FIRST ANNUAL PROGRESS REPORT

concerning

BREEDING AND DEVELOPMENT OF BENTGRASS

Submitted by:

Dr. M. C. Engelke
Turfgrass Breeder and Geneticist
Texas Agricultural Experiment Station – Dallas
Texas A&M University System

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EXECUTIVE SUMMARY
FIRST ANNUAL PROGRESS REPORT
BREEDING AND DEVELOPMENT OF BENTGRASS

Principle Investigator: Dr. M. C. Engelke

Research Associate: Ms. V. G. Lehman

RESEARCH PERIOD OF THIS REPORT: 8 April 1985 to 1 November 1985

Susceptibility to heat stress limits use of bentgrass for high quality playing surfaces in the Southern and Central United States. In the fall of 1981, a group of individuals in the north Texas area interested in bentgrass established a fund-raising organization named Bentgrass Research, Inc., to support bentgrass research at TAES-Dallas. In October 1982, a 3600 square foot sand green was constructed by this group for research purposes. In April 1984, the United States Golf Association, Bentgrass Research, Inc., and the Texas Agricultural Experiment Station joined in a concerted effort for the "Breeding and Development of Bentgrass". A limited collection of bentgrass germplasm had been assembled at TAES-Dallas over the previous 4 years. Most notably were individual plants which had survived naturally under Southern climatic extremes, often in direct competition with other species such as bermudagrass. In total as of November 1985, over 200 vegetative accessions from two countries and five states, 129 seeded accessions from nine countries, and five commercial varieties were included in the collection.

Since the initiation of this program, replicated plantings of most of the elite germplasm has been made to both the sand base green (96 elite clones) and to native blackland soil (230 vegetative accessions). These test sites will provide the initial field performance evaluations under greens and simulated fairway conditions over the next 18 to 24 months. Superior clones will be utilized in specific crosses to create new plants with desirable combinations of traits.

In the spring of 1985, a specialized greenhouse heat bench was utilized to select 196 clones with heat tolerance from a population of approximately 20,000 plants of 'Seaside' bentgrass. A root growth characterization study was initiated in mid-summer 1985 to examine the inherent genetic variation within the germplasm pool and to identify unique rooting characters which may be associated with plants selected for heat tolerance from the heat bench. Twenty clones were randomly selected from the elite vegetative material and included with 25 clones from the heat tolerant POPULATION A selections and from the base population of Seaside.

Research planned for 1986 includes planting and evaluation of the selected heat tolerant bentgrasses for agronomic quality on a sand base green. Using a temperature controlled water bath system, experiments are planned to correlate the tissue tolerance and root tolerance to high temperatures between the unselected base population of bentgrasses and those selected for heat tolerance. Utilizing the specialized heat bench, comparisons are planned to determine the relative heat tolerance of commercial bentgrass varieties. Heat susceptible and heat tolerant genotypes will be examined morphologically to identify characters which may be associated with the mechanism of biological heat tolerance.

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Breeding and Development of Bentgrass

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I. INTRODUCTION

This annual report, as required in the contract, is for the period of 8 April 1985 to 1 November 1985. Ms. Jo Ann Treat, President, Texas Research Foundation, and Mr. Charles W. Smith, Director, Administration and Services for United States Golf Association, signed the contract agreement effective 8 April 1985. A check for the first quarter funding arrived shortly thereafter, and the appropriate accounting procedures were established through the Texas Research Foundation. The following, although considered as an annual report for 1985, summarizes the accomplishments of the past 7 months.

II. PERSONNEL

The bentgrass breeding project which was ultimately approved included a full time Research Associate (RA) position (100% Bentgrass Breeding) and approximately 500 hours (1/4 time) technical support. In August 1985, Bentgrass Research Inc., provided additional funding for the current year only to create a temporary half-time technical support position. The RA position was filled on 1 June 1985 with the rehire and redirection of Ms. Virginia Lehman (Vita appended). She formerly served as RA on the Turfgrass Breeding Project prior to attending graduate classes at Texas A&M in pursuit of her Ph. D. degree. Ms. Lehman has completed on campus class requirements and is enrolled in graduate level courses at University of Texas - Dallas, simultaneously maintaining full time employment responsibilities with this project. The half-time technical support position is presently filled by Ms. Sherrie Anderson, who holds a B.S. degree from Texas A&M.

III. IMPLEMENTATION - HISTORY

The Bentgrass Breeding program, although not officially initiated until 8 April 1985 (when contracts were signed between Texas A&M Research Foundation on behalf of the Texas Agricultural Experiment Station and United States Golf Association), was initialized in July 1980 with the establishment of the turfgrass breeding position with Texas Agricultural Experiment Station at Dallas. Numerous collection trips were conducted throughout the southern United States from 1980 to the present during which several unique bentgrass plants were acquired.

In the fall of 1981, a group of individuals in the North Texas area interested in bentgrass established a fund-raising organization named Bentgrass Research, Inc., to support bentgrass research at TAES-Dallas. Since 1981, the group has expanded to include numerous clubs, industry personnel, and other associations throughout the Texas-Oklahoma area. In October 1982, a 3600 square foot sand-based green was constructed by Bentgrass Research, Inc. on which management related research was to be conducted, however, logistical problems associated with primary research efforts at Dallas resulted in program delays and eventual redirection. In March 1984, the United States Golf Association Turfgrass Research Committee (letter date 23 March 1984 from Mr. Wm. H. Bengeyfield) solicited a proposal for "Breeding and Development of Bentgrass for Putting Greens in the Southern United States". In early April 1984, the project leader met separately with the Associate Director of the Experiment Station, and with selected members of Bentgrass Research, Inc.'s

Executive committee to discuss the possibilities of a joint funding effort to provide an adequate financial base with which to conduct this program. In a memorandum dated 13 April 1984, Dr. Robert Merrifield, Associate Director, emphasized the need for support from both USGA and Bentgrass Research, Inc. in order to mount a viable breeding program.

Negotiation between the two funding organizations proceeded over the next few months with the final agreement for Bentgrass Research, Inc. to provide funding for the "Breeding and Development of Bentgrass" through the United States Golf Association to the Texas Agricultural Experiment Station-Dallas. No restrictions were to be placed on the funding provided by Bentgrass Research, Inc., in order to provide funding for selected and approved capital equipment items needed specifically to support the Bentgrass Project. The funding level was significantly lower than originally anticipated however, the program was initiated 8 April 1985. The project includes a position of Research Associate which requires an M. S. degree or higher.

IV. RESEARCH ACTIVITIES

Various phases of research which have been initiated during 1985, and proposed research experiments are as follows:

A. GERMPLASM ACQUISITION

INTRODUCTION: Genetic diversity and the collection of plant materials which possess unique biological and agronomic characteristics are essential to the conduct of every plant breeding program. With the ultimate objective of creating new plant types which possess multiple traits, the first and possibly the most important step is to assemble plants possessing one or more desirable characteristics. Bentgrasses in general possess highly desirable turf-type characteristics, yet when used under marginal environmental conditions, many of these desirable traits are lost or become obscure due to other biological limitations of the plant, such as its general lack of heat tolerance, disease susceptibility, and poor recuperative ability under high temperature conditions. In order to compensate for these biological deficiencies, expensive management practices are often employed such as syringing and/or light frequent irrigations, or frequent fungicide applications to overcome disease pressures resulting from higher humidity under high temperatures. It first becomes necessary to assemble the genes by which the plant will be able to overcome these biological limitations. Our prime objective in acquiring germplasm concentrates on plants which possess inherent heat tolerance, improved root growth and persistence characteristics, and disease resistance. These characters, once identified must, be combined with desirable turf characteristics to create a new plant which will persist in the natural environment more efficiently.

OBJECTIVES: Assemble a germplasm pool of unique bentgrasses possessing genetic characteristics which reduce or eliminate the biological limitations of the species under natural environmental conditions.

PROGRESS: The acquisition of bentgrass germplasm was initiated in September 1980, with vegetative plugs from the Decatur Country Club, in Decatur Texas and from the surrounding area. During November 1981 and again in April 1983, in cooperation with Dr. Doug Hawes, former Agronomist, USGA Green Section, collection trips were conducted throughout Central-South Texas coastal regions during which several additional bentgrass were acquired which appeared to survive under high temperature and high humidity conditions typical of that region. When the USGA/Bentgrass Research, Inc. joined the Texas Agricultural Experiment Station in the Bentgrass Breeding and Development Program, approximately 230 vegetative accessions were in pots in the greenhouse, with 50 early accessions being maintained under minimal maintenance on blackland soil.

As of 1 October 1985, the bentgrass germplasm at TAES-Dallas consists of the following:

Vegetative Accessions,	232	Japan and the United States
Vegetative Accessions,	196	Heat tolerant selections
Vegetative Accessions,	98	Progeny of Seaside Bentgrass
Seeded Accessions, P.I.	129	9 countries
Commercial Varieties	5	Penncross, Penneagle, Prominent, Seaside, PSU 126

FUTURE WORK: Germplasm acquisition is an ongoing program. In cooperation with the USGA Green Section Agronomist, the GSCAA network of golf course superintendents, turf industry personnel and fellow scientists, we hope to acquire those unique plants which inherently possess superior biological characteristics. Special attention must be directed to those regions of the country where the species is considered marginal, such as the humid southeast and the arid and semi-arid southern United States.

B. GERMPLASM ASSESSMENT

INTRODUCTION: Understanding the extent of the genetic diversity available within a germplasm pool is as important as possessing it. Through well-defined controlled studies either in the laboratory, greenhouse, or under natural field conditons, the actual assessment of a plants worth is necessary. In cooperation with other scientific disciplines, as well as within our own project objectives, screening and evaluation procedures are developed, refined and employed to aid in identification and characterization of the germplasm resources available.

No single procedure, or approach will resolve the total needs for characterizing plant performance, however, each procedure used must be effective, precise, and usable in a breeding program. Too often techniques or procedures developed by other disciplines are limited in the size and scope of the study needed to accommodate the needs of the plant breeder, and do not permit sampling or handling large populations of individual plants. Through conventional plant breeding procedures, it is possible to create populations of plants numbering in the thousands from which we must selected those few plants with the desirable characteristics. Therefore, it is important to consider limitations in procedural development. Often times simple greenhouse and/or laboratory procedures can be employed to reduce the number of plants to be tested under field conditions. This is particularly important for turf trials designed to define limits of environmental adaptation. Such regional and national testing programs must be conducted using only the elite or most promising of plant material due to time, labor and financial constraints.

ASSESSMENT - GREENHOUSE HEAT TOLERANCE

OBJECTIVES: Evaluate heterogeneous, heterozygous populations of turf-type bentgrasses for response to high soil temperatures. Select individual plants which demonstrate superior performance under high soil temperature conditions. Identify major agronomic and biological characteristics unique to the survivors.

PROGRESS: A specialized greenhouse bench measuring 1.2 by 2.4 meters (4 ft x 8 ft) (Figure 1) was constructed to permit selection and evaluation of turfgrasses under high soil temperatures under controlled environmental conditions (Engelke, 1984; Engelke et al. 1985). This bench was seeded to 'Seaside' bentgrass, a highly heterogeneous, heterozygous population in May 1985. Optimum growth conditions, including temperature, moisture, and nutrition were maintained for 6 weeks to obtain a turf stand (Figure 2A). The bench was sub-divided into 98 grids each measuring 15.2 cms square to permit more uniform assessment of plant performance. A single plant was selected at random from each of the 98 grids to provide the base population for future comparison. Soil temperatures were gradually raised to 40 C and maintained for 5 weeks. After 21 days, over 50% of the original population was decimated (Figure 2B). After 28 days of 40 C soils, the single most desirable plant was selected from each grid (Figure 2C) (POPULATION A). After 35 days, one more plant was selected from each grid (POPULATION B), yielding a total of 196 plants (A and B) selected for survival under high soil heat stress. As observed in Figure 2C, few plants remained in each grid (POPULATION B) which possessed green living tissue. An initial evaluation of differences between the base population and the selected populations (A and B) may indicate that tiller number is a contributing factor to survival (Figure 3). The base population had a range of 1-13 tillers per plant with a mean tiller number of 4.95. POPULATION A had a range of 2-13 tillers per plant with a mean tiller number of 5.82.

FUTURE WORK:

A. Determine response of cultivated bentgrass genotypes to high soil temperatures.

Objective: Screen currently commercially available bentgrass genotypes for heat tolerance utilizing the greenhouse selection technique previously described.

Procedures: Establish the commercial genotypes in the heat bench. Evaluate clipping yields, general agronomic performance, and the number of days until apparent death while under heat stress.

B. Evaluate the tissue tolerance of those plants selected for root heat tolerance.

Objective: Aid in the mechanistic determination of heat tolerance.

Procedures: Immerse shoot tissue of clones selected for heat tolerance and those of the unselected base population in high temperature water baths, and determine the change in electrolytic concentration utilizing the technique of Wallner et al., (1982).

C. Determine morphological differences between heat susceptible and tolerant bentgrass genotypes.

Objective: Determine possible mechanisms of heat tolerance.

Procedures: Place selected heat tolerant genotypes and individuals from an un-selected base population under heat stress.
Morphological characters to evaluate:

a. Stomatal density
b. Root vascular bundle diameter
c. Epidermal layer thickness
d. Tiller formation

ASSESSMENT-GREENHOUSE ROOT CHARACTERIZATION

OBJECTIVES: Identify individual plants which have the ability to generate deeper, faster growing and more profuse rooting systems.

PROGRESS: An evaluation of bentgrass root systems was initiated in August 1985 utilizing a mini-rhizotron (Figures 3 and 4). Twenty elite clones of the plant material acquired from collection trips by Engelke and others, 25 clones each of the BASE population and POPULATION A from the heat bench are currently being evaluated for the following root morphological traits:

a. root length
b. rate of root elongation
c. number major intersections
d. root mass/cm increment in depth
e. shoot mass
f. root area
g. shoot area
h. root/shoot ratios

FUTURE WORK: A. Evaluate additional elite bentgrasses for superior rooting ability.

Objectives: Compare genotypes chosen from the initial cycle of selection with additional germplasm acquisitions.

Procedures: Utilize mini-rhizotrons with germplasm exhibiting extremes in root characters from the current studies as standards for the next cycle of selection.

ASSESSMENT-FIELD PERFORMANCE

OBJECTIVES: Identification of genotypes with superior agronomic traits on native and sand modified soils.

PROGRESS: Fifty accessions of bentgrass were planted in native blackland soil during 1983. An additional 30 clones were added during spring of 1985. Minimal cultural attention was devoted to these plantings until the initiation of this bentgrass breeding program in 1985. Field notes on general growth habit, spread, texture, and flowering were taken during 1985. Multiple point plantings (8 plugs per plot) of 96 clones of bentgrass were planted 24 September 1985 on the sand base green with two replications. This material includes the vegetative accessions collected from throughout the South. On 9 October 1985, 230 vegetative accessions were planted on blackland soil, also in multiple point plantings. Evaluations of spread, color, texture, and other agronomic features will be assessed on the replicated material planted in the sand and blackland soil. Fifty clones of the material planted on the green were also moved to Oregon for field assessment of flowering and generation of seed for progeny testing.

FUTURE WORK:
A. Field assessment of bentgrasses selected for heat tolerance compared to unselected base population which survived heat stress.

Objectives: Identify heat tolerant bentgrasses which also possess good agronomic characteristics necessary for utilization on high quality playing surfaces.

Procedures: Plant vegetative propagules of clones selected for heat tolerance on a modified sand green during spring of 1986.

Characters to evaluate:

a. rate of spread
b. texture
c. color
d. surface smoothness
e. susceptibility to incidental diseases

ASSESSMENT-GROWTH CHAMBER FLOWERING

OBJECTIVE: Determine external stimuli necessary to induce flowering.

PROGRESS: Twenty-five elite clones of vegetative material have been selected to determine photoperiod response. This plant material is currently being induced to flower under short photoperiods and controlled temperature conditions in a growth chamber.

FUTURE WORK: A. After flowering is initiated, controlled crosses will be made for generation of seed.

Objective: Generate selfed and crossed progeny which may then be evaluated for possible combination of desirable traits in one individual.

Procedures: Make controlled crosses utilizing emasculation techniques, and generate selfed progeny by bagging immature inflorescences.

V. LITERATURE CITED

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Wallner, S. J., M.R. Becwar, and J. D. Butler. 1982. Measurement of turfgrass heat tolerance in Vitro. J. Amer. Soc. Hort. Sci. 107:608-613.

VI. LIST OF FIGURES

V. G. Lehman
Research Associate - Turfgrass Breeding and Genetics
Texas Agricultural Experiment Station at Dallas
17360 Coit Road
Dallas, Texas 75252

Area of Specialization:

Turfgrass Breeding and Management

Academic Record:

B.S., 1976, Texas Tech University, Horticulture, with honors
M.S., 1981, University of Idaho, Plant Science

Professional Accomplishments:

1985 - present: Research associate, specializing in bentgrass breeding, TAES-Dallas.

Aug. 1984 - May 1985: Instructor, Agronomy 105 labs, Soil and Crop Science, Texas A&M University. Simultaneously completed classwork for Ph.D., Dr. J. B. Beard, major professor.

Feb. 1982 - Aug. 1984: Research associate, turfgrass breeding, TAES-Dallas. Responsible for evaluation of 5 species for cultivar improvement.

June 1977 - Feb. 1982: Technician, turfgrass seed production and forage improvement, University of Idaho.

Sept. 1974 - May 1977: Groundskeeper with promotion to foreman, Texas Tech University Grounds Maintenance.

Author and co-author of 3 refereed journal articles, 18 progress reports, and 2 popular articles.

Professional and Honor Society Activities:

American Society of Agronomy, Crop Science Society of America, Alpha Zeta, Phi Kappa Phi, and Gamma Sigma Delta.

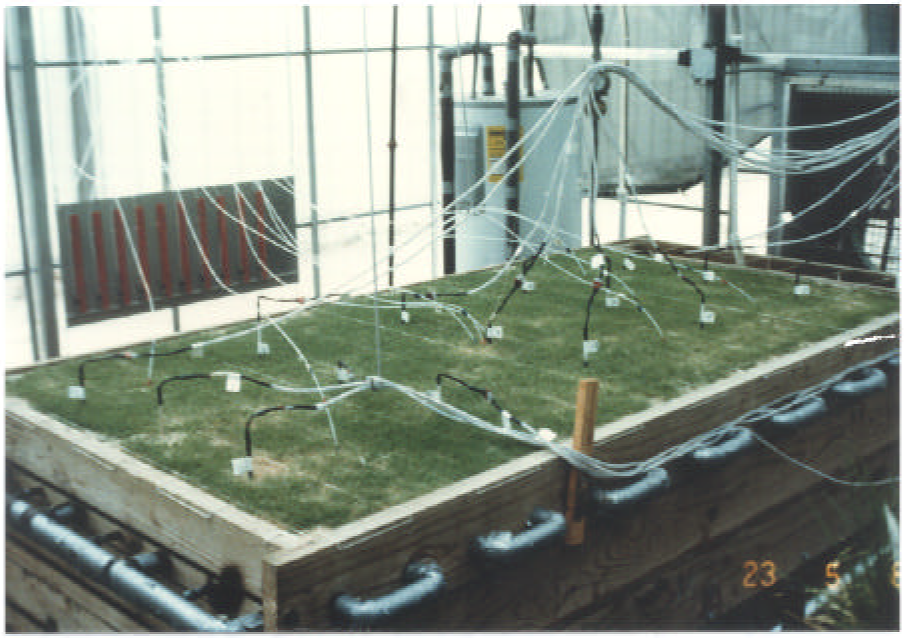

Figure 1. A greenhouse heat bench designed to maintain soil temperatures at 40 to 50 C, seeded to 'Seaside' bentgrass. Temperature probes are used to monitor soil temperatures at 3 levels, with mercury tensiometers used to monitor depth of soil moisture.

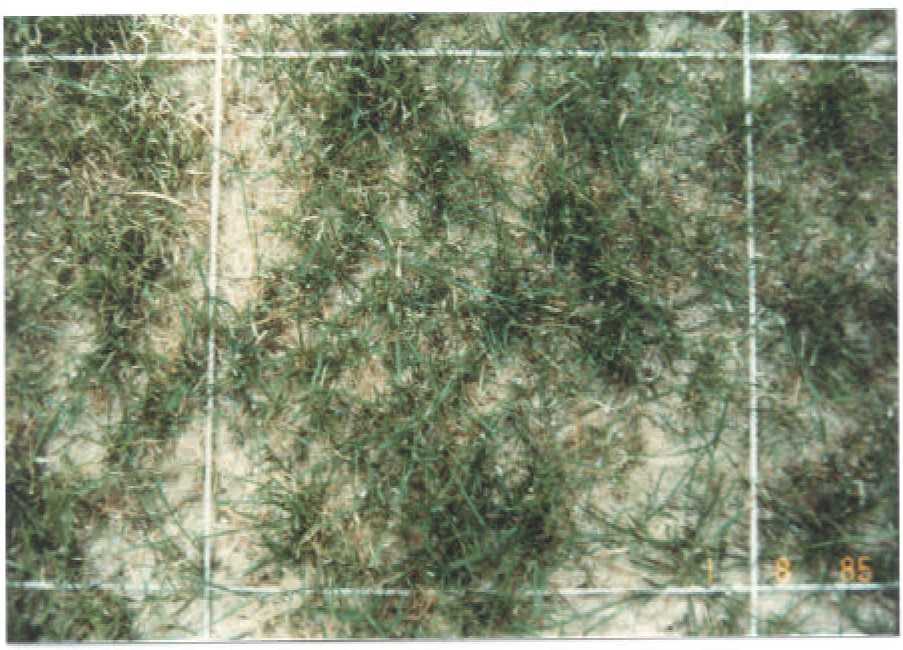

Figure 2A. A 6-week old 'Seaside' turf planted in the greenhouse heat bench, maintained under optimum growth conditions.

Figure 2B. 'Seaside' turf planted in the greenhouse heat bench, after 21 days of 40 C soil temperatures, illustrating over 50% plant mortality.

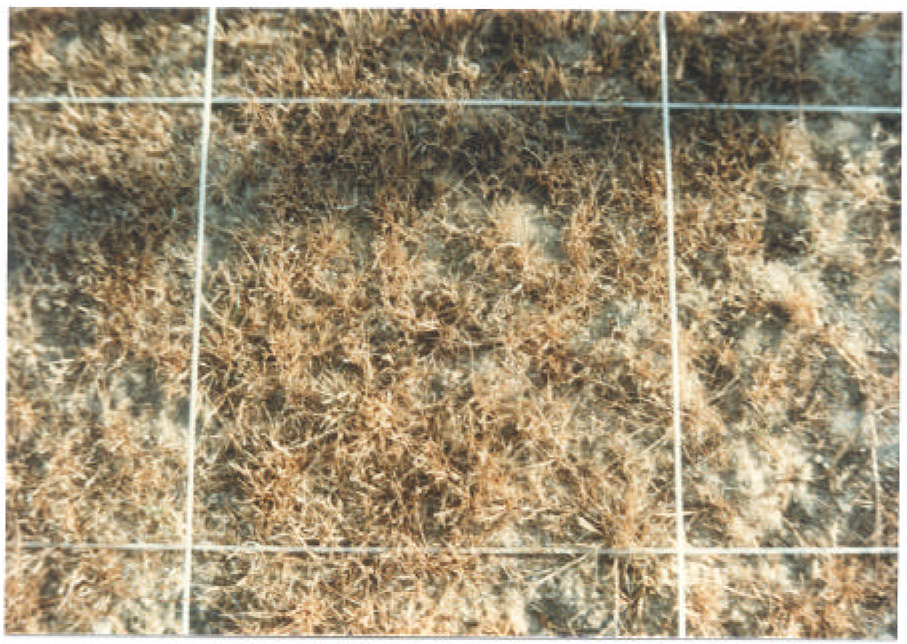

Figure 2C. 'Seaside' turf planted in the greenhouse heat bench, after 28 days of 40 C soil temperatures, illustrating over 95% plant mortality. Population A was selected from surviving plants at this time.

Figure 3. Frequency distribution for number of tillers per plant of indiv-ual bentgrass plants from an unselected base population (Base) and for plants selected for heat tolerance (POP A) using a greenhouse heat bench (Chi square value, 9 df,=27.8, significant at the 0.05 level).

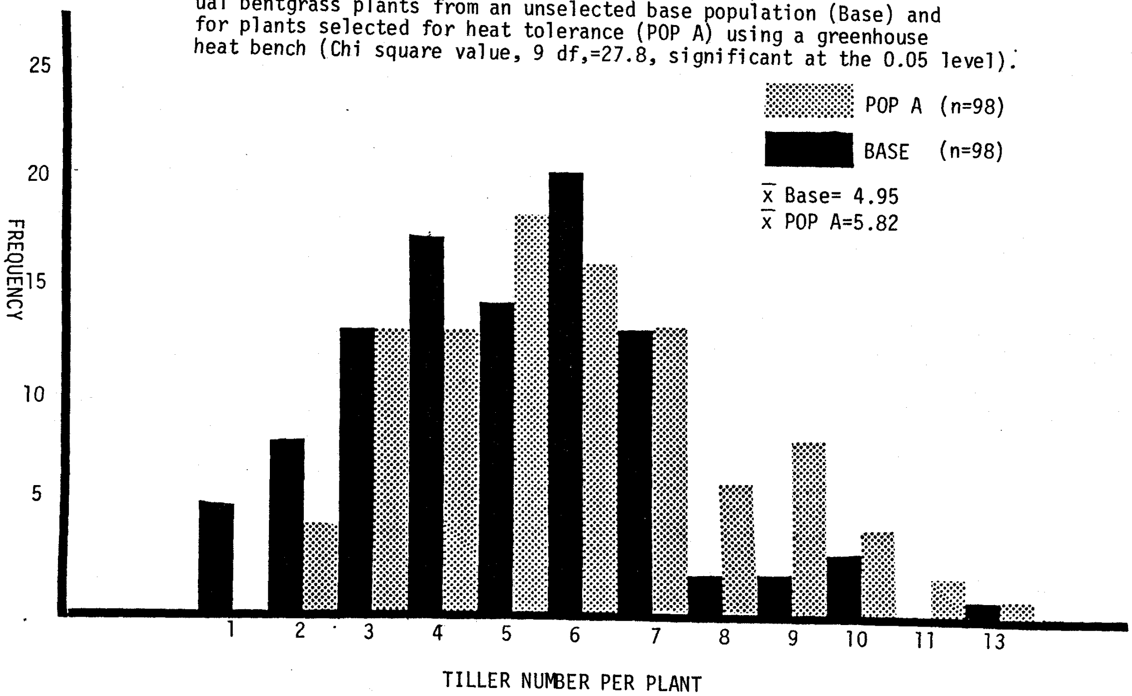

Figure 4. Evaluation of root morphological traits in the greenhouse utilizing mini-rhizotrons.

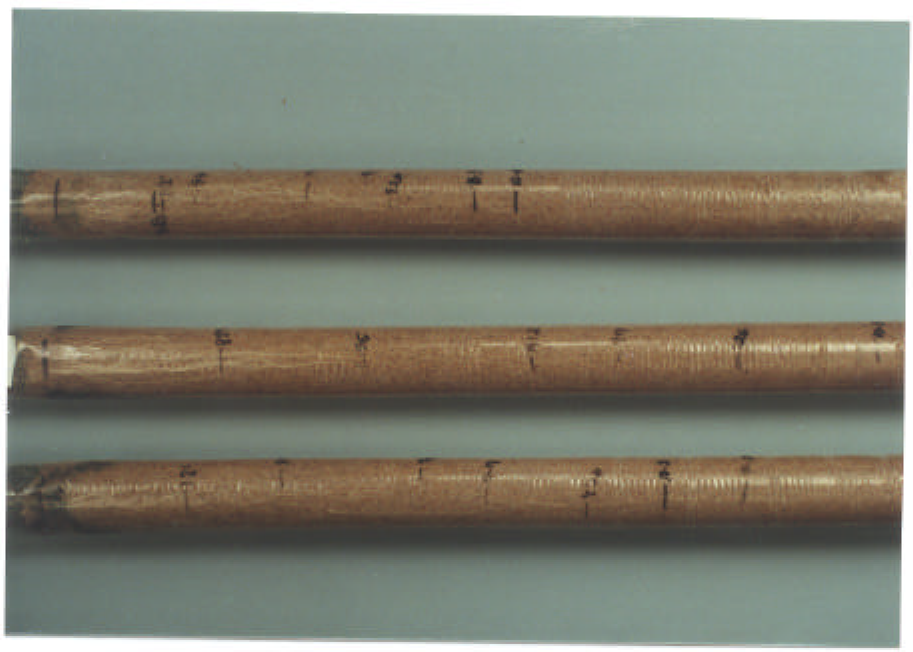

Figure 5. Comparison of bentgrasses for rate of root elongation utilizing mini-rhizotrons in the greenhouse.