgrass Research - 1984. pp. 77-81.

4. "Assessment of the Genetic Potentials for Root Growth of Eleven Warm Season Perennial Turfgrasses under Non-limiting Moisture Conditions" by D. M. Casnoff and J. B. Beard. Texas Turfgrass Research - 1985. pp. 10-14.

5. "Leaf Blade Stomatal Characterizations of Ten Warm Season C-4 Perennial Grasses and Their Association to the Water Use Rate" by D. M. Casnoff, J. B. Beard, D. G. Verwers, and S. D. Griggs. Texas Turfgrass Research - 1985. pp. 15-18.

6. "Spring Root Decline (SRD): A Research Summary" by S. I. Sifers, J. B. Beard, and K. S. Kim. Texas Turfgrass Research - 1985. pp. 19-30.

7. "Comparative Assessment of Wilting Tendency of Warm Season Turfgrasses" by K. S. Kim and J. B. Beard. Texas Turfgrass Research - 1985. pp. 143-148.

8. "Criteria for Visual Prediction of Low Water Use Rates of Bermudagrass Cultivars" by S. I. Sifers, J. B. Beard, and K. S. Kim. Texas Turfgrass Research - 1986. pp. 22-23.

9. "Morphological and Physiological Plant Parameters of Bermudagrass Cultivars with Low Nitrogen Requirements" by S. I. Sifers and J. B. Beard. Texas Turfgrass Research - 1986. p. 22.

10. "Comparative Drought Resistance Among the Major Warm-Season Turfgrass Species and Cultivars" by K. S. Kim, S. I. Sifers, and J. B. Beard. Texas Turfgrass Research - 1986. pp. 28-30.

11. "Leaf Blade Stomatal Characterization and Potential Evapotranspiration Rates of 12 Cool-Season, C-3 Turfgrasses" by R. L. Green, J. B. Beard, and D. M. Casnoff. Texas Turfgrass Research - 1986. pp. 8-9.

12. "Investigations of Root Hair Size, Number, and Distribution of Seven Species of Warm-Season Turfgrasses" by R. L. Green and J. B. Beard. Texas Turfgrass Research - 1987. pp. 4-11.

13. "Turfgrass Morphological Characteristics Associated with the Evapotranspiration Rate" by K. S. Kim and J. B. Beard. Texas Turfgrass Research - 1987. pp. 49-51.

14. "An Assessment of Cutting Height and Nitrogen Fertility Requirements of Adalayd Seashore Paspalum" by S. I. Sifers, J. B. Beard, K. S. Kim, and J. R. Walker. Texas Turfgrass Research - 1987. pp. 81-85.

C. SCIENTIFIC PAPERS PUBLISHED:

1. Johns, D., J. B. Beard, and C. H. M. van Bavel. 1983. Resistance to evapotranspiration from a St. Augustinegrass turf canopy. Agronomy Journal 75(3):419-422.

2. Beard, J. B. and M. C. Engelke. 1985. An environmental genetics model for turfgrass improvement: physiological aspects. Proceedings International Turfgrass Research Conference 5:107-118.

3. Engelke, M. C., J. B. Beard, and P. F. Colbaugh. 1985. An environmental genetics model for turfgrass improvement: developmental aspects. Proceedings International Turfgrass Research Conference 5:127-136.

4. Sifers, S. I., J. B. Beard, and J. M. DiPaola. 1985. Spring root decline (SRD): discovery, description, and causes. Proceedings International Turfgrass Research Conference 5:777-788.

5. Kim, K. S. and J. B. Beard. 1988. Comparative turfgrass evapotranspiration rates and associated plant morphological characteristics. Crop Science 28(2):328-331.

VII. DISSEMINATION OF RESEARCH FINDINGS

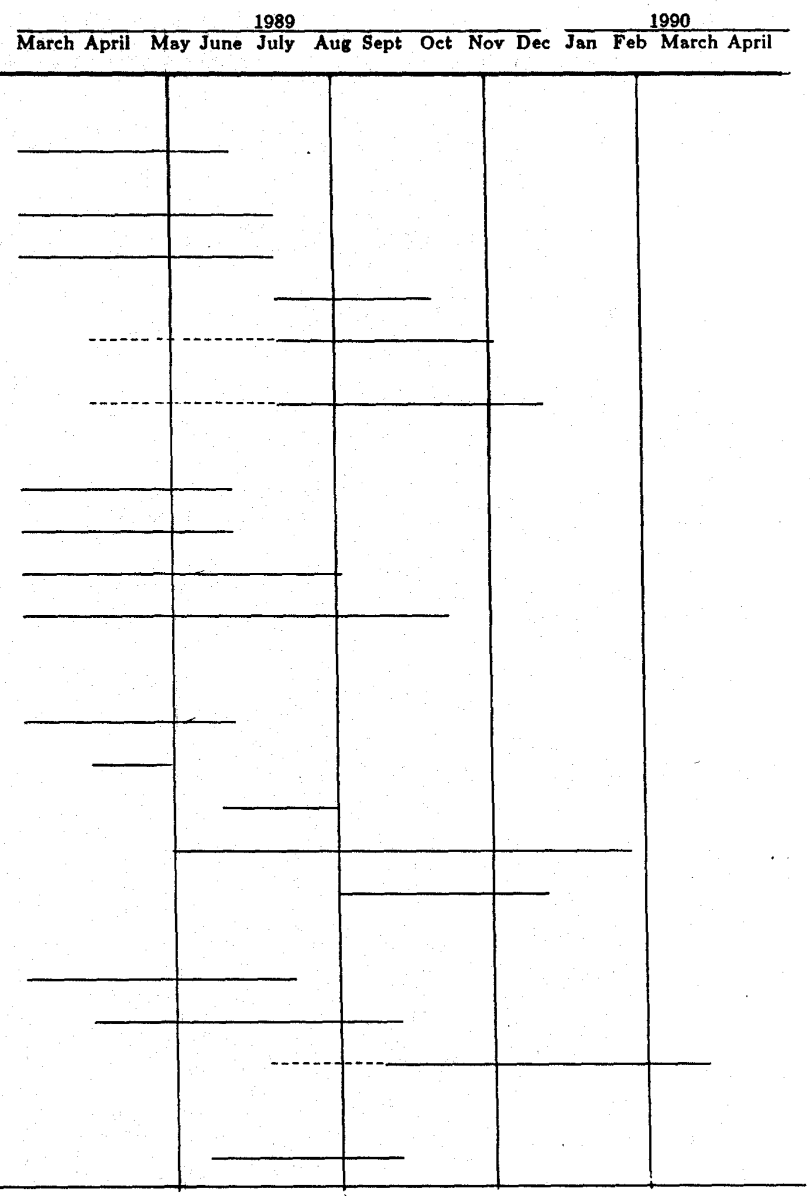
Visibility for the USGA's support of our turfgrass water conservation research program has been achieved through speaking at key national and regional turfgrass conferences during the past year. The general topic is usually in the area of water conservation strategies and research updates related to rooting, water use rates, and drought stress. Addresses for 1988-89 have been or will be given before the following.

1. Symposium on Turfgrass Water Conservation in the Arid Southwest, Las Vegas, Nevada. November, 1988, by J. B. Beard.
2. Texas Turfgrass Conference, Fort Worth, Texas. December, 1988, by S. I. Sifers.
3. Texas Turfgrass Conference, Fort Worth, Texas. December, 1988, by R. L. Green.
4. Massachusetts Turfgrass Conference, Springfield, Massachusetts, March, 1989, by J. B. Beard.
5. International Turfgrass Research Conference, Tokyo, Japan, August, 1989, by J. B. Beard.
6. 1989 American Society of Agronomy Meetings, October, 1989, by R. L. Green.
7. 1989 American Society of Agronomy Meetings, October, 1989, by S. I. Sifers.
8. 1989 American Society of Agronomy Meetings, October, 1989, by M. J. Oprisko.
9. 1989 American Society of Agronomy Meetings, October, 1989, by G. Forrester.

APPENDIX

FLOW DIAGRAM OF TAMU TURFGRASS PHYSIOLOGY LABORATORY RESEARCH OPERATIONS (MARCH, 1989-APRIL, 1990)

Project	Primary Person Responsible
1. Root Hairs:	
a. Manuscript: Root Hair Char.-Greenhouse	RG
b. Evan's Blue Char.	MO
c. Storage Methodology	MO
d. Manuscript: Evan's Blue	MO
e. Effect of Drought on Root Hairs-Greenhouse Study 1	MO
f. Root Hair Char.-Field Study 1	MO
2. Carbohydrates:	
a. Manuscript: SRD-St. Aug.-Fate of ^{14}C	WR
b. General Carbohydrate Lit. Review	WR
c. Carbohydrate Analysis & ^{14}C-St. Aug.	FG
d. PGR-St. Aug.-Fate of ^{14}C (Lit. Review-Study Harvested)	FG
3. Water Use Rate:	
a. Manuscript: Zoysiagrass ET	CA
b. Centipedegrass ET, Stomata	CA
c. NMSU Bermudagrass ET	CA
d. Mower Blade Shaprness-ET	CA
e. Bermudagrass ET, Stomata	CA
4. Iron:	
a. Preliminary Study	WR
b. Evaluation of St. Aug.	WR
c. Third Study	WR
5. Nitrogen Economy:	
a. Manuscript	RG



TURFGRASS STRESS PHYSIOLOGY LABORATORY

TEXAS A&M UNIVERSITY

I. PERSONNEL

II. RESEARCH ORGANIZATION

III. PROJECT SUMMARY AND HIGHLIGHTS

March, 1989

I. PERSONNEL

Robert Green, PhD, Postdoctoral Res. Assoc., Lab Supervisor
Curtis Atkins, BS student in Ag Economics, half-time Lab Technician (water use rate)
Gary Forrester, BS, MS student in Turfgrass Science (carbohydrate)
Fernando Gonzalez, BS student in Turfgrass Science, half-time Lab Technician (carbohydrate)
Marianne Oprisko, BS, MS student in Turfgrass Science, full-time Lab Technician (root hairs and vital staining)
Noel Manning, BS student in Physics, half-time Lab Technician (statistics/computer)
Bill Richie, MS, Research Assistant (carbohydrate and iron)

II. TURFGRASS PHYSIOLOGY LABORATORY RESEARCH ORGANIZATION

1. Root and Root Hair Characterizations Among the Major Warm-Season Turfgrasses.

   a. Characterize root hair density and length by microscopic analysis.

   b. Estimation of total cumulative root length and surface area, including contribution of root hairs, by microscopic analysis.

   c. Assessment of vital and mortal stains for determining root hair viability.

   d. Characterize root hair viability among the major warm-season turfgrasses.

   e. Determine effects of soil moisture stress on root hair density and viability in warm-season turfgrasses.

   f. Anatomical description of buffalograss roots (in the planning phase).

2. Investigations Into Carbohydrates and Their Movement in Warm-Season Turfgrasses During Active Growth, Dormancy, and Greenup.

   a. Determine the fate of radioactive ^{14}C labeled carbohydrate during spring root decline (SRD) in leaf, crown, and root sections of St. Augustinegrass.

   b. Determine concentrations of sugars (glucose + fructose + sucrose), starch, and structural carbohydrate along with fate of radioactive ^{14}C labeled carbohydrate during SRD in leaf, bud, stem, and root sections of St. Augustinegrass and bermudagrass.

   c. Determine seasonal concentrations of sugars (glucose + fructose + sucrose), starch, and structural carbohydrates along with fate of radioactive ^{14}C labeled carbohydrate in leaf, bud, stem, and root sections of St. Augustinegrass as influenced by multiple levels of N fertilization.

   d. Determine the fate of radioactive ^{14}C labeled carbohydrate in leaf, bud, stem, and root sections along with whole-plant morphological measurements of St. Augustinegrass treated with PGR; locate a PGR that will promote concentrations of carbohydrate in root and crown tissues.

3. Determination of Water Use Rate, Leaf Extension Rate, Shoot Density and Stomatal Density Among Cultivars of Warm-Season Turfgrass Species Under Controlled Light, Temperature, Humidity, and Wind Speed Conditions.

   a. Within a collection of 24 bermudagrass cultivars.

   b. Within a collection of 11 zoysiagrass cultivars.

   c. Within a collection of 10 St. Augustinegrass cultivars.

   d. Within a collection of 6 centipedegrass cultivars.

   e. Within a collection of 6 bermudagrasses developed at New Mexico State University.

   f. Determine the effects of flurprimidol and mefluidide on the ET rate, shoot growth, and quality of St. Augustinegrass maintained at optimal and suboptimal soil moisture levels.

   g. Determine the effects of mowing with dull blades on the ET rate, canopy morphological characteristics, and quality of St. Augustinegrass and bermudagrass.

4. Investigations Into Nitrogen Economy and Morphological Responses to Nitrogen of Warm-Season Turfgrasses.

   a. Determinations of nitrogen economy among the major warm-season turfgrasses using N-balance and ^{15}N methodology with emphasis on plant morphological characteristics.

   b. Determinations of the effects of multiple levels of N fertilization on N-economy, total tissue carbon content, leaf and shoot morphology and total root length and morphology (in the planning phase).

5. Electrophoretic Characterizations of Isoenzymes of Warm-Season Turfgrass Cultivars.

   a. For a collection of 24 bermudagrass cultivars.

   b. For a collection of 18 zoysiagrass cultivars (in development phase).

6. Developing Innovative Technologies for Alleviation of Iron Deficiency in Turfgrass.

   a. Develop whole plant as well as bioassay techniques for the screening of grasses for Fe stress resistance.

   b. Cultivar screening to determine differential iron stress resistance (in planning phase).

c. Describe the partial replacement of N fertilizer with Fe fertilization; equal quality, slower growth, etc. (in planning phase).

d. Investigate the effects of iron and cytokinin (possibly other compounds) applications on root longevity and activity (in planning phase).

III. PROJECT SUMMARY AND HIGHLIGHTS

1. Root and Root Hair Characterizations Among the Major Warm-Season Turfgrasses.

   a. Root hair density and contribution to total root length and surface area are different among the major warm-season turfgrasses, and different among bermudagrass cultivars. Amount of root surface area available for water absorption helps us understand differences among turfgrasses in terms of drought resistance.

   b. Root hairs contribute from 72 to 99% of total root length among warm-season turfgrasses.

   c. Root hair viability (freshly harvested roots) can be determined by staining with Evan's blue. We need to know what percentage of root surface area is viable in terms of functioning in water and nutrient uptake. Viability of root hairs is, on the average, 85% among the major warm-season turfgrasses.

2. Investigations Into Carbohydrates and Their Movement in Warm-Season Turfgrasses During Active Growth, Dormancy, and Greenup.

   a. We have verified that movement of radioactive labeled carbohydrate is associated with SRD. During SRD, levels of radioactive carbohydrate are lower in root and stem sections in SRD plants than for non SRD plants. This physiological phenomena is associated with root die back.

3. Determinations of Water Use Rate, Leaf Extension Rate, Shoot Density, and Stomatal Density Among Cultivars of Several Warm-Season Turfgrass Species Under Controlled Light, Temperature, Humidity and Wind Speed Conditions.

   a. There is considerable variation or genetic potential in ET rate (under nonlimiting soil moisture) at the intraspecies and interspecies levels. There is a general lack of a positive relationship between ET rate and stomatal density and thus breeding programs designed to develop water conserving warm-season turfgrasses, especially for irrigated conditions, should place priority on plant parameters that increase canopy resistance and decrease leaf area.

   b. Application of flurprimidol (Cutless) significantly reduced ET by an average 18% for 15 and 5 weeks, low and high soil moisture, respectively. It also significantly reduced leaf extension rate by an average 83% for 17 and 8 weeks, low and high soil moisture, respectively.

4. Investigations into nitrogen economy and morphological responses to nitrogen of warm-season turfgrasses.

   a. N efficiency appears to be strongly associated with N partitioning among various plant parts. This phenomenon is closely associated with plant morphological characteristics that develop acceptable turfgrass quality; high leaf and shoot density, narrow leaves, etc. There are differences in N partitioning among the major warm-season turfgrasses.

5. Electrophoretic characterization of isoenzymes of warm-season turfgrass cultivars.

   a. A collection of 23 bermudagrass cultivars can be divided into 18 groups based on unique patterns of aconitase, alcohol dehydrogenase, phosphoglucomutase, phosphoglucose isomerose and shakimic acid dehydrogenase. Of the 23 cultivars 14 can be individually identified.