FIRST YEAR

PROGRESS REPORT

concerning

PHYSIOLOGICAL INVESTIGATIONS

in

DEVELOPING WATER CONSERVING, MINIMAL MAINTENANCE TURFGRASSES AND CULTURAL SYSTEMS

Volume 1

Submitted By:

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I. INTRODUCTION

This first year Progress Report, as required in the contract, is for the period from March 31, 1983 to March 31, 1984. Dr. Robert G. Merrifield, Associate Director of the Texas Agricultural Experiment Station, signed the contract agreement on March 28, 1983 with Mr. Chuck W. Smith of the United States Golf Association signing on March 30, 1983.

A check for the first quarter funding of this research project arrived in late April and the appropriate accounting arrangements were initiated through the Texas A&M Research Foundation. The formal arrangements were completed within a two week period and we were authorized to spend money under an assigned research account on May 9, 1983. Thus, a five week period or 20% of the initial six month reporting period was devoted to activities not related to the actual conduct of experiments per se. Fortunately, there were several areas of investigation already underway that could be accelerated rapidly once funds were available. Thus, the lag time for start-up of the research program was minimal.

This report will consist of the following: A description of the implementation phase including organization, personnel procurement, and research facilities development. This will be followed by a summary of research progress based on the annual plan of work submitted for the first year. Next are sections on the budget status and on publicity related to the research project. Finally, there is presented an annual plan of work for the second year, plus an appendix of papers being prepared for publication.

Although not required, a preliminary report on the project was submitted by J. B. Beard on June 6, 1983. The six month progress report was submitted September 30, 1983. Selected portion of these reports will be included in this first year report as appropriate.

II. IMPLEMENTATION

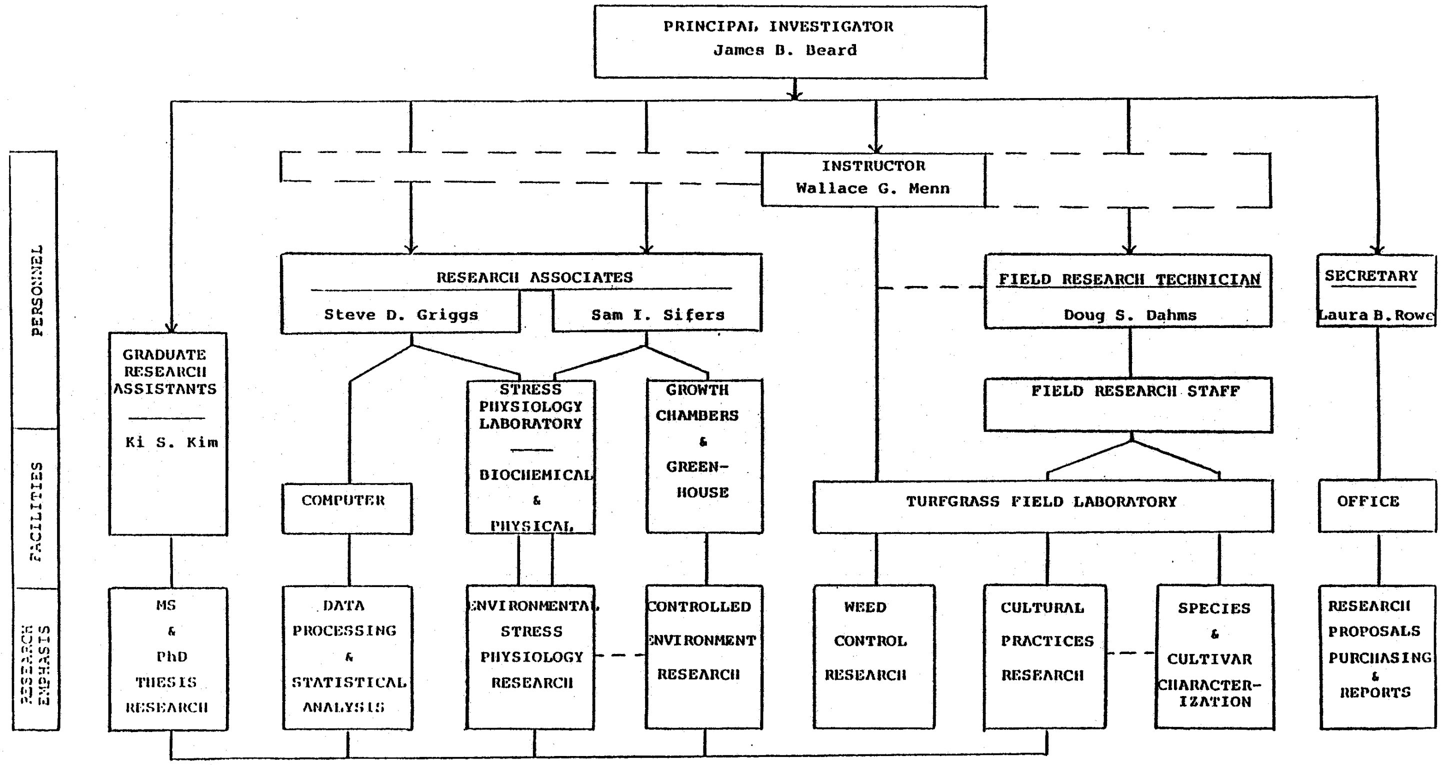
The first six weeks were devoted to (a) reorganization of the project and (b) interviewing and employment of project personnel. The design and construction of facilities needed to activate the proposed experiments were also initiated. These activities are summarized in the following three sub-sections.

A. Organization

The increased research emphasis in the area of water conservation and minimal maintenance turfgrasses required a reorganization of both the project personnel, including the new positions added, and the associated areas of project research emphasis. A flow plan illustrating the new organizational structure being utilized on this project is shown in Figure 1. All areas of research emphasis, except for the weed research conducted by Wallace Menn, will involve this research project to varying degrees.

Mr. Steven D. Griggs has been designated the overall project coordinator under Dr. Beard. He is responsible for maintaining and checking purchase orders, monthly expenditures, and monthly budget summaries in relation to projected expenditures. He is working closely with Ms. Jayne Littleton, who has been designated the Texas A&M Research Foundation Representative for this project.

Figure 1.



TURFGRASS RESEARCH PROJECT ORGANIZATIONAL STRUCTURE
TEXAS A&M UNIVERSITY - COLLEGE STATION, TEXAS

B. Personnel

The first phase in implementation of the research project involved the interview and selection of project personnel. The existing TAES positions which had already been filled included Wallace G. Menn, Instructor; Douglas S. Dahms, Agricultural Research Technician; and Laura B. Rowe, Secretary. Resumes of these individuals are attached.

In anticipation that the project would be funded by the USGA, Mr. Steven D. Griggs was employed in August of 1982 as a Research Assistant using alternate grant funds in the interim period. The second Research Assistant position was filled by Mr. Sam I. Sifers on June 1, 1983. A resume for Mr. Sifers is attached.

To sustain the high level of research activity planned at the Turfgrass Field Laboratory, a group of hourly student workers was employed for the summer growing season. These workers represented an average 150 hours per week. The level of employment of hourly workers was phased down to approximately 60 hours per week for the winter period.

The only position that remained unfilled was that identified as the Graduate Student position. Unfortunately, all quality graduate students had accepted assistantship offers at other institutions before the funds became available to activate the position. An alternative, Post-Doctoral position has been established and was filled by Dr. David M. Casnoff on September 14, 1983. Dr. Casnoff's resume is attached. He will be providing leadership in the studies of rooting potential and root morphological characterization at both the interspecies and intraspecies levels as well as the stomatal characterization studies on the same species used in the rooting investigations.

These researchers are very well qualified in terms of both formal training and past experience to accomplish the objectives of this research project. Their strong personal dedication and interest in this research motivates them to make the extra effort and dedicate work time well above a 40 hour week in order to achieve our goals.

Instructor: Wallace G. Menn graduated from TAMU in 1963 with a Bachelor of Science degree in Agronomy. He served two years as a First Lieutenant in the U.S. Army. Following military service, he worked one year as a GS-7, Soil Scientist with the USDA. He returned to graduate school at TAMU in 1966 and received his Master of Science degree in the field of Turf Nutrition in the Spring of 1968. Upon graduation, he accepted the position of Research Associate in Turf Research and worked for one year under Dr. George McBee. With the departure of Dr. McBee in 1969, Mr. Menn assumed full charge of turf research activities at TAMU for one year. During 1970, Dr. Richard Duble took charge of the Turf program and Mr. Menn devoted most of his efforts toward applied research and teaching. In 1972, he accepted the position of Golf Course Superintendent at TAMU and continued teaching Agronomy 428 and began teaching Agronomy 302, Recreational Turf. During this same period, he developed a new course, Agronomy 430, titled Turfgrass Operations. He continues to teach both of these courses on a yearly basis. In March, 1982, he moved back to a full-time research and teaching position in the field of Turf where most of his efforts will be toward applied research with special emphasis on weed control. Mr. Menn served as Program Chairman for the Annual Texas Turfgrass conference for the period of 1969-74. He has held several executive positions in the Texas Turfgrass Association and is also a member of the Southern Turfgrass Association. He holds a Certified Pest Control Operators license and is a Registered Landscape Irrigator.

Agricultural Research Technician: Douglas S. Dahms. Born and raised in Glen Ellyn, Illinois. Attended SMU and Memphis State University, before coming to Texas A&M in 1980. Currently a part time student, with senior classification, majoring in Agronomy (Turf Management). Has been employed the last four years in the Turfgrass Section of the Soil and Crop Sciences Department. The last two years he has served in the position of Agricultural Research Technician, in charge of the Turfgrass Field Laboratory operations. Doug's wife, Kay, currently attending the School of Veterinary Medicine.

Research Assistant: Steven D. Griggs is a native of El Paso. He received a B.S. Degree in Floriculture from Texas A&M University in 1979. The following two summers were spent at El Paso, Texas, working with Dr. Garold Horst at the Texas A&M Research Center. In El Paso, he assisted Dr. Horst with various turfgrass projects while completing the field research portion of his Masters thesis dealing with mulching mowers and their influence on tall fescue turfs. During the school semester he taught Agronomy 301, Basic Soils labs while completing his course work. Currently, he is working with Dr. Beard as a research assistant while completing the written portion of his thesis.

Research Assistant: Sam I. Sifers, Jr. graduated from Ohio University in 1951 with a B.A. degree in Government and History. He immediately entered the United States Air Force. He held many high level staff and command positions and attained the rank of Colonel prior to completing his Air Force career in 1979. Senior level career assignments included duty as: Inspector General, Defense Mapping Agency; Vice Commander, 322nd Tactical Airlift Wing; Base Commander, Lackland Air Force Base; Deputy Director for Inspection, Headquarters, United States Air Force. He completed resident schooling at the Armed Forces Staff College, and also completed the Air War College and the Industrial College of the National Defense College.

Pursuing a life long interest in turfgrasses, he enrolled at Texas A&M University in 1981, where he completed the requirements for a B.S. degree in Agronomy, with a major in Turf Management. He will complete the course and thesis requirements for a Master of Science in Agronomy within the next year. The thesis topic is the morphological and physiological bases of minimal maintenance turfgrasses. He has been a Teaching Assistant in Soil and Crop Sciences serving as the Laboratory Instructor in Turfgrass Science (Agro. 428).

Post-Doctoral Fellow: David M. Casnoff graduated from the Pennsylvania State University in 1975 with a B.S. degree in Agronomy (Turfgrass Management). He immediately entered Graduate School at the Pennsylvania State University and graduated with an M.S. degree in Agronomy (Soil Physics). His thesis project was "Soil Strength and Soil Temperature: Their Effects on the Root Growth of Tall Fescue." In May of 1978, he began his Ph.D. program in quantitative genetics at the University of Nebraska - Lincoln. The Ph.D. degree was conferred as of August 12, 1983. The thesis project was: "Nitrogen: Its Effects on the Expression of Prolificacy and its Utilization by Prolific and Non-prolific Genotypes of Maize."

Dr. Casnoff is currently a Post-Doctorate Fellow at Texas A&M University working with Dr. James B. Beard. He has gained insight into root studies and root evaluation techniques due to his 8 years of work with both tall fescue and maize root systems. This experience will be of great value in the rooting investigations for which he is responsible.

Graduate Research Assistant: Kisun Kim received his B.S. in Horticultural Science from the Seoul National University, South Korea, in 1978. After his military service in the Korean army, he returned to S.N.U. as a graduate student. During his stay in S.N.U. he was admitted to Graduate study at Texas A&M University. Since the Fall of 1981 he has been taking courses, and working as a Graduate Research Assistant at the turfgrass field lab under the direction of Dr. James Beard. Currently, he is working on root growth studies in the rhizotron and comparisons of evapotranspiration rates and drought resistance of the major warm season grasses.

C. Facilities Development

In addition to good personnel, the proper physical facilities are required in order to solve each problem. By July 1 of 1983 both the Turfgrass Field Laboratory building and plots, as well as the Stress Physiology Lab, had been refurbished and reorganized to meet the requirements of the planned research.

While most of the required physical facilities were already in place, there were four specific research facilities that needed to be repaired or constructed.

Water-Heat Stress Simulator - The electronic control system and associated dewpoint and temperature sensors were inoperative. After considerable testing, it was concluded that the costs for repair of the existing units would be so high that the best alternative would be the installation of an entirely new unit. This involved a switch from the electronic control unit built by Scientific Systems of Louisiana to a lower cost, but an equally effective, system available from Rheem Manufacturing of North Carolina. Installation of the new system was completed in early August of 1983. With these modifications the Texas A&M Physical Plant personnel can now repair the unit as needed at a considerably lower cost, whereas the other unit had to be shipped back to the manufacturer. Environmental test simulation runs involving monitoring of temperature, dewpoint, wind velocity, and carbon dioxide level in the chamber were made since then (Figure 2). Minor modifications in the dewpoint sensing element were then made. The system was made fully operational by December 5, 1983. Steve Griggs and Sam Sifers were involved in these activities.

Rainout Shelter - A rainout shelter is essential for drought studies that will be conducted during the upcoming years. The first attempt at construction of a low cost rainout shelter proved unsuccessful during 1982. This unit was destroyed during a strong wind storm. The rainout shelter was redesigned during June of 1983; construction was completed over the next 6-week period; and the unit was then tested (Figure 3). Some minor modifications were made. On August 25, 1983, the eye of the tropical hurricane Alicia passed right over College Station, Texas. We were most pleased that the rainout shelter weathered this heavy wind storm without problems. One remaining problem was to strengthen the construction materials in some of the supporting joints. This work was completed in April of 1984. The rainout shelter is now fully operational for the 1984 growing season. Design and construction of the rainout shelter was accomplished under the leadership of Sam Sifers.

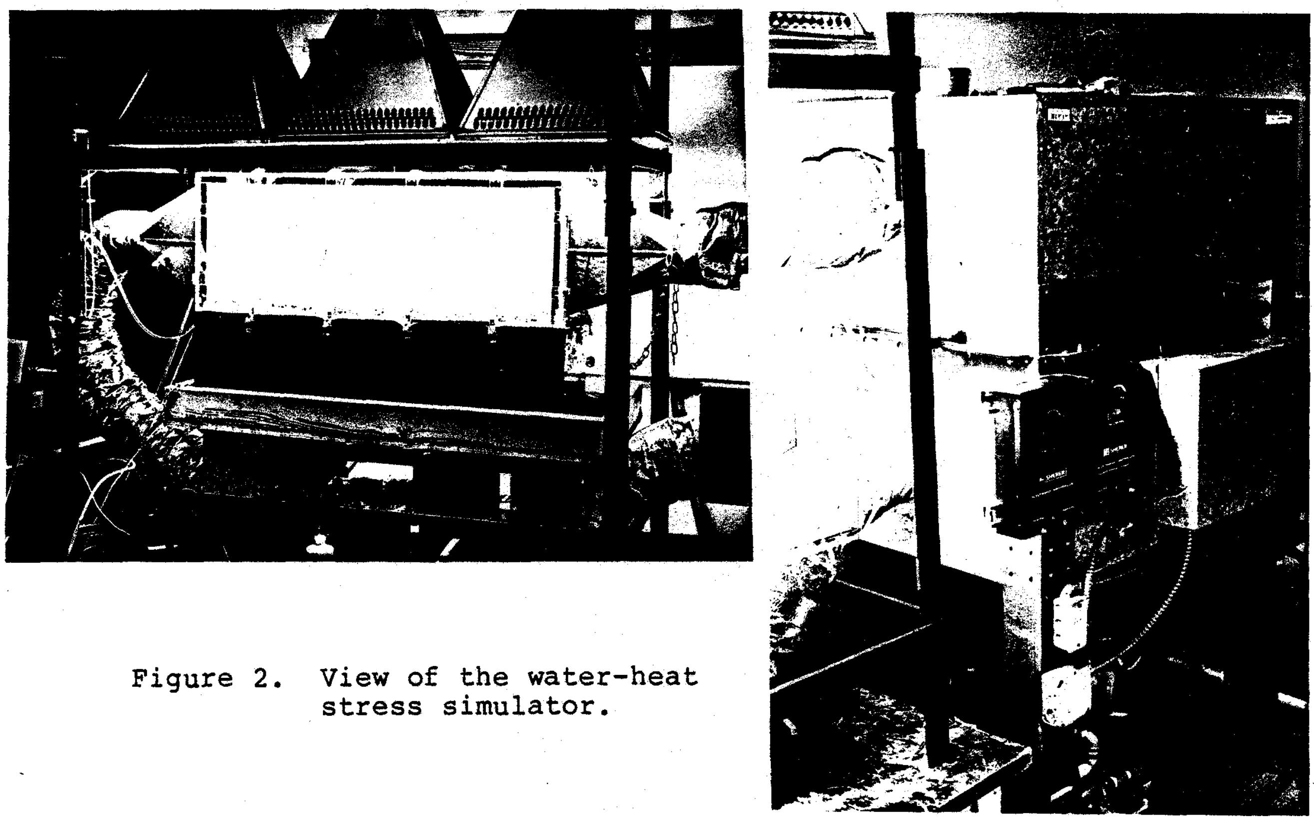


Figure 2. View of the water-heat stress simulator.

Figure 3. View of the moveable rainout shelter structure which is covered with an opaque polyethylene sheet with a saran-shade cloth placed on top when in use.

Cultural Systems Field Study Area - Well drained field plot areas are essential for studies involving the assessment of cultural practices as they affect water use rates and drought resistance. In preparation for the initiation of these studies in 1985, a set of field plots were established during the 1983 growing season. This involved installation of a 25 cm deep (minimum) sand root zone over a subsurface drain line system consisting of 10 cm laterals on a 4 meter spacing, plus installation of two underground irrigation lines and associated rotary, popup sprinkler heads (Figure 4). Subsequently the 5,230 square foot area was vegetatively planted to Tifway bermudagrass. Vegetative coverage of the plot area was achieved during the 1983 growing season. Complete establishment should be achieved by July of 1984. The cutting height and nitrogen nutrition treatment differentials will be initiated at that time. This project has been under the direction of Doug Dahms, Sam Sifers, and Wallace Menn.

Root Column Monitoring Facility - A controlled system was needed in which to study the maximum genetic potential for root growth at both the interspecies and intraspecies level. The system developed involved seventy-two tubes of 10 cm (4 inches) in diameter and 210 cm (84 inches) in length. The tubes were constructed from schedule 40 PVC tubes which were precut into seven 30 cm (12 inch) long segments. Each segment was joined to the next with a 10 cm (4 inch) wide piece of 8.75 cm (3.4 inch) diameter rubber tire innertube. A series of six support benches each holding twelve tubes were then constructed. The bottom 30 cm section of each tube was filled with pea gravel. The upper 6 sections were filled with washed masonry sand having 50% of the particles in the 0.2 to 0.5 mm range. The sand was placed in the individual tubes in 1 to 2 liter increments followed by extensive tamping. This approach continued in each 30 cm (12 inch) section of PVC tube, with the next higher tube being connected and the procedure repeated until the entire 210 cm length was constructed. The bottom of each tube was capped, with each cap having four holes of 3 mm in diameter placed randomly in the bottom to ensure adequate drainage of gravitational water through the column. The root column research facilitiy also included a trickle irrigation system arranged in a looped construction which was integrated with a nutrient injection apparatus. A preliminary experiment was conducted to determine the effectiveness of this method for assessing the maximum rooting potential. Slight modifications were then made in the water-nutrient injection system. Since then the root column system has proven very satisfactory. This project has been under the direction of Dave Casnoff and Sam Sifers.

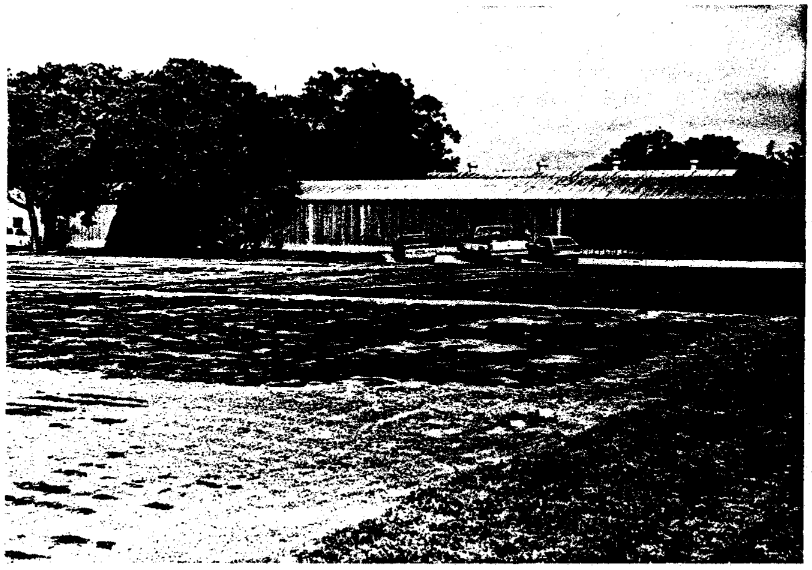


Figure 4. View of the cultural systems field study area to be used in future water use rates and drought studies.

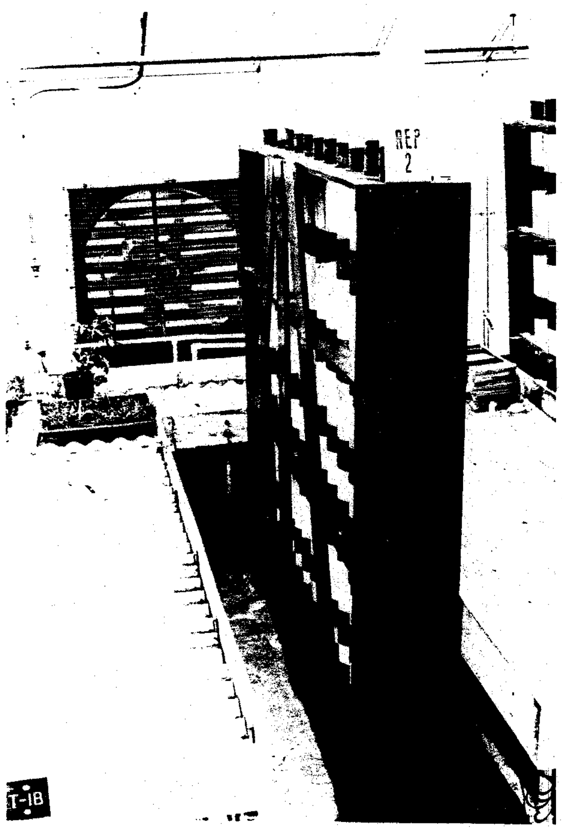


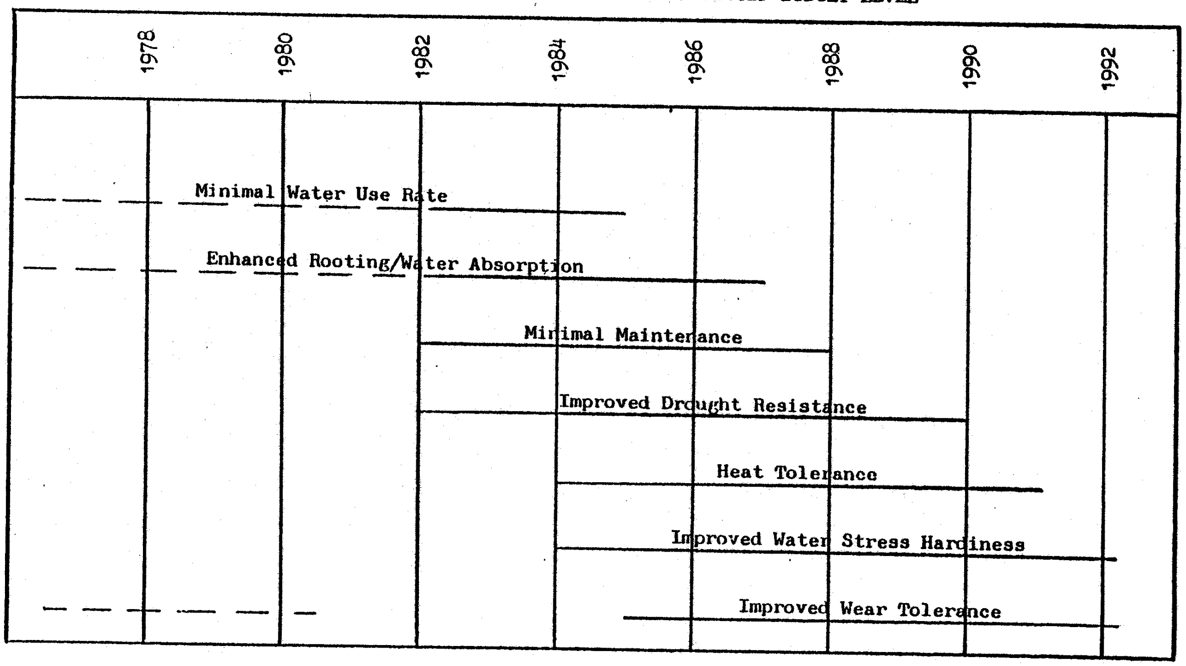
Figure 5. View of the root column monitoring facility as it is currently operational in the greenhouse.

III. STATUS OF FIRST YEAR ANNUAL PLAN OF WORK

The long range plan of research developed as part of the original project proposal in shown in Figure 6. This overall plan does not need adjustment based on the progress made during the first year. Within any one specific problem area a similar fundamental research approach is being utilized. This approach is summarized in Figure 7, which is a flow plan for the coordinated pursuit of research concerning the development of water conserving, minimal maintenance turfgrasses and cultural systems. This overall approach continues to be the main theme used in this investigation.

An individual flow plan for the first year's research was also developed as shown in Figure 8. The flow plan represented an optimum and assumed no breakdowns in equipment, no unanticipated loss of turfs due to disease or insect problems, and a full compliment of personnel. Our original goal was to complete a minimum of 70% of this annual plan of work.

Figure 6. SCHEDULE OF RESEARCH ACTIVITIES BASED ON THE PROJECTED BUDGET LEVEL



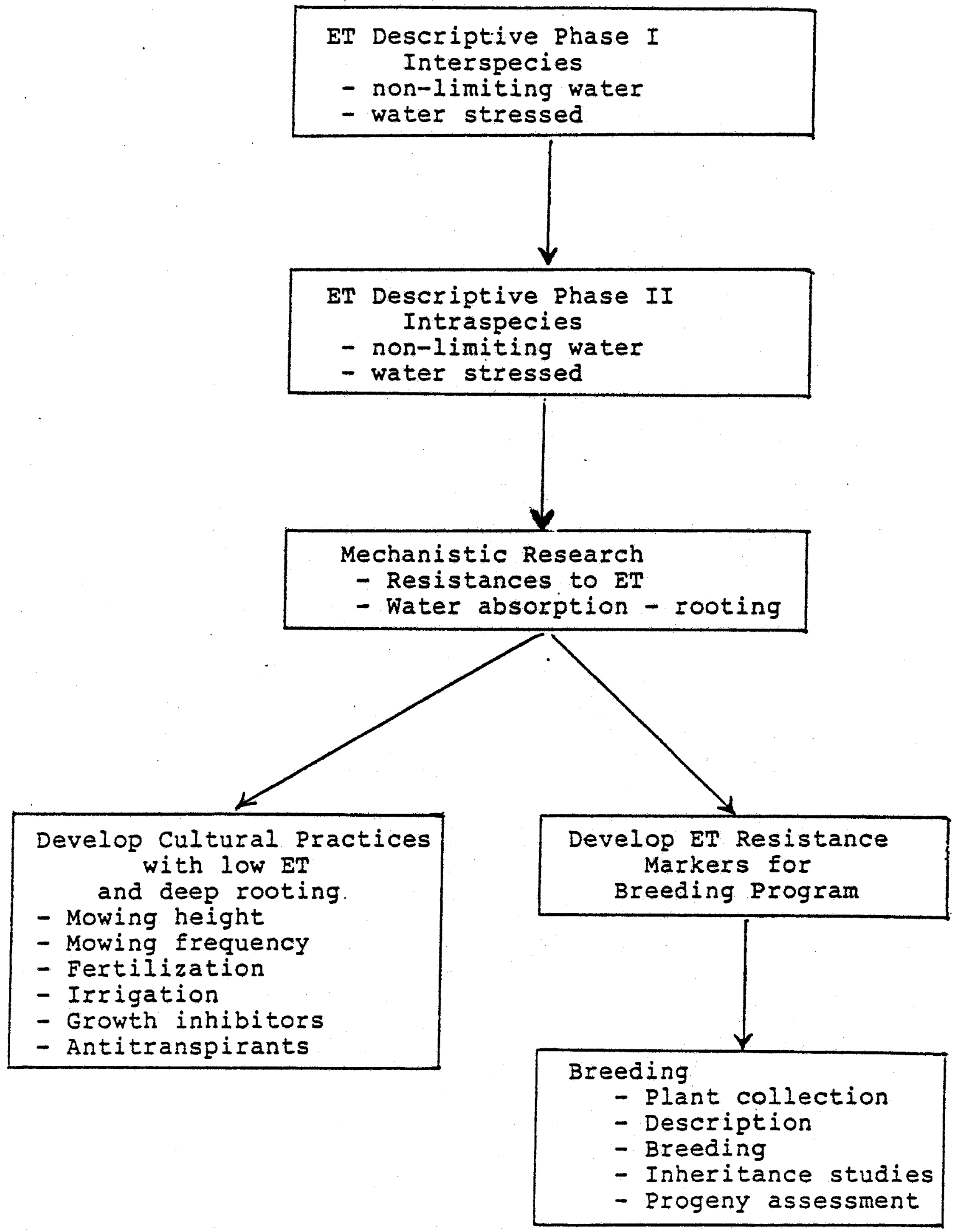
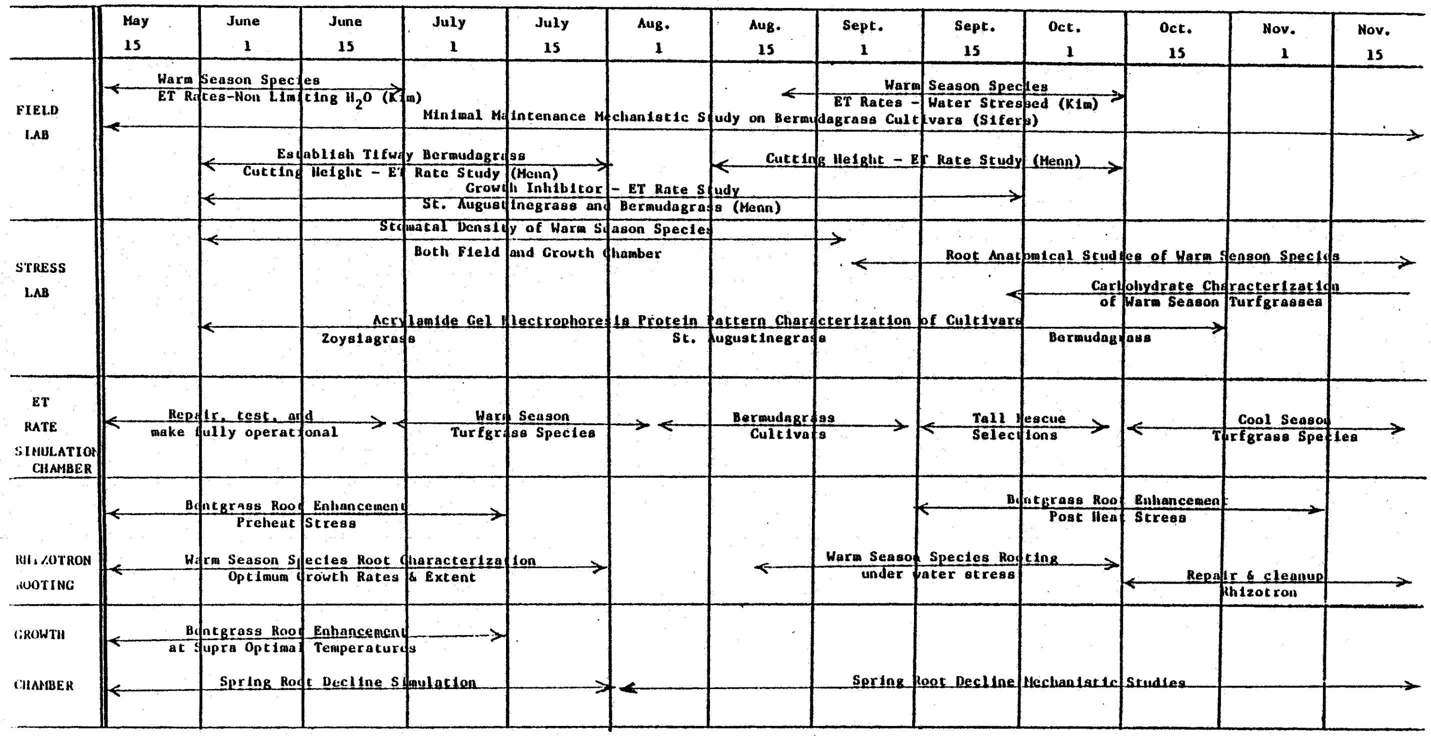


Figure 7. A flow plan for the coordinated pursuit of research concerning the development of water conserving turfgrass and cultural systems.

Figure 8.

1983 FLOW PLAN OF USGA GRANT RESEARCH PROJECT
TURFGRASS PROJECT, TAMU, COLLEGE STATION



The current status of the research as of April 1, 1984 is summarized in Table 1. Of the thirteen original research objectives, eight have been completed with three others well along to completion. The research accomplished during this year was well within our original goal of completing at least 70% of the annual plan of work.

Table 1. A First Year Status Report of the Degree to Which the Thirteen Research Objectives Were Completed.

Problem Area	Research Objective	First Year Status
Minimal Water Use	A-1	Completed
	A-2	Completed
	A-3	50%
	A-4	50%
	A-5	10%
	A-6	Completed
	A-7	Completed
Enhanced Rooting	B-1	Completed
	B-2	80%
	B-3	- -
	B-4	Completed
	B-5	Completed
Improved Drought Resistance	C-1	Completed

The research objectives involving A-4 and A-5 were dependent on an operational water stress simulator. This simulator was not made fully operational until December of 1983. Research was then initiated and has been sustained on a continuous 7-day basis since. One replicate for each of three species can be run each week, or an equivalent of one grass species per week. This means that a 12 week period or 3 months is required to characterize the evapotransporation rates of 12 turfgrass species. Coordinated with this is objective A-3, which is the characterization of the stomatal densities and shoot morphology of these grasses when grown in a controlled environment growth chamber. Upon completion of the study these various plant characteristics will be evaluated as to their specific association with the evapotransporation rate. If the simulation chamber could have been made operational earlier, these three objectives would have been completed within the original projected first year time frame.

The research objective B-3 was not initated because of the complexities of the problem encountered. Special research techniques are required and it appears that it is best approached initially under field conditions utilizing a combination of the rhizotron and rainout shelter. The initial phases of this study will be conducted during the summer of 1984.

STATUS OF FIRST YEAR ANNUAL PLAN OF WORK

Detailed research objectives for the year were presented in the Annual Plan of Work submitted prior to initiation of the research. Summaries of the current status of these objectives will constitute the remainder of the presentation in this section. More detailed scientific papers representing research completed during the year are included in the Appendix. These are early drafts and thus are included in the report on a - NOT FOR PUBLICATION - basis.

A. OBJECTIVES FOR MINIMAL WATER USE RATES:

1. Determine the comparative potential evapotranspiration rates of 11 warm season turfgrass species under non-limiting moisture conditions. First of a two year study. (Species Comparison) S. Sifers and K. Kim.

   Status - Two full experiments have been completed as part of the first year of this two year study under non-limiting water conditions.

   Results - The potential evapotranspiration rates of eleven C-4 warm season turfgrasses and one C-3 cool season turfgrass were evaluted in mini-lysimeters utilizing the water balance method. The turf plots were constructed to ensure a natural environment surrounding each mini-lysimeter. Potential evapotranspiration rates of each species were measured under nonlimiting soil moisture conditions. The grasses were mowed at a 3.8 cm (1.5 inches) cutting height and fertilized with 0.25 kg N are^{-1} (0.5 lb N per 1,000 sq. ft.) per growing month.

   Significant differences in potential evapotranspiration rates were observed at both the interspecies and intraspecies levels. Emerald zoysiagrass, buffalograss, Tifgreen bermudagrass, and centipedegrass had low potential evapotranspiration rates; while tall fescue, St. Augustinegrass, bahiagrass, and Adalayd sand knotgrass were characterized as having very high rates. Common bermudagrass, Tifway bermudagrass, Meyer zoysiagrass, and blue grama possessed intermediate potential evapotranspiration rates. See more detailed paper in Appendix.

2. Assess the realtionships of shoot morphology to the potential evapotranspiration rates of the 11 major warm season turfgrass species. First of a two year study. (Mechanistic and Development of Screening Technique) K. Kim and S. Sifers.

   Status - The first year encompassing two experiments has been completed.

Results - In conjunction with the first objective just discussed, the same plant materials were assessed in terms of growth and morphological characteristics that could reduce the evapotranspiration rate. Good correlations were found between a low evapotranspiration rate and a (1) slow vertical leaf extension rate, (2) high shoot density, (3) narrow leaf width, and (4) prostrate growth habit. In contrast, leaf water potential measurements did not correlate with the evapotranspiration rate. See more detailed paper in Appendix.

3. Compare the stomatal characteristics and densities among 11 major warm season and 12 major cool season turfgrasses under uniform growth chamber conditions. (Mechanistic Study) D. Casnoff.

Status - Replicated stomatal counts have been completed on a 0.5 x 0.5 mm area of both the abaxial (directed away from the axis) and adaxial (directed toward the axis) sides of the leaf for five warm season and one cool season turfgrass species. Stomatal counts for the six remaining warm season turfgrasses should be completed by September of 1984.

Results - The data collected suggest that there are significant differentials for stomatal densities among the six species studied thus far. Within any given species, there are usually more stomates per given area on the adaxial as compared to the abaxial side of the leaf. Highest overall stomatal densities were found in Emerald and Meyer zoysiagrasses; followed by Texas Common St. Augustinegrass, Common centipedegrass, Argentine bahiagrass, and Kentucky-31 tall fescue. Relationships between the stomatal densities and evapotranspiration rates of these turfgrass species will be investigated as soon as the data collection phase is completed.

4. Establish the accuracy with which the water stress simulation module reproduces representative evapotranspiration rates observed in the field. (Techniques Study) S. Griggs.

Status - The conduct of this experiment was dependent on a fully operational water stress simulation chamber. A much longer time was required to fully replace the electronic control system in the simulation chamber as well as to conduct appropriate testing to make it fully operational for the types of studies being conducted. Thus, full implementation of the detailed experiments was not achieved until early 1984. For the past several months, the chamber has been maintaining good constancy in dew point which is the critical factor in these experiments. Five warm season turfgrasses and one cool season turfgrass have now been assessed in the chamber in terms of potential evapotranspiration rates.

Results - Among the six species, the relative rankings of potential evapotranspiration rates under non-limiting moisture conditions are in comparable order to that previously found under field conditions. Although it is too early to draw final conclusions, it appears that there is very good correlation between results obtained in the simulation chamber relative to those monitored under typical field conditions. Thus, it is anticipated that the fifth objective in this section involving an assessment of evapotranspiration rates among twelve cool season turfgrasses can be accomplished in the chamber and will accurately reflect field conditions. This experiment is projected to be completed in nine weeks assuming no breakdowns in the chamber.

5. Assuming the simulation module proves representative, determine the comparative evapotransporation rates of 12 cool season turfgrass species. First of a two year study. (Species comparison) S. Griggs.

Status - It is anticipated that the stress simulation chamber can be freed to initiate this study in nine weeks. In preparation for this, a set of cool season turfgrasses has been established in the mini-lysimeters and are currently being maintained in the cool room of the greenhouse complex. Drs. Shearman, Carrow, and Butler have cooperated in providing established turfs to be utilized in this study.

6. Determine the potential of leaf growth inhibitors in water conservation. Two year study. (Mechanistic and Cultural Studies) W. Menn.

Status - A greenhouse study with St. Augustinegrass and two field studies with Texas Common St. Augustinegrass and Tifway bermudagrass have been completed. The two growth inhibitors being assessed were flurprimidol (Cutless) and mefluidide (Embark).

Results - Experiments under both greenhouse and field conditions confirmed the hypothesis that growth inhibitors have potential as a cultural technique to achieve water conservation. The reduction in evapotranspiration rates has been in the order of 15 to 35%, depending on the specific environmental conditions and the inherent shoot growth rate of the turfgrass species involved. This is based on the assumption that the growth regulator being used is effective without phytotoxicity or adverse morphological effects on leaf and stem development. It should be emphasized that the use of growth inhibitors in water conservation is a strategy that has potential for use under irrigated conditions. This does not imply that it is equally of value under periodic water stress or severe drought conditions. See more detailed paper in Appendix.

7. Compare the influence of cutting height and nitrogen rate on the evapotransporation rates of 11 major warm season turfgrasses. First of a three year study. (Improved Cultural Systems) K. Kim and D. Dahms.

   Status - First year of a three year study is completed. The initial phase involved field assessments of the water balance using mini-lysimeters.

   Results - Preliminary results revealed that the evapotranspiration rate increases as the mowing height and/or nitrogen level are raised. The combined cutting height - nitrogen level regime that produced the most rapid leaf growth rate, also was associated with the highest evapotranspiration rate, regardless of the species involved. Those species with high nitrogen requirements are more sensitive to nitrogen fertility than to mowing height in terms of the evapotranspiration rate responses. In contrast those species with a low nitrogen requirement are characterized by evapotranspiration rates which are more effected by mowing height than nitrogen fertility level. See more detailed paper in Appendix.

B. OBJECTIVES FOR ENHANCED ROOTING/WATER ABSORPTION:

1. Characterize the root systems of 11 warm season turfgrass species under non-limiting and water stressed conditions. First of a two year study. (Species Comparisons) S. Sifers and S. Griggs.

   Status - The initial characterization of the root systems of 11 warm season turfgrass species which have been growing in the glass faced root observation boxes of the rhizotron for three years is now completed. The data are now being compiled. Due to severe low temperature stress conditions, all of the warm season turfgrasses must be replanted in the rhizotron. It is anticipated that the second year of this investigation can be commenced in July of 1984.

   Results - Observations reveal substantial differences among warm season species at the interspecies level under non-limiting moisture conditions. There is variability in depth, diameter, branching, and rate of root extension. Details of potential variability in root hairs (including length, density, and longevity of life span) are yet to be determined. Current efforts are being devoted to the development of a reliable research technique.

2. Assess the genetic potentials in root growth rate of 11 major warm season turfgrass species under non-limiting moisture conditions.. First of a two year study. (Mechanistic Study) D. Casnoff.

   Status - This investigation was initiated in January of 1984. Seven 30 cm sections of 4 inch PVC tube were connected together by use of rubber tire innertubing. This 210 cm long tube construction was filled with washed sand. One plant, defined as one node (including shoot, crown, and roots) was transplanted in each tube. The buffalograss was seeded (i.e. one seed = one plant per tube). Two harvests were scheduled with the first taken March 27. The second harvest is planned for the middle of May. The data taken were (a) number of roots intersecting the 30, 60, 90, 120, 150 and 180 cm depths, as well as (b) the weights of roots found from the 0-30, 30-60, 60-90, 90-120, 120-150, and 150-180 cm sections of the 210 cm tube construction.

   Results - The following results were found for the first harvest date. Root length extensions ranked from longest root extensions to shortest were as follows: Texturf 10 bermudagrass, Texas Common St. Augustinegrass, FB 119 bermudagrass, Tifgreen bermudagrass, Tifway bermudagrass, Emerald zoysiagrass, Adalayd sand knotgrass, Common centipedegrass, Argentine bahiagrass, Meyer zoysiagrass, and Texokla buffalograss. Total root weights ranked from greatest to least were as follows: St. Augustinegrass, Texturf 10 bermudagrass, FB 119 bermudagrass, Tifgreen bermudagrass, Tifway bermudagrass, Emerald zoysiagrass, Adalayd sand knotgrass, Common centipedegrass, Argentine bahiagrass, Meyer zoysiagrass, and Texokla buffalograss. The ranking of maximum rooting potential at the interspecies level for the 11 warm season turfgrasses was positively correlated with the total root weight.

3. Investigate the relationship of rooting to water use rate under water stress conditions. Preliminary. (Mechanistic Study) S. Sifers.

   Status - This problem is a rather complex one in terms of developing the proper approaches that will generate reliable data in line with the objectives. It appears that the preliminary investigations will involve coordinated use of the rhizotron and adjacent rainout shelter facilities. The current plans are for the initial phase of this study to be conducted during the summer of 1984 under field conditions.

4. Conduct exploratory studies of root enhancing agents. First of a two year study. (Mechanistic and Cultural Studies) S. Griggs.

Status - Investigations were conducted in both the field and rhizotron, as well as in a controlled environment growth chamber under heat stress conditions. The Penncross creeping bentgrass was maintained at a 1.8 cm (0.5 inch) cutting height. There have been difficulties in establishing the proper heat stress levels in the growth chamber.

Results - Preliminary results indicated a positive response from several organic compounds in enhancing root growth under typical conditions of summer heat stress. There have been difficulties in stabilizing the heat stress regime in the growth chamber which has necessitated the restart of several experiments. A particularly attractive aspect is to develop an organic compound which can affect carbohydrate partitioning in terms of a more favorable balance for the root system relative to the shoots. A great deal of research remains to be done in this area. We have currently decided to alter our technique from the use of full turfs to individual plants utilizing a column system similar to that described earlier in B-2 where the root column monitoring facility was utilized.

5. Determine the cause of spring root decline of warm season turfgrasses as well as methods to minimize its effects. First of a three year study. (Mechanistic Study) S. Sifers.

Status - The first phase under this objective was to develop a technique to successfully simulate the spring root decline phenomenon under controlled environment conditions in growth chambers. This would provide a final confirmation concerning the occurrence of the spring root decline phenomena. The second phase of the study conducted during the past year involved studies regarding the environmental factors controlling induction of spring root decline. To conduct these experiments a group of eighteen individual root observation boxes were constructed and established to turfs primarily of Tifway bermudagrass, but also some of Texas Common St. Augustinegrass. The primary thrust of this phase of the research was to determine the specific Winter and Spring environmental conditions required to induce spring root decline.

Results - The simulation regime involved establishing the low temperature discoloration and dormancy phases in a cold chamber at temperatures of 42°F (5°C) for a period of two months followed by placing in a separate growth chamber at a temperature of 92°F (33°C). Under these conditions, complete spring root dieback was observed with all new root initiation occurring from the meristematic areas on the crowns and on the nodes of lateral stems. This experiment was repeated a second time with similar results. This confirms the existance of spring root decline as a separate entity unto itself.

In subsequent studies replicated sets of Tifway bermudagrass were placed in two warm temperature regimes of 90°F (32°C) and 75°F (24°C) following the low temperature discoloration-dormancy period . In this case, spring root decline was observed to occur as previously observed in the higher temperature regime, but did not occur at the lower temperature. Additional studies are underway concerning this aspect of the investigation. However, it appears that the rate of warming in early spring immediately following greenup is a critical factor in determining whether induction of spring root decline occurs. For the past four years these investigations have been partially supported by a series of grants from the O.J. Noer Research Foundation. This segment is included in the report at the request of Dr. Bengeyfield to provide an overall view of the research underway that affects rooting and water conservation. See more detailed paper in Appendix.

C. <u>OBJECTIVE FOR IMPROVED DROUGHT RESISTANCE</u>:

1. Characterize the morphological, anatomical and physiological responses of 11 major warm season turfgrass species that develop during the onset and progression of water stress. First of three year study. (Mechanistic study) K. Kim and S. Sifers.

   <u>Status</u> - An initial study has been completed on 11 major warm season turfgrass species. More detailed investigations are scheduled for the 1984 growing season utilizing the recently completed rainout shelter.

   <u>Results</u> - The water use rates of the 11 major warm season turfgrass species decreased in direct proportion to the degree of soil water stress. The relative rankings among the 11 species in terms of their evapotranspiration rates did not show large relative changes between the optimum moisture versus water stress regimes, with one exception. In the case of bahiagrass, it had a very high evapotranspiration rate under nonlimiting moisture conditions, but exhibited a very low evapotranspiration rate under progressive water stress. This suggests that an adaptive mechanism exists in bahiagrass that may be of great significance in the study of water conservation and drought resistance. It is hoped that this avenue of inquiry can be pursued in the near future. From the physiological standpoint, there was some association between the leaf water potential and drought resistance.

Table 2. SUMMARY OF THE C-4 WARM SEASON TURFGRASSES UTILIZED IN STUDIES A - 1, 2, 3, 4, AND 7; B - 1, 2, AND 3; AND C - 1.

Turfgrass Species		
Common Name	Scientific Name	Cultivar
Bahiagrass	*Paspalum notatum*	Pensacola*
Bermudagrass	*Cynodon dactylon*	Arizona Common*
Bermudagrass	*Cynodon dactylon*	Texturf 10
Bermudagrass	*C. dactylon* x *C. transvaalensis*	Tifgreen
Bermudagrass	*C. dactylon* x *C. transvaalensis*	Tifway
Buffalograss	*Buchloe dactyloides*	Common*
Centipedegrass	*Eremochloa ophiuroides*	Common*
Sand Knotgrass	*Paspalum vaginatum*	Adalayd
St. Augustinegrass	*Stenotaphrum secundatum*	Texas Common
Zoysiagrass	*Z. japonica* x *Z. tenuifolia*	Emerald
Zoysiagrass	*Zoysia japonica*	Meyer

*Seeded

Table 3. SUMMARY OF THE TWELVE C-3 COOL SEASON TURFGRASSES SELECTED FOR STUDY IN 1984-86.

Turfgrass Species		
Common Name	Scientific Name	Cultivar
Kentucky bluegrass	*Poa pratensis*	Merion
Rough bluegrass	*Poa trivialis*	Sabre
Annual bluegrass (annual)	*Poa annua* var. *annua*	College Station source
Annual bluegrass (perennial)	*Poa annua* var. *reptans*	Minnesota source
Creeping bentgrass	*Agrostis palustris*	Penncross
Colonial bentgrass	*Agrostis tenuis*	Highland
Chewings fescue	*Festuca rubra* var. *commutata*	Jamestown
Hard fescue	*Festuca ovina* var. *duriuscula*	Scaldis
Tall fescue	*Festuca arundinacea*	Kentucky 31
Tall fescue	*Festuca arundinacea*	Rebel
Perennial ryegrass	*Lolium perenne*	Manhattan II
Wheatgrass	*Agropyron desertorum*	Crested

IV. BUDGET STATUS

The Texas A&M Research Foundation has set up a group of subclassifications of expenditures which allows us to keep a more detailed record of cost centers. The classifications are summarized as follows:

<u>Stress Lab 4893 - 1</u>
On Campus Payroll
Maint./Repair - Res. Equipment
Supplies - Research
Equipment - Purchase
Other Expenses
Domestic Travel

<u>Turfgrass Plots 4893 - 2</u>
On Campus Payroll
Maint./Repair - Res. Equipment
Supplies - Research
Equipment - Rental

The receipt of invoices and final billings of a number of items can be delayed by as much as thirty days. Thus, we cannot give a firm figure as to the current level of expenditures. However, based on our available records, the overall expenditures for the initial year were approximately $475.00 above the original budgeted amount. We are quite satisfied to be this close to the original budget. The past year's expenditures by categories are now being assessed and a detailed budget in terms of subcategories for expenditures will be established for the upcoming year.

V. PUBLICITY

During the last year considerable effort has been devoted to speaking at Turfgrass Conferences and to writing technical and popular articles concerning the TAES water conservation research sponsored by the USGA. Hopefully these efforts will assist in the fund raising activities of Mr. Don Spencer. It also should give national recognition to the USGA and to the Texas Agricultural Experiment Station for their efforts in solving the water shortage problems facing the turfgrass industry in the upcomsing decades.

A. <u>Talks Presented</u>:

Dr. J.B. Beard had the opportunity to present talks on the subject of water conservation and the research being conducted at Texas A&M University under sponsorhsip of the USGA at three national turfgrass conferences and eight regional/status turfgrass conferences during the past 18 months.

National Conferences:

Breeding for Water Conservation and Low Maintenance Cultivars. International Turfgrass Conference of GCSAA, Atlanta, Georgia, February, 1983.

Identifying Future Turf Needs As Related to Water. Annual Mid-Winter Conference, The American Sod Producers Association, San Antonio, Texas, February, 1983.

Turfgrass Research Update. Canadian National Turf Conference, Toronto, Canada, March, 1984.

Regional and State Conferences:

Maximizing Rooting of Grasses. Florida Turfgrass Conference, Tampa, Florida, October, 1982.

Managing Environmental Stresses on the Golf Course. North Central Turfgrass Exposition, Arlington Heights, Illinois, November, 1982.

Watering Effects on Turfgrasses. New Jersey Turfgrass Expo, Atlantic City, New Jersey, November, 1982.

Water and Rooting of Turfgrasses. New Jersey Turfgrass Expo, Atlantic City, New Jersey, December, 1982.

New Horizons in Turfgrass Management. North Carolina Turfgrass Conference, Pinehurst, North Carolina, January, 1983.

Turfgrass Research Update. Massachusetts Turf Conference. Springfield, Mass., March, 1983.

Water Conservation Research - A New Thrust. Texas Turfgrass Conference. Houston, Texas, December, 1983.

Turfgrass Research Update. Iowa Turfgrass Conference, Des Moines, Iowa, February, 1984.

American Society of Agronomy Annual Meeting:

Comparative ET Rates of Eleven Major Warm Season Turfgrasses Grown Under Uniform and Optimum Cultural Regimes. K.S. Kim and J.B. Beard. ASA Annual Meeting, Washington, D.C. August, 1983.

B. Papers Published:

Water Use by Turfgrass. 1983. Proceedings of the 54th International Turfgrass Conference. pp. 161-168.

Identifying Future Turf Needs as Related to Water. 1983. Proceedings of the Annual Mid-Winter Conference. The American Sod Producers Association. pp. 3-4.

Comparative ET Rates of Eleven Major Warm Season Turfgrasses Grown Under Uniform and Optimum Cultural Regimes. 1983. Agronomy Abstracts. p. 127.

Comparative Evapotranspiration Rates of 13 Turfgrasses. 1983. Texas Turfgrass Research - 1983. TAES Progress Report 4156. pp. 62-64.

C. Symposium:

J. B. Beard participated in a two day Water Symposium sponsored by the American Sod Producers Association. Twelve turfgrass researchers assembled from around the USA were invited to present papers and participate in the discussions. J.B. Beard presented a review paper on turfgrass water use rates. Included were an assessment of research techniques, a critique of past research, and a report on current water use rate research being conducted at Texas A&M University.

A 66 page manuscript has been written and will be included as one chapter in a book to be published by the University of California Press. A final draft has been sent to Mr. W. Bengeyfield of the USGA Research Committee.

D. Television:

During the first week in June of 1983, an ABC Sports television crew spent a full day at Texas A&M University. They took approximately 54 minutes covering the Turfgrass Stress Lab, Greenhouse, and Field Laboratory facilities. Emphasis was placed on the water-heat stress simulator, rhizotron, and mini-lysimeters with rainout shelter. This material was used for short segments presented on TV during the US Open.

E. USGA - Don Spencer:

Considerable printed and verbal information has been provided to Mr. Don Spencer to assist in his fund raising efforts. He visited the research facilitis at Texas A&M University in February of 1983. At that time he was given a fairly detailed overview of the types of the problems and the research facilities and activities that are required to solve these problems. There was a very good interchange. Subsequently there have been periodic contacts and inputs as requested by Mr. Spencer throughout 1983.

VI. APPENDIX

1. Comparative evapotranspiration rates of 13 turfgrasses.
2. The effects of nitrogen fertility level and mowing height on the evapotranspiration rates of nine turfgrasses.
3. Use of growth regulators to conserve moisture in Common St. Augustinegrass and Tifway bermudagrass.
4. Spring root decline induction studies.

COMPARATIVE EVAPOTRANSPIRATION RATES OF 13 TURFGRASSES

K. S. Kim, J. B. Beard, L. L. Smith, and M. Ganz

INTRODUCTION

One of the key components in a water conservation strategy is the selection of turfgrass species and cultivars possessing low water use rates. In the past, water was readily available at a low cost. Therefore, little attention was paid to such water conservation strategies. This situation, combined with a need for research in many diverse areas of turfgrass culture, resulted in very little research information being generated concerning the water use rates of turfgrasses. However, the general public has now become aware of the developing water problem and is beginning to support research into turfgrass water conservation. Thus, the objective of this investigation was to determine quantitatively the water use rate (evapotranspiration) differentials, if any, among the warm season turfgrasses.

MATERIALS AND METHODS

The evapotranspiration (ET) rates of twelve C-4 warm season turfgrasses and one C-3 cool season turfgrass were evaluated in mini-lysimeters utilizing the water balance method. The turf plots were constructed to insure a natural environment surrounding each mini-lysimeter. The evapotranspiration rates of each species were measured under both non-limiting soil moisture and progressive water stress conditions. During the uniform cultural practices study, all grasses were mowed at a 1.5 inch (3.8 cm) cutting height and fertilized with 0.5 lb nitrogen/1000 sq ft (0.25 kg N/are)/growing month; while for the optimum cultural practices study the cutting height and nitrogen fertilization rate selected were based on established optimums for each species.

RESULTS

Significant differences in evapotranspiration rates were observed at both the interspecies and intraspecies levels. Emerald zoysiagrass, Common buffalograss, Tifgreen bermudagrass, and Common centipedegrass had low evapotranspiration rates; while Kentucky 31 tall fescue, Texas Common St. Augustinegrass, Argentine bahiagrass, and Adalayd sand knotgrass were characterized as having high evapotranspiration rates. Common bermudagrass, Tifway bermudagrass, Meyer zoysiagrass, and Common blue grama possessed intermediate evapotranspiration rates.

The ranking among grasses in terms of their evapotranspiration rates did not show large relative changes between the uniform and the optimum cultural practice regimes and between the two soil moisture conditions. The one exception was bahiagrass which had a low evapotranspiration rate under progressive water stress conditions, in contrast to a high evapotranspiration rate under the non-limiting soil moisture conditions. All grass species exhibited higher evapotranspiration rates when maintained at their optimum nitrogen fertility and cutting height, which was attributed to a more rapid vertical leaf extension rate.

Those grass species possessing a slow vertical leaf extension rate, high shoot density, low leaf area, and prostrate growing habit tended to have low evapotranspiration rates. These investigations prove that turfgrass species do vary substantially (up to 50%) in water use rates. Thus, this criterion can be used when selecting turfgrasses for use in situations where water conservation is an important consideration.

This investigation was partially supported by a grant from the United Golf Association.

THE EFFECTS OF NITROGEN FERTILITY LEVEL AND MOWING HEIGHT ON THE EVAPOTRANSPIRATION RATES OF NINE TURFGRASSES

K.S. Kim and J.B. Beard

Introduction

As much as 50% of the water used in large urban areas during the summer season is for irrigation of lawns and shrubs. In the past, water was readily available at a low cost. Therefore, little attention was paid to water conservation strategies. Water costs have increased substantially and now water availability also is becoming a major concern in growing turfs, especially in warm semi-arid climatic regions of the southern United States.

Reduced water use rates of turfgrasses can be achieved by selection of the appropriate species and cultivar which possess a low water use rate, by certain chemicals which reduce evapotranspiration (ET), and by appropriate cultural practices. The effects of nitrogen fertility and mowing height on the evapotranspiration rate of nine turfgrasses were extensively studied at the TAMU Turfgrass Field Laboratory.

Materials and Methods

The evapotranspiration (ET) rates of nine C-4 warm season turfgrasses were evaluated in mini-lysimeters, utilizing the water balance method. The turf plots surrounding each lysimeter were constructed with the same species as was in each lysimeter to insure representative microenvironmental conditions. The surrounding plot area was fertilized every two weeks at a rate of 0.5 lb N, P, and K/1000 ft^2 (0.25 kg/are) per growing month, and mowed at a 1.5 inch (3.8 cm) cutting height once every week. Irrigation was applied by means of a rotary pop-up sprinkler system for 30 minutes everyday. The ET rates of each species were measured under non-limiting soil moisture condition. Since there were no visual symptoms of diseases or insect injury, no pesticides were applied during the experimental period. Weeds were removed manually as they appeared.

The grasses in the lysimeters were fertilized with 0.5 lb nitrogen/1000 ft^2 (0.25 kg N/are)/growing month and mowed at a 1.5 inch (3.8 cm) cutting height for the uniform cultural practices phase. On the other hand, each species was fertilized and mowed at their respective optima (Table 1) for the optimum cultural practices phase.

Results and Discussion

All nine grass species showed significantly higher ET rates when maintained under their respective optimum cultural practices than when maintained under a uniform cultural practices system.

It was difficult to separate the effects of nitrogen fertilization rate from mowing height as it influenced the ET rates of turfgrasses. However, an increased nitrogen fertilization rate resulted in increased ET rates in three bermudagrasses and Adalayd sand knotgrass; whereas it resulted in decreased ET rates in two zoysiagrasses, buffalograss, and centipedegrass. Since the former grasses are known to be quite responsive to nitrogen fertility, while the latter grasses are known to have a low nitrogen requirement, it is assumed that the effects of nitrogen fertility overshadowed the effects of mowing height on ET rates in nitrogen sensitive grasses such as bermudagrass and Adalayd sand knotgrass.

Increased mowing height resulted in increased ET rates in two zoyiagrasses, St. Augustinegrass, buffalograss, and centipedegrass. It seems that the effects of mowing height on ET rate might overshadow the effects of nitrogen fertility in those turfgrass species, such as zoysiagrass, buffalograss, and centipedegrass, which have a low maintenance requirement. These interpretations can be supported by the positive correlation between ET rates and vertical leaf extension rates of each species.

Summary

Those species with high nitrogen requirements are more sensitive to nitrogen fertility level than to mowing height in terms of ET rate responses, whereas those species with low

nitrogen requirements are characterized by ET rates which are more affected by mowing height than the nitrogen fertility level.

These water use rate - cultural investigations are continuing under grant support from the United States Golf Association.

References

1. Beard, J.B. 1973. Turfgrass: Science and Culture. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. pp. 272-277.

2. Kim, K.S. 1983. Comparative ET rates of 13 turfgrasses. M.S. Thesis. Texas A&M University. p. 63.

3. Johns, D. and J.B. Beard. 1981. Approaches to water conservation in turfgrasses. Texas Turfgrass Research - 1979-80. TAES Progress Report 3833. pp. 13-15.

Table 1. Cutting height and nitrogen fertilization rate utilized for each turfgrass species during the Optimum Cultural System when grown under non-limiting soil moisture conditions.

Turfgrass Species and Cultivar	Cutting Height (inch)	Nitrogen Rate (lb. N/1000 ft^2/ growing month)
Common Bermudagrass	1	1
Tifway Bermudagrass	1	1
Tifgreen Bermudagrass	1	1
Adalayd Sand Knotgrass	1	1
Texas Common St. Augustinegrass	2	0.5
Meyer Zoysiagrass	2	0.25
Emerald Zoysiagrass	2	0.25
Common Buffalograss	2	0.25
Common Centipedegrass	2	0.25

Use of Growth Regulators to Conserve Moisture in Common St. Augustinegrass and Tifway Bermudagrass

In 1981, Drs. Johns and Beard at Texas A&M University in College Station, Texas, showed a close correlation between leaf area index and transpirational water losses from Common St. Augustinegrass [Stenotaphrum secundatum (Walt.) Kuntze] and Tifway Bermudagrass (Cynodon spp.). These studies were centered around the growth regulator, flurprimidol, and several rates were evaluated. A safe rate to recommend is still of concern and is why the 1983 trials were conducted. Another purpose for this study was to confirm results obtained in 1980 and 81, relating to water conservation.

Materials and Methods

This study was divided into 2 phases. One phase was conducted in the greenhouse on Texas Common St. Augustinegrass and the second phase was conducted in the field on Texas Common St. Augustinegrass and on Tifway bermudagrass. Phase one consisted of establishing plugs of St. Augustinegrass in 18 two gallon plastic containers filled with calcined clay and then treating the grass in these containers with the materials listed in Table 1. Materials were applied on 2/24/83 using a small, calibrated atomizer. All containers were fertilized weekly with a complete nutrient solution and watered daily on an as needed basis to prevent wilt. Measurements of water use were taken at an approximate 2 week interval for a period of 8 weeks. Results are shown in Table 1. Measurement techniques were similar to those described in previous progress reports.

The field phase of this study was initiated on Tifway bermudagrass on 6/15/83 using the minilysimeter concept and application techniques as described in previous progress reports. The materials applied in the field to the bermudagrass and their respective rates are listed in Table 2. Five water use rate measurements were made during an approximate 3 month period. Results of those measurements are also given in Table 2.

The second portion of phase two of this study was initiated on 7/20/83 on St. Augustinegrass in the field. A listing of materials and their respective rates is outlined in Table 3. Here again, the minilysimeter concept, application techniques, and measurement methods were very similar to those described in previous progress reports. Results of water use rate measurements is given in Table 3.

A visual assessment of phytotoxic effects of each material and its respective rates pertaining to both grasses was made on 8/23/83 and is shown in Table 4.

Results and Discussions

Looking first at the greenhouse portion of this study, it was found that flurprimidol did cause a significant decrease in the water use rate of St. Augustinegrass. The greatest decrease in water use rate was measured under the lowest rate of flurprimidol. Perhaps this was due to the higher rates causing a distinct thinning of the canopy of the grass thereby allowing greater evaporation from the soil surface to occur.

Stoma-Gro and EP-913 did not effect a significant reduction in water use rate; but instead, the latter actually caused an increase in water use over the untreated check.

In discussing the effect of the materials tested on Tifway bermudagrass, it was found that the untreated check exhibited the lowest overall water use rate measurement; however, only significantly lower than the highest rate of flurprimidol. This unexplainable development may warrant further evaluation on bermudagrass.

As shown in Table 3, all of the chemicals applied to St. Augustinegrass in the field produced very dramatic reductions in water use rate measurements. The most effective treatment in terms of water conservation was that of the combination of mefluidide and flurprimidol. The results of this portion of the study confirmed the earlier work of Drs. Johns and Beard in 1981.

Phytotoxicity ratings showed that neither of the materials were overly phytotoxic to St. Augustinegrass; however, flurprimidol at the 1.25 lb. ai/ac rate on bermudagrass did produce moderate discoloration that lasted several weeks.

Another observation concerned the effect of these materials on seedhead formation on St. Augustinegrass. While the untreated check plot showed prolific seed production, the plots treated with the combination of flurprimidol and mefluidide produced virtually no seedheads at all. The other treatments causing a very low degree of seeding were the 2 rates of mefluidide by itself.

Literature Cited

Stahnke, G.K. and J.B. Beard. 1981. An assessment of antitranspirants on creeping bentgrass and bermudagrass turfs. Texas Agricultural Experiment Station Progress Report No. 4041. 36 p.

Johns, D. and J.B. Beard. 1981. Water Conservation - A potentially new dimension in the use of growth regulators. Texas Agricultural Experiment Station Progress Report No. 4040. 35 p.

Table 1. Effects of 3 Materials on Water Loss From Common St. Augustinegrass Grown in the Greenhouse.

Treatment	Rate	Water Loss*/24 hr Rating Period 3/11/83	3/24/83	4/7/83	4/29/83	Ave. Water Loss Per Treatment	Percent H_2O Saved
EL 500	0.75 lb. AI/ac	194 cd**	188 a	188 c	227 b	199 d	17.1
EL 500	1.0 lb. AI/ac	199 bcd	178 a	199 c	234 b	202 cd	15.8
EL 500	1.5 lb. AI/ac	219 abc	161 a	213 c	238 b	208 bcd	13.6
Untreated Check	---	226 a	172 a	272 ab	292 a	240 a	0.0
Stoma-Seal	0.5% solution	211 abcd	173 a	254 b	281 a	227 abc	5.4
EP-913	5% solution	223 ab	179 a	297 a	307 a	252 a	-4.8

*Measured in Grams.

**Values followed by the same letter are not significantly different at the 5% level of Duncan's Multiple Range Test.

Table 2. Effects of Various Rates and Combinations of Mefluidide and Flurprimidol on the Water Use Rate of Tifway Bermudagrass.

Treatment	Rate lbs. A.I./ac	Water Loss*/24 hr Rating Period 6/29/83	7/21/83	8/3/83	8/25/83	9/9/83	Ave. Water Loss Per Treatment
Mefluidide	0.25	231 a**	200 ab	238 ab	242 a	131 b	208 ab
Mefluidide	0.375	233 a	181 a	196 bc	227 a	123 b	192 ab
Flurprimidol	0.75	218 a	180 a	194 bc	218 a	123 b	187 b
Flurprimidol	1.0	212 a	174 a	202 abc	206 a	140 ab	184 b
Flurprimidol	1.25	233 a	194 a	253 a	217 a	159 a	211 a
Mefluidide + Flurprimidol	0.375 + 0.75	239 a	193 a	218 abc	233 a	139 ab	204 ab
Untreated Check	---	222 a	202 a	170 c	213 a	124 b	186 b

*Measured in Grams.

**Values follow by the sam letter are not significantly different at the 5% level of Duncan's Multiple Range Test.

Table 3. Effects of Various Rates and Combinations of Mefluidide and Flurprimidol on the Water Use Rate of Common St. Augustinegrass.

Treatment	Rate lbs. A.I./Ac	Water Loss*/24 hr Rating Period 8/3/83	8/25/83	9/9/83	Ave. Water Loss Per Treatment	Percent H_2O Saved
Mefluidide	0.25	294 b**	238 b	183 a	238 b	19.6
Mefluidide	0.375	296 b	223 b	186 a	235 bc	20.6
Flurprimidol	0.75	292 b	220 b	138 b	217 bc	26.7
Flurprimidol	1.00	299 b	219 b	146 b	222 bc	25.0
Flurprimidol	1.50	217 b	219 b	147 b	228 bc	23.0
Mefluidide + Flurprimidol	0.375 + 0.75	282 b	200 b	147 b	207 c	30.1
Untreated Check	---	386 a	300 a	202 a	296 a	0.0

*Measure in Grams.

**Values followed by the same letter are not significantly different at the 5% level of Duncan's Multiple Range Test.

Table 4. The Effects of Flurprimidol and Mefluidide on Phytotoxicity to Tifway Bermudagrass and Common St. Augustinegrass.

Treatment	Rate lbs. A.I./Ac	Phytotoxicity Ratings* Bermudagrass	St. Augustinegrass
Mefluidide	0.25	1.2 cd**	2.2 a
Mefludidie	0.375	1.0 d	2.2 ab
Flurprimidol	0.75	1.8 bc	1.3 bc
Flurprimidol	1.00	2.0 b	1.5 bc
Flurprimidol	1.25 - 1.50	3.8 a	1.8 ab
Mefluidide + Flurprimidol	0.375 + 0.75	1.8 bc	2.2 a
Untreated Check	---	1.2 cd	1.0 c

*Rating based on 1 = no phytotoxicity; 9 = severe phytotoxicity.

**Values followed by the same letter are not significantly different at the 5% level of Duncan's Multiple Range Test.

SPRING ROOT DECLINE INDUCTION STUDIES

S.I. Sifers and J. B. Beard

Introduction

Since the initial discovery of the spring root decline phenomenon in bermudagrass and St. Augustinegrass, the TAMU Turfgrass rhizotron has been used each spring to investigate this event. This facility was described and a six year summary of observations was reported upon in PR-4032, Texas Turfgrass Research 1982.

Observations during the winter of 1982-83 can now be added to that data. The winter period temperatures were mild, spring greenup was late, and spring shoot growth was slow. The roots continued to grow at a slow rate for 2 - 4 weeks after low temperature discoloration of the shoots occurred. Subsequently, the root systems remained white and apparently healthy throughout the winter dormancy period. Spring greenup, following upon the mild winter temperatures, was very slow and, as expected, spring root decline was not observed.

In an effort to provide final confirmation that the spring root decline phenomenon exists we began a series of investigations utilizing primarily environmental stress simulation chambers. If this phenomenon could be successfully duplicated under simulated controlled environment conditions, we would be able to conduct detailed studies of the specific parameters that induce spring root decline, determine methods to enhance the rate of recovery, and perhaps determine methods to prevent its actual occurrence. These studies could be conducted regardless of the time of year or seasonal weather conditions.

Materials and Methods

Beginning early in 1983, sods of Tifgreen bermudagrass (*Cynodon* spp.) and Texas Common St. Augustinegrass (*Stenotaphrum secondatum*) were established in glass faced root observation boxes (Fig. 1). The sod dimensions were 11 by 4 inches (28 x 16 cm), while the glass observation face was 24 inches high by 12 inches wide (61 x 30 cm) (Fig. 2). The interior of each box was filled with washed masonary sand to facilitate root observation and future washing for measurement of root biomass. The sods were allowed to root naturally under optimum growing conditions in the greenhouse for a period of 2 months. The turfs initially received 2 lbs each of actual nitrogen, phosphorus, and potassium per 1000 ft sq. (1 kg/100 m^2). Subsequently, a weekly nutrient solution of N-P-K was applied at a rate equal to 1 lb N/1000 ft^2/month (0.5 kg/100 m^2). Tifgreen bermudagrass was mowed weekly at one inch (2.5 cm) and the St. Augustinegrass weekly at 2 inches (5 cm), with clippings removed. No disease or insect problems were observed during the duration of this phase.

Study I. After 2 months of root acclimation the four replicate boxes of each species were placed in a growth chamber at 42°F (5 °C). Low temperature shoot discoloration occurred after two weeks. The turfs were retained in the same growth chamber for a 2 month period. Subsequently, they were transferred to a second growth chamber maintained at a temperature of 92°F (33 °C). Both growth chambers had been modified with high light intensity lamps which simulated a light intensity of 90% full sunlight. The chambers allowed full control over temperature and a day length of 14 hours.

Study II. For further confirmation this experiment was repeated a second time in the Fall of 1983. In terms of experimental procedure, the initial rooting period as well as the low temperature discoloration-dormancy simulation phase were the same as previously described. The same two grasses (Tifgreen bermudagrass and Texas common St. Augustinegrass) were utilized. However, upon transferring to the higher temperature greenup phase a split treatment was utilized involving 90°F (32 °C) and 75°F (24°C). Again, no damage associated with insect or disease activity was observed during the period of this study. The turfgrass cultural conditions were the same as described in the spring study.

Results

Study I. The established roots on the glass face maintained a white, healthy condition throughout the low temperature discoloration and dormancy phases, even though there was total loss of chlorophyll in the shoots. Some green color could be observed in the nodes, especially those on the lateral stems. Upon placement in the high temperature environment, new green shoot initiation occurred within 4 days. No new root growth was initiated from the tips of the existing roots throughout the subsequent two-week period in the high temperature chamber. The existing roots turned brown between 2 and 6 days after greenup. All new root initiation and growth arose from meristematic areas in the crowns and the nodes on lateral stems near the surface of the soil, and began after approximately one week in the 92 ^{o}F (33 ^{o}C) environment.

Study II. Results of this fall study were very distinct and contrasting. At 90 ^{o}F (32 ^{o}C) the existing roots ceased growth and turned brown 4 days after shoot greenup began. New root initiation occurred 6 and 7 days after shoot greenup. Initiation was from the meristematic regions in the crowns and in the nodes of lateral stems as described in the previous study. However, at the lower 75 ^{o}F (24 ^{o}C) temperature, only slight root discoloration was observed and after a period of 8 days root growth extension was reinitiated from the tips of the existing roots. Thus, it appears that a high temperature [greater than 75 ^{o}F (24 ^{o}C)] at the time of shoot greenup which would stimulate rapid shoot growth and a high demand for carbohydrates may be critical in inducing the occurrence of spring root decline.

Summary

This series of experiments provided a final confirmation that spring root decline exists as a separate phenomenon, rather than it being caused by low temperature kill, low temperature fungi, or some other external effect. This does not say that either one or a combination of these stresses could not accentuate the seriousness of spring root decline. But rather, it is a phenomena in and of itself which must be taken into consideration in relation to spring turfgrass cultural practices. Thus, the turf manager should consider a higher cutting height, a modest to low nitrogen fertility level, avoidance of extensive vertical cutting, and irrigation as needed to avoid water stress in order to insure the most rapid rate of root replacement following spring root decline.

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Figure 1. Root observation box with door closed.

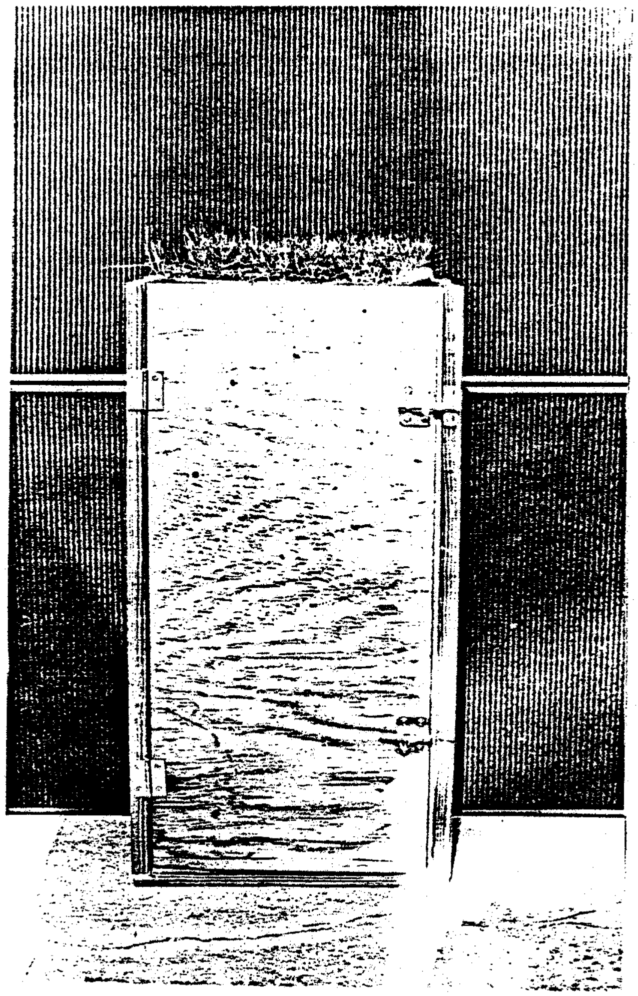

Figure 2. Root observation box with door opened showing how roots appear following spring root decline.